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CURTIS'S AND HARVEY LTD EXPLOSIVES FACTORY, CLIFFE AND CLIFFE WOODS, MEDWAY
ARCHAEOLOGICAL SURVEY AND ANALYSIS OF THE FACTORY REMAINS

Volume 1 of 2

Rebecca Pullen, Sarah Newsome, Andrew Williams and Wayne D Cocroft

ARCHAEOLOGICAL
SURVEY AND INVESTIGATION

ENGLISH HERITAGE

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Rebecca Pullen, Sarah Newsome, Andrew Williams
and Wayne D Cocroft

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SUMMARY

Between November 2010 and January 2011 English Heritage undertook detailed archaeological survey and analysis of a former chemical explosives factory covering approximately 128 hectares of estuarine marshland in the north-west corner of the Hoo Peninsula, Medway. The study was undertaken as part of the wider Hoo Peninsula Historic Landscape Project and presents a comprehensive record and analysis of the surface remains along with the first meticulous and accurate plan of the whole site and a detailed history of the factory. Initially, Hay, Merricks & Co set up a small-scale gunpowder storage facility here in 1892. Then in 1898, the site was acquired by Curtis's & Harvey Ltd who quickly established a new chemical explosives factory. The works grew rapidly, and during the First World War it became a government-controlled establishment manufacturing a range of propellant and blasting explosives with a primary focus on producing naval cordite. It was a short-lived enterprise, closing around 1920 due to the post-war reduction in demand for munitions. The site is on land owned by the Port of London Authority and managed by tenant farmers. There is no public access to the site.

CONTRIBUTORS

The preliminary aerial photographic survey was carried out by Fiona Small. Fieldwork was undertaken by Sarah Newsome, Rebecca Pullen, Wayne Cocroft, Andrew Williams, Derwin Gregory, Marcus Jecock, Magnus Alexander and David McOmish. Rebecca Pullen carried out the background research, prepared the survey data and wrote the report, incorporating contributions and edits from Sarah Newsome, Wayne Cocroft and Andrew Williams. David Went and Laura Holland commented on the final draft. Philip Sinton produced the final survey drawings and Andrew Williams produced plan and section drawings of the standing buildings. Unless otherwise stated, ground photographs were taken by Steve Cole and new aerial photographs were taken by Damian Grady.

ACKNOWLEDGEMENTS

English Heritage is extremely grateful to the Port of London Authority and Keith Loveridge for allowing access to the site. Thanks are also due to Peter Kendall, Helen Winton, Edward Carpenter and Fiona Small for valuable contributions, to Lis Dyson for her support and to Trevor Pearson for technical advice. Particular gratitude goes to Gill Moore (Cliffe and Cliffe Woods Parish Council archive), Amanda Thomas, Clifford Dowsett and various residents of Cliffe village who kindly shared family history, memories and images.

ARCHIVE LOCATION

The English Heritage Archive, The Engine House, Fire Fly Avenue, Swindon, SN2 2EH.

DATE OF SURVEY AND REPORTING

The survey was undertaken between 1 November 2010 and 25 January 2011, and the report was published in 2013.

Cover image: Aerial view of the factory remains focussed on Area E in the middle of the site, orientated with east at the top. Photograph: Damian Grady, NMR 26890/013 8MAR2011 © English Heritage

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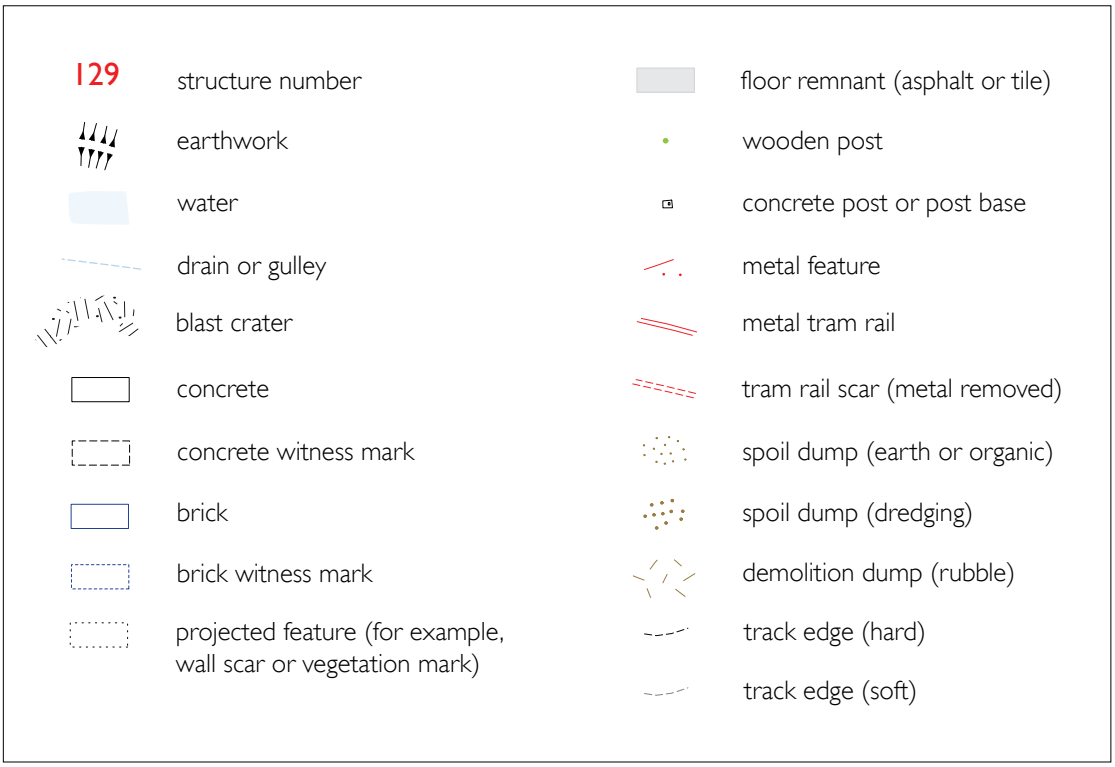

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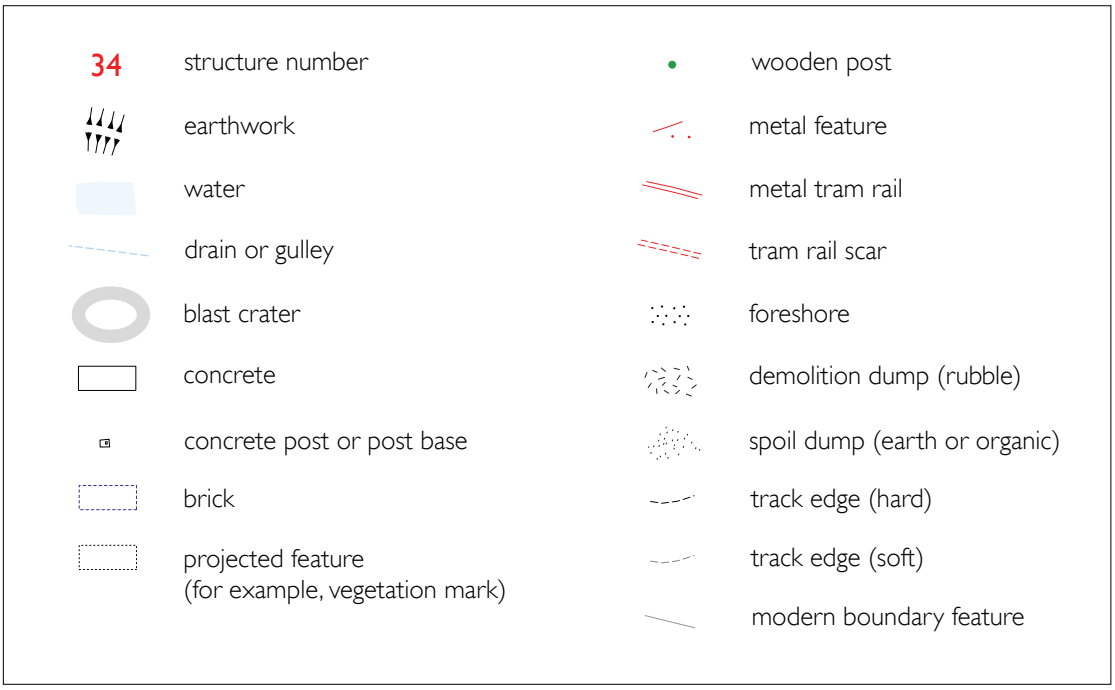


1. INTRODUCTION

This report presents a comprehensive description and analysis of the nature of the remains of the former chemical explosives works at Lower Hope Point on Cliffe Marshes (Figure 1). It provides the story of the site's development and use as currently understood and presents for the first time a detailed and accurate plan of the whole site.

The investigation was undertaken as part of English Heritage's Hoo Peninsula Historic Landscape Project (RaSMIS number 5733) which aims to provide a greater understanding of the historical development of the Hoo Peninsula in order to underpin strategic decision-making in the face of anticipated major development (Carpenter *et al* 2013). The wider research into the historic landscape of the Hoo Peninsula encompassed integrated techniques including a palaeoenvironmental review (Hazell 2011), historic landscape characterisation, detailed aerial photographic transcriptions and historic area assessments to provide an informative overview of the story of landscape change and development across the peninsula. Within the project remit, a few specific sites were chosen to receive a finer-grained approach to recording and interpreting their nature and significance - the former explosives works at Lower Hope Point on Cliffe Marshes was one of them.

Figure 1: Location map.

The factory remains cover around 128 hectares of Cliffe Marshes, a wide tract of reclaimed estuarine saltmarsh near Lower Hope Point in the north-west corner of the Hoo Penninsula, along the south banks of the River Thames. The layout of the First World War phase of the explosives factory survives largely intact as earthworks, concrete foundations and a few standing buildings. Most of the factory buildings have been demolished or reclaimed for reuse, leaving behind a complex of concrete foundation floor slabs, protective earthwork traverses (blast protection mounds), embanked earthen tram-beds and narrow drains. Surviving details - such as concrete plinths (machine beds), witness marks for walls, remnant floor coverings, tanks, pipes and iron fittings - give some insight into the form and function of the buildings that once stood there. The standing buildings that do survive are predominantly reinforced concrete structures erected during the First World War and a few earlier brick-built administration building; all are roofless.

The potential of this open and unpopulated marsh adjacent to a major British shipping route as a location for explosives handling was first recognised by the Scottish gunpowder company Hay, Merricks & Company Limited (*see* section 3.3). In 1890, they submitted a draft licence applying for permission to blend and store gunpowder at Lower Hope Point (KHLC CKS-S/NK/A/C/1/19) and by 1892 the works was added to the national register of licensed explosives factories (as 'Factory No. 154'), although gunpowder was not physically manufactured here (HMSO 1893, 4). In 1898, Hay, Merricks & Co, along with eight other gunpowder firms, was incorporated into Messrs Curtis's & Harvey Limited as a newly constituted public company (Hodgetts 1909, 355). As part of this merger, Curtis's & Harvey Ltd acquired the land and limited gunpowder handling facilities on Cliffe Marshes. Nationally, this was a time of great change in the explosives industry with gunpowder rapidly being superseded by chemical explosives. The new 'smokeless' propellants, such as cordite, were preferred for their greater efficiency and accuracy (*see* section 4). Curtis's & Harvey were quick to capitalise on this revolution (*see* section 3.4): in 1898-9, they purchased adjacent land from the Cobham Hall Estate and in 1900, at this newly enlarged 'Cliffe-at-Hoo' site, they founded their only factory to be established after being incorporated as a Limited Company (Hodgetts 1909, 364).

From mid-1901 the site was authorised to manufacture gunpowder, 'nitro-cotton' (guncotton) and various nitroglycerine based explosives, namely cordite, blasting gelatine and gelatine dynamite (HMSO 1902; Cooper-Key 1903, 4). By the end of 1901, the company was fully engaged in the production of cordite at Cliffe (KHLC CKS-S/NK/A/C/1/186). Between 1902 and 1904 at least seven further amending licences were issued (Cooper-Key 1904, 4) including authorisation for the manufacture of cordite M.D. (HMSO 1904) and for the chlorate-based explosives Cheddites (Cooper-Key 1904, 4). This period marked the beginning of a rapid diversification into a wide variety of explosive recipes and brands and with that came an impressive rate of physical expansion and development across the site itself. By 1908, the factory was described by HM Chief Inspector of Explosives as 'one of the largest in the kingdom' (Cooper-Key 1908). The site continued to grow in this way and, by the outbreak of the First World War, about half of the area now covered by the factory remains had been developed. The war generated demand for explosives on a scale far bigger than the country had ever seen

before (see section 3.5). As a result, in early 1916, Curtis's & Harvey Ltd's Cliffe factory was declared a controlled establishment under the terms of the 1915 Munitions of War Act (TNA BT 31/35980/59657 vol 3). Growth of the factory was particularly extensive during 1916 (Crozier 1917, 1) when a major state-owned First World War extension to the works, known as 'HM Cordite Factory', was constructed along the eastern edge of the existing complex to provide a massive increase in capacity for production of cordite (MALSC 06a_DE_Series_1001_1200/DE1087_3). Rapid expansion was quickly followed by rapid decline; the end of the war brought a cessation in official war work, a dramatic drop in demand for explosives and nationwide economic depression (see section 3.6). Manufacture at the Cliffe factory had ended by 1921, and a letter sent in 1922 described the whole factory as being in the course of demolition (KHLC CKS-S/NK/A/C/1/124). In November 1921, the eastern half of the site, HM Cordite Factory, was sold to the War Office, confirming the end of all manufacturing in this area (ibid). Less than two years later, the War Office resold the land formerly known as HM Cordite Factory to Herbert Moses Thomas of Lincolnshire (MALSC 06a_DE_Series_1001_1200/DE1087_3). By 1931, all of the former factory land on Cliffe Marshes was under the ownership of the current holders, the Port of London Authority (PLA) (KHLC CKS-S/NK/A/C/1/186), and apart from occasional limited military activity during the Second World War, it has been used as grazing marsh by tenant farmers ever since.

The rapid expansions of the factory and need for a local workforce influenced population growth in the nearby village of Cliffe, such that an additional school was constructed in the village in 1907 to accommodate the overflow of pupils. The village physically expanded too, and as well as the better known factory houses relating to the nearby Portland cement works, some purpose built housing was erected for the explosives factory workers around 1912 (see section 8.6).

Curtis's & Harvey's explosives works at Cliffe was one of only a handful of factories mass producing powerful propellants like cordite in the early 20th century (see section 8.5). Much of the layout, building styles and technology employed at Cliffe are thought to have been largely based on the existing cordite works at Royal Gunpowder Factory (RGPF) at Waltham Abbey in Essex which, as the Royal establishment, was at the forefront of British explosives production and technology, and would have been the inspiration for many smaller establishments like Cliffe. The nature of the factory's location on Cliffe Marshes - a greenfield site with good shipping access and high potential for expansion - offered ideal conditions for establishing chemical explosives works. Unsurprisingly, equivalent contemporary explosives factories were also located on marshland at Pitsea Hall Farm and Kynochtown in Essex, and Uplees in Kent, on marginal estuarine land at Holton Heath in Dorset, and, similarly, in sand dunes at Hayle in Cornwall and Ardeer in North Ayreshire; all as a result of the same pull-factors.

The extent and completeness of plan of the factory remains at Cliffe is significant; they tell us much about the scale and nature of the explosives manufacture, and the vast area covered by the factory remains gives some sense of how important this site was to the character of the area and the local economy. Of particular note is the number of standing reinforced concrete buildings, predominantly in the 1916 HM Cordite Factory development, but also in two examples in **Area E** (see Figure 2) thought to have been

erected shortly before the outbreak of the First World War. Reinforced concrete ('ferro-concrete') had a very limited uptake as a construction material in the British explosives industry (Cocroft 2000, 103-4). As such, the examples at Cliffe represent a rare survival of the material used in this context (see sections 8.3 and 8.5). Most are the roofless shells of former cordite drying stoves (structures **153**-**154**, **205**-**212** and **222**-**231**), but reinforced concrete has also been used to construct the paired press house ranges (**246** and **247**) and in the paired acetone recovery stove ranges, where the material has been used to construct partition walls between bays which project from a central brick wall (**244** and **245**).

Unfortunately, very little exists in the way of contemporary maps or site descriptions produced by or for Curtis's & Harvey and, as the site was comprehensively stripped of any equipment, structures and materials that possessed a resale value following its closure, many interpretations of the previous form and function of buildings presented here rely solely on archaeological evidence.

1.1 The survey

Non-invasive archaeological survey of the former explosives works on Cliffe Marshes was initially proposed by English Heritage as part of the wider Hoo Peninsula Historic Landscape Project (Newsome 2009; Carpenter *et al* 2013). The aim was to carry out a measured survey in order to accurately record and analyse the surface remains (see Appendix 1), and for the first time to produce a detailed and accurate plan of the whole site (see Appendix 4).

The survey was undertaken between 1 November 2010 and 25 January 2011 by staff from English Heritage's Archaeological Survey and Investigation Team. The timing of the fieldwork was chosen to avoid the spring and summer months so as to minimise the impact of the survey on ground-nesting birds, and to make the most of improved visibility and access while vegetation was low.

Fieldwork was carried out by eight members of staff, with teams of between two and six surveyors working on site at any one time. The survey was conducted using a combination of survey grade Global Navigation Satellite System (GNSS) equipment and a total station theodolite (TST), and worked within Ordnance Survey (OS) National Grid coordinates. A detailed statement of methodology is provided in section 9.

The resultant survey data was processed, tidied up, and then redrawn as a detailed 1:1000 scale hachured site plan. The full final version of the survey drawing is provided across a series of A3 pull-out sheets in Appendix 4 in Volume 2 of this report.

Terminology

Descriptions throughout this report include use of the word 'structure' to refer to any feature, or group of features, interpreted as the remains of a building or factory component or the physical indication of their former presence. In many cases, only the earthwork traverse (a blast protection mound surrounding an explosives building) survives to show the location of a building. In other instances, the only surviving trace

of a building might be a clear rectangular area of shorter discoloured grass betraying a concrete surface below the vegetation, or the presence of a tank or group of manholes suggesting the function of an area. It was deemed necessary to select a single term, and although ordinarily the word 'feature' would be favoured when describing earthworks or vegetation marks, it is not a sufficient word for conveying the often complex combinations of material remains that frequently indicate the presence of an individual building amongst the factory remains. Therefore, factory components described as 'structures' are variously earthworks, standing building remains, clear vegetation marks, negative cut features and non-portable structural components (such as concrete footings, plinths or tanks), as well as any combination of the aforementioned that relates to a former single factory building or element. Thus, 'structure' has been taken to signify the interpretation of physical elements indicating the presence of 'a building or other object constructed from several parts' (Pearsall 1999, 1423) relating to the factory remains.

Marks witnessing the former presence of a wall lines, floor coverings and mountings for machines survive in association with many of the building foundations; these are referred to as 'witness marks' in this report.

Another term used frequently throughout the report is 'dyke'; used to refer to the larger steep-sided drainage ditches that divide up the marsh into field-like portions, in order to distinguish them from descriptions of factory drains, culverts and pipe trenches. Although the term can be used to denote 'a linear earthwork comprising a bank or ditch, or both' (Darvill 2008, 138), here it is used specifically to denote 'an artificially excavated drainage ditch' (Whittow 1984, 158).

Labelling

Although primary documentary sources reveal that Curtis's & Harvey had established a numbering system for buildings at their Cliffe factory, these sources only enable us to assign original numbers to a handful of structures on the site. With this in mind, a new numbering system was established to accompany the survey drawing to provide a way of orientating the reader, and of anchoring individual descriptions, essential for a site of such great size and complexity. The new number sequence runs consecutively from **1** to **284** and includes all identifiable discrete 'structures' (see explanations of terminology above) believed to belong to the factory complex. Numbers have not been assigned to generic features found factory-wide, such as tramway embankments, culverts and manholes, or to features identified as having origins either pre- or post-dating the operational period of the explosives works. Linear features and features grouped in a linear arrangement were also noted in several instances across the factory site, in the form of post arrangements, extensive culverts and alignments of distinctive triangular foundations. The five clearest linear features have each been assigned a number to aid description and identification: linears **L1** to **L5**. The four wooden jetties connecting the factory to the Thames shipping route have also been labelled for ease of identification: jetties **J1** to **J4** ordered by construction date from earliest (**J1**) to latest (**J4**). Finally, to further aid orientation around the site and to provide a simplified grouping system for geographically and functionally related structures, the area of investigation has been divided into eleven zones, **Areas A** to **K**, predominantly using the drainage dykes as boundaries (Figure 2). These zones have been used to order the descriptions of factory structures in section 6.

Appendix 1, in Volume 2 of this report, provides a reference table for the full structure number sequence, including NGR coordinates and, where known, original Curtis's & Harvey factory building numbers.

*Figure 2: Reduced version of full survey, showing Areas **A to K** as used to organise descriptions of the factory remains throughout this report. Drawn by Philip Sinton © English Heritage.*

1.2 Location

The remains of the former explosives works (NMR TQ 77 NW 121) are located on Cliffe Marshes in the north-west corner of the Hoo Peninsula, on the North Kent coast (see Figure 1), covering an area of 128 hectares. The site is situated at NGR TQ 72399 78947, immediately to the north of the village of Cliffe in the parish of Cliffe and Cliffe Woods (Figure 3). The site is positioned at Lower Hope Point on the south bank of the River Thames, where the river turns and broadens into the Thames Estuary; the site is bounded to the north and west by a high concrete sea wall (Figure 4). Historically, the area around Cliffe village and Cliffe Marshes formed part of Kent. However, since 1998 it has been under the administrative control of Medway Unitary Authority, although it still falls within the ceremonial county of Kent.

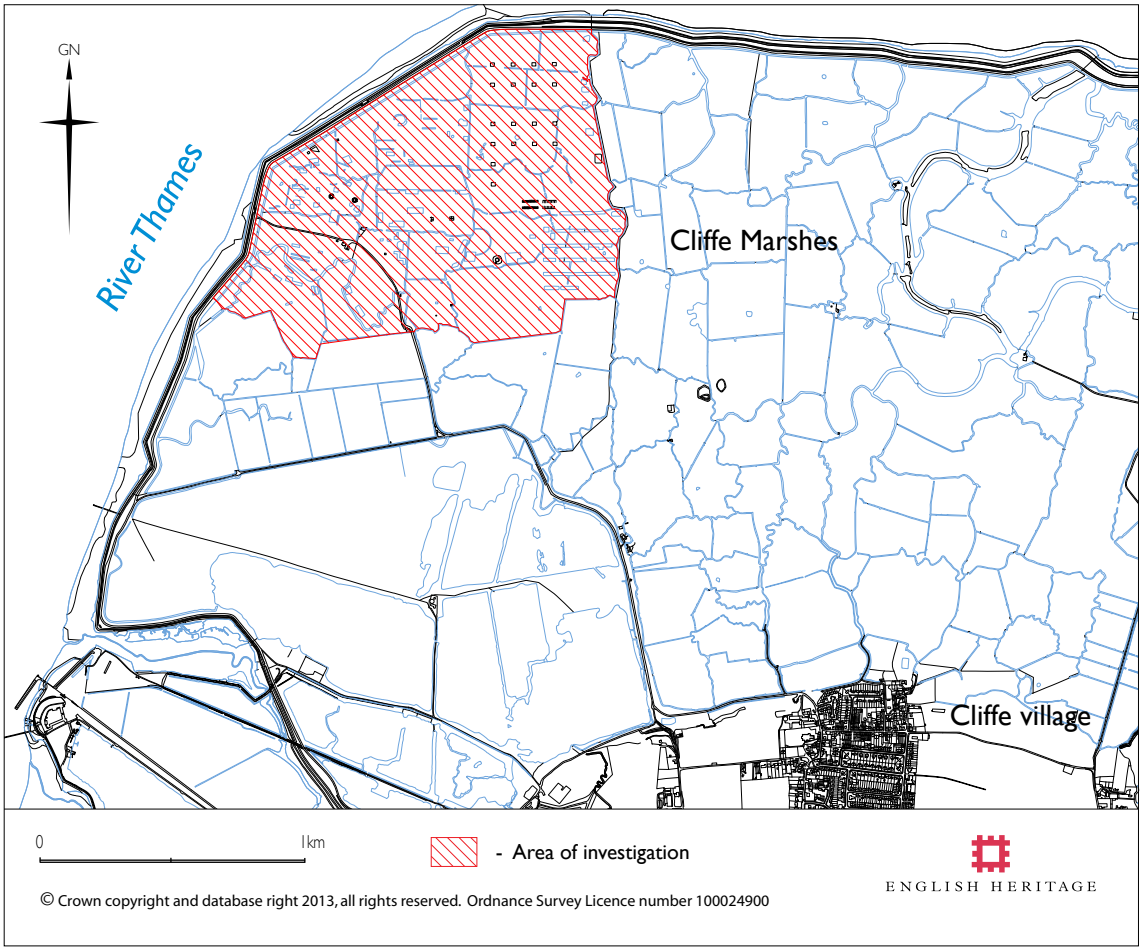


Figure 3: Area of investigation, shown in relation to the north end of Cliffe village.

Figure 4: Remains of the explosives works at Cliffe from the air in 2011, looking north-east. NMR 26890/003 08-Mar-2011, Damian Grady © English Heritage.

1.3 Topography, geology and land use

Cliffe Marshes is an extensive area of reclaimed estuarine salt-marsh; consequently the ground is almost uniformly level at 2m above Ordnance Datum (OD), rendering it vulnerable to waterlogging and occasional flooding.

The geology underlying Cliffe Marshes consists of thick surface deposits of alluvium overlying Woolwich Beds of sands and clays and Thanet Beds of sand. These bedded sands seal layers of Upper Cretaceous chalk bedrock that underlie the entire peninsula (BGS 1978, sheet 272 Chatham, Drift edition). The underlying chalk protrudes as a broad east-west ridge forming a marked spine to the whole Hoo Penninsula and a strong physical contrast to Cliffe Marshes which end at the foot of the northern escarpment.

The historic northern end of Cliffe village focussed on St Helen's church adopts a commanding position on the edge of this high ground at a height of 10m OD, and takes its name from this cliff-top position (*see* Figure 3). From here it overlooks the marshland below and on clear day, views stretch right across the estuary to the Essex coast.

The land is owned by the Port of London Authority (PLA) and is currently farmed as grazing marsh by a tenant as part of the DEFRA North Kent Marshes ESA Tier 1 scheme (DEFRA 2002; PLA 2010); with a current grazing stock of sheep and horses. The international importance of the wetland environment at Cliffe is acknowledged by its inclusion in the Thames Estuary and Marshes Ramsar site. The area is also accredited

with national environmental significance, and is protected and managed accordingly as part of the South Thames Estuary and Marshes Site of Special Scientific Interest (SSSI).

It must be emphasised that the site is on private land, with no right of public access. The remains are a potentially hazardous environment of unfenced, deep, steep-sided ponds (water-filled borrow pits) and drainage dykes, unmarked open tanks and manholes, crumbling masonry and protruding metalwork, often partially masked by vegetation. In addition, regular shoots take place throughout the wildfowling season to manage the local bird population. Unauthorised visits are therefore illegal and potentially dangerous. It is, however, possible to view the site at a distance from the public right of way along part of the sea wall.

2. PREVIOUS RESEARCH

A very brief account of the factory appeared in Hoggett's *The rise and progress of the British explosives industry* (1909, 354-65). Subsequently, given the complexity and extensive nature of the factory remains at Cliffe, there has been very little archaeological investigation or published discussion focussed on the explosives works.

Amongst the local community there is interest in the social history of the site, but its industrial archaeology has not been addressed in any detail. Passing mention of the factory is made in several publications relating to the history of the local area, typically with an emphasis on factory employees and often focussing on the unfortunate accidents they encountered (eg Munday 1994; Thomas 2008). In his pictorial books about Cliffe, Allan Cherry includes a pair of formal photographs of the staff lined up in their Curtis's & Harvey uniforms with anecdotes from personal accounts (Cherry 1998, 54-5). He also published what currently appears to be the only known photograph of the factory prior to the dismantling of the buildings, which is thought to have been taken around 1908 and probably shows the early acid-handling and guncotton preparation area towards the west side of the site (Cherry 1991, 29) (Figure 5).

Figure 5: Curtis's & Harvey Ltd Explosives Factory taken around 1908, showing the acid and guncotton processing buildings in ***Area B****, with the taller structures of the nitroglycerine factory in* ***Area A*** *just visible in the background © Cliffe and Cliffe Woods Parish Council, reproduced by kind permission of Pat Leviston.*

The first clear acknowledgement of the site's archaeological significance was highlighted through an overview of the its history and brief description of the upstanding remains presented by Wayne Cocroft in *Dangerous Energy* (2000, 143-4). This remained the only published description and interpretation of the factory remains until the instigation of this analytical investigation.

In 2005 Wessex Archaeology undertook a field assessment of features along the foreshore on behalf of Kent County Council as part of the North Kent Rapid Coastal Zone Assessment Survey (RCZAS) (Wessex Archaeology 2006). The results included production of brief descriptions for each of the four degraded wooden jetty structures

fringing the factory site to enhance existing historic environment records for Kent County Council; the jetties (**J1** to **J4**) are discussed in section 6.2 of this report.

In 2007, on behalf of the Royal Society for the Protection of Birds (RSPB), Archaeology South-East undertook a historic environment desk-based assessment of the Cliffe Pools RSPB reserve immediately south of the explosives factory site, the broader study area for which takes in the very southern edge of the factory extents (James 2007).

In 2010, as part of the Hoo Peninsula Historic Landscape Project (HPHLP), English Heritage's Aerial Survey and Investigation Team completed an air photograph assessment covering Cliffe Marshes. This provided a useful overview and context for the site and the marshland surrounding them, and highlighted a number of factory structures that had been removed in more recent times, many as a result of the relocation and rebuilding of the sea wall in the 1980s (Figure 6). Since then the wider HPHLP has continued to increase our understanding of the historical development of the peninsula through integrated research techniques including: an historic area assessment of neighbouring Cliffe village, historic landscape characterisation and a palaeoenvironmental review (Hazell 2011) both covering the whole peninsula, other nearby historic area assessments and several site-specific recording and analysis projects (eg Gregory and Newsome 2010; Williams and Newsome *forthcoming*) including this particular investigation.

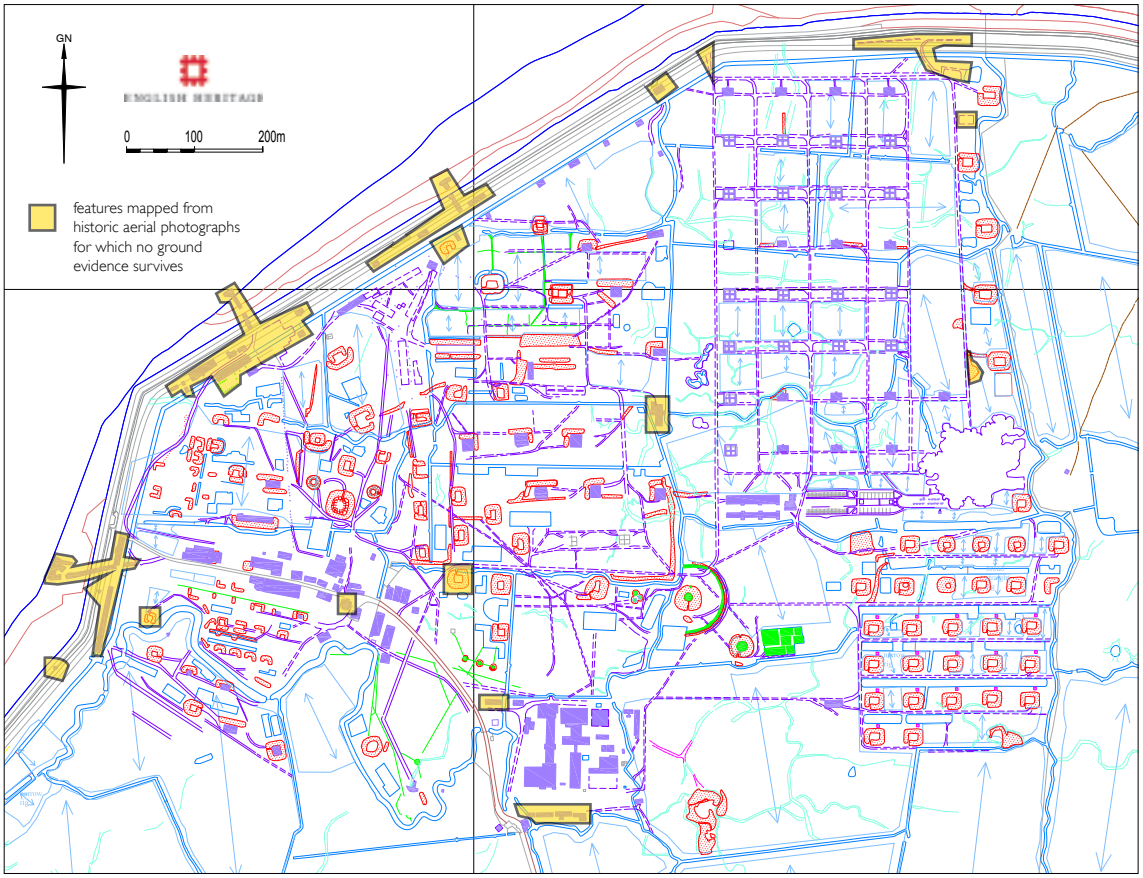


Figure 6: The explosives factory remains at Cliffe as mapped from aerial photographs, highlighting the features that are no longer identifiable on the ground © English Heritage.

3. ARCHAEOLOGICAL AND HISTORICAL BACKGROUND

The main purpose of this section of the report is to review the history of the explosives works, the marshland site it adopts and the extent and nature of the documentary sources.

3.1 Documentary sources

Given that the industrial activity on Cliffe Marshes is little over a century old, there is surprisingly little primary documentation directly describing the factory's buildings and activities. The poor survival of documentation relating to the site may be in part attributed to the disruption caused by a number of company mergers. In 1898, Hay, Merricks & Co was amalgamated with Curtis's & Harvey Ltd. Then, in 1918, Curtis's & Harvey were brought under a new umbrella company called Explosives Trades Ltd, renamed Nobel Industries Ltd in 1920. Nobel Industries then merged with other firms in 1926 to form Imperial Chemical Industries Ltd (ICI), and in 1932, ICI (Explosives) was formed. Most recently, ICI was acquired by AkzoNobel in 2008 (Cocroft 2000; AkzoNobel 2011; Grace's Guide 2012a; 2012b). Contact was made with both ICI and AkzoNobel during the research for this report, but unfortunately no corpus of official company records were identified and no further information was gained.

The main sources of primary documentary evidence were gathered from records held at The National Archives in Kew (TNA), Kent History and Library Centre in Maidstone (KHLC) and Medway Archives and Local Studies Centre in Strood (MALSC). The most useful unpublished contemporary documents are site sales particulars and an accompanying plan from 1923 relating to the scheduled auctioning of the eastern area of the site known as HM Cordite Factory, which include detailed descriptions of the function and construction of most buildings in this part of the factory and details of some aspects of the general machinery and infrastructure holdings (MALSC 06a_DE_Series_1001_1200/DE1087_3). Other key primary documents relating to the factory include: application documents and a plan submitted by Hay, Merricks & Co in 1890 proposing a gunpowder works at Lower Hope Point (KHLC CKS-S/NK/A/C/1/19); an early 20th-century draft layout for cordite magazines at Cliffe (TNA WO 78/5434); Sewers' Commission valuation assessments from the 1920s for land at Cliffe held by Curtis's & Harvey (within KHLC CKS-S/NK/A/C/1); Board of Trade company records relating to Curtis's & Harvey (TNA BT 31/35979/59657; BT 31/35980/59657); and a collection of digitised maps of the Earl of Darnley's Cobham Hall Estate holdings which included land gradually bought through the staggered expansions of the factory, available from MALSC. The detailed records of the local Sewers' Commission (held at KHLC), whose responsibilities for the upkeep of the sea walls were financed by an annual wall scot (tax) imposed upon local landowners, have also provided numerous snippets of valuable information.

A small number of photographs of the factory staff and buildings have been identified in private collections and within the photographic archive maintained by Cliffe and Cliffe Woods Parish Council, some of which have been published (Cherry 1991; 1998; Thomas 2008). Some of these images appear within this report.

Published primary sources include: two editions of 25-inch OS mapping surveyed in 1895 and 1907 (Ordnance Survey 1897a; 1897b; 1908a; 1908b); several articles and announcements in local newspapers relating to incidents and events involving the factory at Cliffe; and reports were produced by His/Her Majesty's (HM) Inspector of Explosives including investigative reports into accidents occurring at the factory in 1902, 1904, 1908, 1911, 1914 and 1917 and national annual reports for the years 1892-1921. These official reports prepared by HM Inspector of Explosives were all published by HMSO, and were predominantly accessed via the 'House of Commons Parliamentary Papers Online' database, maintained by ProQuest (http://parlipapers.chadwyck.co.uk/marketing/index.jsp).

Almost no published secondary sources of information directly regarding the site exist, the main exceptions being a contemporary description of the holdings and activities of Curtis's & Harvey Ltd in Hodgett's (1909) account of the British Explosives Industry and Cocroft's (2000) brief descriptive account of the factory published in *Dangerous Energy.*

3.2 Pre-explosives works

The following account of the factory's development is prefaced by a brief overview of the history of land use relating to this portion of Cliffe Marshes in the periods preceding the site's association with explosives storage and manufacture.

The marshland at Cliffe was reclaimed from estuarine salt-marsh through a process of draining and embankment to create grazing marsh and reduce flooding. This extensive undertaking still accounts for the overriding character of the marshland along the northern edge of the peninsula, and has been described as providing Kent with '… many acres of fine pasture land' (Bignell 1975, 42). The precise date of the marshland reclamation is uncertain. Although small-scale reclamations probably took place in Roman times and by Dutch workmen and engineers during the 17th century, the drained landscape seen today is generally attributed to medieval undertakings (Bowler 1968, 99-237).

Prehistoric and Roman

As any remains from the Prehistoric or Romano-British periods are sealed under considerable alluvial deposits, relatively little is known about the site in the periods preceding these major drainage operations. Kent Historic Environment Record (HER) contains entries for a number of spot finds and small scale excavations that produced evidence for prehistoric and Roman activity close to, but not directly on, the factory site. A number of short articles and notes have been published in *Archaeologia Cantiana* relating to the vicinity in these periods (eg Nightingale 1952; Evans 1953; Hutchings 1989). In his thesis *Reclamation and Land Use of the Thames Marshes of North West Kent*, Bowler (1968, 100-105) surmises that utilisation of these river lowlands began around the mid-1st century AD and continued into the mid-4th century, including habitation sites right out on the marshes themselves.

Situated on the banks of the Thames, only around 8km north of Watling Street and Rochester Bridge and close to important Romano-British centres at Rochester (Durobrivæ) and London, Cliffe was well located and connected in the Roman period. Archaeological investigations near Cliffe have unearthed possible evidence of Roman salt workings (Nightingale 1952; Chaplin and Coy 1961; Hutchings 1987), indication of a

long-lived local industry of Belgic ceramic production and a late 1st to early 2nd century cremation cemetery (Chaplin and Coy 1961).

Early medieval

Cliffe enjoyed reasonable importance in Saxon times; a church was founded at Cliffe by King Offa of Mercia in 774 AD and Saxon leaders gathered at Cliffe for their national synods during the 8th and 9th centuries (Hasted 1797, 498-515). The Domesday Book for Kent, compiled in 1086 AD, lists Cliffe in Shamwell Hundred, with land owned by the 'Archbishop of Canterbury's monks' (notionally the Abbey) and the Bishop of Bayeux (Morgan 1983, 3,6; 5,110). Cliffe was quite a sizeable town with a long tradition of agrarian concerns until it was devastated by fire in 1520 (Hasted 1797, 498-515). Cliffe village would not peak in size again until the height of industrial production in the area at the start of the First World War.

Medieval and post-medieval: marshland character

As previously stated, the character of the area is most strongly derived from the pattern of drainage ditches dividing up the marshland in a process of land reclamation and management believed to have started in the medieval period. This mass reclamation is generally attributed to the efforts of medieval 'inners' (those taking in land and enclosing it) beginning in the 13th century; by 1540 much of Cliffe Marshes was enclosed or 'inned' (Bowler 1968, 99-237).

Upstanding mounds believed to be the evidence for salterns are found in large numbers across Cliffe Marshes. Salterns are places where crystalline salt was extracted from salt-water using a process of evaporation or by the washing of salt-impregnated sands, and are often found exploiting small coastal inlets and tidal marshlands. The tell-tale earthworks are waste mounds resulting from gradual build-up of discarded sands, silts, ash and pottery (Went 2011). During recent aerial photographic survey work by EH across the whole of the Hoo Peninsula, a total of 100 mounds were identified as possible salterns and added to eight existing records, although for some sites the interpretation may be less certain than others (E Carpenter, pers comm). Within the bounds of the explosives works site itself, aerial photographs revealed one mound of this character towards the centre of the southern edge of the factory; this possible saltern was recorded as part of the detailed survey (NMR TQ 77 NW 223) (see section 5.3). None of the possible salterns identified through aerial survey appear to correspond with wicks (outlying farm premises) marked on local maps dating back as far as Russell's 1695 map of Cliffe Level (KHLC CKS-S/NK/P/8A). This may be because sites actively engaged in salt-production were not recorded, but it is more likely that the mounds had gone out of use by or before the 17th century and could have had considerably earlier origins.

MacDougall (1979, 45) went so far as to describe the marshes as 'damp, inauspicious swamps that could be used only for sheep or cattle grazing'. Numerous sheepfolds, or wicks, and sheep washes labelled on the 1860 first edition 25-inch OS map confirm that prior to the establishment of explosives manufacture, the area was being used primarily as grazing marsh for sheep. The presence of one such sheepfold, now adopted by the remains of a later brick sheep wash and associated building platform (NMR TQ 77 NW 307) (located between structures **255** and **256**, see section 5.4), is marked on Russell's 1695 map (Figure 7) and on 25-inch OS maps surveyed in 1895 and 1907

(Ordnance Survey 1897b; 1908b), potentially suggesting a continuous function for over three centuries. This sheepfold is depicted as a small chimneyless non-domestic building in a small enclosure surrounded by seven much larger fields (H1-H7 on Russell's map) that made up an elongated area of marsh known as 'Mole Wick' occupied at the time by tenant Jonathan Ware (*see* Figure 7). Russell's map also shows a second sheepfold located on future factory land, this time paired with two small ponds, owned at the time by the heirs of the Duke of Richmond and farmed by tenant John Pickler (KHLC CKS-S/NK/P/8A) (NMR TQ 77 NW 309). This is also labelled as a sheepfold on 25-inch OS maps from 1860 and 1897, suggesting that it represents another site of great longevity (Ordnance Survey 1897b; 1908b). Hints of pond-like earthworks were noted here during the survey and can be seen in the area between structures **47** and **140** (*see* section 5.4). In addition to these early examples, a further sheepfold (NMR TQ 77 NW 308) appears on 25-inch OS maps from 1860 onwards, and another sheep wash (NMR TQ 77 NW 310) first appears on the 1897 25-inch OS map and is still identifiable on the ground today south-west of structure **162** (*see* section 5.4).

Figure 7: Detail from George Russell's 1695 map of Cliffe Level, showing two sheepfolds and the area that would become the explosives factory (within the yellow border). KHLC CKS-S/NK/P/8A © Kent History & Library Centre, Maidstone; reproduced by kind permission.

Also within the area of investigation are two isolated ponds, probably created to provide drinking water for grazing animals. The ponds were first depicted on the 1860 1st edition 25-inch OS map, but are thought to have earlier origins. Their present form seems largely unchanged since 1860 (*see* section 5.2).

In the nearby village of St Mary's Hoo, Mr Henry Pye pioneered extensive drainage schemes across his farmland at St Mary's Hall in the second half of the 19th century (MacDougall 1980). This encouraged a more widespread trend bringing a return from waterlogged poor-yielding farms back to improved ground, and is thought to be partially responsible for abating the rampant marsh malaria which was carried by mosquitos flourishing in stagnant water. Pye is also credited with introducing mechanisation including steam-ploughing, threshing and drilling (Bignell 1975, 43; MacDougall 1980). Cliffe Marshes no doubt benefitted from these efforts. This activity could account for the extensive pattern of linear drainage ridges that were identified underlying factory features and noted across both the factory site and adjacent areas of undeveloped grazing marsh (see section 5.1).

A sequence of maps of the Cobham Hall Estate holdings in the late 19th century and early 20th century (MALSC U0565_E700; U0565_E701; U0565_E702) show that a large proportion of what would eventually become factory land was under the ownership of the Earl of Darnley (Figure 8). Gradually over time, these marshland parcels were bought up by Hay, Merricks & Co, and then by Curtis's & Harvey as the explosives works expanded (see Table 1).

Figure 8: Extract from a map of the Cobham Hall Estate from the 1860s; showing land then owned by the Earl of Darnley (Cobham Hall Estate land coloured in brown), much of which would eventually become part of the factory site. MALSC U0565_E700, Medway Archives and Local Studies Centre, Strood; reproduced by kind permission.

Coastal gun batteries

In response to potential threats from revolutionary France, a coastal gun battery (NMR TQ 77 NW 33 & 34) was established at Lower Hope Point in 1796 on land that forms the north-west corner of the area of investigation for this report (Kelly & Co 1855a, 307). The battery was arranged in a fan-like layout enclosed within a sub-rectangular space delimited by a continuous drainage ditch. Four gun positions were arranged facing the river in a wide arc protected by a semi-circular bank. To their rear stood an additional small structure with very thick walls, probably the ammunition store (TNA MFQ 1/830; TNA WO 396/34). In his article on the military architecture of the Thames defences, Crookshank (1916, 220) states that the fort at Lower Hope Point was dismantled in 1820 after the long peace following the Battle of Waterloo. Although the guns were removed and its military operations curtailed, the battery remained standing for some years, and in 1860 the buildings were surveyed by the OS and collectively labelled as 'obsolete' on the 25-inch map (Ordnance Survey 1860a) (Figure 9). A reference to repairs to the battery taking place in 1854 (Kelly & Co 1855a; 307) probably relates to use of the site as a public house, the 'Anchor and Hope', in the mid- to late 19th century.

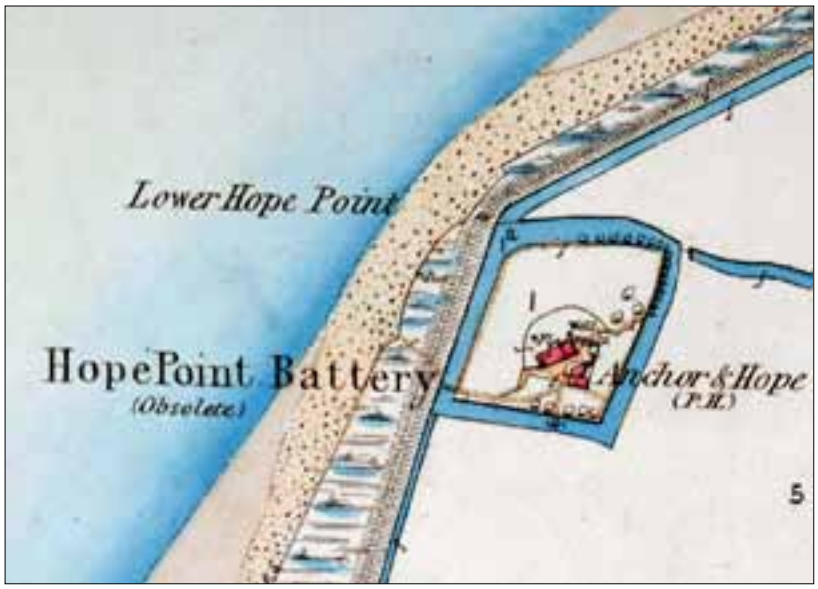


Figure 9: Extract from the 1860 1st edition 25-inch Ordnance Survey map, Kent sheets IV.9, showing the disused Hope Point Battery and the Anchor and Hope Public House. MALSC U0565_E689, Medway Archives and Local Studies Centre, Strood; reproduced by kind permission.

The site has largely been obliterated by subsequent use of the site; principally the construction of 'Hope House', a late 19th-century domestic residence, and by the later relocation of the sea wall and associated drainage ditch. In the annual report of HM Inspector of Explosives for 1900 (HMSO 1901, 9-10), an officer of the Royal Engineers was recorded as intruding under false pretences at the Curtis's & Harvey explosives factory, having mistaken one of the magazine mounds for the nearby 'disused battery' marked on his map.

In 1900, some fifty years after the closure of the 18th-century battery at Lower Hope Point, a new battery (NMR TQ 77 NW 33 & 34) with two 12-pounder quick firing guns, an engine house, personnel shelters and two outlying electric light placements, was constructed (KHLC CKS-S/NK/A/C/1/51; KHLC CKS-S/NK/A/C/1/60). Crookshank (1916, 223), states that it was the only 'fort' constructed at this time in the Thames Defences scheme, and goes on to explain that the battery was particularly notable for its unusual

use of new technology, that is steel plate buildings and electric searchlights for effective night-time defence. This 20th-century battery was built 740m to the south-west of the earlier position and falls outside of the area of investigation for this report, it remained operational until the end of the First World War.

Both the 18th- and 20th-century coastal batteries at Lower Hope Point are covered in more detail in a separate English Heritage research report (Pullen and Newsome *forthcoming*).

Navigation beacons

The 18th-century battery at Lower Hope Point was flanked by two open iron-framed navigational beacons, one on the foreshore ('The Point Beacon') and the other to the rear of the battery (Figure 10). Although it is unclear when the beacons were first erected or whether the beacons or the battery came first, they pre-date the area's association with explosives manufacture and are likely to have remained in use during, and perhaps even following, the factory's period of operation. The tumbled remains of the Point Beacon now lie on the foreshore and the circular base of its inland partner was recorded during the EH survey of the factory grounds (*see* section 5.5).

Figure 10: The Point Beacon on the edge of the River Thames, undated (after Cherry 1998, 52) © Allan Cherry, reproduced by kind permission..

Anchor and Hope public house

For a short period in the mid-late 19th century, while the 18th-century battery at Lower Hope Point was out of use but still standing, the 'Anchor and Hope' public house was opened in a building at the south-east edge of the battery complex (*see* Figure 9). It is mostly likely that establishment of the alehouse marked a reuse of an existing part of the battery complex, rather than construction of a new purpose-built building. A licensed publican, Mr Joseph Henry Germain, is recorded at the Anchor and Hope in 1847 (Bagshaw 1847, 310), and subsequent trade directories log the inn as active in the 1850s and 1860s (Kelly & Co 1855a, 308; 1855b, 1312; 1862, 789; Melville & Co 1858, 313). By 1874 the establishment no longer appears in the records having presumably closed (Kelly & Co 1874, 1209). No remains of the pub survive; like the battery, it has been erased by later use and remodelling.

Hope House

Historic OS maps and licensing dates for the Anchor and Hope indicate that a large domestic dwelling, 'Hope House', replaced the structures relating to the battery and the pub at some point between 1862 and 1895. OS 25-inch maps from 1897 and 1908 show that Hope House had a different footprint and alignment to the battery, and a supposed photograph of the residence - a grand 2-storey property complete with tennis court - implies that it was a completely new structure erected after buildings relating to the battery and the pub had been demolished (Figure 11). Although it is uncertain whether Hope House was built before or during Hay, Merricks & Co's ownership of the adjacent fields, the house was still in use when Curtis's & Harvey acquired the site in 1898. Hope House no long stands; the building was no more than a traceable footprint by the time aerial photographs were taken by the RAF in the mid-1940s, but the actual date of demolition is unknown. Hope House and its occupants are discussed with reference to their factory associations throughout the text and the building is also briefly covered in a separate English Heritage research report (Pullen and Newsome *forthcoming*).

Figure11: Hope House and tennis courts, circa *1901 (after Cherry 1998, 53) © Allan Cherry, reproduced by kind permission..*

3.3 Gunpowder storage at Cliffe

The area's association with explosives began in about 1890 when Hay, Merricks & Company Limited, a gunpowder manufacturing firm of Roslin, Midlothian, acquired the site at Lower Hope Point with a view to establishing a new gunpowder works. A draft licence for the establishment of a gunpowder factory at Lower Hope Point, Cliffe, was produced in 1890, confirming that the Scottish company had acquired the land by this time. The proposed site was to be a 'factory' in name alone, as the licence only permitted operations necessary for the blending and storing of gunpowder. Furthermore, letters from September 1890 accompanying the draft licence, state that the gunpowder would be made at the firm's Roslin gunpowder factory and conveyed to the Lower Hope Point site which would be used purely 'as a depot for gunpowder awaiting delivery to Purfleet for HM Government, or to Export Vessels for our foreign trade'. These same letters also allude to some level of local resistance to the proposal (KHLC CKS-S/NK/A/C/1/19).

Figure 12: Hay, Merricks & Co's proposed gunpowder factory layout for Lower Hope Point, 1890. KHLC CKS-S/NK/A/C/1/19 © Kent History & Library Centre, Maidstone; reproduced by kind permission.

The draft licence documents are accompanied by a plan showing the proposed layout of the site, depicting 14 new buildings: 11 magazines, a blending house, a boiler house and a stove, along with a magazine keeper's house reusing buildings on the former battery site and a jetty 40 yards (36.58m) in length (ibid) (Figure 12). Term 10 of the draft licence allowed for the addition of a tramway, and specified that tram rails within 3 yards (2.74m) of any part of a 'danger building' must be made 'of wood, brass or other suitable material'. Further to this, the First Schedule of the draft licence details the constructional specification for buildings:

> 'Every danger building to be of one storey only and to be surrounded with a good and substantial mound of earth, at least as high as the eaves of the building about which it is placed' (KHLC CKS-S/NK/A/C/1/19).

As well as mounds being constructed around every danger building, it was also suggested that a large mound should also be built on the landward side of the sea wall, opposite the jetty, to protect against possible explosion during unloading. Magazines were to be of brick, stone or concrete with arched roofs of the same material, lined throughout with closely jointed wood. Walls were to be kept painted or varnished, and substantial outward-opening wooden doors were to be fitted. The blending house and stove house were each to be lightly constructed of wood with a slate, tile or felt-covered roof, with a closely fitted wooden floor and painted or varnished walls (ibid).

The Second Schedule of the draft licence outlines the maximum quantity of explosives, and of personnel, permitted in the various building types at any one time. The Third to Sixth Schedules detail the minimum permissible distances to be maintained between various other structures both within and beyond the factory site (ibid).

On 22 December 1892 Hay, Merricks & Co was assigned 'Factory No. 154' in the national register of licensed explosives factories for the site on Cliffe Marshes, and were issued with a licence for 'blending, dusting, drying and packing gunpowder' by HM Inspectors of Explosives (Explosives Inspectorate 1893, 4; Cooper-Key 1903, 3). The company then proceeded to established its works at Lower Hope Point (NGR: TQ 72238 78865). However, only two of the proposed 14 buildings along with a connecting tramway and a jetty (**J1**) (NMR TQ 77 NW314) for the delivery of gunpowder to and from the works, positioned further north-east than initially proposed, were ever erected (Cooper-Key 1903, 3). Buildings equivalent in position to those numbered '2' and '11' on the 1890 plan (*see* Figure 12) appear on the 1897 25-inch OS map (Figure 13), and seem to correspond to structures **1** and **2** located by the EH survey. By a subsequent amending licence the site was also sanctioned for the storage of detonators and electric

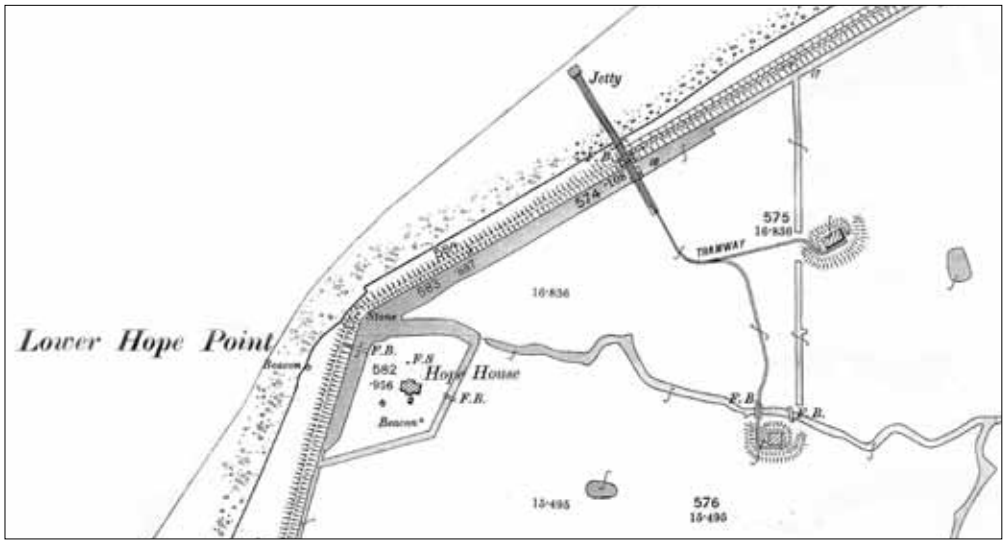


Figure 13: Extract from the 1897 2nd edition 25-inch Ordnance Survey map, Kent sheets IV.9 and IV.10, as revised in 1895, showing the early gunpowder buildings and Hope House (Ordnance Survey 1897a; 1897b).

detonators. Essentially, the Hay, Merricks & Co 'factory' at Cliffe became little more than a large magazine with a capacity of 400 tons (406.4 tonnes) (Cooper-Key 1903, 3).

As yet, a copy of the 1892 licence has not been traced so we can only draw on the information related by Cooper-Key and cannot be certain how closely the final specifications laid out in 1892 mirror those drafted in 1890. Likewise, as the survey revision dates of the 25-inch OS maps (1895 for the1897 publication, and 1907 for the 1908 publication) fall a few years either side of the date when the site passed from Hay, Merricks & Co to Curtis's & Harvey in 1898, it is unclear whether any additional buildings were constructed prior to the handover, although the descriptions given in an Explosives Inspectorate report from 1902 do imply that the site remained a two-building enterprise until after 1898 (Cooper-Key 1903).

3.4 Pre-war chemical explosives manufacture at Cliffe

By the late 19th century, the heyday of gunpowder was coming to an end and new chemical explosive technology was rapidly taking its place (Cocroft 2000, 119-54). Perhaps the most significant advance was the development of a new smokeless propellant, produced from a mixture of nitroglycerine, guncotton and mineral jelly (in the ratio 58:37:5); the compound was invented in 1889 and patented in 1890, soon becoming known as 'cordite' after the long cord-like strands it was extruded into. Following its addition to the national list of authorised explosives in 1894 (HMSO 1895, 5), cordite was quickly adopted for military purposes, which soon created a high demand for its manufacture.

At the end of December 1898, Hay, Merricks & Co and a further eight gunpowder firms were incorporated into Messrs Curtis's & Harvey Ltd as a newly constituted public company (TNA BT 31/35979/59657 vol 1; Hodgetts 1909, 355), the nine former firms being:

- Curtis's & Harvey Ltd, with factories at Hounslow, Tonbridge, Glyn Neath, Kames, Glenlean
- Hay, Merricks & Co Ltd, Roslin, near Edinburgh
- John Hall & Son Ltd, Faversham
- Pigou, Wilks & Lawrence Ltd, Dartford
- Ballincollig Royal Gunpowder Works Ltd, near Cork
- The Kennall Vale Gunpowder Co, Perranwell Station, Cornwall
- The East Cornwall Gunpowder Co, Liskeard, Cornwall
- The Midlothian Gunpowder Co Ltd, West Calder
- The War & Sporting Smokeless Powder Co Ltd, Trimley, near Ipswich

The modest gunpowder establishment at Cliffe Marshes retained its official national identity as 'Factory No. 154'. Curtis's & Harvey recognised the great potential of their acquisition as an excellent location for the manufacture of high explosives, and in 1900 at the 'Cliffe-at-Hoo' site they founded their only factory to be established after being incorporated as a limited company (Hodgetts 1909, 364).

An estate map of 1897, highlighting land under the ownership of the Earl of Darnley's Cobham Hall Estate, includes several fields within a parcel amounting to 223 acres, 1 rod and 33 perches (just under 94.5ha) on Cliffe Marshes that were occupied by T Phillips,

and that were later to become part of Curtis's & Harvey's vast development (Figure 14) (MALSC U0565_E701). The fields include those immediately adjacent to the initial three fields over which Hay, Merricks & Co's original gunpowder facilities had spread, but do not cover land further east that remained undeveloped until after the 25-inch OS map for this area was revised in 1907. It is therefore reasonable to assume that it was directly from the Cobham Hall Estate that Curtis's & Harvey purchased land in 1898-9 in advance of establishing their own factory on the site in 1900. This also ties in neatly with the fact that the four north-west fields from the 1897 estate plan are not included within the Cobham Hall holdings on their subsequent 1905 estate map (MALSC U0565_E702) (*see* Figure 17). Over the next two decades, Curtis's & Harvey would continue to buy up land on the fringe of their existing factory holdings as the enterprise progressively grew in scale and scope (*see* Table 1).

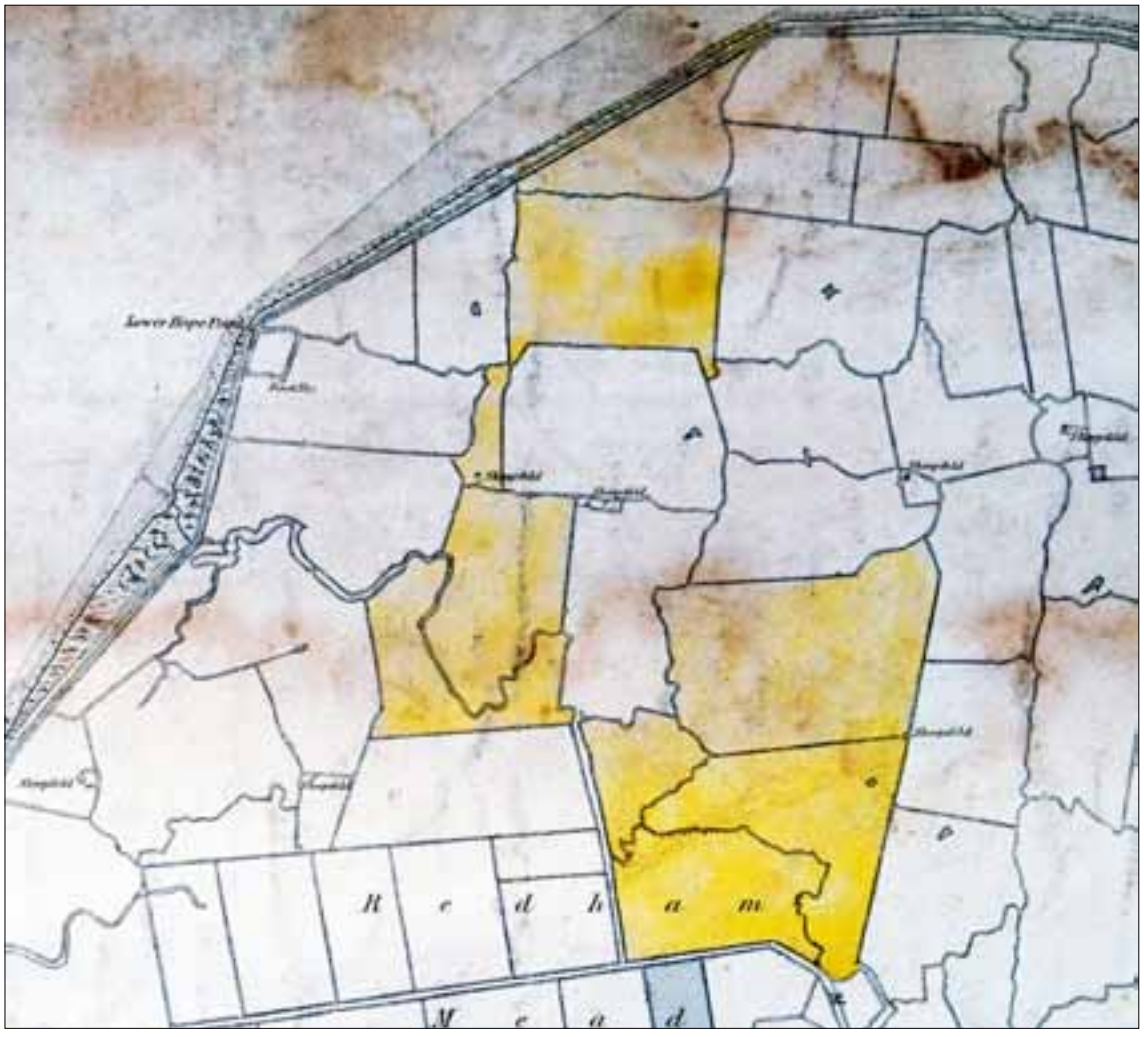


Figure 14: Extract from an 1897 map of the Cobham Hall Estate; showing land then owned by the Earl of Darnley (Cobham Hall Estate land coloured in yellow), much of which would eventually become part of the factory site. MALSC U0565_E701, Medway Archives and Local Studies Centre, Strood; reproduced by kind permission.

A site plan, drawn onto the 2nd edition 25-inch map of 1898, almost certainly represents developments proposed by Curtis's & Harvey around the turn of the century (*see* Figure 15). In addition to the two buildings which had been erected by Hay, Merricks & Co this

Figure 15: Plan from around 1898-1900, thought to show Curtis's & Harvey Ltd's proposed layout for a new explosives factory on the site of Hay, Merricks & Co's existing gunpowder works. TNA WO 78_5434 © The National Archives, Kew; reproduced by kind permission.

plan, like that produced in 1890 (see Figure 12), shows fourteen proposed structures. However, both the arrangement of the buildings and the numbering system differs slightly from that proposed in 1890, and a pencil label to the left of the site says 'Cordite Magazines'. This could represent another proposed layout, this time by Curtis's & Harvey

for cordite magazines, but again one that for some reason did not reach construction stage. Perhaps there was an initial thought to use Cliffe simply for storage of cordite before aspirations grew to include the production of cordite on site.

Census data collected in 1901 for Cliffe-at-Hoo civil parish lists three separate households at Lower Hope Point (TNA RG 13/718). In the first household (no. 99), William Murray, is described as the powder magazine keeper; his sons John and James were both powder magazine labourers and Benjamin Bridge, a clerk for the works, lodged with the family. Details show that William Murray was born in Roslin, Midlothian, and as such almost certainly came to Cliffe as an employee of Hay, Merricks & Co. Census data from 1911 indicates that he remained in employment as gatekeeper and watchman following acquisition of the site by Curtis's & Harvey (TNA RG 14/3856), as did his son John, also a gatekeeper, who died in an explosion on site in 1904 (Cooper-Key 1904). The second household (no. 98) includes William Crockett and his family. Mr Crockett is described in 1901 as a 'carpenter and joiner journeyman' and may also have had connections to the explosives works (TNA RG 13/718). Whereas the address for the first two households is given as 'Lower Hope Point, Powder Works', the third household is listed simply as at Lower Hope Point. This third household (no. 208) comprised Joseph McCleak and family and, although the census data does not formerly name the property, it seems probable that the McCleaks were occupying Hope House at this time. Mr McCleak is described in 1901 as a 'Foreman – Powder, Nitro Glycerine'; this would make him one of the earliest identified employees at the explosives works rather than the powder store. Interestingly, the of birthplace for his two children (the youngest being just two years old) is recorded as Waltham Abbey, Essex (ibid); presumably McCleak previously worked at the Royal Gunpowder Factory before moving to take employment with Curtis's & Harvey's new enterprise at Cliffe.

The McCleaks' move to Cliffe from a pre-existing explosives establishment is not the only example of this. In his account of the British Explosives Syndicate Factory at Pitsea Hall Farm, Essex (on the opposite bank of the Thames to Cliffe), Williams (2010, 216) states that in 1900, the chemist at the Pitsea factory, McIntosh, handed in his notice in order to take up a position of factory manager for Curtis's & Harvey. This move can be traced in a local trade directory (Kelly & Co 1903, 187). The nitroglycerine factory for cordite production at the Pitsea Hall Farm works was completed in 1894, so when McIntosh was recruited to oversee the new factory at Cliffe he would have brought with him several years of experience working with these new explosive technologies.

Given the rapid progress in explosives technology, a further amending licence was applied for, and from 3 June 1901 the site was authorised to manufacture gunpowder, 'nitro-cotton' (guncotton) and various nitroglycerine based explosives, namely cordite, blasting gelatine and gelatine dynamite. The construction of a cordite plant was approved and a government contract was obtained (HMSO 1902; Cooper-Key 1903, 4). By the end of 1901, the company was fully engaged in the production of cordite at Cliffe (KHLC CKS-S/NK/A/C/1/186), and by 1902 it was no longer involved in the blending or storage of the more archaic black powder; indeed, the factory had its authorisation for processing gunpowder withdrawn (HMSO1903). At least seven further amending licences were issued between 1902 and 1904 (Cooper-Key 1904, 4), variously permitting the erection of a guncotton drying stove ('No. 48' mentioned in a later accident inquiry)

and other unspecified buildings (licences 1102 & 1112) (Desborough 1904, 3), and giving authorisation for the manufacture of cordite M.D. (HMSO 1904) and the chlorate-based explosive Cheddite (Cooper-Key 1904, 4). Between 1904 and 1908 the number of buildings at the works increased substantially, in part due to the commencement of dynamite production in 1905 and the addition of several cartridge huts in 1907/8 (Cooper-Key 1908). Unfortunately, the licence documents themselves and the factory plans that once accompanied them, tantalisingly referred to in several accident reports, have not been traced and may not have been retained for archiving.

Such was the rate of diversification and expansion that by 1908 the factory was described by HM Chief Inspector of Explosives as 'one of the largest in the kingdom' (Cooper-Key 1908). Many of the land acquisitions made by Curtis's & Harvey to facilitate this expansion can be traced through sewerage rates assessments which were calculated by acreage. By 1909-10, Curtis's & Harvey were liable for sewerage rates on a total of 107 acres, 2 rods and 30 perches (43.58ha) at Cliffe (KHLC CKS-S/NK/A/C/1/124), and in 1911 the factory was described as covering a large space having been continually added to in recent years with the aim of increasing the output of explosives (Cooper-Key 1911, 2). This pattern of expansion by regular purchase of adjacent land parcels continued until the factory reached a peak holding in 1916. The details of this acquisition process from 1910 onward are listed in Table 1. No documentary evidence has been found for acquisitions prior to this date, although, as stated above, Lord Darnley's Cobham Hall Estate was the likely vendor.

Table 1: Land purchases made by Curtis's & Harvey Ltd at Cliffe

Year	acreage	hectares	description	prev. owner	source
1910	15a, 3r, 24p 20a, 0r, 25p 31a, 1r, 0p 7a, 1r, 38p	6.44ha 8.16ha 12.65ha 3.03ha	Allotment in Great Mead Eighteen Acres Lentwick Thirty Acres Seven Acre Marsh	Earl of Darnley	MALSC U0565_E700; MALSC U0565_E702
1911/12	39a, 2r, 31p	16.06ha	Cistern Marshes & building	Smith-Marten?	KHLC CKS-S/NK/A/C/1/124
1913/14	5a, 0r, 0p,	2.02ha	marsh	Sir J. Hawley, devisees of	KHLC CKS-S/NK/A/C/1/124
1915	10a, 1r, 18p	4.17ha	part of Snares Marshes (No. 549)	C. Snelling	KHLC CKS-S/NK/A/C/1/124; KHLC CKS-S/NK/A/C/1/132
1915*	11a, 2r, 13p	4.69ha	Allotment in Great Mead	Earl of Darnley	MALSC U0565_E700; MALSC U0565_E702
1915/16*	12a, 2r, 34p	5.15ha	The Mead	Earl of Darnley	KHLC CKS-S/NK/A/C/1/124; KHLC CKS-S/NK/A/C/1/132
1915/16	75a, 2r, 37p	30.64ha	The Mead Marshes	Robertson	KHLC CKS-S/NK/A/C/1/124
1915/16	12a, 2r, 34p	5.15ha	The Mead	Earl of Darnley	KHLC CKS-S/NK/A/C/1/124; KHLC CKS-S/NK/A/C/1/132
1915/16	140a, 2r, 15p	56.90ha	Mole Wick Marshes (occupied by farmer Glover Long)	Trustees of E Raphael	KHLC CKS-S/NK/A/C/1/124

** These two land purchases could be the same event recorded slightly differently. Most of the portion depicted in MALSC U0565_E702 was never built on by Curtis & Harvey, and documents from the 1920s attribute 'The Mead' to their ownership but describe it separately to the land described as 'Explosives factory' (KHLC CKS-S/NK/A/C/1/132).*

The factory at Cliffe suffered a significant number of accidental explosions and fires during its operating years, many of which caused horrific and often fatal injuries to staff working in the immediate vicinity (*see* Appendix 3). Official inquiry reports were produced by HM Inspector of Explosives for the more catastrophic events, and provide insightful contemporary descriptions of the site layout, processing routines and workforce. Contemporary newspaper articles relating to a handful of the accidents are also known.

The earliest identified of these official accident reports dates to late 1902 (Cooper-Key 1903); it describes an explosion of partly-mixed cordite in a cordite paste mixing-house on Monday 15 December, verifying that construction and use of a cordite plant began soon after licence had been granted in 1901. The incident killed two men, Arthur Pepper and William Whiting, and severely injured a third. The explosion left a blast crater some 16 feet (5m) wide and 4 feet (1.2m) deep. It destroyed the wooden building known as 'No. 18'; shattering the thick concrete foundations into small blocks, tearing up corrugated iron roofing sheets and nearby tram rails and sending debris flying over considerable distances in all directions. Such was the ferocity of the blast that an article in *The Times* (1902) described the explosion as having shaken the neighbourhood for miles around, shattering windows in Cliffe village, even being felt as far away as Chatham and Rochester. The inquiry report lists other buildings in the vicinity of the mixing-house giving their factory numbers and in some cases a brief description: 'No. 15' was the final washing house, 'No. 17' was the wash-water house with iron roofing sheets, 'No. 40' was a range of cordite stoves constructed as a series of compartments (probably an earlier incarnation of **129**), and 'No. 43' was a magazine with two iron doors and a protective earthwork (Cooper-Key 1903, 5). In several cases, distances between these buildings and the site of the accident are given, from this it seems likely that 'No. 18' was located approximately where the remains of structure **138** now stand.

A proposal drawn up in December 1903 for a 5-inch howitzer and two 15-pounder guns firing across Cooling Marshes, shows a potential impact zone covering part of what would later become part of the factory development (KHLC CKS-S/NK/A/C/1/59). Accompanying documents include an agreement signed on 6 April 1904, between HM Commissioners of Sewers and the War Department, to allow the firing practice to take place as proposed between 31 July and 7 August 1904, and detailed maps showing the location of the temporary gun emplacements (on Northward Hill to the north of High Halstow), and the maximum projected impact zone. The line of the impact zone implies that some of the factory buildings shown on the 1908 25-inch OS map (structures **115** to **120**, and jetty **J2**) could not yet have been built, as it is inconceivable that such a volatile site would have been placed at risk. This agreement thereby allows us to date at least some of the pre-war expansions, including the construction of a second jetty, **J2** (NMR TQ 77 NW 315), to between late-1904 and the 1907 25-inch OS map revision date.

Several incidents were recorded at Cliffe in 1904 giving rare details about the buildings that characterised these early years of the factory. On 4 February, an accident in a guncotton stove resulted in the death of factory workers George Kenknight and William Frederick Moon. The inquiry report details an explosion in building 'No. 48', described as a drying house for nitro-cotton that had been constructed early in 1903 in response

to amending licence No. 1102 (Desborough 1904). Descriptions of the building based on Desborough's report are further discussed in section 4.2.

Less than a fortnight later, on 18 February 1904, an explosion occurred in a nitroglycerine separating house, this time killing four people and injuring another four; John Murray, Daniel O'Donnell, William Henry Know and Elijah Talbot all lost their lives. Unfortunately, only the first two pages of the official accident report have been located, but several useful descriptive details were gathered from these introductory paragraphs (Cooper-Key 1904). The incident occurred in a building referred to as 'No. 14 - the separating house'. However, descriptions in the report indicate that this was actually equivalent to a more complex structure, typically called a nitroglycerine hill, in which both nitration to form nitroglycerine and the subsequent separation (using a 'nitrator separator') took place. Cooper-Key adds that this building was one of those known by the factory workers as a 'round house' due to its shape (ibid). His detailed account of the content and processes carried out within the building is covered in more depth in section 4.2. The annual report of HM Inspector of Explosives for 1904 mentions that a mistake during the charging of a 'mild steel egg' (vessel for acid mixing) with acid for use in the 'new nitrator' on the 5 July that year, caused one death by inhalation of nitrous fumes (HMSO 1905, 59); this highlights that a new Nathan patent type nitrator had recently been installed, perhaps to replace one destroyed on 18 February.

By the first decade of the 20th century cordite had virtually replaced traditional gunpowder as the main propellant in military use. This period also marked the beginning of the great naval race between Britain and Germany (1906-1914), and the construction of the Dreadnought battleships, with huge guns and equally huge appetites for cordite.

A 1907 valuation list for the parish of Cliffe lists property owned by Curtis's & Harvey on Cliffe Marshes as comprising: powder works, jetty, tramways, nine cottages used as stores, pasture land, the manager's house with garden and four further houses each with a garden (KHLC CKS-S/NK/A/C/1/33), thereby adding detail to what we already know from the OS map revision from the same year (Figure 16) (Ordnance Survey 1908a; 1908b). Unfortunately, the document does not include a value for the acreage owned by the factory at this time.

The year 1907 also saw a revision of the 25-inch OS map covering Cliffe Marshes, published as the '1908 edition'. Depiction of the works on this edition is comprehensive and detailed, with buildings, protective mounds, tramways and two jetties covering an area of approximately 37ha across parts of **Areas A** to **F** (*see* Figure 16), amounting to just under a third of the size that the factory would eventually reach (*circa* 128ha). That said, some published examples of this map show nothing but white space in place of the factory, leading Oliver (1993, 56) to suggest that the explosives works may have been treated as a secret installation. The third and largest factory jetty, **J3** (NMR TQ 77 NW 313) is absent from the 1907 25-inch OS revision, and so belongs to the factory expansions leading up to, or at the beginning of, the First World War. It was almost certainly in place by 1916.

On 5 June 1908 an explosion in a dynamite cartridge filling hut known as building 'No. 26a' killed the two women, Clara Goodyer and Julia Munns, working inside it (Cooper-

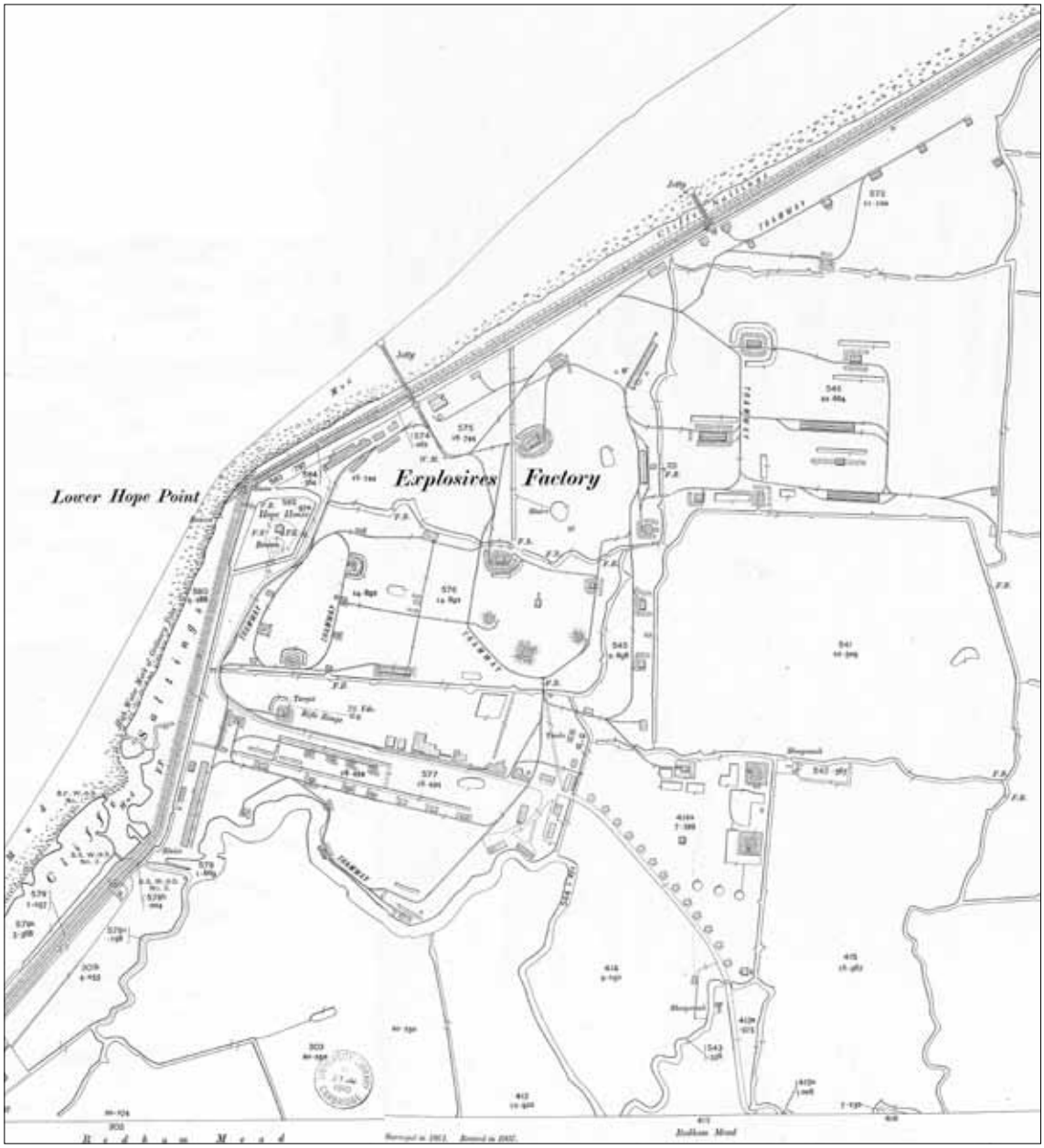


Figure 16: Extract from the 1908 edition 25-inch Ordnance Survey map, Kent sheets IV.9 and IV.10, showing the extent of the factory complex as surveyed in 1907 (Ordnance Survey 1908a; 1908b).

Key 1908). The small wooden hut was completely demolished, its concrete foundations were cracked and the two large metal pumps for filling the paper cartridge wrappers were dislodged. Descriptive details of the building and apparatus are given in section 4.2.

On 31 August 1908, the Earl of Darnley granted Curtis's & Harvey free access rights and permission to 'make a road and tramway' over a strip of land within the Manor of Cliffe, running west along Pickles Way from the large pond at the north end of the village to the point where it would turn north to meet the south end of the existing factory road (MALSC U0565_T337). No evidence that a tramline was ever extended along this section has been noted on the ground.

A map produced in 1905 showing the Earl of Darnley's Cobham Hall estate includes annotations added at a later date that highlight areas sold off. These include two portions of land that were subsequently developed as the factory complex expanded (MALSC U0565_E702). The larger of these two marshland plots sits centrally at the southern edge of the factory complex and was sold in 1910. The remains of structures **194**-**196** and **267**-**284** are located here, but the majority of the area, which extends some 500m south from the southern reaches of the factory buildings, was never developed. A second area to the west was sold in 1915 (Figure 17).

On 26 July 1911 a violent explosion of a bogie cart (a small, hand-pushed lidded truck for conveyance of explosives and other materials) and the nitroglycerine washing and

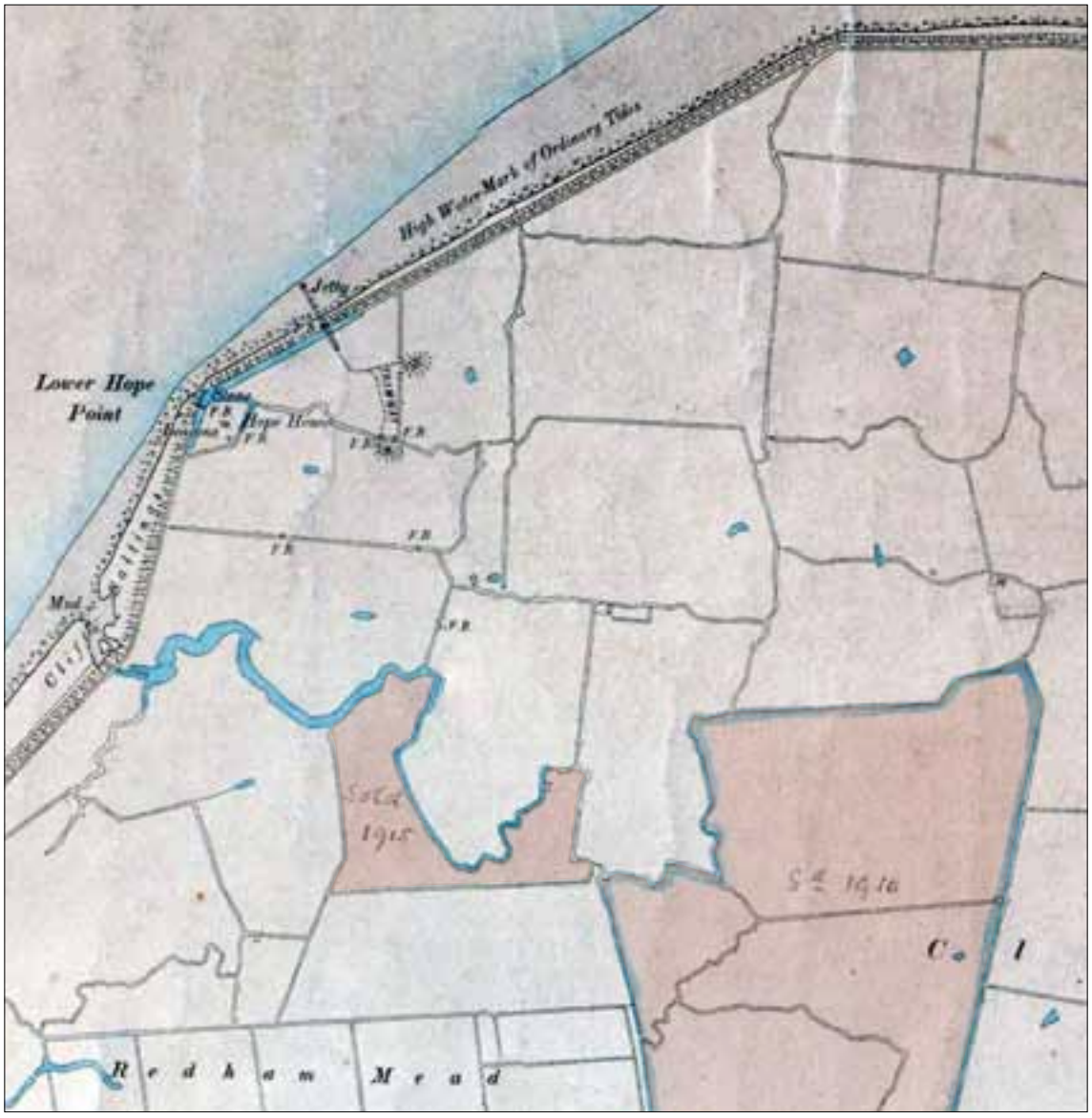


Figure 17: Extract from a 1905 map of the Cobham Hall Estate with later annotations; showing land sold by the Earl of Darnley (coloured in red), much of which would eventually become part of the factory site. MALSC U0565_E702, Medway Archives and Local Studies Centre, Strood; reproduced by kind permission.

filtering house known as 'C3' killed three factory workers - Ernest Law, Charles Hawkins and George Walkinshaw - and injured three others. The explosion caused severe and widespread damage affecting almost all of the buildings across the factory complex, many of which would have to be completely rebuilt (Cooper-Key 1911; Munday 1994, 25). Reportedly, the blast was so violent that windows as far away as Hope Battery and Cliffe Fort were shaken from their frames (*Chatham, Rochester & Gillingham News* 1911a). The accident report gives a detailed description of building 'C3' prior to the damage caused by the explosion, and is discussed in more detail in section 4.2 (Cooper-Key 1911).

A letter from Curtis's & Harvey to the local Commission of Sewers, dated 24 March 1914, makes reference to an application for an amending licence to approve a proposal for the construction of fourteen new magazines to be known as buildings M11-M15 (KHLC CKS-S/NK/A/C/1/186). Presumably, magazines known as M1-M10 were already in existence elsewhere on the site. Valuation documents prepared for the sale of the eastern half of the factory in 1923 (MALSC 06a_DE_Series_1001_1200/DE1087_3) show that five magazines numbered M11-M15 were indeed built (**203**, **204**, **219**-**221**). The documents do not verify whether they were constructed where and when originally planned however, the layout of these five large structures may indicate how they fit into the phased development of the site. Unlike the rest of the structures in the north-east block, they do not sit in such rigid formation or ignore the pre-existing drainage features; instead they fit snuggly alongside the twists in the drainage dyke that marks the eastern extent of the factory expansions. This more organic use of space and the fact that the initial proposal to build them was submitted several months before the onset of war, suggests that they pre-date the neighbouring grid of drying stoves and blending houses to their west. However, given their marginal location, it may be that the rest of the HM Cordite works were already planned, so the magazines, built first because of an urgent need, were pushed to the periphery of the site. Alternatively, the construction of HM Cordite Factory could have delayed the proposed building of M11-M15, giving them the appearance of ad hoc additions to more ordered elements of the wartime expansions.

In its description of the desired new buildings, the proposal letter set out how far from the sea wall they would be built:

> 'the distance which the nearest of these buildings (M11) maintains from the river walls is 575 yards, and in addition the river wall is protected from this magazine by a mound of earth the height of the eaves of the building. These proposed magazines are further from the river wall than our existing magazines' (KHLC CKS-S/NK/A/C/1/186).

This distance does not correspond with the actual location of the five magazines, even with the later relocation of the sea wall taken into account; either the letter should have said 575 feet (*circa* 175m) rather than 575 yards (*circa* 526m) or the proposal was originally intended for another spot. It is also not clear which structures amongst the factory remains relate to the 'existing magazines' mentioned in the letter.

As previously mentioned, a 1905 map of the Cobham Hall Estate depicts an area that was sold by the Earl of Darnley in 1915 to become part the explosive works (*see* Figure 17) (MALSC U0565_E702). This area was one of several plots that made up an area of marsh formerly known as The Great Mead (MALSC U0565_E700) (*see* Table 1). The

plot remains largely undeveloped, but it is crossed by the southern end of the factory's main access road and contains the foundations of a handful of small buildings: structures **81**, **162**, **164**-**165**, and part of **L4**.

3.5 First World War

Britain entered the First World War on 4 August 1914, a development that was to generate demand for explosives on a scale far bigger than the country had ever seen before. On the 8 August 1914, the government passed the first of the Defence of the Realm Acts (DORA), under which it secured power and authority to acquire land and control all necessary assets for the production of munitions (Cocroft 2000, 155-7). Disenchantment with the government's handling of the war led to its fall in May 1915 and the formation of a coalition government under Asquith. Soon after this, the Munitions of War Act was passed under which a Ministry of Munitions was established and through which Lloyd George spearheaded a national armaments drive. The Act increased state control of armaments production; amongst other provisions it allowed the government to pronounce essential factories as 'controlled establishments', to create 'National Factories' and to convert private factories for war work, designating them *His Majesty's Factory* (ibid).

On 6 March 1916, Curtis's & Harvey's Cliffe factory was declared a controlled establishment under the terms of the Munitions of War Act (TNA BT 31/35980/59657 vol 3). Value assessments undertaken by the Commission of Sewers at Rochester for land at Cliffe belonging to Curtis's & Harvey, suggested that although expansions onto previously undeveloped parts of the marshland site had taken place in 1910, 1912 and 1914, growth was particularly extensive during the early years of the war up to 1916 (KHLC CKS-S/NK/A/C/1/124) (*see* Table 1). Similarly, a note in an accident report from January 1917 states that 'there have been great extensions due to the requirements of the war, and the factory is now very considerably larger than it was two years ago' (Crozier 1917, 1), and a letter from Curtis's & Harvey to the Upper Medway Conservancy dated 5 April 1917, states that the factory continued to be working towards meeting the high demand for conveyance of explosives for naval and military purposes (MALSC S/MN/AC27/10). An additional letter from Curtis's & Harvey to the Sewers Commission dated 7 June 1917 declares that a colossal 500,000 gallons (1.89 million litres) of water were being used every day at the factory (KHLC CKS-S/NK/A/C/1/186).

Auction documents from the sale of the factory in 1923 show that this major First World War extension to the works was known as 'HM Cordite Factory' (**Areas G** and **H**, part of **Area I**, and **Areas J** and **K**). Although this eastern section of the site was probably managed by Curtis's & Harvey, it was state-owned and under the occupation of HM Government (MALSC 06a_DE_Series_1001_1200/DE1087_4). Details in the sales particulars confirm that all buildings constructed as part of HM Cordite Factory were designed purely for production of cordite and preparation of acids, guncotton and nitroglycerine intended for cordite manufacture (MALSC 06a_DE_Series_1001_1200/DE1087_3). Additionally, a number of letters written in 1921, when the site was being decommissioned and prepared for sale, appear to suggest that the government-owned structures within the HM Cordite Factory area were specifically Admiralty buildings (KHLC CKS-S/NK/A/C/1/124), and as such were intended to increase the factory's output

in order to meet wartime naval demand for cordite. This further confirms the impact of the Munitions of War Act and the importance of the enterprise at Cliffe.

Unfortunately, the annual report of HM Inspectors of Explosives for 1913 (HMSO 1914), is largely incomplete, and all annual reports from 1915 onwards are considerably reduced in length and detail. Consequently, specific references to the explosives authorised for production at Cliffe during and following the First World War are not well documented.

In 1916, a First World War anti-aircraft artillery site, equipped with one 3-inch 20cwt gun and one 6-pounder Hotchkiss gun, was in place within the general vicinity of the explosives works at Cliffe (NMR TQ 77 NW 152) (Dobinson 1996a, 294-6).

On 24 October 1917, a nitrator-separator house at the Cliffe factory exploded killing two people and injuring a further eleven; no detailed incident report was prepared following this accident (HMSO 1918, 12).

The annual report of HM Inspectors of Explosives for 1918 describes an accident at Cliffe in early March of that year where a fire in an acetone recovery compartment spread rapidly to 'no less than 103 cordite drying compartments in two ranges', so that both ranges, separated by a distance of 30 yards (27m), were burnt out (HMSO 1919, 4, 10). The report interchanges between calling the bays acetone recovery compartments and cordite drying compartments (once the acetone had been driven off, the cordite may have remained in the bays for drying, but the construction of new cordite drying stoves in **Area E** immediately to the south suggests this was not the case), but this account can only refer to the adjacent sub-divided ranges described in this report as structures **244** and **245**. Despite the fact that the accident resulting in one life lost and three workers incurring injuries, uncharacteristically, no official accident investigation report appears to have been prepared for this incident and so details are slim. Bowler (1968, 368) is probably referring to this accident when he suggests that it was soon after a large explosion in 1918 that the factory closed. However, contrary to this view, parts of the factory, including at least one of nitrator-separators, remained operational for a few years after this date. It is likely, however, that capacity was reduced and that storage rather than manufacture may have been the focus of these later years.

In 1918, in anticipation of the impending downturn in the explosives market that would come with the end of the war, Curtis's & Harvey was subsumed by a national merger into Explosives Trades Ltd, a new umbrella company. It brought together 29 companies which collectively made up the majority of the UK explosives industry at the time, and was renamed in 1920 as the more widely recognisable Nobel Industries Ltd (Cocroft 2000, 109; Grace's Guide 2012b).

On 11 November 1918, Armistice Day marked the end of the First World War.

From the outbreak of war in 1914 the number of factories increased each year until by 1918 a total of 73 new explosives factories had been licensed. 1918 saw the official end of special war work (HMSO 1919) and the end of peak manufacture. 1919 saw a dramatic drop in production with 36 fewer factories operating than in 1918 and the annual report of HM Inspectors of Explosives for that year noted that 'a considerable number of

factories ceased to exist, especially in the neighbourhood of London' (HMSO 1920, 3). Numbers dropped again by fourteen in 1920 and by another six in 1921 (HMSO 1919; 1920; 1921; 1922).

3.6 Inter-war years

By 1920-21, it is apparent that the factory at Cliffe was no longer engaged in such intense activity as was seen during the war years. A letter from Curtis's & Harvey dated 26 August 1920 reveals that, with regards to the local wall scot (tax), the Poor Rate Assessment of the Factory was being reduced almost by half (KHLC CKS-S/NK/A/C/1/124), presumably because manufacturing operations had largely ceased by this date. Further to this, on 13 January 1921, a letter regarding the revision of valuation of lands and premises belonging to Curtis's & Harvey states that 'some of their lands are in their own occupation, some in the occupation of agricultural tenants, and some in the occupation of the Admiralty' (ibid). Again, this is suggestive that some or all manufacturing operations had come to an end and that certain areas were being leased for grazing. Subsequent correspondences on 18 January 1921, states that Curtis's & Harvey were at this time not liable for the Admiralty/government buildings, and that the Admiralty had handed plant and buildings over to the Disposal Board who were making arrangements to remove everything from the ground. This area was subsequently sold to the War Office (ibid).

On 5 July 1921, Curtis's & Harvey Ltd (as landlords) and John Robertson Esq. of Manor Farm (as tenant) signed two agreements to let land for grazing; one for the 40 acres combined of fields '396', '397' and '416' (MALSC 06a_DE_Series_1001_1200/DE1087_2), and another for the 31½ acres of field '417' (MALSC 06a_DE_Series_1001_1200/DE1087_1). A plan accompanying the agreement regarding field '417' marks the north-east corner of the area with the annotation: 'Temporarily fenced off by Robertson being covered with admiralty buildings – John Robertson 27th July 1921' (ibid). The fenced off area refers to the space occupied by the remains of guncotton drying stoves **267** to **283** and **267a** to **283a**. Despite the presence of a fence, allowing non-factory tenancy of the land immediately between the acid and guncotton processing area and the drying stoves clearly suggests that manufacturing operations had ceased in these adjacent areas.

On 7 July 1921, a report was prepared by the Protection Sub-Committee of the Home Office to assess the potential need to protect explosives stores from armed attack or raids by members of Sinn Fein. Curtis's & Harvey's magazines at Cliffe were listed as one of eight establishments holding high explosives that were recommended as being worthy of this protection (TNA CAB 24/126), a clear indicator that explosives were still stored in relatively large quantities at the works, even though manufacturing had ceased.

On 22 November 1921, over 231 acres (95ha) of land across the eastern section of the site, known as HM Cordite Factory, was sold to the War Department, including over 72 acres (30ha) of undeveloped marshland to the south of **Area H** (KHLC CKS-S/NK/A/C/1/124). This confirms the end of all manufacturing on this part of the site. As is usual on the closure of an explosives works, the buildings were probably 'thermally remediated' by setting fire to the structures with the intention of removing any explosive or chemical residues (W D Cocroft, pers comm).

An official letter from the clerk to the Commissioners of Sewers sent on 30 May 1922 pronounces that 'the whole of the factory is in course of demolition. The Manager's (sic) house, offices, gate-keepers House (sic) and some of the stores and magazines are still occupied, but no manufacturing is being carried on. Some of the machinery has already been scrapped, and the whole is being demolished and realised as soon as possible' (KHLC CKS-S/NK/A/C/1/124). The letter also clearly states that according to Curtis's & Harvey's surveyors, all manufacturing at the factory had been closed down by this date, thereby confirming that as with HM Cordite Factory, production on the west side of the works had now also ended. Confusingly, the same letter also notes that part of the premises on land sold to HM War Department, formerly the Admiralty buildings of HM Cordite Factory, was now occupied by a manufacturing firm; no further interpretation or explanation for this has been identified, but it could refer to the continued presence of Curtis's & Harvey in maintaining parts of the site for storage. A further letter written on 26 June 1922, confirms that some buildings were still in use but that it was anticipated that this use would cease and all plant and machinery would be sold or cleared over the following six months (ibid).

On 15 February 1923, an official letter from the clerk to the Commissioners of Sewers stated that since June 1922 'very material changes have been made at the Factory by way of demolition and removal of buildings and plant' (KHLC CKS-S/NK/A/C/1/124). A month later on 17 March 1923, another letter describes that machinery had now been sold off and removed, and that most of the buildings had been demolished with a few remaining as empty shells. Only scattered small parts of the works were still in use, mostly in the magazines, and only for storage of explosives. The manager's house, offices and administrative buildings were all unoccupied but not derelict (ibid).

Valuation documents and sales particulars from 1923 (MALSC 06a_DE_Series_ 1001_1200/DE1087_3; 06a_DE_Series_ 1001_1200/DE1087_4) show that the site was put up for resale within a year or so of its purchase by the War Office. At this date any salvageable material had been removed, and a large quantity of plant and machinery for the eastern HM Cordite Factory section was sold off. A valuation assessment for 1924-5, undertaken by the local Commissioners of Sewers, records that Curtis's & Harvey still owned a total of roughly 172 acres on Cliffe Level at this time. The document describes 160 acres (about 65ha) as 'Explosives Factory', while a further 12 acres are attributed to 'The Mead', which covered land that remained undeveloped at the south-west edge of the factory holdings, south of **Area C** (KHLC CKS-S/NK/A/C/1/132). This 65-hectare area of the factory site equates neatly to the total western portion of the site that did not come under the estate taken on by, and then sold by, the War Department.

On 10 September 1923, land formerly known as HM Cordite Factory was sold off by the War Department for £6,500 to Herbert Moses Thomas of Amber Hill, Boston, Lincolnshire (MALSC 06a_DE_Series_1001_1200/DE1087_3).

In 1926, Nobel Industries was merged with three other large chemical companies, (Brunner, Mond and Co, the United Alkali Co and the British Dyestuffs Corporation), to form a new public company, Imperial Chemical Industries Ltd (ICI), and in 1932 a new company known as ICI (Explosives) was formed (Cocroft 2000, 109; Grace's Guide 2012a).

On 21 March 1929, a letter to the Sewers Commission mentions a recommendation of clearing out of the 'delph drain' along Messrs Curtis's & Harvey's frontage, thus indicating that former factory land at the west side of the site was still under their ownership at this time (KHLC CKS-S/NK/A/C/1/160). Two years later, a map from 1931 entitled 'Cliffe Estate' suggests that the Port of London Authority (PLA) had taken ownership of all of the former factory land by or during this year (KHLC CKS-S/NK/A/C/1/186). No intermediate owners are known, presumably because the western half of the site passed directly from Curtis's & Harvey, under the ownership of ICI, to the PLA.

A further series of letters exchanged between the Sewers Commission and the PLA in the mid-late 1930s, show that that various drainage ditches on the former factory site were inspected and cleaned to identify and remove any potential materials of an explosive nature (KHLC CKS-S/NK/A/C/1/186). In 1935, concern was raised by local farmers Mr Long and Mr Smith that the delph ditch required cleaning but that it would be a risky and potentially 'explosive job' because it ran through the Curtis's & Harvey site. The letters state that some factory elements were actually built in the ditch other stretches of which were filled with rubbish; this included masonry, motor parts and ironwork resulting from buildings being blown up after the factory closed. An accompanying plan, dated 1931, marks structures **103** and **104** each with an 'x' to denote buildings that had been blown up some years ago, and marks two points nearby on the delph ditch each with a larger 'X' to show where associated debris was blocking the ditch and would need to be broken up and removed (ibid).

3.7 Second World War

Although the site was not used for industrial purposes during the Second World War, it appears to have seen occasional use by the military for general ammunition disposals and training activities. At the east side of the site there is a large irregular pond-like feature, measuring over 100m in diameter, created by numerous clustered craters (NGR: TQ 7275 7874). Map evidence and descriptions forming part of the 1923 sales particulars prove that a laboratory building stood in this area until at least 1923, and historic aerial photographs show that the craters were created before 1946. In a personal account given to Rebecca Pullen in June 2011, local resident Clifford Dowsett recalled childhood memories of a large chalk circle marked on the ground in this area which was used for aerial target practice roughly around D-day, 1944. The craters look fairly fresh with pale halos of upcast on aerial photographs taken by the Royal Air Force (RAF) in 1945 and 1946, which may support this interpretation (NMR RAF 106G_UK_1447 frame 1073 01MAY46; RAF CPE_UK_2065 frame 3110 14 MAY 47).

Aerial photographs from 1941 and 1947 show that wooden jetties (**J1**, **J2** and **J3**) along the periphery of the site, formerly used for the import and export of raw materials and finished explosives, were severed across their landward ends during the Second World War to render them useless in the event of an invasion attempt (F Small, pers comm). Although **J4** is not clearly visible on aerial photographs, it would have been treated in the same way.

In addition to wartime activities relating directly to the area of investigation, the area immediately surrounding the former factory site was heavily involved in military defence schemes at this time. A Type Q airfield bombing decoy (NMR TQ 77 NW 122) - an arrangement of lights designed to simulate ground actvity on an airfield - was established on the marshes in an attempt to draw German bombers away from RAF Gravesend (Dobinson 2000, 250). An associated control bunker survives roughly 1km to the south of the explosive works (NMR TQ 77 NW 146) (Figure 18). No further ground evidence has been identified. It remains uncertain whether the site was abandoned before or after it became operational.

Figure 18: Decoy control bunker for the Type Q airfield bombing decoy on Cliffe Marshes. NMR BB94_08743 31-Mar-1995, Dank Silva © English Heritage.

A Naval Coast Type QL bombing decoy, number 703, administered by NORE Command was also built at Lower Hope Point (NMR TQ 77 NW 150). It comprised a shelter and electrical lighting and was constructed between April and May 1943 as part of the deception operations, code-named 'Cockade' and later 'Fortitude', to disguise the preparations for Operation Overlord - the invasion of Western Europe (Dobinson 2000, 177-180). No ground evidence for this site is known.

A Heavy Anti-Aircraft Artillery battery covering Lower Hope (NMR TQ 77 NW 151), known as battery TS14 (and probably also as TS26), was located to the south of this site on Redham Marsh during the Second World War, approximately 300m south of the southernmost factory remains (Dobinson 1996b, 473). The earthwork remains of the gun emplacements are visible on aerial photographs and some concrete surfaces are visible from the ground. It is not clear what other elements of the battery survive, some of which may have been masked by spoil deposits resulting from dredging activity in the past decade.

In October 1945, five months after the end of the war in Europe, the War Office issued instructions for the cessation of Army demolitions on Cliffe Marshes, with the caveat that isolated cases of Navy demolitions would be permitted in the event of an emergency (Hansard 1945).

3.8 Post-war to present

Vertical aerial photographs taken by the RAF in 1945, 1946 and 1947 show that in the mid-1940s the site was in a remarkably similar state to how it is found today, with only small changes having occurred since. The most notable difference between then and now is that the photographs show fairly dense tree coverage around many of the building remains across the western side of the complex which has now been largely removed. Trees were planted between factory buildings to provide additional protection from accidental explosions by acting as barriers capable of absorbing blast debris. The line of the old sea wall, and consequently the marginal areas of the factory lost

Figure 19: Extract from 1946 RAF aerial photograph of the site, showing relatively dense tree coverage and riverside factory remains lost since the sea wall was rebuilt in the 1980s. NMR RAF 106G/UK/1447 1073 01-May-1946 © English Heritage.

during the subsequent rebuild in the 1980s, were also still in place at that time (Figure 19). Subsequent RAF aerial photography of the site from 1955 shows that the mature vegetation across western parts of the site had gone by this time (Figure 20); this could have been the result of dramatic tidal flooding in 1953, rather than an act of intentional clearance.

Figure 20: Extract from an RAF vertical aerial photograph of the site taken in 1955, showing that most of the tree cover had been removed by this time. NMR 540 RAF.1699 0113 12-Aug-1955 © English Heritage.

During the 1950s, the strategic position of Lower Hope Point was exploited again for the movement of explosives. Following an arrangement made in 1950 between the Air Ministry and the PLA, three new barge mooring buoys were installed for the RAF in 1952 at Lower Hope Reach. The moorings enabled barges carrying explosives to 'lie off' during loading operations at various points in the Thames Estuary (TNA MT 81/192). Additionally, by the end of 1953, an agreement was drawn up between the PLA and the Ministry of Transport and Civil Aviation by which the PLA agreed to provide, install and maintain two large mooring buoys for large ocean-going vessels, located about 1km south-west along the riverside from factory jetty **J3** (TNA MT 81/104). These should not be confused with the nearby RAF mooring facilities for non-seafaring barges (TNA MT 81/192). The larger moorings were predominantly intended for Admiralty use and for shipment and handling of Category C Government explosives in the Port

of London, but with provision for handling Category B explosives if ships were carrying a mixed cargo. Cliffe Anchorage was also proposed as an alternative to the existing Chapman Anchorage off Canvey Island on the opposite side of the Thames. Associated correspondence from 1954 records that the ammunition jetty would only be required in peace time. In direct relation to this, the local planning authority was directed to refer any proposals for development of the land around Cliffe to the PLA (TNA MT 81/104). Cliffe Anchorage was used in this format for explosives movements until 1962, when use of the moorings was terminated and the buoys were removed by the PLA (TNA MT 81/192).

The North Sea Flood of February 1953 resulted from the combination of an unusual spring tide and a severe storm event, causing widespread flooding along the east coast, including extensive destruction along the Thames estuary. Cliffe Marshes did not escape the damaging effects, and although improvements to the sea wall supposedly began at Cliffe in 1958, a year later than planned (Bowler 1968, 361), evidence from historic aerial photographs shows that it was not until sometime after March 1981 that the sea wall adjacent to the factory was rebuilt (F Small, pers comm). This rebuild required the line of the sea wall to be moved by up to 90m inland and with it the drainage dyke running along its inside, a process that had the effect of destroying the remains of several structures relating to the factory remains (see Figure 6).

As early as 1921, documents suggest that gradually the factory land was being returned to grazing marsh occupied by tenant farmers. Local resident Clifford Dowsett, whose father had managed stock on the site for a time, recalled that a number of the reinforced concrete stalls comprising acetone recovery stoves **244** and **245** had been converted for use as pig stys (C Dowsett, pers comm to R Pullen, June 2011). Low corrugated iron roof sheets inserted for this purpose were noted in a couple of these stalls during the survey. The site continues to be under management for grazing of sheep and horses, and for wildfowl conservation and shooting.

Since the mid-1990s, one or two small buildings have fallen into greater states of disrepair or been removed entirely (for example, structures **66** and **95**), but little other discernible change has taken place.

3.9 Timeline

1820 Curtis's & Harvey Ltd were established as a company

1889 Committee headed by Abel and Dewar developed the smokeless propellant 'cordite'

1890 Cordite was officially patented

A draft licence was prepared detailing a proposal by Hay, Merricks & Co Ltd for the establishment of a gunpowder 'factory' at Lower Hope Point (KHLC CKS-S/NK/A/C/1/19)

1892 22 December, Hay, Merricks & Co Ltd issued with a licence for blending, packing and storage of gunpowder at Cliffe (Cooper-Key 1903, 3)

1894 Cordite added to the national list of authorised explosives (HMSO1895, 5)

1895 OS 25-inch survey revised, the resultant map shows two gunpowder buildings, tramlines and a jetty on the site (Ordnance Survey 1897a)

1897 November, a powerful storm breached the sea wall in several places in Cliffe Parish (Bowler 1968, 324-5)

1898 24 November, Curtis's & Harvey Ltd of Hounslow was officially incorporated under the Companies' Act through a merger of established gunpowder firms including Hay, Merricks & Co Ltd. Takeover included acquisition of 'Lower Hope Point Powder Works' on Cliffe Marshes and was back-dated to 31 December 1897 (TNA BT 31/35979/59657 vol 1)

1900 Curtis's & Harvey Ltd founded their own factory at Cliffe on the site of the Hay, Merricks & Co gunpowder works (Hodgetts 1909, 364)

1901 3 June, an amending licence sanctioned establishment of a nitroglycerine plant and manufacture of nitroglycerine-based explosives including cordite, blasting gelatine and gelatine dynamite at Cliffe (Cooper-Key 1908, 8)

1902 15 December, explosion in building 'No.18', cordite paste mixing house (*The Times* 1902; Cooper-Key 1903)

1903 26 October, amending licence No. 1102 was granted, permissions included the erection of a building for drying guncotton (Desborough 1904, 3)

Amending licence No. 1112 was also granted, permitting erection of further factory buildings, details unknown (Desborough 1904, 3)

Cordite M.D. authorised for manufacture at Cliffe (HMSO 1904)

1904 4 February, explosion in building 'No. 48', guncotton stove (Desborough 1904)

18 February, explosion in separating house (Cooper-Key 1904)

By April, an amending licence permitted development to facilitate manufacture of the chlorate-based blasting explosive 'Cheddite' at Cliffe, and allowed further factory growth based on longer drying times needed for Cordite M.D.

compared to ordinary cordite (Cooper-Key 1904, 4)

5 July, mistake in new nitrator (Nathan patent type) caused one death by inhalation of nitrous fumes (HMSO 1905, 59)

1905 Dynamite manufacture commenced at Cliffe (Cooper-Key 1908, 8)

1907 OS 25-inch survey revised, the resultant map shows detailed layout of the factory including buildings and tramlines (Ordnance Survey 1908a; 1908b)

Valuation list for Cliffe Parish details property owned by Curtis's & Harvey Ltd as comprising: powder works, jetty, tramways, nine cottages as stores, pasture land, Manager's house and four houses with gardens (KHLC CKS-S/NK/A/C/1/33)

1908 5 June, explosion of dynamite killed two young women engaged in filling cartridge cases in hut '26a' (Cooper-Key 1908)

31 August, the Earl of Darnley granted Curtis's & Harvey licence to 'make a road and tramway' over land within the Manor of Cliffe, between the south end of the factory and Cliffe village (MALSC U0565/T337)

1910 Curtis's & Harvey Ltd bought four plots of land from the Earl of Darley's Cobham Hall Estate holdings on Cliffe Marshes (MALSC U0565_E702)

1911 26 July, explosion in nitroglycerine hut (*Chatham, Rochester & Gillingham News* 1911a; 1911b; Cooper-Key 1911)

1914 24 March, a proposal for four new and larger magazines was put forward (KHLC CKS-S/NK/A/C/1/186)

29 April, explosion in a cordite drying stove during conversion to an acetone recovery stove (Coningham 1914)

8 July, gelignite was being produced and distributed by this date (MALSC S/MN/AC27/10)

4 August, Great Britain entered the First World War

1915 Reference to use of aerial guns at Hope Point Battery for the protection of the explosives factory at Cliffe (*Chatham, Rochester & Gillingham News* 1915)

Curtis's & Harvey Ltd bought a plot of land on Snares Marshes near Cliffe belonging to C. Snelling (KHLC CKS-S/NK/A/C/1/132)

Curtis's & Harvey Ltd bought a portion of land from the Earl of Darley's Cobham Hall Estate holdings on Cliffe Marshes (MALSC U0565_E702)

1916 Documented presence of anti-aircraft artillery guns within the general vicinity of the explosive works at Cliffe (Dobinson 1996a, 294-6)

6 March, Curtis's & Harvey Ltd declared a 'controlled establishment' under the 1915 Munitions of War Act (TNA BT 31/35980/59657 vol 3)

Mid-year a second de-nitrating plant was constructed to cope with waste

acids from increased on site nitroglycerine manufacture (Crozier 1917, 1)

22 December, an explosion occurred in the new ('second') de-nitrating plant (Crozier 1917)

1917 5 April, letter from Curtis's & Harvey to the Upper Medway Conservancy suggests that the factory was still working towards the high demand for explosives for Naval and Military purposes (MALSC S/MN/AC27/10)

24 October, a nitrator-separator house exploded killing two people and injuring eleven (HMSO 1918, 12)

1918 8 March, outbreak of fire in an acetone recovery stove resulted in two whole ranges comprising over 100 stoves being burnt out (HMSO 1919, 4, 10)

29 November, Curtis's & Harvey Ltd was subsumed as part of a merger of multiple businesses to form a new national company: Explosives Trades Ltd (Cocroft 2000, 109; Grace's Guide 2012b)

11 November, Armistice Day marked the end of the First World War

1920 Explosives Trades Ltd renamed Nobel Industries (Cocroft 2000, 109; Grace's Guide 2012b)

26 August, a letter regarding the local wall scot (tax) declares that the Poor Rate Assessment for the factory was being reduced almost by half (KHLC CKS-S/NK/A/C/1/124), presumably because operations had largely ceased

1921 13 January, a letter states that some of Curtis's & Harvey's lands are in their own occupation, some occupied by agricultural tenants and some occupied by the Admiralty (KHLC CKS-S/NK/A/C/1/124)

18 January, letters confirm the Admiralty had handed the plant and buildings of HM Cordite Factory over to the Disposal Board who were making arrangements to remove everything from the ground (KHLC CKS-S/NK/A/C/1/124)

5 July, agreement between Curtis's & Harvey and farmer John Robertson Esq. to let fields '396', '397', '416' and part of field '417' for grazing, suggests that the factory had ceased operations (MALSC 06a_DE_Series_1001_1200/DE1087_1; 06a_DE_Series_1001_1200/DE1087_2)

7 July, Curtis's & Harvey's magazines at Cliffe were deemed worthy of protection against attacks or raids by Sinn Fein (TNA CAB 24/126)

22 November, Curtis's & Harvey sold about 100 acres (40.5ha) of land, formerly 'HM Cordite Factory', to HM War Department (KHLC CKS-S/NK/A/C/1/124)

1922 30 May, an official letter from the clerk to the Commissioners of Sewers described the whole of the factory as in course of demolition; manufacturing had ceased, and only some domestic buildings, stores and magazines were still in use (KHLC CKS-S/NK/A/C/1/124)

1923	15 February, 'very material changes have been made at the Factory by way of demolition and removal of buildings and plant' (KHLC CKS-S/NK/A/C/1/124)
	17 March, machinery had been sold off and removed; most buildings had been demolished, a few magazines remained for storage of explosives and administrative buildings were unoccupied but not derelict (KHLC CKS-S/NK/A/C/1/124)
	10 September, HM War Department sold the land formerly known as HM Cordite Factory to Herbert Moses Thomas (MALSC 06a_DE_Series_1001_1200/DE1087_3)
1924 & 5	Valuation assessment by Commissioners of Sewers records Curtis & Harvey as owning a total of 172 acres on Cliffe Level (KHLC CKS-S/NK/A/C/1/132)
1926	Nobel Industries were merged with three other companies to form ICI Ltd (Grace's Guide 2012a)
1929	21 March, a letter suggests that land at the west side of the site was still under Curtis's & Harvey's ownership (KHLC CKS-S/NK/A/C/1/160)
1931	PLA map suggests that all of the former factory land had come under their authority by or during this year (KHLC CKS-S/NK/A/C/1/186)
1932	ICI (Explosives) formed (Grace's Guide 2012a)
1939	3 September, Britain entered the Second World War
1944	Part of the site may have been used for aerial target practice
1945	8 May, the Second World War ended in Europe
	October, War Office issued instructions for the cessation of Army demolitions on Cliffe Marshes (Hansard 1945)
1950	Arrangement for three mooring buoys to be positioned at Lower Hope Reach for explosives barges to 'lie off' during loading (TNA MT 81/192)
1952	Installation of three RAF mooring buoys for explosives movement at Lower Hope Reach (TNA MT 81/192)
1953	1 February, major tidal breach of the sea wall resulted in expansive flooding, causing widespread destruction and loss of life along the Thames
	Installation of two Admiralty mooring buoys for explosives movement at Lower Hope Reach (TNA MT 81/104)
1958	Sea wall improvements began in some parts of Cliffe parish (Bowler 1968, 361)
1962	September, use of explosives moorings at Cliffe was terminated and mooring buoys were removed (TNA MT 81/192)

1980-90s	Sea wall adjacent to the explosives works was completely rebuilt and relocated further inland sometime between 1981-1999 (F Small, pers comm)
2008	ICI was acquired by AkzoNobel
2010-11	English Heritage large-scale survey and investigation of the factory remains

4. OVERVIEW OF MANUFACTURING PRODUCTS AND PROCESSES

Very briefly, the history of explosives technology began just over one thousand years ago when the intense energy produced by substitution of nitrates into the combustion process was realised. The resultant early explosives are referred to as 'blackpowder' and latterly as gunpowder. This technology was refined and developed across continental Europe from the later medieval period onward, forming a long association with firearms and, by the 17th century, the widespread use of gunpowder for blasting in mines and quarries (Cocroft 2000, 1-21). During the second half of the 19th century, explosives development entered a distinct era of technological advancement. Complex chemical compounds were employed to great effect, giving rise to a new explosives industry and marking an almost complete break from the age of gunpowder. The most notable aspects of this new chemical explosives industry were the invention of detonators and the harnessing of various nitro-compounds to create more efficient propellants and blasting substances. The new explosives were desirable for their reduced bulk and relatively smokeless nature. Not only were the innovations more science-based, requiring different manufacturing premises, with the increased volatility of the new explosive products the factories producing them had different locational needs. Large open spaces on marginal, sparsely populated land were preferred, and so isolated sites in coastal and riverine positions were often favoured (Cocroft 2000, 119). In this respect, Lower Hope Point on Cliffe Marshes provided an ideal spot, with the added bonus of being on the Thames shipping route. The history of explosives technologies has been covered in more detail elsewhere and can be consulted in publications by various authors, for example Guttmann (1895), Dolan and Oglethorpe (1996, 11-13) and Cocroft (2000).

4.1 Explosives produced at Cliffe

From its establishment under Hay, Merricks & Co in 1892 until it passed into the hands of Curtis's & Harvey Ltd in 1898, the site dealt solely with gunpowder. Hay, Merricks & Co's licence permitted only blending, packing and storing of gunpowder, but did not run to manufacture (Cooper-Key 1902, 3). Letters accompanying the 1890 draft licence state that the site would be used purely as a holding depot for gunpowder produced at Hay, Merricks & Co's Roslin factory before shipment to Purfleet or for foreign trade (KHLC CKS-S/NK/A/C/1/19).

Manufacture of guncotton and the nitroglycerine-based explosives cordite, blasting gelatine and gelatine dynamite at Cliffe was approved by licence in 1901 (Cooper-Key 1902, 4; Explosives Inspectorate 1902, 56-9). As a result, the range of authorised explosives produced at Cliffe was brought up to five different types, placing the site among a handful at the forefront of explosives technology. This advance marked the beginning of a rapid diversification into a wide variety of explosive recipes and brands and with that came an impressive rate of physical expansion across the site itself. Other important developments at Cliffe included amending licences allowing development of facilities for manufacture of chlorate explosives or 'Cheddites' in 1903 (Cooper-Key 1904, 4), and for the production of dynamite in 1905 (Cooper-Key 1908, 8). By 1909, seven of the Curtis's & Harvey's 'permitted' explosives were the invention and sole property

of the company: Rippite, Curtisite, Bobbinite, Dragonite, Kolax, Excellite and Cliffite (Hodgetts 1909, 355), and all but Bobbinite (a low explosive gunpowder derivative) were produced at Cliffe. By 1914, the factory was licensed to produce and handle as many as 38 different explosive products (Explosives Inspectorate 1915, 48-54), these were predominantly explosives categorised as within Class 3 Divisions 1 and 2, denoting explosives whose preparation wholly or partly involves nitroglycerine or other liquid nitro-compounds. In addition, the factory was producing a number of Class 4 chlorate mixture explosives, as well as a number of fuses and percussion primers. A full list of explosive products licensed for production at the Cliffe factory for the years 1892-1914 can be viewed in Appendix 2.

Classes of explosives authorised for manufacture or importation into the United Kingdom, as defined by HM Inspectors of Explosives in 1914 (Explosives Inspectorate 1915, 43-7):

Class 1	*Gunpowder*
Class 2	*Nitrate mixtures*
Class 3	*Nitro-compounds*
Class 4	*Chlorate mixtures*
Class 5	*Fulminate*
Class 6	*Ammunition*
Class 7	*Fireworks*

Unfortunately, with the advent of the First World War in 1914, the annual reports produced by HM Inspectors of Explosives were considerably thinned down and consequently detailed records of the specific factories authorised for production of various explosives are not available for the years following 1914. The wartime reports do include very brief accounts of incidents involving explosives, and from these it is possible to extrapolate that Ammonium Perchlorate was being processed by or before 1917, and that Tonite was being stored and probably produced by or before 1921.

Briefly, the main explosives and constituents of explosives handled at Cliffe were*:

Acetone: a solvent used to aid incorporation and gelatinisation in some forms of cordite; it is then driven off by drying and so is not present in the finished cordite

Blasting gelatine: a mixture of 7-8% nitrated cellulose and nitroglycerine, forming a yellow jelly-like plastic mass, exploded by means of a detonator

Cheddite(s): a term applied to a group of blasting explosives made by mixing a powdered chlorate or perchlorate with a fatty substance, such as castor oil, commonly used in quarrying

Cordite: is a double-base propellant formed from the combination of guncotton, nitroglycerine and mineral jelly; it is usually produced as cord-like strands, and a number of different forms exist, for example Cordite MK1 and Cordite MD

Dynamite: explosive formed by mixing nitroglycerine with an inert siliceous earth (often the finer grained earth 'kieselguhr')

Fuze: (fuse) a device for initiating the explosion or detonation of an explosive at a given time

Gelatine dynamite: 80% nitroglycerine, 20% mixture of saltpetre and woodmeal; it has a jelly-like consistency and is commonly used as a blasting explosive

Gelignite: 65% nitroglycerine, 35% mixture of saltpetre and woodmeal; it has a jelly-like consistency and is commonly used as a blasting explosive

Guncotton: an explosive produced by the nitration of cotton, a type of nitrocellulose and the basis for a number of common propellants and blasting explosives

Gunpowder: also known as blackpowder; a mechanical mixture of saltpetre, sulphur and charcoal

Mineral jelly: also known as vaseline, it was added to cordite as a lubricant and chemical stabiliser

Nitric acid: HNO_3 – a strong oxidising agent, used as the nitrating agent in the nitration process

Nitrocellulose: or more correctly 'cellulose nitrates'; an explosive produced from cellulose, either cotton or wood pulp, under the action of strong nitric acid, and with sulphuric acid as a dehydrating agent

Nitroglycerine: $CH_2(NO_3)CH(NO_3)CH_2(NO_3)$ - made by treating glycerine with nitric acid and sulphuric acid to form a colourless, transparent, viscous, oxygen-rich explosive liquid

Primer: also known as igniters, explosives placed between the percussion cap and the main charge

Propellant: explosive substances which, when burnt in a regulated manner, will produce gases that can be controlled to do work

Sulphuric acid: H_2SO_4 – concentrated sulphuric acid acts as a dehydrating agent in the nitration process; it is also used in manufacture of nitric acid

Tonite: a blasting explosive comprising thoroughly purified guncotton mixed or impregnated with a nitrate or nitrates

*Definitions predominantly adapted from Cocroft's publication *Dangerous Energy* (2000, 290-3).

4.2 Manufacturing processes

The main explosive produced at the Cliffe factory was cordite, manufacture of which involves blending dry guncotton with nitroglycerine. Both guncotton and nitroglycerine are explosives in their own right and both were produced at Cliffe, essentially in factories within a factory. The methods of manufacturing guncotton, nitroglycerine and cordite have been covered to varying levels of detail elsewhere (eg Fitzgerald 1895; Anderson 1898; Englebach 1899a, 1899b, 1900; Arkas 1900; Cocroft 2000), and will only be briefly outlined here to provide a general overview of the processes carried out in the structures described in section 6.0 of this report. Details of the precise methods used at the Cliffe factory are not fully known, but a fair understanding of the manufacturing set-up has been inferred from various documentary sources and the nature of the physical remains. Details described in the official accident inquiry reports produced by HM Inspectors of Explosives and in the sales particulars for auction of the HM Cordite Factory in 1923 (MALSC 06a_DE_Series_1001_1200/DE1087_3) area have been particularly useful in that respect. The preparation methods for a range of other explosives known to have been produced at the factory on a smaller scale will be outlined, but not described in detail due to the relative lack of definable process evidence amongst the factory remains.

Guncotton

Guncotton is a type of cellulose nitrate, more commonly but incorrectly known as nitrocellulose. Guncotton is made by treating cotton waste with nitric and sulphuric acid,

and specifically refers to cotton nitrated to contain 13.2 per cent nitrogen or greater (Shreve 1945, 445-8). At Cliffe, guncotton was made within the factory, but in some cordite factories it would have been acquired from an external supplier. The acids factory and guncotton factory within a complex like this one would normally have been run as a single administrative unit within the overall factory. This unit would be fairly distinctive; the buildings were predominantly large warehouse-like structures often with more than one storey, and unlike many other areas of the factory, the buildings were closely co-located and were not surrounded by protective earthworks, primarily due to the relative stability of the processes and materials handled within. For ease of reference, key stages in the manufacturing process have been highlighted in the text below.

The first stage of guncotton manufacture was the acquisition and preparation of the raw ingredients. In an era before the development of acid-resistant glass and metal chemical plant, the problems of storing and moving nitric acid were such that it would usually be manufactured within the explosives works; however, evidence for primary preparation of acids has not been identified at Cliffe. It is thought that both nitric and sulphuric acid were probably imported to the factory rather than being produced on site, though the acids may have been further purified and concentrated upon arrival. In many explosives factories, it was common practice to acquire sulphuric acid from commercial suppliers and then concentrate it to the required levels within the works. One possible interpretation for a group of small heavy-duty cuboid structures recorded in the First World War acid factory at Cliffe (**185a-e**) is that they represent the surviving basal element of a set of acid towers used for concentrating sulphuric acid up to the required strengths. The concentration of contemporary chemical works along the highly industrialised banks of the Thames, along with direct access to riverine transport, may have been two of the factors that attracted Curtis's & Harvey to the site on Cliffe Marshes, providing a ready supply of locally-produced chemicals and as such removing the need for in-house production of acids.

Raw cotton waste would arrive in large bales (probably in hundredweight bundles) requiring **bale-breaking**, often by a large machine, to prepare the cotton for **picking**. Picking involved hand-sorting, most likely by women, to remove any fragments of wood, wire and rag etc. Once sorted, the cotton went for **willowing**, a process by which the cotton was loaded into a powerful teasing/carding machine known as a Willow. This consisted of a large spiked drum revolving within a chamber fitted with further internal spikes which tore open the fibres to render them suitable for acid absorption. The teased cotton was often rolled at this point (possibly using another part of the same machine) or cut up and then rolled, before being passed on to the **drying** room on a conveyor belt known as an 'endless band'. The cotton was dried using a series of huge ovens heated by blasts of steam or hot air; this reduced the water content of the cotton to further increase its potential for acid absorption. The dry cotton waste was then weighed into charges and packed into tin **cooling** boxes; after 24hrs or so the cooled cotton charges were ready to be saturated with acids and would be moved into the dipping or nitration room.

Treatment with acids, in this case nitration, was commonly referred to as **dipping** in this process. The dipping house would contain a series of dipping pans, each holding an accurate measure of mixed sulphuric acid and nitric acid in a ratio of 3:1. Above

the dipping pans a series of tall lattice-work structures would carry off the noxious fumes produced by the chemical reaction. Cotton was placed in each pan for about five minutes to absorb the required weight of acid. The saturated charges were then squeezed and moved into individual earthenware pots for **digesting**. The chemical process was then complete, but the material required several stages of physical manipulation before the guncotton was ready. Further **cooling** also took place in the dipping house; the floor of this large room was divided into shallow tanks in which multiple earthenware vessels stood to cool for around 24 hours. The cooled pots were removed using iron tongs and transferred to a separate building for **spin-drying**. The cotton was removed from the pots and placed inside a centrifugal wringing machine where it was spun at 1,200rpm for a short time, leaving it relatively dry and free of excess acid; any waste acid collected by this process was usually sold on to a contractor. The cotton was then washed by **potching/poaching** in a large wooden tank of water agitated by a revolving wheel; these potching machines represented technology borrowed from the paper industry. The foreman would then taste (!) the cotton to ensure no detectable acid residue remained, and once satisfied, the cotton could be stored in these tanks for a couple of weeks. The cotton was removed by a worker wading into the tank in large boots; it was then rung dry or spun again in the centrifuge and moved to the boiler house or 'vat house'. In 1905, a less labour-intensive alternative known as the **Nathan-Thompson Displacement Process** was developed which removed the need for separate dipping, squeezing, digesting, spinning and immersing stages. As a result many factories converted their dipping rooms into **nitrating** rooms by installing rows of displacement tanks supported on an acid-resistant brick floor (Cocroft 2000, 126-7). Documentary evidence suggests that the First World War guncotton factory at Cliffe had a nitrating room (**178**) rather than a dipping room (MALSC 06a_DE_Series_1001_1200/DE1087_3), but it remains unclear whether the method was used from the beginning or whether it represents an upgrade. Likewise, it is not known which method was employed in the earlier guncotton production area at the east side of the site.

In the boiler/**boiling** house the cotton was boiled in huge vats for 4-5 days to remove all unwanted less stable compounds; upon removal from the vats, the cotton had a soggy, oatmeal consistency. In this form it then underwent rounds of **churning** in a beating engine to create a pulp, and further **washing** in a poaching machine. The pulp was then tested, caustic soda was added and the pulp was blended with other batches to give a consistent product. Dry guncotton is extremely sensitive and so the batches were then **immersed** in water until their water content was around 25%, making them safe for handling and storage. It was kept wet until it was required for use in the preparation of cordite and other explosives.

For conversion into cordite and other explosives, the guncotton first had to be **dried** out. This took place in a series of stoves either constructed as a row of small conjoined cells dried by hot air, or in rooms heated by steam pipes acting like radiators (as in the likely first incarnation of structures **129**, **130** and **131** at Cliffe), or as individual huts surrounded by earthwork traverses and dried by hot air piped in at temperatures of about 100°F (38°C) from external fan sheds (demonstrated by structures **267-283** and **267a-283a**). The dried guncotton was then weighed out into brass-lined boxes or water-proof canvas bags and carried to the final washing house to meet with the finished nitroglycerine.

Nitroglycerine

Nitroglycerine is a colourless, syrupy liquid created by treating glycerine with concentrated nitric acid and concentrated sulphuric acid. It is a key ingredient in most propulsive explosives and in a large number of 'disruptive' (blasting) explosives. Once made, the nitroglycerine at Cliffe was used primarily to nitrate guncotton (by saturation) to form cordite paste, but was also used as a constituent in the manufacture of blasting gelatine and gelatine dynamite. The methods of nitroglycerine production are complex and were subject to continual change to improve efficiency and stability; this makes the exact processes employed at Cliffe difficult to identify. Essentially, during the time that the Cliffe factory was open, there were two main basic set-ups for creating nitroglycerine. In earlier methods the nitration and separation phases of the process were undertaken using separate pieces of equipment, but more efficient methods were quickly developed in which nitrating and separating took place using a single piece of equipment. By 1905 this newer Nathan-patent type equipment and methods were in place at Cliffe. Several explosions and subsequent reconstruction of key buildings in the nitroglycerine factories at Cliffe add further to the complexity of unravelling the process. Comprehensive contemporary descriptions of the manufacture of nitroglycerine have been used to prepare the following simplified explanation: see publications by Nathan and Rintoul (1908), Martin and Barbour (1915, 88-91), RCHME (1994, 182-6) and Foreman (2001) for greater detail. Buildings which housed key parts of the manufacturing process have been highlighted in the text below for ease of reference.

Combining the acids with glycerine took place in the **nitrating house**; this was often the most distinctive and imposing building in the factory. Surrounded by a complete earthwork circuit double the height of those associated with other dangerous buildings (or danger buildings as they were termed at the time) it was often known by staff simply as 'the hill'. The nitrating house was a tall building divided into several levels, and was accessed by a tunnel through the earthwork. Immediately adjacent to this would have been the **charge house** from which acids and glycerine were released into the nitration apparatus when required. The charge house would have been set slightly higher than the nitrating house, usually mounted on top of the earthwork traverse itself. Acids stored in cylindrical vessels referred to as '**acid eggs**' were forced by compressed air to rise up through pipes to the charge house. Bogie carts containing glycerine were normally raised by a windlass-operated winch to fill the glycerine tank in the charge house. Glycerine could be raised in pipes if preferred, but this method required gentle heating to render it more fluid. From the charge house, the acids were released into a mixed acid tank in the upper level of the nitrating house, and the glycerine into an adjacent tank. In some later set ups an intermediate charge house was no longer required.

The mixed acids were then released into the **nitrator**, a large lead vessel housed on the middle layer of the building, and kept at a steady 16°C (it should be noted that the nitrating house itself, and not just the specific tank within, was sometimes also referred to as the nitrator). The glycerine was then sprayed by an injector into the base of the mixed acids, which were constantly stirred by bubbles of compressed air. The resulting reaction is exothermic (heat-producing), so the nitrator was continuously cooled by coiled lead pipes of cold water or brine that ran through the tank. Additionally, the nitrator sat above a large bath of cold water called a **drowning tank** into which the mix

could be dropped and drowned in the case of a dangerously hot reaction. Rigorous temperature control was of great importance throughout the factory, but particularly so in the nitroglycerine 'hill' where one person was responsible at all times for watching the thermometer and keeping, temperature consistent (Arkas 1900, 419). For safety reasons, processes in the nitroglycerine factory were kept below 22°C; this, combined with the high freezing point of nitroglycerine (13°C), presented only a narrow window of safe handling temperatures before conditions could become treacherous.

Once glycerine had been introduced to the acid mix, the resultant nitroglycerine gradually separated out from the remaining waste acids to form an oily layer floating on top of the waste acids. In early nitroglycerine manufacture, this took place in a separate **separating tank** where displaced nitroglycerine was syphoned off. The displaced nitroglycerine was allowed to run over the edge of the tank and along a gutter into the **pre-wash tank**, where it began several rounds of washing and refining with water and finally with warm soda solution. At this point, the waste acids left in the separator were run straight out of the nitroglycerine hill into an **after separating house**, where it could settle for several days to separate out any residual nitroglycerine. Once separated out, the nitroglycerine was skimmed off the surface and subjected to further washing in water (Martin and Barbour 1915, 89). This process was soon replaced by safer and more efficient equipment in the form of a combined **nitrator-separator,** allowing the after-separating house to be entirely removed from the process. This advancement in practice allowed any residual nitroglycerine in the waste acids to be destroyed immediately following nitration (ibid).

At Cliffe, the discrete nitrating and separating tanks in structure **31** had been replaced by a Nathan, Thompson and Rintoul type nitrator-separator by summer 1904 (Explosives Inspectorate 1905, 59). In this new method, excess residual nitroglycerine was destroyed immediately after nitration by addition of water, which raised the temperature, and with agitation by compressed air which brought the temperature back down. Eventually the nitroglycerine separated out fully and was removed by tap as a residue floating above the diluted waste acids (Martin and Barbour 1915, 88-91).

From the pre-wash tank, the nitroglycerine was run by lead-lined wooden guttering into a **wash house**. Here the nitroglycerine was washed inside large, lead-lined vessels, several times with warm, weak soda solution and then with filtered water, all constantly agitated by injection of compressed air. As with the nitration process, the wash tanks sat above a drowning tank into which the solution could be emptied if the temperature exceeded safe levels. The nitroglycerine was then run through a **filtration tank** to remove any remnant water and unwanted residues. It was then ready to be weighed and incorporated into to early manufacturing stages other explosives. Due to its extreme instability, storage of nitroglycerine was not permitted and so it was only made for immediate conversion into one of the explosives authorised for production at the factory. This necessitated that other ingredients of the intended explosive product, such guncotton in the case of cordite manufacture, had to be brought in the correct proportions to the nitroglycerine final washing house where the finished nitroglycerine was produced, thus allowing the volatile liquid to be absorbed straight away and removing risk through unnecessary handling (see Cooper-Key 1903, 4). At RGPF

Waltham Abbey, a red flag flew continuously over the nitroglycerine factory buildings to highlight the constant danger (Arkas 1900, 419).

Residues, or 'sludge', from the settling tank was removed and burnt and the wash waters were carefully drained into a settling pond or ponds. Waste acids and contaminated waters separated out at various phases of the process were drained into a **wash water settling house**, where residual nitroglycerine was allowed to settle at the base of the tank (whereas nitroglycerine floats on acid, it sinks in water), where it could be collected and disposed of. At RGPF Waltham Abbey, this pond was purposely exploded on a weekly basis to destroy any remaining trace of nitroglycerine (Fitzgerald 1895).

Cordite

The principal ingredients of cordite are guncotton and nitroglycerine, with a token measure of mineral jelly, combined in that order to the ratio 37:58:5. Once guncotton and nitroglycerine have been prepared as outlined above, cordite can be manufactured by blending the two and manipulating the resultant compound into a paste that can be forced into long cord-like strands of varying diameters for use as a smokeless propellant in munitions. Cordite preparations at Cliffe ranged from small rifle rounds tested on site, to the much thicker rope-like cordite which was packed off site into the huge shells carried by the Royal Navy's Dreadnought battleships.

The first stage in the manufacture of cordite is to introduce nitroglycerine to a batch of dry guncotton. Once the nitroglycerine has been fully filtered, guncotton was brought in batches of the correct weight (possibly in brass-lined boxes) to the **final washing house**. Here, the correct quantity of nitroglycerine would be weighed out from the filter tank, probably into jugs made of gutta-percha (natural rubber), and poured into the guncotton boxes (Cooper-Key 1903, 4; 1911, 6). Once saturated with nitroglycerine, guncotton is known as cordite paste or dough.

Each box of cordite paste was then taken to one of the **mixing houses**, here the contents was roughly kneaded by hand in a lead-lined basin before being rubbed through a fine copper-wire mesh into a sail-cloth bag. Kneaded paste was often stored in an **expense magazine** until it could be moved to the next stage in the process.

Next, cordite paste was taken to the **incorporating house**. Here mineral jelly (vaseline) and acetone were added to the paste and thoroughly blended into the mix in a large drum with revolving screw blades; these incorporating machines were slight modifications of those used for kneading bread dough and were belt-driven from an overhead rotating shaft. The mineral jelly acted as a chemical stabiliser, whilst acetone was added as a solvent which encouraged gelatinisation of the cordite paste into a more mouldable medium. During the First World War, there was a recognised international shortage of acetone so some purpose-built wartime factories, such as Holton Heath in Dorset, were constructed with provision to manufacture their own supply of acetone (Bowditch and Hayward 1996, 37-40; Cocroft 2000, 157-9). Despite having a large purpose-built wartime element, acetone, does not appear to have been made at Cliffe. As seen with the procurement of acids, the proliferation of nearby chemical works along the Thames probably also negated the need for on-site manufacture of acetone.

The paste was moved from the incorporating house to one of a series of adjacent **press houses**, each containing a heavy-duty hydraulic presses driven by hydraulic power generated in a nearby **hydraulic accumulator**. The great pressure inflicted on the cordite forced it to be extruded through a die into long cords of a yellowish-brown twine-like material, varying in diameter according to need. Narrow 'rifle' cordite was initially wound onto reels, whereas larger diameter cordite was cut into sticks.

At this point it was necessary to remove the acetone. To do this, the cordite sticks or reels were laid out in special drying rooms known as **acetone recovery stoves** and heated to great temperatures. This 'baking' process drove off the acetone as a vapour, and allowed it to be recovered and distilled in the adjacent **acetone recovery house**.

The finished cordite was then moved to one of a number of **blending houses** where sticks of the same diameter but from different batches would be jumbled up by hand to form bundles with a consistent content before being boxed for a final drying phase. In some cases, at this stage in the process strings of narrow cordite would be twisted together on **reeling** machines to form cords and ropes of thicker diameter before being cut into short lengths. The cordite was taken from the blending house and stacked on racks within a **cordite drying stove**, to drive off any residual moisture and to keep the product dry in storage. After manufacture, cordite from the large on-site storage **magazines** would normally be boxed and shipped to a filling factory for assembly into various types of propellant charges and rounds.

Dynamite and other nitroglycerine-based blasting explosives

The presence of a nitroglycerine factory also allowed the company to manufacture a variety of other nitroglycerine based explosives, primarily those used for blasting in extraction industries. These included dynamite, a mixture of nitroglycerine with an inert siliceous earth (fine grained 'kieselguhr', with an ability to absorb three times its own weight of nitroglycerine, was used at Cliffe), gelatine dynamite, a mixture of nitroglycerine with saltpetre and woodmeal, and blasting gelatine, which was formed by mixing nitroglycerine with nitrated cellulose. All were normally packed in stick form. The Cliffe site would have included buildings containing apparatus for grinding and sieving the Kieselguhr, though these have not been specifically identified.

Dynamite was packed into paper cartridge wrappers to form sticks, before being boxed for storage or dispatch. This was done using filling or loading machines often referred to as 'dynamite pumps' that were housed in small, lightweight packing huts and usually operated by women. At Cliffe, each hut contained two hand-operated filling machines, and each filling machine would have been worked by a single member of staff. The finished cartridges were sent via a small wooden chute into boxes in the porch area of the hut where they were periodically collected by factory 'runners' who also brought in fresh supplies of paper wrappers and bulk explosives. A detailed description of the dynamite cartridge filling apparatus and process at Cliffe is outlined in an official accident report from 1908 (Cooper-Key 1908). It is thought that many of the smaller traversed structures in the west and south-west areas of the site were probably used for cartridge filling and packing of blasting explosives.

Cheddites and other chlorate-based explosives

Cheddites are chlorate-based explosives made by mixing a powdered chlorate or perchlorate with a fatty substance, such as castor oil. They were most commonly produced for the quarrying industry. Cheddite, in a handful of different commercial preparations, is the only chlorate-based ('Group 4') explosive listed as being manufactured at Cliffe in the Explosives Inspectorate reports for years up until 1914 (see Appendix 2), but it is possible that further chlorate mixtures were added to the factory's repertoire during the First World War. From the registering of an incident on 8 December 1917, we know that ammonium perchlorate was being handled on site. The cause of the explosion is listed as 'R. D. Composition B', suggesting that it was a research department (RD) laboratory test (Explosives Inspectorate 1918, 13). Descriptions of contemporary production methods and building designs have not been identified, and as such the area of the factory employed in the preparation of Cheddite can only be speculated upon.

Minor accidents recorded as occurring in buildings associated with production of Cheddites at Cliffe give a limited insight into some of the operations and equipment present. These include Cheddite mixing pans, revolving copper granulating pans, steam pipes for heating, and drying machines, one of which contained residues of perchlorate of ammonium dust which spontaneously ignited on communication with wood-meal in 1919 (Explosives Inspectorate 1904; 1907; 1909; 1919).

4.3 Building regulations

All aspects of explosives factories, including construction, layout, technical procedures and monitoring regimes, were subject to strict government regulations in order to achieve maximum safety. Avoiding or reducing the severity of destruction caused by accidental explosions, and the knock-on disruption to productivity and profit, was paramount. The basic parameters for these safety regulations were (and still are) set by the 1875 'Explosives Act' (Public Statutes General 1875, **38 Victoria, c. 17**), under which the Explosives Inspectorate was constituted as a regulatory organisation responsible for implementation of the legislation, which included a new national licensing system. The minimum distances allowed between certain building types were stipulated, the use of particular designs and materials was specified, and provision of individual blast protection walls or traverses around certain buildings was demanded. The Act also made compulsory the registration and investigation of all accidents involving explosives or fire at licensed explosives premises. An official booklet of regulations for ammunition factories produced by the Ministry of Munitions in 1915 included conditions ranging from the quantities of different explosives permitted to be stored in any one building, to use of electric lighting, cleaning regimes, provision of lightening conductors and even the banning of flannelette underclothing (TNA MUN 5/147/1122/73). These codes of practice were frequently revised following technological developments and in the wake of major accidents; the upshot of fatalities and structural damage was often alterations in practice and improvements in safety. For example, following an accident at the Cliffe works in 1911, Curtis' & Harvey devised a method of constructing a slightly dished concrete platform rendered in smooth cement in front of the doors of danger buildings, in order to contain any spilt liquid and intended to be covered with 1 inch of water at all times

(Cooper-Key 1911, 7). No obvious instances of this were identified whilst surveying the factory remains.

Danger buildings, or danger ('clean') areas, refer to designated sections of an explosives factory or building where loose explosives may have been encountered (Cocroft 2000, 290). Generally speaking, danger buildings were constructed with generous spaces between them; these distances could be reduced in the case of buildings intended to house less sensitive, or smaller quantities of, explosives, such as dynamite cartridge filling huts. Equally, where a danger building did not face on to another factory structure, or where the adjacent building had a mound that could double up to protect both buildings, a blast mound across that side may have been unnecessary; this can be seen in several cases at Cliffe, including structures **7** to **9** and **143** to **148** amongst others. All surviving traverses at Cliffe are built of earth, although it is possible that some may have had corrugated metal revetments that have since been removed (see section 6.2). Towards the end of the 19th century there had been a brief trial period of using concrete or brick-lined traverses as blast protection around danger buildings, but by the dawn of the 20th century the accepted rule was that basic earthwork mounds provided the most effective absorption of blast debris (Cocroft 2000, 103).

The principal consideration governing the design of most danger buildings was a preference for flimsy constructions which offered minimal resistance to an explosion, thereby minimising the severity of the overall effects. As such, most of the smaller danger buildings at Cliffe had walls of lightweight timber or corrugated sheet metal, although larger buildings were usually constructed in brick for structural soundness. The Cliffe factory is particularly notable for its extensive adoption of reinforced concrete ('ferro-concrete') as a construction material; this use represents a rare occurrence and is certainly a rare survival (see sections 8.3 and 8.5). It survives in the roofless press houses (**246** and **247**) and acetone recovery houses (**244** and **245**) in HM Cordite Factory and, even more unexpectedly, it has been used to construct danger buildings, in this case cordite drying stoves erected just before, and during, the First World War (**153**-**154**, **205**-**212**, **222**-**230**). Whereas the more traditional brick structures produced a shower of missiles in the event of an explosion, thereby requiring traverses to keep such missiles in or out, the way in which reinforced concrete responded to a blast meant that protective mounds were not at the time deemed necessary (Guttmann 1908b). Nevertheless, despite this apparent advantage, reinforced concrete appears to have seen little uptake as a staple building material in the wider British explosives industry (Cocroft 2000, 103-4).

Inside the factory buildings, guidance for good practice was similarly strict, dictating operations, machinery and materials. All danger buildings, regardless of function, were characterised by division into 'clean' and 'dirty' working areas. No personnel were permitted into the much larger 'clean' working area until they had removed all loose artefacts (such as coins and matches) and had changed into 'clean' regulation clothing. These 'clean' areas were usually marked by toeboards or a painted line, and had floor surfaces that could be easily kept clean and free from explosive residues. Materials inside the buildings were all specified in order to aid cleaning of spilt chemicals, to resist the corrosive properties of acid, or to reduce the potential for sparks or the spread of fire; for example lead- or zinc-lined floors and walls, acid-resistant bricks and the use of

gritless asphalt. Details in the 1923 sales particulars for HM Cordite Factory clearly show that many of the buildings at the Cliffe factory had their internal walls and sometimes their roof clad with timber (MALSC 06a_DE_Series_1001_1200/DE1087_3). This timber 'match-lining' provided insulation to help maintain required temperatures in buildings made of concrete or lightweight corrugated iron sheets, it also made easier the task of keeping buildings rigorously clean and, crucially, was an anti-spark material. Evidence for the use of match-lining inside contemporary explosives magazines has also been identified at St Mary's Marshes, 7km east of the factory remains at Cliffe (Newsome and Pullen 2013). The number of staff allowed in particular danger buildings at any one time, and the quantity and type of tools permitted inside, were also strictly controlled.

4.4 Power sources

Power was central to the majority of factory operations. Power houses identified at Cliffe include diesel motor rooms, hydraulic accumulators and probable electricity generators. However, for most structures and processes it has not been possible to distinguish whether the motive power was provided by diesel engines, electric motors powered by a remote generator, or by hydraulics served by an accumulator tower. Most machinery in the factory, especially in the pre-war periods would have been belt-driven. As such, a handful of large power houses could have driven several processing buildings all containing multiple machines.

Diesel

Power houses driven by diesel engines are sometimes recognisable amongst the building remains due to the presence of small subterranean tanks for storing oil, for example structure **186** in **Area G**.

Hydraulics

Another important source of power at Cliffe was the use of hydraulics. Hydraulic accumulators were used to provide the huge amounts of power required to drive the rams in the hydraulic presses that forced the cordite paste into long strings. Structures **248** and **249** in **Area J** are the remains of a pump house and adjoining hydraulic accumulator tower base, which would have powered the adjacent cordite press houses (**246** and **247**) and probably also provided the motive power for machines in the nearby incorporating house (**251**).

Steam

Despite its heavy presence at the factory, steam was used predominantly for temperature regulation and heating of various processing buildings, rather than as a direct source of power for operating machinery. The only confirmed boiler house identified at Cliffe is structure **193** in **Area G**, but there would have been several more across the site to provide heat for the numerous drying stoves and temperature-reliant processing buildings. In the 1880s, Quinton Hill guncotton factory at RGPF Waltham Abbey, for example, had a total of five boilers to provide steam for heating and power (Cocroft

2000, 124). The furnaces in the boiler houses at Cliffe are likely to have been coal-fired, but at present no direct evidence for coal use has been identified.

Electricity

Physical evidence for the use of electricity to power machinery at the factory is fairly elusive, but the 1923 sales particulars for HM Cordite (MALSC 06a_DE_Series_1001_1200/DE1087_3) list the presence of a 'motor show room', and numerous 3 and 5.5 h.p. d.c. motors (see section 6.18). Electricity was certainly employed throughout the factory for lighting, although it was not necessarily used from the outset and may have only been installed part way through the life of the factory. Several ceramic insulator fragments are located within and around the remains of structure **44** in **Area B**. This combined with the presence of moulded concrete plinths thought to have supported a number of small motors in this building, suggest that it functioned as an electricity power house. Conduits for cables are visible in the remains of several of the standing structures, and interior lights can be seen hanging from the ceiling in a rare photograph of staff taken inside one of the processing buildings (Figure 21). Use of electric lighting in the HM Cordite Factory complex is confirmed by listing of a lot in the 1923 sales particulars that contained '510 feet of electric light cables' (MALSC 06a_DE_Series_1001_1200/DE1087_3). Interestingly, these cables are described as buried in the ground (ibid), and so, in at least some parts of the factory, the cables were buried rather than running above ground between wooden or concrete posts.

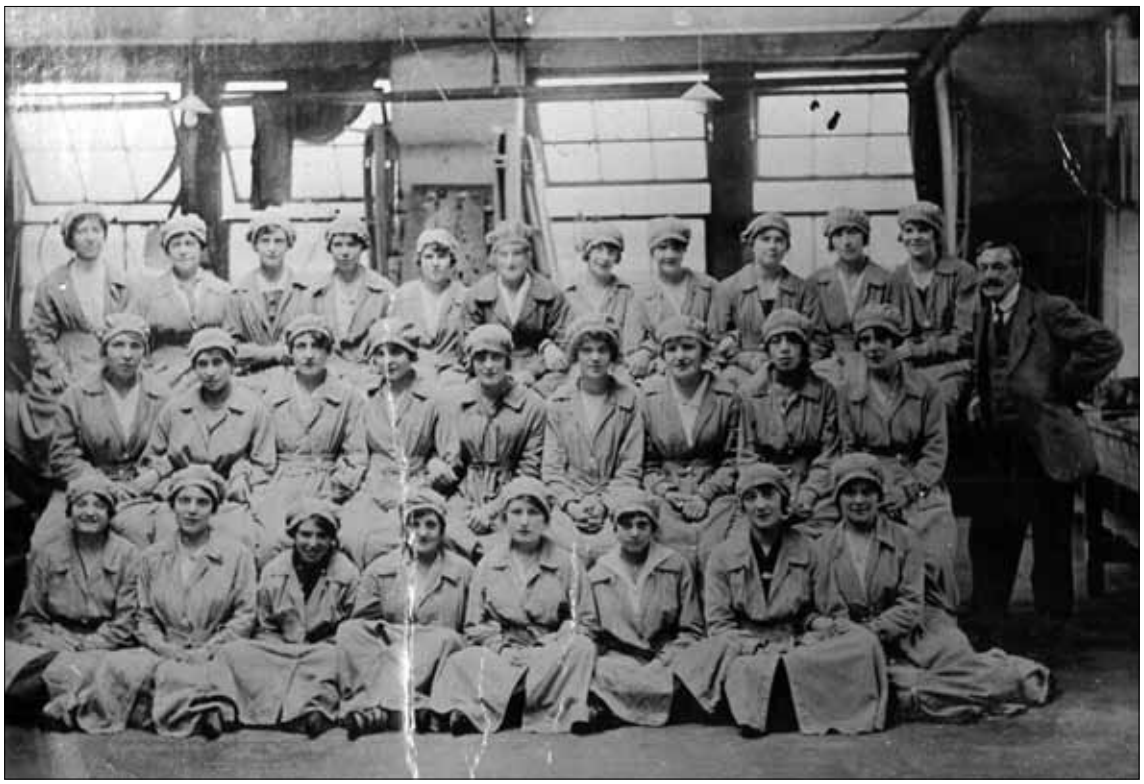


*Figure 21: Staff at Curtis's & Harvey's Cliffe factory, taken during the First World War WW1, showing the interior of what might be structure **251** © Cliffe and Cliffe Woods Parish Council, reproduced by kind permission of Joy Dan.*

The nature of the material processed within a building determined whether internal lighting was permitted, or whether external lamps positioned alongside windows or squints were used to illuminate activities within. In non-danger buildings, such as the acid factory and any welfare and administration facilities, use of conventional ceiling lights was perfectly acceptable; whereas the potential for sparks or over-heating, however small, was too risky to allow electricity in the more dangerous areas of the factory (Jenkins 1891). Installation of electricity in any processing areas would have been under the general advice that lightening protectors should be used, all wires should be enclosed and all fuse boxes should be outside the building (ibid). In buildings where permanent lighting was not required for processing activities, such as the cordite drying stoves, hand-carried lamps with sealed sturdy glass covers would be used when required. However, in danger buildings where volatile material may be present, such as the guncotton drying stoves, external lamps were shone through doorways or through thick glass windows to illuminate activities within and to allow internal thermometer gauges to be checked from outside (ibid). A number of structures at Cliffe have a wooden, or sometimes concrete, post between the presumed doorway location for a building and the point of entry through a traverse, suggesting a mounting point for an external lamp.

4.5 On-site conveyance

The movement of materials, water and power around site was fundamental to the smooth operation of a factory of this scale and complexity. Consequently, the various parts of the site would have been meshed together by a complicated network of tramlines, pipelines and drains.

At Cliffe, the movement of bulk raw materials, chemicals and explosives largely relied on a tram system which linked most processing buildings. Where they passed over open marshy ground, the tramlines ran along the top of low earthwork embankments, and where they entered or approached buildings they were often set within smooth concrete tram-beds (see section 6.2). The standard 24-inch narrow gauge railway track varied in material due to location. For at least part of the factory's life, rails within 24ft (7.3m) of the doors of danger buildings were made of wood or brass to remove the possibility of sparks (KHLC CKS-S/NK/A/C/1/19); elsewhere tram rails of steel and iron were used. The bogie carts that navigated the rail network were 9ft long with a wheel-base of only 1ft 11in, and wheels made of iron (Cooper-Key 1911, 6). In response to an explosion involving a bogie cart in 1911, Curtis's & Harvey introduced a linoleum lining carried up to a beaded edge all the way around their bogie carts (Cooper-Key 1911, 7). A series of vessel types were used for moving the materials within buildings and to contain chemicals and explosives for transport within bogie carts. Buckets, bags, jars, tins and carboys were designed specifically to minimise any disruption to their contents, and so resilient relatively inert materials such as acid-resistant glass, natural rubber (gutta-percha), brass and leather were preferred.

Pipes were also used in abundance for the movement of acids, steam and compressed air. A dense web of pipes would have run through and between most buildings, often carried aloft by lines of support posts. In describing the abundance of large steam pipes criss-crossing the site at RGPF Waltham Abbey, Englebach (1899a, 107) declared that '…

it requires a knowledge of their immense value to become reconciled to their exceeding ugliness!'. Steam pipes would have been particularly common because they were vital to ensuring that all factory buildings were maintained at an even regulated temperature, especially through the colder months of the year. In addition to pipes, lead-lined wooden guttering with a weighted canvas cover over any sections between roofed buildings was used to move nitroglycerine the short distances between processes.

Water was another very important component in the functioning of the factory. As well as being required in abundant quantities for processing in the acids and nitroglycerine departments, large amounts were harnessed for steam. In addition to this, the pattern of creeks and drainage dykes across the marshland offered the potential for a ready-made network of inland waterways. The narrow nature of the majority of the dykes and the frequent foot and tram crossing points identified during the survey, suggest that tramways rather than waterways were by far the main form of transport within the factory. Nevertheless, a few building remains in the south-west area of the site look like they may have once had small creek-side wharves (for example **82** and **96**), and it is known that contemporary factories like the one at Waltham Abbey made use of a narrow canal network to move some materials around site (Cocroft 2000, 119).

4.6 Import and export

As previously discussed, the initial function of the factory was as a store for gunpowder produced in Scotland. In a letter dated 19 September 1890 from Hay, Merricks & Co to the local Commissioners of Sewers (KHLC CKS-S/NK/A/C/1/19), conveyance of gunpowder from Roslin to Cliffe is described as follows:

> 'The gunpowder is made at our factory (properly so called) at Roslin nr. Edinburgh and sent by Steamer to London – being conveyed from the site to the magazines by very high class sailing barges especially licensed and engaged in no other work – the Barrels & Cases are made for the purpose and must be of a certain strength etc.'

Although Curtis's & Harvey's subsequent venture at Cliffe involved self-production of a range of explosive products and their constituents, there is no clear evidence for on-site production of nitric or sulphuric acid, both of which were required in generous quantities for the preparation of guncotton and nitroglycerine. It is likely that acids were brought to the site in carboys on barges from one or more of the numerous contemporary chemical works located along the banks of the lower Thames. Due to the need for acids of precise purity and concentration, spent acids recovered after the nitration process may have been recycled back to the originating chemical works, or collected for use by other commercial contractors, rather than being fed directly back into the acids department at the explosives factory. Mineral jelly was also acquired commercially rather than produced on-site; likewise, glycerine would also have been shipped in, having been procured as a by-product of soap and candle manufacture (Cocroft 2000, 150). Similarly, acetone used at Cliffe almost certainly came to site from production plants elsewhere, such as RGPF Waltham Abbey and, presumably, fuel to stock the various power houses was also brought into the site in large quantities by boat or wagon.

In addition to import of chemicals, raw cotton was brought in to provide the cellulose component in making guncotton. In early guncotton manufacture, cotton straight from the pods would have been utilised, but latterly use of raw, undyed and unbleached cotton waste was adopted, having the advantage of already being purified and picked-clean (Guttmann 1895, 92). Although currently unproven, it seems likely that cotton waste used at Cliffe was brought in from the Lancashire cotton mills.

After manufacture, cordite would normally be boxed and shipped to a filling factory for assembly into various types of propellant charges and rounds. At this time, it is documented that gunpowder and cordite were conveyed from RGPF Waltham Abbey to Woolwich and Purfleet in special 'powder' barges which displayed a red warning flag and could be sunk in five minutes in the event of an explosion (Fitzgerald 1895, 313; Arkas 1900, 420). No doubt similar barges were utilised at Cliffe for the movement of explosives leaving the gunpowder magazines, and latterly, leaving the chemical explosives factory. Cordite from Cliffe would probably have been shipped for testing at Woolwich or Purfleet.

Physical evidence for the shipment of substances to and from the Cliffe factory survives as the remains of four former jetties with wharves along the factory's river frontage (**J1** to **J4**). The greater cargo capacity offered by boats, along with the separation from places of habitation and the shortened routes across the Thames between Cliffe and the acid factories and testing and filling facilities along the north banks of the river, offered a more favourable option than the impracticalities of transporting sensitive cargo by road.

A letter from Curtis's & Harvey Ltd to the Upper Medway Conservancy, dated 5 April 1917, gives some insight into how some of the finished explosives were exported during the First World War (MALSC S/MN/AC27/10). The letter requests the return of 'an empty metal explosives rectangle…No. 188', which had been the receptacle used for the packing and conveyance by rail of 50lbs of gelignite supplied in July 1914. It also states that in 1917, the works were in urgent need of these containers for the carriage of explosives for naval and military requirements.

5. DESCRIPTION AND INTERPRETATION OF THE PRE-FACTORY FEATURES

Across the area of investigation, a number of the features identified pre-date the marshes' association with explosives manufacture. Some of these early features, such as the network of drainage dykes, fundamentally shaped the landscape and have played a key role in both constraining and enabling the development of the works, influencing the factory layout visible today.

5.1 Drainage features

The remains of the explosives works are not the only obvious man-made features on the site. The factory remains overlie a marshland backdrop, itself the product of a labour-intensive enterprise – primarily a medieval undertaking on the peninsula, but one subject to continual programmes of active maintenance and modification, such as the dredging of drainage dykes (see section 7.2).

Cliffe Marshes, and the vast tracts of marshland along the north fringe of the peninsula, are criss-crossed by a complex network of narrow deep-cut drainage dykes, which control water levels and create parcels of rich grazing pasture. While many of the drainage dykes follow purposeful angular lines, in stark contrast, the network also encompasses numerous natural creeks that have been adopted and enhanced as part of the water-management system. These take much more fluid meandering paths across the marsh and often flow out into the estuary, creating natural linkages between the Thames and the peninsula's inland waterways.

Comparison between various editions of the 25-inch OS map of Cliffe Marshes highlights a number of places where modern dyke-cutting or infilling have taken place. Additionally, in a few locations across the explosives works, re-cut dykes truncate 20th-century factory features and, across much of the site, modern dredging spoil created by drainage management was recorded over the top of factory remains.

A number of palaeochannels representing the former paths of natural creeks were noted winding across the marsh as shallow sinuous channels - sometimes broad, sometimes narrow, and occasionally braided. Although a number of these were recorded during the survey, they have been removed from the survey drawing so as not to be confused with the formal drainage dykes or factory drains. Prominent palaeochannels were mapped by EH's aerial photographic transcriptions of the Cliffe Marshes (Figure 22).

The fields created by the lattice of drains have been further manipulated to maximise the amount of dry pasture available for grazing. Regular low spread parallel banks were noted beneath the factory features across virtually the whole of the site, varying in prominence, width and orientation between different areas (Figure 23). Unlike plough ridges (of which they are reminiscent), the marshland ridging is another element of water-management - creating gullies alternating with higher strips of ground that stay drier for longer portions of the year, allowing better growth of grass. The presence and variability of underlying drainage ridges across the site was recorded as part of the aerial photographic survey of the area (see Figure 5.1 Dykes, palaeochannels as above).

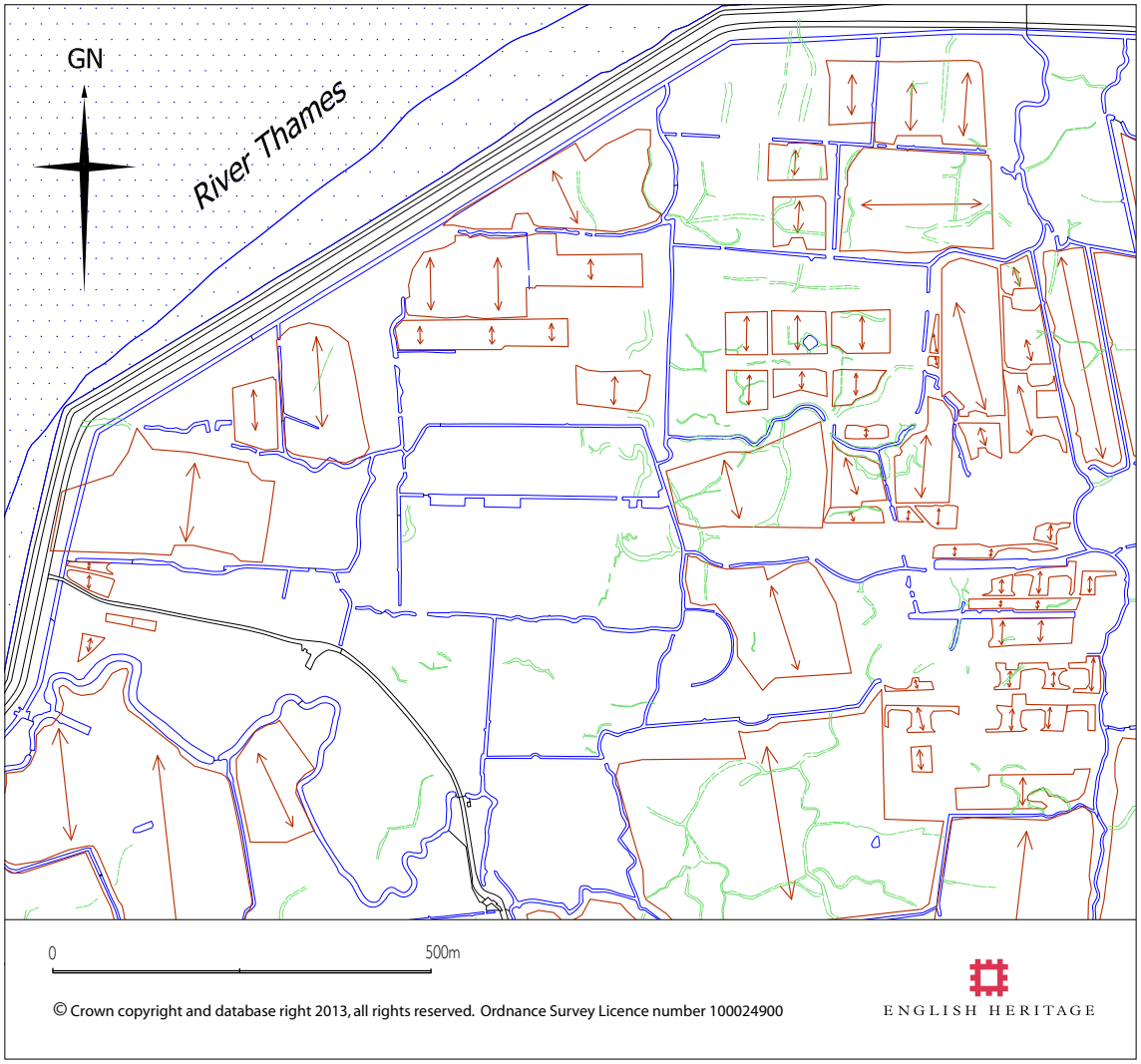


Figure 22: Adapted from an extract of mapping from air photos, showing the extensive survival of marsh drainage ridges and former natural water courses (palaeochannels). Surviving drainage ridges are shown as areas of parallel ridges outlined in red with the orientation of the ridges indicated with an arrow, and traces of palaeochannels are shown in green © English Heritage.

*Figure 23: Drainage ridges in the area north of structure **27**, showing up clearly in the snow. Photograph: Wayne Cocroft, 2010 © English Heritage.*

5.2 Ponds

Within the area of investigation there are two ponds that survive largely in the same form as they were depicted on maps pre-dating the establishment of the factory. They were probably created to provide drinking water for grazing animals.

A sub-rectangular pond, located in **Area C** at the south-west limit of the factory remains (NGR:TQ 7160 7878) is recorded on the 1st edition 25-inch OS map of the area published in 1860, but could have originated considerably earlier. Cut on a NE-SW alignment, it measures 26m x 10m and is flanked by low spread mounds of upcast spoil heaped along its two long sides. A narrow, shallow, water-filled gully connects the pond to the right-angled corner of a drainage dyke some 65m to its south-west.

A distinctive diamond-shaped pond (NGR:TQ 7248 7894), also depicted on the 1st edition 25-inch OS map published in 1860, is located close to the later remains of cordite drying stove **227** in **Area K**. The feature is roughly square in plan at the top; set at 45 degrees to grid north it appears as a diamond shape with slightly concave sides when mapped. Leading into the point of each corner is a very narrow slight gully that would drain into the pond at times when the surrounding ground was water-logged. The pond is roughly 20m in diameter, broadening to over 30m where water funnels in at the corners.

5.3 Mounds

Prior to the construction of any of the characteristic blast protection mounds that now cover the former factory site, the flat expanses of the marshland near Cliffe would have been adorned by mounds built to provide grazing stock with refuge from the water-logged ground during the wetter months, and by platforms constructed for sheepfolds or created by localised salt-workings.

In the north-east portion of the site, the regular pattern of pronounced drainage ridges thought to predate the factory overlie a low, flat-topped, sub-rectangular mound, close to the mounds of magazine structures **220** and **221** in **Area K** (NGR:TQ 72722 78947). The mound measures around 18m x 12m in plan and is crossed by the drainage ridges on a north-south alignment. The east end of the mound, and the drainage ridges that run

Figure 24: Extract from the survey showing possible saltern mound NMR TQ 77 NW 223, at the southern edge of ***Area K*** *(grid square = 100m) © English Heritage.*

Figure 25: Low circular mound with encircling gully, located in ***Area F****. Photograph: Rebecca Pullen, 2011 © English Heritage.*

up over it, are in turn truncated by a long tramway embankment running north to south alongside the north-east magazine group. This suggests that the mound is of fairly early origin in the localised sequence of land use, and may be the remnants of a medieval or post-medieval sheepfold or animal refuge mound.

The earthwork remains of a possible saltern (remains from the salt production process – *see* section 3.2) or sheepfold (NGR: TQ 72346 78217) (NMR TQ 77 NW 223) were recorded at the south edge of **Area H**. A group of irregular earthworks roughly enclose an area of 90m x 40m and comprise a low level, sub-rectangular space bracketed by a bank at the north end and a pair of angular hollows to the south (Figure 24). A similar but less coherent line of irregular mound and sub-rectangular platforms was recorded along the north edge of a drainage dyke in the east corner of **Area H**, immediately south of structure **280** (NGR: TQ 72784 78333). This complex may be the remains of another saltern or sheepfold that has been disturbed by the braided course of a palaeochannel, managed drain cutting and the nearby factory expansions.

Within a wide meander in the main drainage dyke that marks the southern edge of the area of investigation in **Area F**, there is a very low, neat circular mound surrounded by a narrow ditch, with traces of flanking scarps to the north-west and south-east of the encircling gully (NGR: TQ 71905 78338). The central mound has a diameter of about 8m, stands no more than 0.25m high and is encircled by a shallow gully 0.9m wide with a possible narrow causeway or entrance on the west side. Approximately 1.5m outside the gully, and flanking the north-west and south-east quarters of the feature, are traces of a low spread back scarp. The function and date of this feature remain uncertain; the possibility that the ditched mound had some connection either with use of the site as an explosives works, or with management of the site for agricultural purposes, has not been dismissed (Figure 25).

5.4 Sheepfolds and sheep washes

A group of dispersed scooped earthworks were noted in the area between structures **47**, **140** and **141** (NGR: TQ 71900 78640). The earthworks have been interpreted as traces of an old sheepfold or wick and its associated ponds (NMR TQ 77 NW 309), marked in this location on Russell's 1695 map of Cliffe Level (*see* sheepfold in field 'E8' in Figure 7) (KHLC CKS-S/NK/P/8A) and on subsequent 25-inch OS maps published in 1860 and 1897.

A small sheep wash (NMR TQ 77 NW 307) was recorded between structures **255** and **256** in **Area J**. The feature is a keyhole-shaped, brick-lined structure sunk into the ground so that the top row of bricks is flush with the ground surface. The circular chamber at the north end has an internal diameter of 1.7m and an external diameter of 2.3m. A narrow opening about 0.3m wide on the southern side creates an exit from the wash chamber into a 4.5m long brick-lined passage with a sloped base leading back up to ground level (Figure 26). In association with the sheep wash, a slight rectangular earthwork platform sits approximately 12m to the north-west. Comparison with the second edition 25-inch OS map published in 1897 clearly shows a structure accompanying the sheep wash in the same position as the platform. Russell's 1695 map of Cliffe Level illustrates a wick or small barn in this location within an area of marsh then known as 'Mole Wick', occupied by tenant Jonathan Ware (*see* Figure 7) (KHLC CKS-S/NK/P/8A). Although the brick sheep wash is clearly later than the wick drawn by Russell, the site may have been used for stock management for at least two centuries.

*Figure 26: (left) Remains of brick sheep wash (NMR TQ 77 NW 307) in **Area J**, with circular chamber and exit ramp in the foreground, and structure **247** in the background. Photograph: Rebecca Pullen, 2011 © English Heritage.*

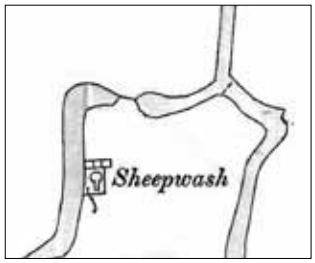


*Figure 27: (above) Extract from the 1897 2nd edition 25-inch Ordnance Survey map, Kent sheet IV.10, showing the sheep wash (NMR TQ 77 NW 310) close to the site entrance in **Area F**.*

A second almost identical small brick sheep wash was recorded close to the main factory entrance from the village (NMR TQ 77 NW 310), just west across the road from structure **162** in **Area F**. This example also consists of a low brick-lined circular chamber measuring about 1.75m across its interior (2.3m externally). Sloping gradually up and out from an opening in the south side of the chamber is a narrow 3.5m long brick-lined passage. No other directly associated features were noted. This late 19th-century feature is slightly later in origin than the previous example, and does not appear on 25-inch OS mapping until the second edition published in 1897 (Figure 27) (Ordnance Survey 1897b).

The sheep washes would have been fed by water from the adjacent creeks or drainage ditches. Sheep would be thrown in turn into the chamber which would act as a shallow bath for washing or medicating, before being released up and out along the narrow passage to dry out on clean pasture. Dipping sheep was undertaken to kill lice, to prevent disease and to wash the fleece prior to shearing.

It is plausible that, following the change in land use from pasture to industry, these features could have been incorporated into the factory complex and used as sumps or drains, though no direct evidence of this was noted during the fieldwork.

5.5 Defence and domestic structures at Lower Hope Point

All trace of the 18th-century coastal battery at Lower Hope Point, and of the Anchor and Hope public house that opened there in the wake of the battery's closure, has been erased by subsequent use of the site for construction of the domestic residence 'Hope House' and by relocation of the sea wall and associated drainage ditch in the 1980s.

Beacon base

The only extant feature thought to be roughly contemporary with the battery is the base of a navigation beacon surviving as a low, flat-topped circular earthwork, located south-east of the slightly raised track that skirts the eastern side of the plot for Hope House. It measures roughly 5m in diameter at its base, gently rising 0.3m to a flat circular top with a diameter of 3.5m. It consists of a circular concrete plinth now almost entirely covered by earth, with six 25mm-wide (1 inch) threaded iron studs protruding 0.15m from the surface in a hexagonal layout with a diameter of 1.8m (Figure 28).

The size and form of the feature, along with historic map evidence, indicates that this is the base for one of a pair of beacons set either side of the sea wall at Lower Hope Point, to assist navigation along the estuary. The superstructure for its seaward partner, 'The Point Beacon', once stood as a tall, open iron-framed erection (*see* Figure 10), but now lies prone in a degraded state on the foreshore close to its original position (*see* Figure 28). These beacons pre-date the area's association with explosives manufacture, but are likely to have remained in use during, and perhaps even following, the factory's period of operation. A 'post' is labelled on the foreshore in the position of The Point Beacon on the first edition 25-inch scale OS map published in 1860 (*see* Figure 9) (Ordnance Survey 1860a). However, the earliest identified depiction in the survey area is on a War Office chart from 1886, which shows the two beacons at Lower Hope Point partnered

with a second pair located precisely one sea mile to the south-west, on the north bank of the mouth to Cliffe Creek (TNA WO 78/4963). After this, the beacons are both clearly marked on the second edition 25-inch OS map published in 1897 (see Figure 13) (Ordnance Survey 1897a).

Figure 28: Remains of the beacon base in ***Area A*** *(left), and the collapsed superstructure of the Point Beacon on the foreshore (right). Photographs: Rebecca Pullen, 2011 © English Heritage.*

Hope House

Historic OS maps published in 1860 and 1897 and licensing information for the Anchor and Hope noted in various editions of the *Kelly's Directory* for Kent, show that between 1862 and 1895 structures relating to the battery and the pub were removed and a large domestic dwelling, 'Hope House', was constructed in their place (see Figures 11 and 13). Although it is uncertain whether Hope House was built before or during Hay, Merricks & Co's ownership of the adjacent fields, census records from 1901 state that the then nitroglycerine foreman at Cliffe, Joseph McCleak, and his family were resident at Lower Hope Point (TNA RG 13/718), probably in Hope House, suggesting that the house may have served a similar purpose when Curtis's & Harvey acquired the site in 1898.

Traces of a firm foundation platform were recorded under a thin covering of grass where Hope House once stood. The foundation extends at least 12m x 12m, and probably spreads a little further to the north and west (Figure 29). At the south end of the platform, the footings of a concrete or cement wall were recorded flush with the ground and seem to denote an entrance porch or similar; from this point traces, of a track preserved only as a vegetation mark run south to join what became the main factory road. Along the edge of the drainage ditch west of the platform are the remains of a brick drain cover and traces of concrete rubble, indicating that parts of the building's infrastructure were truncated during excavation of the new ditch line in the 1980s.

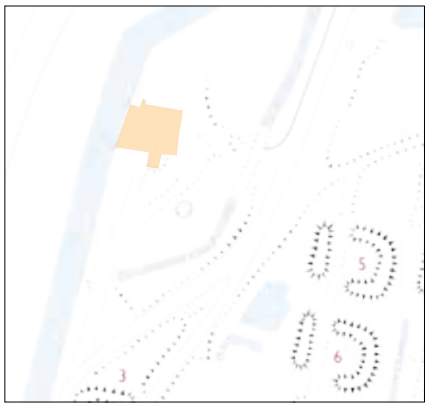


Figure 29: Extract from the survey showing the footprint left by Hope House (orange), with the circular beacon base to its south-east (not to scale) © English Heritage.

6. DESCRIPTION AND INTERPRETATION OF THE FACTORY REMAINS

The nature of the factory remains at Cliffe, in particular the continual expansion and piecemeal infilling, means ordering the descriptive text is complex. Every effort has been made to keep the order as logical as possible. Factory-wide features, such as tramway embankments and water-filled borrow-pits, are covered first, followed by numbered structure-by-structure descriptions, grouped by geographical area.

To aid orientation through the descriptions, a numbering sequence has been assigned for all identifiable discrete structures believed to belong to the factory complex: structures **1** to **284**. In addition, five linear features, or linear alignments of grouped features, have each been assigned a number to aid description and identification: linears **L1** to **L5**; as have four jetties with surviving structural elements: jetties **J1** to **J4** (Figure 30). Numbers have not been assigned to generic features such as tramway embankments, culverts and manholes, or to those features identified as having origins either pre- or post-dating the operational period of the factory; descriptions for these features are grouped under collective sub-headings. Additionally, to provide a quick reference for location and orientation, the site has also been subdivided into 11 spatial zones named areas **A** to **K** (*see* Figures 2 and 30). Areas **A** to **K** have been used to order the descriptions throughout section 6.0. Descriptions start in **Area A** in the north-west area of the site where the earliest explosives-related remains are situated; they then follow a broad geographical route, with consideration of inter-related structure groups and of the manufacturing flow lines where known, ending in **Area K** the north-east part of the site. See Volume 2 of this report where a reference table for the structure number sequence is provided in Appendix 1, and a full version of the final 1:1000 EH survey, drawing complete with structure number labels, is available as a series of A3 pull-outs in Appendix 4.

6.1 Overview of the factory complex

At first glance, the surveyed factory remains appear as a jumbled mess of donut shaped mounds and rectangular building bases, tessellated into marshland plots separated by winding drainage dykes and interconnected by a web of embanked paths. On further inspection, the change in approach to development over time becomes apparent – the older areas of the factory towards the west have grown organically and pragmatically respects the pre-existing landscape features, whereas the eastern First World War expansions of HM Cordite Factory pay little regard to the pattern of drainage, marching across the site in a rigid grid, no doubt following a pre-planned layout prepared off site.

Few buildings still stand and those that do are almost all roofless and in a degraded state. All material that could be reused was stripped away for its scrap value when the site was finally closed and auctioned in the 1920s. Little escaped this dismantling. The reinforced concrete buildings, due to the single-use nature of the material, and a handful of brick structures, are all that remain. Much of the site is characterised by features found throughout the whole factory, in particular the low embankments that formerly carried narrow-gauge tramlines for the bogie carts used to move explosives and other

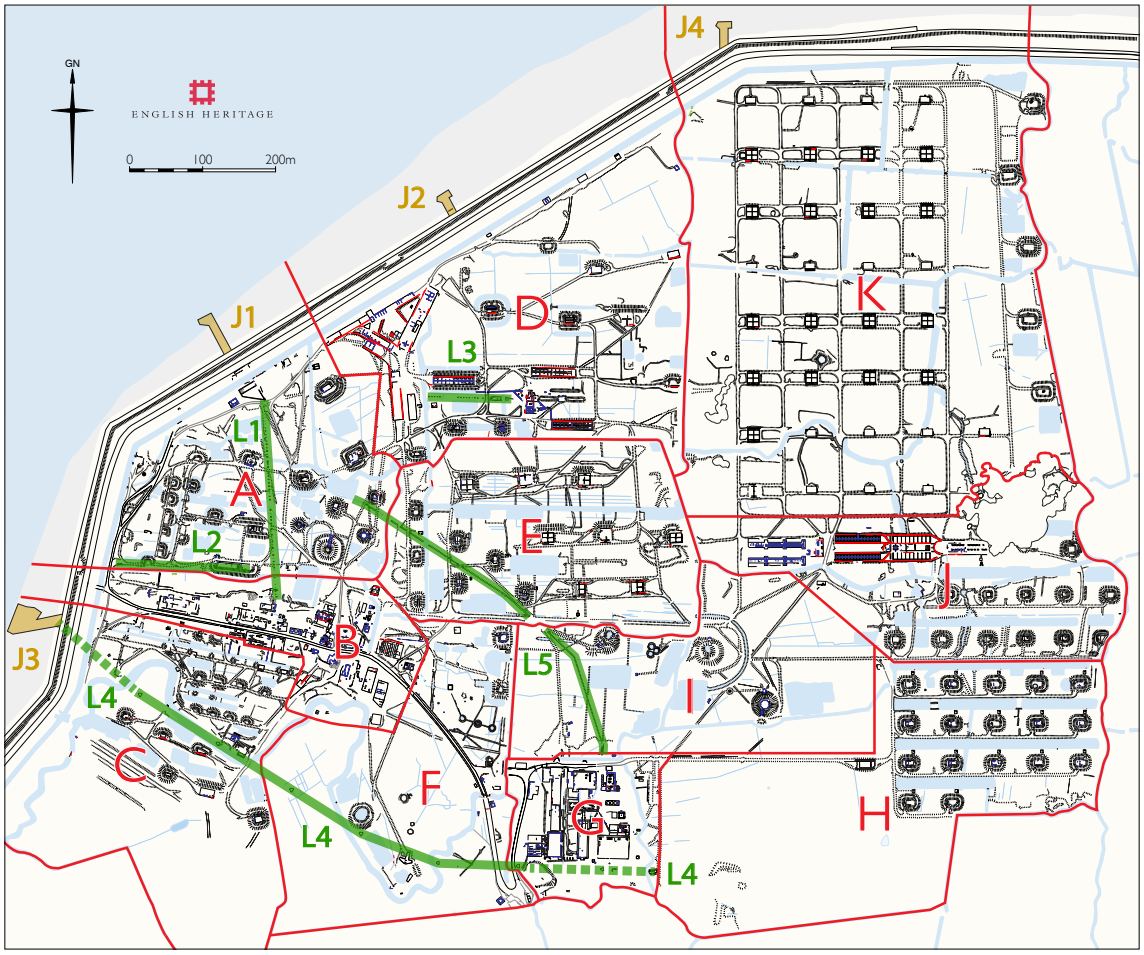


Figure 30: Location of ***Areas A*** *to* ***K****, Linears* ***L1*** *to* ***L5****, and Jetties* ***J1*** *to* ***J4*** *© English Heritage.*

materials around the site, and the neatly sculpted steep-sided earthwork traverses built to enclose the more dangerous factory buildings up to the height of their eaves. Interspersed between the factory features are large water-filled borrow-pits (pond-like features) created by extraction of earth for building the protective traverses, and the sinuous drainage dykes, of medieval or post-medieval origin, that were cut to keep the surrounding land dry enough for grazing.

The site is covered throughout by grass. A few mature trees are sparsely dotted around the site, concentrated predominantly in the central west area, and scrubby regrowth is beginning to colonise several of the earthwork traverses and some of the buildings with holes in their foundations. During the operational years of the factory, the marshland would have been far more densely covered with trees, providing a secondary line of blast protection between the various danger buildings (*see* section 8.2), and some ornamental screens along the main access road and close to the administration buildings in **Area B** (for example, structure **66** in section 6.5).

6.2 Features found factory-wide

Tramways: tram rails, tram-beds and embankments

The most consistent and coherent features are the interconnected low, narrow tramway embankments linking almost all areas and structures in the factory complex. The only building groups not served by the tramways are those predominantly associated with administrative functions or relating to the cotton preparation and acid-handling activities at the start of the manufacturing processes. Characteristically, the embankments sit 0.1-0.4m above the marshy ground: the level tops measure between 1.5-3m wide, broadening to 4-5m at the base (Figure 31). At frequent intervals, small platforms protrude from the linear earthworks roughly a metre from junctions on the tramway network. These have been interpreted as the locations of the 'tumbler' systems of points levers that were used to control the route taken by bogie carts.

Figure 31: Embanked tramway earthworks clearly visible running between buildings in the north-east corner of ***Area K****, looking south-west. Also note the blocks of marsh drainage ridges underlying the factory features, and the unusual instance of paired parallel tramways (right hand side). Extract from NMR 26892/030 08-Mar-2011, Damian Grady © English Heritage.*

In a few places, usually alongside the foundation slabs of factory buildings, sections of concrete tram-bed survive with lengths of the iron rails in situ; elsewhere, rails have largely been removed for recycling. Particularly fine survivals of the tram rails and tram-beds can be found in the north-west corner of **Area D**. Here, a smooth cambered concrete render forms a well-drained tram-bed surface, with iron rails running between buildings (Figure 32). The tramlines are the standard 24-inch narrow gauge railway track with rails set uniformly at 0.6m apart.

Sales particulars drawn up in 1923 for the auctioning of the eastern half of the factory, formerly known as HM Cordite Factory, includes sale of the tram rails (equivalent to over 8km of railway track) for scrap or reuse under Lot 122:

> 'The network of 24in Light Railway Track (20lb and 14lb rail) as laid about the factory comprising approximately 18,306 yards of 20lb rail equivalent to 9,153 yards of railway track, and 14,288 yards of 14lb rail equivalent to 7,144 yards of railway track on metal sleepers, together with 208 sets of points and 189 tumblers, also 1 turntable complete (3ft 6in by 2ft 0in)' (MALSC 06a_DE_Series_1001_1200/DE1087_3).

The two rail specifications mentioned (20lb and 14lb) probably reflect measures of strength expressed as weight per yard, and may reflect differing rail requirements for individual factory areas, or different rail styles for use over the earthen embankments compared to those set into concrete tram-beds. For stretches of tramline immediately approaching individual danger buildings, wooden or brass rails were used as an alternative to iron and steel, thus reducing the possibility of sparking causing explosions. No remnants of wooden or brass rails survive, but many danger buildings are approached by concrete tram-beds with open paired grooved where rails have been removed.

*Figure 32: (above left): Iron tram rails and cambered concrete tram-bed near structure **107**. NMR DP141545 07-Mar-2011, Steve Cole © English Heritage.*

*Figure 33: (above right): Wooden posts that formerly supported a tramway where it crossed a drainage dyke, looking north from structure **2**. NMR DP141533 07-Mar-2011, Steve Cole © English Heritage.*

To facilitate movement of materials around the site, the tramways would have had to cross the drainage dykes in several places. There are now no tramway bridges standing, but square-section wooden posts were noted protruding from the water just north of structure **2** where the tramway would once have crossed (Figure 33). The low height of the posts (flush with the banks either side of the drainage dyke) and their sturdy nature, suggest that these carried the weight of the tramline rather than a pipeline.

Changes to the layout and use of the tramlines can be seen in a few places across the site. In some places, the earlier lines of tramways are traceable as faint vegetation marks or as the slightly raised base of largely eroded embankments. In other rare places, a degree of stratigraphy is visible where later tram embankments appear to overlie or

truncate earlier routes. The seemingly uncommon practice of altering the tram routes probably reflects the nature of new development as the factory expanded over time, in that the majority of expansions were undertaken on previously undeveloped land or as upgrades to individual buildings, rather than wholesale remodelling of existing areas.

In the far north-east corner of the site the only instance of a double or paired tramway was noted. Here, two embanked tramways run side-by-side for nearly 300m in an east-west direction with a narrow linear depression marking the separation between the pair (see Figure 31). This is shown particularly clearly on historic aerial photographs from the 1940s (NMR RAF 106G_UK_1447 1073 01MAY46). The double track capacity may represent an area of regular traffic from the cordite drying stoves and magazines of **Area K** to the factory jetties for export, or a way to segregate carts travelling in opposite directions on a busy section of the network, these being carts from the magazine and from the cordite drying stoves in this area.

Borrow-pits and earth bunds

Large pond-like features, predominantly rectangular with rounded corners and often paired with adjacent mound-protected structures, are common throughout the factory remains. These straight-sided 'ponds' are waterlogged borrow-pits created by removal of the clay-rich soil to build the hefty protective banks constructed around all buildings which housed processes with the potential for accidental explosions. Generally, these pits look little more than simple extraction pits. However, the dramatic drop in the water table at drier times of the year, often highlighted by aerial photography, reveals greater complexity, often in the form of rectilinear internal divisions (Figure 34). Ground survey also underlined the frequency with which many of these features appear to tie-in with the drainage systems on site. On the other hand, these apparent patterns and associations could be the fortuitous result of a particular excavation method rather than an intentional act with a functional purpose.

On the whole, there is little variation in the basic characteristics of the numerous earth traverses recorded across the site. With a few exceptions, the majority have slightly convex steep sides with near flat or faintly domed tops, giving them a fairly rounded profile. Customarily, the protective traverses were built up to the height of the eaves of the building. Several of the mounds are still impaled with remnant iron tie-pins likely to have secured wooden or iron revetments to help maintain the shape and stability of the earthwork. In a report from July 1911, HM Chief Inspector of Explosives, Major Cooper-Key (1911, 2), states that 'there is no natural protection afforded by the ground, but the distances maintained between the various buildings are more than up to our requirements, and artificial mounds of a substantial character

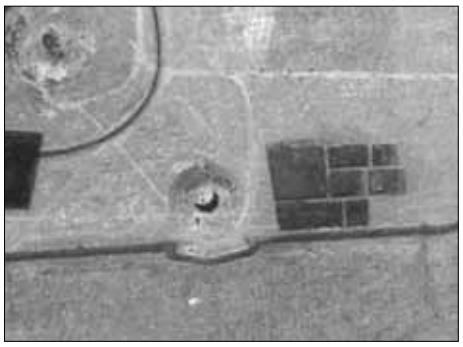


*Figure 34: Extract from an RAF vertical aerial photograph of the site taken in 1955, showing the rectangular divisions within the base of the borrow-pit east of structure **168** revealed by dry ground conditions. NMR 540 RAF.1699 0113 12-Aug-1955 © English Heritage.*

have been freely erected, -the nitro-glycerine buildings in particular being doubly protected'.

Drains, gullies, culverts, pipes and drain covers

Across the factory site, numerous stretches of narrow drainage gullies, pipe trenches and brick-lined culverts are visible, though in most cases neither their full extents, nor the features they connect, are clear. On the whole, they are visible in short stretches that would have housed pipes connecting various closely located buildings, tanks and settling ponds. In addition, there are numerous brick manholes of varying form and size across the site, suggesting that we are only seeing some of the drainage network where it survives on the surface. There may be many pipes still buried.

L5

Amongst these drainage features, **L5** is particularly worthy of mention. The narrow drainage gully can be traced continuously for just over 0.5km, crossing much of the central area of the site from the east edge of the borrow-pit north of **29** in **Area A**, to an intricate brick manhole at the southern edge of **Area I** (see Figure 30). The feature is physically overlain by each tramway embankment that it encounters, at which points it passes through low arched brick tunnel entrances, each 1m wide (Figure 35). Brick archways of the same style are also present where **L5** its path crosses with the large drainage dykes, suggesting that it formerly carried one or more pipes rather than functioning as an open drain. The length of **L5** does not appear to be brick-lined, as seen with other drains elsewhere on site; however, any easily accessible bricks may have been removed for their resale value. Absence of any clear physical link between **L5** and any of the structures that it passes leaves its specific function undisclosed. However, it is perhaps worth noting that its position could, for example, have allowed it to serve both nitroglycerine groups; perhaps as a means of providing clean water, or for removing waste water or spent acids for purifying and recycling or for save disposal. The construction phase of **L5** remains unclear; it could be one of the earliest factory developments in **Area E** with subsequent expansions in the tram network being carried over the top of the drain on brick supports or it could be contemporary with, or later than, the tramways with the brickwork having been inserted to allow the drain and tramways to collocate.

*Figure 35: Water-filled drain **L5,** with the top of the brick arches just showing either side of where they carry the drain beneath an embanked tramway, adjacent to structures **I51** and **I51a** (top right corner), looking south-east. Photograph: Rebecca Pullen, 2011 © English Heritage.*

Posts and post bases

Posts and post bases survive in varied states of repair across the site. Posts are either wooden or concrete, and post bases are mainly concrete. There were certainly once many more timber posts across the site but many have likely been lost through rot or reuse. Predominantly, posts were used to carry pipelines above ground level, but they may also have carried cables, or been used in isolation as lamp posts outside buildings where internal lighting was not permitted due to issues of safety. Posts survive to a much greater extent across the western half of the site, but we know that they were also in use on eastern areas of the site because an auction lot of '39 Concrete Pillars as standing… each approx. 10 feet high' is listed in the 1923 sales particulars for HM Cordite Factory (MALSC 06a_DE_Series_1001_1200/DE1087_3). At 10 feet (3m), these posts were particularly tall, and so may have been related to the nitroglycerine hill (**168**) which was the tallest structure in the HM Cordite complex.

Where posts or post bases exist in isolation, they have been described in conjunction with the nearest building. Where clear alignments of posts or post bases have been identified they are described below as structures **L1** to **L4**.

L1

*Figure 36: Part of concrete post alignment **L1**, meeting structure **24** (top left corner), looking north-east. Extract from NMR 26890/025 08-Mar-2011, Damian Grady © English Heritage.*

One of the most striking linear features on the site, **L1**, is a double line of square-section concrete posts seen marching across the site for around 260m between structures **24** and **38** (see Figure 30). It would have functioned as a support carrying one or more elevated pipes. The posts look a lot like modern concrete lamp posts arranged in close pairs consistently set 0.6m apart, with each pair sharing a coarse concrete foundation (Figure 36). They are made of concrete with small gravel inclusions, and appear to have been pre-formed in a single piece, regardless of height. In most cases, the posts measures 0.17m square, often but not always with the two outward-facing corners moulded to give a 2cm deep chamfer. Down the centre of each post is a single narrow, vertical iron pipe with a neatly filed top, these were probably to reinforce the post as

there are no basal entry holes to suggest that the pipes were also used to house or convey cables, gas or liquid.

Several variations in the nature of the posts exist, the most notable inconsistency being in the height of the posts. In two places **L1** seems to respect a perpendicular tramway, at these points, the posts either side of the tramway are slightly broader (0.2m square) and sit on raised and more substantial foundation blocks. Only the northern of these groups of four wider posts survives to its full height with each post being approximately 4m high, making them considerably taller than any of the surrounding posts (Figure 37). An iron bolt was also noted protruding from the more southerly pair of the four. It can logically be assumed that the broader posts in the southern group of four were also taller than the rest of the alignment. There is a third place, between structures **19** and **20**, where **L1** crosses a tramway at right angles, but here there is no discernable change in the post widths or height; possibly the tramline had gone out of use before the posts were erected. Conversely, where perpendicular drainage dykes are crossed, the post heights do not appear to be affected.

*Figure 37: Part of **L1**, showing the northern group of taller concrete posts straddling the perpendicular path of a tramway embankment, looking west. Extract from NMR DP141568 07-Mar-2011, Steve Cole © English Heritage.*

A large number of the posts have lost some or all of their concrete jackets, leaving only the iron pipe standing; several have also had their pipe cut-off at ground level. Nevertheless, due to the neatly filed nature of the complete pipes, it was possible to tell which were intact and so to calculate the full heights of many of the posts, giving an overall profile to **L1** (Figure 38). The post heights appear to create three inclined segments; each stretch begins with a post pair 2.1-2.4m high at the north end and gradually decreases in height as the line moves south until it meets one of the taller arrangements crossing a tramway, here the height is 'reset' to just over 2m before gradually reducing post-by-post again until the next tramway is encountered. South of the northernmost tramway crossing, the shorter posts have a pair of parallel lines of smooth cement along the edges of their top surface orientated perpendicular to the line of posts. In these examples, the central iron pipe is only 2.5cm (1-inch) in diameter, rather than the wider 4.5cm seen in the posts to the north. This may represent a change in pipe attachment or simply a different method of producing the posts.

*Figure 38: Part of **L1**, showing the posts at the north end aligned on a notch in the top of structure **24**, looking north. Also note the fall in post heights from north to south between structure **24** and the taller group of four posts, and again in the group of posts immediately to their south. Extract from NMR DP141606 07-Mar-2011, Steve Cole © English Heritage.*

Along two stretches of **L1**, a low, lumpy bank of earth was recorded, sometimes alongside the line of posts, and in other places surrounding the posts. It does not appear well-formed enough to constitute a former tramway or embanked path, and probably is no more than upcast created by digging holes for the post foundations. Two tall brick manholes were also recorded in close proximity to the post alignment, and a partially buried salt-glazed ceramic pipe was noted close to the north end of **L1**.

The general alignment and reach of **L1** seems to focus on structure **24** at its north end. A series of rectangular notches in the top of the walls of **24** appear to continue this alignment through the south wall of **24** before angling west by 45 degrees to convey any associated pipes and/or cables directly through the building and on towards the jetty beyond (**J1**) (*see* Figure 38). The focus of the southern end of **L1** is less clear. Although the post alignment ends just north of structure **38**, the ground in this area shows signs of disturbance where additional posts may have been removed. The linear bank of a buried pipeline with protruding iron fittings can be traced running east from this area to a point close to structure **43** and could be associated with **L1**.

The most probable explanation for structure **L1** is that it provided support for one or more elevated pipelines for moving raw material (probably liquids driven by compressed air) from the landing point at jetty **J1**, towards the acid and guncotton works in **Area B**. The inconsistent heights appear to respect intersections with tramways and could reflect the position of side branches running off to service various buildings. Alternately the height changes may reflect the limits of how far compressed air could move a material

along the pipeline. Perhaps secondary pumps were placed along the routes, or inclines were added to aid the pumps through gravity.

On the 1908 OS map, the absence of structure **24** and the presence of both of the tramlines that **L1** appears to respect would suggest that **L1** was not built until after that date. However, a feature of this nature may not have been mapped by the OS, and so we cannot be certain that its absence from the map proves that it was a later addition.

L2

A second post alignment, **L2** (similar to, but less coherent than **L1**), runs intermittently for about 175m between structure **19** and a point close to the tarmac track west of structure **10** (*see* Figure 30). Like **L1**, **L2** is thought to be part of an elevated pipeline. When in use, **L2** probably continued west to meet buildings that have since been removed by the rebuilding of the sea wall. It may also have extended east beyond **19**, possibly even to join **L1**, however, no evidence for this is visible on the ground. **L2** comprises two lines of posts, roughly 20cm apart. Unlike **L1**, the post arrangement is staggered rather than in parallel pairs, possibly because this requires less posts to cover an equivalent distance or because they were carrying a lesser load than **L1**. At the west end of **L2**, the posts are of consistent form: square-section concrete posts 17cm in diameter and each with a central iron reinforcing pipe, just as seen in **L1**, and generally stand at around 1m tall. The east end of the alignment is more varied, here the posts are set into the inside face of the earthen traverse along the south side of structure **19** and they comprise a mixture of square concrete posts and both round- and square-section wooden posts (Figure 39). A short line of four wooden posts was noted on the opposite side of the parallel drainage dyke but with no obvious relationship to **L2**.

As seen with **L1**, **L2** also uses taller posts to 'hop' over the tramway embankment west of structure **19**; in this case the posts are 3m tall and are 20cm square, compared to the posts either side which are shorter and narrower. These two posts are also distinguished from the others by displaying a thin iron hook protruding from the top of each. Although the hooks are small, they are large enough to hold a cable or to carry brackets for suspending a pipe (Figure 40).

A possible associated off-shoot to **L2** was noted running north and stopping just south of structure **12**. It is a more dispersed line of four single, square-section posts, each 17cm in diameter, positioned along the east edge of the tramway serving structures **12**, **13** and **14**. The distances between the posts are longer and less consistent than recorded elsewhere, suggesting either that a number of posts have been entirely removed, or that they are lampposts relating to the adjacent small huts, rather than an intentional alignment.

The date of construction of **L2** remains uncertain. As stated in the discussion of **L1** above, a feature of this nature may not have been mapped by the OS, and so we cannot be certain that its absence from a map proves that it had yet to be built. The posts at the east end of **L2** are set into the protective bank alongside structure **19** (*see* Figure 39); comparing the ground remains with representation of **19** on the 1908 25-inch OS map, it is clear that the building underwent a substantial remodelling extending it east and almost doubling the size of its footprint sometime after 1907 (for structure **19** *see section 6.3*).

*Figure 39: (left) East end of **L2** where posts are set into the earthen traverse of structure **19**, looking west. Photograph: Rebecca Pullen, 2010 © English Heritage.*

*Figure 40: (right) West end of **L2** showing staggered arrangement of posts, and iron hooks protruding from the top of the tallest two posts, looking west. Photograph: Rebecca Pullen, 2010 © English Heritage.*

Even with the former, shorter form of **19**, as seen on the 1908 OS map, if **L2** had been in existence then some of its posts would still have been collocated with the traverse. Erection or modification of the traverse would then have greatly disturbed any posts, but they could simply have been reinstated. Indeed, the occasional use of wooden posts could possibly represent posts reused from elsewhere on site, or quick replacements for broken concrete posts. Additionally, foundations for the posts were not visible within the traverse for structure **19**, which suggests that **L2** is most likely to predate the traverse, initial construction and later extension of the earthwork having buried the post bases.

L3

A neat alignment of eighteen small concrete blocks was recorded running for a distance of just over 100m on an east-west line roughly between structures **114** and **132** (**L3**) (see Figure 30). Almost all of the blocks are constructed of coarse concrete and set flush with the ground surface. Where they are seen in full they measure 0.85m x 0.48m in plan. In the centre of each block is a small sharply defined rectangular hole, 160mm x 110mm, aligned across the width of the block and often surrounded by a residue of bitumen (Figure 41). The concrete blocks almost certainly represent the bases for a line of upright rectangular-section posts, probably of wood rather than the reinforced concrete seen in **L1** and **L2**. Perhaps the posts supported steam pipes to heat nearby buildings; there would have been a great many runs of wooden posts carrying steam pipes when the factory was operational.

*Figure 41: (left) One of the concrete post bases that make up **L3**. Photograph: Rebecca Pullen, 2011 © English Heritage.*

*Figure 42: (below) Part of **L4** showing four of the triangular bases and the arrow-shaped slab of structure **105**, looking south. Extract from NMR 26892/004 08-Mar-2011, Damian Grady © English Heritage.*

L4

Perhaps the most distinctive alignment recorded during the survey was a broad sweep of six widely spaced six-sided polygonal concrete bases (**L4**) curving across the south-west edge of the site (see Figure 30). Shaped as equilateral triangles with corners cut-off, the coarse concrete slabs are all orientated each oriented with a long edge following a notional curvilinear line drawn between them, while the blunted points face out to the west and north-west (Figure 42). The shape and proportions of the bases are consistent, and all, bar one slightly smaller example, would sit snuggly inside an equilateral triangle with sides of 6.75m. On the surface of the slabs, three thick threaded iron studs, cut-off and bent flush with the surface, were recorded, one in each corner. Other than these iron fittings the slabs are featureless. Several aerial photographs of the site from the 1940s clearly show a seventh slab on land lost to the river since the sea wall was repositioned (see Figure 6); the location of this extra component strongly suggests the function of the **L4** alignment was closely linked to the main jetty at the western edge of the factory (**J3**). It appears to have run from this jetty to the guncotton processing area, or 'acid factory', at the southern edge of the site. They also seems to line up directly with arrow-shaped structure **105** and end at T-shaped structure **195** (see Figure 42). One possible interpretation is that the foundations supported the upright elements of an aerial ropeway for the transport of lighter, more stable, materials from the jetty (such as raw cotton waste). An alternative suggestion is that they could be the supports for an elevated pipeline, possibly to dispose of waste water into the Thames. Such a pipeline would have required intermediate supports that may have been of lighter construction.

Jetties

During the factory's operating years, at least four wooden jetties were built into the River Thames (*see* Figure 30), all of which have some physical remains still standing: jetties **J1** to **J4** (Figure 43).

Examination of RAF aerial photographs from the 1940s revealed that the surviving structures were severed at their landward end during the Second World War as a precaution against potential enemy invasion (F Small, pers comm). This disconnection from the mainland was furthered during the 1980s when the sea wall was moved inland and rebuilt as a more substantial concrete structure. Today the remains of the abandoned jetties are in varying states of disrepair. For reasons of practicality and safety, the extant wooden structures of the jetties could not be included in the survey of the factory; although these features were all assessed in 2005 as part of the North Kent RCZAS (Wessex 2006). The remains of **J1**, **J2** and **J3** were accurately transcribed using vertical aerial photographs as part of the HPHLP aerial photographic survey, but **J4** was not easily identifiable in the available photographs (*see* Figure 6).

*Figure 43: (left to right) Remains of wooden jetty structures **J2**, **J3** and **J4**; note how they are all now cut off from the shoreline. Extracts from (left to right) NMR 26892/028, 26891/044, and 2682/032 08-Mar-2011, Damian Grady © English Heritage.*

J1

The earliest of the jetties, **J1** (NMR TQ 77 NW 314) was constructed around 1892-3 by Hay, Merricks & Co to serve their new gunpowder depot. It first appears on the second edition 25-inch OS map revised in 1895, shown with a purpose-built tramway connecting it to structures **1** and **2**, Hay, Merricks & Co's original gunpowder magazines (*see* Figure 13) (Ordnance Survey 1897b). Subsequent depiction on the 1907 25-inch OS map revision shows that the jetty continued to be used after the site was acquired by Curtis's & Harvey, and that several buildings had been erected along the inside of the sea wall in this area by that time, presumably associated with loading and unloading (Ordnance Survey 1908a; 1908b). The North Kent RCZAS recorded the remains as monument 'WX19102'; a group of fifteen squared wooden piles (each about 0.3m x 0.3m in section and 0.5m-1m high), arranged in five rows that extend into the river for 30m (Wessex Archaeology 2006, 75).

J2

The second jetty to be constructed, **J2** (NMR TQ 77 NW 315), is located approximately 350m north-east of **J1**. It first appears on the 1907 25-inch OS map revision (Ordnance Survey 1908b), and was most likely erected by Curtis's & Harvey's after 1904 when that part of the site was within the agreed danger zone for proposed howitzer firing across the marsh suggesting that the area was undeveloped at that time (KHLC CKS-S/NK/A/C/1/59) (see section 3.4). The North Kent RCZAS recorded the remains as monument 'WX17746'; a steel pile and grid structure on the foreshore and the remains of a wooden jetty 40-50m long and 30m wide at the river frontage (see Figure 43). Individually, the piles measure about 0.3m x 0.3m in section and 5-6m in height, and were arranged in four rows (Wessex Archaeology 2006, 61). A coarse concrete foundation with slightly chamfered edges was noted at the foot of the sea wall by both the RCZAS and the recent EH survey and is presumably related to the jetty (NGR: TQ 71969 79145). The foundation measures 6.6m x 0.9m in plan and has three small rectangular bitumen witness marks (0.26m x 0.17m) evenly spaced along its surface.

J3

The next jetty built to serve the factory, **J3** (NMR TQ 77 NW 313), is larger than the first two, and is situated at the far western extent of the site. It was absent from the 1907 25-inch OS map revision and a description of the factory as having only two jetties in 1909 (Hodgetts 1909, 364) confirms that it was built later, although probably, given the main expansion phases of the factory, it was most probably built before 1916. The North Kent RCZAS recorded the remains as monument 'WX17744': a steel pile and grid structure on the foreshore, consisting of wooden piles and iron fittings (Wessex Archaeology 2006, 61). It is a large and fairly complex arrangement, covering an overall area of about 50m x 30m. It has a three-pronged layout: a landing stage orientated north-south forms its river frontage and, from this, three separate lengths of jetty run east towards the shoreline (see Figure 43). (see Figure 43). The two southern jetty sections are formed of three parallel rows of squared wooden piles, whereas the northern stretch is narrower and comprises only two rows of piles. The rows of piles are topped with long beams supporting a flooring of horizontal wooden planks, and the piles are fixed with diagonal crossbeams. The jetty platform stands to some 8m in height, though the southern stretch appears to be lower than the rest of the complex. Reconstruction of the full structure from historic aerial photographs shows that it was the southern arm of the jetty that provided connection to the factory.

J4

The final jetty built to serve the factory, **J4** (NMR TQ 77 NW 341) is located adjacent to the change in angle of the sea wall at the north-west corner of **Area K**. It was built as part of the large wartime factory extension known as HM Cordite Factory, which was principally constructed in 1916. **J4** is depicted on a detailed plan from 1923, associated with the auction of HM Cordite Factory (MALSC 06a_DE_Series_1001_1200/DE1087_3), in a position matching the location of the timber remains, but it is also marked incorrectly on a less detailed contemporary map showing the extent of the area for auction (MALSC 06aDE_Series_1001_1200_DE_1087_4) (Figure 44). The

accompanying sales particulars describe the jetty as timber-built and still functional in 1923. Measuring 97 feet long by 8 feet wide (29.5m x 2.4m), with a wider staithe at the far end where the river reaches 20 feet deep at high water; it was erected and maintained under a licence from the Port of London Authority, and as such was subject to annual payments (ibid).

The North Kent RCZAS recorded the remains as monument 'WX17747': a steel pile and grid structure on the foreshore, consisting of three rows of square-section wooden piles, with a 30m wide at the river frontage (*see* Figure 43). Individual piles measure 0.3m x 0.3m in section and 5m tall; additionally, two horizontal timbers and one diagonal brace remain (Wessex 2006, 61).

The remains of the timber structure are not easily identifiable on historic aerial photographs. Nevertheless, photographs taken in 1946 clearly show that, before the sea wall was moved inland in the 1980s, a branch of tramline ran directly from the corner in the tram network north-west of structure **197** and out across the external north drainage dyke to meet the jetty (NMR 397, RAF/106G/UK/1563 frame 4024; NMR 334, RAF/106G/UK/1447 frame 1073).

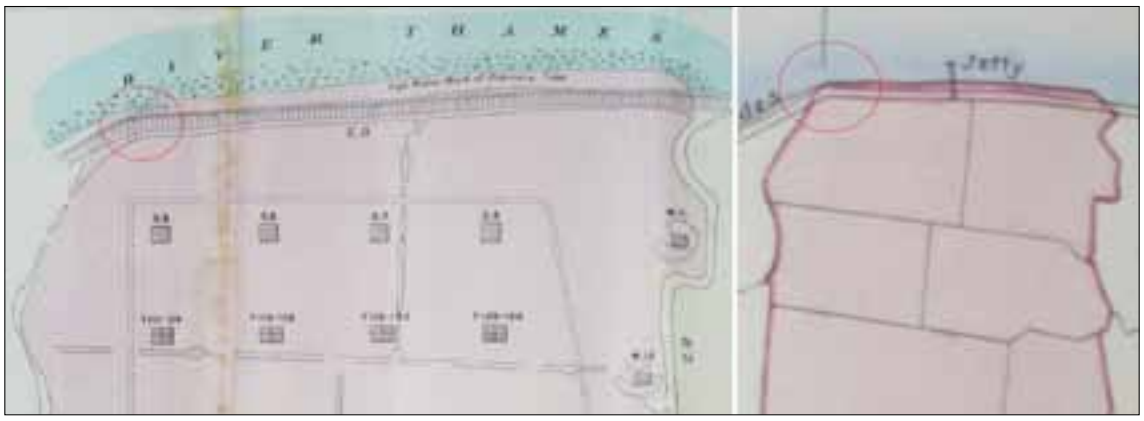


*Figure 44: Extracts from maps of the site accompanying the 1923 sales particulars for the auction of land formerly known as HM Cordite Factory, showing jetty **J4**. The map on the left shows **J4** in the correct position, whereas in the image to the right it should be marked in the position indicated by the red circle. MALSC 06a_DE_Series_1001_1200/DE1087_3 (left), and MALSC 06aDE_Series_1001_1200_DE_1087_4 (right), Medway Archives and Local Studies Centre, Strood; reproduced by kind permission.*

Residual materials

When the factory closed in the early 1920s all reusable materials - brick, tile, metal fittings, pipes, cables, corrugated iron sheets, timber and asphalt - were stripped away to sell for reuse elsewhere. Nevertheless, occasional remnants survive throughout the factory site either in situ within building remains or as pieces of surface debris.

A number of forms of hard-wearing acid-resistant 'blue' engineering bricks survive across the site, concentrated particularly in the building remains in **Areas B**, **D**, **G** and **I,** where exposure to acid and other chemicals was most likely. They are found as floor surfaces,

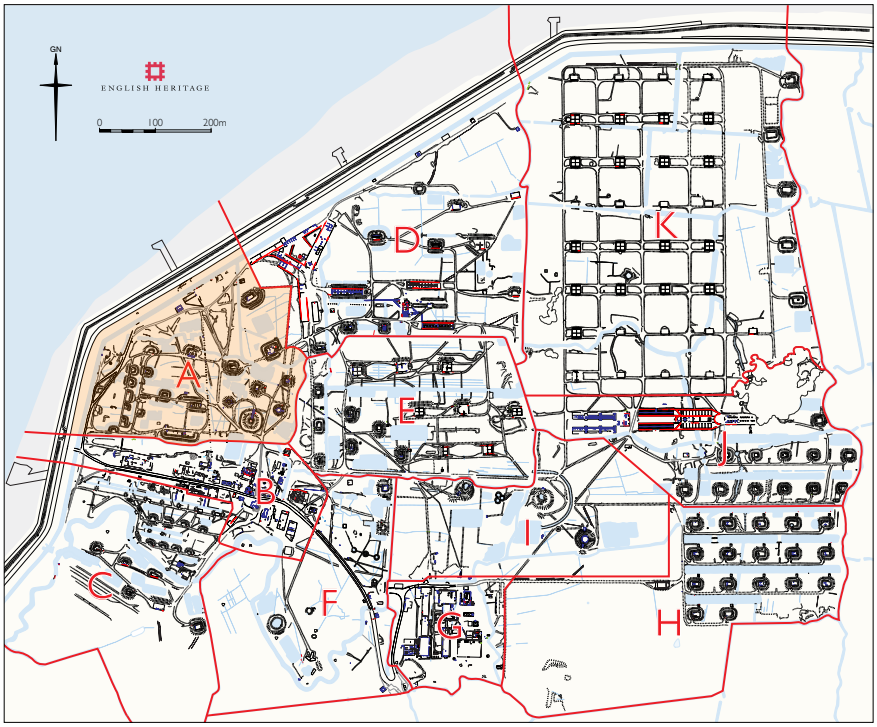
moulded integrated floor drains and as splash protection for the lower few courses of some brick plinths. These well-fired bricks come in a variety of designs: incised diamond-pattern hatching, a deep central groove to give two raised square blocks, or a plain smooth surface. Examples at Cliffe included some marked 'ATLAS' in raised lettering stamped within the frog. As well as the acid-resistant bricks there are several varieties of building bricks used for walls and machine beds, including examples stamped with makers names such as: 'RAMSAY', 'CAPEL', 'HARRIS PEARSON, STOURBRIDGE' and the London Brick Company as 'LBC PHORPRES'. Red quarry-tiled floors survive in small patches on the concrete slabs of several structures, and decorative tiles have been identified marking the thresholds to the domestic or administrative structures **46** and **66** (see section 6.5). A single fragment of ridged window glass strengthened with an integral wire mesh was also noted.

*Figure 45: Part of an earthenware acid valve found near acetone recovery house **132**, shown open (left) and then twisted 90 degrees to closed (right). NMR DP141559 and DP141560 07-Mar-2011, Steve Cole © English Heritage.*

In addition to building materials, a number of other artefacts relating to factory processes were found as loose debris across the site. These included iron brackets and fittings and ceramic insulators. A variety of distinctive moulded industrial earthenware pieces are also present. A number of sections of ceramic pipes and pipe junctions were found across the site, including wide salt-glazed pipe sections stamped 'DOULTON & CO LIMITED, LONDON, LAMBETH'. A 'Hathernware' ceramic valve, made by the Hathern Station Co Ltd, Loughborough, for use with acids was also identified next to acetone recovery house **132** (Figure 45). Industrial ceramics of this kind formed an important component in chemical plants before acid-resistant metals were developed around the start of the First World War (Cocroft 2000, 150).

There were also several glass jars and bottles contemporary with the factory's operating period, including an 'R.WHITE' brand lemonade bottle.

6.3 Area A: including the pre-war nitroglycerine factory



***Area A** shaded orange.*

This area saw more remodelling during the factory's period of operation than most other areas, particularly in the form of piecemeal infill. Comparing the surveyed remains to the 1907 25-inch OS map revision it is clear that, although the north-west corner of the site was already quite heavily developed by 1907 (see Figure 16), numerous structures and tramlines were added or modified over subsequent years.

Structures 1 and 2 - former gunpowder buildings

The earliest surviving elements relating to the site's association with explosives are structures **1** and **2**, recorded towards the north-west corner of the factory; along with tramways linking them to jetty **J1**. In the early 1890s, Hay, Merricks & Co is known to have built two structures, from an original proposal for fourteen, for the purpose of blending, packing and storage of gunpowder that had been manufactured at the firm's Roslin factory (HMSO1893, 4; Cooper-Key 1903, 3). These buildings are clearly depicted on the 1895 25-inch OS map revision (Ordnance Survey 1897a) (see Figure 13). The survey recorded earthworks and building foundations which match this depiction. Structures **1** and **2** are the surviving remains of these original gunpowder buildings, with alterations and additional tramway connections, suggesting that the early structures were subsequently encompassed into Curtis's & Harvey's new factory and adapted for use in the production of chemical explosive products.

Structures **1** and **2** are characterised by clasped opposing curved earthworks, one sitting almost inside the other, forming a protective embanked circuit with two entrances surrounding a central danger building (Figure 46). Amongst the factory remains, this particular earthwork layout is unique to the pair of early structures. Both share a

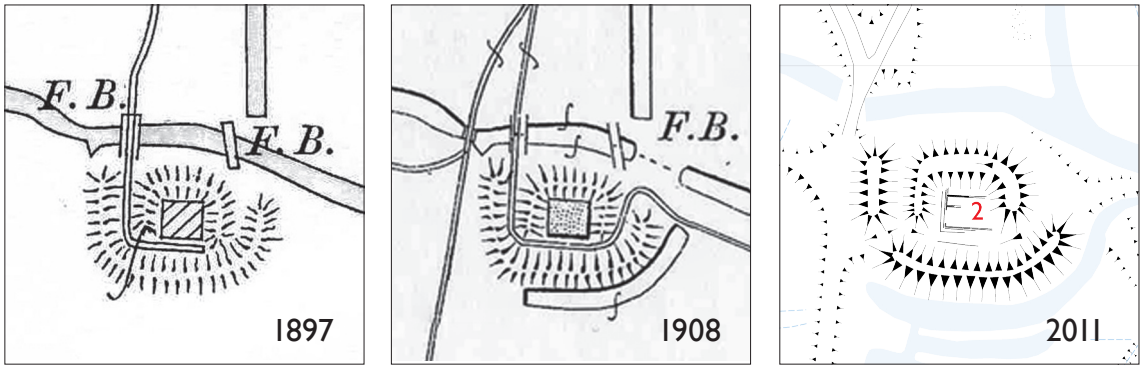


Figure 46: Structure **2** *as mapped by the Ordnance Survey (left and centre), and by English Heritage (right), showing the durability of the earthwork form, unchanged apart from where an entrance point has been broken through it in the south-west corner sometime after 1908, in contrast with the busy changing pattern of the tramways serving it, including the tramline that once crossed the drainage dyke by a wooden bridge (left: Ordnance Survey 1897a; centre: Ordnance Survey 1908a; right-hand image: © English Heritage).*

footprint of equivalent size, covering an area approximately 40m x 30m, and each of the earthwork formations surrounds a rectangular concrete building foundation served by a tramway along the southernmost edge of the building. The interior features of these two structures differ. The foundation for structure **1** comprises a simple rectangular slab, 13m x 6.6m, with remnants of a brick wall surviving up to four courses in places around its south-west end. A wide, salt-glazed ceramic pipe was noted set vertically into the concrete in the south-west corner of the floor. The foundation within structure **2** is more complicated: it appears to be punctuated by four parallel rectangular holes across its length, a construction method most likely employed to facilitate air circulation beneath and around a wooden floor. The east end of the foundation has been partially buried by gradual slumping of the earthwork embracing it. These differences could be interpreted as indicating that structure **1** was used for gunpowder blending or packing and structure **2** as a magazine for dry storage, although it should be noted that this analysis is the reverse of the labels given on the proposed layout plans (KHLC CKS-S/NK/A/C/1/19) (*see* Figure 12).

In the case of structure **2**, the later erection of additional buildings on the surrounding ground resulted in a slight remodelling of the bank in the south-west corner in order to create a third point of entry related to a re-routing of nearby tramlines (*see* Figure 46 composite survey extracts). Redundant wooden bridge supports for the earlier tramline protrude from under the water in the drainage dyke to the north (*see* Figure 33).

It is clear that these structures were adapted for reuse by Curtis's & Harvey, but the specific use to which they were put is less clear. The robust nature of their protective earthworks, and their location between the nitroglycerine factory (**30**, **31** and **32**) and the cordite processing complex in **Area D** may have made them ideal logical candidates for conversion into mixing houses for combining nitroglycerine with guncotton to create cordite paste, though this has not been proven.

Structures 3 to 14

Structures **3** to **14** form a group of structures in the north-west corner of the site roughly organised into three rows aligned north-south. They are all small simple structures, each comprising a level platform (averaging 4m x 6m in size) protected on one or more sides by an earthen mound. There are few clues to their function, but their size and simple repetitive construction might suggest that they once housed small wooden huts for packing cartridges for explosives like dynamite or Cheddites.

The 1908 25-inch OS map indicates part of the sequence of construction in this area. This shows that only about half of the buildings in this group had been erected by the time of the 1907 revision (**3**, **4** and **10** to **14**), and that many of these had smaller earthen traverses or none at all (see Figure 16). In subsequent years, structures 5-9 and a tramline to their west were inserted into this area. It is likely that the addition or enlargement of traverses to the pre-1907 buildings was undertaken at the same time as the erection of the new buildings, as a safety measure reflecting the close proximity of huts in this part of the factory.

At the western edge of the area, the tarmac track diverges to pass along either side of structure **3** before reconverging. An L-shaped earthen mound forms a protective barrier to the north and west of structure **3**. The platform belonging to the structure faces south-east onto the tarmac track which runs at an oblique angle to the mound.

South of this, structure **4** is far less coherent. It appears to face west on to the embankment of a former tramway, and has a low, poorly-formed traverse to its east and a lower, sub-circular mound, perhaps a former building platform, to the south-west, which appears to have partially collapsed across the adjacent tramway. About 35m south of **4**, at the point where the tramline meets a T-junction, traces of concrete rubble and a possible level platform indicate a third structure in this row. Comparison with the 25-inch OS map surveyed in 1908, shows that the current line of the track carried both tram and track, and that structures **3**, **4** and, as surveyed a third to their south, were in place by the 1907 survey revision date (see Figure 16). The historic map evidence shows structure **3** without a mound, and structure **4** is depicted with short straight protective mounds north and south, and a borrow-pit to its east. The contrasting evidence from the survey highlights the extent of later modifications in this area.

South-east of structure **4** sits structure **10**. It has a slightly more substantial C-shaped earthwork traverse, open to the south, where it is bounded by an embanked tramway. The level area enclosed by the mound is featureless, apart from a single concrete block with three iron studs protruding from its top and a wavy edge formed from corrugated iron shuttering; presumably this was once the base for a small machine. Structure **10** is shown on the 1907 25-inch OS map revision (see Figure 16); the borrow-pit to its rear has seen some remodelling due to the later addition of nearby tramlines and structure **9**.

Abutting the north-east corner of the traverse around structure **10** is the terminal end of a tramline running north with a row of five structures set against its eastern edge (**5** to **9**). At the southern end of this branch of tramway, structures **9**, **8** and **7** each have an L-shaped protective mound along the north and east edges, similar to that seen in

structure **10**. Structures **9** and **8** also exhibit a low narrow bank marking the southern edge of the building platform. To the north of these are a further two structures with similar platforms and concrete blocks (**6** and **5**), however each is surrounded by a C-shaped earthwork traverse enclosing the north, east and southern side and a short straight mound to the west with a space for the tramway to pass through the centre. The addition of a protective mound to the west may reflect the close proximity between these structures and the tramway to their west. As discussed above, neither the tramline serving these five structures, nor the structures themselves, had been constructed by the 1907 survey revision of the 25-inch OS map (*see* Figure 16).

At the north end of this row, the tramway curves east and passes alongside the open south side of another C-shaped traverse (**11**), again with a small internal platform approximately 3.5m x 6m in plan. A pair of small buildings without earthworks is marked in this position on the 1908 25-inch OS map (see Figure 16). It is unclear whether structure **11** replaced these, or whether it represents the larger western building and was latterly enhanced by addition of a protective mound.

Immediately south of structure **11**, and aligned north-south along the east edge of the tramway, are a further three structures of similar form and proportions to the others noted in this area (**12**, **13** and **14**). The northern most (**12**) comprises a C-shaped traverse with a 'detached' fourth side, similar in size and layout to structures **5** and **6**. The small platform enclosed by the pair of mounds was almost entirely taken up by a tank or the foundation plinth for a suspended floor (to allow air circulation beneath a wooden floor) approximately 6m x 4m in plan and marked by the top of a concrete kerb flush with the ground; the interior space is slightly lower but this is now turf-filled so the true depth was not witnessed. Traces of brick at the west end of the concrete edge suggest a possible outer brick top of the kerb. A concrete block with a wavy edge was again recorded, this time in the south-east corner. A neat, narrow C-shaped borrow-pit hugs the exterior line of the main earthwork mound. Structure **12** is clearly depicted on the map, albeit without the section of bank to the west (ibid) (see Figure 16). This extra mound was probably added as a safety measure when nearby structures **5** and **6** were built sometime after 1907.

Moving south from structure **12**, the connecting tramway is cut by a drain joining two borrow-pits before proceeding towards the remains of **13** and **14**. Structure **13** is represented by a single straight earthen mound, 16m long, with no obviously associated building foundation, though the space immediately to its south could have functioned as a small platform. To the south, structure **14** comprises an L-shaped traverse on the south and east sides of a small square featureless platform. About 35m south of **14** the tramway feeds into a T-junction; at this point, where the tramline turns east, a low level platform may mark the former location of a small structure. The 1908 25-inch OS map depicts buildings in approximately equivalent positions to structures **13**, **14** and the possible platform to their south. In the case of structure **14**, the building marked on the OS map differs from the layout suggested by the field evidence, indicating that a change in form, and possibly function, took place in the years following 1907. The map shows that there were previously three small buildings, one to the north of the mound and two smaller conjoined structures to the west, on the opposite side of the north-south tramline in this location (*see* Figure 16).

Structure 19

South-east of structure **14**, the tramway runs along the north side of structure **19**, a long east-west building foundation with an elongated C-shaped earthen mound hugging its east, south and west edges. The earthwork is 70m long and embraces a concrete platform measuring roughly 50m x 8m in plan. As discussed in section 6.2, the line of the earthwork is punctuated by the broken-off stumps of nine square-section wooden and concrete posts that make up the eastern portion of post alignment **L2** (see Figure 39), thought to have carried an elevated pipeline. It is not entirely clear whether these were set into the mound (more likely), or whether the mound was constructed around them. Towards the centre of the foundation, the remains of an internal brick wall with 3-4 courses survive alongside a patch of asphalt flooring and two small plinths or machine beds with protruding iron studs. At the west end of the building, and on the north side of the associated tramway, a small square concrete base (3.7m x 3.7m) with marks witnessing the former presence of a brick superstructure, appears to be closely related to the function of the larger building. Structure **19** is clearly depicted on the 1908 25-inch OS map (see Figure 16). However, comparison with the field evidence clearly shows that the building was extended to the east at some point in the years following 1908, probably when the nearby tramways were rerouted and structure **18** was erected. It would also appear that the enlargement of structure **19** required the route of the drainage dyke to its south to be slightly remodelled; a hint of the more direct route taken by the dyke prior to this alteration is still visible today.

Structures 15 to 18

Although the main tramway now curves north from the east end of structure **19**, another tramway embankment leads directly north from near the centre of the platform and runs for about 45m before encountering structure **18**; this tramline is shown on the 1908 25-inch OS map, whereas neither the route to its east nor structure **18** had not been built by the 1907 survey revision date (see Figure 16). The earlier tramline is cut by a narrow drain and overlain by the southern earthwork mound associated with structure **18**, suggesting that it had gone out of use by the time structure **18** was constructed. By truncating the former north-south tramline, construction of **18** also cut connections between structures **16**, **17** and **19**. The line of the old tramway is still traceable in short faint segments.

Structure **18** has a rectangular concrete foundation, 20m x 8m in plan, and slightly higher than the surrounding ground. The slab is flanked to the north and south by straight earthworks, 38-40m long and slightly off-set from one another. A concrete tram-bed runs along the north edge of the foundation on the inside edge of the north mound. Hints of internal divisions were noted across the floor, and witness marks at either end of the slab indicate that the building had a brick superstructure. At the west end of the foundation, remnants of asphalt flooring were recorded, along with the low rectangular concrete plinth of a small machine bed with an L-shaped arrangement of blue 'Atlas' acid-resistant engineering bricks set on edge in the adjacent floor.

Tucked against the external edge of the northern traverse for **18**, is the small concrete building foundation of structure **17**. The concrete slab measures 7.8m x 4.6m in plan

with rounded corners. The scars of former brick wall across its surface suggest a building 7.12m x 4m (about 23ft x 13ft), either divided into three narrow internal spaces, or with a floor supported on dwarf walls for air circulation. The south-east corner of the foundation is buried under a dump of demolition rubble. The 1908 25-inch OS map shows a pair of small buildings served by a north-south tramway and associated with a protective mound to their south (*see* Figure 16); the now missing second building may explain the demolition rubble. Truncation of the north-south tramline and construction of **18** in the years following resulted in the addition of a short curving tramway or path embankment in order to maintain access from the tram network to west end of structure **17**.

West of **17**, the paired earthworks of **15** straddle the east-west tramline between structures **13** and **18**. Structure **15** closely resembles **5**, **6** and **12**, in that it comprises a C-shaped mound opposite a short straight mound, which together enclose a small rectangular platform. Akin to structure **12**, the interior space appears to be slightly sunken. An iron-studded concrete block was recorded partially buried in the internal north edge of the mound. This, along with the slightly narrower dimensions of the platform compared to similar structures, suggests some slumping of the bank material has occurred. The 1908 25-inch OS map shows no trace of this building.

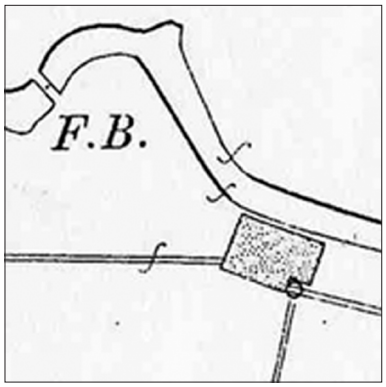


*Figure 47: Structure **16** as depicted on the 1908 OS map, showing a tramway turning circle at the south-east corner of the building (Ordnance Survey 1908b).*

Moving north from **17** is structure **16**. The abandoned line of a tramway, truncated at oblique angles by later lines, would once have linked **16** with **17** and ultimately with **19**. This was superseded by a tramway that can be seen along the southern edge of **16**. Structure **16** is defined by a rectangular concrete foundation flanked on its north and west sides by an L-shaped earthwork with a narrow dip in its surface, suggestive of a pipe entering the building from the north. The main slab measures 13.3m x 9.4m, and has a lower concrete step 1.3m wide is visible around its south and east edge, with hints of continuation on the west side. The central area of the concrete floor is severely cracked and slumps at odd angles. There are traces of brick wall scars across the surface and smooth squares of cement were recorded in the two southern corners. The outermost south edge is marked by a slightly raised narrow brick wall with three iron bolts protruding from its top. The 1908 25-inch OS map shows structure **16** as a stand-alone building with no earthwork; it also indicates that at one time the tramline went through the building or under a porch along its south edge, possibly with a turning circle marked at the tramway T-junction tucked within its south-east corner (Figure 47). The lack of protective mound and existence of integrated tramway features might suggest that

this was a large storage shed frequently accessed by carts on the tram network. Later construction of the earthwork mound appears to have interrupted the line of a drainage dyke that formerly passed close to the north side of the building.

Structures 21 and 22

Returning to the outer north-west edge of **Area A**, a rapid walkover was undertaken across the strip of land between the inside of the sea wall and the parallel drainage dyke. The partially visible remains of a few concrete platforms relating to the factory were identified (**21** and **22**), however, only short traces of concrete edges (not sufficient to provide confident dimensions for any of the foundations) were glimpsed, due to dense vegetation cover. Comparison of this area with the 1908 25-inch OS map shows that before the relocation of the sea wall and internal ditch in the 1980s, these structures formed part of a complex of buildings along the south-east bank of the ditch and were connected by tramways to jetty **J1** immediately to their east (see Figure 16). The majority of the ditch side north-east of structure **22** has been buried beneath a layer of material deposited during dredging of the drain in January 2011, monitored by Natural England (see section 7).

Structures 23 and 24

On the opposite bank of the drainage ditch to structures **21** and **22**, stand brick building **23** and concrete structure **24** (Figure 48). Structures **23** and **24** may have functioned as a pair, possibly relating to the storage, weighing and administration of materials entering and exiting the factory via the adjacent jetty, **J1**.

Structure **23** is a brick-built single-storey building, orientated NE-SW, with a double-pitched roof. The building is constructed in dark, poor quality reddish-brown bricks (possibly reused or seconds) in irregular Flemish bond, and stretcher bond to the partition walls, and appears to show evidence of a second phase of construction or remodelling. A single, off-centre partition wall along the length of the building divides the

*Figure 48: Structures **23** (left) and **24** (right), seen from the air. Extract from NMR 26892/021 08-Mar-2011, Damian Grady © English Heritage.*

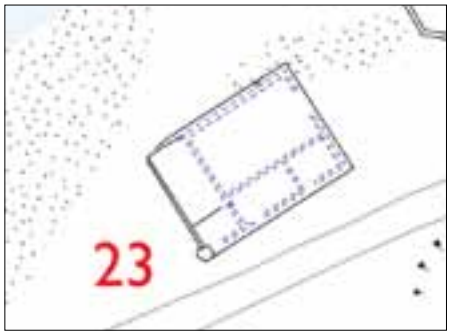


*Figure 49: Extract from the survey showing structure **23** in plan (blue dashed lines denote brick, solid black lines are concrete) © English Heritage.*

*Figure 50: The south-east and north-east elevations of structure **23**, showing the two distinct forms of door and window openings, and the remains of the lightweight roof. NMR DP141536 07-Mar-2011, Steve Cole © English Heritage.*

internal space into a wide full-length room along the north-west side; and the narrower south-east side is divided into two small rooms by a perpendicular partition wall (Figure 49). The roof is largely missing; a handful of purlins and rafters and a single piece of corrugated iron sheeting are still in situ in the south corner, and there are open notches or pockets for the timber roof structure in the top of all the partition walls (Figure 50). Like most of the standing remains on the site, the gable ends stand higher than the line of the lightweight roof that once abutted them. Impressions in the mortar show that the corrugated iron roof sheets rested on the inner leaf of the two long external walls, whereas the top of the outer leaf supported a concrete gutter. A recess or door jamb in the internal leaf of the brickwork surrounding each doorway indicates that the doors were inward-opening, and so the building is most likely to have been used for administrative purposes or for storing equipment or fairly inert materials.

Access into the large north room is through a 2m-wide wide doorway in the north-east elevation; the opening is topped with an arch constructed of two courses of headers and would probably have held a high double door. There were no windows into this room and the interior is fairly featureless. The interior brickwork remains largely exposed, only

the north wall has been rendered which might be an indication of repair work, and the top of the render bears the wavy-edged impression of the corrugated metal roof.

The smallest of the three rooms is in the east corner. An arched window with a concrete sill, and a neatly blocked arched doorway in the room's north-east wall, match the double header row arch of the adjacent door into the north room; these all appear to belong to the first phase of the building. A further door and window in the room's south-east elevation are notably different in style; these have squared openings topped by flat concrete lintels with a slight chamfer, and probably relate to a remodelling of the building associated with the blocking of the arched doorway (see Figure 50). The interior walls of this room are coated with a thick 2-7cm smooth concrete render. As well as covering all internal traces of the blocked doorway, witness marks in the render show that a rectangular window frame was set behind the arched window opening, indicating that the rendering in this room also belongs to the second phase of the building. Inside, beneath the north-east window, is a deep rectangular recess for a junction box or fuse box with a tail leading out through the south-east wall, and alongside the window are various plug marks for sockets, switch boards or similar. A single brick has been removed at a height of just over 2m (7ft) in the short partition wall to provide a conduit for cables or the like through to the west room, and witness marks were noted at approximately 1.8m above floor level for a shelf or cable run along the north-west and north-east walls.

The third room, in the west corner of **23**, has an arched door and window in the south-east elevation that match those associated with the first phase of the building. Notable inside the room is a pair of parallel horizontal recesses, each a single brick wide and deep, running around all four walls, with a gap of three brick courses between them. The lower recess is positioned approximately 1.5m above floor level. The grooves could have held wooden batons for shelves or cupboards, but they are also akin to the grooves in the walls of concrete magazines seen at St Mary's Marshes (NMR TQ 77 NE 181) for attaching timber match-lining (Newsome and Pullen 2013). Though, if this was the purpose of the grooves in structure **23**, one would expect to see more recesses spaced across the whole height of the wall. A short section of painted timber punctuated by protruding iron bolts survives in the lower recess (Figure 51). Cut-off tram rail segments protrude in a horizontal line through the north-west partition wall of the west room, six courses above the parallel recesses, possibly functioning as tie bars.

The building's concrete foundation slab extends 3m beyond the south-west end of the standing brick structure, measuring approximately 12m x 8.6m. Several indicators suggest that the building extended across this area at one time. The exposed ends of knocked-back projecting brick walls are visible at both external corners on the south-west gable end, along with the footings of where the south-east wall previously extended. Smooth cement flooring survives in a neat rectangle, suggesting that there was once a small room at in the south corner, and a larger room in the space to its rear (see Figure 49). This concrete flooring is seen in section beneath the gable end wall, but has been removed from the rest of the exposed foundation (Figure 52). It is unclear whether removal of this end of the building is contemporary with the blocking of a doorway and insertion of a new door and window into the east room, or whether it was demolished as part of the overall decommissioning of the factory buildings.

*Figure 51: (left) Recessed grooves within the west room of structure **23**, with part of a wooden baton in situ. Photograph: Wayne Cocroft, 2010 © English Heritage.*

*Figure 52: (right) The south-west corner of structure **23**, showing the basal course and exposed ends of a knocked back projecting brick wall. Photograph: Wayne Cocroft, 2010 © English Heritage.*

Structure **23** is absent from the 1908 25-inch OS map; the map shows a group of large and small buildings along either side of a tramline in this area which must have been removed after 1907 before structures **23** and **24** were constructed (see Figure 16).

Next to brick building **23** is structure **24**: a large and distinctive concrete edifice unlike anything else recorded on the factory site. Featureless narrow reinforced concrete walls, 0.4m thick x 2.2m high, mark out the trapezoidal footprint of a roofless building with no indication of ever having been covered. The concrete walls show evidence of cracking and patched repairs, and a series of notches were noted in the top of the walls, seemingly aligned with the paired posts of the elevated pipeline **L1** (see Figure 38). The internal space is divided into two large exposed bays by a single partition wall of equivalent dimensions to the external wall; the larger space is roughly triangular, with a smaller rectangular bay to its north-west. Both internal spaces have a featureless concrete floor, now largely under grass, and a large 6-7m-wide opening for access at the north-east end (see Figure 48). Traces of a concrete yard were recorded beneath the grass in front of these entrances.

Comparison of the surveyed remains with the aerial photographic transcription of the site and with the 1:2500 scale OS map published in 1961, show that before the sea wall was rebuilt further inland, structure **24** was much larger with four equally sized rectangular bays on the north-west side, rather than just one (Figure 53). The vague

traces of a concrete foundation recorded as structure **22** on the other side of the dyke were almost certainly part of **24** before the building was truncated by the realignment.

Neither structure **23** or **24** is shown on the 1907 25-inch OS map revision, but the point where **L1** now meets the concrete of structure **24** is labelled 'W.M.', denoting a weighing machine (or water main, but more likely the former in this case) (Oliver 1993, 183), on the corner of a tramline, presumably relating to goods entering or exiting the site by way of the nearby jetty **J1**. Just west of this position, the map shows a group of large and small buildings along either side of a tramline which must have been removed after 1907 before structures **23** and **24** were constructed (see Figure 16).

Based on its layout and internal features, structure **23** could be interpreted as a pair of small offices with a larger store room, weigh room or workshop adjoining, and may have related to the checking and recording of materials coming in and out of the site via the adjacent jetty (**J1**). Likewise, the form of structure **24** seems most reminiscent of a series of large storage bays and could have been used as a holding space for material entering the factory at the jetty, such as bales of raw cotton or carboys of acid. Together, structure **23** and **24** could have replaced the possible storage units and weighing machine identified on the 1908 25-inch OS map.

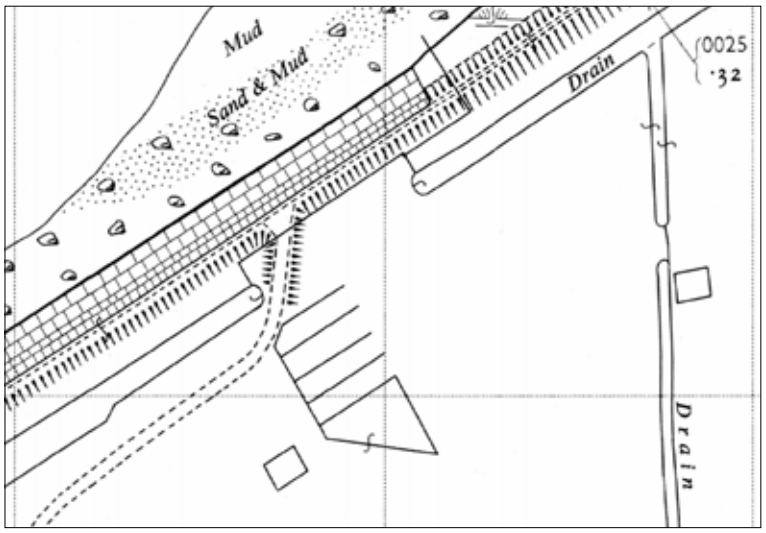


*Figure 53: Structures **23** and **24** as depicted on the 1961 OS map, showing the full extent of structure **24** before its north-west three bays were destroyed (Ordnance Survey 1961).*

Structure 25

A short distance north-east are the remains of structure **25**; a small rectangular concrete building foundation, 10m x 9m in plan. Standing 0.3m proud of the floor in the western corner is a distinctive, raised ring-shaped tank (2.9m external diameter, 1.5m internal diameter) with a rectangular concrete plinth adjoining its south side and a section of salt-glazed ceramic pipe exiting from its base on the north side. Although the structure appears to be closely related to the drainage dyke along with the sea wall immediately to its north, this relationship is potentially misleading because the dyke was realigned to this position in the 1980s. This building is absent from the 1908 25-inch OS map, and at that time there was a tramline located in the position now adopted by the drainage dyke (see Figure 16). The function of structure **25** remains unclear.

Structure 26

Structure **26** appears to be the remains of a large conjoined pair of deep concrete tanks, located against the east bank of a drainage dyke, east of structure **25**. On three sides the tanks stand to a height of 0.23m, but along the northern edge, earth has been mounded up so that the ground rises to meet the top of the concrete. Internally, they have been faced with a cement render, and each measures approximately 6.2m x 2.8m, and is at least 1.2m deep. At the west end, the main tanks are adjoined by two smaller concrete boxes linked by a scrap of surviving concrete surface flush with the top of all four (Figure 54). No suggestion for a former superstructure is evident. The concrete construction may have related to water management; and absence from the 1908 25-inch OS map confirms that structure **26** was built during or after 1907.

*Figure 54: Structures **26**, looking south-west. NMR DP141566 07-Mar-2011, Steve Cole © English Heritage.*

Western nitroglycerine factory, structures 30 to 32

In the south-east corner of **Area A** is structure **31**, a large sub-circular earthen mound standing to twice the height of most other traverses nearby, and with a distinctive stepped profile which is unique amongst the factory remains at Cliffe (Figure 55). The interior of the mound formerly housed a nitroglycerine nitrating house, in this case one equipped with a nitrator-separator, since we know that the separate nitrating and separating tanks in structure **31** were replaced by a nitrator-separator in 1904 (Explosives Inspectorate 1905, 59). Flanking the nitroglycerine hill are the smaller circular mounds of two further buildings relating to the nitration process: structures **30** and **32**. These are thought to be wash houses where the newly prepared nitroglycerine was washed to remove any unwanted residues and then filtered to remove any remnant water (*see* section 4.2). The well-formed earthworks of the wash houses sit at 45 degrees to the entrance of nitroglycerine hill **31** (**30** to the north-west and **32** to the north-east), each spaced as little as 20m away from the larger mound between them. This group is located in the same position as the earliest nitroglycerine factory at Cliffe built around 1901, but it has been remodelled and rebuilt on more than one occasion since then, due to damage caused by accidents in 1904 (Cooper-Key 1904; HMSO 1905, 59) and 1911 (Cooper-Key 1911), and perhaps also as a result of tightening safety regulations.

*Figure 55: Structures **30**, **29**, **32** and **31** (clockwise from top) from the air, looking north-west. Extract from NMR 26890/030 08-Mar-2011, Damian Grady © English Heritage.*

Structure 31: nitroglycerine hill

The substantial earthwork of structure **31** has an overall diameter of 45m, and a sub-circular footprint created by a roughly square earthen traverse softened by broad rounded corners. In profile the traverse comprises a broad flat-topped basal earthwork bank circuit, 1.4m tall, topped by a second earthen bank circuit with a smaller diameter of 30m, bringing the overall mound height to about 3.2m and creating a mid-height level terrace all the way round the exterior (see Figure 55). The stepped traverse is interrupted on its north side by a single entrance to a long brick gallery that leads through the earthwork into a central open space that would once have contained a lightweight 2-storey building. The internal space is relatively small owing to a degree of bank subsidence; even taking this into account, the building that once stood within the protective embrace of the mound is unlikely to have had a footprint exceeding 9m in any direction. A neat narrow depression in the top of the traverse at its south side suggests a former point of access for a pipe serving the upper floor of the building within.

The entrance on the north side consists of an elongated roofless passage, 11m long, flanked by high brick revetting walls that increase in height in a series of steps roughly matching the profile of the mound (Figure 56), ending in a vaulted tunnel which opens into the interior. The flanking walls have an angled face on their external north end, and ascend in three distinct steps from the outside of the mound to a maximum height about 1m above the top of the traverse, before stepping down once on the south side to the top of the vaulted tunnel. Encased within a rectangular elevation, the vaulted brickwork

*Figure 56: Structure **31**, looking south-west. NMR DP141523 07-Mar-2011, Steve Cole © English Heritage.*

comprises an arch of four concentric header rows - a sturdy construction which could have supported additional weight if necessary. There is also some suggestion in the brickwork above the tunnel that there may have been a structure over the entrance at one time (Figure 57). One possible explanation for this robust vault is contained within the official accident report for an explosion involving the early nitroglycerine mound in 1904. This informs us that the glycerine tank was supplied by means of a bogie cart and windlass (Cooper-Key 1904, 4), that being a lift operated by a winding mechanism, instead of using a pipeline and compressed air. Historic photographs of contemporary sites show that cart lifts were sometimes located in front of the main entrance through the traverse; in these cases, carts were raised from the tramway and then moved inside on rails fixed above the entrance.

Nitroglycerine hill **31** is surrounded on all sides by the embanked courses of tramways and paths (*see* Figure 55). Leading directly to or from the north entrance of **31**, the broad sweep of a tramway connects this building to the nearby circular nitroglycerine wash house **30**. Also apparently serving the entrance of **31**, a short straight embankment, thought to be a pathway, leads across to another tramline to the east. A series of narrow drains or gullies were noted criss-crossing this area along with a handful of small brick manholes.

Structure **31** is clearly depicted on the 1908 25-inch OS map as a fairly large rectangular building surrounded by a sub-rectangular earthwork mound with an access corridor on the north side (Figure 58). Although largely consistent with its present form, the OS mapping differs in that the depicted earthwork has a much smaller footprint and does not appear to be stepped in construction, though this could just be the depiction style rather than an earlier form of the mound. However, it is most likely that the difference in mound size is because the map shows an earlier form of the nitroglycerine hill – a major accident in 1911 almost certainly resulted in repairs and new regulations which will have led to the form seen today (Cooper-Key 1911). Additionally, the OS map illustrates **31** in isolation with no directly associated tramlines, perhaps suggesting that acids,

*Figure 57: (far left) Entrance to the access tunnel inside nitroglycerine hill **31**, with possible evidence for a structure on top of the brick arch. Photograph: Rebecca Pullen, 2011 © English Heritage.*

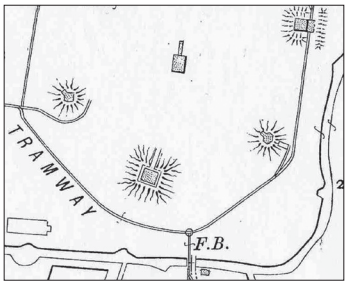


*Figure 58: (left) Structures **28**, **32**, **31**, **30** and **29** (clockwise from top right) as shown on the 1908 OS map (Ordnance Survey 1908b).*

glycerine and guncotton were brought to the building by hand or by pipe at that time. The brief description of an accident occurring in this building in 1910 indicates that the nitroglycerine house was served by steam pipes that approached structure **31** in wooden casings (Explosives Inspectorate 1911, 118).

Structures 30 and 32: nitroglycerine wash houses

Flanking the nitroglycerine hill are the remains of two circular wash houses **30** and **32** (see Figure 55). The two structures share several traits: both measure about 22m in overall diameter and their well-formed steep-sided mounds both stand to a height of 2.2m. Encased within each mound is a roofless circular brick revetment with a short narrow brick-lined approach and an arched entry tunnel accessed from the east (Figure 59). Internally, the brick walling stands to a full height of 3.5m, which protrudes approximately 1.4m above the top of the earthwork. At present, the remains of structure **30** are in a poor state of repair when compared with those of structure **32**; apart from the brick entranceway and about a quarter-arc of the circular brick structure, the walls of **30** have largely collapsed into the centre and without the revetting brick walls, parts of the inner face of the earthwork have also slumped. The circular revetments of **30** and **32** are very similar in construction, each has brick walls in English bond topped by a projecting course of headers under a flush header row. In the case of structure **30** only, this is then capped

*Figure 59: Structure **32**, looking west. NMR DP141519 07-Mar-2011, Steve Cole © English Heritage.*

*Figure 60: The interior face of the revetment wall belonging to structure **30**, showing the wall cavity and the mid-height line of joist sockets. Photograph: Rebecca Pullen, 2011 © English Heritage.*

by a render-covered chamfered top concealing two further courses. The walls are 0.8m thick, constructed of two brick faces separated by a central void, seen in section where walling for structure **30** has partially collapsed (Figure 60). Internally, at a height roughly equivalent with the top of the earthwork, a row of joist pockets for the suspension of a wooden floor for a second storey are clearly visible in the brickwork of both **30** and **32**. It is likely that a free-standing timber 'roundhouse' would have stood within the circular brick walls, with a narrow gap left between the two for access and to allow light into the building, much like those recorded at RGPF Waltham Abbey (*see* Foreman 2001).

Where **30** and **32** visibly differ is in their entrance features. The brick entrance to structure **30** is a tall and robust construction comprising a wide arched opening 1.75m across and 2m tall. The circular walling continues above the arch to match the rest of the structure, but with an intermediate pair of stepped back rows above the arch on the external face (Figure 61, and *see* Figure 59). Either side of the arch, the approach is protected by angled brick flanking walls that extend for around 3m and reduce in height from the top of the circular brick wall towards the foot of the traverse, forming a revetment for the break in the earthwork. On the interior face of the entrance, the mark of a shallow double-pitched roofline abutting the brick is visible as a render line, suggesting that an internal porch or covered passage would once have led into the timber roundhouse. In contrast, the entrance to structure **32** appears less robust. The doorway is of similar dimensions, but in this case the angled flanking walls stop at the same height as the doorway arch and the upper courses of the circular tower continue unaffected above the arch. In addition to these variations, structure **32** shows clear traces of a previous entrance on its west side, now blocked by earth, suggesting that either the current eastern entrance is a later alteration or that a pair of entrances once co-existed. Just visible above the earth now mounded across the former entrance are the upper courses of a narrow vaulted brick tunnel, 3.3m tall, with a rectangular exterior profile (Figure 62); the arch and neat blocking brickwork are also visible in the interior face of the tower. Evidence for an equivalent blocked doorway round the west side of structure **30** is less conclusive, and any really ephemeral traces in the traverse slopes may have been masked during the survey as this area was then under a light covering of snow. There are possible hints of the top of an angled flanking wall under the grassy top

*Figure 61: (left) The external face of the entrance to structure **30** on the east side of the earthwork. Photograph: Rebecca Pullen, 2011 © English Heritage.*

*Figure 62: (right) Structure **32** showing the blocked entrance within the west side of the earthwork. Photograph: Rebecca Pullen, 2011 © English Heritage.*

of the traverse; the lower courses of brickwork on the opposite side look like they may have been disturbed, and depiction of this building in the 1907 25-inch OS map revision suggests there once may have been an opening on this side (see Figure 58). No traces of a former tram or path embankment could be found in front of either of the blocked entry points, but that does not rule out use by foot or for pipes or guttering.

The main wide entrances to **30** and **32** are both served by tramways; each has a dedicated short branch curving off from a main tramway that passes close by the east side of the mound. Several embanked tramways and paths were recorded in this area; the physical link between structure **30** and the nitroglycerine hill **31** is clear in the form of a looped tramway, but the connection between **31** and **32** is not so immediately tangible.

Structure **30** and **32** both appear in association with nitroglycerine mound **31** on the 1908 25-inch OS map, and at this point in time both are shown with a short entrance porch or tunnel on the north-west side. In addition, structure **32** is depicted with a small building or shed between the mound and the tramway branch, in the position of the present entrance through its east side (see Figure 58).

Structures 29 and 29a

North of the nitroglycerine hill is a very tidy rectangular traverse (see Figure 55): structure **29** was served by a tramway branch entering through a narrow opening in the south-east corner of the earthwork. The mound encloses a concrete building foundation, 10m x 6.2m in plan, with space for the tramline to terminate just outside its southern end. The floor is clearly divided into two portions by the remnants of a narrow brick wall with a central doorway.

Outside the earthwork, reached by a short path branching off from the north side of the tramway serving **29**, is a concrete foundation measuring 5m x 3m in plan, and standing 0.15m proud of the ground surface (**29a**). Standing atop the southern end of the foundation, adjacent to a distinct dip in the earthwork traverse surrounding **29**, is a small rectangular concrete plinth, 0.3m high and topped with iron studs. Structure **29a** is comparable to equivalent structures recorded elsewhere across the site (**149a-152a** and **267a-283a**), and as such it probably represents the foundation of a fan shed for the generation of hot air to dry materials stored or processed inside structure **29**. The internal divisions on the foundation for **29** are reminiscent of the 'dirty' and 'clean' areas clearly defined in many danger buildings. Combined with the presence of fan shed **29a**, this suggests that **29** was a drying stove. Nonetheless, in this location one might more readily expect it to be some sort of settling house associated with the neighbouring nitroglycerine group.

The 1908 25-inch OS map depicts structure **29** as an isolated building with a narrow ancillary structure at its north end; the mapping shows no earthwork, no fan shed and no tramline connection at this time (*see* Figure 58). It is possible that originally structure **29** was only accessed by foot, that it initially had an alternative function, or that it had only recently been constructed at the time of the survey revision (1907) and had yet to be incorporated into the operation of the factory.

Structure 28

Located north along the tramway from **32**, structure **28** comprises a straight stretch of earthwork built up to the east, and on the west side a C-shaped earthwork enclosing a small building foundation with a porch or tramway terminal at its southern end. The main concrete foundation measures around 5m x 6m and is dominated by three parallel rectangular recesses indicating the remains of a foundation plinth for a suspended floor used encourage a dry atmosphere within the building. A single row of brick survives in places around the periphery of the slab and on top of the concrete floor divisions. Structure **28** is clearly depicted on the 1908 25-inch OS map, which appears to illustrate that where the tramline ran between the two earth bunds, it once passed through an ancillary structure, or was at least covered by a shelter. It also shows that **28** was, at that time, directly connected to structure **2** by a tramline that has since been removed and replaced by a borrow-pit (*see* Figure 16). The embanked tramways and paths to the west and south of **28** show a good deal of stratigraphy: **28** and the tramway serving it appear to sit on top of earlier routes, and the line of drain **L5** is culverted underneath two tramways but truncates a central raised path. The area as depicted on the 1908 25-inch OS map seems to suggest a different phasing: structure **28** and the tramline bisecting it are clearly in place by 1908, but the other tramlines now seen to the west and south of the traverse do not appear to have been constructed. Alternatively, if the tramway west of the mound was obsolete by 1907 it may not have been mapped, and could therefore still be earlier. The precise function of **28** is unclear, but it is likely to represent the position of a nitroglycerine processing building, possibly relating to the washing, filtering and settling processes.

Structure 27

Directly north-west across the drainage dyke from **28** is structure **27**, the largest of the single-storey, rectangular mounded structures on site, and with a traverse arrangement not directly repeated elsewhere amongst the factory remains. The traverse comprises two earthworks: a straight section along the south-east side and a roughly C-shaped mound with a short projection inwards at the east corner (Figure 63). The earthwork lessens in height and projects slightly at the north corner; the purpose of this is unclear and could be due to general slippage. Inside are two building foundations and a smooth concrete tramway that runs beside the south-east edge of the buildings foundations, and which enters and exits the space through narrow gaps between the two protective mounds. The internal space is divided between the grass-covered floors of adjacent buildings: a larger rectangular concrete foundation with remnants of internal and external brick walls revealing narrow internal doorways and wider external ones, and to its north-east, the trace of a small square platform with a central 0.65m high brick plinth. The 1908 25-inch OS map shows only a small isolated building with no bund and no tramline connections in the position of the smaller foundation slab (*see* Figure 16). The unusual form of the earthworks and a slightly raised area of ground between the two foundations, could hint at a former arrangement where a less substantial traverse snuggly enclosed the smaller building prior to construction of its larger partner. Overall, structure **27** is located in a well-connected position, with easy tramways routes from here to a large number of different factory processing areas, and as such, may have performed a function necessary for several different aspects of explosives production. One possible interpretation is that this was a mixing house, where nitroglycerine could have been combined with guncotton, kieselguhr or a blend of saltpetre and woodmeal to make various blasting explosives. Although a building would only ever be used for mixing with one of these material types, separate mixing houses would be provided for production of each explosive compound.

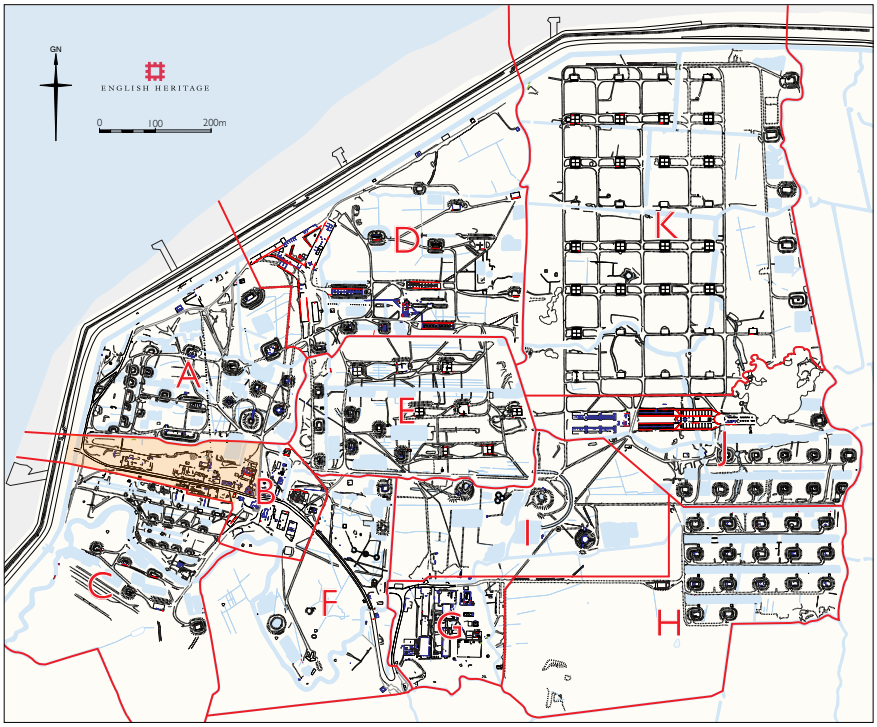
Figure 63: Structure **27** *seen from the air, looking south. NMR 26890/041 08-Mar-2011, Damian Grady © English Heritage.*

Structure 20

Moving south-west of the nitroglycerine complex, structure **20** is a small rectangular concrete foundation slab, 12.6m x 6.8m, with a small square projection at the east end, possibly for an entrance porch. The slab is raised slightly to form a platform about 0.2m high. Thin iron studs protrude from the floor at the east and west ends, and a smooth concrete floor pad is exposed near the east end. It was once served by a tramway running along its north side from the east; this embanked feature appears to turn and

terminate alongside the west end of the building, and the narrower line of an embanked path continues west from this point, having either abutted or been truncated by the turn in the tramway. The 1908 25-inch OS map shows a feature of similar shape to the building foundation in the place where structure **20** is now found (see Figure 16). The mapped feature is depicted as unshaded which would usually indicate presence of a water-filled feature. However, the map depiction does not include a brace symbol (~), which is seen on all the other mapped water features, to indicate that the spaces connected by the brace are included in the same land parcel (Oliver 1991, 111). This, along with the clear resemblance to the building shape of **20**, suggest that the lack of shading is an accidental omission. The function of this building is uncertain, but lack of an earthen traverse and close proximity to the nitroglycerine factory could suggest the presence of an acid or glycerine store.

6.4 Area B: acid-handling, guncotton preparation and utilities



***Area B**, zone of acid-handling, guncotton preparation and utilities shaded orange.*

Moving south across the drainage dyke from **Area A**, the first factory remains encountered take on a different character: the building slabs are much larger, with more surface features and the structures are densely packed, without any protective earthen traverses. The western portion of **Area B** is dominated by a complex of concrete building foundations, often including a dense pattern of plinths and tanks, laid out in a linear arrangement along both sides of the main east-west section of the kerbed road (Figure 64). Individual building functions in this area are difficult to deduce but, overall, the structures were almost certainly engaged in handling acids and producing guncotton, and would have included several buildings dedicated to generating energy. Comparison of the survey results with the 1908 25-inch OS map (see Figure 16) shows that **Area B** was already in use and largely developed, but that it saw a great deal of change in the following years of factory operation. A contemporary photograph of the factory taken

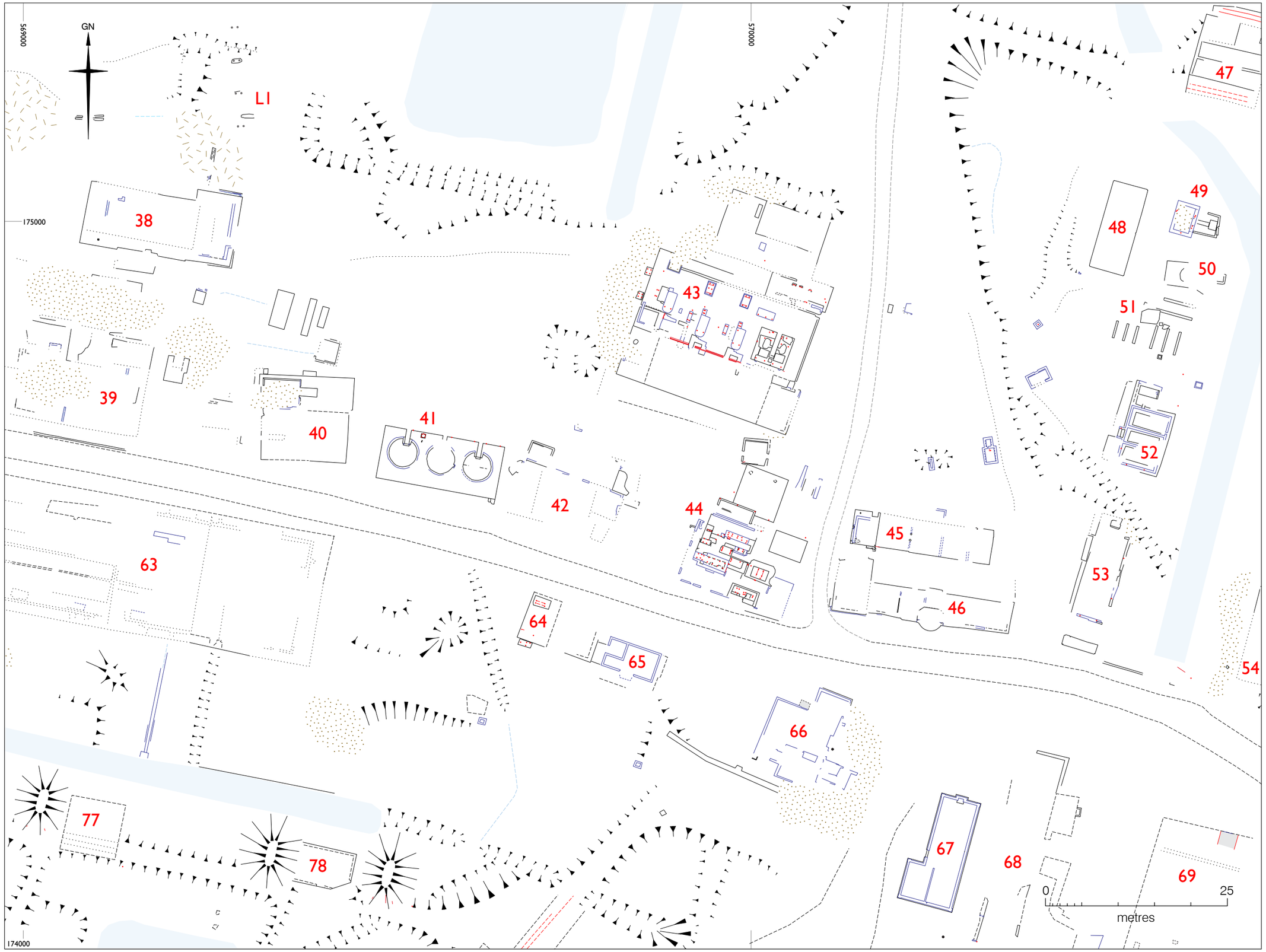


*Figure 64: The central zone of **Area B**. Drawn by Philip Sinton © English Heritage.*

about 1908, appears to show this area viewed from the south-west as it would have looked when mapped by the OS, but before the area was redeveloped and expanded to the form seen in the field evidence (see Figure 5). In several places, neat heaps of large building rubble now indicate a number of demolished structures; the size of the masonry and neatness of the piles suggest clearance by machine.

Structures 33 and 34: rifle range

Starting from the west end and on the north side of the road, the first features encountered are a deep L-shaped ditch and an open, angular, arcing concrete foundation (**33**). The concrete foundation is a wall footing measuring 1.12m wide and 11m in length. The open or concave face of the feature faces east, with evidence for a brick wall 0.75m wide along the top and a small projection in the centre of the west face, suggestive of a small buttress or support wall. A low spread bank runs perpendicular from the centre of the east face of the wall for a distance of about 11m.

Feature **33** is labelled as a 'Target' which, along with a pair of small square rifle rests or markers set '70 Yds' to the east, is described as a 'Rifle Range' on the 1908 25-inch OS map (Figure 65). In 1907, Albert Dodd, one of the 'markers' working on the testing range, was accidentally shot and killed during experiments to test cordite service cartridges produced at the factory (*Gloucester Citizen* 1907).

Structure **34** is a concrete surface measuring 9m x 3.5m, the eastern third of which is slightly lower than the rest and edged by a single course of bricks. Towards the north edge a low concrete plinth, trapezoidal in section, stands to a height of 0.2m. The centre of **34** is positioned 64m (70 yards) east of **33**, in the same position as the two markers shown on the 1908 OS map. Although **34** does not directly resemble the map depiction, one possible interpretation for the low plinth could be that it is was a rifle rest.

It is likely that the rifle range had gone out of use by the time structures **35** and **36** were more or less overlapping the field of fire. A rectangular building in a near complete earthwork traverse is depicted in close proximity to the rifle range on the OS map, with the base of the earthwork's north edge shown as encroaching on the target itself (see Figure 65). No trace of this mound or the building it encircled remain largely due to the imposition of buildings **35** and **36**, but from the map evidence, the L-shaped ditch to the west of the target can be interpreted as the borrow-pit for this missing danger building, rather than as a feature related to the neighbouring rifle range.

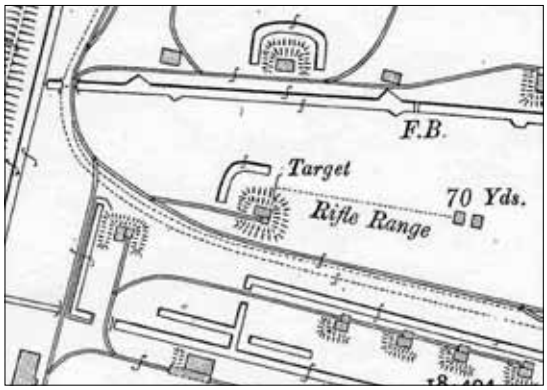


*Figure 65: The rifle range and target relating to structures **33** and **34**, as shown on the 1908 OS map (Ordnance Survey 1908a).*

Several additional factory features survive in the area north of the rifle range, including the intermittent line of a tramway or track running east-west, a short alignment of four wooden posts along the edge of the drainage dyke, and a square-section, cement-faced, brick-lined open drain, 0.65m wide, running north into the dyke and containing ceramic debris suggesting that it previously carried a paired pipe arrangement.

Structures 35 and 36

A large concrete surface is located in the space immediately south of the rifle range. Though the foundations were partially concealed by spreads of manure during the fieldwork, the outline of two adjoining structures were identified (**35** and **36**). Structure **35** is the larger of the two, measuring 41m x 19m. It is positioned alongside the main track and has floor areas for one or more small annexes adjoining it to the north, and a possible external concrete doorstep at the west end. A remnant patch of hatched blue brick flooring survives slightly west of the centre, and imprints of 'Atlas' type bricks are visible in the concrete surface at the west end . Short sections of brick wall foundations a single course high, and several straight vegetation marks at right angles to one another, suggest that the superstructure was built of brick and had several internal subdivisions. A small, slightly raised square concrete platform was recorded at the eastern end, but was largely concealed beneath a recent spread of manure. Adjoining or abutting this to the east is the smaller foundation of structure **36**, measuring 16.5m x 15m in plan and 0.12m high. The main floor is slightly smaller in area and is set a further 0.2m above the slab to form a platform 14m x 13m. The specific function of **35** and **36** remains unknown, but they are likely to have housed processes associated with manufacturing guncotton. Their relative proximity to jetty **J3** and their slight distance from the similarly large slabs of structures **39** and **63** in this area might suggest that this was where the cotton bales were broken up and cleaned by picking and willowing (see section 4.2). Structures **35** and **36** are absent from the 1908 25-inch OS map.

*Figure 66: Part of **Area B** looking north, showing structures **37** to **53** north of the road, and **62** to **68** south of the road. NMR 26890/038 08-Mar-2011, Damian Grady © English Heritage.*

Structure 39

Further east along the roadside is the large concrete foundation of structure **39**. It is possible to trace an area of 57m x 23m of concrete surface extending right up to kerb of the road (Figure 66); however, some of this hard-standing could represent a tram-bed for the tramline which formerly ran along the north edge of the road. Most detail on the floor of the building is now masked by grass and the remains of several rotten heaps of straw or manure. Vegetation marks suggest that the building was divided by several internal walls, and the presence of short lengths of open drains formed of purposely shaped blue floor bricks and a patch of acid-resistant blue brick flooring with a hatched surface, suggest a function relating to the use of acids. Due to its size, location, lack of protective traverse and the presence of blue brick flooring, it is likely that the function of structure **39** related to processes associated with manufacturing guncotton. If, as already suggested, cotton picking processes took place in structures **35** and **36**, it is likely that structure **39**, and **63** to its south, were engaged in the next stages of manufacturing guncotton; possibly nitration or 'dipping' of the cotton, or with washing and pressing the saturated cotton charges (see section 4.2). A pair of tram rail segments were recorded at the west end of the slab aligned perpendicular to the road, presumably these once connected to the tramline formerly paired with the road. A number of large buildings are marked in this area by the 1908 25-ich OS map, but due to the lack of clarity of the shape and size of structure **39**, it is not possible to positively identify whether the mapped buildings included **39** or whether it represents a later rebuild (see Figure 16).

*Figure 67: The tank at the north-west corner of structure **40**. Photograph: Rebecca Pullen, 2011 © English Heritage.*

Structure 40

Just beyond the east of **39** is structure **40**, a smaller concrete foundation set at a slight angle to the road, with a distinctive large hollow in its north-west corner, probably used for, or as, a tank. The main body of the hollow measures roughly 5m x 4m, with a narrow extension at the east end (Figure 67). The north and west edges of the hole are chamfered, whereas other sections of the edge are lined with smooth blue engineering bricks or show the distinctive irregular edge of concrete poured against corrugated iron shuttering. Much of the interior of the hollow is now filled with spoil and concrete rubble, which has also masked its southern edge. A building is depicted in the same position and alignment as structure **40** on the 1908 25-inch OS map. A number

of smaller features were noted in the space between **39** and **40**, including two smaller rectangular tanks (one covered and one open), and three parallel rectangular concrete pads.

Structures 37 and 38

Immediately north of **39** is structure **37**; a small featureless concrete foundation measuring 5.8m x 4m (**37**), and east of **37**, another larger concrete foundation 21m x 9m (**38**). Structure **38**, is L-shaped in plan with the east end projecting 1m north beyond the rest of the slab. Witness marks on the concrete floor surface separate the east end from the west, suggesting that the building was internally divided into at least two rooms. Remnants of brick wall lines, a hatched blue brick floor surface and patches of bitumen survive on the concrete surface at the east end. Along the external northern edge of the east end, a line of shaped acid-resistant blue bricks form a narrow open drain. Another short length of open blue brick drain runs across the floor at the west end of the building. Just off-centre on the southern side of the slab is the stepped inset of a wide entranceway for double doors.

The function of these buildings remains unclear, but location within an area of likely acid-handling and guncotton manufacturing buildings and the presence of blue brick drains suggests a function relating to the use or storage of acid. Paired concrete post alignment **L1** ends a short distance north-east of **38**. If **L1** was an elevated pipeline, then it is reasonable to suppose that the functions of contemporary buildings in this vicinity related to the intake and use of imported acids and such like.

To the north and north-west of structure **38** are two significant heaps consisting of large pieces of demolition rubble; it is unclear whether these piles represent the location of demolished buildings or just convenient clearance spots to tidy up demolition debris. A short section of in situ open concrete drain with a hatched blue brick lining was recorded intermittently underneath the rubble heap to the north of, and in apparent association with, structure **38**. Aligned parallel to the road and running between structure **36** and structure **38** are a series of very narrow ridges spaced at intervals of roughly 0.5m with a slightly bowed alignment in places, thought to be vehicle ruts from fairly modern localised levelling activities.

Structure 41

Structure **41** sits to the east of **40**, continuing the line of concrete slabs along the north edge of the road. The rectangular concrete base measures 16.7m x 7.3m in plan and, at 0.45m tall, it stands considerably higher than other nearby foundations. Projecting from the north side of the slab are five iron hooks for supporting a pipe or cable. The surface of the slab is dominated by a line of three evenly spaced, slightly raised, large circular concrete pads; the north side of each circle is interrupted by a rectangular hole cut to ground level through both the circular pad and the edge of the build foundation itself (Figure 68). The circular features are edged with smooth blue bricks that create a shallow step, beneath which the slab is floored with surviving patches of hatched blue acid-resistant bricks set into a fairly thick cement mortar. A line of uniform small circular depressions is visible across the centre of the eastern circular base; elsewhere the coarse

*Figure 68: Structure **41**, looking east. NMR DP141512 07-Mar-2011, Steve Cole © English Heritage.*

concrete of the bases is fairly featureless and uneven. In addition to the three large circular bases, there is a small rectangular plinth topped with four narrow iron studs and the impression of a small machine or fitting. This building probably held three large tanks, perhaps for washing or spinning, as part of the production processes for guncotton. The gaps along the north edge would allow the tanks to be easily emptied, and presence of blue brick flooring suggests an association with acid-handling. Absence of this structure from the 1908 25-inch OS map illustrates that **41** was erected after its revision in 1907.

Structure 42

Immediately east of **41**, in an area largely masked by grass, are traces of concrete floor surfaces and brick wall footings representing the site of one, or more, small factory buildings (**42**).

Structures 43 and 44

Directly north-east of **42** are two of the most complex building slabs recorded during the survey. Structures **43** and **44** both comprise a jumble of machine beds, iron fittings, changing floor levels and voids in their floors (see Figure 64).

Structure **43** is the larger and more northerly of the two. Its foundation appears to comprise three main rooms or conjoined buildings visible as two concrete slabs connected by a smaller central one. The north-east foundation is characterised by the basal course of a dismantled brick plinth, a neat rectangular hole in the floor, a single wide iron pipe and traces of a possible internal division. At its south-east corner is a small room or building with traces of a red quarry tile floor and several iron fittings and pipes at floor level. This leads into the largest area of structure **43** where the foundation is divided in two on an east-west alignment. The south-west half is a fairly

*Figure 69: Structure **43**, looking south-west. NMR DP141515 07-Mar-2011, Steve Cole © English Heritage.*

blank area or yard marked by the imprints of a blue brick floor, while the north-east area is characterised by at least ten machine-bed plinths of varying shapes and sizes, some brick-built and others concrete (Figure 69). Towards the east edge is the largest plinth: a concrete edifice 1.15m tall and laid-out as a symmetrical pair of conjoined machine-beds, each with a large central hole marking the rough removal of former machine attachments, and with a narrow opening between the two on the north-east side. Also distinctive, are three matching elongated brick plinths, rectangular at one end and semi-circular at the other, with traces of a narrow, shallow wheel pit along the west side of each, marking the probable position of flywheels. Each plinth also appears to relate to an open irregular void in the floor adjacent to the semi-circular end and crossed by a pair of parallel narrow flat iron strips (see Figure 64). Also, though obscured by vegetation, a narrow, gently scooped rectangular hollow lined with red quarry tiles is present next to the west side of each of these plinths. The make-up of the superstructure for this building remains ambiguous, but the ack of any clear brick wall scars points to a light construction of timber or corrugated iron. Spoil heaps and extensive evidence of burrowing, (possibly by badgers) is notable along the west and north periphery of structure **43**.

Immediately south-east of **43** is structure **44**, an L-shaped building with ancillary structures adjoining to the north and east. The main concrete foundation hosts a tight cluster of concrete plinths of mixed size and shape, all topped by patterns of protruding iron studs marking the positions of former machine attachments (see Figure 64). Unlike machine-beds elsewhere across the site, several of those associated with **44** have split-level surfaces with chamfered or curved sections falling away from the top of the plinths (Figure 70). At the north-east end of this slab is another, slightly smaller, square concrete foundation, featureless apart from a couple of L-shaped iron fittings and a pair of small holes in the floor. Nestled between this and the foundation with all the plinths is a narrow rectangular hollow or tank, at least 0.4m deep, and bound by a low narrow concrete wall and to its south by a low chamfered brick wall with bitumen residue on its surface. Likewise, the south-west corner of the main foundation is fringed by a low

*Figure 70: Structure **44**, looking north-east. NMR DP141509 07-Mar-2011, Steve Cole © English Heritage.*

L-shaped hollow, edged by a thin dwarf brick wall with an internally chamfered top suggestive of a tank or sunken yard. At the far north end of **44**, obliquely abutting the square concrete slab to its south-east, is another tank-like feature over 0.4m deep, with stepped-concrete edges raised slightly above ground level. Additionally, based on its close proximity, a small stand-alone concrete building foundation measuring 4.6m x 3.1m has been included in this structure complex.

In and around both **43** and **44**, a number of loose factory components were noted, including several ceramic insulators (see Section 6.2). A potential interpretation is that one or both of these buildings functioned as a power house for the surrounding acid and guncotton processing plant; presence of insulators suggests that electricity was the power being produced. The unusual shaped plinths belonging to structure **43** appear to be moulded in such a way as to support small stationary motors with space for belts and drive wheels to the side (see Figure 70). Consideration of the 1908 25-inch OS map suggests that structure **44** pre-dates structure **43** (Ordnance Survey 1908b). Absence of **43** could be tentatively used to suggest that it was built as a larger, more modern replacement for **44**, if both were once power houses. Nevertheless, the precise function of these two buildings remains unproven.

Structure 58

Moving south of the tarmac road, structure **58** is marked by the presence of three parallel concrete beams, each 1.0m wide. The northern two measure 5m in length, whilst the southern beam is 6m long extending an extra metre to the east. In addition, this southern beam has a slightly bevelled edge along its south side, and its position suggests that it may have abutted a former tramline running along this side, though there is no clear evidence that these features were in operation concurrently. Structure **58** was probably the base for a lightweight building or superstructure. It is absent from the 1908 25-inch OS map, at that time this position was crossed by the line of a former narrow linear borrow-pit enclosing a row of buildings to the south (**59** to **61**, see section 6.7).

Structure 62

Around 70m east of **58** is a similar feature, again formed of three parallel concrete beams, but this time conjoined by a fourth perpendicular beam forming a closed eastern end. This feature is surrounded by a number of other seemingly related small angular concrete bases, and the group have been collectively assigned structure number **62**. All are absent from the 1908 25-inch OS map. The largest of these associated bases has a slightly sunken central rectangular space. Adjoining a smaller concrete base to the north are the remnants of a floor of hatched blue engineering bricks.

Structure 63

Structure **63** is a large concrete building foundation measuring 55m x 18.5m The slab is largely covered by encroaching grass, but a number of vegetation marks crossing its surface appear to indicate the position of internal divisions (*see* Figure 64). Along the north edge of the slab, the footings of two red brick machine bases were noted, whilst along the south edge of the slab, the concrete floor mounds up in four sub-rectangular protrusions - a feature unseen anywhere else across the site. As with structure **39** to its north, it is likely that the function of structure **63** related to processes associated with manufacturing guncotton; possibly nitration or 'dipping' of the cotton, or washing and pressing the saturated cotton charges (*see* section 4.2). The physical proximity between structures **62** and **63** could represent a close functional relationship. Running south from the pair of buildings are a series of four parallel brick culverts draining into the nearby long narrow pond (borrow-pit), perhaps removing waste water. Both structures are absent from the 1908 25-inch OS map.

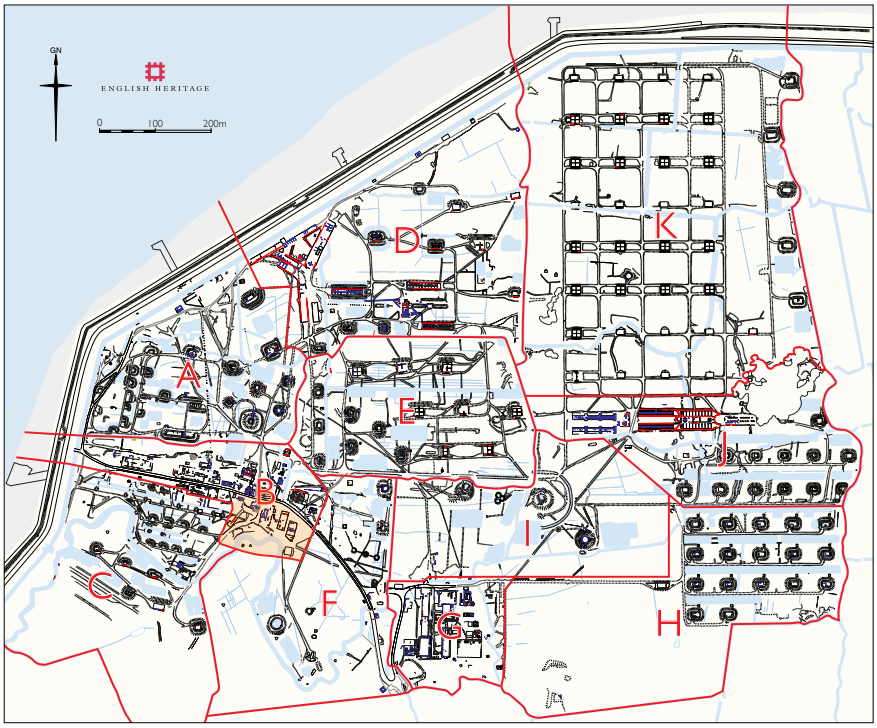
*Figure 71: Structure **64** (with **44** and **65** behind). Photograph: Rebecca Pullen, 2011 © English Heritage.*

Structure 64

Moving east, structure **64** is a small rectangular concrete foundation parallel to the tarmac track. It measures 6.6m x 4.1m and has remnants of a cement surface. Near the north end of the slab is a concrete plinth or machine bed, 0.2m high, with a single cut-off corner to the south-west and two narrow strips of iron running lengthways across the top and secured at each end by a thin iron stud. Halfway along the west edge of

the foundation a large iron pipe, probably for conveying steam, emerges vertically from the concrete floor before turning through 90 degrees into a shoulder joint (Figure 71). Adjoining the south edge of the base is a further small plinth flush with the main slab and punctuated by a number of cut-off iron studs. Structure **64** is absent from the 1908 25-inch OS map.

6.5 Area B: administration and support buildings



***Area B** , zone of administration and support buildings shaded orange.*

The south-east end of **Area B**, along either side of the tarmac road, contains a collection of concrete foundation slabs and the standing remains of three brick buildings (see Figures 64 and 66). Individual building functions in this area are not certain but, overall, the group are interpreted as offices, domestic buildings and support facilities, such as changing rooms and canteens. Comparison of the remains with the 1908 25-inch OS map shows that **Area B** was in use and largely developed by 1907, but that most of the surviving ground evidence relates to a later phase of development (see Figure 16).

Structures 45 and 46: office buildings

On the north side of the road, a pair of building foundations (**45** and **46**), sit in the crook of a T-junction formed by vehicle tracks leading north from the tarmac road towards nitroglycerine hill **31** (see Figure 64). The line taken by these modern wheel ruts roughly follows the former route of a tramline depicted on the 1908 25-inch OS map of this area (see Figure 16).

Structure **46** comprises two rectangular concrete bases. The main foundation is aligned east-west along the road; it measures 20m x 4.5m in plan and is constructed of closely laid concrete beams spanning the width of the floor. Adjoining this at the west end is a

*Figure 72: Structure **46**, showing the remnants of the semi-circular threshold and decorative floor tiles. Extract from NMR DP141600 07-Mar-2011, Steve Cole © English Heritage.*

smaller featureless foundation slab with a footprint 7.7m x 4.8m. The most diagnostic feature of structure **46** is an elaborate entranceway located at the centre of its south edge. Where visible through the encroaching grass, this entranceway comprises a semi-circular concrete threshold at ground level, leading up to a low step surfaced with decorative tiles in a pattern of red, white and blue, then stepping up into a semi-octagonal space with remnant red quarry tiles, before a final step brings it up to meet the main floor (Figure 72). On the opposite side to this threshold is a slight projection in the concrete slab which could suggest a rear entrance, or a perhaps a bay window.

To the rear of office **46** is **45**: a second, slightly smaller, foundation for a building, thought to have had an administrative or support role. With an overall footprint measuring

*Figure 73: Office staff at the Curtis's & Harvey factory, Cliffe, taken during the First World War. The building behind them is thought to be structure **46**. Image © Cliffe and Cliffe Woods Parish Council, reproduced by kind permission of Fred White.*

19.5m x 4.7m, the building comprised of two main internal spaces. At the west end is a floor area raised 0.25m above the rest of the slab, this is entered by a pair of steps on the south side. There are remnants of red quarry tiles on the steps and on a small area of the floor, and a stretch of brick wall footing with render on the internal faces around the north and west edges. Along the exterior of the west end of this slab, is pair of vertically-set ceramic box-tiles. The east portion of the building is larger and appears to have been divided into four internal compartments by narrow brick walls.

On the 1908 25-inch OS map, a single building of similar size and form to **45** and **46** is depicted but it is unclear whether it equates to either of the current remains, or represents an earlier building which they have replaced. The function of this pair of structures is unproven, but the impressive entranceway of **46** is not replicated elsewhere on site and was almost certainly designed for show; as such, it likely that this building was the main office and reception space for the site management, and structure **45** probably had an associated role. A rare photograph taken during the First World War shows office staff from the factory gathered in front of a building with a wide, set-back decorative entrance, that may be structure **46** prior to demolition (Figure 73).

Structure 65

A further group of buildings thought to have had administrative, domestic or supporting functions were recorded on the south side of the tarmac road. At the western edge of this group, structure **65** is a small, single-storey brick building, measuring 7.5m x 4.2m in plan, re-roofed and currently used to store hay. The store is of red brick stretcher bond construction, with a low wide door opening in the centre of the south wall, with evidence of a blocked window to its west, which leads into the main room of the building (Figure 74). A second narrow doorway in the west end leads into a much smaller square room in the north-west corner of the store; the two rooms are not connected internally (see Figure 64). A pair of windows in the north wall provides light for the two interior rooms. Both doorways have timber frames, and the window openings have crudely inserted timber lintels. The internal walls of both rooms are plastered, and the larger room has the remains of an asphalt floor and a set of coat pegs set into the south wall at the west side of the door. A recess in the partition wall of the smaller room appears to mark the position of a stove or similar, and witness marks for shelves or other fixtures

*Figure 74: Structure **65**, looking north-east. Photograph: Rebecca Pullen, 2011 © English Heritage.*

were also noted during the survey. The pitched corrugated iron roof is supported by a lightweight steel truss and timber purlin frame on stepped brick kneelers; this roof is a later alteration. The building sits on a concrete foundation with an apron of exposed concrete running along the east and south exterior. Adjoining the west end of the building is the concrete surface of a yard or small light-weight building. This area is blank on the 1908 25-inch OS map, proving that structure **65** was built later than the revision date in 1907.

Structure 66: 'The Poplars'

An embanked earthwork runs a short distance from the south-east corner of **65** before becoming a more formal concrete path apparently serving the roofless and now largely ruinous remains of brick building **66** (see Figure 64). All of the external walls are in a collapsed state and much of the resultant debris is present as a large rubble heap. Several sections of the internal walls are standing, including an off-centre stack with matching chimneys either side, and a pair of neighbouring door frames leading into two adjacent small rooms; all of which are rendered with a thin layer of cement (Figure 75). Parts of the wall adjoining the chimney stack survive to the height of the roofline, with visible notches to hold purlins. At the point where the north wall would have met the base of the roof pitch, a paired line of small peg holes are thought to relate to the position of a lightweight ceiling. The floor plan is only partially identifiable amongst the rubble and encroaching grass, but where visible it suggests two or more main rooms on the north side of the building, served by the pair of chimneys, and a series of smaller rooms along the south side of the building, giving a maximum footprint of around 14.5m x 14m. There are remnants of a decorative tiled doorstep in the north-west corner where the main entrance would have faced out towards the road (Figure 76).

*Figure 75: (above left) Remains of 'The Poplars' (**66**), looking west. NMR DP141517 07-Mar-2011, Steve Cole © English Heritage.*

*Figure 76: (above right) The decorative tiled doorstep of 'The Poplars' (**66**), looking south-east. NMR DP141599 07-Mar-2011, Steve Cole © English Heritage.*

The building is absent from the 1908 25-inch OS map, but is clearly present on the 1961 edition. Labelled 'The Poplars', it is depicted as surrounded by a garden wall (Figure 77); the abrupt end of the surviving concrete path probably marks the west edge of this former plot. An aerial photograph taken in August 1955 shows the building as being fully roofed with the adjoining garden clearly visible (see Figure 20) (NMR 540 RAF 1699 0113 12AUG55). So, although building **66** is in very poor condition now, it was presumably in a reasonably stable state at the time of the 1960 map revision, and may still have been in use. The Poplars possibly got its name from the line of trees marked on the 1908 25-inch OS map, along the north edge of the main road that approaches the building from the south-east. A tree line in this position is visible on historic aerial photographs from 1947 (NMR RAF/CPE/UK/2065 to 3110), but had been removed by 1955 (NMR 540 RAF 1699 0113 12AUG55). The decorative tiling and the use of chimneys rather than steam pipes for heating, point towards a non-utilitarian function, and the private walled garden suggests domestic rather than administrative use. Thus, **66** has been interpreted as a domestic building, perhaps an on-site residence for one of the managers, foremen or superintendents. Alternatively, the factory may have had a small hospital on site, as seen at the Royal Gunpowder Factory Waltham Abbey, Essex (Cocroft 2000, 189-90); so perhaps The Poplars had a medical function. It is also possible that the building may not have been named or adopted for domestic use until after the factory had closed.

Photographs of building **66** taken by RCHME in March 1995, show more sections of wall than are currently standing, illustrating the structure's continuing deterioration (Figure 78).

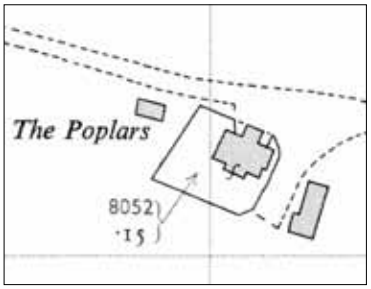


*Figure 77: (left) Structures **65**, **66** and **67** as depicted on the 1961 1:2500 OS map (Ordnance Survey 1961).*

*Figure 78: (below) Structures **67** and **66**, showing the north-facing interior gable wall (right edge of image) that is no longer standing. NMR BB94_08718 31-Mar-1995, Danke Silva © English Heritage.*

Structures 79 and 80

The remains of a tramway embankment were recorded leading away from the south-west corner of **66**; apparently terminating in the concrete foundation of a building (**79**). A stretch of concrete tram-bed approaches structure **79**, with visible grooves that once held the iron tram rails, and continues onto the concrete base for the building. A route marked by vehicle tracks divides **79** from nearby building foundation **80**. Structure **80** is a roughly rectangular concrete base on a slight earthwork platform. The south-east edge of the foundation has a chamfered front edge facing onto a sinuous stretch of the adjacent drainage dyke ('the delph ditch'); this edge is also punctuated by a line of iron studs. Comparison of the ground evidence with the 1908 25-inch OS map suggests that structure **80** was in place before 1907, but that a further two structures, formerly in a triangular arrangement with **80**, had since been removed and one of them replaced by **79** (*see* Figure 16).

The roles of these two buildings are unclear. The tramways connecting them to the rest of the factory have been heavily eroded by later vehicle use, making physical links to neighbouring buildings less distinct. Where slight tramway embankments survive, they suggest that **79** and **80** were perhaps more closely related to activities in **Area C** to the west and/or **Area F** to the east, than with the administration buildings to the immediate north. The form and position of structure **80** could hint at a function linked to moving materials around this part of the site by water - as postulated for nearby structures **82**, **89** and **96** - so structure **79** may have been a storage facility relating to the cartridge packing huts filling **Area C** to the west.

Structure 81

Across the drainage dyke to the south-east, and located close to the water's edge, is a small concrete plinth measuring 4.6m x 3m, with suggestion of a divide running centrally across its width (**81**). Traces of a second small concrete surface were noted to its north-east. This structure is unusual in that it is not located near to any other factory components. It may have functioned in relation to the use of the water for movement, it could have been connected to the rest of the factory by a simple footbridge, or it may be unrelated to the factory complex. It does not appear on the 1908 25-inch OS map.

Structure 67: office building

Standing a short distance to the south-east of the ruins of 'The Poplars', is a simpler and more complete single-storey, roofless, brick building (**67**). Built on a concrete foundation, the external walls of **67** are of orangey-red brick pier (stretcher bond) and panel construction with a pebble-dash render facing on the main panels (Figure 79). The building is L-shaped in plan, with a 15.5m long footprint; the main body of the building is 5.5m wide, widening to 7.6m in a short projection to the west at the south end. A single doorway in the corner of the long west wall leads into the largest of three rooms: a single room encompassing the complete north end of the building, which in-turn opens into two small ancillary rooms arranged side-by-side at its southern end (*see* Figures 64, 66 and 79).

*Figure 79: (above left) Structure **67**, looking north-east. NMR DP141597 07-Mar-2011, Steve Cole © English Heritage.*

*Figure 80: (above right) Structure **67**, showing the circular paint mark above the door, looking north-east. Photograph: Wayne Cocroft, 2010 © English Heritage.*

Externally, a brick plinth in English bond with a moulded brick top runs around the base of all but the long east-facing wall, which has a smooth concrete plinth. At sill level, there is a decorative horizontal brick band on both external west-facing walls and on the short return wall between them. Additionally, the top edges of both gable ends are neatly finished with two courses of stepped-out brickwork. All of the walls are interspersed with ventilation bricks or airbricks located either just above the plinth lines, or just below the roofline. The airbricks are clearly visible in the external walls but they do not project through to the interior. The walls themselves are three brick widths thick, suggesting that the airbricks ventilated a single-brick-wide wall cavity. A single brick chimney breast, in stretcher bond, runs up the exterior of the north end of the building; narrowing at eaves height, it ends in a square chimney cap. In the centre of the chimney breast, just above the plinth line, is a single ventilation brick.

Each of the east and west walls is punctuated by fairly low rectangular windows with concrete sills and flat concrete chamfered lintels (equivalent to those thought to represent a second phase of remodelling in structure **23**, the brick building in **Area A** interpreted as a weighing and checking house associated with jetty **J1**). The windows all appear to have been neatly blocked with English bond brickwork (using Flettons), and subsequently several have been fully or partially reopened. The only door into the building is situated at the southern end of the main west-facing long wall, tucked in the sheltered corner of the L-shaped layout. Although the door itself is missing, the iron frame of an outward-opening door, hinged on the south side is still present, as is the loop for a catch or padlock on the north side. The door is flanked by a pair of blocked windows with green-painted wooden frames; a single concrete lintel supports the wall above all three, and a degraded circular stamp of green and white paint suggests there was once a label or plaque above the door which may have displayed the building's identification number (Figure 80).

Figure 82: (above right) Buried oil tank near Structure ***67****. Photograph: Wayne Cocroft, 2010 © English Heritage.*

Figure 81: (above left) Inside structure ***67****, looking north, showing the small fireplace and the rendered recesses of the blocked windows. NMR DP141518 07-Mar-2011, Steve Cole © English Heritage.*

The building is entered by a concrete step; the height of the threshold, along with witness marks in the render at skirting board level on the interior walls, are suggestive of a former suspended floor. The interior wall render is missing in places and stops purposely at ceiling height on the gable ends, marking the position of a suspended ceiling. Here, light brown bricks in stretcher bond are exposed; a contrast to the bright orangey-red bricks chosen for the exterior brickwork (Figure 81). Where the window blocking is still in place, the brickwork in the shallow recesses left in the internal walls has been rendered over, except for in the western gable end and the small windows either side of the door. The centre of the north wall is marked by a small fireplace with witness marks in the render where the fire surround has been removed (see Figure 81). A clustered group of narrow, vertical pipes or telephone cable conduits are set into the top of the south wall, and appear to be responsible for a large crack emanating from this point. The presence of inserted timberwork could suggest the abandoned building has been reused at some point, possibly as a sheepfold; this may also account for the reopening of several blocked windows.

A single tall square-section concrete post - similar to those recorded in **L1** and **L2** - was noted standing about 3.5m south of the south-east corner of **67**; this was possibly a lamp post or a telegraph post associated with the probable telephone cable conduit in the south wall, and has since fallen down. Additionally, the circular iron top of a tank (probably for oil) is visible set in concrete and sunk into the ground 8m from the south end of the building (Figure 82).

The frequency of blocked and rendered-over windows raises a number of questions: why and when were the windows blocked? Were the windows always blocked? What activities were carried out in this building which may have required these conditions? It could have been another office or domestic space, which had its windows blocked at a later date to create a storage facility. Or, perhaps the activities performed inside were light-sensitive, requiring artificial light in place of daylight; the building being constructed with blocked windows to fit the appearance of the overall area of offices. For example,

there would have been at least one laboratory for the adjacent acids and guncotton preparation area. Although the precise function remains unclear, the 1908 25-inch OS map suggests that structure **67** was erected after 1907 and that it replaced one or more buildings that previously stood in this area (such as **68**). Structure **67** is clearly present on the 1961 OS map edition, adjacent to **66**, 'The Poplars' (see Figure 77). An aerial photograph from August 1955 shows both of these buildings still being fully roofed at that time (see Figure 20) (NMR 540 RAF 1699 0113 12AUG55). So, although building **67** is in a condition of deterioration, it was probably in a reasonably stable state at the time of the 1960 survey, and may still have been in use.

Structure 68

Immediately east of building **67** are traces of concrete under the grass marking the position of one or more buildings covering an area of roughly 37m x 12m (**68**). A pair of concrete patches along the eastern edge of this area was identified as each having surfaces angled down towards the east. The northern of these two ramped patches was topped with cement mortar retaining the impression of a quarry tile floor. Looking at the 1908 25-inch OS map, structure **68** could represent the pair of buildings constructed end-to-end on a NNE-SSW alignment between a triangular road layout and a drainage dyke, marked in this position (see Figure 16). The southern extension of the drainage dyke has since been in-filled. This could indicate that structure **68** was out of use, and perhaps even demolished, before being superseded by adjacent buildings of **67**, **69** and **70**.

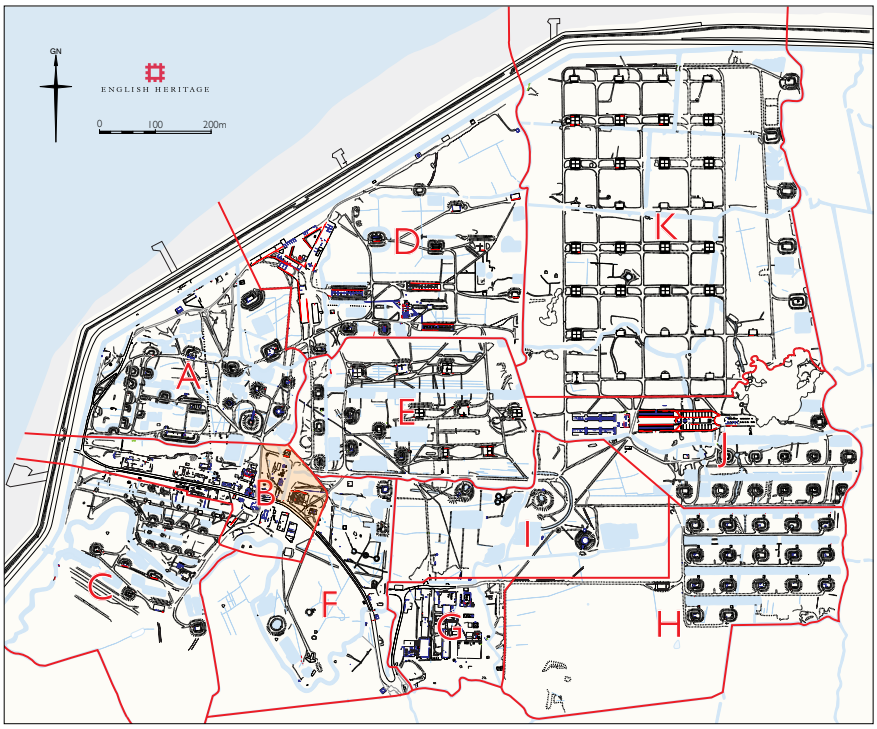
Structures 69 and 70

Two large concrete slabs (**69** and **70**), located to the east of, and parallel to, structure **68**, are also arranged end-on to the road to their north, and share a number of characteristics with one another. Structure **69** is rectangular in plan and measures 33.5m x 13m. Structure **70** appears to be trapezoidal in plan, measuring 34.5 x 14.5m at its maximum dimensions, though vegetation masks the south-west corner. Both slabs have several witness marks for internal divisions, brick wall lines, remnants of red quarry tiles, blue bricks and smooth cement areas of floor. At the east side of the northern end of **69** is an entrance or threshold, marked by an external line of red brick in front of a square area showing the impression of a herringbone pattern brick or tile floor, delimited on either side by a parallel pair of (reused?) iron tram rails set a far greater width apart (2.4m) than seen elsewhere on the site. Remains of a quarry tile surface at the north end of structure **70** could indicate a similar entranceway. Likewise, a slight step in the perimeter of **70** at the south end of the east edge could mark another entrance point. Earthen tramway embankments surveyed to the south-east and, less confidently, to the south-west, may indicate a former transport link running adjacent to the southern end of the paired structures. The function of these buildings is not clear; one possible explanation is that they represent the main men's and women's mess buildings for the factory staff, where there would have been a canteen and other facilities. Neither building is present on the 1908 25-inch OS map.

Structure 71

A short distance to the south is another concrete building foundation measuring 14m x 12.5m (**71**), featureless apart from a small square extension at the southern end of the west side that probably represents the position of an entrance porch. Alongside the foundation is the trace of a concrete tram-bed or path leading from the north to the porch threshold. An iron pipe, probably a former steam pipe for heating the building, emerges from the ground close to the north-east corner of the slab, and a gentle scarp along the eastern edge turning inwards at its southern end, suggests that the building was constructed on a slight low platform. Structure **71** is absent from the 1908 25-inch OS map.

6.6 Area B: further utilities and support buildings



***Area B** , zone of utilities and support buildings shaded orange.*

This part of **Area B** is north-east of the administration buildings and north of the road. It houses a linear group of small irregular building remains (**47** to **53**) laid out on a NNE-SSW alignment and interspersed with several open brick drains and manholes (see Figure 64). The functions of **47** to **53** are unclear; the structures share few similarities with each other and look to be predominantly associated with utilities - either providing or storing energy, or for cleaning and filtering waste water or waste acids. To their east are three large featureless concrete slabs (**54** to **56**), thought to have been large storage sheds or warehouses. East of them is the base of what appears to be a pair of small semi-detached dwellings (**57**), probably a pair of domestic huts used by the factory guardsmen.

Structure 47

At the north end of the group is structure **47**: a square concrete building foundation, 9.6m x 8.7m in plan, with the remains of iron tram rails set in two concrete tram-beds

running east-west against the northern and southern edges of the slab. Most of the foundation is punctuated by a parallel pair of long rectangular holes measuring 8.7m x 2.1m, and 0.4m deep. The northern end of the slab is a level concrete surface partially covered by a square piece of asphalt flooring. This building stands slightly apart from other nearby factory buildings, and is positioned part way along a tramline connecting the guncotton and nitroglycerine manufacturing in **Areas A** and **B** with the guncotton drying buildings in **Area E**. Based on the known manufacturing flow line for HM Cordite Factory in the eastern half of the site, **47** may have been a store relating to guncotton, similar to structure **284** in **Area H**. A structure in the position of **47** is clearly marked on the 1908 25-inch OS map, but the map shows only a single tramline through a covered porch along the south side of the building (*see* Figure 16). This suggests that either the north tramline had already gone out of use or that some later alteration has taken place.

Structures 48 to 53

Moving south-west across the drainage dyke from **47**, the line of small irregular concrete slabs continues south, eventually meeting the road.

Structure **48** is a plain elongated rectangular concrete base, 12.3m x 5m in plan and 0.4m high. It appears on the 1908 25-inch OS map and is labelled as containing or supporting two circular tanks (*see* Figure 16). Traces of a degraded forked embankment were picked up immediately to its south-west, indicating the position of a former track or road that has since been cleared or rerouted. West of **48**, is structure **49**: a rectangular brick tank with a smaller concrete tank adjoined to its eastern edge. The brick tank measures 4.5m x 3m externally, with walls 0.5m wide and 0.55m tall and iron studs in the top, presumably indicative of a cover or superstructure. The open interior of the tank has since been backfilled with a large quantity of rubble. The concrete tank or foundation adjoining this to the east is smaller and lower (3.15m wide x 0.3m high), with a pair of concrete blocks forming a partition down the centre, running east from the wall shared with the brick tank. A short distance to the south is another concrete slab (**50**), measuring 3.3m wide x 0.1m high, with a large jagged hole in the centre where a tank or machine has been removed. The hole is heavily vegetated, masking the full length of the structure, but a photograph taken in 1995 shows a square-sided concrete channel running from the east edge of the foundation out into the neighbouring drainage dyke (Figure 83). The function of structures **49** and **50** remain unclear, but one or both could relate to the location of a well labelled in this general area on the 1907 25-inch OS map revision (*see* Figure 16).

Moving further south, there is a series of concrete beams set flush to the ground (**51**). Two of the beams are roughly on an east-west orientation and six are on a north-south orientation; all measure 0.33m wide but vary somewhat in length. Although a coherent ground plan cannot be confidently reconstructed, the group of beams clearly mark the former location of one or more structures. There is no indication of any building in this position on the 1908 25-inch OS map.

South of the concrete beams is structure **52**, a larger and more complex building slab. It comprises a rectangular concrete foundation raised 0.5m above ground level, and measuring 9m x 6.4m in plan. The floor of the main slab is entirely taken up by

*Figure 83: Structure **50**, looking south-east. NMR BB94_08723 31-Mar-1995, Danke Silva © English Heritage.*

three parallel holes, all at least 0.5m deep, and each surrounded by the remnants of narrow brick walls. There is an entrance on the west side in the form of a narrow set of concrete steps. A concrete path or surface runs along the exterior of the west side, and what appears to be the floor for an ancillary structure exists at the north-west end of the building. The raised nature of structure **52** and the large rectangular holes in its surface could indicate that the building formerly housed a series of large tanks, or that below-floor space was required for pipes relating to the process carried out above, or that a large amount of aeration was required to keep the building dry. It seems most likely that this building was once used for holding or processing waste water or waste acids. A featureless rectangular building is marked in this approximate position on the 1908 25-inch OS map (*see* Figure 16).

Structure **53** refers to the final components at the southern end of this linear group; it is divided from structure **52** by a narrow gully to its north, and to its south is the main tarmac track. The remains comprise a series of narrow concrete and brick beams or kerbs (some with iron studs protruding from the top), which mark out a rectangular space approximately 15m x 6m; a small rectangular concrete slab was also recorded a short distance to the south. Structure **53** appears to equate to the western building in a pair of long narrow buildings marked in this area on the 1908 25-inch OS map (*see* Figure 16) but its function remains unclear.

Structures 54 to 56

Structures **54**, **55** and **56** are three sizable rectangular concrete building foundations flush with ground level and positioned side-by-side to one another; east of structure **53** and north of the tarmac road. The concrete in this area is partly concealed by vegetation. Parallel vegetation lines equidistant from one another running the length of the slabs might suggest narrow channels in the floor, or that the foundations are constructed from a series of separate blocks. All three slabs measure some 10m wide, the two westernmost structures (**54** and **55**) are 18m long, while the eastern structure (**56**) is nearer 20m long (Figure 84). The group are served by a single tramway running along their northern edge, with iron rails set a concrete tram-bed. Although there is

no longer any physical trace of the continuation of this tramway to the west, the 1908 25-inch OS map depicts a tramline coming from the west, passing between **52** and **53** before crossing the dyke by a bridge and then stopping abruptly in what was then a clear area of the site and is now occupied by structures **54**, **55** and **56** (*see* Figure 16). With the tramway extension already partially in place, it could be tentatively suggested that by 1907 this area was earmarked for future factory expansions, and perhaps these structures were already intended for construction and were built fairly soon after the revised OS plan of the site was completed. No specific function has been identified for this group; a dedicated tramway link suggests that they had a direct factory role rather than functioning in an administrative or support capacity. These foundations may have formerly supported large sheds or warehouses, probably with corrugated iron superstructures, used for storage of raw materials such as acid carboys.

*Figure 84: Extract from the survey showing trio of structures **54, 55 and 56**, and the probable semi-detached guards' cottages of structure **57** (not to scale) © English Heritage.*

Immediately south-east of structure **56** is a slightly embanked track that runs from the main tarmac roadway up in a north-easterly direction towards **Area E**. The track is composed of mixed earth and hardcore, and it overlies several features, including tramway embankments and a brick-lined drain. Halfway along the track is a pair of small concrete post pads with square sockets to hold the narrow metal posts of a gate. The track is probably a farm track post-dating the closure of the factory and consequently truncates a number of factory features, but its width and embanked nature suggest that it probably masks the position of a former factory tramway.

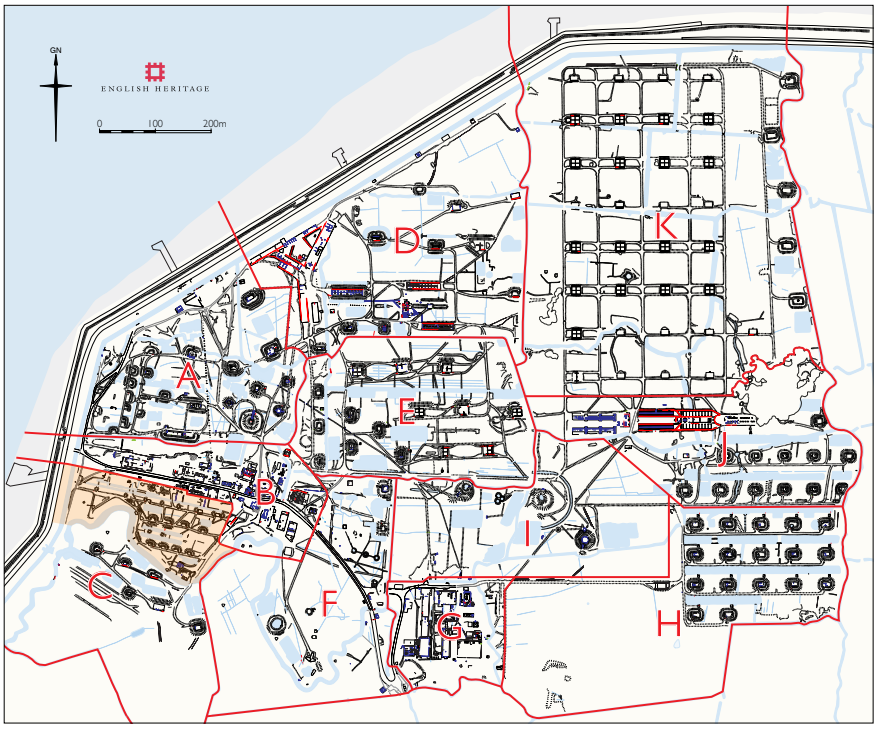
Structure 57: pair of semi-detached cottages

A short distance south-east across the probable farm track, is structure **57**; a rectangular building foundation measuring 12.7m x 8.9m, with a neat arrangement of floor features revealing the symmetrical layout of a pair of domestic spaces. This appears to be the remains of a semi-detached pair of small cottages, presumably a simple, single-storey building that was perhaps the sometime-homes of factory watchmen. The slab is divided centrally along a roughly north-south line, either side of which the features recorded are

mirrored (see Figure 84). Central to the southern edge of the foundation there appear to be two small entrance halls, seen as brick wall scars around a smooth concrete floor; from these visitors would turn 90 degrees and enter the main room with their back to the party wall. The floor of each cottage is covered by a skin of bitumen carrying the imprints of a decorative herringbone brick floor; wall lines are clearly visible through the bitumen. The internal space of each cottage seems to have been divided into three main areas: a large area at the front of the building with a fireplace on its back wall (roughly central to the cottage) and two further rooms behind the fireplace. The first of these is an elongated space behind the entrance foyer and against the party wall, the second is in the corner diagonally opposite the entrance and seems to comprise a small ante-room leading into a roughly square room directly backing onto the fireplace.

In front of structure **57** on the south side, a curved earthwork bank appears to mark the position of a raised path, arcing from two points close to the tarmac road to a single point next to the cottage doorways. Looking at historic aerial photographs of this building from the 1940s and 1950s, this feature shows up well as the pale curving line of a worn or surfaced path; these photographs also show that the building was still standing and roofed until at least 1947, but appears to have been demolished by or before August 1955 (NMR 540 RAF 1699 0113 12AUG55). This general area is shown as undeveloped on the 1908 25-inch OS map, and so structure **57** was almost certainly built after 1907.

6.7 Area C: filling huts north of the 'delph ditch'



***Area C**, zone north of the 'delph ditch' shaded orange.*

Area C encompasses the south-west corner of the factory site, immediately south of the administrative and acid-handling buildings of **Area B**. The sinuous path of a wide drainage dyke, known as the 'delph ditch', bisects **Area C** on a roughly NW-SE axis. To its north,

the structures are small and laid out in ordered rows, to its south the structures are larger and more spread out (Figure 85). North of the dyke, the area is covered by evenly spaced parallel rows of small concrete bases each, with a protective earthwork bank (*see section 6.8 for the area south of the dyke*).

South of the tarmac road and structure **58**, **62** and **63**, are five parallel rows of small structures. The structures within each row are fairly homogenous but there are slight differences in the size and form of structures on different rows. Despite variances, the buildings that once stood in these rows are all thought to have been small huts or sheds, probably for packing explosives (**59-61**, **72-78**, and **83-93**). The surviving remains show that all were built on concrete bases and were protected on at least one side by an earthen mound.

Figure 85: ***Area C*** *from the air looking north, showing the contrast in scale and layout of structures either side of the sinuous 'delph ditch' drainage dyke. NMR 26892/001 08-Mar-2011, Damian Grady © English Heritage.*

Structures 59 to 61

Structures **59**, **60** and **61** form the most northerly row in **Area C**. They each have evidence for a small rectangular building platform or foundation, and both **60** and **61** have an L-shaped protective earthwork bank, 7-8m wide, along the west and south edges of the platforms. The building platform associated with structure **60** is a rectangular concrete foundation measuring about 5.2m x 3.5m, and is partially concealed by encroaching grass. Structure **61** also has a level rectangular area for a building platform; in this case, it is marked to the north by a low narrow bank of earth capping the hard make-up of a wall footing or demolition material, and to the east by a slight inward-facing scarp. Along the top of the slight earthworks associated with **61** are three square-section concrete posts 0.15m in diameter, each with a narrow iron pipe or reinforcing rod through the centre, and a concrete plinth 0.9m x 0.7m in plan with four iron studs in its

top. It is not clear whether these were part of the building make-up or formed features external to the building. Structure **59**, at the west end of the row, differs from the other two: it has the remains of a small rectangular platform with two narrow concrete beams set into the low mound and does not have an accompanying earthen traverse. However, irregular traces of spoil immediately west and south-west of the platform, suggest this may have been removed.

Comparison with the 1908 25-inch OS map shows that this area has been subject to change (see Figure 16). Although the features surveyed equate directly to structures recorded by the OS, the current plan is considerably less coherent than it was during the factory's operation. Most notably, what now appears to be a line of three structures, was formerly a line of four equally spaced buildings; the missing structure was located where there is now a wide gap between structures **59** and **60**. There is no trace of the missing earthwork mound, but a low, flat-topped, sub-rectangular platform may indicate the former position of a concrete building foundation. The OS map also shows that in 1907 structure **59** had a bank around its west and south sides, and that the whole group was surrounded by a narrow ditch, forming a large rectangular enclosure with an entrance at the west end. The southern edge of the former enclosing ditch survives as the main east-west borrow-pit to the south of the row, and as a dry ditch complete with entrance causeway to the north-west. Having been enclosed by water in this way may indicate that processes with a high risk of fire were undertaken in these small buildings; it is thought most likely that they were cartridge filling huts or packing sheds associated with blasting explosives.

Structures 72 to 78

Bounding structures **59** to **61** to the south is a conjoined pair of narrow elongated water-filled borrow-pits, whose distinctive shape might suggest that they had a further function in the factory after the initial earth extraction. Immediately south of the borrow-pits is a row of eight well-formed small ovoid earthen mounds (**72** to **78**) indicating the former presence of a row of small buildings. The whole row is linked by a continuous tramway embankment along its south edge, from which branches spread out connecting all the small structures in this area to eachother, to the main jetty to their west (**J3**) and to the acid-handling and administration areas to the north and east. Each mound has an oval footprint measuring roughly 9.5m x 7.5m. Several of the mounds have a pair of iron bolts or tie-rods imbedded in their southern side; these may have secured iron sheet revetments to prevent earth from slipping on to the adjacent tramway. The presence of small level platforms suggests that the eight mounds relate to seven former buildings and, in most cases, space for a small hut is located east of each mound. Structure **78** is the exception, it has one mound either side of a single building platform. Concrete foundations survive in association with three of these building platforms (**74**, **77** and **78**), the most complete example is part of structure **77**; it measures 7.6m square and shows traces of a divide between the building foundation and an external tram-bed, complete with tramlines running across its southern edge, picked out as vegetation marks across the concrete. Hard-standing was noted on the tramway where it passed each of the building platforms in this row. The probable divide between internal and external space suggests that the buildings themselves had a smaller footprint of 7.6m x 5.2m. Their function remains uncertain, but they may have been small sheds for packing explosives,

similar to that described in an accident report detailing an explosion that occurred inside a cartridge hut in 1908, where two women had been engaged in filling dynamite cartridges (Cooper-Key 1908). Structures **72** to **78** are all identifiable on the 1908 25-inch OS map (*see* Figure 16). The map also suggests that **72**, which is set slightly further west than the rest of the row, was previously much larger with a probable long open-sided covering over the tramline to its south; this change in size and form may represent a change in function. In addition, structure **73** which now has a single earthen mound west of its building platform was mapped in 1907 with a second mound on its east side.

Structures 82 and 89

At the western side of the area, and hugging the eastern edge of a distinct meander in the adjacent drainage ditch, are structures **82** and **89**. Structure **82** was recorded as a rectangular concrete building foundation, 5.2m x 3.5m, partially concealed by grass with a short straight earth mound to its north-east and the line of a tramway embankment running in between the slab and the mound. South of **82** are the remains of **89**. Tucked neatly inside the next bend in the drainage dyke, structure **89** comprises a large earthwork bund orientated NW-SE and the remnants of a concrete drain running from it to the water's edge. Both structures are clearly depicted on the 1908 25-inch OS map, which shows the mounds immediately north-east of a tramline connecting structure **82** with **89** and continuing east to link up with **96** (Figure 86). On the opposite side of the tramline to the mounds, the OS map shows **82** as a simple square building overhanging the edge of the dyke and **89** as a larger rectangular area of land projecting into the water, possibly a small quay or wharf, and housing a small square building abutted on its north-west and south-east sides by sub-circular earthen mounds. Construction of buildings with probable wharves projecting into the central line of a major drainage dyke could suggest that some materials were being moved by boat in this area, or that the water was being directly harnessed in the process carried out in structures **82** and **89**.

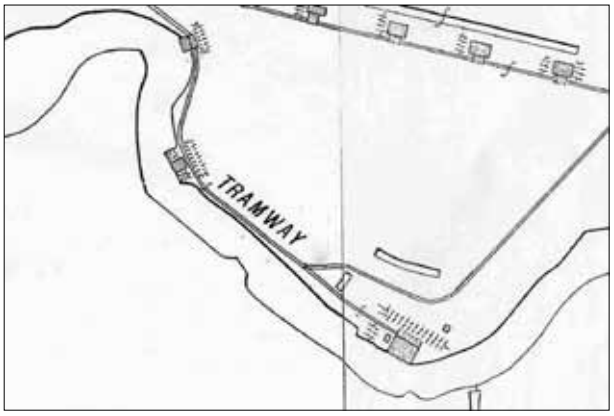


*Figure 86: Structures **82**, **89**, **95** and **96** along the north edge of the 'delph ditch', as depicted on the 1908 OS map (Ordnance Survey 1908a; 1908b).*

Structures 83 to 86 and 90 to 93

Roughly east of **82** is a row of four equally spaced structures (**83** to **86**), served by a single tramway. All four have a small level platform beside the northern edge of the tramline, and each is partially or fully surrounded by earthwork mounds. Only structures **83** and **84** have sections of protective mound south of the tramway, which probably reflects their close proximity to structures **87** and **88**.

The tramline running east from **89** passes along the southern edge of another row of four small earthen platforms (**90** to **93**), all of a size to fit huts of no more than 4.5m x 2.4m in plan and each bounded to the north and east by curved earthwork mounds; remains of iron pins projecting from the ends of the mounds where they abut the tramway suggests some form of metal sheet revetment . Short branches from the north side of the tramway show that carts were unloaded at the west end of the huts. It is not clear whether structure **89** had the same relationship to row **90**-**93** as structure **82** had to row **83**-**86**, and it is worth noting that, unlike **82** and **89**, none of the structures in these rows, nor the tramways serving them, appear to have been constructed by the revision date (1907) for the 1908 25-inch OS map.

Structures 87 and 88

Between the two rows of **83**-**86** and **90**-**93**, is a pair of narrow parallel water-filled borrow-pits, almost certainly produced by removal of soil necessary for the construction of mounds associated with **83**-**86** and **90**-**93**. In the narrow gap between the two borrow-pits are two smaller structures, **87** and **88**. Each is marked by a small oval earth mound with a footprint of roughly 8.25m x 6m, very similar to the mounds recorded with structures **73**-**78**. To the east of mound **88** a small level area 6m wide infers the position of a small, potentially free-standing, building. Possible hints of a similar area were noted to the west of structure **87**. By comparison of form, **87** and **88** appear to be most closely equivalent to structures **73**-**78** to the north, but unlike **73**-**78**, this pair had not been constructed by the time of the 1908 25-inch OS map. Their restricted position might suggest that they were inserted at a later date to relieve pressure on nearby buildings, or as a response to increased demand or technological advancements.

Structures 94 and 96

Tucked in the corner formed by two meandering drainage dykes south of **92** and **93**, is a group of three structures (**94**-**96**). Structure **94** is a square concrete building foundation measuring approximately 10m x 9m, served by a tramway running south from the main administrative area to the north, and curving to pass alongside the north edge of the slab before heading north-west towards structure **89**. Brick wall scars noted across the concrete surface suggest that the building was subdivided into six internal spaces. Low concrete machine beds, 0.23m high, stand in the two north-west compartments, and small squares of smooth cement survive on the two most northerly corners of the floor.

Structure **96** has a well-formed earthwork bank along the north-east and north-west edges of a concrete building foundation. The east end of the bank has collapsed and the slumped material abuts the south side of the adjacent structure **95**. The concrete slab measures 10.5m wide and extends south from the earthwork to meet the edge of the drainage ditch. Much of the slab is concealed beneath a spread of spoil and rubble, but the surface appears to rise in a slight step as you move away from the water.

The south-east corner of **94** is overlain by the earthwork traverse associated with structure **96**, suggesting that **96** was built after **94** had gone out of use and been demolished. In contrast, whereas the 1908 25-inch OS map clearly depicts structure **96**,

nothing is shown in the area of structure **94** (see Figure 86). Either **94** was not mapped because it had already gone out of use, or it had not yet been constructed.

Structure 95

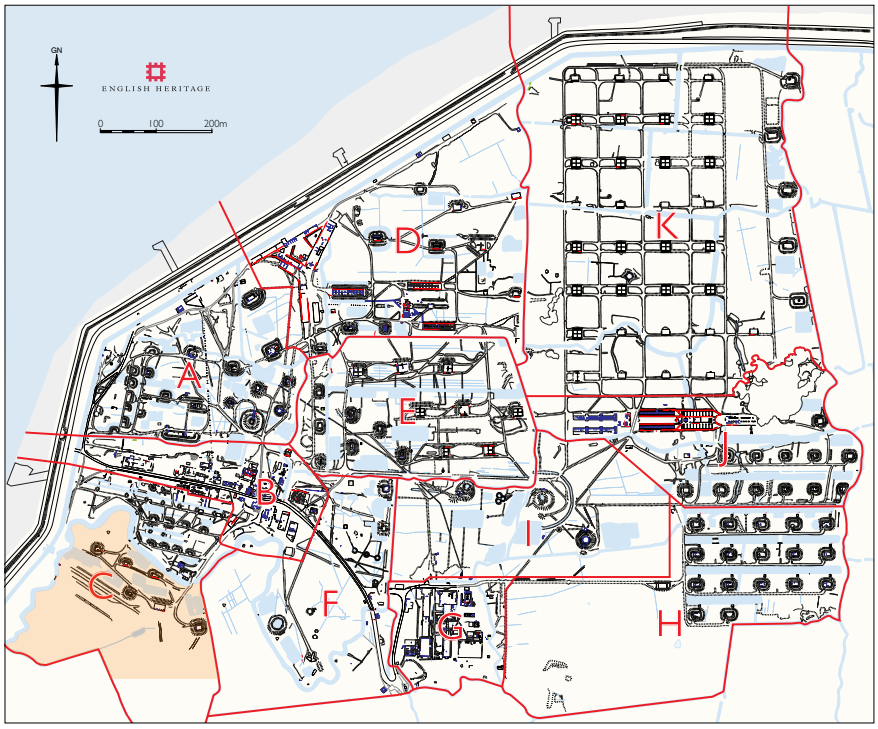
Located north-east of **96**, structure **95** is a distinctive small brick-built barrel-vaulted structure standing 2m tall on a concrete foundation slab 2.3m x 2m in plan (Figure 87). The brick superstructure has a footprint of 1.9m x 1.7m, and is orientated NW-SE. An opening in the south-east elevation indicates that the building faced out towards the line of a passing tramway, the embankment for which has now been largely eroded by modern vehicle tracks. The opening measures about 1.3m high x 0.75m wide. Internally, the opening projects back for about 1.3m to create a small interior chamber the same size and profile as the doorway and there are remnants of a thick concrete floor. A pair of large iron hinges located alongside the south-west side of the doorway and a horizontal iron loop intended to receive a central bolt or lock on the opposite side, signify the former presence of a heavy-duty outward-opening door. The whole exterior of the building is covered with remnants of a cement render with a blackened surface; where this has eroded it exposes common modular red bricks in English bond, topped by a barrel vault built of a segmental arch comprising four concentric bands of headers. Interestingly, photographs of the site taken by RCHME in 1995, show structure **95** close to an identical brick building that was located at the west side of structure **96**, and orientated with the opening facing south-west towards the drainage ditch (see Figure 87). Comparing the photographed location of the second brick structure to the 1907 25-inch OS map revision, it is clear that both **95** and its matching partner had been built by 1907. Demolition or removal of the second structure at sometime between 1995 and 2010 may account for some of the spoil and rubble accumulated across the surface of structure **96**.

*Figure 87: (left) Structure **95**, with the top of its former partner just visible in the background, looking west; (right) the concrete foundation of structure **96** and the second barrel-vaulted brick structure that has since been demolished, looking south-west. NMR BB94_08740 and BB94_08741 31-Mar-1995, Danke Silva © English Heritage.*

At present, the most satisfactory interpretation for the function of structure **95** and its missing partner, is that they were expense magazines, used for holding particularly sensitive small explosive components.

Given the likely function of structure **95** and its missing partner as small expense magazines, it is thought that this localised area of the factory might have been engaged in manufacture of primers, fuses and possibly detonators. We know that the Cliffe factory held authorisation to produce primers and 'fuzes' from 1905 onwards (see Appendix 2). Alternatively, an extract from an amending licence for additional dynamite cartridge filling huts at Cliffe includes a stipulation that 'suitable shelter cupboards outside the building' be provided where quantities of explosive exceeding 5 lbs could be kept in advance of use (Cooper-Key 1908, 3). Structure **95** is located in an area thought to be dominated by the remains of cartridge filling huts, and so the idea that it may have functioned as one of these 'shelter cupboards' certainly merits consideration.

6.8 Area C: dispersed danger buildings south of the 'delph ditch'



***Area C**, zone south of the 'delph ditch' shaded orange.*

A tram route runs east of **95** and **96**, and crosses at a gap in the 'delph ditch' to enter the area that marks the south-west extent of the factory remains. Here the tram network continues into a dispersed group of six buildings (**97** to **102**), all danger buildings, as indicated by the large protective earthen traverses surrounding them, and all considerably larger than the rows of structures to their north (see Figure 85). The tramway layout, and a concrete fixture on the south-west bank of the drainage dyke, suggest that there was previously a second access point to this zone in the form of a bridge opposite structure **89**. The 1908 25inch OS map indicates that this area was not developed until later in the factory's life (see Figure 16). The marginal position of

these buildings in relation to the factory's cordite manufacturing buildings, suggests that they were part of a separate processing area, probably for the production of alternative explosives products. As such, it is thought that the large danger buildings in this corner of the site could relate to the manufacture of blasting explosives such as Cheddites or gelatine explosives. Their size is suggestive of either the mixing of the raw explosive materials or the storage of the final products; they are too large to be cartridge filling huts.

Structures 97 and 100

Starting in the north-west corner, structure **97** is a large, steep-sided, sub-square earthwork traverse with a narrow opening in its south-east side leading out to a tramway embankment with in situ remnants of iron rails. Iron tie-pins, probably for revetments, protrude on both sides of the entrance through the earthwork. The traverse circuit measures 25m in diameter and surrounds a rough concrete building foundation with witness marks in the surface where tram rails entered along the southern edge of the internal space. An almost identical structure (**100**) was recorded 80m to the south-east. In this example the tramline entered along the north side of the building, adjacent to a concrete dwarf wall which may mark the divide between 'clean' and 'dirty' areas of the building. These buildings were probably mixing houses, drying stoves or magazines.

Structures 98 and 99

North of **100**, is a pair of rectangular concrete building foundations (**98** and **99**), both served by a tramway running along their southern edge. In each case, the stretch of tramway immediately adjacent to the building has a concrete bed complete with grooves that once held the iron rails. The foundation for **98** measures 6.4m x 4m in plan and is bounded along its north, east and west sides by an open C-shaped earthen bank. South-east of this is the foundation of structure **99**, which has a tightly angled L-shaped earthwork along its west and north-east sides, and a long stretch of concrete tram-bed to its south. Although the foundation deceptively appears to be much larger than that of **98**, the oblique angle of the associated earthwork would only allow for a slab of a similar size to **98**. These buildings may have been magazines to store finished explosives.

Structure 101

South of **99**, structure **101** is a large rectangular concrete building base with a single straight section of mounded earth bounding its northern edge. Measuring about 9.5m wide, the steep-sided earth bank is equivalent in width to the other mounds in this area; however, at 42m in length it overshoots the concrete foundation by several metres at either end, and remains open to the south, presumably because no further buildings were erected beyond it in that direction. The building foundation measures 19.5m x 10m in plan, with a slightly lower concrete step 0.4m wide around its perimeter. The witness marks of an external brick wall, and several other features, were recorded along the southern edge of the foundation. Most notable are three narrow trapezoidal concrete plinths equally spaced at 4m centre-to-centre, and each measuring 0.63m x 0.43m at the base and 0.46m x 0.18m at the top, and standing 0.9m high with two threaded iron studs protruding from the top; in shape these are unlike any other plinths recorded on

Figure 88: (left) South edge of structure ***101*** *showing the iron tank and trapezoidal concrete plinths, looking west; (right) detail of one of the trapezoidal concrete plinths. Photographs: Rebecca Pullen 2011 © English Heritage.*

the site (Figure 88). Close to these, was a small low pair of rectangular concrete plinths or machine beds. Towards the south-east corner of the foundation, is the top of a large, horizontally-set, cylindrical riveted iron tank with a circular opening; it is partially buried in the ground, abutting the concrete slab and presumably held oil. Although the tramway layout is not entirely clear in this area, the building appears to have been served by a tramline along its northern edge, between the building and its associated mound.

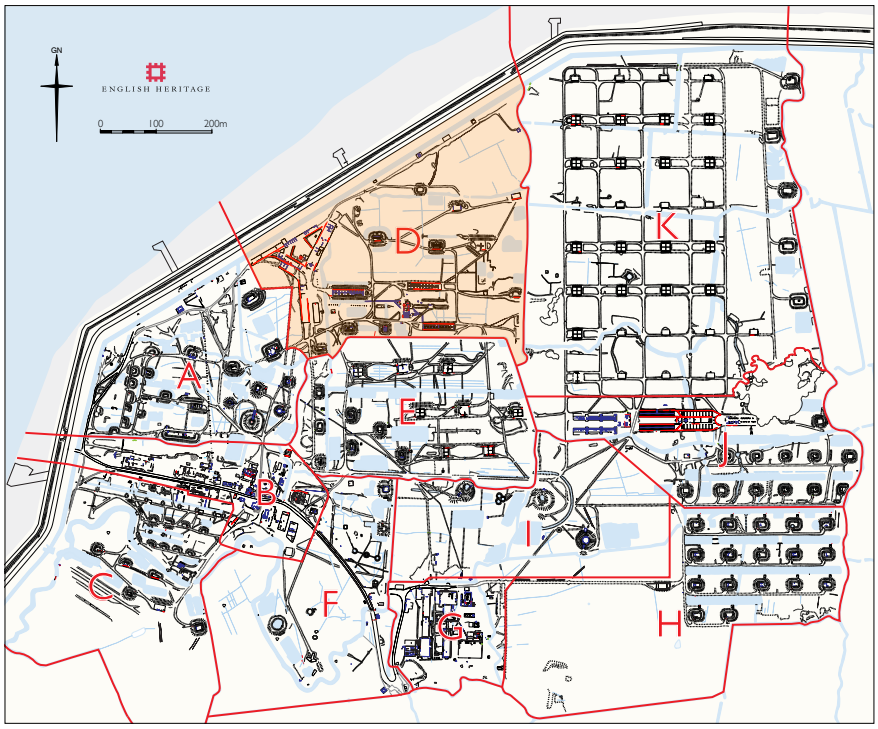
Structure 102

South-east of **101** is structure **102**. A curving tramway leading south from the administrative area turns and ends in the entrance to a large sub-square earthwork traverse. The traverse has an external diameter of 30m and is entered through a narrow gap in the north-west corner. It surrounds a concrete building foundation 10m x 8m in plan with scars suggesting a brick superstructure. At the north end of the foundation, next to the entrance, a strip of concrete 2.8m wide indicates a porch or covered area from which the tram carts could be loaded and unloaded. This may have been a mixing house, drying stove or magazine.

South-west of these structures is an intriguing set of four parallel, discontinuous, and apparently 'floating', linear features. It is unlikely that they all relate to the tramway network; some probably represent remnant stretches of paths, roads or buried pipes. From north-east to south-west the group comprises: the low embankment of a path or buried pipe measuring 3m wide and traced for over 90m; a wide probable tramway measuring 6m wide by almost 150m in length and diverging into a forked junction at its south-east end; and a probable road or possible tramway some 100m long and 5.5m wide which appears to turn and run into or under the bank to its north-east. A fourth

and final bank is set slightly apart from the other three. It is traceable for 75m and measures about 4.5m wide. Along its length, three small rectangular blocks, possibly not in situ, but each spaced 13m (centre-to-centre) from the next, are just visible through the grass. The forked appearance of the bank previously described could be caused by the continuation of the turn in the third bank emerging on the far side. It is no longer apparent where these banks are leading to and from, but they could represent movement of materials or services to or from the estuary, or the beginnings of further planned factory expansion that never came to fruition. A double-chamber brick drain cover that could relate to the suggested buried pipes was noted at the edge of the drainage dyke around 25m north-west of the banks. South-west of these features is a sub-rectangular pond that pre-dates the sites association with industry (see section 5.2).

6.9 Area D: cordite processing established pre-war



***Area D** shaded orange.*

Area D is at the centre of the northern edge of the site and the south-west half of the area is densely covered with very large concrete building foundations mostly without protective earth traverses. In contrast, the north-east half of the area contains a series of much smaller and more spread out buildings, most of which are enclosed by traverses.

At the western edge of **Area D** is a distinctive closed Y-shaped group of large concrete building slabs forming a triangular courtyard at the north end, with a long north-south rage projecting from the southern corner of the complex (Figure 89). There are no upstanding building remains in this group, but witness marks for dividing walls suggests that they were brick-built and comprised long ranges of small cells in single or back-to-back rows. Encroaching grass masks a number of slab dimensions and surface details, and the generally disturbed nature of the surrounding ground made

this area particularly challenging to survey. Based on elements of the physical remains, clues from contemporary accident reports and analogy drawn with the comparatively well understood remains of HM Cordite Factory, these large building slabs have been attributed to the processes of cordite manufacture. For example, structure **108** houses the distinctive foundations for hydraulic cordite presses, and structures **129**, **130** and **131** are known from records to have been built as cordite drying stoves and then converted to acetone recovery stoves in 1914 (Coningham 1914). Most of the buildings in this triangular arrangement were constructed after the 25-inch OS map of the area was revised in 1907.

Perhaps unexpectedly for such a disturbed area, there appears to be a greater occurrence of in situ iron tram rails and cambered cement tram-beds here than has survived or been seen elsewhere on the site (Figure 90). Tramlines are seen running along the edges of each slab; they appear to connect all the main slabs with one another and to join most parts of the group up with the rest of the factory.

*Figure 90: Iron tram rails and cambered cement tram-bed between structures **107** and **108**, looking south-west. NMR DP141543 07-Mar-2011, Steve Cole © English Heritage.*

Structure 106

Structures **106** and **107** are two long conjoined building foundations aligned parallel to the main boundary drain and the sea wall beyond (see Figure 89). The long narrow concrete foundation of **106** measures 65m x 7m. Abutting the length of its south-east edge is a slightly cambered tram-bed of smooth concrete 3.2m wide, with the iron rails largely intact and three distinct sets of points where tramlines branch off to the south-east. Changes in surface material and slight vegetation marks suggest that either the building was divided into at least three main areas, or that the slab supported three adjacent buildings. Whereas the majority of the slab is constructed of a coarse concrete raft, the central segment was surfaced with a much finer concrete and showed signs of previously being floored with asphalt. Although no building of this size or layout is depicted on the 1908 25-inch OS map, the largest of a group of four smaller buildings shown in this location could represent the south-west end of **106** (see Figure 16).

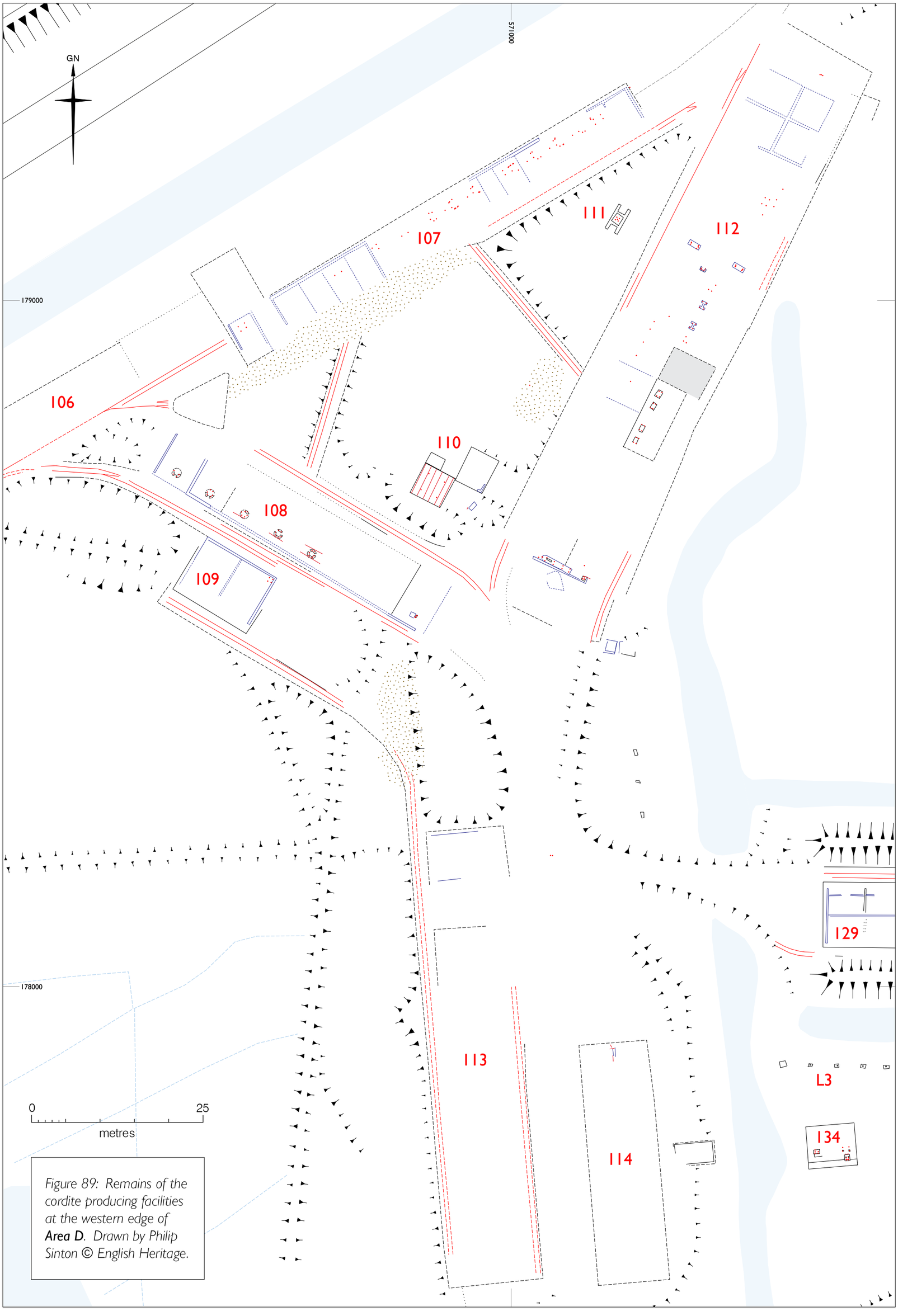


Figure 89: Remains of the cordite producing facilities at the western edge of ***Area D****. Drawn by Philip Sinton © English Heritage.*

Structure 107

At the north-east end of **106**, the adjacent tram rails stop abruptly, and the concrete slab abuts another long range (**107**), set just slightly further from the dyke. Structure **107** comprises a long narrow concrete building foundation measuring 68m x 7.2m, with an annexe (7m x 8.5m) at the south-west end. The main slab is divided along most of its length by the witness marks of brick walls, betraying the layout of a row of individual cells each with an internal footprint of about 3.5m x 6m and an open front to the south-east facing onto a tramline serving the whole range. On the floor surface along much of the slab, small circles of white mortar (0.15m in diameter) each surround a group of four narrow cut-off iron studs, they appear to be laid out with four of the circles in a square arrangement in each cell. The level of preservation makes it difficult to ascertain whether this range comprised 18 identical cells, or a variety of different small working areas. No structures are shown in this area on the 1908 OS map. One possible explanation for this building, implied by the small separate cells and by the interpretation of nearby buildings as part of the cordite manufacturing process, is that it may have been used as an incorporating house for the addition of acetone with cordite paste.

Structure 108

Also facing into this central triangular space is structure **108**, another elongated coarse concrete building foundation with similar proportions to **107**. It measures at least 46m x 9m and is set on a NW-SE alignment with tramlines that branch off from nearby structure **106** and run beside both long edges of **108**. The tramline along the north-east side of **108** appears to truncate an earlier tramline approaching at an oblique angle from structure **107** to the north-east, presumably indicating a change in function or layout of the buildings in this area. A brick wall scar was recorded along the length of the slab forming a back wall to the south-west; additionally, short segments of brick wall footings surviving at the north-west end suggest that there was a brick superstructure comprising up to eight individual cells with frontages opening into the central triangular space. Based on these witness marks, the cells measured about 6.7m x 5.3m internally, each with a low circular machine base located towards the back wall of the cell. From the north-west end, the first five cells have surviving examples of these circular concrete bases. The machine bases comprise three low curved segments of concrete, 0.22m high x 0.3m wide, arranged in a ring with gaps of 0.35m between each segment (Figure 91). The concrete segments are covered with a thin surface of smooth cement render with visible pouring marks; and protruding from the top of each segment is a pair of thick threaded iron studs. Narrow parallel iron plates flank either side of the bases and align with the length of the building. The eighth cell, at the far south-east end of the slab, contains a small pair of rectangular plinths, one brick and one concrete with protruding iron studs. Based on the distinctive form of the circular concrete bases, **108** has been interpreted as a cordite press house. It probably once contained large hydraulic presses similar to those known to have been in use at RGPF Waltham Abbey (Figure 92), and may have been powered by structure **110**, thought to be the base for a hydraulic accumulator tower.

Structure 109

Running along the back wall of structure **108** is a pair of tramlines which separate it from the back wall of a smaller building (**109**). Structure **109** comprises a concrete base with

*Figure 91: (above left) Detail of a hydraulic press base in structure **108**. NMR DP141541 07-Mar-2011, Steve Cole © English Heritage.*

Figure 92: (above right) A preserved hydraulic cordite press displayed at the Royal Gunpowder Mills visitor site, Waltham Abbey, Essex. Photograph: Rebecca Pullen 2011 © English Heritage.

evidence for two brick-built cells of comparable form and dimensions to those described in **108**. The paired cells of structure **109** face out to the south-west, where a further tramline approaches from the south-east. Extant fragments of a wall of yellowish brick with remnants of a smooth render on the interior elevations survive in places. No machine bases were noted, but a cluster of iron studs are visible in the north-east corner of the south-east cell. Based on the proximity of **109** to **108**, and the similarity of the cell sizes, it seems likely that the two building had the same, or closely related, operational functions; that is, relating to the pressing, reeling or cutting of cordite.

Structure 112

The third side of the triangular arrangement of building slabs is formed by a concrete building slab of considerable size, structure **112** (see Figure 89). The foundation measures 94m x 19m and incorporates tramlines running the length of both long sides. It probably supported a collection of rooms or buildings, each engaged in slightly different processing activities, inferred from the constantly changing pattern of witness marks, floor level fittings, floor surfacing materials and plinths, across the surface of the slab.

At the north-east end, low remnants of brick walls survive, rendered on both faces, and arranged in a quadrant of four small square rooms, each measuring around 5m in internal diameter. Further south-west, the next section of the foundation is characterised by clustered groups of iron studs cut-off at floor level and two low rectangular concrete machine bases. In two instances, groups of four studs were recorded set within a mortar floor fitting, H-shaped in plan. Immediately south-west, are the traces of what may be divisions or rooms; these include witness marks for brick walls, a rectangular area of surviving asphalt flooring with curled-up edges and a rectangular area containing a line

of four small concrete plinths standing to 0.1m high and each topped by four iron studs. Towards the far south-west end of the slab are the remains of a large cement-rendered red-brick plinth, measuring 4.7m x 0.85m x 0.65m high, with a semi-circular terminal at its north-west end and long iron studs protruding from its top.

A long building, or range of buildings, with a single tramline along its north-west side is depicted in the location of **112** on the 1908 25-inch OS map; it appears to be equivalent to **112**, but judging by its position relative to **123**, structure **112** may have been extended at the north-east end after the 25-inch OS map was revised in 1907.

The function of structure **112** is uncertain, but there are a number of possible explanations. It is another potential candidate for the incorporating house in this area, a function also postulated for the more recently constructed **107**. Alternatively, as one of the few buildings in this group erected before 1907, it could have been an acetone recovery house before nearby structures **129**-**131** were converted from cordite drying stoves to acetone recovery during 1914 (Coningham 1914).

Structure 111

Structure **111** is a lone concrete plinth with an H-shaped footprint, sitting between the large building slabs of **107** and **112**. It measures 4m x 2m in plan and stands to a height of 0.4m above ground level. Located centrally on the structure is a further concrete plinth measuring approximately 1.2m square by 0.2m high, with an arrangement of five tall iron studs in its top, presumably the bedding plinth for a machine (Figure 93).

*Figure 93: Structure **111**, looking east. NMR DP141546 07-Mar-2011, Steve Cole © English Heritage.*

Structure 110

In the internal angle created by structures **112** and **108**, are three small concrete platforms which collectively constitute structure **110** (*see* Figure 89). Two plain concrete pads were recorded flush with the ground surface; the larger of these retains remnants of a brick-walled superstructure. The third foundation measures approximately 5m square x 0.5m tall and is crossed on a NE-SW alignment by flat iron strips and a square

arrangement of four thick iron studs. Although this area is shown as only partially developed on the 1908 25-inch OS map, a structure labelled as a well is marked in the equivalent position to structure **110** (see Figure 16). The function of **110** remains unclear, but it could relate to the well; it has also been suggested that this may be the base for a hydraulic accumulator or 'pump house' (similar to structure **248**), that would have powered the adjacent press houses of structure **108**.

Structure 113

Structure **113** is another very large slab, now almost entirely grassed over, located south of where structures **108**, **109** and **112** converge. The coarse concrete foundation measures 66m x 14m, and along the inside length of both its long sides are slots that once held iron tram rails. At the north end, where the grass cover is less advanced, there are hints of brick divisions across the width of the foundation. This building had not been built at the time of the survey for the 1908 25-inch OS map.

Structure 114

Structure **114** is another largely grassed-over featureless concrete slab, measuring 35m x 10.5m, located east of and parallel to **113**. This is one of the few buildings in this area that is marked on the 1907 25-inch OS map revision (see Figure 16). It appears to have been divided in two along its length, with separate tramlines serving each of the long frontages suggesting that it comprised two back-to-back rows of cells. East of **114** is a small concrete base 5.6m x 3.2m in plan and 0.2m tall, that also appears on the map.

Structures 121 and 122

Structures **121** and **122** are a pair of small low earthworks that appear different in form from the rest of the factory features (Figure 94). Located a short distance north-east of **112**, structure **121** is a low sub-rectangular platform with a smaller sub-square platform on its north-east corner. At the centre of the smaller platform is an oval hollow with a pattern of twelve threaded iron bolts with hexagonal nuts arranged in two clusters of

*Figure 94: (far left) Structures **121**, and **122** from the air, extract from NMR 26892/016 08-Mar-2011, Damian Grady © English Heritage; (left) detail from the main survey drawing © English Heritage.*

four and two lines of three. The feature appears to abut or underlie the tramway to its west; conversely, a low earthen mound at the south end of the main platform gives the impression of partially overlying the tramway embankment. One possible interpretation is that **121** represents the base for a wireless mast.

Structure **122** is a small low U-shaped earthwork with a footprint of 10m x 10m, and an opening in the north-east side of its slightly disturbed banks. Neither **121** or **122**, nor the tramline alongside which they sit, is depicted in the 1908 25-inch OS map. It is thought that these two features are connected and may represent military activity relating to training or defence activities after the factory closed.

Structures 115 to 118

North-east of **121** and **122**, structures **115** to **118** form a line of four widely spaced small rectangular non-descript concrete building foundations, parallel to the main drainage ditch that forms the north-west boundary to the site. From the south-west end: structure **115** is a small plain slab of coarse concrete measuring 6.3m x 3.6m, structure **116** is a coarse concrete slab measuring 9.8m x 7.3m and 0.05m thick with the scars of two internal brick dividing walls, structure **117** is a featureless slab of coarse concrete measuring 13.3m x 7.3m, and structure **118** is a partially overgrown foundation of coarse concrete measuring 6.5m x 7.3m, with a rectangular opening in the floor at the north-west end and the suggestion of a second adjacent void. These buildings first appear on the 1907 25-inch OS map, which shows they were previously connected to each other, and to a building adjacent to nearby jetty **J2**, by a tramway running along the line now occupied by the head dyke to their north-west (*see* Figure 16). So, unlike their present location, during the factory's operation, these structures would have been quite some distance from the nearest main drain. The map also shows that there was formerly a fifth small building a short distance north-east of **118**, adjacent to which the associated tramline terminated. A proposal map from December 1903 for practice firing of large guns across Cooling Marshes and a subsequent agreement document signed on 6 April 1904 allowing the firing to take place as proposed between 31 July and 7 August 1904, shows that the potential impact zone included land now occupied by structures **115** to **120** and jetty **J2** (KHLC CKS-S/NK/A/C/1/59). It is unlikely that agreement would have been given if parts of an explosives factory - a site of high potential volatility - fell within the predicted impact zone; thus, suggesting that structures in this area were most likely built between late-1904 and the 1907 the revision date of the 1908 25-inch map, after the large gun testing ceased.

There is now an embanked earthen path or track along the south-east edge of structures **115** to **118**; it is wider and less well formed than the clear tramways recorded elsewhere. It could represent a relocation of, or addition to, the tramway shown on the 1908 OS map, or it could be a more recent track created to aid access across the marshy ground for the management of grazing stock.

Structure 119

East of structure **118**, a short branch of tramway splits off and heads south east, terminating at another small structure (**119**) on the banks of one of the main drainage

ditches. Although it is now largely buried under dredging silts, the edges of a coarse concrete foundation 6.5m x 5m sitting 0.2m high are clear, as are the scars of brick walls around three sides and the suggestion of a separate porch (or 'dirty area') at the north end. The 1908 25-inch OS map marks a small building in the position of **119** with no related tramlines (see Figure 16), at the time **119** would have been a very isolated building situated at the periphery of the site. The location of this building and the absence of evidence for a continuation of the tramway on the other side of the drain could be suggestive of a marginal function, or one relating to movement of material by boat.

Structure 120

Structures **120** and **123** to **127** sit to the south of **115**-**118**. All are well served by the tramway network, but they are more widely spaced apart than building remains in the parts of the factory described so far.

The most northerly of these structures is **120**, a small featureless concrete foundation (9.5m x 6.5m) enclosed by a C-shaped earthwork traverse to its south and a straight section of mound to the north. The earthwork embankment of a tramway runs between the two mounds and along the north edge of the foundation, connecting **120** with structure **115** and to a junction adjacent to **124**. Structure **120** is clearly depicted on the 1908 25-inch OS map, with what looks like a short section of double tramline immediately west of the building, possibly a passing place or holding area (see Figure 16). The historic mapping also highlights the fact that **120** was previously connected by tram to **117**; ephemeral traces of this earlier line were recorded during the survey and are now partially overlain by a small earthen mound.

Structures 124 and 125

Structures **124** and **125** are two featureless rectangular concrete building foundations, east of **120**. Both measure roughly 14.5m x 9m, with hints of a former brick superstructure, and traces of a lower concrete tram-bed and the remains of iron tram rails running beside their south edges. Whereas **124** is bounded on the northern side by a C-shaped earthwork mound, **125** is left completely open; this may reflect a difference in function between the two buildings, or that blast protection may have been deemed unnecessary for **125** because it sits in a more isolated position away from adjacent buildings and tramlines. Neither appears on the 1908 25-inch OS map.

Structure 127: cordite drying stove

Structure **127** is south-west of **125**, along a narrow and poorly formed embanked tramway or path. It comprises a fairly square building foundation, 16.5m x 13.5m in plan, with remnants of an asphalt floor and traces of four equally-sized internal divisions laid out as a quadrant. The slab is enclosed by a triangular arrangement of straight earthen mounds along the north and south-west edges, and a tramway along the south-east (Figure 95). A second tramway serves the north side of the foundation and connects it to **126** to the west and to **123** beyond. The foundation is one of a series of distinctive four-room buildings recorded across much of the north-east quarter of the whole site. In plan form it is directly equivalent to the better preserved examples of **143**-**146** to the

Figure 95: Structures (clockwise from top) ***127****,* ***126****,* ***123****,* ***120*** *and* ***124****, from the air looking south-east. Extract from NMR 26890/043 08-Mar-2011, Damian Grady © English Heritage.*

south, which all have evidence for brick superstructures. Structures **127** and **143**-**146** are also equivalent in plan form to the 20 reinforced concrete four-room buildings: **153** and **154** at the southern edge of **Area E**, and **205**-**212** and **222**-**231** covering much of **Area K**. Details in the 1923 sales particulars for HM Cordite Factory (MALSC 06a_DE_Series_1001_1200/DE1087_3) identify the reinforced concrete buildings of **Area K** as cordite drying stoves and, based on this analogy, structure **127** (as well as **143**-**146** and **153**-**154)** has been interpreted as a set of four conjoined cordite drying stoves sharing a single structure. Structure **127** is absent from the 1908 25-inch OS map, as are all cordite drying stoves of this physical form, suggesting their form is a later adoption.

Structures 123 and 126

Structures **123** and **126**, located west of **127**, share several traits with one another. Each is completely enclosed within an earthwork traverse with a footprint of roughly 32m x 27m, with openings on the east and west sides allowing the line of a tramway to enter and exit along the southern edge of the building platform (*see* Figure 95). A narrow depression in the north stretch of both traverses could represent the entry or exit point for a pipe serving the building. The internal remains of both buildings comprise a rectangular concrete foundation, 12-14m x 8m, punctuated by three large parallel rectangular holes with chamfered edges running the length of the slab. A slight projection that could indicate the position of a door was recorded at the east end of the slab for **123**. Like a number of similar forms across the site, it is unclear whether these holes represent spaces for tanks, or whether they were to encourage air circulation under a timber floor for a magazine or drying room. The main difference between these two structures is the form of their associated waterlogged borrow-pits: whereas **123** is almost entirely enclosed by borrow-pits hugging the external line of the traverse, **126** is bracketed to the north and south by a pair long borrow-pits. The 1908 25-inch OS clearly shows both **123** and **126**. At this time (1907), structure **126** was open to the east, the traverse extension on this side was probably added when neighbouring building **127** was erected sometime after the OS survey was completed (*see* Figure 16).

Acetone recovery group

Structures 129 to 131: acetone recovery stoves (formerly cordite drying stoves)

Moving south, the next block of factory remains encountered are **129**, **130** and **131**. These are three very similar long east-west slabs, all with traces of a double row of cells or compartments along their length. The ground between these buildings is crossed by a number of open brick culverts apparently converging at structure **132**, a complicated central foundation covered with various plinths and iron fittings (Figure 96).

Structures **129**, **130** and **131** form a coherent trio of slabs, all characterised by the same surface features but varying in their degree of visibility and preservation, the only distinct difference being that structure **129** alone is enclosed on three sides by earthwork mounds. The large concrete foundations measure around 56m x 9.5m in plan, and a 1.8m-wide concrete tram-bed with several surviving portions of iron tram rails adjoins the long north and south edges of each slab. The slabs are each divided along an east-west line by the witness marks of a central brick spine wall, with shorter perpendicular partition walls projecting from it to create twenty back-to-back compartments in two lines of ten, with the spine wall forming the back wall for each. Further witness marks along the length of the foundations, appearing most commonly as vegetation lines, were noted in the probable position of the front walls of the compartments, set a short way back from the terminal ends of the partition walls to create a protective screen between each cell, and each with a central opening for a door. Along the back of each line of compartments, a square-section channel was recorded running for the length of five cells and turning at right angles at the centre of the slab where they enter or exit the building on the south side of **130**, and on the north side of **131**; this detail is not visible on the remains of **129**, which is subject to greater grass encroachment than the other two (*see* Figure 96). It is thought likely that these channels carried under-floor pipes. Details surviving on structure **131** suggest that a slightly raised concrete floor extended across the top of these channels, enclosing the pipes below, and remnants of asphalt floor surfacing were noted in **130** (Figure 97).

On 29 April 1914, an explosion in cordite stove 'T22' killed labourer Job Geer, who had been carrying out alterations to convert the cordite stove into an acetone recovery stove. The official accident report prepared by Major H Coningham (1914) provides a useful description of the building, which can be identified by its form, location and dimensions as equivalent to the eastern half of structure **129**, which must have been extended from ten stoves to the twenty stoves now visible at some point in the subsequent years. Details of the accident allude to a building situated 13yrds (12m) from a drainage ditch, and surrounded by a protecting mound; both the 1908 25-inch OS map for this area and the EH survey data show **129** as the only structure in this group of three which was bounded by an earthwork traverse, and as being only half the length of the current foundation. Coningham describes the building ('T21-T30') as comprising ten licensed cordite stoves arranged in two back-to-back rows of five compartments either side of a central, 14-inch wide (0.36m), east-west brick spine wall. Narrower 9-inch wide (0.23m) brick partition walls, projecting above the roofline to act as fire walls, separated the individual compartments. The external front wall of each compartment or cell was constructed of corrugated iron with a central doorway; the witness line

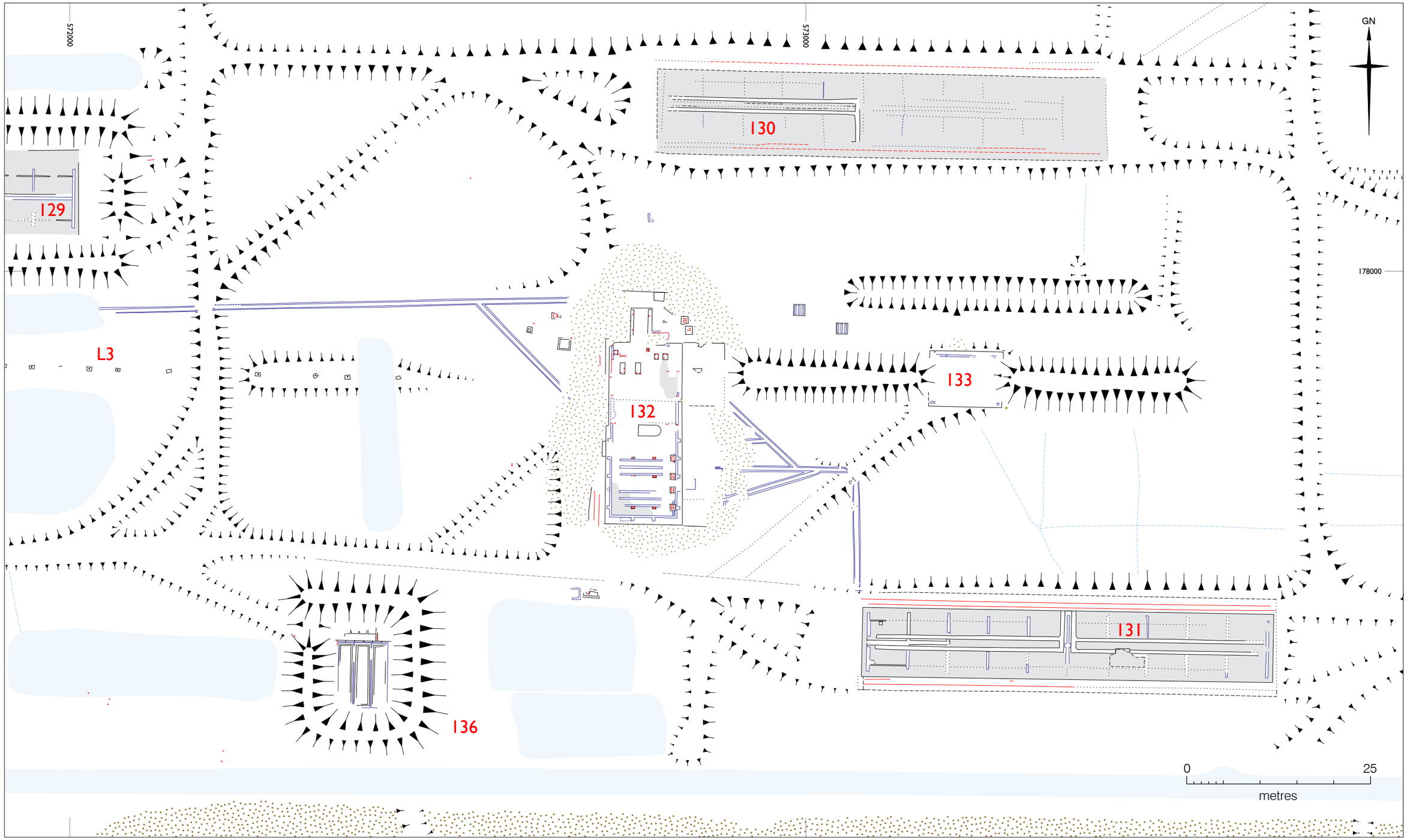


Figure 96: Remains of the acetone recovery facilities. at the southern edge of ***Area D****. Drawn by Philip Sinton © English Heritage.*

*Figure 97: Structure **131** showing the channels in the concrete slab and the remnants of asphalt flooring, looking west. NMR DP141563 07-Mar-2011, Steve Cole © English Heritage.*

of this wall with its regular doorway openings was picked up particularly clearly when surveying the remains of structure **129**. According to Conningham (1914), the whole structure was roofed with corrugated iron sheets on a timber frame, and the walls of each compartment were fitted with wooden match-boarding. Both the walls and ceiling were lined with soldered zinc sheets, producing cells with internal dimensions of 17ft x 9ft (5.2m x 2.7m) in plan and 7ft3in (2.2m) tall, corresponding closely with the surveyed evidence for structures **129**, **130** and **131**. The concrete foundation was floored with *Val de Travers* asphalt, three quarters of an inch thick, which was continued up the walls for a couple of inches to create a tight seal with the zinc-covered walls. Converting the cordite stoves into acetone (solvent) recovery stoves included fixing acetone recovery pipes in place and filling the void between the iron front wall and the match-boarding with asbestos waste. Coningham notes that by April 1914, twenty-six cordite stoves had been converted over the past twelve months - six in this block, and presumably a further twenty relating to structure **130** or **131**. A final note in Coningham's report suggests that new cordite stoves, presumably to replace those converted for acetone recovery, had recently been constructed using the preferred modern method of facing walls with neat cement, rather than using a separate lining liable to create potentially dangerous 'traps' for nitroglycerine to build-up (Coningham 1914). Precisely when, after Coningham's report, structure **129** had its capacity doubled is unknown, but presumably it took place at a similar time to when HM Cordite Factory was developed in early years of the First World War. Structure **129** also seems to be referred to as building "No. 40', cordite stoves', in the accident report for an earlier incident in December 1902 (Cooper-Key 1903, 5).

*Figure 98: Structure **132** from the air showing the complex layout of plinths and hints of the network of brick-lined channels connecting it to the acetone recovery stoves either side, looking north. Extract from NMR 26890/048 08-Mar-2011, Damian Grady © English Heritage.*

Structure 132: acetone recovery house and yard, with associated brick-lined culverts

Between the trio of acetone recovery stove buildings is structure **132**, a concrete building foundation with an array of surface features including plinths, dwarf walls and floor drains. The main foundation measures approximately 25m x 10m in plan on a north-south alignment (Figure 98). A narrow projection at the north end appears to form an entrance flanked by thick dwarf concrete walls, leading out to an ancillary building or yard. At the north end of the main building foundation are the remains of a floor of acid-resistant hatched blue bricks, topped by several low concrete plinths of varying dimensions. A further two possible opposing east and west entranceways are identifiable as smooth blue brick thresholds with large iron floor fittings, just north of the centre of the slab. To the south of these opposing doorways, the footings of a brick superstructure were recorded around the perimeter of the foundation; the wall included small integral brick buttresses at 2m intervals, potentially indicating a building of more than one storey in height. A large concrete machine bed stands close to the entrances, and south of the plinth are two sets of parallel dwarf brick walls on an east-west alignment. Along the southern stretch of the east wall is a row of concrete cubes faced with cement render and traces of bitumen. Each cube-shaped plinth has a semi-circular arched recess in its base, which mirrors and is aligned over a semi-circular floor drain of shaped blue-bricks; adjacent are remnants of an acid-resistant hatched blue brick floor (Figure 99). The main slab is adjoined along the length of its east side by a lower concrete floor or yard. The layout, size and features of this building and its ancillary structures are reminiscent of the remains of structure **243**, recorded in the later acetone recovery plant to the south-east belonging to HM Cordite Factory, described in primary documents as 'TA2', a 3-storey acetone recovery house with adjoining blue brick yard (MALSC 06a_DE_Series_1001_1200/DE1087_3); as such, **132** is considered to have had

*Figure 99: (above left) The blue brick drain beneath concrete plinths in structure **132**, looking north-west. NMR DP141555 07-Mar-2011, Steve Cole © English Heritage.*

*Figure 100: (above right) View along one of the open brick-lined drains close to structure **132**. NMR DP141549 07-Mar-2011, Steve Cole © English Heritage.*

the same function. In support of this theory, structure **132** does not appear on the 1908 25-inch OS map map, as at the time of the map's revision (1907) the nearby buildings of **129**-**131** were still being used as cordite drying stoves. Structure **132** was almost certainly constructed around the time that these ranges were converted to new acetone recovery facilities.

A distinctive feature type specifically related to structure **132** that is not found in association with **243** (243 may have had elevated pipes instead), is a series of open brick-lined drains or culverts beginning as several drains exiting **132** from its east and west side, before converging into a single drain (Figure 100). To the west, the open drain can be traced for around 66m, at one point purposely channelled beneath a crossing tramway embankment, until it meets the edge of a waterlogged borrow-pit flanking the southern earthwork mound alongside **129**. To the east, the drain turns through 90 degrees as it is channelled beneath a tramway before apparently ending close to the north-west corner of **131**; at this point, a remnant of salt-glazed ceramic pipe survives within the culvert. The pipelines that once occupied the culverts probably related to the process of acetone recovery; however, the culverts do not appear to connect all the acetone recovery stoves in the group to the acetone house and, in particular, structure **130** does not seem to have an associated culvert.

Structure 133

The remains of building foundation **133** are sandwiched between the ends of two east-west aligned earthen banks and raised on an earth platform served by a tramway embankment to the south-west (*see* Figure 96). A long narrow borrow-pit runs 6m north of, and parallel to, the banks. The concrete foundation is 10m x 7.5m in plan, with fragmentary traces of a brick superstructure for a building 9m x 6.5m. Structure **133** and its associated borrow-pit and banks appear on the 1908 25-inch OS map, and

clearly relate to the wider cordite and acetone processing group (see Figure 16). A short distance north-west of **133** are a pair of square concrete bases, each topped by three parallel brick bases for walls or narrow plinths, surviving to a height of 0.3m. The function of these foundations is uncertain, but based on the configuration of the acetone recovery group for HM Cordite Factory in **Area J**, it is thought likely that structure **133** represents the remains of a boiler house providing steam to heat the stoves. Alternatively, it could represent a pump house similar to **242**; but, given the concentration of drains, the pump house might have been an ancillary structures to **132**.

Structure 128

The small structures of **128** and **137** are located at the far east edge of **Area D** on the west bank of the north-south aligned drainage dyke; both are positioned at the terminus of tramways leading east from the acetone recovery group (**129** to **133**). Structure **128** is a small rectangular concrete building platform, enclosed on three sides by an earthwork traverse and served along its southern open side by a tramway, with iron rails and concrete tram-bed recorded in situ. It is worth noting that this tramway embankment appears to have bridged the drainage dyke to continue east for a further 37m; curiously though, it does not continue quite far enough to connect this area to the later grid-plan expansions. The tramway embankment widens in the stretch adjacent to the building foundation and could represent a short section of split track allowing carts to either attend the building or to pass by unobstructed. Neither **128** nor the tramline serving it had been constructed at the time of the 1908 25-inch OS map revision.

Structure 137

At the end of another east-west embanked tramway, a short way south of **128**, is structure **137**, visible as the corner of a concrete building foundation protruding from encroaching grass cover. Traces of another platform of similar size and the ephemeral line of a tramway branch line are also visible just north of **137**, appearing to mark the position of a second building. The 1908 25-inch OS map confirms that this was the case; it clearly shows a pair of diverging tramlines, each terminating at a small building on the west edge of the drainage dyke (see Figure 16). Their location could indicate a function relating to the movement of goods by water.

Structure 134

Structure **134** is a small rectangular concrete foundation. It is located between **129** and **135** but its alignment and position may link it more closely to the functions of structure **114** or to the alignment of concrete post supports of **L3** to its north. The coarse concrete foundation measures 6m x 7m in plan, is 0.1m high, and is topped by two dissimilar small concrete plinths with iron studs in the top. It was noted at the time of the 1907 25-inch OS map revision and illustrated alongside a footbridge leading directly between it and a building in the position of **114** (see Figure 16).

Structures 135 and 136

In the south-west corner of the area dominated by the acetone recovery plant, is a pair

of rectangular earthwork traverses, each enclosing the concrete foundation of a small building (**136** and **135**). A short tramway branch enters **136** through a narrow opening at the north-west corner of the traverse. Inside is a concrete foundation, 9.2m x 7.5m in plan, punctuated by three elongated rectangular holes that take up the majority of the slab, with traces of brick lines along the top of the divides between these voids. In this respect, the building base is similar in form to that of nearby structures **123**, **126** and **141**; the spaces may have had a specific function, such as holding tanks, or they may have served to increase air circulation around the wooden floor. There appears to have been a small porch or lean-to at the north end of the foundation, possibly to receive a bogie cart for loading and unloading. A short distance to the west is **135**, a slightly larger structure on an east-west alignment, with its access point through a narrow opening towards the north-east corner of the mound. The internal concrete foundation is largely masked by a thin spread of spoil and fragmentary brick debris, through which a handful of rough-edged holes were noted. The slab measures approximately 11.2m x 7m in plan, with an indication of a former brick superstructure. Two round-section wooden posts stand close to the structure: one inside the mound at the southern edge of the building platform, and one set into the external west face of the earthwork. Both buildings are depicted on the 1908 25-inch OS map, on which the active tram network of 1907 is shown as far simpler than the remnant embankments in this area might otherwise suggest (see Figure 16) (ibid). Immediately south-west of **135** is a good example of stratified reworking of the factory layout; a tramway embankment running SW-NE is clearly truncated by **135** itself, and by the line of a more recent tramway heading south-east towards the cordite drying stoves known to be of a later date. This earlier tramline is not shown on the OS map, presumably having gone out of use before the 1907 survey revision.

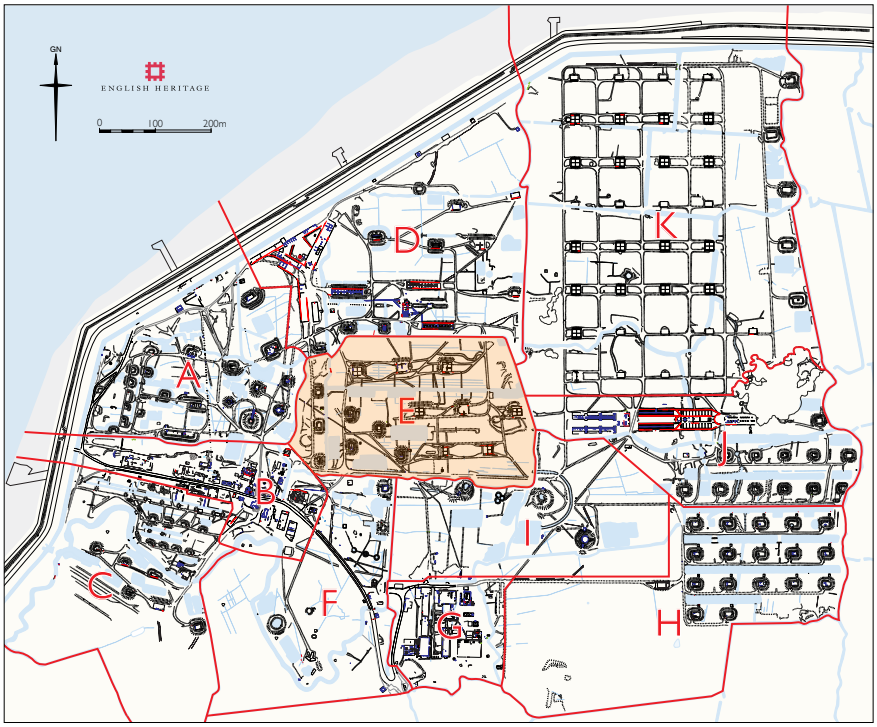
The specific function of these buildings is not known. The presence of traverses suggests that they were danger buildings and their close location to known nitroglycerine and cordite processing areas probably indicates an association. As such, one possible interpretation is that **135** and **136** were mixing houses, used either for mixing cordite paste fresh from the nitroglycerine factory in **Area A**, or for mixing other nitroglycerine based explosives such as blasting gelatine, gelatine dynamite or gelignite (see section 4.2). If these structures do mark the position of cordite paste mixing houses, descriptions of paste mixing house 'No. 18' given in an official accident report following a fatal explosion in 1902, show that they would have been wooden buildings on thick concrete foundations, with adjoining porches (Cooper-Key 1903). Varnished match-boarding lined the internal walls and ceiling, the roofs were of corrugated iron, and the floors were lined with lead sheeting, kept wet at all times. In here, the nitroglycerine-soaked guncotton was roughly mixed by hand and rubbed through a ½inch mesh of copper wire into a sail-cloth bag (ibid).

Structure 138

Following the main tramline west from **135**, it soon branches north and south, connecting it back north to the large triangular cordite processing complex in **Area D**, and south towards a neat row of rectangular earthwork traverses. The first of these structures is **138**, set on an east-west alignment and served by a short branch of tramline entering at the north-west corner. The structure comprises a largely grassed over, small building

foundation with an L-shaped mound bounding its west and south sides, a slightly lower straight section of mound along its north side, and its east side open to the adjacent drainage dyke. Where visible beneath the encroaching vegetation, the concrete foundation slab shows remnants of an asphalt floor, and at its east end there is a small concrete plinth topped by narrow threaded iron studs. This building and its pair of protective mounds are shown on the 1908 25-inch OS map, which depicts the internal structure as a pair of buildings: a larger building by the tram connection at the west side, and a smaller ancillary structure in the area where the small plinth or machine bed survives (see Figure 16). Again, the function of this building is uncertain. As with **135** and **136**, one possible interpretation is that it was a mixing house of some sort. Alternatively, the physical remains and the 1907 OS surveyor's depiction of the **138**, both indicate a small ancillary structure to the east; this might have been a fan shed which would infer that **138** was a drying stove.

6.10 Area E: guncotton drying stoves and cordite drying stoves



***Area E** shaded orange.*

Area E is a roughly trapezoidal area of land created by the pattern of drainage dykes at the centre of the factory, and filled by two distinctive structure groups interconnected by a complex network of tramway embankments (Figure 101). The south-west side of the area contains seven evenly spaced concrete building foundations, each tightly encircled by a protective earthen traverse (**139**-**141** and **149**-**152**). Most of these have been interpreted as guncotton drying stoves, based on the presence of small exterior hut bases comparable with the known fan sheds associated with the guncotton stoves in **Area H** belonging to HM Cordite Factory (**267a**-**283a**). In contrast, the north-east side of **Area E** contains the remains of eight square concrete building foundations, each with evidence for four-rooms in a square arrangement (**143**-**148** and **153**-**154**). Using comparable examples in **Area K** of the HM Cordite Factory site (**206**-**212** and **222**-**231**),

Figure 101: ***Area E*** *viewed from the air, looking west, with cordite drying stoves in the foreground and guncotton drying stoves at the top of the image. NMR 26890/013 08-Mar-2011, Damian Grady © English Heritage.*

these are believed to have been cordite drying stoves. The eight structures survive in dramatically varying states of repair, from stripped-bare concrete foundations (**143**-**148**), to partially standing roofless structures (**153** and **154**).

Apart from structures **139**-**142** along the west edge, the 1908 25-inch OS map depicts **Area E** as undeveloped (in 1907), with the factory presence largely established on land to the north-west and south-west (see Figure 16). Due to its proximity to areas already developed, this part of the site would likely have been the next 'greenfield' parcel to receive attention in the expansion of the factory. Interpretation of the structures in **Area E** is based on direct comparisons with the eastern side of the site where contemporary documentation for the auction of HM Cordite Factory, in 1923 contains a set of basic descriptions of the function and construction of the buildings (MALSC 06a_DE_Series_1001_1200/DE1087_3). The similarity in form and style of construction of the structures in this area, compared to those recorded to the east, is so absolute that a confident assessment has been made that these buildings shared the same functions and were erected at a similar point in the factory's expansion. Furthermore, it may be possible to expand the story of this area's development by suggesting that cordite drying stoves **143**-**148**, **153** and **154** were built by or during 1913 to replace **129**-**131**, which were converted to acetone recovery stoves between late-1913 and early-1914 (see section

6.9). Construction of the visibly similar structures of HM Cordite Factory was instigated shortly after this in response to the outbreak of war.

Structures 139 to 142

Along the western edge of **Area E**, and forming a neat alignment with **138** to the north, is a row of three rectangular earthwork traverses spaced at regular intervals (**139**, **140** and **141**). Each traverse has an overall footprint of approximately 30m x 21m, enclosing an internal space measuring 10m x 5m. All three structures are served by a single tramway embankment running north-south along their external west edge, and accessed by a narrow opening through the mound. In both **139** and **140**, a low scarp or bank was recorded close to the entrance, separating the threshold from the building platform beyond. A thin spread of spoil and small pieces of building rubble covers the interior of both structures, and a square-section wooden post was recorded at the entrance to structure **140**. The partial outline of a concrete foundation punctuated by three large rectangular voids is visible within the interior of structure **141**, similar to those recorded in structures **135** and **136** just north of this area. Vegetation makes it is unclear whether the floors of **139** and **140** were of equivalent construction.

Equidistant between the traverses of **139** and **140** is structure **142**, a small lone concrete foundation, 6m x 4.3m in plan and 0.2m high. At the eastern edge of the slab is a low rectangular concrete plinth, with narrow iron studs protruding from its top. The faint trace of a building outline on the surface is suggestive of a former light timber superstructure. Abutting the south side of the foundation is the base of a square-section wooden post, either a lamp post erected adjacent to a window, or the support for pipes or cables associated with the building. The long straight line of the culverted drain **L4** (*see* section 6.2), passes close to **142**, but with no apparent relationship.

The 1908 25-inch OS map depicts **139** and **140** as open (without traverse) on their east side, because the adjacent area was still undeveloped at that time of the revision (1907), and structure **141** is shown without any protective mound at all (*see* Figure 16). All three structures were located a similar distance from buildings to their west in 1907, as such this difference in layout suggests that the processes undertaken within **139** and **140** differed from those performed in **141**; if they had performed the same function, then they would all have been subject to the same safety regulations, including the requirement for provision of protective blast mounds.

An official accident enquiry describes a pair of guncotton drying stoves erected early in 1903 (known then as buildings 'No. 48' and possible '41'), as sharing a single heater (fan shed) that was located equidistant between the two (Desborough 1904). This may describe the arrangement of structures **139**, **140** and **142**, although at least one of these buildings would have been rebuilt following the fatal explosion.

Structures 149 to 152 and 149a to 152a: guncotton drying stoves and fan sheds

Structures **149**-**152**, the four guncotton drying stoves, have fairly uniform earthwork traverses with an average footprint of about 31.5m x 25m, creating a near-complete

sub-rectangular protective bank around a central rectangular building platform. A break in the bank towards the south-west corner creates an access point into each structure from the adjacent tramway. In **152**, a low ridge across this opening seemingly truncates the line of the tramway: this could indicate that the tram rails terminated several metres outside the building, probably for safety reasons, meaning that guncotton was carried in and out by hand. Slumped traverse material resulting from subsidence is apparent along the internal east and west faces of **149** and **151**; slight breaks of slope along the inner long edges of **150** and **152** could denote the beginning of a similar process of destabilisation. Inside each traverse are the remains of a concrete building foundation: all are now partially covered by encroaching grass, but where visible they average 9.5m x 5.1m in plan. Evidence for internal features is extremely limited, but there are traces of a brick divide 3.2m from the south end of each floor slab. These probably represent the location of a wall line (possibly a dwarf wall) with a central opening, providing a demarcation between the 'clean' and 'dirty' areas of the building.

A short distance north-east of each traverse are the coarse concrete remains of small fan sheds, each comprising a floor slab topped by a smaller raised plinth or machine bed, with traces of bitumen noted on the floor slabs and plinth sides (**149a**-**152a**). Three slightly differing forms of foundation and plinth were noted in this group: the remains of **150a** and **152a** are very similar, while those of **149a** and **151a** are not directly comparable with these or with each other. The foundation slabs for **150a** and **152a** measure about 4.3m x 3.7m, and are crowned by square plinths, 1.2m across, positioned towards the north-east corner with a rectangular impression and six iron studs in the top of each. The foundation for fan shed **149a** measures 5m x 3m and has no obvious evidence for an accompanying machine bed. Structure **151a** measures 2.6m x 1.4m and on its surface is a plinth 1.2m square x 0.24m high, with six iron studs, a T-shaped impression and a rectangular impression in the top. This variation may simply represent use of fans or motors from different manufacturers, thereby requiring differently shaped machine beds. In line with the fan sheds, there is a noticeable depression in the top of each traverse; here, hot air from the fan was piped into the stove to facilitate the drying process.

If this group is interpreted as equivalent to and largely contemporary with guncotton stoves **267**-**283** and fan sheds **267a**-**283a**, then it can be presumed that they were all constructed in the same manner. That being so, descriptions in the 1923 sales particulars can be used to infer that the buildings formerly associated with **149**-**152** were constructed of canvas-lined brick walls, with a timber and corrugated iron roof and asphalt-surfaced floors. Likewise, the accompanying fan sheds were probably built of timber and corrugated iron walls and roofs, constructed on concrete floors (MALSC 06a_DE_Series_1001_1200/DE1087_3). The tramlines associated with these buildings connect them to each other and to factory areas to the north and west, but also seemingly to the nitroglycerine factory in **Area I** to the south and the acid and guncotton processing complex in **Area G** beyond. Interestingly, since **Area G** and parts of **Area I** are known to belong to the wartime establishment HM Cordite Factory, this could mark another place in the factory where the two sister operations were physically connected (that is, the earlier factory elements in the west and HM Cordite Factory in the east).

Central drain **L5** runs through the centre of this group, neatly carried by culverts underneath the tramways (see section 6.2). However, it does not appear to relate to the stoves in any functional or physical way.

Nearby, a slightly staggered line of five or more square-section wooden posts on a north-south alignment seen protruding from the water in the borrow-pit immediately north of structure **152**, is more likely to relate to the guncotton stoves (Figure 102). The tops of most of these posts have broken off or rotted away, but one post towards the centre of the group stands much taller than the others and has an iron hook attached to the top. No obvious start point or destination for the alignment has been identified, but it probably carried pipes or cables across the water. It may be linked to the narrow gullies running north, south and north-west from the edge of the pond, but they do not quite line up and the gullies could belong to the general site drainage system.

*Figure 102: Wooden posts in the water-logged borrow-pit north of guncotton drying stove **152**, looking north. Photograph: Rebecca Pullen 2011 © English Heritage.*

Structures 143 to 148 and 153 to 154: cordite drying stoves

The north-east portion of **Area E** is covered by eight square structures arranged in three east-west rows: the southern pair (**153** and **154**) have partially intact reinforced concrete walls, and as such, initially appear quite different from the other six which survive only as concrete bases (**143** to **148**) (Figure 103). However, the remains of all eight structures include identical concrete building foundations, roughly 16.5m x 14m in plan, with evidence for a square arrangement creating four discrete internal spaces, and frontages served by tramways to the north and south, making this a coherent group of cordite drying stoves constructed in individual blocks of four stoves, with a clear adoption of new construction methods (a change from brick to reinforced concrete) partway through development of the area.

Figure 103: The two forms of cordite drying stove remains present in ***Area E****, showing (top) the floor plan remains of former brick structure* ***147****, looking south-east, and (bottom) the standing reinforced concrete remains of structure* ***153****, looking north-east. Photographs: Rebecca Pullen 2011 (top) and Wayne Cocroft 2010 (bottom) © English Heritage.*

In the six examples without superstructures (**143**-**148**), wall scars divide the space into four equally proportioned rooms, each with internal dimensions of 7.2m x 5.9m and several of which have remnants of asphalt flooring adhering to the concrete. Structures **143**-**145** all exhibit evidence that the external and partition walls were constructed of

brick, rather than concrete as seen in equivalent standing structures **153** and **154**. All six slabs are accompanied by a protective earthen bank along their north side and, for all but structure **146**, along either the eastern or western side as well (*see* Figure 101). Iron bolts or wooden posts survive next to several of the traverse openings through which tramways entered the drying stoves. These are presumed to be tie-pins and support posts for wooden or corrugated iron shuttering used to prevent subsidence of bank material onto the track.

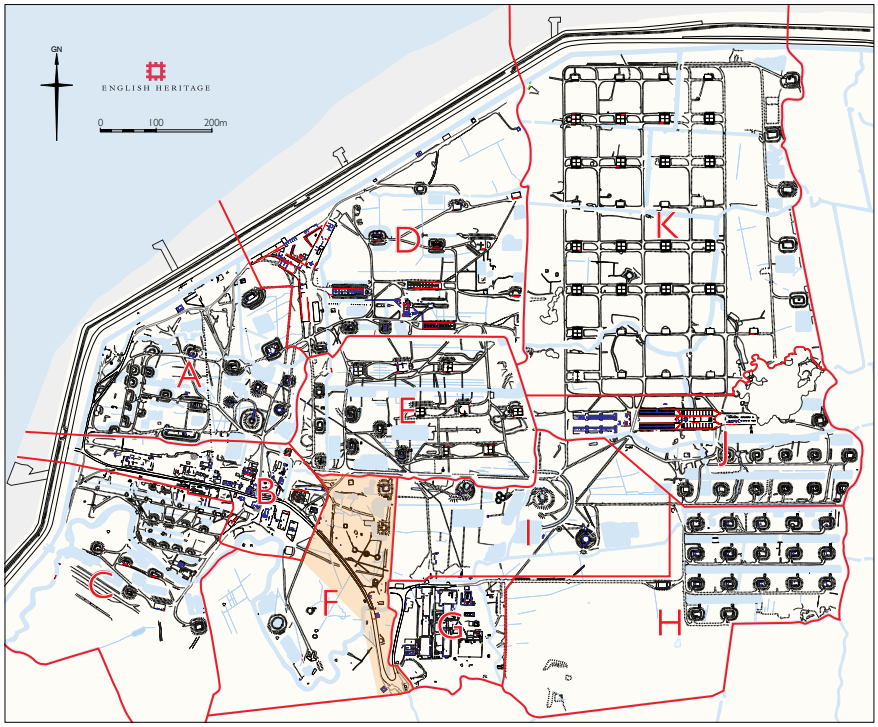
Structures **153** and **154** have superstructures of reinforced concrete. This move from the more traditional brick construction to the use of 'ferro-concrete' reflects a change in philosophy and the adoption of what was deemed a safer construction method. Traverses were utilised only for the brick-built stoves because the two construction materials respond differently to an explosion: whereas brick buildings produced a shower of missiles in the event of a blast, reinforced concrete was anticipated to collapse inwards, and therefore not to require traverses (Guttmann 1908b). This philosophy is reflected in the remains at Cliffe. Earthen traverses are not present in association with the cordite drying stoves that have a reinforced concrete superstructure. Reinforced concrete appears to have had little uptake as a staple building material in the wider British explosives industry (Cocroft 2000, 103-4) and, as such, the examples on the Cliffe site represent a very rare survival (see sections 4.3, 8.3 and 8.5). The fact that brick has a potential reuse value probably explains why the superstructures for buildings **143**-**148** have been dismantled and removed, whereas the superstructures of those built with reinforced concrete, a single-use material, still stand (*see* Figure 103).

In structures **153** and **154**, the east and west walls form gable ends, and the north and south walls each comprise a pair of front elevations with wide central doorways. However, in both cases the two back-to-back stoves forming the western half of the buildings are in an advanced state of collapse (*see* Figure 103). The central wing wall, running north-south between the side-by-side stove pairs, projects beyond the front wall and forms a barrier eliminating any potential continuation of the tramlines approaching the doorways from either side. A central spine wall runs east-west through the middle of the building, forming the back wall for all four stoves. Witness marks on the internal faces of the gable and wing walls betray the former presence of a lightweight pitched roof fixed slightly below the full height of the walls, and holes through the front walls of each stove mark the previous location of various pipes and fixtures. In addition, the continuation of roof scars along the projecting section of the wing walls, along with remnants of asphalt flooring, and the abrupt ending of tram rails suggests the presence of small corrugated iron porches against the external faces of the front walls and backing onto the wing walls. Seventeen directly comparable examples for structures **153** and **154** are located to the north-east in **Area K** (**206**-**212** and **222**-**231**) (*see* section 6.17 for example drawings and detailed descriptions for directly equivalent buildings in **Area K**).

Along the north and south edges of all eight foundation slabs, rectangular concrete forecourts mark the terminal points for tramway branch lines and, in some cases, short segments of iron rails remain in situ. Overall, the embanked tramways follow a complex pattern on a sinuous grid leading between the cordite drying stoves in **Area E**. The tramways serving structures **153** and **154** are unusual in that they have been laid out so that carts could either bypass the stoves on a continuous line, or branch off

into the buildings. This does not match the layout used for the slightly earlier brick-built stoves to the north, or to the large cordite drying stove complex in **Area K** of HM Cordite Factory to the east. East of **148** and south-east of **154**, the tramlines appear to have once crossed the drainage dyke and connected to land belonging to HM Cordite Factory, providing another physical link for movement between the two processing establishments.

6.11 Area F: north-east portion



***Area F**, north-east zone shaded orange.*

Located south of guncotton drying stoves **149** to **152**, **Area F** is bisected by the main site road to create two distinct zones. North-east of the road are two large square traverses and a series of drains, tanks and circular settling ponds, indicating another explosives processing area. Along the edges of the road south of this, the remains of several small buildings thought to relate to access (guard huts or similar) could relate to the changing position of the main factory entrance. South-west of the road is a largely undeveloped area of open marsh crossed by several drainage gullies, with an unusual concrete footing and a pair of large circular hollows reminiscent of exploded buildings grouped along the far south-west limit of the area (*see* section 6.12).

Structure 155 to 157

Structure **155** is a simple concrete surface, largely concealed beneath a thin covering of grass, measuring 8.2m square with traces of a brick wall scar in the south-west corner. Interestingly, the 1908 25-inch OS map for this area depicts a structure close to, but not precisely in, the position of **155**, as a rectangular building surrounded by a rigid square traverse with an opening in the west side to receive a tramline (Figure 104). Two waterlogged borrow-pits still present to the south of the **155** are also shown on the

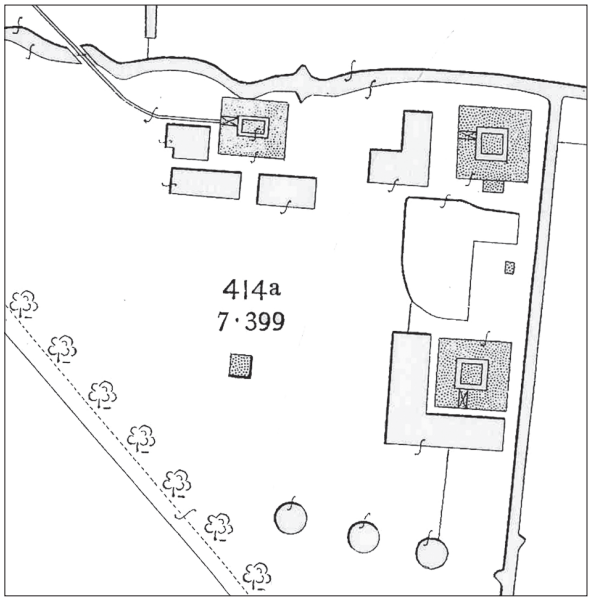


*Figure 104: Structures **155**, **156**, **157**, **158** and **159**, as shown on the 1908 25-inch OS map (revised 1907) - note the atypical depiction of the traverses as solid rather than hachured (Ordnance Survey 1908a; 1908b).*

1908 OS map, whereas a third borrow-pit seen on the map adjacent to the south-west corner of **155** is no longer evident on the ground, having presumably been backfilled with material from the dismantling of the missing traverse.

East of **155** and just beyond an L-shaped borrow-pit is structure **156**: a fairly square, steep-sided earthwork traverse with banks 7-10m wide and an overall footprint 30m in diameter, the eastern side of which has been badly damaged by burrowing. At the north and south ends of this eastern side are low gentle slumps or ramped platforms projecting beyond the neat square form of the traverse. At the north end, this low projection corresponds with a dip in the main traverse; it is unclear whether the depression in the bank has a functional explanation, or whether it is the result of erosive action post-dating any industrial use of the structure. There is no equivalent depression in the bank adjacent to the southern projection, but it does form a platform or bank perpendicular to the east end of an in situ 8m-long chamfered concrete beam or kerb.

Access through the earthwork into the internal space of **156** is marked by a dip, rather than a break, in the northern end of the west side of the traverse. The dip is so slight that either there has been considerable subsidence to fill the space, or the building was only ever entered on foot. Within the traverse is a concrete surface, 9.3m square, surrounded by a red brick revetment with rounded corners and a clear entrance gap adjacent to the dip in the traverse (Figure 105). The wall is constructed in English cross bond, measures 0.54m wide (two brick lengths) and stands to a height of 18 courses. Supporting the lower half of the internal elevations are seven or more low, shallow triangular-section small brick buttresses. The northern side of the wall circuit is bowing and cracking with the weight of the earth retained behind it (see Figure 105), and the eastern side has been largely buried beneath material eroding from the heavily burrowed side of the traverse. This internal revetment is unique amongst the factory remains; if other structures once employed this form of construction, then the brickwork has since been removed. Set in slightly from the line of the brick wall is a low narrow concrete kerb visible in two short sections on the floor; this probably formed a full circuit with an internal dimension of 8m square. Earthwork traverses with internal brick walls

*Figure 105: Structure **156** (clockwise from top left): oblique aerial view looking north-west; interior looking west; detail of the north stretch of the internal revetment wall suffering with subsidence. Photographs: Extract from NMR 26890/039 08-Mar-2011, Damian Grady (top left), and two ground shots, Rebecca Pullen 2011 © English Heritage.*

were used successfully to contain an explosion in a nitroglycerine house at the Nobel explosives factory in Ardeer, and the method was soon adopted at RGPF Waltham Abbey (Macdonald 1991 cited in Foreman 2001, 134). Structure **156** could represent a limited adoption of this construction method at Cliffe.

A narrow gully runs for at least 130m in a westerly direction from the south-west corner of the earthwork. It eventually becomes a brick culvert and appears to be heading towards the tank-like structures of **52** and **53** at the east edge of **Area B**. Across the drainage dyke to the east, a probable continuation of the same drain or pipe trench runs east into **Area I**, where it feeds into a complex of drains associated with the guncotton, nitroglycerine and cordite processing areas.

Tracing a line 45m south from the south-east corner of **156**, a stretch of low spread tramway embankment leads to another slightly smaller square-based earthwork traverse with an overall footprint of 25m x 22m (**157**). A break in the north side of the earthwork creates an entrance into the internal space and is flanked by the remains of a

Figure 106: A corrugated iron earth-filled traverse known as a 'Chilworth Mound' shielding the front of an explosives magazine at the Chilworth Factory, Surrey. NMR AA044446, Wayne Cocroft © English Heritage.

wooden post and a pair of iron tie-pins. The 1908 25-inch OS map depicts the entrance to **157** on the south rather than the north side of the traverse, suggesting that some later remodelling has taken place (*see* Figure 104). The bank material has suffered some internal slumping, leaving the interior space fairly small (6-7m across) for the size of the mound. No internal features were noted.

It is worth noting that where structures **156**, **157** and what might be structure **155**, are depicted on the 1908 25-inch OS map, they are the only factory buildings for which the earthwork traverses are portrayed as grey shaded structures with sharp square corners (*see* Figure 104); all other earthworks are depicted with hachures and more rounded corners (*see* Figure 16). Presumably, these traverses were constructed in a different manner, for example the earth may have been covered with corrugated metal sheeting to create 'Chilworth Mounds' (Figure 106).

The specific function of these three structures is not known, but the sturdiness of their associated traverses, perhaps of Chilworth-type construction, indicates a set of large danger buildings handling volatile processes. Their position slightly away from the two identified guncotton and cordite producing complexes might indicate that the trio of buildings were engaged in processes relating to the production of other explosives, perhaps for mixing ingredients to form Cheddites. Cheddites do not require nitroglycerine and so this might explain the distinctive difference in building construction. However, they could possibly relate to production of gelatine dynamite, blasting gelatine, or gelignite, which do all require nitroglycerine.

*Figure 107: Structure **158** (left and centre) as recorded during the survey at the start of 2011, detail of hole cut into the corner to hold a superstructure or cover, and (right) with the sides reduced to ground level, as seen in Summer 2012. Photographs: Sarah Newsome 2011 and 2012 © English Heritage.*

Structure 158: tank

Towards the centre of this area is structure **158**: a large tank constructed of poured layers of fairly course concrete with a slightly stepped profile to create a narrow ledge around the interior (Figure 107). The tank stands to a height of approximately 1m, and measures 6.25m x 6.8m in plan, with internal dimensions of 5m x 5.6m. A series of small rectangular holes were noted cut into the top of the tank walls, and in conjunction with the internal ledge, may suggest the former presence of a superstructure or cover. Narrow gullies betraying the location of drains connect **158** into a network of drains and to the circular ponds **159**. The tank and the ponds are clearly visible on the 1908 25-inch OS map (see Figure 104). Since the English Heritage survey was undertaken in 2011, the standing concrete walls around tank **158** have been reduced to ground level (see Figure 107).

Structure 159: linear trio of settling ponds

Structure **159** collectively refers to a line of three interconnected circular ponds located south-east of tank **158**, all of which were recorded during revision of the OS 25-inch map in 1907 (see Figure 104). Each of the three features measures 10-10.5m in overall diameter; all have a very low encircling earthwork 2-3m in width at the base and a central circular water-filled depression 3-5m in diameter at the top, and are arranged in a straight line with approximately equal spaces of 20-22m centre-to-centre between ponds. Each encircling bank is broken in one or two places to allow drains to feed into and out of the pond. Relative heights above OD recorded along the length of the drains connecting the ponds, suggest a probable direction of fall bringing waste water or acids from concrete tank **158** into the western pond and then filtering south-east through the second and third ponds before running north into the pond adjacent to structure **157**. However, it cannot be ruled out that waste liquid may have been moved through ceramic pipes or by compressed air, in which case the apparent fall in level along the gully may be entirely misleading. The bank around the eastern pond is the most prominent, and earthwork heights diminish slightly from east to west; this may correspond with the increasing depths of the ponds from west to east in response to the fall recorded along the interconnecting drains, thus creating more upcast spoil and higher banks.

These features are thought to represent a group of settling ponds. Waste water or waste acids from various stages of explosives production would eventually reach one or more ponds of this type, which would have been used to separate out any remaining trace of nitroglycerine or other explosives (see section 4.2). The presence of setting ponds close to structures **155**, **156** and **157** could give further clues to their function. For example, it might suggest they were more likely associated with the production of Cheddites than dynamite, because the former involves incorporation of a fatty substance such as castor oil and any excess of oil and nitroglycerine from waste waters could be separated out by settling ponds.

There are more linear drains south of **159**, including a stretch connecting to the pond south of **156** on a line running in between two of the settling ponds of **159**. These drains were narrower and less deep than those interconnecting the ponds, and irregular heights

along the bottom of the gullies do not allow for a direction of fall to be identified. It is possible that these slots denote the line of robbed out pipes.

As well as the drainage gullies, several tramway embankments, some less coherent than others, cross this area. Interestingly, there are lots of connecting routes but relatively few buildings. The ephemeral nature of some of the tramways, especially the two running north in the area to the east of structure **57**, might indicate routes abandoned before the closure of the factory. Alternatively, they might have carried raised footpaths rather than tramlines. This area of drainage gullies is bounded to the south by a stretch of embanked tramway running west towards **Area B** that is truncated by the tarmac road.

Structure 160

A short distance south of this tramway or path, the main road forks, creating an off-shoot leading east. The tarmac surface of this section of road is only seen for around 20m before it is lost under a large spread of earth and rubble, previously it would have continued across the dyke and into **Area G**, the acid and guncotton processing facility for the wartime HM Cordite Factory. Adjacent to the northern edge of the fork in the road is the concrete foundation of a small rectangular building, structure **160**. The slab measures 7.4m by at least 9.5m; the eastern extent of the slab is beneath the earth and rubble. Located at the fork in a road, this might have been a guard hut or gatehouse.

A semi-circular arc of low earthwork bank appends the north edge of the building slab. It is unclear whether this feature relates to the function of the building, but it seems most likely to represent a disused pond, truncated by construction of a later building. Had it formerly been a circular pond its overall diameter would have been about 10.2m, making it very similar in form to those of structure **159**. Arguably, some of the more slight drainage gullies close to **159** could instead be associated with **160**. A cluster of small brick manholes a short distance to the south-west indicate further below-ground drainage in this area. This location is blank on the 1908 25-inch OS map.

Structure 161 and 163

Towards the southern end of the spread of debris next to **160**, is a firm level rectangular area of ground measuring 9m x 4.45m, indicating the location of a concrete slab beneath a thin covering of grass (**161**). The 1908 25-inch OS map shows a building in this location, depicted with a probable west-facing frontage and two small ancillary structures to the rear (see Figure 16). At the time of the 1907 OS revision, structure **161** marked the southern limit of the factory complex; this combined with its position next to the main access track might imply that **161** was a guard hut associated with the former factory entry point, possibly similar to **57**.

West across the track from **161** is the trace of another small featureless concrete slab measuring 5m x 3m in plan (**163**). The date and function of this are unknown, and **163** is absent from the 1908 25-inch OS map.

Structure 162

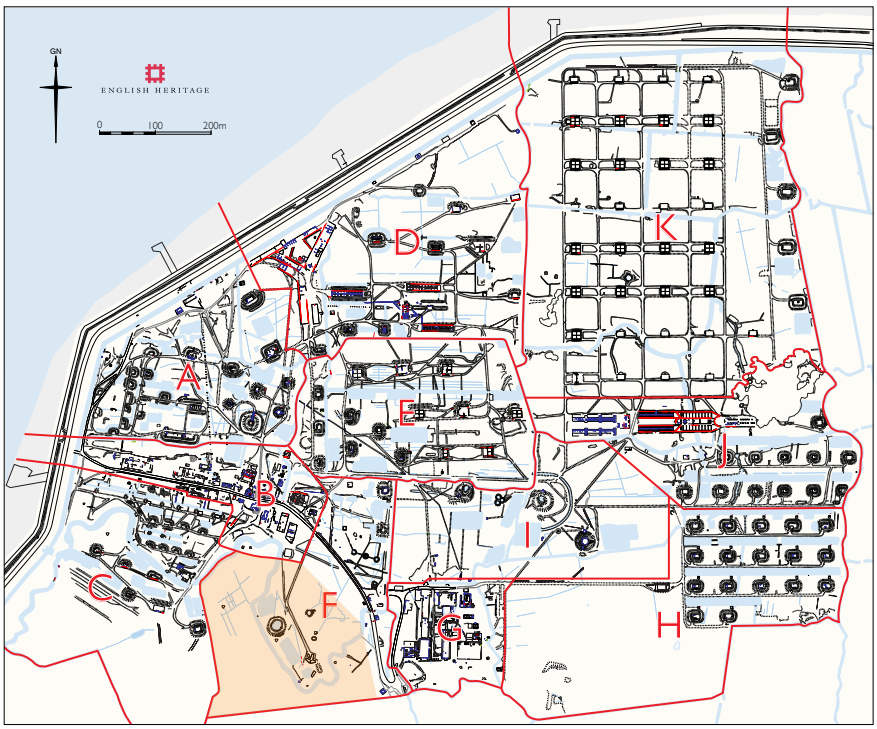
Through the modern gate to the south of **161** and **163** are the remains of a small building immediately east of the tarmac road (**162**). Structure **162** is a concrete foundation, connected to the road by a short stretch of concrete path leading from the north end of the slab. The remains of brick wall footings describe a building 6.6m x 4.1m in plan, divided into three internal rooms or cells, with a pair of small rooms at the north end and a large full-width room to the south. There are traces of a quarry tile floor at the north end of the smaller rooms. Roughly level with the southern edge of **162**, a line of small metal fittings and a central concrete pad cross the width of the tarmac road; these are thought to mark the former position of a double gate across the access road to the factory. Presumably **162** was used as a security point or guard hut to receive those entering the site. Structure **162** is absent from the 1908 25-inch OS map, it might therefore represent a later construction to replace structure **161** if the factory entrance was moved south in response to post-1907 factory expansion. Beyond **162**, the tarmac road continues for a further 140m before meeting the edge of the area of investigation.

Structures 164 and 165

At the southern end of this area (which is also the first point reached when approaching the site by the road from the village), are two concrete slabs located on either side of the approach road (**164** and **165**). Immediately west of the road is structure **164**, a concrete slab measuring 8.6m x 8.2m in plan, with the base of a brick structure 5.1m square at its centre and a length of brick wall footing 5m long at both the north-east and south-west edges. Structure **165** is within an area of modern wooden stock fencing beside the east edge of the road, it comprises a concrete foundation 13m x 4m, constructed either in four individual concrete sections or with internal subdivisions. Neither **164** nor **165** appears on the 1908 25-inch OS map, and neither has a clear function, but their strategic position would suggest a gatehouse or guard room type use. As with **162**, these could represent buildings constructed after 1907, relating to southward movement of the factory entrance and to overall expansions east.

Another possibility is that either one or both of these concrete slabs relate to the factory's water main, the line of which runs diagonally across the field south of **Area G**, bringing water from Cliffe village via a buried pipe. A slight earthwork is visible on modern aerial photographs of the site, and its line was marked approximately on the map accompanying the 1923 sales particulars (MALSC 06a_DE_Series_1001_1200/DE1087_3). In particular, the base of a square structure with brick walls in the centre of **164** could possibly relate to a water tower or pump house.

6.12 Area F: south-west portion



***Area F** south-west zone shaded orange.*

The portion of **Area F** south-west of the road is a largely undeveloped expanse of marshland, crossed by a handful of linear and more sinuous narrow drainage gullies, and bounded on three sides by the 'delph ditch' drainage dyke that marks the southern extent of the factory features. In the south-west corner is a small marginal group of structures hugging the bank of the 'delph ditch' (see Figure 42). The group is served by an embanked tramway approaching from the north-west which splits to allow a short branch to meet structure **103** whilst a longer stretch continues to terminate at structure **105** and nearby **104**. A further raised path or tramway was recorded leading from structure **71** to meet the tram route where it diverges just north of **103**. Additionally, a small low circular earthwork mound or platform thought to pre-date the factory is located towards the centre of the area (see section 5.3).

Structures 103 and 104

Structure **103** is formed primarily by a large low circular bank around a broad water-filled central hollow (see Figure 42). The earthwork has an overall footprint of about 36m in diameter, with an encircling bank 8m wide around the northern side and nearer 12m wide around the southern half, where the external face of the bank has a longer and shallower stepped slope. The large square water-filled borrow-pit produced by construction of the earthwork sits to its north. At the southern edge of the feature a concrete slab, 0.45m high, protrudes from beneath the exterior bank material with a levelled area of earthwork to its north creating a small platform flush with the top of the block. In the south-east area of the earthwork, a number of large fragments of heavy duty brickwork lie jumbled on the surface of the bank, these may have come from a factory building that once stood in this location. Closer inspection reveals that some fragments are characteristic of the distinctive sloping entrance walls seen in

the nitroglycerine mounds and wash houses elsewhere on the site (Figure 108). The earthwork is lower and less well formed than those recorded around known danger buildings at Cliffe, but the fragmentary nature of the associated brickwork suggests that the high level of demolition here was caused by an explosion.

*Figure 108: (above left) Distinctive structural brickwork fragments on the bank associated with structure **103**. Photograph: Rebecca Pullen 2011 © English Heritage.*

*Figure 109: (above right) The curving brick edge of a sunken feature appended to structure **104**. NMR DP141591 80 07-Mar-2011, Steve Cole © English Heritage.*

Located across a large rectangular borrow-pit south-east of **103**, structure **104** is the disjointed remains of a further sub-circular feature centred on a 20m-wide water-filled hollow, similar in size to that inside **103**. A low spread mound of spoil flanks the south side of the waterlogged depression, with a small concrete block visible at the very southern edge of the spread, similar to the example associated with **103**. Notably, at the south-west edge of the spoil spread, an in situ concrete block or surface runs towards a cement-faced brick arc, flush with the ground; this might mark the edge of a tank or ancillary structure adjacent to the main drainage dyke (Figure 109). Brick features closely equivalent to this in size, form and position were also recorded in association with mounds **166**, **167** and **168** in the nitroglycerine production group in **Area 1** attributed to HM Cordite Factory. At the eastern edge of the hollow, there are also the remains of a large degraded concrete slab with the appearance of a collapsed wall. In contrast to the area south of **104**, ground north-west of the hollow has been made into a low level platform with a distinct steep linear scarp marking its south-west extent. Similar to **103**, a rectangular concrete block is positioned at the outer edge of the earth spread, flanking the southern side of the circular hollow. North-east of the waterlogged hollow is a short length of steep-sided, well-formed earthwork bank approximately 1m high. In its current location it appears fairly discrete, but when considered as a feature located diametrically opposite the brick arch, it could be interpreted as the blast mound for a former entrance similar to that seen at the southern side of structures **166** and **168**. Interestingly, the footprints of both **103** and **104** are also very similar to those of **166**, **167** and **168**.

Unfortunately, no documentary sources to confirm the previous form or function of these two structures have been identified, but using the 1908 25-inch OS map, it is clear that this area remained undeveloped until after 1907 (Ordnance Survey 1908b). A

plan, accompanying letters exchanged between the Sewers Commission and the PLA in the mid to late 1930s, marks structures **103** and **104** with an 'x' described as denoting buildings that had been blown up some years ago depositing debris in the adjacent drainage ditch that needed to be broken up and removed (KHLC CKS-S/NK/A/C/1/186). In light of these comments it is interesting to note the presence of two large rectangular borrow-pits closely associated with **103** and **104** which imply that both structures formerly had purpose-built earthen traverses that have since been removed or destroyed by explosion. The parallels between structures **104** and **166** are particularly apparent, and the shape and scale of both **103** and **104** are reminiscent of mounded structures **166**, **167** and **168** in the HM Cordite Factory nitroglycerine group. These parallels could indicate that **103** and **104** represent unfinished or destroyed nitroglycerine buildings in **Area F**. Perhaps **103** and **104** were used for producing nitroglycerine intended to be mixed with products other than guncotton to form alternative explosives, for example with inert siliceous earth (often kieselguhr) to form dynamite, or with varying amounts of saltpetre and woodmeal to produce either gelignite or gelatine dynamite.

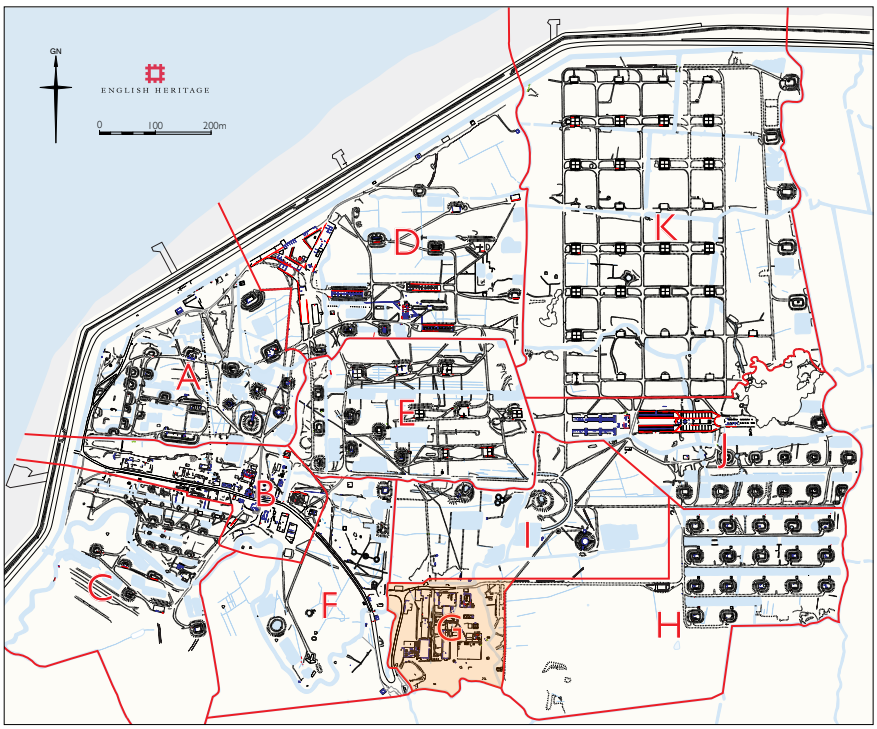
Structure 105

Immediately north of **104**, and forming the termination point of the tramway approaching from the north-west is structure **105**: a curious concrete slab with an arrow- or T-shaped plan and a pattern of iron bolts in the top, measuring 16m x 18m across its longest axes (Figure 110). Its function remains unclear, however its position could link it to the alignment of triangular concrete bases of **L4**, thought to be part of an aerial ropeway or major elevated pipeline leading west from the south central area of the factory out towards **J3**, the largest of the factory's jetties on the River Thames (see section 6.2). One of these triangular bases is located to the south of **104**, and another is east across the drainage dyke from **105** (see Figure 42).

*Figure 110: Structure **105**, looking north-west. NMR DP141590 07-Mar-2011, Steve Cole © English Heritage.*

6.13 Area G: HM Cordite Factory - acid-handling and guncotton preparation

Structures recorded across the eastern side of the site, **Areas G** to **K**, derive from considerable wartime expansion of the factory to meet the abrupt increase in demand for explosives. This rapid growth took place in the form of the development of HM Cordite Factory as a second manufacturing plant for producing guncotton and for converting guncotton to naval cordite. It is thought that most or all of this development began in 1914 and was completed within the first year or two of the First World War.

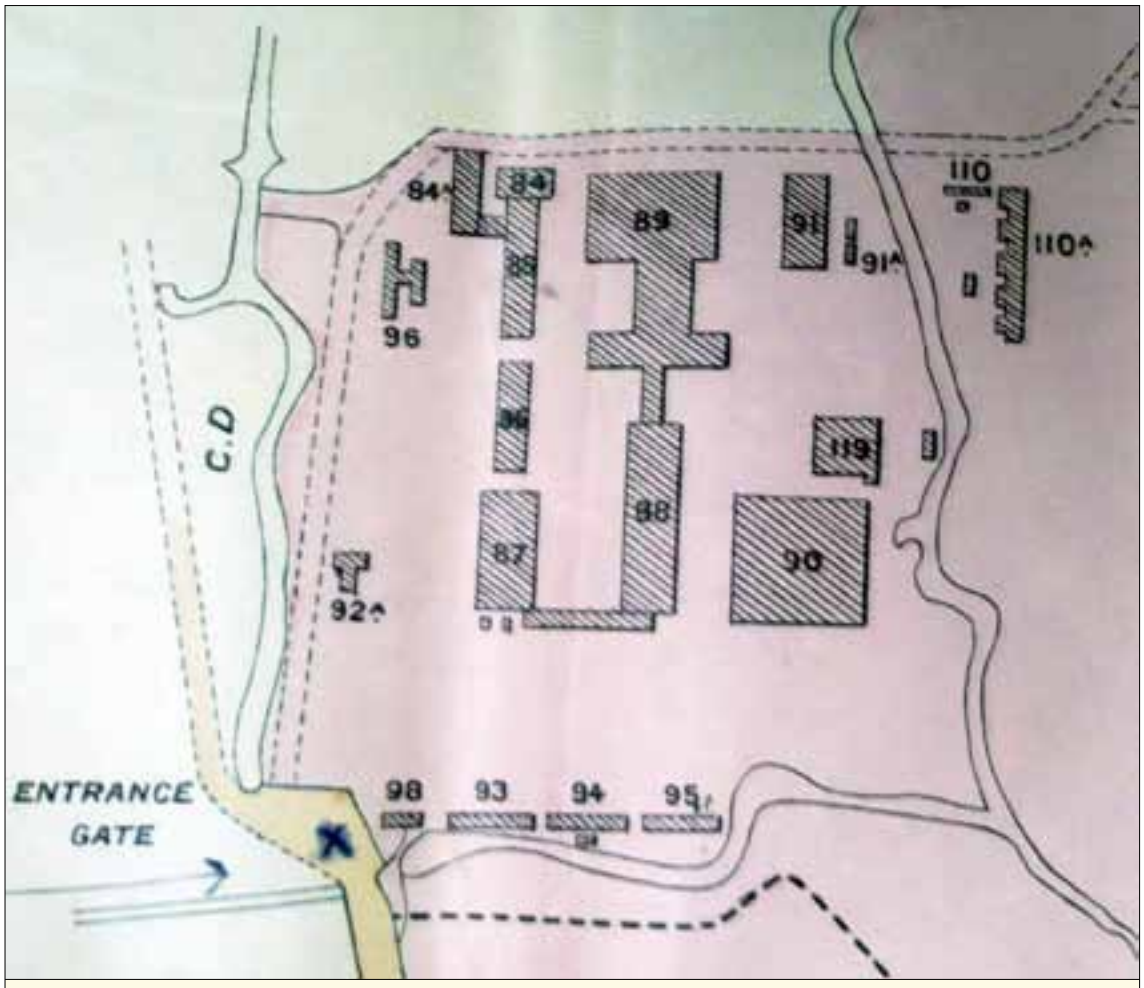


***Area G** shaded orange.*

The existence of descriptive documentation relating to the sale of a large proportion of factory land in 1923 (MALSC 06a_DE_Series_1001_1200/DE1087_3), means functional explanations of structures along the eastern side of the site are much better understood than those described thus far. As a result, the descriptions for **Areas G** to **K** are, where possible, ordered according to their position in the manufacturing process. However, the map accompanying the sales particulars omits several of the surviving structures, and includes representation of other buildings for which no physical evidence was identified. This slight deviation between the 1923 map and the physical evidence is particularly apparent in **Area G** (Figure 111).

Located at the southern edge of the factory site, **Area G** houses a coherent complex of interlinked concrete building foundations (Figures 112 and 113); these mark the entrance to the guncotton manufacturing plant belonging to HM Cordite Factory (ibid). Alongside buildings for processing cotton and acid, are a number of buildings relating to support roles and administration. **Area G** is surrounded on all sides by drainage dykes. It is worth noting that the east-west dyke that marks the north edge of **Area G** is a later addition, not seen on the 1908 25-inch OS map. This dyke is also absent from the map accompanying the 1923 sales particulars (see Figure 111); however, as the track to its south on the map marks the northern edge of the HM Cordite Factory land in this area,

it may simply have been deemed unnecessary to include it. A concrete road (resurfaced with tarmac in places) with concrete kerbs leads into **Area G** from both the south and the west.



84	drying house and covered passage	91a	office and engine man's shed
84a	bale breaking house or motor show room	92a	(no description given)
85	picking room and covered way	93	changing room
86	willowing room and annexe	94	laboratory
87	nitrating house, covered way, annexe and stores	95	wood working shop
88	boiling house and rising corridor	96	new changing rooms
89	washing house and corridor, settling house and annexe, press house and store	98	superintendent's office
90	boiler house and covered way	110	dressing rooms and earth closets
91	diesel engine house	110a	dressing rooms
		119	refrigerator house, annexe and latrines

*Figure 111: Extract from the plan accompanying the 1923 sales particulars for the auction of HM Cordite Factory, Cliffe, showing **Area G** - descriptions relating to the building numbers has been taken from the detailed sales lots. MALSC 06a_DE_Series_1001_1200/DE1087_3, Medway Archives and Local Studies Centre, Strood; reproduced by kind permission.*

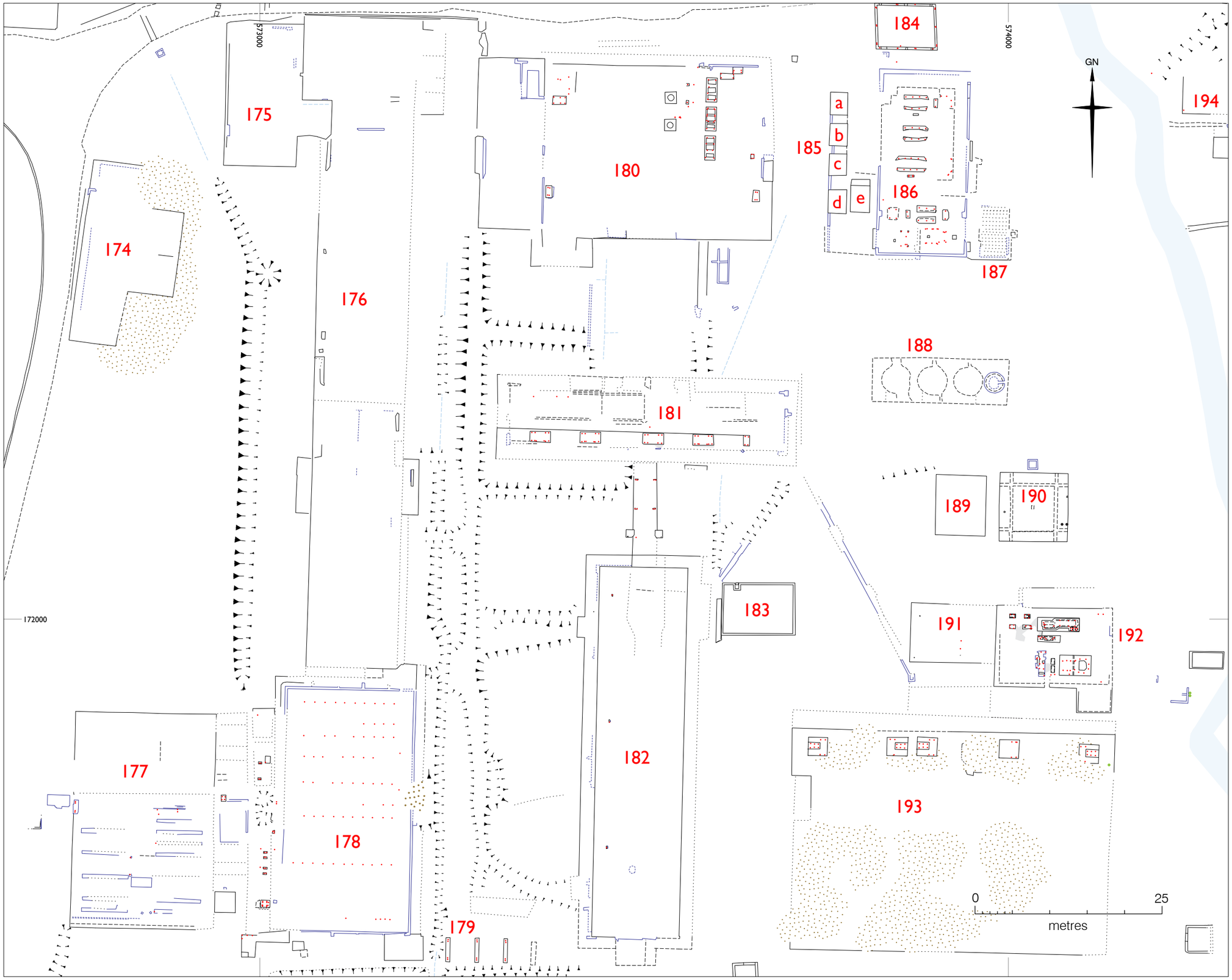


Figure 113: Remains of the acid-handling and guncotton processing facilities in ***Area G****. Drawn by Philip Sinton © English Heritage.*

Figure 112: **Area G** *from the air, looking west. NMR 26890/018 08-Mar-2011, Damian Grady © English Heritage.*

Administration and support buildings

Structure 172

Structure **172** is a concrete foundation 15m x 7.5m with a damaged north-west corner, located beside the northern kerb of the road where it enters **Area G** from the west (see Figure 113). No equivalent building is marked in this location on the 1923 sales particulars map (see Figure 111), and it has no distinguishing features from which to ascertain its function. It is most likely to have had a storage role, perhaps for raw cotton bales waiting to be moved to the bale-breaking, picking and willowing complex.

Structure 174: 'new' changing rooms

Structure **174** is a broadly T-shaped concrete foundation, south-east of **172**, measuring 24.5m x 13m at its maximum and partially obscured by spoil along its east side (see Figure 113). It is described in the 1923 sales particulars as the 'new' changing rooms: a brick building divided into 13 compartments with plastered walls, a timber boarded floor and a match-lined, corrugated iron roof (MALSC 06a_DE_Series_1001_1200/DE1087_3). All staff employed in the chemical and industrial elements of the factory would have had to put on factory-issue safety uniforms and leave behind any extraneous items (loose change, matches and such like) in the changing rooms before entering the processing areas (see section 8.4).

Structures 194 and 195: dressing rooms

A pair of structures, **194** and **195**, just north-east of the guncotton factory (see Figure 113), are defined in the 1923 sales particulars as dressing rooms with associated earth closets (ibid). The western structure (**194**) was known as building '110' and comprised six dressing rooms, the longer building to its east (**195**) was known as '110a' and contained a further seven dressing rooms (see Figure 111). The group all had match-lined corrugated iron walls and roofs, but the dressing rooms had boarded floors and the earth closets had concrete floors (ibid). Structure **194** is a rectangular concrete foundation measuring 5m wide with its full length concealed under grass at the east end. It is adjoined to the south by a roughly square concrete surface leading to a rectangular foundation 5.8m x 2.8m in plan. An open drain runs west from the centre of the concrete surface, linking it to the nearest drainage dyke, surviving in situ beside the dyke as a section of salt-glazed effluent pipe set in a concrete lining. Structure **195** is an earthen building platform, 40m x 5m, with an additional strip of concrete surface 1m-wide along its eastern edge. Moulded into the edge of the concrete, is a narrow open floor drain, connected by a further perpendicular drain to the main dyke to the west. This strip of concrete almost certainly marks the location of the earth closets associated with '110a'. The 'new' changing rooms of **174** may have been built either to replace or to expand the facilities offered by **194** and **195**.

Structure 196

Structure **196** is a small trapezoidal concrete foundation topped by three concrete plinths: two small rectangular plinths and a larger T-shaped plinth, 10.4m x 3.6m at its maximum dimensions, all with patterns of multiple iron bolts protruding from the tops. It is located at the terminal end of a single tramway embankment leading south from **195** (see Figure 113). There is no building depicted or described in this position in the 1923 sales particulars (ibid). Rather than relating to buildings in its immediate vicinity, its function could be more closely tied to the alignment of six triangular concrete foundations (**L4**) which appear to lead from the main jetty at the west side of the site (**J3**) and line up directly with this structure in the east, thought to be part of an aerial ropeway or elevated pipeline (see Figure 42).

Structures 173a and 173b

Returning to the north edge of **Area G**, structures **173a** and **173b** are two trapezoidal concrete bases with concrete kerb edging, almost identical in form. They each sit right against the south edge of a drainage dyke, and seem to represent former crossing points enabling branches off the main road in **Area G** to access the large earthen platform and associated drains on the north side of the dyke in **Area I** (see Figure 113). However, the dyke itself appears to loop out and around the larger base of **173a**, suggesting that **173a** was in place before the dyke was cut. A pair of concrete pads with central iron fittings were recorded opposite this structure (Figure 114). The 1923 sales particulars plan does not include a dyke in this position (see Figure 111); it may not have been drawn because these features and the dyke are just outside of the area covered by the auction event.

*Figure 114: Structure **173a** looking south-west. Photograph: Sarah Newsome 2011 © English Heritage.*

Acid-handling and guncotton preparation buildings

Structure 175: bale breaker house (and 'motor show room')

Structure **175** is where the first stage in the production of guncotton took place, and is described in the 1923 sales particulars documents as '84a', the 'Bale Breaker House', where the raw bales of cotton waste would be broken up (ibid) (see Figure 111). The auction details also give a second function for this building as a 'Motor Show Room', though this might relate specifically to display of detached machinery and other similar lots purely for the duration of the auction. The building is described as a brick building with a corrugated iron roof, and an asphalt-covered concrete floor. It contained an Invincible Centrifugal Pump and electric motor made by F A Greene, a vertical two-cylinder single-acting enclosed-type air compressor made by F W Bracket & Co, paired with a Siemens motor and five electric motors, mostly of an enclosed type, made by Bruce-Peebles (ibid). A concrete foundation survives, measuring 19.2m x 10m, with some sections of brick walls scars visible around the edge. This concrete foundation adjoins the larger concrete base of structure **176** to its east.

Structure 176: drying house, picking room and willowing room

According to the 1923 documentation, structure **176** encompasses the location of three former buildings known then as '84', '85' and '86' (ibid) (see Figure 111); a single number was assigned to the survey data for this area because clear building divisions were not obvious on the ground. Structre **176** refers to a large elongated concrete foundation measuring 87m north-south, with a width of 12m for most of its length, widening to 19m at the north end.

Little detail remains at the north end, though hints of internal divides at the eastern edge could represent a separate smaller room or row of covered cells (see Figure 113). The 1923 sales particulars describe the wide portion at the north end as number '84', a drying house (for raw cotton) with a covered passage; it was a brick building with a concrete floor and a corrugated iron roof, in addition, the surface of the floor in the covered passage was lined with asphalt (ibid).

Moving south along **176** to where it narrows to a uniform width of 12m, the concrete surface remains largely featureless, giving little clue to the internal layout and construction of the buildings. Approximately half way along its length is a perpendicular vegetation line which might mark the division between former buildings '85' and '86'. The northern half of this area houses two narrow concrete plinths and a small low machine bed, 0.03m high with three iron strips and around six iron bolts set into its surface. This area was once '85', the brick-built picking room and a covered passage, with asphalt-surfaced concrete floors and a corrugated iron roof (ibid). A large number of staff, almost certainly women, would have worked in this building carefully sorting through the broken-up cotton bales and picking out any unwanted elements, like wood, wire or rag, by hand, to leave a 'clean' raw product.

The south end of **176** has few distinguishing features. A pair of external rectangular concrete surfaces (7.6m x 2m) on opposite sides of the slab indicate the location of large paired bays or annexes on either side of the building. The witness mark of a brick wall suggests the space was internally divided along at least part of its length, and a cluster of shorn-off iron studs towards the centre of the floor indicate the prior presence of a machine or structural component (*see* Figure 113). The willowing rooms, known as '86', formerly stood at this end of **176**. The building was divided into six compartments and had an additional pair of annexes; all were brick-built with asphalt-surfaced concrete floors and corrugated iron roofs (ibid). In here the picked-clean cotton was passed through a powerful teasing machine, called a willow or carding machine, which broke up the fibrous cotton structure to improve its readiness to absorb the acids.

There is a narrow open channel left by the removal of a buried pipe all along the east side of structure **176**, with small earth causeways crossing it in four locations. Individually, these causeways may indicate the positions for entranceways to the buildings, and collectively they suggest that the covered passage described in association with this range of buildings might have been positioned along the external eastern edge of **176**, providing a sheltered path for movement of staff and materials.

Structure 178: nitrating house

The next concrete slab to the south is structure **178**. This is the foundation of the nitrating house (or dipping room), formerly known as building '87'; it was built of brick with a cement and asbestos sheet roof, and a floor of blue bricks on concrete (ibid). Ancillary to the nitrating house were an annexe, a lean-to, a covered open-sided passage and two stores. The annexe had brick walls and both it and the covered way had a concrete floor and a corrugated iron roof, the lean-to consisted of corrugated iron over a blue brick floor, and the stores were of timber and corrugated iron walls with a concrete floor and corrugated iron roof (ibid). By the time the HM Cordite Factory guncotton plant was built, it is thought that the Nathan-Thompson Displacement Process had been adopted at Cliffe as a less labour-intense processing method for the nitrating house (*see* section 4.2). In this building, the charges of cotton would have been immersed in mixed acid held in rows of displacement tanks or pans, after several hours the acid was run out of the bottom of the tanks and largely recovered for reuse while water was run in from the top of the tank, replacing (displacing) the acid; the newly formed guncotton was then removed to the boiler house (Cocroft 2000, 126-127). Above the tanks, a series of tall

lattice-work structures (fume towers) would carry off the noxious fumes produced by the chemical reaction.

Structure **178** survives as a large rectangular concrete foundation. A basal course of brickwork around much of the perimeter marks the footprint of a building measuring 33m x 17.5m. Outside this wall line is an apron of concrete, roughly 1.3m wide and slightly sloping down away from the building it surrounded (*see* Figure 113). Cement across the concrete floor shows the imprint of the small square paired hollows seen in the base of acid-resistant bricks elsewhere in the site. Much of the floor is gridded with a regular spacing of L-section iron uprights, set into the floor in a plug of mortar and abutted in places by surviving fragments of blue brick (Figure 115). These iron uprights probably formed supports of brackets for displacement tanks on the floor (ibid).

In the north-east corner of **176**, an area of concrete with what appears to be a narrow concrete ramp leading up into it from the west could indicate the position of the former annexe with an entrance coming off a covered way running between the willowing rooms (**176**) and the nitrating house (**178**). Likewise, the two southern corners of the foundation are both adjoined externally by small pads of coarse concrete. The west example is L-shaped in plan and measures approximately 6.4m x 3m at its maximum dimensions, and the east pad is rectangular and measures 5.1m x 3.5m. These may indicate the location of the two stores detailed in the 1923 sales particulars (MALSC 06a_DE_Series_1001_1200/DE1087_3).

*Figure 115: (above left) An upright L-section iron fitting in structure **178** surrounded by mortar imprints of an acid-resistant brick floor. Photograph: Rebecca Pullen 2010 © English Heritage.*

*Figure 116: (above right) Concrete plinth with integral salt-glazed pipe and remnants of a hatched acid-resistant floor, beside the south-west corner of **178**, looking north. Photograph: Rebecca Pullen 2010 © English Heritage.*

A number of small concrete plinths, topped with iron studs and traces of a series of concrete surfaces marked with bitumen residue, survive in the narrow strip of ground between **178** and **177**. Located centrally amongst these features is a small rectangular earthwork surrounding a roughly C-shaped hollow with squared corners, next to this is a small iron box. About 10m further south is a single larger concrete plinth with

three iron studs grouped in each corner, a section of salt-glazed pipe with a diameter of 0.18m adhered to its south side and remnants of hatched blue brick flooring against is west edge (Figure 116). West of this is a concrete pad measuring 2.7m square, which incorporates a sunken rectangular space bounded by blue bricks. Use of blue acid-resistant engineering bricks confirms the building's association with acid-handling. A long linear gully or drain runs directly north from this strip of features, and can be followed north-west into **Area F**; this might have contained pipework to remove waste water and waste acid after cotton batches had been nitrated (displacement could over-weaken the acid rendering it unfit for reuse).

Structure 177

Structure **177** is another large rectangular concrete slab, 29m x 19m in plan, located immediately west of nitrating house **178**. There is no clear evidence for the external wall lines, inferring that a lightweight building material, rather than brick, was used for the superstructure, and a single witness mark across the interior indicates that the building was divided into two rooms or working spaces. The northern end of the foundation is smooth concrete, with several patches of mortar showing the impression of a blue brick floor. The larger south part of the slab appears to have been portioned up by two rows of brick walls aligned east-west and set variously 1m or 2.5m apart. These could represent narrow stalls or working areas, or could be lower load-spreading brick supports for heavy equipment. Curiously, this building does not feature in the 1923 sales particulars for this area (*see* Figure 111), though it may be the 'acid tipping shed' which is described but not numbered or drawn in documents (ibid). The acid tipping shed is described as comprising a floor of blue bricks on concrete, walls of corrugated iron and timber, and a felt and timber roof. This fits fairly well with the surveyed evidence and is one possible explanation for a building positioned next to the nitrating house where the acids were deployed, though alternative explanations are possible.

Structure 182: boiling house

East of nitrating house **178**, the building remains continue to follow the manufacturing flow line from raw cotton to guncotton. Structure **182** is a long concrete slab measuring 53m x 15.5m wide. Small rectangular projections for porches or ancillary structures exist at the south end, the north end of the east side and opposite embanked paths at either end of the west side (*see* Figure 113). Occasional hints of an external brick wall, along with a slight step up from the surrounding coarse concrete apron, outline a central rectangular building footprint, 50m x 12m, of a smoother concrete. The imprints of an acid-resistant blue brick floor are visible in remnant patches of mortar on the concrete slab. The 1923 sales particulars describe this structure as building '88', a two-storey boiling house: the ground floor was surfaced with blue bricks, while the first floor utilised timber surfaced with asphalt; the walls were constructed of timber and corrugated iron topped with a corrugated iron roof (ibid). In here, freshly nitrated cotton was probably boiled in large vats for 4-5 days to remove all unwanted less stable compounds, creating a product with a soggy oatmeal consistency (*see* section 4.2).

Structure 179

Structure **179** is a row of three concrete beams and the vegetation mark for a fourth; collectively seeming to connect the south ends of structures **178** and **182**. The beams are spaced equidistantly, 3.3m apart, and each is aligned north-south with a pair of iron bolts at either end. Jointly, they probably supported a long narrow structure with a wooden floor, and could indicate the location for the rising corridor listed as part of boiling house '88' (**182**) in the 1923 sales particulars (ibid). The corridor was described as being built of a timber and blue brick floor, with walls of corrugated iron and steel and a corrugated iron roof (ibid). It would have been a ramp to access upper floors, rather than a ladder or stairs. Running north from **179**, and filling the space between the two linear building groups, is an earthwork embankment with several perpendicular off-shoots. It has very similar dimensions to the tramways seen elsewhere across the site, but it has no physical connection to the wider network and could instead be a set of footpaths.

Structure 183: tank

Structure **183** is a large concrete tank measuring 9.7m x 7m in plan, located next to the projection or porch base at the north-east corner of boiling house **182**. On the inside of its north edge is a rendered brick manhole which appears to be a later addition, and probably housed a pump or pipe maintenance point (Figure 117). The tank is likely to relate to the large quantities of water being handled in the adjacent boiling house.

*Figure 117: (above left) Structure **183**, looking south-east. NMR DP141570 07-Mar-2011, Steve Cole © English Heritage.*

*Figure 118: (above right) One of the large plinths within structure **181**, with remnants of an acid-resistant blue brick floor. Photograph: Sarah Newsome 2011 © English Heritage.*

Structure 180 and 181: washing house, settling house, press house, and store

The concrete floor of a narrow 12m long path or covered passage leads north from the north end of **188**. Four small rectangular holes in the concrete floor, filled by mortar and iron fittings, hint at a former iron superstructure. A concrete plinth sits either side of the surface, each with its top angled slightly down and away from the path.

To the north of the corridor is structure **181**, a large building foundation measuring around 40m x 15m overall. It comprises an east-west orientated building, 37m x 8m

in plan, marked by brick wall scars and surrounded by a concrete apron 1.7m-wide for the floor of an external walkway (see Figure 113). Along the south edge of the interior space is a row of five concrete machine beds; all would have abutted the wall at their southern side, projecting 1.4m out from it. The western four plinths all measure 2.8m x 1.4m in plan and 0.32m high, with ten iron studs projecting from the top (Figure 118). The fifth example is much narrower at 0.8m across, and only has four iron studs in the top. Most of the plinths are covered with a smooth cement render, and are abutted by the remains of a blue brick floor with a large square pattern. A series of witness marks across the surface of the slab suggest that the building had several internal divisions. Along its northern edge, **181** is met in two places by narrow embanked paths which run north between it and structure **180**. Traces of a concrete surface to the paths survives in places with, perhaps unexpectedly, the scars of a brick wall line running along the west edge of the western path. The paths probably line up with the position of former doorways leading into structure **180** and **181**. Additionally, several brick-lined culverts and channels of former pipelines appear to converge at structure **181** (see Figure 113).

Moving north, structure **180** is another large concrete foundation, measuring 40m x 24m, that appears to have been divided internally into two main areas (see Figure 113). At the east end, is a larger room containing several small concrete plinths, primarily located around the internal edges of the space, each with protruding iron bolts. Towards the north-east corner sits a line of three low rectangular concrete plinths, all 3.2m x 1.4m in plan with three rectangular segments set within the top: some of these segments are depressions, some are flush with the outer plinth and others are additional blocks sitting 0.23m proud of the main plinth. This variation appears random, rather than a repeating pattern across the features; it is unclear whether the differentiation denotes different machine forms, remodelling for reuse, or partial demolition. West of these, is a pair of low concrete plinths each measuring 1.5m square with a circular hole, 0.8m in diameter and 0.1m deep, at the centre (Figure 119). A smaller area at the west end of the slab contains only a single brick plinth, 3.7m x 1.5m in plan, in the north-east corner and surrounded by a thin brick wall.

Structures **180** and **181** are not differentiated from each other in the 1923 sales particulars. Both buildings, along with the corridor south of **181** and the area between the paired paths linking **181** to **180**, are depicted as a single entity described as building '89': washing house and corridor, settling house and annexe, and press house with an adjoining store. Overall, the group is described as having corrugated iron roofs and all were built with brick, apart from the corridor which had walls of corrugated iron and steel (ibid).

If the logical spatial layout for the order of processes is taken into account, along with matches between the physical evidence and details of the specific materials used for individual buildings in this area described in the 1923 sales particulars, it seems likely that structure **181** was the washing house, and that structure **180** probably contained the settling house and press house. That said, the detailed lots of machinery and plant at the end of the 1923 sales particulars describes building '89' as being, or including, a guncotton hydraulic pump house, containing one belt-driven three-throw horizontal force pump made by Robert Warner & Co, and one motor-driven three-throw horizontal force pump made by Mather & Platt Ltd, both protected by an iron fence (ibid). It is thought

possible that, based on form, the hydraulic pump house itself is now represented by structure **190**, which is not individually mapped or described in the 1923 documents (*see* Figure 113).

The washing house would have included churning and poaching machines to beat and wash the guncotton pulp. The pulp was then immersed in water and brought to a safe-handling state (a water content of 25%) in the settling house; guncotton intended for cordite production would be kept wet until it was ready for conversion (*see* section 4.2). Existence of a press house in the guncotton manufacturing complex is interesting. It is unlikely that guncotton intended for cordite production would have been pressed, as this would make it much more difficult for the nitroglycerine to be absorbed. It may, therefore, imply that there was the capability to manufacture compressed blocks of guncotton for use in demolition charges and torpedo and mine filling. Whether HM Cordite Factory actually engaged in production of this type alongside cordite for shell filling, remains unknown.

*Figure 119: Mixed plinths within the remains of structure **180** and, in the background, the cuboid forms of structures **185a**-**185d**, looking east. NMR DP141583 07-Mar-2011, Steve Cole © English Heritage.*

Structure 184: tank

Along the east edge of **Area G** is a final row of structures, the north end of which is marked by structure **184**, a large concrete tank sitting almost flush with ground level. It measures 8m x 6m in plan with walls 0.3m thick. Iron bolts suggestive of a cover or superstructure are located around the top of the tank sides, and a series of notches in its top may have held inlet and outlet pipes.

Structure 186 and 187: engine house and office

Immediately south of tank **184** is a tightly packed group of structures. Central to the group is structure **186**, a raised concrete floor 25m x 12m in plan, edged with the remnants of a brick wall, and with a lower 2m wide strip of floor at the north end (*see* Figure 113). The north half of the slab has remnants of a red quarry tile floor, and three raised concrete plinths that have been shaped to hold horizontal cylindrical tanks roughly 3.5m x 1.2m in size (Figure 120). At the south end, there are a further five plinths: the westernmost is flush with the floor but the others are raised concrete blocks, the central pair of which appears to have been shaped to hold a horizontal cylindrical tank between them.

*Figure 120: (left) Structure **186**, looking north-west with the cuboid forms of structures **185a**-**185d** in the background; (right) detail of plinth with curved recess designed to hold a cylindrical tank or motor within **186**. Photographs: NMR DP141580 07-Mar-2011, Steve Cole (left), and Sarah Newsome 2011 © English Heritage.*

Along the east edge of the building are two entrance points: a concrete threshold towards the centre of the wall and a step topped with hatched blue bricks leading down into an ancillary space in the south-east corner. The ancillary room is structure **187**: a small featureless foundation measuring 7m x 3.5m in plan, formed of narrow concrete beams bounded by the witness marks for brick walls, with a single small concrete manhole adjoining its eastern edge.

According to the 1923 sales particulars, structure **186** was formerly building '91', a diesel engine house, and **187** was building '91a', an adjoining office (ibid) (*see* Figure 111). The engine house is described as having red tiles on a concrete floor, brick walls and a corrugated iron roof. The office had a concrete and timber floor with brick walls and a corrugated iron roof. The document suggests there was also a third building in this group: the engine man's shed, located immediately north of the office and built entirely of corrugated iron on a concrete and timber base (ibid). No physical evidence for this third concrete base survives. The diesel engines in the engine house may have provided power to belt-driven apparatus, such as willowing and poaching machines, in the surrounding buildings. The shaped pairs of concrete plinths in **186** could have supported either large diesel storage tanks, or the diesel engines themselves.

Structures 185a to 185e

Structures **185a**-**85e** are a distinctive group of five cuboid structures located immediately west of engine house **186** (see Figures 113 and 119). Each is formed of thick brick walls covered by a coarse-gritted cement render with elements of an internal iron structure and some evidence of charred material in the base (Figures 121 and 122). The five structures are arranged so that **185a** to **185d** form a north-south line of four, while **185e** is slightly set apart to the east of **185d**. They each measure 3m x 2.3m in plan, and stand 1.8m tall. All have flat tops apart from the south-west example, **185d**, which is slightly cambered. The cuboid forms are too small to have provided internal working space, none have an obvious entrance, but all have a large rough-edged hole puncturing partially through the roof and one side, as though a fitting or door of some sort has been removed. Additionally, they appear to be linked along their western side by dwarf concrete walls.

These structures are not obviously depicted or described in the 1923 sales particulars (ibid). This may be because the group had already gone out of use and been stripped of any reusable material before the time of the auction, or perhaps more likely is that they constituted part of the diesel engine house. Despite its close proximity to the diesel engine house (**186**) the group does not appear to have been directly associated with the production of power. Their form might suggest that they were furnaces associated with the generation of hot air for use in the buildings in guncotton manufacture in **Area G**; nonetheless, several other explanations are plausible. The concrete cubes are quite reminiscent of the bases of nitric acid production stills; however, the associated elements of a nitric acid plant are missing. Similarly, and possibly more likely in this context, they are evocative of the bases of acid recovery stills, such as Nobel's acid recovery stills installed at Pitsea in 1903 (Williams 2010, 180-6). Alternatively, they might be the remains of the 'destructors' (waste incinerators) mentioned in the report of a small fire at the Cliffe factory in 1918 (Explosives Inspectorate 1919, 12).

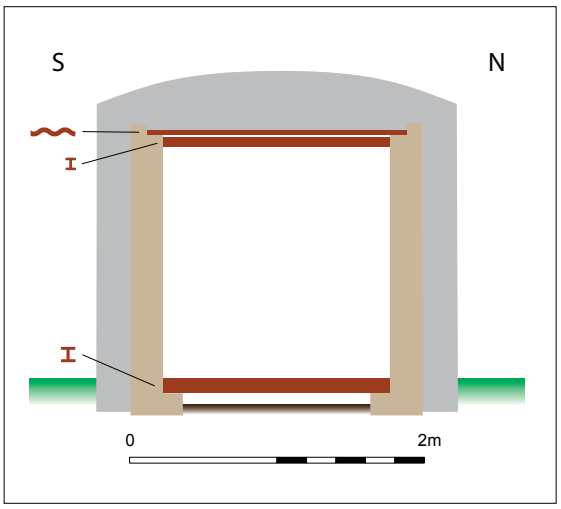


*Figure 121: (above left) Structure **185d**, looking north. NMR DP141584 07-Mar-2011, Steve Cole © English Heritage.*

*Figure 122: (above right) Schematic section through structure **185d** showing the internal ironwork, brick walls and external concrete shell. Drawing: Rebecca Pullen © English Heritage.*

Structure 188

Structure **188** is a lone concrete slab, 18m x 6m in plan, located to the south of **186**. Most of its surface is taken up by four prominent circular features. The western three circular features each measure roughly 3.8m in diameter, and look like voids or scars left by the removal of a set of circular tanks. At the east end of the slab there is a smaller penannular cement-rendered brick plinth, 0.22m high, with an open notch at its east side (Figure 123); this forth circular feature is particularly reminiscent of the three probable tank bases previously described with structure **41** in **Area B**.

Structure **188** is not depicted or described in the 1923 documents (MALSC 06a_DE_Series_1001_1200/DE1087_3). It stands slightly apart from the other buildings and seems to be grouped in the area of service buildings for the guncotton production, rather than forming a direct part of the manufacturing flow line. Its proximity to washing house **181** could suggest that **188** was a store for the soda that was added at this point in the process. Alternatively, the bases could signify centrifugal spinning machines used to wring out the cotton pulp at various points in the process to remove excess liquid (*see* section 4.2).

*Figure 123: Structure **188** looking north-west. NMR DP141579 07-Mar-2011, Steve Cole © English Heritage.*

Structure 189 and 190

A short distance to the south of 188 is a pair of building foundations. Structure **189** is a featureless concrete slab measuring 8m x 6.5m. To its east is **190**: a slightly larger square concrete slab with bitumen marks on the surface showing the position of walls and possibly of a central column or support (*see* Figure 113). Beside the north edge of **190** is a small brick manhole, measuring 1.3m square. Once again, neither of these structures is depicted or described in the 1923 documents (ibid). Structure **190** bears some resemblance to structure **248** and, as such, it can be tentatively interpreted as the base of another hydraulic accumulator tower, with structure **189** possibly representing a small associated pump house (with pumps possibly driven by the diesel engines in engine house **186**). If so, it is likely that power produced in these buildings was closely associated with the guncotton washing and pressing facilities in nearby structures **180** and **181**. Hydraulic power was being used in other parts of HM Cordite Factory to power the cordite

presses. Logically, it would have been harnessed in the presses of the guncotton factory too, which could explain the similarities between **190** and **248**.

Structures 191 and 192: refrigerator house and annexe

South of **189** and **190** is a further pair of concrete slabs, structures **191** and **192**. Structure **192** is the largest of the pair: it measures 15.5m x 10.5m and has a small ancillary room projecting south from the south-east corner. The main floor area supports three fairly large concrete machine beds, a group of four smaller concrete plinths (0.5m tall), a brick plinth and remnants of a red quarry tile floor laid in a diamond pattern set obliquely to the walls (Figure 124). The two concrete plinths in the north-east corner are 0.7m tall and each have the well-defined imprint of a machine on their surface, punctuated by tall iron studs. As seen elsewhere, the pair might have supported a single steam engine with the drive wheel fitted vertically into the space between them (something like a 'Warwick Engine'). In the centre of the southern side of the slab, a single flanged iron steam pipe emerges vertically from the ground and turns 45 degrees to enter the building between two of three 0.2m-high plinths aligned along the south edge of the slab (*see* Figure 124).

*Figure 124: Structure **192** (left): large plinth showing the clear imprint of a machine preserved in its top, (right) smaller concrete plinths surrounded by remnants of a red quarry tile floor, looking north with structure **190** in the background. Photographs: NMR DP141572 07-Mar-2011, Steve Cole (left), and Rebecca Pullen 2010 © English Heritage.*

The 1923 sales particulars for this area show that this building was formerly the refrigerator house, '119', known to have contained a gear-driven horizontal single stage double-acting air compressor made by Bracket & Co, paired with a Siemens electric motor (Siemens was another local firm with a large factory at Woolwich), which explain the presence of the large machine beds (ibid) (*see* Figure 111). The function of the refrigerator house was to cool water and other liquids that were then pumped through in coils in various aspects of processing to maintain safe working temperatures. The

building was constructed of a tiled floor on a concrete base, with brick walls and a corrugated iron roof, and it either encompassed or adjoined an annexe and four latrines. The annexe was of brick walls and a corrugated iron roof on a concrete floor, and the latrines were timber and corrugated iron structures on a concrete base (ibid).

Structure **191** is concrete base sitting flush with the ground and measuring 11.3m x 8m in plan. It adjoins the west wall of refrigerator house **192**, and is featureless apart from two iron bolts towards the centre of the floor, and a number of small rectangular holes in the concrete. Along its south side is a lower concrete surface with a brick manhole at the west end, leading into a brick-lined drain connecting building **191** with probable washing house **181** (see Figure 113). Structure **191** was not individually mapped for the 1923 auction, but is a strong candidate for the annexe described with the refrigerator house. The lower surface to the south might be the concrete floor of the latrine block.

Structure 193: boiler house

South of **191** and **192** is the large concrete slab of structure **193**. It measures roughly 43m x 29.5m, with a probable entrance on its west side and the buried surface of a possible a pathway running along the north edge. The surface is now largely concealed under several spoil heaps and a thin layer of grass, but protruding from the spoil at the north end of the slab are five large coarse concrete plinths (see Figures 112 and 113). All but one are topped by a second smaller plinth, the upper part of the fifth plinth now rests loose on the ground a few metres to the north. The lower portion of the plinths measure 2.6m x 2.5m across and 0.4m high, with four iron studs at either the east or west end, and at the opposite end of each sit the smaller plinths, measuring 1.6m x 1m in plan and 0.68m high, with a further six narrow threaded iron studs protruding from the top of each. A short section of a salt-glazed ceramic kerb, possibly forming part of a hexagonal circuit, is partially visible through the grass cover in the space at the centre of the row. Towards the north-east corner of the concrete floor, the remains of a single square-section wooden post survive set in mortar and cut off at ground level. The area surrounding **193** contains a number of dispersed manholes and small tanks (Figure 125).

The 1923 sales particulars list **193** as building '90', the boiler house, described as already partially demolished at the time of inventory. It housed a Cumberland Electrolitic Boiler protection set with an electric motor and dynamo, and was constructed of brick walls, a corrugated iron roof and a floor described as 'rubble'. A covered way and five stack bases are also itemised, equating to the path along the exterior of the north wall and the five concrete plinths stacks within (ibid). This large boiler house is probably where steam for heating the buildings in **Area G**, and possibly adjacent areas as well, was produced and controlled. Coal-fuelled furnaces were most likely used to heat the water for steam production.

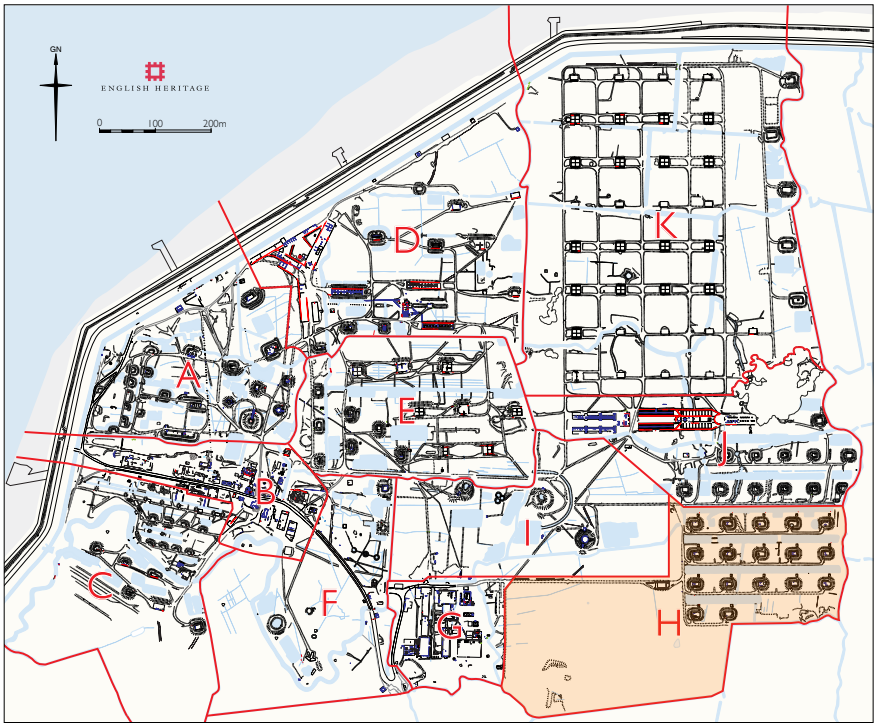
*Figure 125: Paired concrete tank and brick manhole south of structure **193**, looking north-west. Photograph: Rebecca Pullen 2010 © English Heritage.*

Missing structures

The 1923 sales particulars detail the former presence of a further five buildings for which no trace survives; according to the accompanying map, immediately to the east of the road and in line with structures **177** and **178**, was a small T-shaped building known as '92a' (ibid, and see Figure 111). No explicit explanation or description is given for its function or construction, but it could be another possible contender for the unmarked acid tipping shed. Additionally, there was previously a row of four buildings in a linear arrangement running east-west along the north bank of the drainage ditch that defines the southern edge of this area. From west to east these were: the Superintendent's office '98' (in four compartments and with fitted cupboards), changing rooms '93' (in six compartments), a laboratory '94' (comprising a passage and seven compartments, with two water closets nearby) and a wood workshop '95' (in six compartments, see Figure 111). The Superintendent's office was brick-built with a timber boarded floor and a match-lined corrugated iron roof, all other buildings in the group had timber and match-lined corrugated iron walls, with boarded floors and corrugated iron roofs (ibid). All that survives in this area is a concrete drain, a circular brick manhole and an irregular flat topped mound at the west edge, which could be formed for debris gathered from the demolished missing buildings.

The sales particulars also describe a building as 'Messrs. Curtis's & Harvey's charging house', which housed a charging set consisting of an electric motor coupled to a generator made by the Electric Construction Company (ibid), but it remains unclear to which structure amongst the factory remains of HM Cordite Factory this refers.

6.14 Area H: HM Cordite Factory - guncotton drying stoves



***Area H** shaded orange.*

Area H encompasses the south-east corner of HM Cordite Factory and of the entire explosives works site. It is accessed by a single tramway leading east from **Area G** across an expanse of undeveloped marshland. Most notably, it houses a gridded arrangement of seventeen large sub-rectangular earthen traverses, each paired with the remains of a small external structure on the north-east side (**267**-**283** and **267a**-**283a**) (Figure 126). These are known from the 1923 sales particulars to be guncotton drying stoves belonging to the HM Cordite Factory complex (MALSC 06a_DE_Series_1001_1200/DE1087_3). Additionally, there are also the possible earthwork remains of two salterns that pre-date the factory and are of probable medieval origin (see section 5.3).

Structure 284: store

Structure **284** is located at the west edge of **Area H**, where the tramway from **Area G** widens to the south to create a small building platform with tramlines either side, allowing carts to pass north and south before reconverging to the east. A 27m-long stretch of the concrete tram-bed, at the typical width of 2.5m, with clear impressions from the 2 foot-gauge tram rails seen as vegetation lines spaced 0.65m apart, survives to the north side of the platform. The platform comprises a concrete building foundation 15.3m x 9.1m in plan, constructed of narrow parallel concrete rafts aligned east-west. The 1923 sales particulars describe the building in this position as store '103', which comprised a timber floor, timber and corrugated iron walls with sliding doors and a corrugated iron roof (ibid). The tramway leads directly east from this storage point into a gridded arrangement of seventeen former guncotton stoves, suggesting that **284** was a temporary holding area for wet guncotton before it was moved to the drying stoves.

Figure 126: **Areas H** *(foreground) and* **J** *from the air, looking north. NMR 26891/019 08-Mar-2011, Damian Grady © English Heritage.*

Structures 267 to 283 and 267a to 283a: guncotton drying stoves and fan sheds

Area H is dominated by a group of seventeen sub-rectangular earthwork traverses (**267**-**283**) laid out parallel on an east-west alignment in three rows of four, with a further row of two to the south, and each is paired externally with a small concrete base (**267a**-**283a**) (*see* Figure 126). The 1923 sales particulars label these structures as a group of guncotton drying stoves, each with an associated fan shed (ibid). The stoves were formerly known as 'N11' through to 'N27', and are described in the sales particulars as constructed of canvas-lined brick walls, with timber and corrugated iron roofs and asphalt floors. The accompanying fan sheds were numbered buildings '65' to '81', and were built of timber and corrugated iron walls and roofs, constructed on concrete floors (ibid). Three of the building foundations (**270**, **274**, and **279**) have sub-circular craters 5-7m in diameter cutting into their concrete bases; these are likely to relate to the use of the site for munitions disposal following the closure of the factory (*see* sections 3.8 and 7.1).

The earthworks belonging to the drying stoves are fairly uniform in their size and shape, with an average footprint of about 31.5m x 25m and 1.8m high, creating a near-complete sub-rectangular protective bank around a central rectangular building platform. In all cases, a break in the bank towards the south-west corner provided an access point by which material could be moved from a short branch off the main tramway into the internal space. A low ridge sits across the opening of each earthwork, effectively truncating the line of the tramway off-shoot, so presumably the guncotton was moved in and out of the danger building by hand. Diagonally opposite the entrance and in line with the concrete base to its rear, each earthwork traverse has a noticeable depression in the top of the bank. In addition to this, many of the banks have distinctive breaks of

slope, particularly along their northern and eastern external edges, which could relate to constructional elements such as corrugated iron revetments, though this is speculative.

The 'danger buildings' within these large traverses survive only as concrete building foundations measuring 10m x 6.5m overall. Inside the buildings, there appears to be a single internal brick wall division about 3m from the west end of the floor slab; possibly a dwarf brick wall with an opening, almost certainly demarcating the divide between the 'clean' and 'dirty' areas of the building. In addition to this, a narrow rectangular depression recorded adjacent to the west end of some of the building foundations may suggest the presence of a porch or covered access path.

Each external fan shed base (**267a**-**283a**) measures 3.6m x 4.1m, and 0.3m tall and atop the north-east corner of each is a small concrete plinth approximately 1.1m square in plan and 0.3m tall, with a square notch missing from the north-east corner and a pattern of narrow iron studs and the impression of a machine in the top. (Figure 127). The dip in the north-west corner of the earthwork relates to the conveyance of hot air from the fan shed into the guncotton drying stove to facilitate the drying process. Only structure **283a** varies from the standard form seen in this group; at 4.7m x 4.1m in plan and 0.3m high its concrete base is slightly larger than other examples in this area. A seam in the concrete located 1m from its eastern edge divides the foundation on a north-south alignment, and a roughly T-shaped concrete plinth, topped by two rows of five iron bolts, sits in the SE corner of the slab (see Figure 127). The reason for this difference in form is not clear; it could be as simple as a reuse of a pre-existing fan type from elsewhere in the factory.

Figure 127: Fan shed bases in ***Area H*** *(clockwise from left): structure* ***272a****; detail of the typical plinth top belonging to* ***282a****; detail of the atypical plinth top belonging to* ***283a****. Photographs: NMR DP141647 08-Mar-2011, Steve Cole (left), and Rebecca Pullen 2010 © English Heritage.*

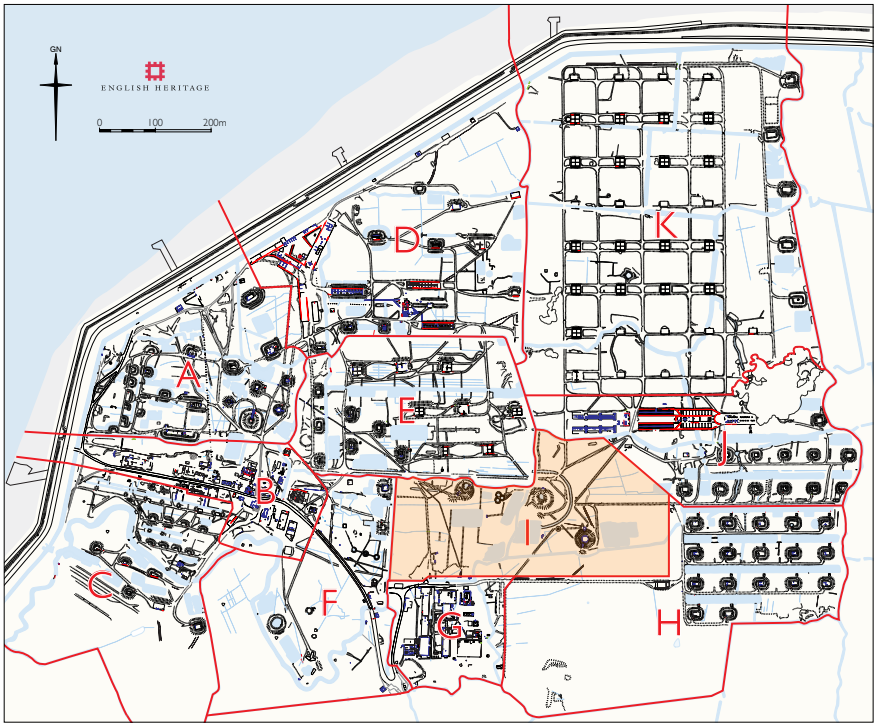
In four locations, a narrow earthwork projects finger-like for 7-10m from the north edge of the east-west tramlines: namely between the pairs of **272** and **273**, **274** and **275**, **277** and **278**, and **279** and **280**. These earthworks are of a similar height to the embanked tramway, but are noticeably narrower at only 2.7m wide. They do not appear to lead to small platforms like the paths leading to postulated earth closets found at the north-east

end of the site, and they exist in addition to the small earthwork lobes that supported the points systems for the tram rails; as such their function remains uncertain.

Structure 266

Structure **266** is the hint of a lone building platform, 5.6m x 6.6m in plan, visible only as a firm level area framed by a vegetation mark, located immediately north-west of the guncotton stoves. The north-south tramway ends at a T-junction next to **266**, from here it connects with the second nitroglycerine zone (**166**, **167** and **168**) to the west in **Area I**, and a group of cordite paste-mixing houses and associated magazines to the east in **Area J**. No structure is indicated in this location in the sales particulars from 1923 (ibid), and its function remains unknown.

6.15 Area I: HM Cordite Factory - nitroglycerine group



***Area I** shaded orange.*

Area I is north-west of **Area H** and the two are connected by a tramway running west from structure **266**. It contains a small number of large dispersed structures, interpreted as the second nitroglycerine processing area for the explosives works, developed as part of HM Cordite Factory to cope with the increased demand for military explosives brought on by the outbreak of the First World War. The area is laid out roughly as a broad arc of structures, principally comprising three large earthen mounds with integral elements of structural brickwork (**166**, **167** and **168**), interspersed with small circular ponds, brick plinths and a network of tramways, paths and drains (Figure 128). The zone immediately surrounding this group remains relatively undeveloped, attesting to the volatile nature of the processes undertaken here. The generous spacing may also reflect lessons learned following several accidental explosions in the earlier nitroglycerine group in **Area A**.

Figure 128: ***Area I*** *from the air, showing the large earthwork traverses of (top to bottom) structures* ***168****,* ***167*** *and* ***166****, looking east. Extract from NMR 26890/013 08-Mar-2011, Damian Grady © English Heritage.*

Structure 168: nitroglycerine house

At the south-east end of **Area I** is structure **168**. Arguably this would have been, and perhaps still is, the most imposing structure on the site. Thought to have been constructed around 1914-15, it is the second of two nitroglycerine hills confidently identified amongst the factory remains (the other being structure **31**). Apart from a handful of associated features to its north-west (**167**, **170** and **171**), structure **168** is located in relative isolation compared to most other factory structures. It sits in an area of open marshland, equidistant between the acid and the guncotton processing plant (**Area G**) and guncotton drying stoves (**Area H**) belonging to HM Cordite Factory. To its east is a large water-filled borrow-pit created during construction of the mound, and the drainage dyke running along its southern edge has been re-routed to bow around an ancillary bund covering the main entrance to the mound (see Figure 128).

The 1923 sales particulars describe the building in this position as 'B2', a 'Nitro Glycerine Hill, including building on piles', comprising a timber superstructure surrounded by 18-inch thick brick walls, with a concrete floor and a timber and felt roof (MALSC 06a_DE_Series_1001_1200/DE1087_3). The nitroglycerine hill would have contained the nitrating house - a multi-storeyed building in which acids were combined with glycerine to form nitroglycerine - and probably an adjacent lift or winch tower up to the charge house. The 'building on piles' associated with 'B2' is almost certainly the lift tower and charge house. The charge house would have received acids piped up from an acid egg and glycerine winched up in a bogie cart using a windlass-operated lift (see section 4.2).

Externally, **168** is a large domed earthwork mound with a 37m-wide circular footprint and steep slightly convex sides. The protective mound stands 4m high; within it is a

large hexagonal space floored with concrete and surrounded by tall brick revetting walls (Figure 129). The main access to the nitroglycerine house was through a broad rectangular brick entrance in the southern side of the mound. Externally, the opening measures 2.5m wide by 1.3m high and is topped by a substantial 0.36m-wide lintel of coarse poured concrete, supporting a 16-course brick elevation reaching a height of 3.5m above ground level (Figure 130). Flanking either side of the entrance is a pair of brick revetting walls, projecting 6.5m out from the opening. They are steeply angled to match the slope of the earthwork, and step out at the base by a single brick width roughly coped with concrete render. Internally, the concrete lintel slab carries the main hexagonal retaining wall over the entrance.

*Figure 129: (above left) Structure **168** from the air, looking south. Extract from NMR 26891/026 08-Mar-2011, Damian Grady © English Heritage.*

*Figure 130: (above right) Looking into structure **168** through the large southern entrance, with the low vaulted tunnel entrance visible within. Photograph: Wayne Cocroft 2010 © English Heritage.*

Opposite this opening is an oval earth bund standing 0.7m tall. It is positioned 3m from the base of the main traverse, allowing the tail end of an embanked tramway to access **168** from the east (see Figure 129). Its purpose appears to have been to absorb any blast force projected through the entrance in the event of an explosion; however, it looks to be of insufficient height for this purpose, and there are no structures south of **168** to warrant such protection.

There is a second opening into the mound in the form of a low narrow vaulted tunnel that reduces in height gradually as it enters the interior from the north side. The vaulting comprises four concentric courses of headers. On the inside of the structure, this is seen as an arch flush with the wall and starting from floor level (Figure 131). On the outside of the mound, the tunnel's archway initially opens into a rectangular recess created by parallel retaining walls, which splay-out in a curve to clasp the south half of an ovoid tank marked by a ring of bricks set flush with the ground (Figure 132). The floor of the tunnel

is formed by a thick smooth slab of concrete incised by a central narrow channel lined with blue engineering bricks. The tunnel was the exit point for the finished nitroglycerine on its way to the washing and settling facilities to remove any remaining excess acids and it would have contained a narrow lead-lined wooden gutter for this purpose (see section 4.2).

Immediately west of this external tunnel opening are the remains of two square-section concrete posts protruding from the mound, one fairly complete and the other broken-off close to its base, possibly representing the position of lamps or a pipeline. Close to the posts is a long narrow rectangular concrete slab, 5.5m x 0.8m, set into the base of the earthwork.

*Figure 131: The waterlogged interior of **168**, showing the construction of the revetting wall, with the low tunnel entrance on the north side, and notch in the brick parapet at the north-east side. Photograph: Sarah Newsome 2011 © English Heritage.*

*Figure 132: The low vaulted tunnel exiting from the north exterior of **168** into an ovoid tank or yard. Photograph: Sarah Newsome 2011 © English Heritage.*

The revetting wall is a complete hexagonal circuit of brick, built right against the inside of the earth mound, creating a space within the mound 11m in diameter (see Figure 129). The walling is 4.45m tall and built in rough English Bond, reinforced internally by full-height brick piers set centrally to each elevation. Despite this several, settlement

and stress cracks are clearly traceable through the brickwork (see Figure 131). Overall, the brickwork is utilitarian and quickly thrown up; the only carefully constructed section is the bull-nosing on the south-east jamb of the main entrance. The internal face rises from a 16-course high basal band of brickwork which then steps back twice, each time by a single brick width, to create two further bands finally topped by a soldier course of bricks. Joist pockets 0.2m square were recorded at 1.75m high in all but the south and south-west elevations. In a couple of places, smaller square sockets were noted just above the upper stepped line in the wall, about 3m above ground level.

From the exterior, the upper courses of brickwork appear as a low parapet projecting 0.5m above the top line of the mound, with a line of square-headed iron bolts with rectangular plates or washers projecting out from the external face. Encircling the exterior of this walling, a narrow slot in the earthwork may indicate a former pipe channel. Additionally, there is a slight dip in the top of the mound in line with a distinct rectangular gap in the brickwork at the north-east side (see Figure 131).

Inside the mound, the floor surface is fairly overgrown and often under water. The central slab has witness marks for walls of timber or corrugated iron that, where seen at the east side, respect the angle of the main retaining wall. A defined rectangular building foundation sits roughly in the centre of this surface. At the north end of this slab, dwarf walls suggest the outline of a small rectangular structure that once stood opposite the internal opening to the low vaulted tunnel. A further concrete slab forms the floor, extending through the large southern entranceway into the interior; it has a series of eight or more small square sockets spaced evenly along the centreline of the entrance.

The map accompanying the 1923 sales particulars depicts **168** in a different form to the physical remains, it shows a rectangular building within the traverse and a smaller ancillary building (presumably on piles) outside the east edge of the traverse, the two buildings appear to be connected by a passageway (ibid, and Figure 133). Rather than being a round or hexagonal timber house to emulate the revetments, the nitrating house was indeed a free-standing rectangular building, confirmed by the rectangular concrete floor slab within the mound. Square joist pockets at two heights in the revetment wall would have helped to support the two elevated floor levels within the nitrating house, along with an external timber walkway for access to various pipe and tank inlets. Equally, a winch tower on the east side (as depicted on the 1923 plan) would explain the dip in the mound and gap in the brick parapet on that side.

The nitroglycerine production facilities focussed at **168**, are thought to have been constructed as part of the extensive wartime factory expansions at Cliffe in 1914-6. Official records suggest that in mid-1916, a second de-nitrating plant was constructed, to cope with the waste acids from the increased on-site nitroglycerine manufacture (Crozier 1917, 1), confirming that additional nitroglycerine production facilities had been recently added. A contemporary description of nitrator-separator equipment in a 'modern' nitroglycerine hill, including diagrammatic measurements, closely reflects the height dimensions of the structural remains of **168** (Martin and Barbour 1915, 89-90). A nitroglycerine production facility of this date would almost certainly have been built to use the Nathan-Thomson-Rintoul nitration process. With this system, use of a

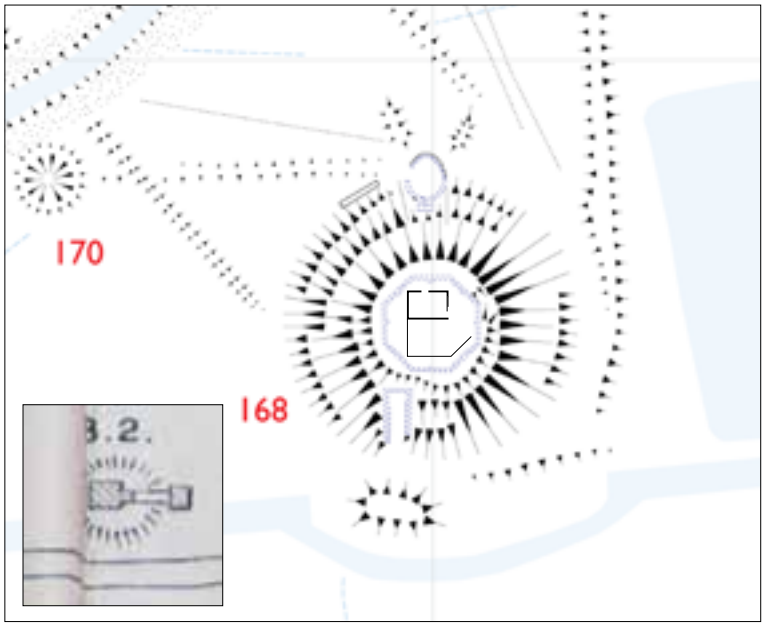


Figure 133: Extract from the survey showing nitroglycerine hill ***168****, with an inset of the equivalent detail from the 1923 sales particulars. Main image © English Heritage; inset image MALSC 06a_DE_Series_1001_1200/DE1087_3, Medway Archives and Local Studies Centre, Strood, reproduced by kind permission.*

nitrator-separator within the nitroglycerine hill removed the need for an after-separating house (ibid, 89) (see section 4.2). Structure **168** is fairly similar in form to the remains of nitrating house E2 in the North Site, Edmonsey Mead factory at RGPF Waltham Abbey; the main differences being that the Watham Abbey example had a basement level, and therefore a much bigger drowning tank, and that its bogie lift tower was immediately outside the main entrance to the mound, rather than tucked around the side (Cocroft 2000, 132-35). Like E2 at RGPF Waltham Abbey, evidence for a bogie lift to raise glycerine, and possibly acids, to the tanks at the top of structure **168** may indicate that acid eggs and compressed air were not required for this building.

Structures 170 and 171

A tramway or path leads west from the north exit of nitroglycerine mound **168**, and is truncated on a 45 degree angle by a narrower linear embankment before terminating at the neat circular earthwork of structure **170** (see Figure 133). The feature, 9.7m in overall diameter, comprises a low circular bank with a short steep external slope, and a deeper but more gentle concave slope on the inside, creating a bowl-shaped interior.

Structure **171** refers to a group of three roughly parallel rectangular concrete bases, all measuring 2.7m x 0.65m in plan and each topped with a brick plinth, south-west of **170**. The top of the brick plinths have a U-shaped profile with a thin mortar surface, possibly designed to hold a horizontal cylindrical tank about 1.5m in diameter (Figure 134).

Unfortunately, neither structure **170** nor **171** is defined by the 1923 sales particulars, but their location suggests a function linked to the nitroglycerine plant. One possible explanation is that they represent the remains of a denitration facility. The hollow of **170** could be the seat for an acid egg into which waste acids, separated from nitroglycerine by the nitrator-separator in the nitroglycerine hill, would be run by pipe. The brick supports of **171** could be the supports for an acid supply tank, into which the waste acid would be raised from the acid egg by compressed air so that it could be passed through the

denitration towers. However, no evidence for denitration towers was identified in this area, and evidence for a bogie lift to move materials to the top of nitroglycerine house **168**, suggests that use of acid eggs and compressed air was not necessary (although it is possible that both methods were in place). As such, there is insufficient detail in the physical and documentary evidence to make an interpretation beyond the notion that **170** and **171** were integral to the nitroglycerine plant.

*Figure 134: The moulded brick plinths of structure **171**, looking south-west. Photograph: Sarah Newsome 2011 © English Heritage.*

Structures 166-167: nitroglycerine wash houses and wash water separating house

In the large open area to the north-west of nitroglycerine hill **168** are two further circular mounds of a similar scale: structures **166** and **167**. Unlike structure **168**, both are in a very poor state of preservation, exhibiting large central water-filled craters and collapsed brick entranceways, giving the impression that the structures have been blown up, either purposefully or accidentally (see Figure 128). They each have an overall circular footprint of 35-40m in diameter, comprising a doughnut-shaped earth bank standing 2m high with a fairly rounded profile. The large craters are fairly uneven, skewed slightly north of centre, and are smaller in size than the original interior space due to the build-up of debris and inward slumping of the bank. Despite the level of destruction, the position of brick-lined entrance and exit points are clear in both examples (Figure 135). The collapsed and in-filled remnants of a wide square-section entrance tunnel are visible on the south-west side of **166** and the south side of **167**, much like that seen intact in structure **168**. Another similarity shared with **168** is that, in both cases, this blocked opening faces a small ancillary earth bund, and the line of an embanked tramway is clearly traceable exiting the opening and turning sharply between the large and small earthworks. On the opposite external face, each mound has a line of brick flush with the ground protruding from the foot of the bank; in the case of **166** it follows a reasonably tight arc with a slightly pinched end, but in the case of **167** it is distinctly trapezoidal (see Figure 135). These catchment tanks or forecourts are very reminiscent of comparable features associated with nearby nitroglycerine hill **168**, and also further afield on the south-west side of structure **104** in **Area F**. Structure **166** also has a small segment of the low vaulted brick tunnel that would have led from the inside of the mound out to the brick arc, and again, is reminiscent of the example in nitroglycerine hill **168** (see Figure 135).

Figure 135: (clockwise from left) Collapsed vaulted brick tunnel on the north-east side of ***166****; in-filled wide entrance on the south-west side of* ***166****; and trapezoidal tank or forecourt on the north side of* ***167****. Extracts from NMR DP141682, DP141683 and DP141679 08-Mar-2011, Steve Cole © English Heritage.*

Despite the obvious similarities in form, such a high degree of degradation means that **166** and **167** cannot be confidently interpreted as having performed the same function as each other during their operational years and, when surrounding features are taken into consideration, a number of differences between the two become apparent.

Structure **167** is surrounded by a complex of tramways, tracks and drains connecting it directly to **Areas E**, **H** and **J** and, thereby, to both the pre-war part of Curtis's & Harvey's explosives works to the west and to the government controlled portion, HM Cordite Factory, to the east. Roughly mirroring the footprint of the mound, a loop of embanked track or tramway runs around the east side of **167** and terminates at the discrete mound to its south, and from this, two parallel straight paths lead south-east towards the north and south entrances to nitroglycerine hill **168** (Figure 136). Additionally, three long straight tramways on the east or north-east side of **167** connect it with the rest of the factory. Several embanked tracks and tramways associated with **167** cross, underlie and are enclosed by, the semi-circular drainage dyke around the eastern side of the structure. As such, any junction-relationships are masked by the line of the ditch and its dredging upcast. In contrast to **167**, structure **166** appears to be served only by a single tramway approaching the large south-west entrance from **Area E** to the north-west. Both buildings, along with the majority of those across the whole factory complex, would also have been connected by networks of pipes and cables that are no longer visible.

The most striking difference between **166** and **167** is the presence of a semi-circular drainage dyke sweeping around the east side of **167** to create a small radial area of

enclosed ground 20-30m out from the foot of the mound (see Figures 128 and 136). Combined with borrow-pits and drainage dykes to the west of **167**, the semi-circular ditch creates a seemingly purposeful enclosure, making **167** look like it has received special treatment, perhaps by being defined as a dangerous space. If the ditch was excavated to function contemporaneously with the nearby factory structures, then it could have been installed as physical boundary, possibly to act as a firebreak.

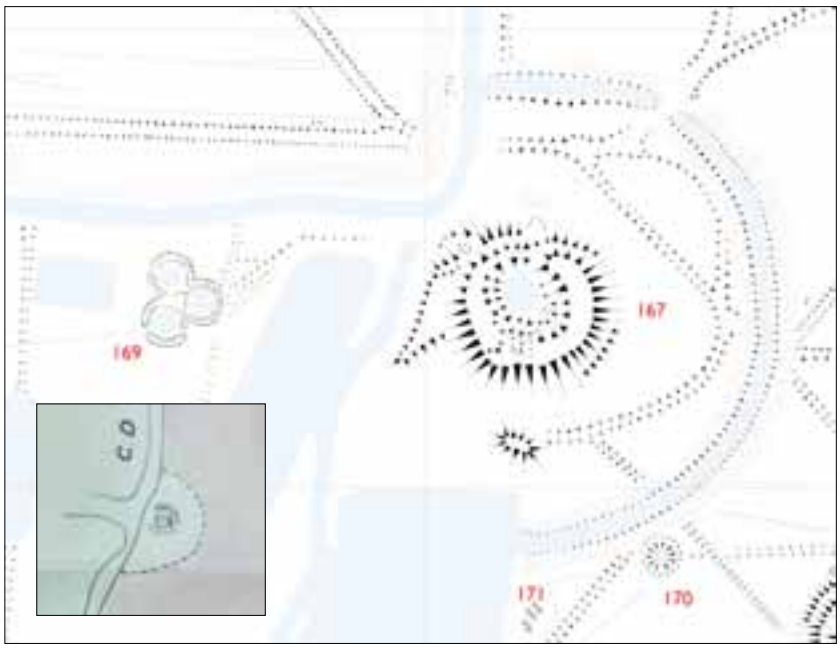


Figure 136: Extract from the survey showing wash house ***167*** *and nearby structures, with an inset of the equivalent detail from the 1923 sales particulars. Main image © English Heritage; inset image MALSC 06a_DE_Series_1001_1200/DE1087_3, Medway Archives and Local Studies Centre, Strood, reproduced by kind permission.*

Like the factory structures close to it, the semi-circular ditch post-dates the 1907 25-inch OS map revision (Ordnance Survey 1908b). If the boundaries indicated by the map accompanying the 1923 sales particulars are taken literally, then structures **166** and **167** were both outside the area encompassed by HM Cordite Factory (MALSC 06a_DE_Series_1001_1200/DE1087_3). Despite this, the plan depicts a small rectangular building clasped by a pair of curvilinear banks in the location of **167**, with a semi-circular dotted line drawn around the east side of **167** (see Figure 136). The dotted line most likely represents the, now truncated, loop of tramway around the east side of **167**; it does not match the drawing style used for other dykes on the map and its alignment appears closer to **167** than that of the ditch. Evidence seems to suggest that the semi-circular drainage dyke was excavated after the factory ceased operations. Apart from a narrow causeway in the north-east, the semi-circular ditch cuts through all of the surrounding features and is flanked on both sides by a low spread bank of dredging spoil which overlies the adjacent tracks – the ditch looks intrusive, likely cut after the factory closed. Nevertheless, as seen elsewhere, the tramways could have been carried across the dyke on wooden bridges, and subsequent managed dredging may have masked earlier relationships. If the semi-circular ditch was cut some time after the construction of **167**, it could even have been excavated to create a manageable stock enclosure, or simply to have improved the drainage of this area for grazing. However, a big effort has been made to cut the ditch parallel to the mound of **167** and to its encircling tramway, an act that looks intentional and seems questionable if the adjacent features were no

longer in active use. One possibility is that the ditch was excavated during the Second World War when parts of the site were thought to have been used for controlled disposal of explosives and munitions (*see* section 3.7). The ditch could have provided a physical borderline for safety. Disposal of munitions might also explain the current state of disrepair of the mounds forming structures **166** and **167**. As such, taking all of the preceding discussion into account, the question of whether the semi-circular ditch dates from or post-dates the factory's years of operation, and what its relationship was to the surrounding factory features, remains unsolved.

No definitive reference to these two structures has been identified in the documentary records. It is thought most likely that structures **166** and **167** were both wash houses, or were a pair comprising one wash house and one wash water settling house, associated with nitrating house **168**. If this was the case, they would have received waste acids for further washing and filtering to extract any unwanted residues and to clean the acids for reuse or resale (*see* section 4.2). Waste acids were normally moved from nitrating houses by gravity through a series of covered lead-lined gutters, being too volatile to be carried or propelled by compressed air (Cocroft 2000, 131). Whilst it is tempting to interpret the pair as nitroglycerine wash houses, based on their proximity to **168** and the relative isolation of the group overall, the lack of additional structures usually found adjacent to nitroglycerine production (such as acid sheds), and the absence of any mention of them in association with **168** ('B2') in the 1923 sales particulars, could imply that they belonged to a separate element of the factory process. Either **166** and **167** were always outside the boundary of HM Cordite Factory, or the west part of **Area I** was retained by Curtis's & Harvey for storage after the sale of the rest of the HM Cordite Factory land in 1923. Similarly, the presence of the semi-circular ditch around **167**, and glimpses of structural elements similar to those seen in **168**, may indicate that **167** was built as a nitroglycerine hill that was latterly replaced by a modernised version in the form of **168**, and either became redundant or was converted to a wash house or settling house. The precise nature of the relationships between the structures in **Area I** and their individual functions remain, at least partially, unresolved.

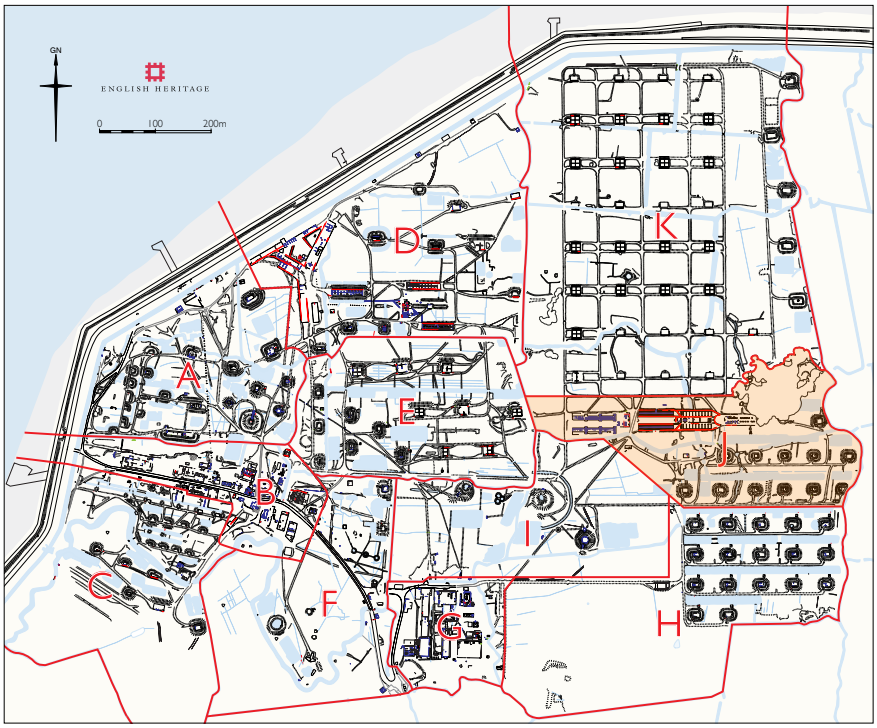
Structure 169: settling ponds

Roughly equidistant between the mounds of **166** and **167** is structure **169**: a tight cluster of three circular features in a clover leaf formation (*see* Figures 128 and 136). Each circular feature is 10-12m in overall diameter. Much like nearby **170**, they are each formed of a narrow low circular bank with a concave scooped-out centre, now filled with ground water. The three pits or ponds are all interconnected by narrow breaks in their banks. The whole group appears to be served by a tramway or path approaching from the north-west and by a pipe channel or drain traceable for a considerable distance, leading from the south-east edge of the group to the space between mounded structures **156** and **157** in **Area F** (thought to be mixing houses for Cheddites or gelatine-type explosives, *see* section 6.11). Possible explanations for **169** include settling ponds associated with the washing processes for nitroglycerine, or the hollows for acid eggs, both of which would have been present in the nitroglycerine factory.

In the far south-west corner of **Area I**, beyond the nitroglycerine group and its large waterlogged borrow-pits, the ground is marked only by a few long linear drainage gullies

or former pipelines, a small number of brick manholes and a single embanked tramway running south from **Area E** and ending in a large irregular-shaped earthen platform. The platform borders 100m of the drainage dyke along the south edge of **Area I**, and faces the concrete emplacements of **173a** and **173b** on the opposite bank. It could have been used as a large storage area for raw materials coming to the site on freight ships, such as acid carboys for use in the adjacent guncotton (**Area G**) and nitroglycerine plant (**Area I**).

6.16 Area J: HM Cordite Factory - cordite preparation



***Area J** shaded orange.*

After being saturated with nitroglycerine in **Area I**, guncotton charges would then have moved north-west into **Area J**, where all the final chemical and physical processes were carried out. **Area J** is divided into two distinct areas; the south-east part is occupied by rows of large sub-rectangular earthwork traverses similar to those in **Area H** to the south, whilst the north-west portion contains a long east-west alignment of large cordite processing buildings, including four long, standing buildings subdivided into multiple individual compartments (Figures 137 and 138, also see Figure 126).

Structure 254: fitter's shop

Structure **254** is a rectangular concrete building foundation situated at an apparent junction between three converging tramways, 150m north-east of **167**. It measures 11.5m x 5m in plan, with a small area of partial floor collapse and an evenly spaced row of four iron studs along the southern edge. Although **254** sits close to the path of three different tramways, only the embankment running NW-SE appears to connect directly with the building. Contemporary documentation from 1923 describes **254** as building number '105', a fitter's shop with walls constructed of timber and corrugated

iron, a corrugated iron roof and a concrete floor (MALSC 06a_DE_Series_1001_1200/DE1087_3). This would have been one of several fitters', engineers' and carpenters' shops across the site, and would have contained tools such as lathes, planing machines, drills and hydraulic presses for the maintenance of parts and machinery including the bogie carts, incorporating machines and drying fans.

Structure 255: weigh house and store

South-east along the tramway from **254** is structure **255**: a rectangular concrete foundation measuring 10m x 7m. Six brick plinths sit on top of the slab; only one in the north-east corner is in its original position, the other five are much larger and have at some point in the past been toppled onto their sides (Figure 139). A purposefully curved surface on what would have been the top sides of the fallen plinths looks as though it may have held a tank at one time, and a thick concrete render on the end of the plinths suggests that a coating was added in situ using corrugated shuttering. The 1923 sales particulars explains that these are the remains of building number '104', weigh house and adjoining stores. It had walls of timber and corrugated iron, a corrugated iron roof and a concrete floor, and is described as having had brick bases on the floor of the store (ibid).

*Figure 139: Structure **255**, looking north-east with **247** in the background. Photograph: Rebecca Pullen 2011 © English Heritage.*

Structures 252 to 253 and 264 to 265: magazines and expense magazines

The south-east half of **Area I** is dominated by twelve sub-rectangular earthwork traverses arranged in neat rows, slightly smaller than the guncotton stoves of **Area H** to the south and without accompanying fan sheds. Although at first glance all twelve appear the same, we know from the 1923 sales particulars that the majority were cordite paste mixing houses (**256**-**263**), but that four of the outlying structures were magazines: namely, **252**, **253**, **264** and **265**. All four structures are almost identical in form, each with a footprint of about 30m x 25m, composed of high earth banks with a single entrance opening in the south side, encircling rectangular concrete building foundations that are partially overgrown so that the full extents are indistinct. Where visible in structure **253**,

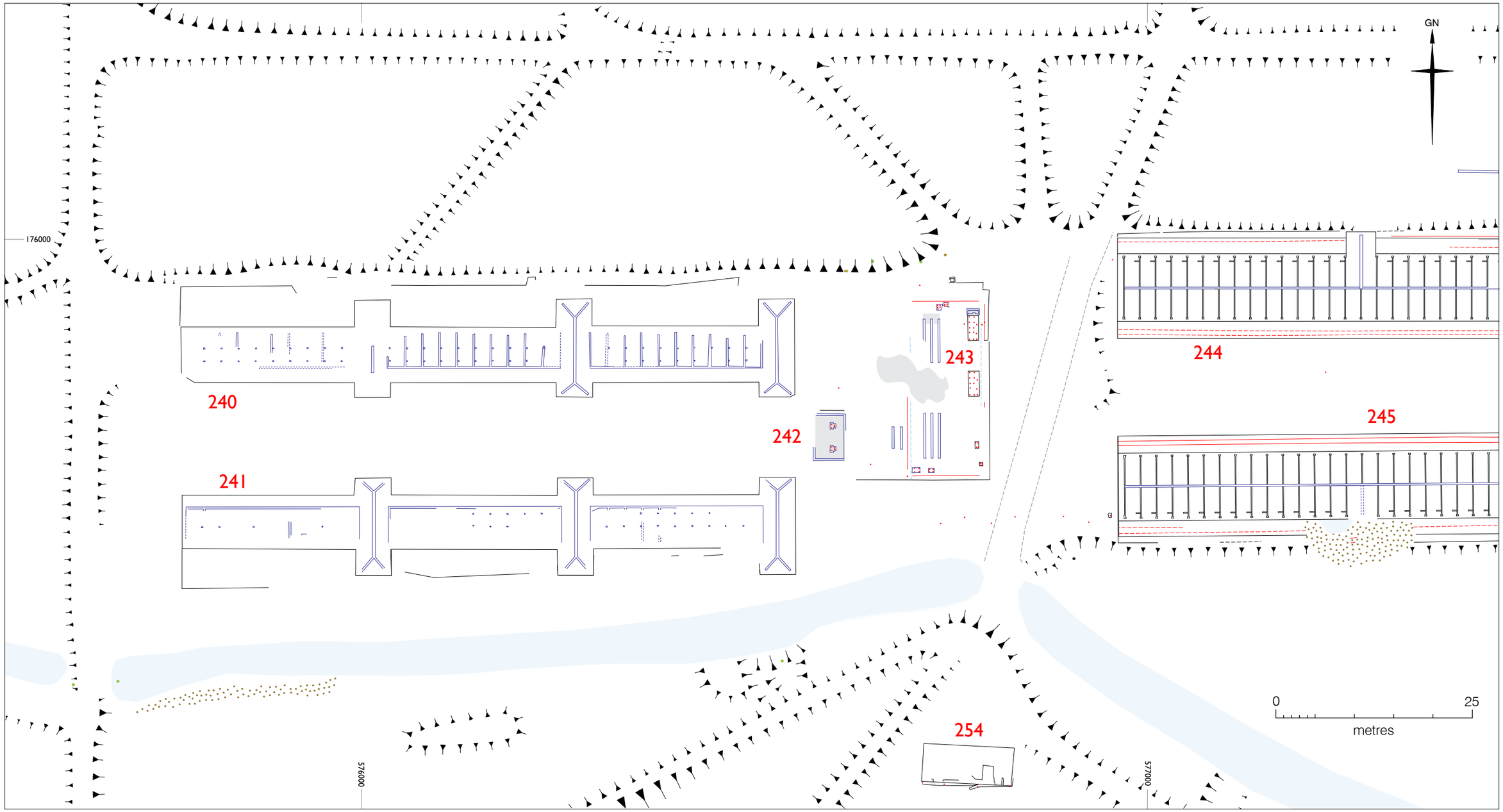


*Figure 137: West portion of the remains of the acetone recovery facilities in **Area J**. Drawn by Philip Sinton © English Heritage.*

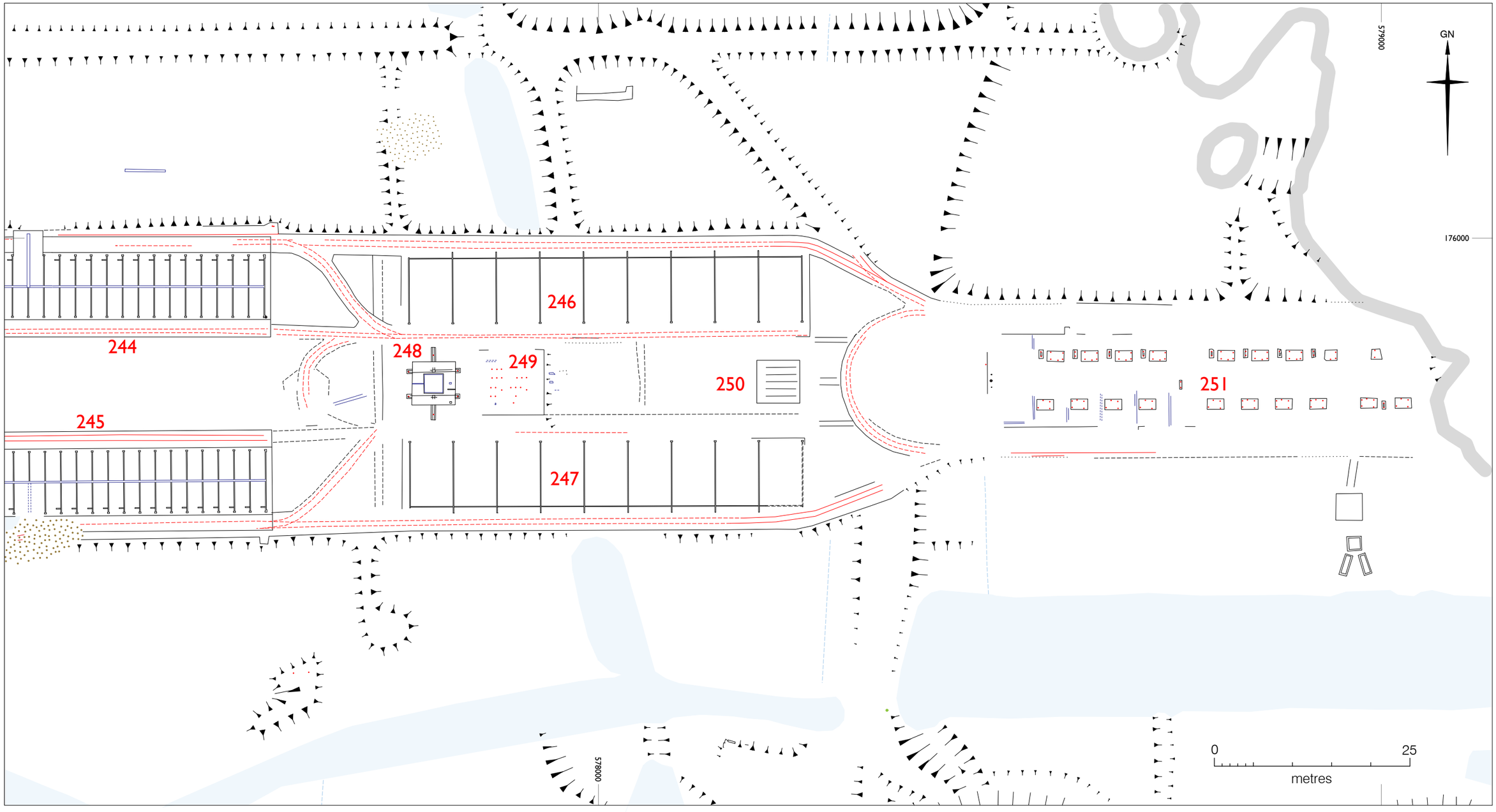


Figure 138: East portion of the remains of the acetone recovery facilities. at the northern edge of ***Area J****. Drawn by Philip Sinton © English Heritage.*

the slab measures 7.3m x 8.5m. All four structures appear to have had a narrow porch or external area appending the east end of the slabs, measuring 2.5m wide, to receive a bogie cart. Structures **253**, **264** and **265** all have short sections of tramway branching-off from the main east-west line to allow access through the southern opening in the earthwork, but structure **252** appears to have required the bogie cart to pause on the main tramway.

According to the sales particulars from 1923, all four buildings had concrete and timber floors, and match-lined corrugated iron walls and roofs. Structures **253** (formerly 'X8') and **264** ('X9') were both magazines, whilst structures **252** ('X7') and **265** ('X10') were expense magazines (ibid), therefore each pair of adjacent structures comprised one magazine and one expense magazine. An 'expense' magazine was normally one used to store part-manufactured explosives in between processing phases (Cocroft 2000, 290-3). The specific difference in use between the magazine and expense magazine in each pair remains unclear. Based on location in relation to adjacent processing facilities, it is likely that structures **264** and **265** were used to store newly produced cordite paste from the nitroglycerine factory **Area 1** pending its move to the adjacent mixing houses (**256** to **263**). In contrast, 252 and 253 were probably used to store fully mixed cordite paste awaiting movement into the nearby incorporating house, structure **251**.

Structure 256 to 263: cordite paste mixing houses

The group of eight earthwork traverses in between the two aforementioned pairs of magazines are structures **256** to **263**. They are laid out in two rows of four on an east-west alignment, staggered so that the north row sits one structure further west than the row to its south. Each traverse encircles a small rectangular concrete building foundation (see Figure 126). The 1923 sales particulars lists them as buildings 'E4'-'E11', cordite paste mixing houses, each with walls and roofs built of match-lined corrugated iron, and floors of concrete and timber (MALSC 06a_DE_Series_1001_1200/DE1087_3). In the mixing houses, batches of cordite paste (guncotton freshly saturated with nitroglycerine) were roughly kneaded by hand in lead-lined basins before being rubbed through a fine wire mesh (see section 4.2).

With the exception of **263**, the earthwork structures each cover a sub-rectangular area 27m x 24m in plan. All eight have a break in the bank towards the south-west corner, through which material could be moved into the internal space from a short branch off the main tramway. A low ridge sits across this opening, effectively truncating the tramway branch line meaning that the cordite-paste would have been moved in and out of the danger building by hand. There is some irregularity in the form and slope of the banks which has been attributed to disturbance from vegetation, burrowing, grazing or poaching.

Inside the earthworks are traces of concrete building foundations measuring 8.8m x 5.5m overall. The concrete is visibly divided into a main area about 6.4m across, adjoined by a smaller area at the west end measuring 5.5m x 2.4m; this ancillary area was probably a covered porch and may represent the 'dirty' area of the danger building (Figure 140). Several of the less vegetated slabs show an arrangement of four small rectangular cut

*Figure 140: Structure **258**, showing (left) the interior space divided into a main building floor and a slightly lower narrow porch or 'dirty' area; (right) the small square floor holes that mark where a lead mixing vessel once stood. Photographs: Rebecca Pullen 2011 © English Heritage.*

holes forming a square just over 1m across, slightly off-set to the north-east from the centre; the holes indicate where the hefty lead mixing vessel was secured to the floor of each building. A small circular hole in the southern edge of the foundations marks the position of an internal drain or heating pipe.

Structure **263** differs slightly in that, owing to its position tight against the edge of a drainage dyke, the earthwork is incomplete and forms an L-shaped protective mound on the north and west sides of the slab. The adjacent dyke runs diagonally across where the south-east corner of the earthwork would usually be, and a much lower bank sits along the edge of the ditch on the factory side. Although this arrangement gives the appearance that the building has been cut by the ditch, and indeed the internal space is not large enough for a building of equivalent dimensions to those in the rest of the group, the lower bank along the edge of the ditch is stratigraphically beneath the main traverse, and so this earthwork probably enclosed a smaller building from the outset.

Structure 251: incorporating house

Structure **251** is a large concrete slab aligned east-west, with its eastern end destroyed by the large area of Second World War bomb crater damage (see section 7.1), located approximately 50m north of the paste mixing houses, and reached by a tramway running north-west from magazine **252**. This slab forms the eastern end of a long east-west alignment of large cordite processing buildings (Figure 141). The sales particulars from 1923 lists the building in the position of **251** as 'J6 (1-34)', an incorporating house with 32 compartments, two motor houses and an annexe containing a vaseline house and two boot rooms. They were constructed of brick walls with corrugated iron roofs, and concrete floors surfaced with asphalt in all but the annexe (ibid). In the incorporating house, mineral jelly (vaseline) and acetone were added and thoroughly blended into the cordite paste using mixing drums based on modified belt-driven commercial bread dough kneading machines. Mineral jelly acted as a chemical stabiliser, and incorporation of the solvent acetone helped to improve the malleable nature of the paste (see section 4.2).

Figure 141: The long east-west alignment of large cordite processing buildings in ***Area J****, looking north. NMR 26891/007 08-Mar-2011, Damian Grady © English Heritage.*

The concrete foundation measures 12m wide and survives to 57m in length, with the trace of tram rails alongside the north and south sides of the building. Along the internal length of the slab are two rows of rectangular concrete plinths aligned so the two rows are slightly staggered in relation to one another (Figure 142, and *see* Figure 138). The plinths almost certainly represent the machine beds that once supported the incorporating machines. They are principally orientated east-west, measuring 2.1m x 1.3m in plan and 0.3m high, each with up to five iron studs in the top. Around half of the plinths, mainly along the north side of the slab, are paired with a smaller lower rectangular plinth orientated north-south, measuring 1.12m x 0.56m in plan, with a rectangular groove lengthways in the centre of the top. The sides of the plinths are all covered with a thin layer of smooth off-white cement render.

Figure 142: Structure ***251*** *from the air, looking north-west. NMR 26891/013 08-Mar-2011, Damian Grady © English Heritage.*

A photograph taken during the First World War shows female staff at Curtis's & Harvey's Cliffe factory formally posed in large well-lit building with belt driven machinery in the background (Figure 21). Based on the date of the photograph, and on comparison with contemporary pictures taken inside an equivalent building at RGPF Waltham Abbey (see Cocroft 2000, 139, fig 5.35), the staff photograph may have been taken in an incorporating houses, either in **Area D** or here in **Area J**. However, the witness marks of several brick partition walls are visible on the floor of **251**, which could suggest that, rather than being a large open plan room, it comprised individual compartments measuring about 4.1m wide, each containing a single machine base or a pair of bases.

To the south of incorporating house **251**, approached along a short length of narrow concrete path, is a small group of structures comprising a square featureless concrete platform measuring 3.5m square, and three small concrete tanks or manholes, all made of poured-concrete walls 0.2m thick (*see* Figure 138). The group is arranged in a roughly linear layout between the incorporating house and the elongated borrow-pit to its south; it is possible that proximity to the pond-like borrow-pit played some role in their function. It is possible that these are the annexe with a vaseline room and the two boot rooms described in the 1923 sales particulars.

Structures 246-247: cordite press houses

The tram rail scars that run alongside the incorporating house (**251**) converge to its west, forming a central semi-circular rail arrangement, where they also split to run along the external long edges of **246** and **247** (*see* Figure 138). Structures **246** and **247** are a mirrored pair of elongated standing concrete buildings, a short distance west of **251**, that are divided into individual cells. Both buildings are roofless, with reinforced concrete walls arranged to form a row of nine bays opening onto the central space between the two structures (Figure 143). As mentioned above (structures **153** and **154** cordite drying stoves, *see* section 6.10), the use of reinforced concrete as a construction material is known to have had limited uptake in the British explosives industry and, as such, the examples on the Cliffe site represent a rare survival (*see* sections 4.3, 8.3 and 8.5).

*Figure 143: Paired concrete structures of **247** (foreground) and **246**, looking south-east. NMR DP141708 08-Mar-2011, Steve Cole © English Heritage.*

The 1923 sales particulars list structures **246** and **247** as cordite press houses 'J4' and 'J5 (1-9)', each with a set of nine press rooms and a lean-to boot house. The press houses are described as having concrete and asphalt floors, with reinforced concrete walls and a corrugated iron roof. The lean-to structures were floored with timber and had walls of match-lined corrugated iron with corrugated iron roofs (MALSC 06a_DE_Series_1001_1200/DE1087_3). Cordite paste was moved from the incorporating house to the press houses where it was passed through a hydraulic press under great pressure and extruded into long cords of varying diameter, according to need (see section 4.1).

Structures **246** and **247** are identical in construction: both are aligned east-west and comprise nine individual bays on a concrete foundation, and each is served by tramlines running along both long sides of the structures (see Figures 138 and 144). The only discernible difference is that the easternmost bay in the southern range (**247**), has almost entirely collapsed or been demolished. A 50m long spine wall forms the outward-facing 'rear' side of each building. From this, partition walls project out 8.3m to create nine separate bays at intervals of 5.5m, all facing into the central area between **246** and **247**. Corresponding to each partition wall is a short length of wall projecting 0.75m from the rear of the spine wall which acts as a support or buttress. The walls are all constructed of reinforced concrete, with integral piers and coping. As the partition walls stretch away from the long spinal wall they slope gradually downwards in height so that the two buildings are trapezoidal in section (see Figure 144). Although there are no front walls to the bays, witness marks for set back entrance walls enclosing each were noted inside the bays, and were these probably not made of concrete (Figure 145).

The interior of each bay is rendered in fine grained cement which stops short of the full wall height, denoting the position of a lightweight roof structure carried on square-section rafters running parallel to the front entrance wall through square holes in the partition walls. The roof scar visibly pitches down towards the front of the buildings, parallel with the sloping top line of the partition walls (see Figures 144 and 145). Thin iron pins, and the holes where pins have been removed, project through the rear spine wall at a level just below the height of the iron roof. These probably held a wall plate to support the roof. The partition walls stand taller than the roofline, creating a series of parapets: these increased the structural stability of the building and reduced the possibility of a fire spreading from one bay to the next in the event of an accident. Each partition wall has a collection of holes for elements such as pipes, conduits and bearings boxes, and evidence for former features or fixtures was also noted in the floor of the bays (see Figures 144 and 145). Set between the openings in the middle the bay floor are five or six iron studs; in the south press house range (**247**), these studs are substantial and appear to delimit a backfilled pit or recess within the floor, suggestive of a heavy machine fixture with a circular footprint, almost certainly the scar left by a cordite press. Many of the floor surfaces are largely obscured by debris and vegetation, but in **246**, a smaller group of studs were noted set within a smaller recess, with witness marks for a small motor or machine on the east side of the marks. These differences might indicate that the two press house ranges were engaged in preparation of cordite of different sizes or uses. The pattern of fixtures in the floor of **246** may indicate that cordite produced in here was of a thinner diameter than that made in **247**, the adjacent extra witness marks could relate to reeling machines used to reel the narrower cords.

Figure 145: Inside a cell in press house range ***247****, showing roof and walls scars, and various openings and conduit holes in the walls. Photograph: DP141655 08-Mar-2011, Steve Cole © English Heritage.*

The rear wall of every bay is pierced by a pair of equally spaced large rectangular openings raised above ground level (see Figure 145). Corresponding to the exterior side of each of these, is a set of square sockets in the concrete floor (see Figure 144). The holes could suggest the presence of a platform for loading between the press houses and the tramway through the openings, however, the location of a huge hydraulic press in the centre of each bay would not leave much room for moving material around the sides, and so they were most likely large windows.

At the external west end of both press house ranges, are witness marks for the corrugated iron lean-to structures mentioned in the 1923 sales particulars (ibid). Also along this roof scar is a line of fairly substantial iron brackets to suspend a pipe; the witness marks for the lean-to appear to respect the brackets as though the corrugated iron sheeting went round the hooks (Figure 146).

Figure 146: Cordite Press House ***246****, showing iron brackets and witness marks for a lean-to structure at the west end. Photograph: Wayne Cocroft, 2010 © English Heritage.*

South-west of **247**, a short narrow earthwork ending in a slightly wider platform projects south from the main east-west tramway embankment. It is similar in form to structures **201**, **202**, **213** and **214** in **Area K** and, although it was not assigned a structure number, it might represent the former location of one or more earth closets.

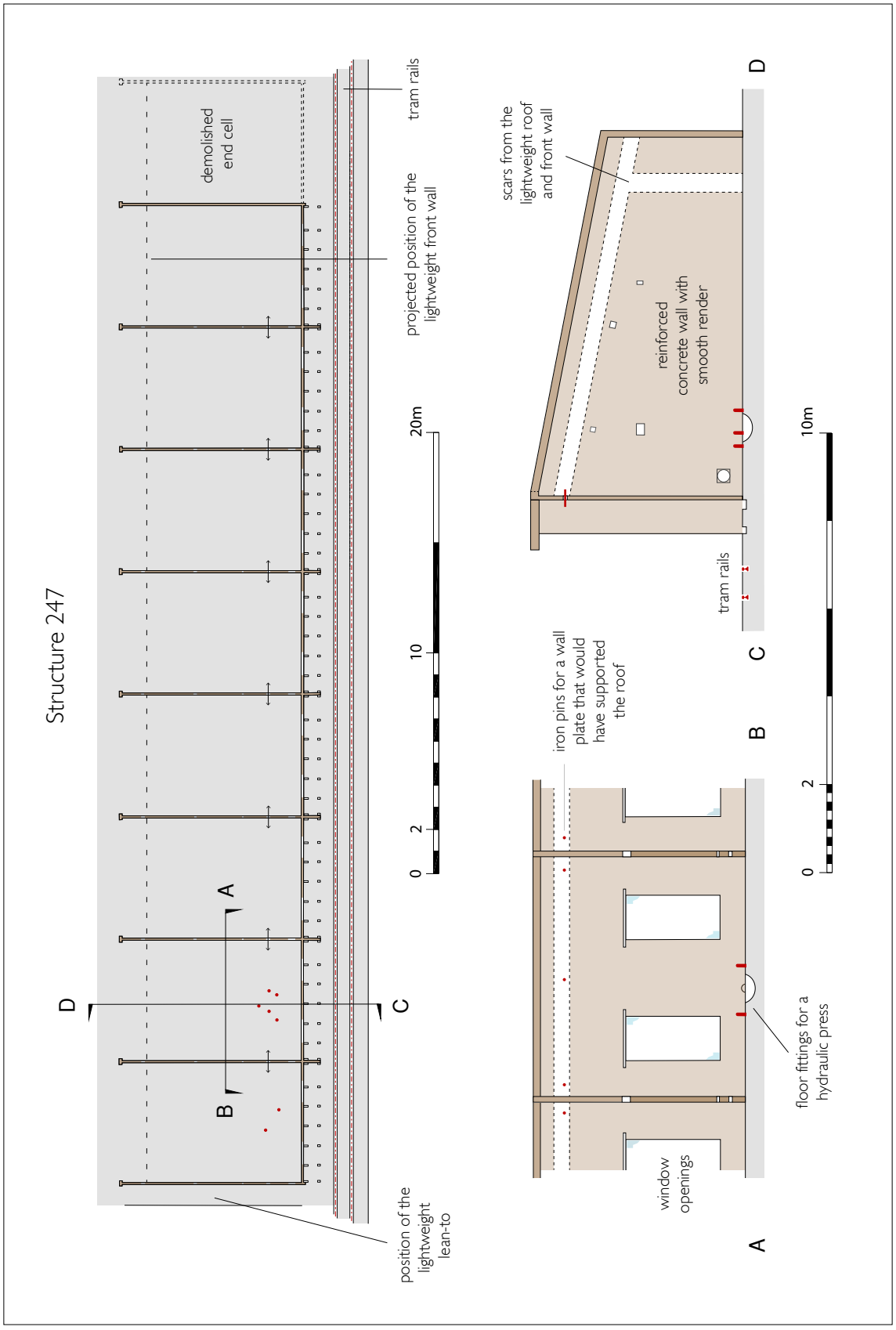


Figure 144: Schematic measured plan and section drawings of cordite press house ***247****. Drawn by Andrew Williams and Rebecca Pullen © English Heritage.*

Structures 248 and 249: pump house and hydraulic accumulator

Structures **248** and **249** are two roughly square concrete building foundations positioned side-by-side at the west end of the linear space between press houses **246** and **247**. The western slab, **248**, is a robust and fairly detailed foundation, it sits slightly proud of the ground surface, measures 5.5m square and has a series of rectangular concrete piers projecting from its edges (Figure 147). Single elongated piers, 1.8m x 0.55m, project from the north and south edges, and a pair of shorter piers project from the east and west edges. In all cases, the concrete piers or plinths have a central shallow flat-based groove, 0.22m wide, along their length and a large iron bolt protruding from the surface. East-west across the centre of the slab is a slightly raised area of concrete 3m wide and inset within this is a brick-edged depression measuring 2.3m square internally. The robust nature of **248** suggests it supported a facility that involved notable weight or movement.

*Figure 147: Probable hydraulic accumulator base **248**, with remains of cordite press house **247** behind, looking south-east. Photograph: Rebecca Pullen 2011 © English Heritage.*

Immediately east of this is **249**, a concrete slab roughly 8.6m square in plan, with a dense pattern of iron fittings in four rows across its centre. The western edge of the foundation is covered by grass, concealing any physical relationship between **248** and **249**.

The 1923 sales particulars describes a pair of buildings (under the machinery lots rather than with the buildings) which could be **248** and **249** . Buildings '106' and '107' are listed as a pump house with a concrete floor, brick walls, and a match-lined corrugated iron roof, but only '107' is depicted on the map (ibid, and see Figure 148). It further specifies that '106', the cordite press pump house, contained one hydraulic accumulator made by J Wake & Co, used at 500lbs per square inch working pressure (which comprised a ram, lift, cut-out gear, a centred cylinder and a ballast tank filled with Thames ballast, along with nearly 30ft of hydraulic pipe, various valves and a tarred pine frame), as well as three motor-driven three-throw hydraulic pumps, and a further belt- and countershaft-driven pump and motor, all made by Greene (ibid). It is possible that structures **248** and **249** may have shared a superstructure, and were mutually reliant on each other. Structure **248** is a likely contender for housing the J Wake & Co hydraulic accumulator which would have served the cordite presses in nearby **246** and **247**; structure **249** could have been its associated pump house. Hydraulic power generated in these buildings may also have been used to drive machines in the nearby incorporating house (**251**).

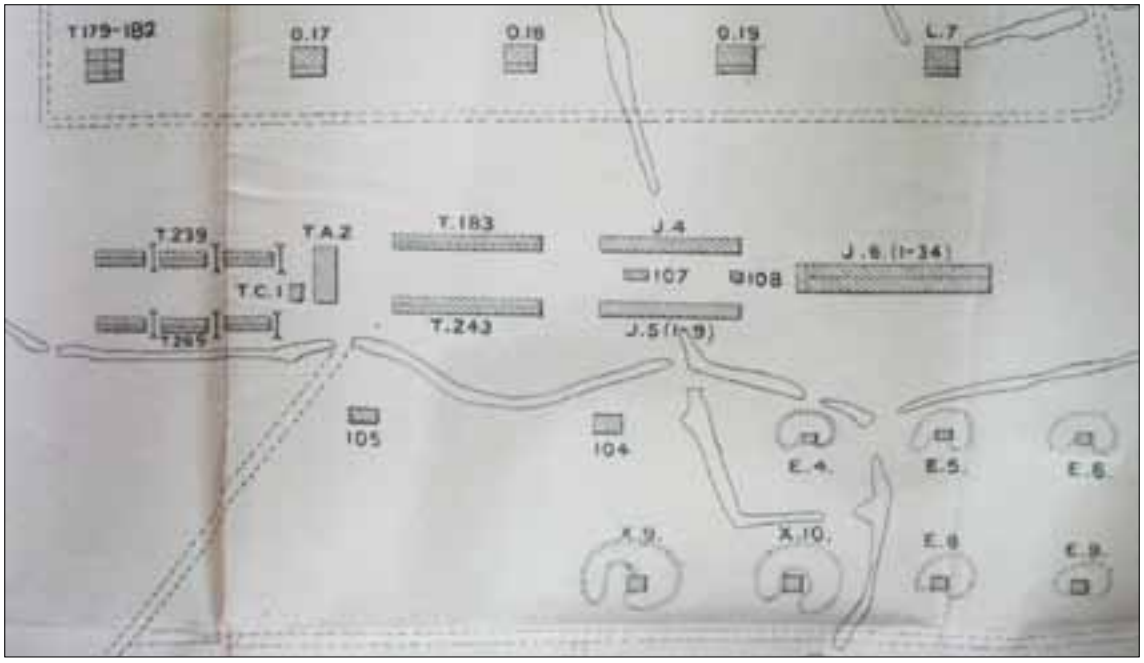


Figure 148: Detail from the map accompanying the 1923 sales particulars for HM Cordite Factory, Cliffe; showing buildings in ***Area J*** *and the southern edge of* ***Area K****. MALSC 06a_DE_Series_1001_1200/DE1087_3, Medway Archives and Local Studies Centre, Strood; reproduced by kind permission.*

Structure 250: office

Structure **250** is a is a featureless foundation slab measuring 2.5m square and constructed of narrow concrete beams, located west of **249**. According to the 1923 sales particulars, this was an office known as building '108', and had a brick structure with a timber floor and a match-lined corrugated iron roof (ibid).

Structure 239

Structure **239** is the remains of a small concrete foundation, about 7m long and at least 1.8m wide, with no distinguishing features, located a short way north of press house **246**. The 1923 sales particulars do not refer to a structure in this location. The only potential clue to its former function is its location next to a complex junction in the tramway network, so it may relate to the points system.

Structures 244 and 245: acetone recovery stoves ('remains of')

Continuing west from press houses **246** and **247**, next in the linear arrangement of cordite processing buildings are the parallel structures of **244** and **245** (*see* Figures 137, 138 and 141). Each range comprises a roofless standing structure composed of a long central spine wall of brick, with reinforced concrete partition walls projecting from it to create 30 individual narrow compartments in two back-to-back rows of 15 (Figures 149 and 150). Again, the use of reinforced concrete as a construction material is known to have had limited uptake in the British explosives industry and, as such, the examples on the Cliffe site represent a rare survival (*see* sections 4.3, 8.3 and 8.5). The

*Figure 149: Structure **245** showing the cement rendered outward-facing cells, looking north-east with **244** behind. NMR DP141685 08-Mar-2011, Steve Cole © English Heritage.*

space between structures **244** and **245** and the pair of cordite press houses to the east, is occupied by a network of concrete tram-beds, including a second semi-circular arrangement, all with grooves for iron rails or the rails themselves visible (see Figure 138).

The 1923 sales particulars labels these two structures as the 'remains of acetone recovery stoves' 'T183' (**244**) and 'T243' (**245**), implying that they had been decommissioned and, perhaps, stripped of reusable materials before the time of the auction. It also states that there were four sets of 14 stoves in one range and two sets of 30 stoves in the other (ibid); the former presumably refers to structure **244**, which has four atypical cells adjacent to the central projecting wall, which may have had an alternative use. The construction materials are described simply as floor of concrete and asphalt with walls of reinforced concrete (ibid). Unusually, no description of the roofing material is given in the sales particulars, perhaps supporting the notion that the buildings had already been partially dismantled.

As soon as the cordite was extruded in the press house, the acetone - which rended it more pliable for moulding - needed to be removed by a process of acetone recovery. To do this, the cordite sticks or reels were laid out in drying rooms (stoves) and heated to great temperatures, whereby the acetone was driven off as a vapour (see section 4.2).

The annual report of HM Inspectors of Explosives for 1918 (Explosives Inspectorate 1919, 4, 10), describes an accident at Cliffe in early March of that year where a fire burnt out 103 stoves in two adjacent ranges of the acetone recovery plant, spaced about 30 yards (27m) apart. Although no detailed accident report was prepared for this incident, the description given in the annual report can only refer to structures **244** and **245**. It may be reasonable to suppose that this major structural damage was not repaired and, as such, would account for the description of the buildings as 'remains of' acetone recovery stoves and the absence of any recorded roofing material in the 1923 sales particulars.

The two buildings are almost identical in form. Structure **244** survives in a marginally better condition than **245**, but both buildings have holes in their walls, areas of collapse and significant signs of reddened fire-damaged concrete, presumably as a result of the

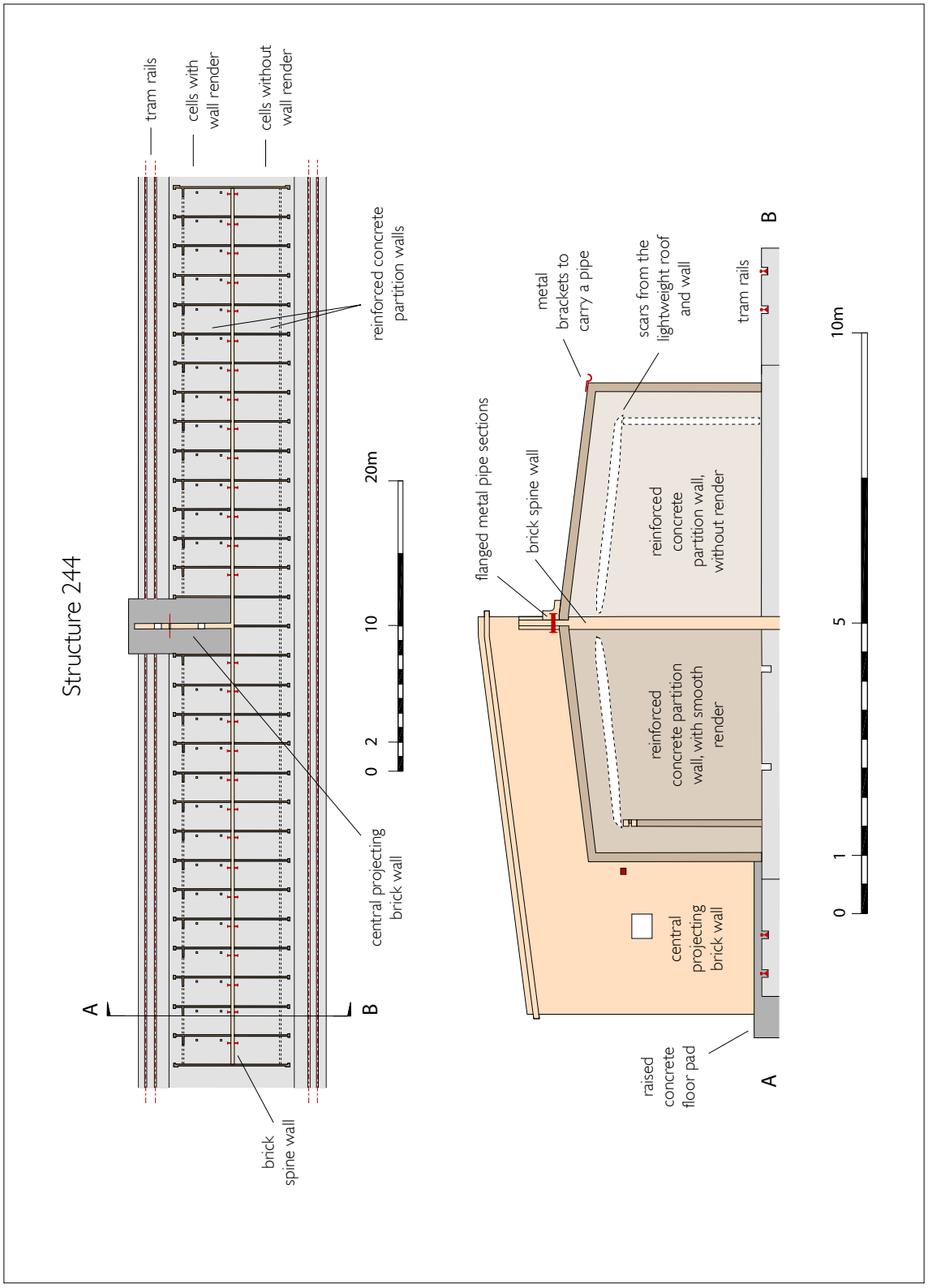


Figure 150: Schematic measured plan and section drawings of acetone recovery building ***244****. Drawn by Andrew Williams and Rebecca Pullen © English Heritage.*

fire in 1918 (ibid). Overall, each building range has a footprint of 60m x 8m, which is divided into 30 compartments each with internal dimensions of 3.25m x 1.9m. The long brick spine wall is built in stretcher bond and stands to a height of 4.15m - eight courses taller than the perpendicular stove walls - and forms the back wall to each of the stove compartments. At the point where each cell wall abuts the main spine wall a short brick pier or buttress stands between the top of the cell wall and the top of the spine wall (Figure 151).

In structure **244**, a high partition wall projects northwards from the spine wall at the centre of the building; at about 4.7m, it stands taller than the spine wall and projects almost 7m out from it, bisecting the tramway along the north side. The wall is constructed in English Bond with integral pier and coping; its top line slopes down slightly as it projects north to give a trapezoidal elevation, and it sits on a slightly raised concrete foundation that forms the floor in the compartments either side of it (see Figure 150). The equivalent wall in structure **245** appears to have collapsed, along with a long section of the top of the brick spine wall above the height of the steam pipes.

The individual cell walls echo the trapezoidal-shaped elevation, with integral pier and coping seen in the single high projecting wall. Uniformly, they measure 4m long and are about 3.5m tall at the spine wall, reducing to 2.4m at the outer edge. Flanged iron pipes inserted during the bricklaying protrude through the spine wall on both sides, just above the height of the projecting cell walls (see Figure 151). Presumably, the flange marks a junction onto which a right-angled pipe 'elbow' attached, taking the pipe down through the roof into the compartment below.

The compartments themselves are not all identical, there are two distinct types; the north-facing row of cells in **244** and the south-facing row in **245** (that is, all of the outward-facing cells) are of one form, and the inward-facing row of cells for **244** and **245** are all of a second form. The main distinction is that the back walls (spine wall) in the outward-facing compartments are surfaced with a fine cement render up to the height of the adjacent cell walls. The render continues seamlessly around all the compartment walls, creating a homogenous and easy to clean internal surface with no crevices in which residues could build up (see Figure 151). The back wall of the inward-facing compartments is bare brick, and the render on the side walls has largely flaked off and may have been of poorer quality than that in the fully rendered cells. Another difference is in the evidence for a front wall and entrance to each stove. The outward-facing cells have a narrow brick wall covered in a thick layer of concrete render next to a doorway, topped by a lintel composed of a slot for a narrow timber beam sandwiched between two single courses of concrete rendered brick (see Figure 151). Conversely, the inward-facing bays have no surviving solid front wall remnants and no clear scar for a wall line in this position, and may have had a more lightweight arrangement of corrugated iron or timber. One feature attributed only to the inward-facing rows of compartments is a line of small stepped brick piers with quarter circle shaping on their outer edge, positioned on the top of each cell wall approximately a third of the way along the length from the spine wall (see Figure 151). These mounts would have supported a pipe, possibly a steam pipe, along the length of the range; well above the height of the lightweight roof.

*Figure 151: (upper pair) Acetone recovery stoves **245** (left) and **244** showing the outward-facing rendered cells; (lower pair) structure **244** showing the inward-facing cells without render. Photographs: (top left) NMR DP141686 08-Mar-2011, Steve Cole; (top right and bottom left) Wayne Cocroft 2010; (bottom right) NMR DP141659 08-Mar-2011, Steve Cole © English Heritage.*

Only four cells differ from this form; the cells either side of the tall projecting wall at the centre of **244**, and the pair immediately behind them all lack evidence for steam pipes piercing the spine wall. This suggests that their function was different from the adjacent compartments, and this probably reflects the 1923 description of four sets of 14 stoves (ie 56) in 'T183', despite there being a total of 60 compartments (MALSC 06a_DE_Series_1001_1200/DE1087_3).

Composite use of brick and reinforced concrete walls like this was not noted anywhere else in the factory remains, but the unusual mix of construction materials are not fully reflected in the 1923 summary for the auction.

The rendering and solid front walls within the outward-facing cells suggests that they housed 'loose' explosives or processes where residue build up needed to be avoided. This evidence, coupled with the pipe supports above the inward-facing compartments could indicate that the outward-facing stalls were where the cordite was dried on free-

standing racks to drive out the acetone, and that the corresponding cells on the inward side might each have held a heat exchanger to facilitate this.

The concrete walls of the inward-facing bays are in a particularly poor state of repair and are heavily degraded with many large holes in the walls and the fabric is distinctly reddened; this suggests that the 1918 fire was more ferocious in the inner areas of **244** and **245**.

Very low, inserted corrugated iron sheet roofs exist in a few of the stove bays. Based on the memories of local resident Clifford Dowsett (pers comm to R Pullen, June 2011), these have been identified as the ruins of pig stys; the remains of structures **244** and **245** were repurposed for use as pig stys for a period in the Second World War.

Leading west from the south-west corner of **245** is a row of seven irons pipes set vertically in concrete blocks and cut-off at ground level. These could be the remnants of reinforced posts used to carry a pipeline between the acetone recovery stoves and the adjacent acetone recovery house (**243**).

Structure 243: acetone recovery house and blue brick yard

Moving west, structure **243** is a concrete building foundation, the north and west sides of which are predominantly concealed under grass. Where visible, the slab edges suggest a foundation measuring approximately 25m x 17m, with a small concrete manhole adjoining the north end (see Figures 137 and 141). The 1923 sales particulars list this building as 'TA2', an acetone recovery house standing 3-stories tall, with an adjoining blue brick yard. The walls were constructed of steel, corrugated iron and Asbestos Cement Sheeting (ACS), the ground level had a blue brick floor, the first and second floors were surfaced in timber on a steel frame and the building was roofed with more ACS (MALSC 06a_DE_Series_1001_1200/DE1087_3). Use of steel appears to have been relatively rare, and only employed where a stronger structure was required to support buildings standing two or more storeys in height. This structure is thought to be closely equivalent to structure **132** in **Area D**, which has also been interpreted as an acetone recovery house. Acetone driven out of the cordite as a vapour in the acetone recovery stoves was returned to liquid state by distillation in the acetone recovery house, ready for reuse. It is possible that acetone was recovered by absorption of the vapour into another chemical prior to recovery by distillation.

The slab is divided along its length by the scar of a corrugated iron sheet wall. Similar scars at the east, north and south edges suggest that the acetone recovery house measured about 22.3m x 9.8m in plan and was located on the east side of the slab. This leaves an area 25m x 6.5m to its west likely to be the adjoining yard, which is featureless apart from a pair of dwarf brick walls or plinths towards the southern end, measuring two brick widths wide (0.25m), 2.8m long and 0.48m tall. Across the ground floor of both the house and yard are the remnants of a hatched blue brick floor.

The ground floor surface of the acetone recovery house is more complex and contains a number of brick and concrete plinths (Figure 152). At both the north and south ends of the building, there are sets of three parallel brick plinths all measuring 5.5m long and two

*Figure 152: Remains of acetone recovery house **243**, with structure **244** in the background, looking north-east. NMR DP141667 08-Mar-2011, Steve Cole © English Heritage.*

brick widths wide, only the south-east plinth still stands to its full height of 0.48m above the floor level. A covering of cement render on the sides of the plinths shows signs of a black bitumen coating in places. At the outer end of each group is a pair of small roughly square cement-rendered and bitumen coated brick plinths, each about 0.66m high with four iron studs protruding from the top. Along the eastern wall is a pair of larger lower concrete plinths, each 0.33m tall with matching arrangements of 12 to 13 iron studs protruding from the surface. North of these plinths is a purposeful rectangular area of smooth-surfaced blue brick flooring. A further pair of small concrete machine bases survives in a heavily degraded state in the south-east corner of the building. Open floor drains, formed of moulded blue engineering bricks integral to the brick floor, run just inside the east and west wall scars of the building, confirming a function associated with the presence of liquid chemicals, in this case acetone recovered from vapour.

Structure 242: pump house

Structure **242** is a smaller rectangular concrete slab immediately west of **243**, comprising a 6m x 4m foundation with remnants of a hatched-surface blue brick floor and an exterior brick wall. Towards the centre are two small plinths of blue engineering brick, both T-shaped in plan and 0.25m high with rounded corners and four iron studs protruding from the top. The 1923 sales particulars lists this building as 'TC1', a pump house with a loft above, comprising a brick structure with a corrugated iron roof and a blue brick floor (ibid). The specific function of the pump house in relation to the acetone recovery complex is unclear; it may have been used to pump recovered liquid acetone into storage tanks or back towards the incorporating houses ready for reuse.

Structures 240 and 241: acetone recovery stoves

Beside **242**, at the far west end of this long linear arrangement of cordite processing buildings, are the parallel long narrow concrete building foundations of structures **240** and **241** to its south (see Figures 137 and 141). The 1923 sales particulars reveal that,

like buildings **244** and **245**, this pair of structures had also been acetone recovery stoves (ibid). They are described as comprising six sets of ten stoves across two ranges; apparently, three of the sets were incomplete at the time of auction, implying that only one of the two ranges was ever completed. Structure **240** was referred to as 'T239' and structure **241** was 'T269'; presumably, as there were 30 bays in each range the northern group was fully 'T239-T268' and the southern group was 'T269-T299'. They are described as constructed of reinforced concrete protected by brick angle dividing walls, with roofs of asphalt-covered timber and a floor of asphalt on concrete (ibid, and *see* Figure 148). Nearby structures **244** and **245** to their east are described as the 'remains of acetone recovery stoves', while this group is described as partially incomplete, inferring that construction of structures **240** and **241**, probably to replace **244** and **245** after the fire-damage inflicted by a large explosion in 1918 (Explosives Inspectorate 1919, 4, 10), was in progress but unfinished at the time that this part of the factory ceased to be operational. It is possible that neither **240** nor **241** saw use before the factory closed.

The two large foundations, each 78m long, are covered with witness marks and brick wall remnants, marking the layout of the former brick superstructure. Each foundation is partitioned along its length into three clear sections, marked by wall scars for what appear to have been free-standing brick walls that extended several metres beyond the 7m width of the main slab and fork into Y-shaped arrangements at either end (Figure 153, *and see* Figure 148). These wall scars are located at the east end and at points one third and two thirds along the slab from this. The spaces created between the angled dividing walls each show evidence for a 22m long spine wall along the inward facing side of the slab, with projecting brick party walls creating rows of ten narrow bays or cells all opening out onto a lower concrete surface, 5.2m wide, on the external side of the building, facing away from the partner structure. The witness marks show that each bay measured 4.6m x 1.95m internally. There are two small square scars on the floor of each bay abutting one of the dividing walls - in structure **240** these are against the internal east-facing wall, whereas in **241** they are against the internal west-facing wall - they may relate to the former position of apparatus or drying racks (*see* Figure 137). The absence of evidence for under-floor pipework like that seen in the earlier acetone recovery stoves in **Area D** (**129** to **132**), probably suggests that, as with nearby acetone recovery stoves **244** and **245**, elevated pipes were now used in preference, reflecting the

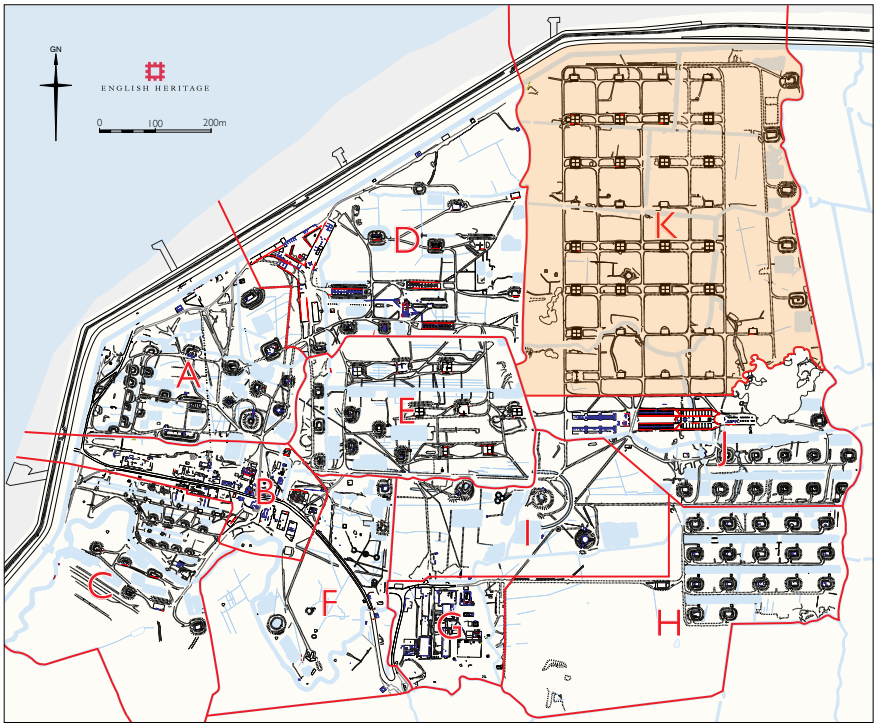
*Figure 153: Acetone recovery stove foundation **240**, showing traces of the angled brick wall scars. Photograph: NMR DP141670 08-Mar-2011, Steve Cole © English Heritage.*

contemporary shift in opinion towards the general belief that steam dries more efficiently if it enters the building at top.

Along the north side of structure **240**, the line of an embanked tramway appears to merge with the narrow concrete forecourt in front of the acetone recovery stoves (*see* Figure 137). No equivalent evidence is present for a tramway along the southern side of structure **241**; but, given that structure **241** may never have been completed, it is possible that construction of an embanked tramway along its southern edge was planned but never built. The wider tram network in this area provides links from this pair of acetone recovery stoves to the blending houses and cordite drying stoves of HM Cordite Factory in **Area K** to the north, but there is also a single tramline link from here, crossing the drainage dyke to the west and joining structure **240** with cordite drying stove **148** and the rest of **Area C**.

Once the acetone had been successfully driven out of the finished cordite it would have been moved to the blending houses and cordite drying stoves for finishing (*see* section 4.2).

6.17 Area K: HM Cordite Factory - cordite blending, drying and storing



***Area K** shaded orange.*

Moving north from the acetone recovery stoves, the site opens out into a very large and ordered area of buildings arranged in regimented lines and serviced by a grid of interconnected tramways (Figure 154). The grid is formed of five parallel tramways aligned north-south and connected by junctions to a series of east-west tramways which serve buildings located midway between each north-south tramway. Each junction has a corresponding small platform for the tumbler points controls. The structures in the gridded zone are of two distinct forms: roofless square buildings each partitioned

Figure 154: The north end of ***Area K*** *showing the regular gridded layout, looking south-east. NMR 26891/001 007 08-Mar-2011, Damian Grady © English Heritage.*

into four internal spaces (**205**-**212** and **222**-**231**), and less visible rectangular bases with no remaining superstructure (**197**-**200**, **215**-**218** and **232**-**238**). Additionally, along the eastern edge of the area, beyond the main gridded layout, a third structure type is present in the form of a dispersed line of large sub-rectangular earthwork traverses (**203**, **204** and **219**-**221**).

Structures 197 to 200, 215 to 218 and 232 to 238: cordite blending houses

There are fifteen slabs with no remaining superstructure. Each is positioned immediately north of the tramway that services it, and all comprise a coarse rectangular base 14m x 9m, raised 0.2m above the surrounding ground surface (**197**-**200**, **215**-**218** and **232**-**238**). Small concrete blocks are located in the centre of the north, east and west sides of the main slab. With the exception of structure **197**, the concrete blocks positioned at the east and west ends of the foundation are semi-circular in plan, whilst the blocks to the north are rectangular; the function of these features has yet to be determined. Additionally, most of the slabs have traces of a 1.25m wide concrete apron along the south exterior and partway up the east and west exterior of the buildings.

The 1923 sales particulars describe this group as blending houses 'O5'-'O19', built of match-lined corrugated iron on a timber and concrete floor (MALSC 06a_DE_Series_1001_1200/DE1087_3). It was in the blending houses that the individual batches

of cordite sticks would have been mixed together to ensure a consistent product and then bundled as required by size or weight, ready for the final drying stage. At this stage in the process, strings of narrow cordite may have been twisted together on reeling machines to form thicker cords and ropes before being cut into short lengths.

In its current condition, blending house number **215** (formerly 'O9'), is cut straight through the middle by a drainage ditch; however, the map accompanying the 1923 sales particulars shows it located on the north side of a drainage ditch, prior to any truncation (ibid). Presumably, the dyke was recut during the major drainage maintenance and remodelling untaken following the breaching of the sea wall and flooding event of 1953 (see section 3.8).

When the site was sold by the War Department in 1923, there was also a laboratory known as 'L7' standing at the east end of the southernmost row of blending houses (**236**-**238**) (see Figure 148). The sales particulars describe it as comprising seven compartments fitted with benches and two sinks; it had a match-lined corrugated iron superstructure and a timber floor. There were also two corrugated iron W.C. structures with concrete floors associated with the laboratory (ibid). The laboratory was probably used for testing the quality and uniformity of the finished cordite batches. The building was destroyed by aerial target practice during the Second World War; no in situ evidence survives, but there was a marked increase in the quantity of concrete rubble fragments noted close to its former location (see sections 3.7 and 7.1).

Structures 205 to 212 and 222 to 231: cordite drying stoves

As previously stated, the blending houses form only part of the regular layout that dominates the north-east portion of the site. They are interspersed by two blocks of larger standing reinforced concrete structures, each partitioned into four equal internal compartments (**205**-**212** and **222**-**231**) and located on the same gridded plan as the blending houses (see Figure 154).

The 1923 sales particulars state that these were cordite drying stoves, with each building divided into four individually numbered stoves in a numbering sequence running from 'T111' through to 'T182' (ibid). For the purposes of this survey, each conjoined group of four stoves was assigned a single structure number and treated as one building with four rooms, for example structure **205** was formerly known as stoves 'T111-114'. The stoves are described as having comprised reinforced concrete walls, corrugated iron roofs lined with ACS and concrete floors surfaced with asphalt (ibid); only the corrugated iron and ACS elements have been removed. After the cordite sticks had been blended, they would have been taken to a cordite drying stove and laid out on racks to drive off any residual moisture and ensure that the product was kept dry in storage (see section 4.2). Eventually, boxes of the finished cordite would have been transported ready to be packed into shells for naval use, probably leaving the factory via nearby jetty **J4**.

Overall, there are seventeen of these buildings, making a total of 68 cordite drying stoves within the HM Cordite Factory portion of the explosives works at Cliffe. Structures **205**-**212** and **222**-**231** are identical to **153** and **154** in **Area E** (see section 6.10). In general,

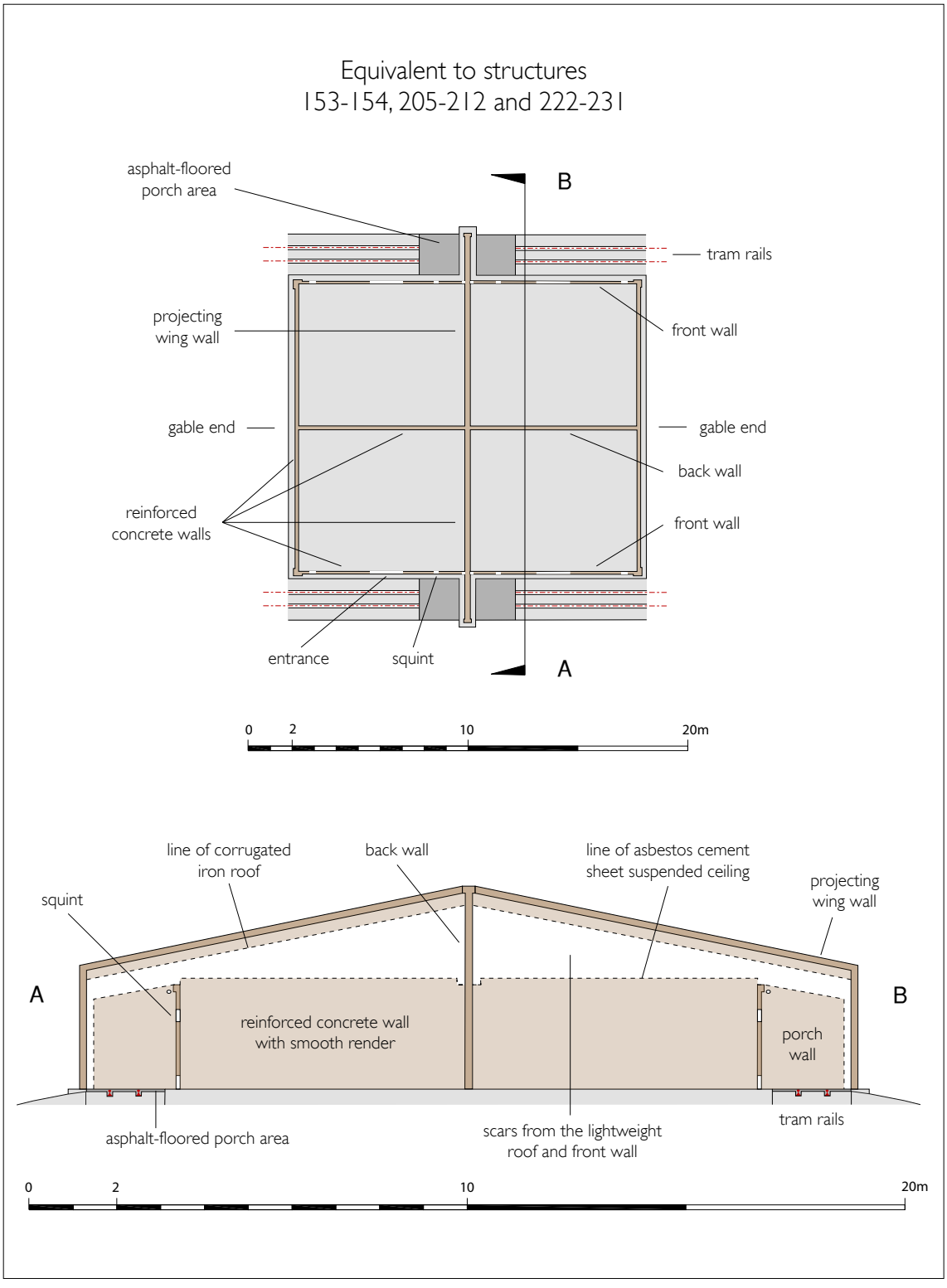


*Figure 155: Schematic measured plan and section drawings of cordite drying stoves, as seen in structures **153-154**, **205-212** and **222-231**. Drawn by Andrew Williams and Rebecca Pullen © English Heritage.*

they are arranged in four rows of four structures, with a further two (**230** and **231**) next to the blending houses in the south-west corner of **Area K**. Each building is sandwiched between discontinuous parallel embanked tramways, terminating outside the entrance of each stove on their north and south sides. All are of the same form and construction, the only difference being variation in the level of preservation, so that in some cases component features had degraded, been removed, or were no longer visible.

The footprint of each standing structure is 15.7m x 13.3m, divided into four interior spaces measuring 7.6m x 6.5m apiece, and each is built on a slightly raised coarse concrete foundation, 0.25m wider on all sides than the building footprint (Figure 155). The west- and east-facing exterior elevations of each structure are gable ends, 4.6m tall at the centre. At this height, a partition wall runs between the gable walls forming a barrier between the back-to-back stoves. At 2.4m, the north and south elevations are much lower, each consisting of the front wall and entranceway to a pair of adjacent cordite drying stoves. A wing wall runs north-south between the side-by-side stoves, mirroring the pitched line of the gable ends and projecting 2.2m beyond the front elevation to form a barrier between tramways terminating on either side (Figure 156).

*Figure 156: Cordite drying stove **205**, showing the rough-surfaced coating on the west gable end (left); and a detail of the pitched top, iron hooks, bitumen stain and small holes. Photographs: Rebecca Pullen 2011 © English Heritage.*

The exterior elevations of the gable end walls show evidence of a thick coating of rough surfaced pinkish-white asbestos-like material, covering the wall to a height equivalent to that of the front walls. This was probably a form of fire-proofing. In most cases, this covering has been entirely removed, leaving only trace remnants and the occasional marks where the material has been cleaned off. In a couple of cases, a proportion of this material remains in situ, the best example being on the west-facing gable exterior of structure **205** where the coating is almost complete (see Figure 156). A slight pitch or chamfer was noted along the top edge of the material on **205**; now much degraded, it appeared that this once continued across the full width of the wall, perhaps to direct water away from the surface. The coating is divided into four sections by three vertical channels that mark the former location of wooden or metal batons. Additionally, at the top of each of the four sections, is a large iron hook set slightly off-centre. The asbestos-like coating covers the hook's back plate but leaves the line of hooks protruding. Just above the upper edge of the wall coating is a narrow horizontal bitumen stain, and immediately above this is a line of widely spaced small holes through the concrete, possibly from rods supporting a lightweight structure inside the stove (see Figure 156).

Figure 157: Cordite drying stove ***205*** *(clockwise from top left): squint window detail; circular opening for a pipe at the base of the front wall; damage and degradation of the walls; and south- and west-facing elevations of the south-west stove compartment showing the roof scar and smooth square floor for the lean-to porch. Photographs (clockwise from top left): Wayne Cocroft 2010; NMR DP141706; DP141707; DP141705 08-Mar-2011, Steve Cole © English Heritage.*

The paired stoves that make up the north and south elevations of each structure are entirely symmetrical (see Figure 155). Each stove frontage has a central opening 1.5m wide by 2m tall, with rough edges where a door frame has been removed. Centrally within the portion of wall between the doorway and the wing wall between the stoves is a small rectangular window or squint. In a few examples, the wooden frame survives, in others the wood has gone but a series of fine iron pins protruding from the iron frame reinforcements of the walls are visible; these would have held the wooden frame in place (Figure 157). Squints would have been used to monitor conditions inside the stove, perhaps providing a view of an internal temperature gauge, and may also have provided

a point for an external lamp to have been hung, providing a light to the interior without the risk of taking a lamp inside. Most of the stoves have a tiny square hole through the wall and located part way up on either side of the doorway. There are also two vertically grouped sets of holes punched through the front elevation, positioned in the basal corners at either side of the front wall. In each case, there is a square opening at floor height, occasionally with remnants of a shaped concrete insert to create a smaller circular opening, and above this is a vertical line of four small circular holes (see Figure 157). The larger openings could have held a heating pipe or a vent, while the smaller holes may have held bolts for a lightning conductor, brackets to hold a vertical pipe, or other fixtures for electric cables.

Terminating beside the entrance of each stove are the grooves for tram rails set 1.85m apart within a concrete tram-bed (see Figure 155). In at least one example, a square arrangement of small holes in the floor denotes the position of a buffer where the rails stopped. Witness marks on the floor and on the face of the projecting wing wall show that there was a small square porch or covered area where the tramlines ended; remnants in some structures show that they were floored with asphalt (see Figure 157).

Inside there are no features or fittings on the stove floors or walls, implying that the cordite was dried on free-standing racks. On the internal walls, two different roof scars are visible. The upper mark follows the pitched angle of the gable end and wing wall; on the wing walls this scar is continuous beyond the line of the front elevation, suggesting that the iron sheeting at this point continued down to form the roof of the porch. A second lower scar extends the line of the front elevation horizontally around the other three taller walls (see Figure 157). Apart from the horizontal line of small holes across the gable walls, there are no features pertaining to how the roof, or roofs, would have been supported and secured. In one case, a single bolt was noted projecting upwards from the top of the front wall directly over the position of the doorway, this may relate to fixing a corrugated iron roof in place. The 1923 sales particulars specify that the roof was constructed of corrugated iron lined with ACS (MALSC 06a_DE_Series_1001_1200/DE1087_3); the two roof line scars might denote a pitched corrugated iron roof above a flat suspended ceiling of asbestos cement sheets, creating a more efficient insulating layer for the drying space below. Below the level of the lower ceiling line, the walls are covered in a fine grained render, but above this mark the poured concrete is bare; there is also render above the upper roofline where it would be exposed to the elements, albeit with coarser material.

Evidence for how this large group of cordite drying stoves was powered and heated is decidedly absent. There are no remnants of posts or gullies marking the position of a steam pipe network, and there are no unaccounted for building foundations to suggest the presence of a boiler house, pump house or generator. It is most likely that the stoves were heated by steam pipes, perhaps piped long distance from buildings in **Area J**, or even from **Area D** beyond the limits of HM Cordite Factory. If wooden posts had been used to support lengths of pipework they may have been reclaimed for reuse when the factory materials were stripped prior to sale of the land.

The deep pond immediately north-east of **227** pre-dates the factory expansion and is discussed in section 5.2.

Structures 201, 202, 213 and 214: earth closets

Structures **201**, **202**, **213** and **214** are the remains of four small platforms reached by narrow embanked pathways leading off from the main tramways between the rows of blending houses and cordite drying stoves. With the exception of structure **201**, a remnant of concrete floor is visible on the surface of each platform, suggestive of small buildings with footprints approximately 3m square. In two cases (**202** and **213**), the concrete survives in a coherent L-shaped form with a linear concave depression along the southern edge suggestive of a drainage or water run-off function (Figure 158). Through a process of elimination using the building lot descriptions in the 1923 sales particulars, these features have been interpreted as single-compartment earth closets, which would have been topped by a simple corrugated iron superstructure (ibid). The sales particulars do not assign building numbers or locations to the earth closets, but they do list a total of 20 in the HM Cordite Factory:

HM Cordite Factory, earth closets

Form	*Quantity*
1 compartment	*9*
2 compartments	*6*
3 compartments	*1*
4 compartments	*1*
6 compartments	*3*

Suggestions for other earth closet locations in the HM Cordite factory areas might be structure **239**, the earthwork platform projecting south from the tramway close to the south-west corner of **247**, and possibly the narrow, finger-like, banks projecting north from various tramway sections between the guncotton drying stoves in **Area H** and between cordite paste mixing houses **257** and **258** in **Area J**.

*Figure 158: Structure **202** looking east, showing the low platform with L-shaped concrete floor with moulded floor drain. Photograph: Rebecca Pullen 2011 © English Heritage.*

Structures 203, 204, and 219 to 221: *magazines*

Structures **203**, **204**, and **219** to **221** are a widely spaced row of five large earthwork traverses surrounding concrete building foundations, located in the far north-east corner of the site, beside the dyke that marks the eastern extent of the factory (see Figure 154).

The five structures are all very similar in size and form. Each has a footprint of about 30m x 35m, comprising a sub-rectangular protective earthwork traverse, 9-10m wide and about 1.7m high, surrounding a rectangular concrete building foundation 15m x 8.3m in plan. In all cases, the concrete slabs are almost entirely covered by moss and grass, masking any surviving floor details. A break in the west side of each traverse indicates the entrance to the building and, with the exception of **204**, all are connected to a main north-south tramway by a short branch line. The tight angles of the junctions with the main tram network imply that materials passing through these buildings both came from, and went back out to, the north. Structure **204** sits immediately adjacent to the main tramway; the west edge of its traverse partially overlies the tramway, probably as the result of some bank slippage, rather than being a stratigraphic relationship.

There is a sub-circular crater 5.5m in diameter inside structure **203**, and another nearer 3m in diameter within structure **221**; both probably relate to the use of the site for munitions disposal following the closure of the factory (see section 7.1).

The 1923 sales particulars refer to these buildings as magazines 'M11'-'M15' (**203**, **204**, **219**-**221** correspondingly); additionally, 'M11' and 'M12' (**203** and **204**) are listed as being 'with vestibules' (ibid). Each was constructed with match-lined corrugated iron roof and walls, and with timber floors in the magazines and plain concrete floors in the vestibules (ibid). These magazines were probably used for storage of the finished cordite products before they were boxed and shipped (probably via jetty **J4**) to a filling factory for assembly into various types of propellant charges and rounds (see section 4.2).

A letter dated 24 March 1914 from Curtis's & Harvey Ltd to the local Commission of Sewers, specifically refers to a proposed application for a licence to construct five magazines for the storage of 'finished Explosives and other authorised explosives of classes 1 to 4'; referring to the planned magazines as 'M11'-'M15', with 'M11' closest to the river wall (KHLC CKS-S/NK/A/C/1/186). Some discrepancies in the distance given for the proposed location of 'M11' from the river wall could indicate that these structures were not erected in the same location as initially proposed (see section 3.4). It does, however, suggest that this group was certainly planned, and probably constructed, as part of a pre-war expansion in the first half of 1914, rather than as a subsequent wartime reaction to increased national need. This would also imply that the line of magazines was erected some time before the development of HM Cordite Factory, rather than as an ad hoc latter addition, and as such would initially have been in a very marginal location. Perhaps the development of HM Cordite Factory was already anticipated, and structures **203**, **204** and **219** to **221** were most urgently required and so were built first but kept to the periphery of the area in readiness for development of the new cordite works. This proposed earlier date might also account for why - unlike other structures belonging to HM Cordite Factory - these magazine buildings appear to follow the drainage pattern, rather than the more rigid grid layout of other structures in **Areas H**, **J** and **K**.

6.18 HM Cordite Factory - machinery

Along with descriptions of the buildings in HM Cordite Factory, the 1923 sales particulars name a number of pieces of factory machinery also up for auction (MALSC 06a_DE_Series_1001_1200/DE1087_3). Although the equipment is not all clearly linked to individual buildings or processes in the dedicated auction lot, it is worth noting the pieces listed as present. The 'excellent modern machinery' is described as including: horizontal and vertical force pumps, a hydraulic accumulator, a gear driven horizontal double-acting air compressor, a Cumberland Electrolitic boiler protection set, an *Invincible* centrifugal pump and motor, a vertical 2-cylinder air compressor, an *Electric Construction Co* charging set, and 3 and 5.5 h.p. d.c. motors (ibid). Where machinery was listed with its associated building, it has been included in the description for the equivalent structure in this report (see structures **175**, **180**, **181**, **192**, **193**, **248** and **249**).

7. DESCRIPTION AND INTERPRETATION OF THE POST-FACTORY FEATURES

7.1 Craters

Two types of crater were noted during the survey. Firstly, there are several craters that appear to result from aerial assault or aerial target practice, the most obvious example being the vast irregular shaped cluster of conjoined bomb craters spanning up to 150m across, located at the far eastern edge of the site in **Area J** (*see* Figures 141 and 142). The extensive cratering has partially truncated incorporating house **251** and entirely destroyed a laboratory building described in the 1923 site auction documents (MALSC 06a_DE_Series_1001_1200/DE1087_3). Local resident Clifford Dowsett recalls childhood memories of a large chalk circle marked on the ground in this area that was used for aerial target practice around the time of D-day, 1944 (C Dowsett, pers comm to R Pullen, June 2011). Smaller examples of this type of crater, often clustered in conjoined groups, were recorded west of **226** and **230**, and north of **105** (Figure 159).

Figure 159: Pair of conjoined bomb craters, west of structure **226***, looking north-east. Photograph: Rebecca Pullen 2011 © English Heritage.*

In addition to the craters found on open ground, small single craters, measuring 4-6m in diameter, puncture the concrete slabs of several building foundations (**166**, **167**, **203**, **221**, **270**, **274** and **279**). Without exception, this trait was found only in structures completely surrounded by earthwork traverses. The structures appear to have been specifically selected for this purpose, and may represent controlled disposal of military munitions. The highly disturbed remains of structures **103**, **104**, **166** or **167** could also be the result of planned disposals, or else represent buildings destroyed by accident.

In May 1945, the Second World War ended in Europe. In October of the same year, the War Office issued instructions for the cessation of army demolitions on Cliffe Marshes, with the caveat that isolated cases of navy demolitions would be permitted in the event of an emergency (Hansard 1945). This suggests that at least some of the craters identified result from military disposal of munitions during, and possibly following, the Second World War.

7.2 Dredging spoil

Low amorphous spreads of earth were recorded along the sides of several of the drainage dykes, often overlying and masking factory features including tramway embankments and foundation slabs. In most cases, these were fairly firm and covered with grass and, thereby were interpreted as upcast from ditch clearance carried out several years ago. During fieldwork in January 2011, dredging work was undertaken on behalf of Natural England along the boundary dyke running parallel to the landward face of the sea wall; sediments were removed by mechanical excavator and deposited in a broad band along the outside of the ditch, closest to the sea wall (Figure 160). As stated in section 6.3 (*see* **21** and **22**), it was unfortunately not possible for all sections along the outside of this drainage dyke to be checked for remnants of factory structures before dredging material had masked much of the area.

Figure 160: Active dredging of the drainage dyke alongside the sea wall, and associated sediment spreads, looking east. Photograph: Rebecca Pullen 2011 © English Heritage.

7.3 Modern boundary features

The area of investigation included a number of modern boundary features, including gates, fences and pens, primarily to manage animals and access. A number of small rectangular stock pens built of wooden posts are located either side of the main southern entrance to the site, close to the foundations for structures **164** and **165**.

The main factory road passing through the south-west part of the complex is still used to access the site for management of grazing stock and wildfowl.

8. DISCUSSION AND CONCLUSIONS

The short but intense relationship between Cliffe Marshes and explosives manufacture was played out at a critical time in the evolution of the overall British explosives industry. The end of the 19th century saw a dramatic break from well-established black powder technologies. Recent scientific advancements revealed the great potential held by chemical-based explosives and, in response, new manufacturing methods and products were quickly embraced nationwide. The establishment of a facility for blending, packing and storing gunpowder at Cliffe in 1892, came just two years after the patenting of cordite. This proved to be unfortunate timing. Cordite swiftly deposed gunpowder as the propellant explosive most favoured for use in military propellants, and as new research developed ever more efficient and desirable chemical-based products, gunpowder technology quickly became limited to suppling charges for certain types of mining and quarrying, for antique weapons and for fireworks. This national pattern of development and demand in the explosives industry is illustrated by the rapid change in direction at Cliffe, marked by the conversion of the existing gunpowder storage facilities into a modern chemical explosives factory capable of preparing a wide range of nitro- and chlorate-based explosives, employing the latest technologies and expanding at a considerable pace.

In-depth analytical survey and background research has made possible production of a detailed map of the remains allied to a fairly comprehensive history of the factory's development. The research has allowed details of phasing, layout, construction, technological advancements and day-to-day operations of the explosives works and, from this, the wider significance and role of the factory has been identified.

8.1 Phasing

A broad phase plan for the development and expansion of the explosives works at Cliffe has been created from historic maps and contemporary documents, and from the physical remains (Figure 161). The overall pattern is that expansion radiated out south and east from Lower Hope Point and the adjacent structures first constructed for the gunpowder facility. The most visually distinct transition in development at Cliffe is the dissimilarity between the layout of the pre-war factory on the west side of the site and subsequent wartime expansions to their east. Unpicking the less pivotal phases in the development of the site has been more problematic (*see* section 8.3 for specific examples). The likelihood of further fieldwork, such as excavation, being able to sharpen the phasing is doubtful, although it might refine the understanding of the processes.

1890s

The association between Lower Hope Point and explosives began in the 1890s. Despite official authorisation in 1892 for the proposed layout and operational capacity, Hay, Merricks & Co's initial scheme for a gunpowder works with 14 buildings was never fully enacted. In their six active years at the site, only the jetty and two of the firm's planned buildings were erected, and even these were not quite in the proposed positions (*see* Figure 12). All three of these structures are still visible amongst the factory remains (**J1**, and structures **1** and **2**) and, as such, represent the first phase of explosives-related

development at Cliffe. Lack of full uptake of the scheme may be indicative of the decline in demand for gunpowder in the last decade of the 19th century, when cordite first became available on the explosives market.

Early 20th century

In the years 1900-1914, the spread of factory facilities seems to have been gradual and pragmatic, resulting in an organic pattern of continual growth with buildings being slotted into spaces between existing structures and drainage ditches. This is in stark contrast to the regimented plan within the government established HM Cordite Factory area, which was erected on undeveloped marshland during the early years of the First World War.

The 1907 25-inch OS map of the site has been the main source of information for the first expansion; it provides a detailed picture of the extent to which the factory had developed and of the individual buildings that had been erected by that year (Ordnance Survey 1908a; 1908b) (*see* Figure 16). Information regarding the dates and areas of various land purchases (*see* Table 1), letters proposing construction of new magazines (KHLC CKS-S/NK/A/C/1/186) and clues gleaned from the descriptive text within various official accident reports prepared by the Explosives Inspectorate, have also added to the overall understanding of the factory's phased expansion. Unfortunately, regular remodelling of buildings and departments, either for repairs following accidents or for modernising of facilities, make the identification or depiction of anything more than a fairly coarse phasing across the western side of the site quite challenging.

First World War

The rigid structure of the final phase of factory development - the wartime expansions - suggests the imposition of a layout from plans drawn up off-site, paying little regard the position of existing drainage ditches. It was probably designed and constructed in a single episode.

It was known previously that the factory complex at Cliffe had expanded extensively eastwards across open land during the First World War, but it was unclear what specific form the new manufacturing had taken (Cocroft 2000, 161). It can now be stated with confidence that the wartime expansions were solely to provide a huge increase in capacity for cordite manufacture to meet military demands. This included provision of a second guncotton factory and a second nitroglycerine factory to feed the new cordite production line.

Whereas acetone recovery was only adopted in the western parts of the factory in 1914 (**129** to **132**) (Coningham 1914), in the 1916 construction of HM Cordite Factory, acetone recovery facilities were integral to the designed layout from the start (**240** to **245**). This may simply reflect a general movement in manufacturing practice; alternatively, provision of acetone recovery facilities may support the idea that HM Cordite Factory was designed specifically (perhaps even solely) to manufacture naval cordite.

The new eastern expansions did not include increased production or diversification of the other forms of explosives manufactured at Cliffe.

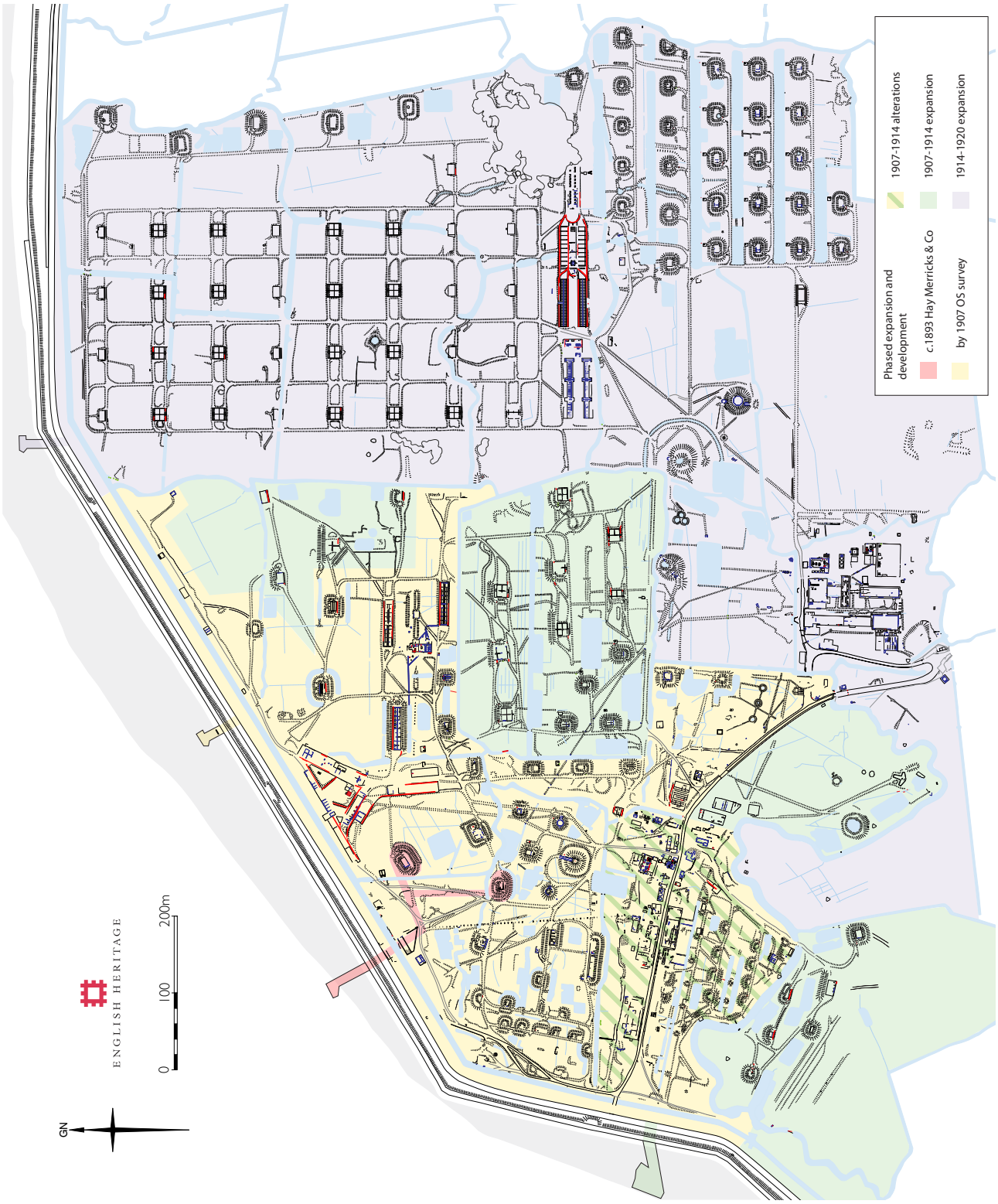


Figure 161: The main expansion and development phases of the factory. Drawn by Philip Sinton © English Heritage.

It is interesting to note that Curtis's & Harvey had clearly anticipated that the expanding factory complex at Cliffe would eventually cover an area even greater than that achieved by the time operations ceased. Details of marshland plots purchased from the Earl of Darnley's Cobham Estate in 1910 (MALSC U0565_E702) (*see* Table 1), and a map marking factory land sold to HM War Department in 1921 (KHLC CKS-S/NK/A/C/1/124), show that the factory owned a large area of land to the south of the site that was never developed, including up to 12 hectares south of **Area C** and over 30 hectares south of **Area H** (*see* Figure 17). So, whilst the factory remains cover a footprint of 128 hectares, this was part of a total of over 165 hectares of marshland owned by the firm and which could have developed if their fortunes had worked out differently.

Second World War

Although the factory closed in the early 1920s, some areas of the complex appear to have had seen some reuse during the Second World War when Lower Hope Point area formed an important strategic position in the Thames Estuary (*see* section 3.7). This is demonstrated by the existence of a Type Q airfield bombing decoy to draw enemy planes away from RAF Gravesend (Dobinson 2000, 250), a Naval Coast Type QL bombing decoy (Dobinson 2000, 177-180), the earthwork remains of gun emplacements belonging to a Heavy Anti-Aircraft Artillery battery, located approximately 300m south of the southern end of **Area F** (Dobinson 1996b, 473), and by the wartime severing of all four wooden jetties to remove any easy landing points along this stretch of the Thames.

The most obvious feature attributed to this period is the large area of conjoined water-filled craters at the eastern side of the site, interpreted as the location of a target for aerial bombing practice around 1944, rather than the result of enemy aerial assault. Smaller single craters within the floors of several traverse-surrounded buildings may represent controlled disposal of military munitions (*see* sections 3.7 and 7.1). Additionally, holes in many of the reinforced concrete walls of the standing buildings in **Areas E**, **J** and **K** might result from use of the site for military training after the factory had closed. In October 1945, a few months after the Second World War had ended, the War Office called for a cessation of Army demolitions on Cliffe Marshes (Hansard 1945), confirming that land on, or near, the factory site had been under military use for munitions disposal and possibly training operations during the war.

A small number of specific structures amongst the factory remains are thought to have wartime associations. The office-like structure **67** is unusual for its blocked windows and for the evidence of conduits to house wiring or telephone cables in excess of those seen in other buildings on the site (*see* section 6.5). It is unclear when or why the windows were blocked and internally rendered-over. The building may have changed function during its active use, perhaps from an office to a storage facility requiring less light and more wall space. Alternatively, the activities performed inside may have required artificial light in place of daylight, the building having been constructed with blocked windows purely to fit the appearance of the other offices. Aerial photographs have shown that building **67** was still standing in 1955 and so could have been functional during the Second World War (NMR 1680, 540_RAF_1699 frame 0113). One explanation for the blocked windows and concentration of cable conduits could be that the building had been reused as a military radio station.

The low earthworks of **121** and **122** in **Area D** were also interpreted as having potential Second World War associations (see section 6.9). Structure **121** is a small earthen platform with a sunken hollow containing an arrangement of iron bolts set into the ground at its north-east end. One possible interpretation for this is that it marks the former position of a wireless mast. To its south is **122**, a low U-shaped earthwork bank also thought to result from military activity relating to training or defence activities after the factory closed. Activity taking place on the site during the Second World War may have been more widespread than this, but it has left little or no physical trace.

8.2 Site layout and manufacturing flow lines

Expansion over time was not the only factor to influence the layout of the factory, the site was also physically organised according to process and risk. A simple schematic of the site, dividing it up into broad functional areas, probably not dissimilar to the 'departments' into which the factory was organised (see section 8.4), has been prepared in order to provide an overview (Figure 162). From this the relationship between function and spatial layout is clear: the administration, acid and guncotton zones are tightly packed and traverse-less, whereas structures in the areas dealing with nitroglycerine, cordite and blasting explosives are generously spaced and often protected by substantial mounds.

Safety

As with the interiors of the buildings themselves, the factory zones would each have been categorised as 'clean' or 'dirty' areas, depending on whether or not loose explosives were handled in that space (see sections 4.3 and 8.3). A danger area fence would have provided a material reminder of this separation. The cordite factory at Hayle in Cornwall is described as being divided along these lines into an 'outside' division and an 'inside' division, marking the difference between the less dangerous 'outside' departments, and the very dangerous 'inside' departments (*The Graphic* 1901).

The basic parameters for safety regulation in the industry were set by the 1875 'Explosives Act' (Public Statutes General 1875, **38 Victoria, c. 17**). One way in which the application of these regulations and concerns can be seen evolving is through the increasingly generous provision of space between danger buildings as the factory expanded east (see Figure 161). Being located on marginal land meant that it was easy to uphold the regulation distances between certain building types and even, as was often the case, to exceed the minimum required spacing (Cooper-Key 1911, 2). The specific layout of earthen traverses also follows obvious safety considerations. Where new danger buildings were erected relatively near to existing buildings, it is clear that the position of the entranceway and the side along which the tramline ran were both dictated by the nature of the surroundings and by their potential to threaten, or be threatened by, the stability of processes within neighbouring buildings.

Aerial photographs from the 1940s show that much of the site was once moderately tree-covered, probably planted as protective barriers around buildings capable of absorbing a proportion of any exploded debris (see section 3.8). The trees complemented the blast protection provided by careful spacing of danger buildings,

rigorous construction of earthwork traverses and use of pre-existing drainage dykes as natural fire breaks. In describing a similar combination of measures affording blast protection at RGPF Waltham Abbey, Jenkins (1891, 367) stated:

> 'At the factory, as is often the case, the powder buildings are spread over a considerable tract of low-lying ground, covered with trees, and intersected with numerous water-channels. The trees are valuable as screens in the case of explosion, and the water furnishes both motive-power and safe means of transport. The buildings are light brick and wooden structures, partly surrounded, as a rule, by heavy traverses, designed to prevent an explosion from being communicated to the other buildings in their neighbourhood.'

Although most of the trees have now been removed, aerial photographs from the 1940s suggest that the west side of the site was formerly peppered with trees or large shrubs (see section 3.8 for details), almost exclusively across the area developed before the 1907 25-inch OS map revision (Ordnance Survey 1908a; 1908b). It seems likely that the trees were planted concurrently with the construction of the traverses, rather than being added later. Their restriction to the pre-1907 features could suggest that their use as secondary blast protection was abandoned as building design moved towards use of ferro-concrete in the lead up to the war, or that there was simply too little time to establish trees on the more rapidly constructed parts of the site. The 1907 25-inch OS map clearly shows that the main track from the southern site entrance was lined with trees along its north-east side, presumably as an aesthetic act, and perhaps as a visual shield masking the factory complex from view on the approach to the offices.

Transport

Safety was not the only consideration; efficiency was also a prime concern in the layout of the factory. The major logistical consideration for a site of this size and extent was transport, and so the layout of the tram network was intrinsic to the overall form and function of the factory. Narrow-gauge tramlines ran along the top of low embanked earthworks carrying bogie carts (small hand-pushed trucks) for conveyance of explosives and other materials between processing buildings. It was anticipated that an accurate map of the tram network would aid understanding of the manufacturing flow lines in areas of the site where function was felt to be less well understood. However, it is not possible to tell the direction in which trams moved on various stretches of line (probably both directions, allowing the return of empty bogie carts), and across much of the tram network loops suggest that most buildings were easily accessed from almost all others nearby. In the event, therefore, mapping the arrangement of the tramway embankments has not added as much clarity as was hoped.

Detailed survey of the tramways has, however, highlighted that the original western half of the site and the eastern wartime addition, HM Cordite Factory, were not run entirely as two totally separate factories. In several places tramlines ran up to and across the drainage dykes thought to form a boundary between the two areas, for example, adjacent to structures **128**, **148** and **167**. Although the production lines were separate in these two areas, they would have used the same imported raw materials and

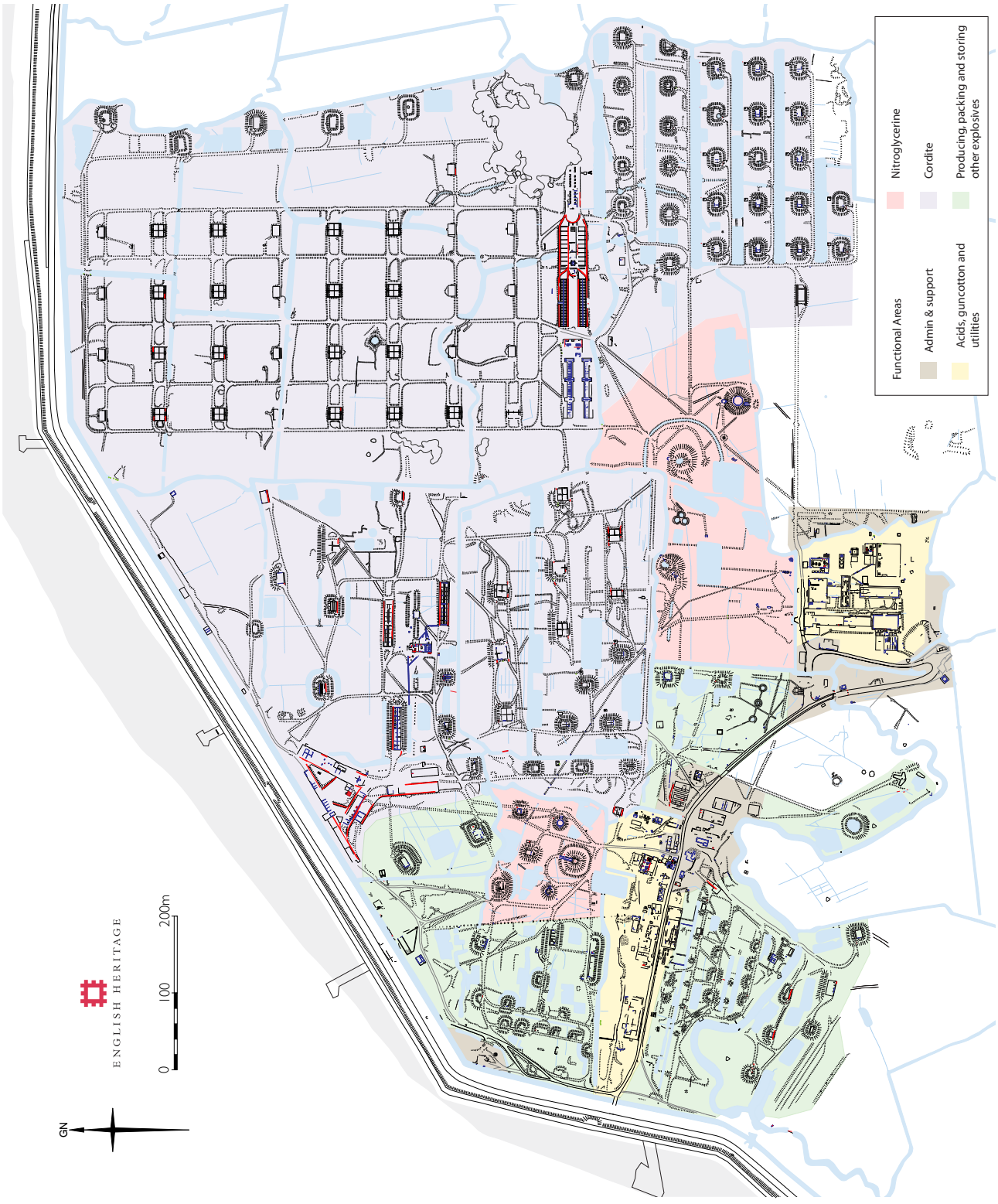


Figure 162: The main functional zones of the factory complex. Drawn by Philip Sinton © English Heritage.

export vessels, which were centrally managed, and they probably shared a number of maintenance and welfare facilities.

Despite the density of tramlines, other access routes seem to have been kept to a minimum. Apart from one arterial road snaking from the southern entrance to the earliest jetty (**J1**) via the large western jetty (**J3**) and Hope House (shown most clearly on the 1907 OS maps - *see* Figure 16), there were few surfaced tracks for wagons, bicycles or personnel. In some cases, embankments seemingly too narrow for trams may have been footpaths raised above the marshy ground. It is unlikely that workers themselves were ever moved around site on the tramways.

Although we know that tramways and the arterial roadway were the main form of transport within the factory (*see* section 4.5), a small number of the building remains at Cliffe once had small creek-side wharves for movement of materials or people by boat (**82**, **89**, **96** and **119**). Additionally, the presence of four timber jetties on the factory periphery (**J1** to **J4**) gave the site good connections to the major Thames shipping route, providing convenient facilities for importing raw materials and exporting finished explosives.

Absence of surviving pipelines or associated support posts leaves a distinct gap in the surviving evidence. Presumably, they were recovered for scrap when the site was closed and sold in the 1920s. Had more of these features remained in situ, they would have given a stronger sense of which buildings were directly linked to one another, by what function they were linked (for example, spent acids passing from one building to the next) and how and from where various buildings were powered.

Departmental layout

Departments grouped buildings, and people (*see* section 8.4), by processes and location. The layout of buildings within different departments was structured according to logistical considerations and risk. The overall design and layout of processing areas in a nitroglycerine factory were largely based around allowing chemicals to flow from process to process by gravity. Some sites such as the huge Nobel Explosives Co factory at Ardeer made use of the local topography by erecting the nitroglycerine buildings at intervals down natural slopes to facilitate the gravitational movement of chemicals (Dolan and Oglethorpe 1996, 37-48). At a flat site like Cliffe this was a trickier feat: buildings required several storeys and, where against-gravity movement was required to convey chemicals to the upper levels, compressed air pipelines or vertical winches were used.

The earliest building remains, structures **1** and **2**, each express a unique form of clasped earthwork configuration not used elsewhere on the site. This style probably represents a recommended safety design for protective traverses from the 1890s, construction guidelines for which were probably altered by the time new danger buildings were erected at the factory in the early 20th century.

In the acid-handling and guncotton preparation department, the relative danger of accidental explosions was low. This meant that buildings could be arranged close together to facilitate a quicker and more efficient production line and to reduce handling

times for the corrosive acids. In contrast to this, the guncotton drying areas and cordite production zones presented greater risk of explosion and so the need for generous spacing and use of protective traverses became paramount. At Cliffe, this distinct difference in layout between one process area and the next in the production line is best demonstrated by features in the south and south-east areas of the site (**Areas G** and **H**), where the tightly packed buildings of the acid and guncotton preparation area then lead into the widely spaced and traverse-encircled guncotton drying stoves.

The factory layout also clearly shows that the ratio of building types changed over time. In the pre-war cordite factory, one nitroglycerine hill (**31**) supplied the nitroglycerine that eventually produced cordite to feed about 32 cordite drying stoves (constructed in groups of four). In comparison, in the wartime HM Cordite Factory, one nitroglycerine hill (**168**) provided the nitroglycerine used to produce cordite to feed 72 cordite drying stoves (also in groups of four). Some of this disparity results from the fact that a proportion of the nitroglycerine produced in the earlier, western nitroglycerine hill (**31**) was being used for production of various blasting explosives as well as for combining with guncotton to make cordite. The eastern nitroglycerine hill (**168**), on the other hand, appears to have been used solely for production of naval cordite. However, other factors may also have been at play. During the war, continuous round-the-clock working was crucial to meet the high military demand for cordite. Multiple batches of different thicknesses were being produced day and night, and stoves needed to be ready for emptying and refilling on a rotational basis. Access to a large number of drying stoves reduced or removed the need to wait before new batches could enter the final drying phase, thereby increasing the overall rate of production. Later cordite preparations, such as Cordite MD, had a lower nitroglycerine content, but required a longer drying time, which further added to this need for extra stoves (Cocroft 2000, 140).

Descriptions in the eight official accident reports known for the site (see bibliography in section 11 for full references) and the lot listings in the 1923 sales particulars (MALSC 06a_DE_Series_1001_1200/DE1087_3) show that each factory building was uniquely numbered or alphanumerically coded according to function (Table 2). Judging from the style of building codes mentioned in the accident reports, alphanumeric coding seem to have been introduced sometime between 1908 and 1911. Prior to this, buildings from the older areas of the factory are described purely by number (for example, cordite paste mixing house 'No. 18', in Cooper-Key 1903), or with a letter as a suffix (such as cartridge hut 'No. 26a', in Cooper-Key 1908). The refined alphanumeric system was a later adoption, with letters used to identify the process undertaken within the building preceding a number used to differentiate been different buildings of the same function, for instance magazine 'M14' (**220**) and blending house 'O9' (**215**). Even so, throughout the factory, including the wartime areas, buildings in the acid and guncotton factory and those with maintenance functions were known only by number, such as the fitter's shop '104' (**255**), or with letters as a suffix, for example bale breaker house '84a' (**175**).

The coding system used at Cliffe appears to be similar, but not identical, to the one employed at the Royal Naval Cordite Factory at Holton Heath in Dorset. The use of specific codes at Holton Heath is explained by Bowditch and Hayward (1996, 29-30) where, as well as single letters with numbers, combinations of letters were used to signify buildings in which several processes took place (for example 'ABC' meant that nitration,

separation and washing of nitroglycerine all took place in that building). Unfortunately, the meanings behind alphabetic coding used at Cliffe is less apparent and equivalent levels of detail are not known, but several of the building codes used at Cliffe have been deciphered from the primary references available (*see* Table 2 and Figure 148).

Table 2: Alphabetic coding used for buildings at the explosives factory, Cliffe

A-	*nitrating house (nitroglycerine, Area A)*	*N-*	*guncotton drying stove*
B-	*nitrating house (nitroglycerine, Area I)*	*O-*	*cordite blending house*
C-	*final washing and filtering*	*S-*	*guncotton washing house*
D-	*wash water settling house*	*T-*	*cordite drying stove*
E-	*cordite paste mixing house*	*T-*	*acetone recovery stove*
F-	*cartridge huts*	*TA-*	*pump house (acetone recovery)**
J-	*incorporating house*	*TC-*	*acetone recovery house*
J-	*cordite press house*	*X-*	*magazines and expense magazines (incl. guncotton or cordite paste)*
M-	*magazine (finished cordite)*		

*other pump houses nearby were coded with a number only

Building codes or numbers would have been clearly displayed on the outside of each building (*see* Figure 80). There may even have been signposts placed at various locations across the site, such as at junctions in the tram network, especially important for a site frequently enveloped in thick and disorientating sea mist.

Manufacturing flow lines

It is difficult to identify and decipher any visible traces of how the manufacturing process flowed between machines, buildings and areas in the physical remains at Cliffe. As a result, functional interpretations for various groups of structures are largely fairly broad, and only where complementary documentary evidence exists were the finer elements of individual building functions and the order by which materials moved from building to building, and from process to process, clearly identified. Essentially, whereas the west side of the factory accounts for several intermingled manufacturing flow lines that spiral out from the acid and guncotton works of **Area B**, HM Cordite Factory to the east represents a single process-flow for naval cordite production that can be followed in a largely south to north route through the associated manufacturing buildings. A general overview of the functional zones across the factory giving an idea of the direction of movement through the manufacturing activities is presented in Figure 162 at the beginning of section 8.2.

By modern standards, the production processes for explosive products, from start to finish, were not especially quick. Although documented accounts for the time it took to manufacture various explosives at Cliffe, or equivalent factories, have not been identified, the process is known to have taken weeks rather than days to reach completion. At Chilworth in Surrey, the time it took just to recover acetone from thicker cordite strands was anything from one week up to 40 days (Cocroft and Tuck

2005, 230). Considerations such as prolonged drying times led many factories including Cliffe, to operate in shifts, allowing continuous production, around the clock, seven days a week. This, combined with construction of large numbers of drying stoves, enabled a continuous supply of finished cordite as mentioned above.

8.3 Building forms and functions

Predominantly, the standing remains in the factory complex are those of reinforced concrete buildings constructed around 1914-6 for HM Cordite Factory, along with a handful of probable administrative buildings built sometime between 1907 and 1914. All other buildings have been demolished, presumably during the comprehensive reclaimation of materials in the aftermath of the factory's closure. Nevertheless, witness marks on the concrete foundations and descriptions from contemporary documents have provided information on wall construction materials and layout of internal subdivision for many of the missing structures. From this evidence it would appear that the buildings at Cliffe were largely similar in form and make-up to equivalent buildings recorded across a number of other contemporary explosives factories: most being made of brick, wood or corrugated sheet metal, depending on the nature of the process carried out inside and on the structural requirements of the building.

Danger buildings, in particular, followed a consistent set of constructional considerations: being built of lightweight materials designed to minimise damage to nearby structures and staff in the event of an explosion. Additionally, they were divided internally into clean and dirty areas to reduce the risk of explosions. They had a porch to receive the bogie cart, outward-opening doors and, in the case of the drying stoves, a squint (small window) for reading the internal thermometer from outside. The sales particulars for 1923 provide some detail of the buildings' construction (MALSC 06a_DE_Series_1001_1200/DE1087_3), and inferences can also be drawn from surviving danger buildings at contemporary explosives factory sites, such as Chilworth in Surrey (Cocroft and Tuck 2005, 230).

The unusual depiction of structures **155**, **156** and **157** (**Area F**) on the 1907 25-inch OS map is also interesting (Ordnance Survey 1908a; 1908b). They are the only factory buildings for which the earthwork traverses are portrayed as grey shaded structures with sharp square corners. All other earthworks are shown depicted with hachures and more rounded corners. Presumably these traverses were constructed in a different manner, perhaps the earth was supported by corrugated metal sheeting to create 'Chilworth Mounds' (see section 6.11, Figure 106).

Acid-handling and guncotton preparation

The acid-handling and guncotton preparation zones are recognisable by their position outside the danger area. These buildings often have much larger floor areas than buildings elsewhere in the factory, they are closely co-located and they generally retain traces of acid-resistant brick and tile floor coverings. The remains recorded in **Area G** along with descriptions of their construction materials and functions laid out in the sales particulars from 1923 show this most clearly (MALSC 06a_DE_Series_1001_1200/DE1087_3).

Nitroglycerine preparation

The 1900s nitroglycerine processing group at Cliffe (**30**, **31** and **32**) is unusual for two reasons: the use of circular wash houses surrounded by circular traverses, and the use of two wash houses in association with a single nitroglycerine hill. Surviving examples of both practices appear to be limited to RGPF Waltham Abbey and the Cliffe factory, and those at Cliffe appear to have been closely and consciously modelled on examples at Waltham Abbey (Cocroft 2000, 143).

The original rectangular nitroglycerine buildings erected in 1890 on Quinton Hill at the RGPF Waltham Abbey South Site were rebuilt in 1894 following an explosion. The replacement structures included a washing house and a mixing house, both rebuilt in a new circular form comprising a timber round-house surrounded by a high circular earthwork traverse with an internal revetting brick wall (Cocroft 2000, 130-41; Foreman 2001). This circular form may have been favoured over rectangular constructions because it improves the consistency of airflow and eliminates the potential for cold corners (Cocroft 2000, 130-41). Two years later, a circular design was again employed, this time for two wash houses and a nitroglycerine hill in the new Edmonsey Mead factory, built in 1896 as a second nitroglycerine plant within RGPF Waltham Abbey; this time constructed on the North Site in an area previously dedicated to gunpowder manufacture (ibid). Structures **31** and **32** at Cliffe, with their circular earthen traverses and internal brick retaining walls (interpreted as nitroglycerine washing houses)**,** closely resemble the 1890s nitroglycerine washing houses on the Edmonsey Mead site on which they are almost certainly modelled, and are the only known surviving examples of circular wash house traverses outside Waltham Abbey (Cocroft 2000, 143). Compared with the larger doubled-entranced wash houses at Waltham Abbey, the examples at Cliffe are slightly smaller in overall diameter and only have a single entrance. The large circular First World War nitroglycerine hill at Cliffe (**168**), also bares some resemblance to the nitrating houses of the Edmonsey Mead Waltham Abbey site, albeit on a smaller scale.

The 1900s nitroglycerine group at Cliffe (**30**, **31** and **32**) is also unusual for its use of two wash houses rather than one. The only other known example of this practice is the 1896 Edmonsey Mead nitroglycerine factory at Waltham Abbey (RCHME 1994, 43, 82-5; Cocroft 2000, 130-41, 143). The choice of this form and layout for the trio of circular nitroglycerine buildings at Cliffe appear to have been modelled closely on the Edmonsey Mead outfit, although the Cliffe examples are again slightly smaller in diameter than those at RGPF Waltham Abbey.

Cordite drying stoves

The remains of structures **129**, **130** and **131** in **Area D** represent buildings that had been adapted and converted for a new use part way through the life of the factory. A detailed accident report prepared by the Explosives Inspectorate describes an explosion that occurred in April 1914 during their conversion from cordite drying stoves into new acetone recovery stoves in line with developments in cordite manufacturing methods (Coningham 1914). Prior to their conversion, the cordite drying stoves in this area appear to have been of the fairly new traverse-less 'Quinan System', which used multiple small adjacent bays to split the wet material into small batches, thereby allowing a more rapid drying time (Fraser and Chambers Ltd 1908). Examples of Quinan drying stoves

in use at this time include the guncotton drying stoves at HM Factory Gretna, Cumbria, constructed in 1915 (Cocroft 2000, 163-6).

Conversion of existing cordite drying stoves into an acetone recovery facility created a need for the construction of new cordite drying stoves: at Cliffe the building of which represents a distinct change in style and layout from Quinan-style long ranges of small side-by-side bays (**129** to **131**) to larger drying rooms in square arrangements of four (**143** to **148**, **153** and **154**). Of particular importance at Cliffe is the discovery that reinforced concrete ('ferro-concrete') appears to have been adopted as a building material part way through the construction of these new stoves. The northern eight of the new structures (each comprising a group of four conjoined stoves) were built in brick and enclosed by earthen traverses (**143** to **148**), then as the development spread further south, the final two cordite drying buildings in **Area E** (**153** and **154**) followed the same basic design, but have walls of reinforced concrete and no associated mounds. From this point on in the development of the Cliffe site, reinforced concrete appears to have become the construction material of choice for certain building types: cordite drying stoves, press houses and acetone recovery stoves. This could be because concrete performed the best in the heated drying atmosphere of the stoves, where a lightweight structure was not required. Or it may have been a quick alternative to brick-laying and mound construction in response to the need for rapid development to meet the wartime demand for explosives.

The Hungarian born explosives expert Oscar Guttmann proclaimed the benefits of ferro-concrete buildings in a paper published in 1908 (Guttmann 1908b). However, there appears to have been little uptake of reinforced concrete as a staple building material in the British explosives industry (Cocroft 2000, 103-4). Indeed, by 1910, Guttmann (1930, 930) was suggesting that ordinary concrete (mass, not reinforced) was most suitable for use in magazine buildings and such like. Concrete of any type does not seem to have been used very much at all in the Royal Ordnance Yards in the first two decades of the 20th century (Evans 2006). The extensive use of reinforced concrete in the First World War factory elements at Cliffe is therefore a rare occurance in this context, and the survival of physical remains is currently considered to be unique.

Power

One key group of buildings that remain largely unresolved are the power houses that drove the process buildings (*see* section 4.4). We know that diesel engines, electric motors and hydraulic accumulators were all in use at the Cliffe site, but it is not clear in all areas how many power houses there were, which power sources were used, whether the power sources changed over time with technological advances, or whether the factory used more than one power source at the same time, selecting the type based on the specific physical or safety requirements of each process or machine type.

As well as for direct motive power, steam was harnessed for drying and temperature regulation, and there is a chance that steam power may also have been used for generation of electricity. Unfortunately, the network of pipes that would have conveyed the steam around the factory complex has largely been removed. Likewise, there is little visible evidence for electrical connections between buildings, but we know

from descriptions in the 1923 sales particulars that electric light cables in the HM Cordite Factory complex largely ran below ground and not above (MALSC 06a_DE_Series_1001_1200/DE1087_3).

8.4 Organisation, management and staffing

Details of the organisation of personnel and the day-to-day running of Curtis's & Harvey's factory at Cliffe are limited, but some basic understanding can be drawn together from documentary resources, memories, historic photographs, elements of the physical remains themselves and detailed knowledge of similar contemporary sites.

The staff and buildings were almost certainly organised into departments or divisions for management purposes. Job titles given in various contemporary documents (primarily Explosives Inspectorate reports) allude to the management hierarchy at Cliffe, including some of the departments and staff teams that once structured the workforce. On behalf of the company directors, all workings on the site were overseen by the factory manager; through the operational period of the factory this role was undertaken by:

Factory Managers		
Mr J McIntosh	*circa* 1901-1903	(Kelly & Co 1903; Williams 2010, 261)
Mr A Seip	*circa* 1904-1908	(Cooper-Key 1904; 1908; Kelly & Co 1905)
Mr F M Wharton	*circa* 1909	(Kelly & Co 1909)
Mr T G Shacklady	*circa* 1911-1922	(TNA RGP 14/3856; Kelly & Co 1911; 1913; 1915; 1918; 1922)

Beneath the manager there were one or more superintendents responsible for various departments; at Cliffe this included a superintendent of the high explosives nitroglycerine department (Cooper-Key 1911). By 1911, if not much earlier, an assistant manager was also in evidence at Cliffe (ibid). Chief chemist appears to have been another role of elevated status; in the case of Mr Shacklady it was a role he had progressed to prior to his appointment as the factory manager (Cooper-Key 1904). The chief chemist would have overseen a number of chemists working in several laboratories across the site, some undertaking continual batch testing to ensure consistency and safety whilst others engaged in the continual development of new and improved compositions.

A tier of foremen oversaw the majority of the daily procedures within each department at the Cliffe factory. These included a foreman of the acids department (Explosives Inspectorate 1905, 59; Crozier 1917), a foreman of the guncotton department (Cooper-Key 1911), a foreman of the nitroglycerine hill (TNA RG 13/718; Cooper-Key 1904; 1911), a foreman of the outside labourers (Cooper-Key 1911), and possible reference to a foreman of the dynamite or cartridge filling department (Cooper-Key 1908). The 500 acre Royal Naval Cordite Factory at Holton Heath near Poole in Dorset provides a good equivalent example of this departmental organisation. In operation from 1915, the Holton Heath factory was structured into process-based departments: acid department, guncotton department, engineering department (providing all necessary power), acetone department, acetone recovery department and cordite department (British Association 1919).

In addition, the smooth running of the site would have relied on a workforce of bogie runners, general labourers, fitters, engineers, carpenters and so forth, and alongside the manufacturing, maintenance and scientific roles, the factory had a number of administrative, welfare and security staff. The office team would have included at least one clerk and several short-hand typists to assist the manager and other senior staff (*see* Figure 73). With such a large number of staff, long hours and shift-working, there may have been on-site catering staff and a canteen. There would probably have been an on-site laundry to ensure all regulation uniforms, particularly lab coats and 'clean' area over-garments, were kept clean and free from dangerous residues. Gatekeepers and site watchmen would have monitored people entering and exiting the site, and patrolled during any closure times. Census records tell us that watchman William Murray was living at Lower Hope Point between 1901 and 1911 (TNA RG 13/718; RG 14/3856), though he probably arrived earlier and remained longer than these dates imply (*see* section 3.4).

Departments grouped people, and buildings (*see* section 8.2), by processes and location. What remains unclear is whether wartime expansions at Cliffe - that is construction of a second guncotton factory and cordite production line in the form of HM Cordite Factory - resulted in an enlargement of the existing departments, or the establishment of a set of duplicate departments. From a practical point of view, such a vast site is likely to have required a separate foreman to oversee the new manufacturing zones as well as specific staff trained to operate the newer facilities.

Workers and working conditions

Women workers at the Cliffe factory were not just a feature of the wartime years. Many women were employed at the factory from the start, although their roles were commonly restricted to processes bracketing the more dangerous stages of manufacture, such as cotton bale-breaking and picking, cartridge filling, or cutting cordite into sticks. The full production workforce under the watch of the factory foremen included 'hillmen' (nitroglycerine factory workers), cordite paste mixers, cordite reelers, gelatine mixers and cartridge fillers, amongst numerous other specialised roles. Interestingly, it was noted in a brief combing of the occupation data in census records from 1911 for local employees at the factory (TNA RG 14/3856), that women working as cartridge fillers tend to specify which type of cartridges they were handling, for example 'cheddite packer' or 'dynamite packer', and were therefore not just in generic cartridge-filling roles. Presumably, this also suggests that the small packing huts were not interchangeable for use with different explosive types, even though the apparatus used inside was probably the same. Information detailed above regarding various roles held by staff at the Cliffe factory was collected from the following primary sources: TNA RG 13/718; RG 14/3856; Cooper-Key 1904; 1908; 1911; Explosives Inspectorate 1905; and Crozier 1917.

In a personal account given to local historian Bob Hutchings (1975), published in *Cliffe and Cliffe Woods Parish News*, former cartridge worker Maisie Goodyer explained that during the war years, Curtis's & Harvey provided an overcrowded lorry to bring staff in each day from the Medway towns, and that many other staff walked or cycled daily across the marsh to reach the factory. Indeed, the presence of a cycle shed close to the factory office buildings is mentioned in an accident report from 1911 (Cooper-Key 1911, 4). This

kind of staff travel arrangements and the pattern of a dispersed workforce is similar to that recorded at the contemporary explosives factory at Chilworth, Surrey (Cocroft and Tuck 2005, 224). In the case of another wartime worker, Minnie Rogers, the factory issued her with a bicycle for her journeys to and from work (Dulcie Jones and Amanda Thomas, daughter and granddaughter of Minnie Rogers, pers comm). As well as enabling staff to travel to work easily and cheaply, schemes such as this would have had a wider reach; by giving mobility to many inhabitants of the marginal peninsula towns they were also handing out an element of freedom and broadened horizons.

It was not only buildings and processes that were regulated; equipment and individual conduct was also subject to strict rules. Staff members were required to empty their pockets before entering certain buildings to remove all possibility of sparking from metal coins, matches or other items: to this end, staff even drank from rubber mugs (Cooper-Key 1911, 5). At the RGPF Waltham Abbey, amnesty boxes for the purpose of emptying pockets still stand outside some of the processing buildings.

Regulation uniforms were issued. At Cliffe, during the First World War at least, these were made of heavy-duty red serge (Hutchings 1975). Wartime photographs of female factory workers show that fairly plain, collared overcoats and cloth caps were worn for some roles (*see* Figure 21), and distinctive full length smock dresses with collar and buttoning details were worn for others (Figure 163) (*and see* Cherry 1998, 54). Male factory workers appear to have worn suits and flat caps in heavy-duty fabric (*see* Cherry 1998, 55). In addition, special over-garments, including large over-shoes, would have been required for work in the 'clean' (inner) areas of any danger buildings.

There was good reason behind the strict regulation of conduct and uniform which, along with building layout and manufacturing procedures, were closely monitored by HM Explosives Inspectorate. Accidental explosions, fires and production of noxious fumes were kept to a minimum but errors were not uncommon, and many incidents resulted in fatalities. Thirty-nine reported accidents have been identified relating to Curtis's & Harvey's factory at Cliffe (see Appendix 3). Along with inevitable structural damage, 19 of these incidents caused notable injury to men and women: 60 individuals were significantly wounded, 21 of whom were killed immediately or died soon after as a result, and many others received superficial injuries. Despite the near doubling in size of the factory during the early years of the First World War, the influx of (presumably largely inexperienced) staff and the increase in building numbers does not appear to have caused a notable rise in the number of accidents. This perhaps unexpected pattern was repeated across the British explosives industry as a whole (Cocroft 2000, 187), and is probably a credit to ceaseless striving for improvements in safety regulations and manufacturing methods. Major accidents often inspired technological developments, revision of practice and tightening of safety regulations. Cooper-Key (1911, 7) reports that following an accident at Cliffe in 1911, Curtis's & Harvey adopted a method of placing a slightly dished concrete platform rendered in smooth cement, intended to be covered with 1-inch of water at all times, in front of the doors of danger buildings in order to contain any spilt liquid (no obvious examples were identified amongst the factory remains).

Figure 163: Minnie Rogers (left) and Margaret May Newson in their explosives workers uniforms, taken at the Cliffe factory in 1917, © Amanda Thomas and Dulcie Jones, reproduced by kind permission.

As well as effecting production and working practices, these incidents, and especially the accidental deaths, made a great impact on the local community. Following two fatal explosions at the factory in February 1904, on 9 May, the 34th Company of the Royal Engineers played (and lost) a charity football match against the Cliffe League team in aid of widows and orphans of the victims of the 'Cliffe powder factory explosion' (The Sapper 1904, 278). A number of headstones standing in the graveyard at St Helen's Church in Cliffe mark the final resting place of local residents killed by explosions whilst working at the neighbouring factory. For example, to the north side of the church stands a gravestone to the memory of Henry Charles Hawkins who was killed by an explosion at the factory on 26 July 1911 (Figure 164). He was killed, along with Ernest Henry Law and George Christopher Walkinshaw, by an explosion of cordite paste in a bogie cart and of the nearby nitroglycerine washing and filtering house 'C3' (Cooper-Key 1911; Explosives Inspectorate 1912). One local newspaper reported of this particular accident that '…its destructive effect was undoubtedly the most severe ever experienced in the neighbourhood' (Chatham, Rochester & Gillingham News 1911a). Another described scenes from Cliffe village on the day of the funeral: 'All business in the village was suspended, the blinds of windows were drawn, the route of the procession was lined with sympathetic and sorrowing spectators, and a muffled peal was rung from the church tower, where the flag was flying at half-mast' (Chatham, Rochester & Gillingham News 1911b). The mutual reliance between the local community and the factory was clearly deep and the cost sometimes tragic.

Figure 164: The gravestone of a worker from the nitroglycerine department in ***Area A*** *at the Cliffe factory, erected in St Helen's churchyard, Cliffe. It reads: 'In Memory of Henry Charles Hawkins, who was killed in an explosion on July 26th 1911, aged 26 years'. NMR BB94_08716 31-Mar-1995, Danke Silva © English Heritage.*

8.5 National context and significance

By the end of the first decade of the 20th century, Curtis's & Harvey Ltd were reputed to '…manufacture for every market, and have agents throughout the world' and 'their factory for High Explosives at Cliffe at Hoo' was said to be 'one of the largest and most completely equipped in the Kingdom' (Hodgetts 1909, 354).

The location of the factory along the marshy banks of the River Thames was crucial to its success, simultaneously providing security through isolation and effective access to national and international shipping routes. Location on the Thames was also key to manufacturing operations in that it gave the factory at Cliffe close physical and working ties to the heartland of the British chemical industry for sourcing of raw materials, and to the testing and finishing facilities at important nearby sites such as Royal Arsenal Woolwich and Purfleet magazine. Equally, the existence of modern and highly productive factories on the lower banks of the Thames, including the Curtis's & Harvey works at Cliffe, Kynoch's factory near Corringham and the British Explosives Syndicate factory at Pitsea Hall Farm, both on the Essex coast, allowed Britain to produce and move armaments on a vast and ever increasing scale, which played a considerable role in achieving victory in the First World War.

Sites of this type and period were not just following technological advances from military or academic scientists, they were actively discovering, testing, patenting and implementing the technological advances themselves. Documents record at least two laboratories on site at the HM Cordite Factory portion of the Cliffe works, and others were almost certainly located in the western areas of the factory. Although testing of raw materials, partially manufactured products and finished explosives would have taken up a proportion of time and space in the laboratories, they would also have been used for trialling alterations to explosive recipes or production methodologies. We know that, by 1909, several 'permitted' explosives were the invention and sole property of Curtis's & Harvey Ltd, including: Rippite, Curtisite, Bobbinite, Dragonite, Kolax, Excellite and Cliffite

(Hodgetts 1909, 355); and all but Bobbinite (a low explosive gunpowder derivative) were produced at Cliffe. The company had several factory bases and so invention was not necessarily limited to Cliffe, but it is likely that at some of these explosive products, in particular 'Cliffite', were conceived here.

In 1918, Curtis's & Harvey Ltd and their factory were brought under the umbrella of Nobel Industries. Latterly, Nobel Industries became part of Imperial Chemical Industries Ltd (ICI), and so the explosives works at Cliffe represents one strand in the eventual creation of a giant in the history of chemical industry (ICI).

Comparison with contemporary sites

Experiments with chemical-based explosives in the late 19th century revolutionised the explosives industry, and particularly the nature of military propellants. Although guncotton was being made at a number of factories, either as an explosive in its own right, or as a raw ingredient to supply to other explosives factories (for instance at HM Guncotton Factory in Colnbrook, Buckinghamshire), Curtis's & Harvey's explosives works at Cliffe was one of only a handful of factories involved with the mass production of new powerful propellants like cordite.

Contemporary explosives works manufacturing military cordite during some or all of the same operating years as Cliffe [185]:*

- [029] National Explosives Company: Hayle, Cornwall (1889-1920)
- [044] HM Factory Gretna: Rockcliffe, Cumbria (1915-18)
- [060] Royal Naval Cordite Factory: Holton Heath, Dorset (1915-46)
- [076] Kynoch's: Kynochtown, near Corringham, Essex (1897-192?)
- [077] British Explosives Syndicate: Pitsea Hall Farm, Essex (1891-192?)
- [082] Royal Gunpowder Factory: Waltham Abbey, Essex (1664-1945)
- [194] Cotton Powder Co Ltd; Curtis's & Harvey Ltd: Faversham, Uplees, Kent (1873-192?)
- [270] Chilworth Gunpowder Company: Chilworth, Surrey (1626, 1885-1920?)
- [350] Nobel Explosives Co Ltd: Ardeer, North Ayrshire (1872-present)

*numbers in square brackets equate to gazetteer numbers allocated in *Dangerous Energy* (Cocroft 2000, 274-89)

Cliffe was not the only explosives factory to experience dramatic enlargement in the early years of the First World War. Explosives works at Hayle in Cornwall and Faversham in Kent, saw expansions on a similar scale at this time; likewise the Chilworth factory, however here only cordite finishing processes were undertaken using cordite paste brought in from the Nobel Explosives factory in Ardeer (Cocroft and Tuck 2005). In addition to this, in 1915, new cordite manufacturing facilities were established at Holton Heath in Dorset and at HM Factory, Gretna in Rockcliffe, Cumbria.

The fall in demand for service propellants towards the end of the war and at the start of the 1920s also had a fairly uniform effect on the factories producing cordite. Cliffe was not the only casualty; the factories at Chilworth, Hayle, Pitsea and Faversham also closed their production lines, with HM Factory, Gretna, having closed even before this.

Cliffe was also one of only a few factories producing blasting explosives like dynamite, blasting gelatine and Cheddites during the first decades of the 20th century. This technology had also moved forward significantly by the end of the war but, given the national economic downturn and the factory's reliance on demand for its principal product, cordite, closure of the factory remained inevitable.

*Contemporary explosives works manufacturing blasting explosives during some or all of the same operating years as Cliffe [185] *:*

- [029] National Explosives Company: Hayle, Cornwall (1889-1920)
- [032] Nobel Explosives Co Ltd: Perranport, Cornwall (1893-?)
- [075] The High Explosives Co Ltd; Standard Explosives Company; The Explosives and Chemical Products Co; Ex Chem Industries: Great Oakley, Bramble Island, Harwich, Essex (1899-present)
- [077] British Explosives Syndicate: Pitsea Hall Farm, Essex (1891-192?)
- [194] Cotton Powder Co Ltd; Curtis's & Harvey Ltd: Faversham, Uplees, Kent (1873-192?)
- [350] Nobel Explosives Co Ltd: Ardeer, North Ayrshire (1872-present)

*numbers in square brackets equate to gazetteer numbers allocated in *Dangerous Energy* (Cocroft 2000, 274-89)

Significance

The significance of the Cliffe explosives works site is attributed largely to the extent of the factory remains, which survive in near complete plan form. These visible and buried archaeological remains tell us much about the scale and nature of explosives manufacture on Cliffe Marshes; the vast area covered by the factory gives a very real sense of how important this site was to the character of the landscape and the operation of the local economy. Additionally, the completeness of the site plan provides a graphic illustration of the layout and organisation of contemporary early 20th-century explosives factories in Britain and their development to meet the insatiable demands of the First World War. Many of these sites were also located on previously undeveloped marginal land, often in estuarine or coastal positions.

By virtue of the relatively short life of the Cliffe factory, the processes and factory layout adopted for the manufacture of cordite and other chemical explosives in the first two decades of the 20th century are preserved in a coherent form, and the isolated and treeless nature of the site allows the extent and plan form of the remains to be easily appreciated whether on the ground or from the air. The surviving elements of RGPF Waltham Abbey and Nobel Explosives factory at Ardeer in North Ayreshire present a wider variety of explosives technologies and far longer periods of operation and advancements, but this makes them more difficult sites at which to identify coherent single phases of technological development. Waltham Abbey's North Site at Edmondsey Mead operated between the 1890s and 1914, and so did share a similar duration with the earlier western elements of the Cliffe factory. Likewise, the factory remains at Pitsea Hall Farm in Essex, Hayle in Cornwall and Chilworth in Surrey all represent explosives works that operated from the 1890s until early 1920s. However, the tramways at these sites do not survive well and so the pattern of connections between the different buildings and processing areas is not as visible as it is at Cliffe. Furthermore, the factory at Hayle was

established on a 'continental pattern' (the factory was organised into a 'wet' part and a 'dry' part) and so differed from the normal British practice (Cocroft 2000, 144). With all this in mind, the remains at Cliffe can be seen as a rare example of an early 20th-century chemical explosives factory. with a complete and legible plan form.

Of the explosives factories engaged in similar manufacturing processes and operating around the same time as Cliffe, three are currently recognised for their national significance by being wholly or partially designated as scheduled monuments: RGPF Waltham Abbey (NHLE 1016618), Chilworth (NHLE 1018507) and RNCF Holton Heath (NHLE 1019151). The Chilworth factory site is now contained within a conservation area, and the sites at Waltham Abbey and Holton Heath include a number of additional designations in the form of buildings given listed status; buildings listed in association with explosive manufacture at these two sites are found within and outside the scheduled area. None of these listed buildings share form or functions with those recognised at Cliffe. The former factories at Holton Heath and Uplees, Faversham are now within areas managed as nature reserves and the Pitsea Hall Farm site is within a country park.

Some elements of the layout, building styles and technology employed at Cliffe are thought to have been based on the existing cordite works at RGPF Waltham Abbey in Essex. As the Royal establishment, Waltham Abbey was at the forefront of British explosives production and technology. It was doubtless the inspiration for Cliffe (which copied several key technological developments), and for many other contemporary establishments.

The unusual use of reinforced concrete ('ferro-concrete') is of particular importance at Cliffe. This material was used predominantly in the 1916 HM Cordite Factory development, but also in two buildings in **Area E** thought to have been erected shortly before the outbreak of the First World War. Indeed, the majority of the surviving standing building remains at the Cliffe site are constructed from reinforced concrete, there being little of salvageable value in their demolition. Most of the Cliffe examples are the roofless shells of former cordite drying stoves (structures **153**, **154**, **205**-**212** and **222**-**231**), but reinforced concrete has also been used to construct the paired press house ranges (**246** and **247**) and the partition walls between bays which project from a central brick wall in the paired acetone recovery stove ranges (**244** and **245**). It is known that reinforced concrete had only a short-lived uptake in the explosives industry. No comparable structures have been identified at other explosives factories, and at present it appears that Cliffe contains the unique survival of material used in this context.

The value attributed to the Cliffe factory during its operating years, with regard to its contribution to British munitions supply, is attested by the Government's wartime interest in the site: first by declaring it a 'controlled establishment' in March 1916 (TNA BT 31/35980/59657 vol 3), and then by the development and management of the huge wartime expansion in the form of HM Cordite Factory. Reference to use of aerial guns at Hope Point Battery for the protection of the explosives factory at Cliffe in 1915 (*Chatham, Rochester & Gillingham News* 1915) could support this notion of national significance, although it is likely that the guns were installed here as a strategic point to defend against aircraft following the Thames to London, rather than to protect the factory *per se*.

8.6 Local context and significance

No reliable record of the overall number of staff employed by Curtis's & Harvey at their Cliffe factory has been identified. At its manufacturing peak during the First World War, with shift working allowing continuous processing, the factory was certainly supporting several hundred employees, perhaps even close to one thousand.

Although the largest local employer was the nearby cement factory (NMR TQ 77 NW 149) a short distance south-west of the explosives works, the rapid expansion of Curtis's & Harvey's factory still inevitably affected local people and village facilities. Such a dramatic change from former dispersed and low intensity land use on the marshes to a highly industrialised site employing large numbers of staff could do no less. Indeed, at over 128 hectares, the area of the former factory was about 70 per cent larger than the contemporary size of Cliffe village. The factory would have been an imposing presence.

With the long-established village of Cliffe conveniently located close by, there was no real drive to build on-site workers housing, and no need for construction of a factory hamlet or village. Although many of the factory staff travelled to the site by lorry or bicycle from the Medway towns and other more isolated peninsula settlements (*see* section 8.4), Cliffe village itself saw an influx of residents employed at the explosives works. As a result, a second school for Cliffe village was built in 1907 to cater for the overflowing numbers of children that now overwhelmed the existing school and some purpose-built housing was erected in the village. In 1912 a large house was constructed on Station Road at the very southern edge of the village, specifically for the then manager of the factory, Mr Shacklady, and his family (Figure 165). Although it has since been renamed, the house was originally called 'Curhar' to reflect its connections to Curtis's & Harvey (Cherry 1991, 16). To this day, it is still the first property seen when entering Cliffe using the main road into the village. Additionally, a terrace of four houses on the south side of Cooling Road (numbers 2 to 8) are thought to have been built for explosives factory workers in 1914 (ibid) (*see* Figure 165).

Figure 165: Houses in Cliffe village originally built to house staff from Curtis's & Harvey's explosives factory: (left) the former superintendent's residence on Station Road, built in 1912; (right) numbers 2 to 8 Cooling Road built in 1914. Photographs: Rebecca Pullen (left) and Sarah Newsome (right), 2012 © English Heritage.

Afterlife of buildings

Some elements of the factory could be said to have an afterlife elsewhere in the local area. As well as being broken up and sold for scrap or reuse, some building materials salvaged from the factory following its closure appear to have been reused in a number of sheds and outbuildings that can be seen around the village today. In particular, the design of the lightweight iron and timber buildings, essentially in pre-formed pieces, was such that they could be easily assembled and disassembled, making it possible to move and re-erect them wholesale if desired. A lone corrugated metal shed currently located on the north side of Cooling Road, leading east out of Cliffe is a case in point (Figure 166). The building has a rectangular footprint measuring 9.2m x 7.5m, with a large pair of outward-opening double doors creating an entrance 3.5m wide centrally in its west-facing gable end, and a regular outward-opening door and single small window in its east-facing gable. Comparing the footprint of this shed with the size of the concrete building foundation slabs surveyed on the factory site (excluding those with clear evidence for a brick or concrete superstructure), suggests a possible correlation with the size of structure **2**, **102**, **116**, **120**, **128** or **160**. The wide double doors at one end suggest a building type that required a loading facility. The structure also has the vestiges of a paint scheme adhering to the exterior - red on the roof and green on the walls - which local hearsay suggests was a scheme used at the explosives factory.

Figure 166: Corrugated metal shed located on Cooling Road in Cliffe, thought to have been salvaged from the explosives factory. Photograph: Rebecca Pullen 2011 © English Heritage.

Figure 167: The former 'Terminal Club' in Church Street, Cliffe, another corrugated metal building salvaged from the explosives factory, undated (after Cherry 1998, 30) © Allan Cherry, reproduced by kind permission.

In his *Pictorial History of Cooling and Cliffe*, Cherry (1998, 30), shows a photograph of the 'Terminal Club', in Church Street before it was demolished in advance of new development. Cherry states that the building was originally owned and used by Curtis's & Harvey on their explosives works land, and later re-erected in the village as the British Legion Club after the factory had closed. Judging from the photograph (Figure 167), it appears to have been a fairly large rectangular building with a covered ground floor veranda along at least one of its long sides. No clear correlation to a known factory building has yet been made.

8.7 Conclusions

The archaeological survey of the Curtis's & Harvey factory remains on Cliffe Marshes has recorded a surviving landscape of ruinous industrial buildings, building foundations, earthen traverses, tramway embankments, drains and water-filled borrow-pits dating to the first two decades of the 20th century, around half of which represents a single episode of expansion in response to the munitions drive at the start of the First World War. In addition to the surviving elements of the early 20th-century landscape, a number of earlier land management features survive, such as drainage ridges and sheepfolds, as well as evidence of aerial target practice during the Second World War and agricultural reuse of factory features from the years following the factory's closure.

Bringing together information from both physical and documentary evidence, the analytical survey of the factory remains presents a level of detail and understanding far beyond what was previously known about the site. Not only have discoveries strengthened existing opinions that the site was, and still is, of importance and value to the local community, they have proved that some elements of the operational history and physical design are also worthy of note in the national context of the British chemical explosives industry.

Surviving virtually unchanged since the factory closed in the early 1920s, the well-preserved plan form and layout of the site captures in its entirety the manufacturing process that occurred on the site. Equally important is the fact that these discoveries demonstrate the impact of two of the major influential and pivotal episodes in the history of the British explosives industry; namely the switch from black powders to chemical explosives at the close of the 19th century and the colossal armaments drive associated with the First World War.

Assessment of condition

Despite the ruined nature of the remains, in plan form and layout the site remains virtually as it was when the factory closed around 1921-2. Details uncovered through the investigation of this complex archaeological site have disclosed a wealth of previously unknown information about the story of the explosives works. The nature of these discoveries is neatly summarised by Cocroft (2000, 149) in a description of the acid factory at the RGPF Waltham Abbey:

> 'In some cases, often unremarkable field remains belie the technologically advanced processes these structures once housed. In

other instances, the remains may be unravelled to reveal the positions of machine bases and the flow of liquids through the plant. Despite the unpromising appearance of these remains they can contain invaluable information on the layout of early chemical plants in an era before the growth of the chemical engineering profession'.

While the plan form and extent is well preserved, the condition of individual features is poor, suffering largely from the comprehensive stripping of all reusable materials following the closure of the works. Furthermore, it is likely that thermal remediation (removing trace residues of chemicals by fire) was used to 'clean' the site of all chemical residues by setting fire to the structures. Any remaining standing buildings, such as the reinforced concrete stoves, may have been structurally weakened in the process. Reddening from fire was noted on the interior walls of many of the reinforced concrete structures (Figure 168).

*Figure 168: The remains of cordite drying stove **154** showing the characteristic reddening of the concrete caused by thermal remediation. Photograph: Rebecca Pullen 2011 © English Heritage.*

Further damage to the structural elements may have been incurred as a result of military use of the site for disposal of munitions and as a location for aerial target practice during the Second World War (see section 3.7 and 7.1)

Several riverside elements of the factory have been lost entirely due to the rebuilding and relocation of the sea wall. In addition to this, a number of features have been buried by modern dredging of the drainage dykes, evidenced by comparing the position of the long, low, linear spoil mounds recorded along the edge of several dykes in the central areas of the complex, with historic maps of the factory.

Other processes of decay have a slower impact. The main threats at Cliffe are poaching of the earthworks by grazing animals in the wetter months of the year, salty sea spray eroding exposed walls of the standing building remains and corrosion of surviving metalwork.

In conclusion, the detailed mapping and photography which have captured the complexity, configuration and condition of the remains, will aid understanding of the significance of the factory and its surrounding landscape, and help to inform any future management scheme for the site.

9. SURVEY METHODOLOGY

The enhanced investigation and analysis of the factory remains, or Level 3 survey (Ainsworth et al 2007, 23-4), forms a component of the wider Hoo Peninsula Historic Landscape Project, RaSMIS number 5733. The investigation was undertaken in accordance with objectives and methodologies laid out in the project design for phase 1 of the Hoo Peninsula Historic Landscape Project (Newsome 2009), and in the project brief for proposed archaeological survey of the explosives factory remains (Newsome 2010a). A comprehensive risk assessment compiled prior to undertaking the survey takes into account potential hazards presented by the marshland environment with its deep drainage ditches and poorly maintained footbridges, grazing stock and decaying factory remains (Newsome 2010b).

The field investigation was carried out between 1 November 2010 and 16 February 2011, by Rebecca Pullen, Sarah Newsome, Wayne Cocroft, Marcus Jecock, David McOmish and Magnus Alexander of English Heritage's Archaeological Survey and Investigation Team, Andrew Williams of English Heritage's Architectural Investigation Team and Derwin Gregory, English Heritage Professional Placement in Conservation (EPPIC).

The survey was conducted using Trimble R8-2 differential Global Navigation Satellite System (GNSS) receivers linked to a single on-site base station fixed to the National Grid using the Trimble VRS network to access the Ordnance Survey system of active stations (OSNet). Recent tests of this system indicate that the method used to fix the base station is likely to achieve a RMS accuracy of better than 10-20mm in plan and 15-30mm in height (Edwards et al 2008). Survey of the standing buildings, where satellite reception was obscured by walls, was carried out using a combination of Trimble 5600 series total station theodolite (TST) equipment and graphical survey. Point data gathered using the TST was imported into Trimble GeoSite Office 5.1 software where the raw data was checked for errors and transformed to OS National Grid coordinates based upon the GNSS observed control point data collected at each TST station setup point. Andrew Williams and Wayne Cocroft undertook additional measured survey with tapes to produce plan and section drawings of buildings with standing remains. Andrew Williams also produced accompanying detailed building descriptions.

All archaeological features, from large earthwork traverses to the location of individual iron studs protruding from the remains of machine beds, within the area of investigation were surveyed. A system of line coding was used in the field to differentiate between topographical points on the earthworks and between different construction material types such as concrete, brick or metal. Due to their riverine location it was not possible to survey the four jetties belonging to the factory complex as part of the GNSS ground survey; the location of three of these features (**J1** to **J3**) has been taken from data accurately mapped by Fiona Small of English Heritage's Aerial Survey and Investigation Team from historic aerial photographs; **J4** was not visible on aerial photographs. Similarly, for reasons of time pressure and health and safety, it was decided not to survey the tops of all the drainage dykes crossing the site. These have been taken from the 1:2500 current OS MasterMap data. However, factory borrow-pits were surveyed (the tops only) because they had been purposefully constructed as part of the industrial complex.

At times, the fieldwork encountered adverse weather conditions including widespread ground water-logging and heavy snowfall; every effort was made to re-check areas surveyed in conditions of low visibility where details may have been missed.

A composite draft survey plan was produced within OS National Grid coordinates and AutoCAD 2007 3D Map software. The plan was printed at scale 1:1000 and used as a base map by Sarah Newsome and Rebecca Pullen for a programme of rapid walkover checking and annotation. Any relevant alterations and additional information based on these field notes were then used to tidy and enhance the raw survey data through a systematic editing of the AutoCAD drawing. The final hachured earthwork plan was produced by Phil Sinton of English Heritage's Imaging, Graphics and Survey Team using Adobe Illustrator software, and is presented in full at scale 1:1000 as Appendix 4.

As outlined at the beginning of this report, a numbering system was established to accompany the survey drawing and to provide a way of tying individual descriptions to specific features across a site of such great size and complexity (*see* section 1.1). The number sequence runs consecutively from structure **1** to **284** and includes all identifiable discrete features thought to belong to the factory complex, with 'structure' being used as a non-descriptive umbrella term to refer to each set of features making up the remains of a former building or key feature. For instance, this could be an earthwork traverse around the former position of a hut or the concrete foundation of a building. Use of the term 'structure' in this report is not intended to imply the existence of a superstructure (*see* section 1.1). Numbers have not been assigned to generic features such as tramway embankments, culverts and manholes, or to features identified as having origins either pre- or post-dating the operational period of the explosives works. Linear features and linear alignments of grouped features were also noted in several instances across the factory site, in the form of post arrangements, extensive culverts and alignments of distinctive triangular foundations. The five clearest linear features have each been assigned a number to aid description and identification: linears **L1** to **L5**. In addition, the four wooden jetties connecting the factory to the Thames shipping route have also been labelled for ease of identification: jetties **J1** to **J4** ordered by construction date. To act as a quick reference for location and orientation, the site has also been subdivided into eleven spatial zones named **Areas A** to **K**. Appendix 1 provides a reference table for the structure number sequence, with **Area A** to **K** locations, centre point NGR coordinates and original Curtis's & Harvey numbers detailed where known.

In compliance with English Heritage guidelines (Dickinson 2008), the project archive will be deposited with the English Heritage Archive at The Engine House, Fire Fly Avenue, Swindon, SN2 2GZ, where it will be available for public consultation. Several instances of material culture were noted amongst the general surface debris, but no finds were collected or retained for archive.

10. ABBREVIATIONS USED IN THE TEXT

ACS	Asbestos Cement Sheet
BGS	British Geological Survey
DEFRA	Department for Environment, Food and Rural Affairs
EH	English Heritage
EHA	English Heritage Archive, Swindon
EPPIC	English Heritage Professional Placement in Conservation
ESA	Environmentally Sensitive Area
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HER	Historic Environment Record
HM	His/Her Majesty's
HMSO	His/Her Majesty's Stationery Office
ICI	Imperial Chemical Industries Ltd
KHLC	Kent History and Library Centre, Maidstone, Kent
MALSC	Medway Archives and Local Studies Centre, Strood, Kent
NGR	National Grid Reference
NHLE	National Heritage List for England (nationally designated heritage assets)
NMR	National Monuments Record
NMRC	National Monuments Record Centre, Swindon
OD	Ordnance Datum (height above sea level)
OS	Ordnance Survey
PLA	Port of London Authority
RCZAS	Rapid Coastal Zone Assessment Survey
RGPF	Royal Gunpowder Factory (Waltham Abbey)
RNCF	Royal Naval Cordite Factory (Holton Heath)
rms	Root mean square
SSSI	Site of Special Scientific Interest
TNA	The National Archives, Kew, London
TST	Total Station Theodolite
VRS	Virtual Reference Station

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2K/16764 frames DPI41501-DPI41636	07-MAR-2011	English Heritage, Steve Cole
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