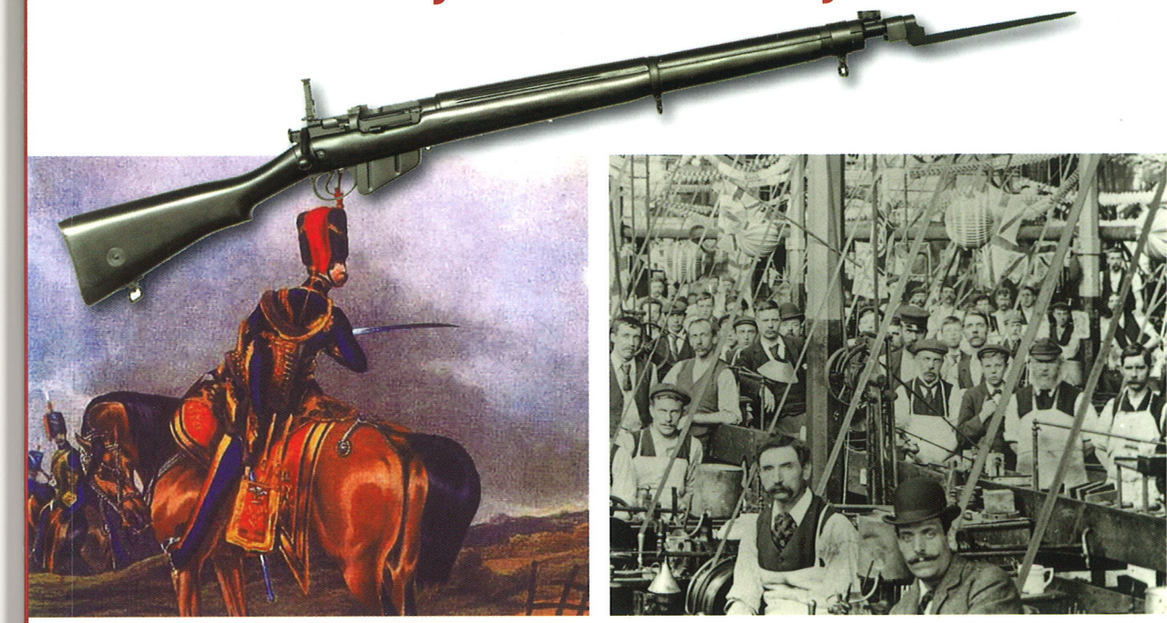
LEA VALLEY series

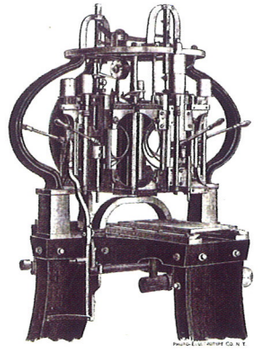
FROM GUNPOWDER TO GUNS

the story of two Lea Valley armouries



Jim Lewis

LEA VALLEY series



Dr Jim Lewis is well known as an authority on the Lea Valley. In *From Gunpowder to Guns* he tells the story of two Lea Valley armouries that were responsible for supplying weapons and explosives to British and Commonwealth forces for over 200 years. It is also the story of historical government failings that have an echo in events surrounding some of today's major military conflicts. The author reveals, for the first time, how the lack of understanding in the design, development and manufacture of weapons by high-ranking Government officials placed the British armed forces in considerable danger during the Crimean War.

From Gunpowder to Guns describes how the Royal Small Arms Factory, at Enfield Lock, became the first in Britain to manufacture weapons with interchangeable parts, with machine tools purchased from America. The extraordinary story of the growth of the Royal Gunpowder Mills at Waltham Abbey starts with basic explosives and continues through to Barnes Wallis's bouncing bomb, the development of rocket propellants, the exploration of space and the spin-off of modern materials used in everyday objects.

Other titles in the series:

Water and Waste – four hundred years of health improvements in the Lea Valley
Battleships, Buses and Bombers – a history of transport in the Lea Valley

Forthcoming titles (Autumn 2009):

Industry and Innovation – the technological revolution in the Lea Valley
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To Michael,
Hope you enjoy the book,

FROM GUNPOWDER TO GUNS

the story of two Lea Valley armouries

Jim Lewis

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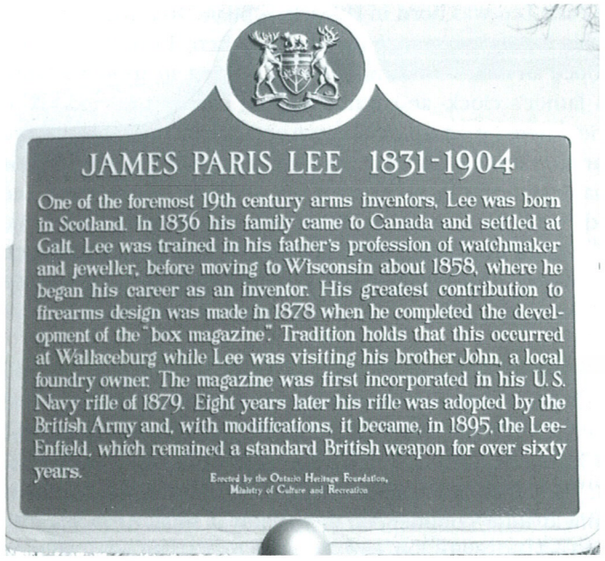

A plaque erected by the Ontario Heritage Foundation, close to the site of the John Lee foundry in Queen Elizabeth Municipal Park, on the north side of the Sydenham River, to commemorate the claim that James Paris Lee fired the first shot from his prototype rifle, in 1879, into an oak plank on the opposite bank.

Amazingly, the later Mk. 4 version of the Lee-Enfield can still be seen in use around the world today. This is not only a lasting tribute to Lee, but it is an acknowledgement of the engineering skills of the Lea Valley workforce who, over the years, produced this weapon in vast quantities.

REFERENCES

House of Lords Record Office, London, subject: "The Trials of nine descriptions of Breech-loading Rifles accepted for competition in accordance with the terms of the War Office Advertisement of 22/10/66", reference, Reports Commissioners 1886-68, XVI, pp.32-4.

Lewis, James H., "The Development of the Royal Small Arms Factory (Enfield Lock) and its Influence Upon Mass Production Technology and Product Design c.1820-c.1880", unpublished PhD thesis, Middlesex University, December 1996.

Skennerton, Ian D., *The Lee Enfield Story*, published by Ian D. Skennerton, Australia, 1993,

Note 1

The Enfield Pattern 1853 rifle was the first weapon in Britain to be made under the mass-production system using interchangeable parts.

Note 2

By 1856 the War Office was responsible for weapon procurement for the armed forces. Formerly this role had been performed by the Board of Ordnance.




5. OVER TWO HUNDRED YEARS OF INNOVATION AT WALTHAM ABBEY

It is probably fair to say that most people do not generally know how the workforce of one small Essex country town helped to change the way our lives are lived today. Without the ongoing research and technical developments that were carried out at what was to become the Royal Gunpowder Mills, and later the Royal Armament Research and Development Establishment (RARDE), our lives might have turned out very differently.

In the twelfth century the town's Abbey was governed by the rules of the Augustinian Order and it is thought that it was the monks who first set up a fulling mill within its precincts, used for the preparation of cloth, and a corn mill, for grinding flour, on channels dug to bring water from the River Lea. Therefore, if this is true, it could be claimed that the monks had inadvertently created the facilities that allowed the later explosives industry to become established at Waltham Abbey, an industry that lasted for over three-hundred years.

About the year 1665 Samuel and Ralph Hudson acquired the mills and converted them for the manufacture of gunpowder. A title deed of 1669 refers to the existence of two powder mills and outhouses for "grindinge, boylinge, corninge and dryinge of powder". By the beginning of the eighteenth century the mills were under the control of the Walton family.

To improve the efficiency of the production process, the celebrated engineer John Smeaton was engaged by William Walton to design new water-powered edge-runner incorporating mills. These were to replace the rather dangerous stamp mills that were operated by a line of workmen, who each had to repeatedly bring down a heavy beam of timber into a bowl of potentially explosive mixture. The job of the workmen was to operate each individual stamp mill until it was judged that the ingredients were suitably crushed and incorporated. Edge-runner, as the name implies, refers to the orientation of the two grindstones that are vertically mounted as opposed to the horizontal mounted stones that are found in corn and other early mills.

Sadly, William Walton did not see all the fruits of his investment in the gunpowder business, as he died intestate in 1711. Philippa, his 35-year-old widow, took over the mills and successfully ran them despite having the added responsibility of caring for her family of ten children.

The Board of Ordnance, a department of government, was the major purchaser of gunpowder for both the Army and Navy. As the eighteenth century progressed, Britain, with her extended empire and deteriorating international relations, needed control of the supply of gunpowder for her armed forces. As demand increased in time of conflict there were further problems in obtaining consistently good-quality powder from the many private manufacturers. A solution to the problems came about when the government purchased the mills at Faversham, Kent in 1759 and, in 1787, those at Waltham Abbey, which were bought from John Walton, the great grandson of Philippa Walton. Philippa had died in 1749 at the age of 74, 38-years after taking over the mills from her late husband.

The man who had been appointed to purchase the mills on behalf of the government was the Deputy Comptroller of the Royal Laboratory at Woolwich, Major, later Lt. General, Sir William Congreve. The sum agreed was £10,000. Congreve was placed in charge of the mills and spent a further £35,000 on buildings and improvements. With Congreve at the helm, Waltham Abbey was about to become a centre of excellence and innovation that would reach forward almost to the millennium. His first task was to set down strict rules for working safely and also for producing powder of uniform quality. This he did by engaging the best of Walton's workmen and also by ensuring that an interchange of knowledge and procedures took place between Waltham Abbey and Faversham.

It was not until 1789, after all the new processes and procedures were

Lt. General Sir William Congreve (1741–1814) was appointed to purchase the mills at Waltham Abbey on behalf of the British government. In 1787 Congreve bought the mills from John Walton for £10,000.

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Major General Sir William Congreve (1772–1828) who, in 1814, succeeded his father and was responsible for continuing the modernisation and expansion of Waltham Abbey gunpowder mills. Congreve is probably better known for improving the gunpowder rocket.

firmly in place, that Waltham Abbey produced its first quality powder. To prove the superiority of his powder Congreve set up a trial on Marlborough Downs where ten-inch shells were fired by nine-pound lots of gunpowder taken from different manufacturers, including six in the private sector. The Waltham Abbey powder propelled Congreve's shells over five-hundred yards further than all the others except one (which still fell one hundred and sixty yards short of his greater range of 4,430 yards).

In 1814 Sir William Congreve was succeeded by his son, also William, as second Baronet and Comptroller of the Royal Laboratory at Woolwich. Young William was also given responsibility for the supervision of all the government gunpowder factories – Ballincollig in County Cork had become number three when it was acquired in 1804. William was a talented inventor who had received his technical education at the Royal Academy at Woolwich. In 1791 he was attached to the Royal Laboratory where his father was Comptroller and it was probably these connections that allowed William to carry on in his father's footsteps and continue the programme of expansion and innovation at Waltham Abbey. One of his early improvements came in 1815 when he patented (No. 3937) a superior type of machine to granulate powder once it had been pressed. Some years after it was introduced into production it was reported that the operation of the machine could not be bettered during the period that gunpowder manufacture lasted.

A live firing by the Rocket Troop of the 95th (Rifle) Regiment of Foot of Congreve gunpowder rockets during a re-enactment at the Royal Gunpowder Mills in July 2007.

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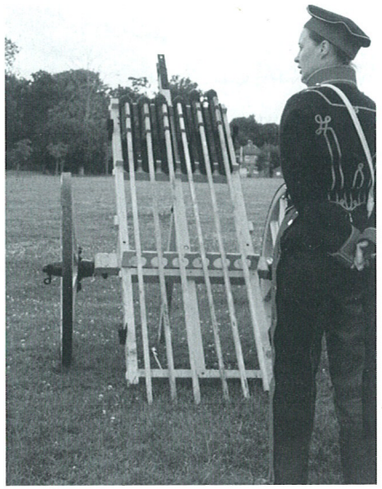
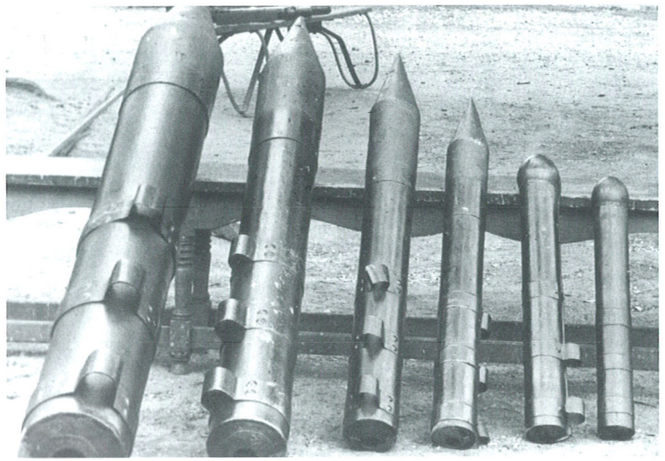
One of William's most memorable inventions was the improved gunpowder rocket. A crude form of the missile had been used against British troops in India during the late eighteenth century. By the early nineteenth century Congreve, through his experiments, had doubled the range of the rocket to around two-thousand yards and he later set up a factory to manufacture them on West Ham Marsh, adjacent to the River Lea at Bromley-by-Bow. As would be expected, he obtained all his powder for rocket production from the Royal Gunpowder Mills at Waltham Abbey.



Rocket Troop member standing next to Congreve rockets ready for firing. The largest Congreve rocket ever manufactured weighed 32 pounds; the head measured three feet and required a stabilising stick of 15 feet (4.57 metres).

Although not always accurate, sometimes due to the strength and direction of the prevailing wind, the rockets were used with some effect during the Napoleonic campaign at Boulogne, Copenhagen, Leipzig and Waterloo. When such new weapons were introduced to the theatre of war there were reports that their noise, glare and incendiary power caused panic amongst the enemy. Interestingly, Congreve's rockets are famously recorded in the United States national anthem in the verse "the rocket's red glare, the bombs bursting in air". This refers to the conflict with America between June 1812 and December 1814 when the rockets were employed in the bombardment of Fort McHenry.

By the middle of the nineteenth century there was a growing need for an explosive more powerful than gunpowder, as the size of guns increased, through advancements in manufacturing machinery and engineering technology. These improvements in artillery caused



A range of William Congreve's gunpowder rockets.

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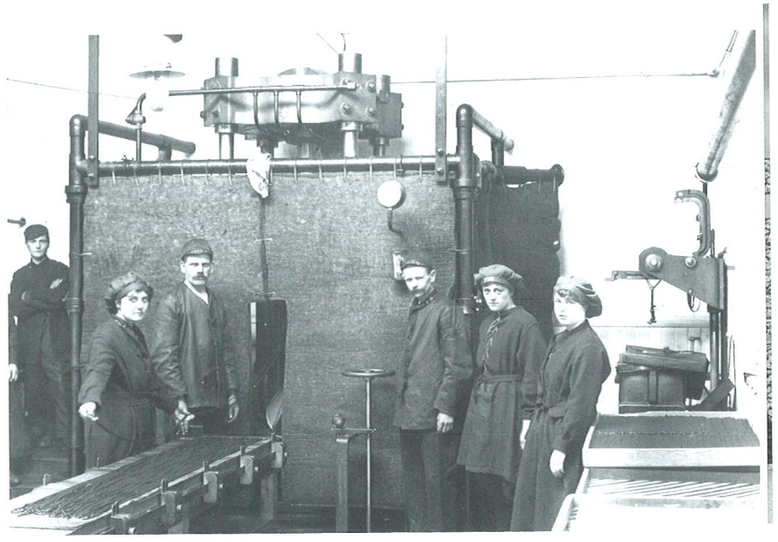
Sir Frederick Abel (1827–1902) KCB, FRS, was the War Office Chief Chemist. He was responsible for developing the explosive Cordite, which was manufactured in large quantities at Waltham Abbey.

the demise of Congreve's rocket for battlefield purposes but they were adapted as flares (the parachute flare was a Congreve invention) and they were also used for firing safety lines to ships in distress during rescues at sea.

On the Continent, gun cotton (a mixture of nitrating acids on raw cotton) was emerging as the new powerful explosive. Production however was slow and hazardous. In 1863, Sir Frederick Abel, the War Office Chief Chemist set up an experimental plant at Waltham Abbey to test his ideas regarding the safe production of gun cotton. His experiments were successful and the end product proved stable, which gave the ability to manufacture large quantities of the material. Perhaps the greatest compliment to Abel was that his process was widely copied and the product was welcomed not only by the military but also by civil engineers who used it for blasting in quarries and mines.

In 1847 the Italian chemist Ascinao Sobrero, working under T.J. Pelouze at the University of Torino discovered Nitroglycerine, a highly volatile liquid explosive formed by the combination of glycerol and nitric and sulphuric acids. In 1867 the Swedish chemist, Alfred Nobel was able to combine Nitroglycerine with absorbent clay and his invention became Dynamite. In 1890 Sir



Process workers at the Royal Gunpowder Mills in front of a Cordite press. The woman to the left of the picture is holding a length of Cordite, a so-called smokeless explosive. Women workers were taken on at the factory for the first time during the Great War.

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Frederick Abel's Explosives Committee, which included the talented chemist Sir James Dewar, devised a new propellant by adding nitrating acids to glycerine and combining the mixture with gun cotton and mineral jelly to form what became known as Cordite. Abel and Dewar patented the invention on behalf of the British government. Apart from devising an explosive that was more stable than some of the earlier materials, it could now be manufactured in long cords by extrusion from a hydraulic press, hence the name Cordite.

Colonel Sir Frederic Nathan (1861–1933), Superintendent of the Royal Gunpowder Mills, Waltham Abbey, 1900–1909.

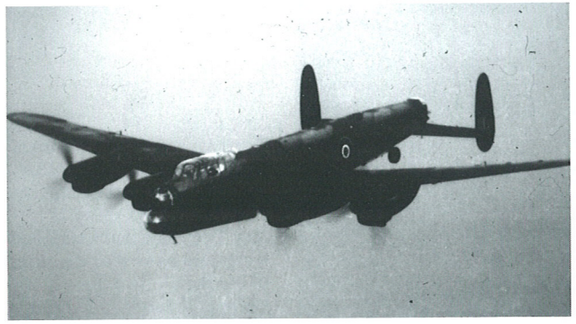
In the early twentieth century, under the Directorship of Colonel Sir Frederic Nathan, Waltham Abbey saw many improvements in the production of Cordite and gun cotton. Nathan also introduced improvements that were designed to increase efficiency and save money. One of these was a new recovery process for acetone, a solvent used in the manufacture of Cordite. The nitration plant was redesigned for the production of Nitroglycerine and he also introduced new plant for the booster explosive, Tetryl. The improvements and expansion at Waltham Abbey, the only government factory at the time, were, to say the least, opportune, as they allowed large quantities of explosives to be manufactured for the Allies during the First World War.

Apart from the sad human losses and carnage created by war, there is always another inevitable outcome: a rapid increase in technological change brought about as one side strives to gain a major advantage over the other. The First World War saw, for the first time, the coming together of two relatively new technologies, that of the aeroplane and the wireless. The Second World War was to prove no exception to this rule. As each of the belligerents fought for technical supremacy pushing forward the developments in radar, jet engines and explosives at an accelerated rate, an unusual twist to the story took place. The rocket as a weapon of war came back onto the agenda, not quite in the Congreve format as used against military targets, but in the shape of the V2 rocket programme, this time in a more powerful form to be used against a civilian population. Ironically the development was now by German scientists who were leading the world in this secret research.

Sir Barnes Wallis (1887–1979) CBE, FRS, RDI, inventor of the "bouncing bomb" used in the famous raid by the Dambusters (617 Squadron).

As the war continued, the attention of the Allies turned to the vast German manufacturing capability, particularly in the area of the Ruhr Valley that was keeping their military supplied. In Britain, a bold plan was hatched to destroy the Ruhr industries by destroying their source of power. The idea was to breach the three major dams Mohne, Sorpe and Eder to flood the area, which would also deny manufacturers the use of valuable water and reduce the production of electricity. The British inventor Barnes Wallis, then working for Vickers-Armstrong at Brooklands, Surrey, came up with the idea of a bouncing bomb, which he calculated would cause a breach in a dam if dropped at a precise height and distance from a dam wall by an aircraft travelling at the correct speed.

An Avro Lancaster of 617 Squadron that has been specially adapted to deliver the "bouncing bomb" invented by Barnes Wallis.



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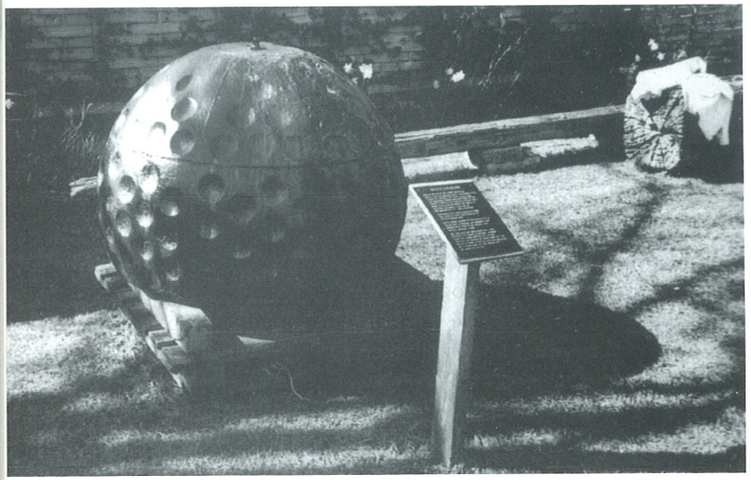

An early version of Barnes Wallis's "bouncing bomb", round in shape and dimpled like a golf ball.

The first experiments used sphere-shaped bombs dimpled like golf balls but eventually a shape similar to that of a large oil drum was most successful. To ensure a maximum breach, Wallis realised that the bomb would have to sink below the water to a required depth when it met the dam wall, after bouncing across the surface of the reservoir and thus also avoiding the German torpedo nets (the nets had been placed a little distance in front of the wall to prevent underwater missile attacks). Using electric motors to apply backward spin to the bomb before it left the aircraft solved the problem. On the night of 16th–17th May 1943, nineteen specially adapted Avro Lancaster bombers of 617 Squadron, later to become known as the Dambusters, set out from RAF Scampton in Lincolnshire and, despite heavy losses of aircrew and aircraft, achieved their objective.

The final shape of the Barnes Wallis "bouncing bomb" that was dropped on the dams in Germany's Ruhr Valley in May 1943. The dams supplied water and were also a source of electrical power for German industry.

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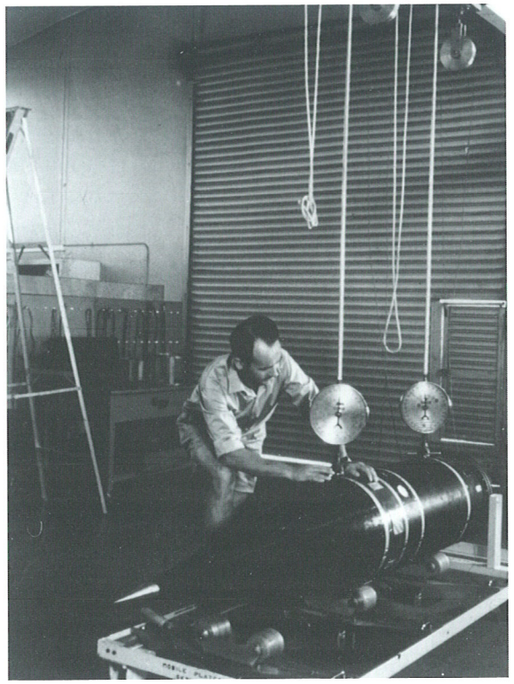
Interestingly the explosive material, a mixture of TNT (Trinitrotoluene) and aluminium, used in each of the bouncing bombs was known as RDX (Research Department composition X). The material's discovery began in Germany in 1899 and was further developed by the German scientist Hertz in the early1920s. After initial investigation of the explosive at Woolwich, new production facilities were set up at Waltham Abbey and manufacture began in early 1939. So in a somewhat ironic way the work that had begun in Britain with Congreve's gunpowder rocket had been taken over and developed beyond recognition in Germany and then used against the British; while the German developed RDX explosive had been manufactured in Britain and used against the enemy in the Dambusters raid.

On 28th July 1945 the Royal Gunpowder Mills closed and on 30th July it reopened as an experimental wing of the government Armament Research Department. This was a major change in status for Waltham Abbey as the site moved from what was effectively a manufacturing facility to one that would become a world leader in experimental science, not just in explosives, but in advanced chemical engineering and rocket propellants. Much of this work was carried out on the facilities that had been established on the south side of Waltham Abbey and known to the workforce as the south site (the original gunpowder mill complex was known as the north site). To achieve the new objectives, graduate engineers, scientists and chemists were recruited and they soon became established as a highly regarded scientific development team. By October 1946, Waltham Abbey had become the Chemical Research and Development Department and would play a major role in designing and experimenting with a range of new materials that would, in the longer term, have a considerable spin-off for not just the military, but also for industrial and domestic markets.

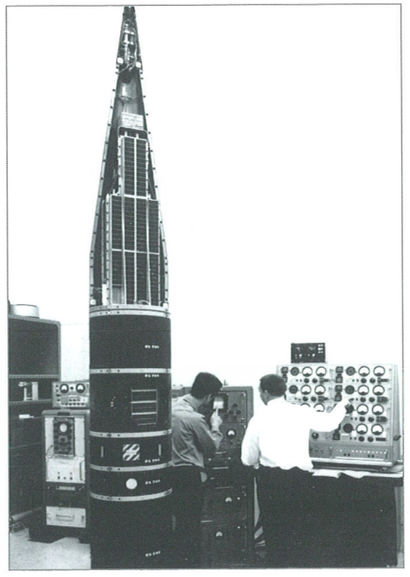
The wartime rocket attacks on Britain and the development of fighter aircraft equipped with jet engines meant that methods of warfare and defence would never be the same again and strategies would have to change dramatically. It was no coincidence that Waltham Abbey was now placed at the forefront of the new emerging technological challenge. For most people this was an anxious period when the world held its breath as it entered a sensitive and critical phase in history. A phase that would become known as the Cold War, which in turn was to provoke an arms race between East and West.

As the Western world's relations with the East became increasingly strained, the emerging technology of the rocket, as a new form of

A Skylark rocket on its launcher. Considerable development of the rocket and its propellant took place at Waltham Abbey, which culminated in the first successful launch from Woomera, Australia in February 1957.



An engineer of the Space Physics Group, Leicester University, preparing the Skylark payload.



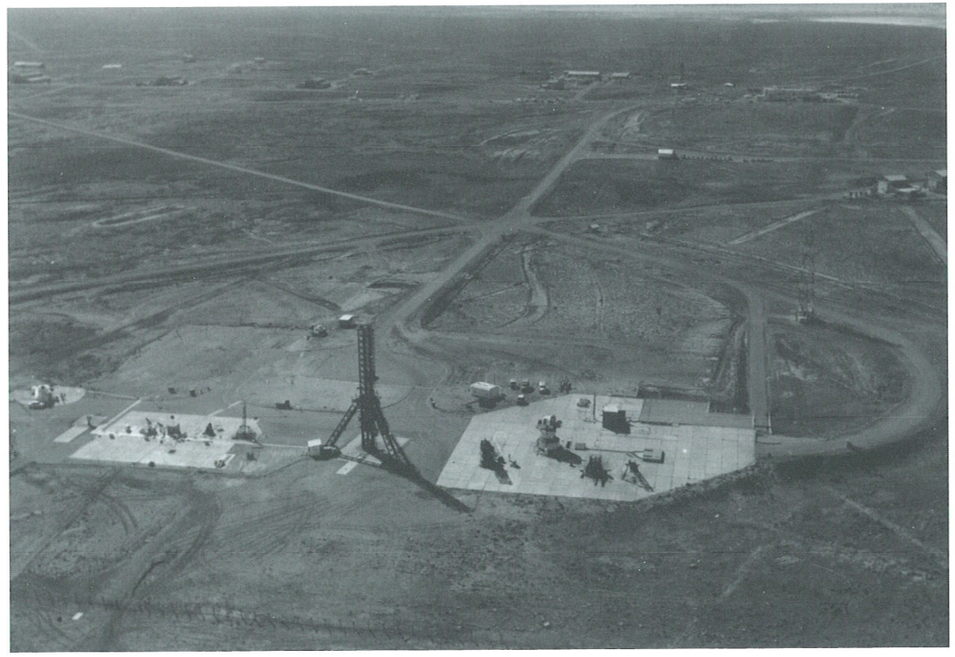
Engineers of the Space Physics Group checking a Skylark rocket in the laboratory at Leicester University circa 1967.

A recovered instrument section of a Skylark rocket from the Australian desert.

defence and attack, was being developed by both camps. Interestingly these developments were being ably assisted by scientists who were either taken or had gone voluntarily to countries like Britain, the U.S.S.R. and America and had previously worked within the German V2 missile programme. The push for technological supremacy seemed to begin in earnest with the successful launch, in October 1957, of Sputnik by the Soviet Union, the first artificial satellite to orbit the Earth. This was followed a month later, again by the Soviets, when a live dog was carried into orbit. Naturally, much publicity was given to these events and almost four months later America was forced to respond with the launch of Explorer One, its first satellite. It is probably fair to say that what has become known as the 'Space Race' had begun in earnest.

Range 'E' at Woomera, Australia. In the foreground can be seen the Skylark launcher and test shops. Lake Koolymilka is in the background.

In the meantime at government establishments in Britain like Farnborough in Hampshire, Wescott in Buckinghamshire and Waltham Abbey in Essex, things had not stood still. Although not as dramatic as the Soviet and American satellite launches, Waltham



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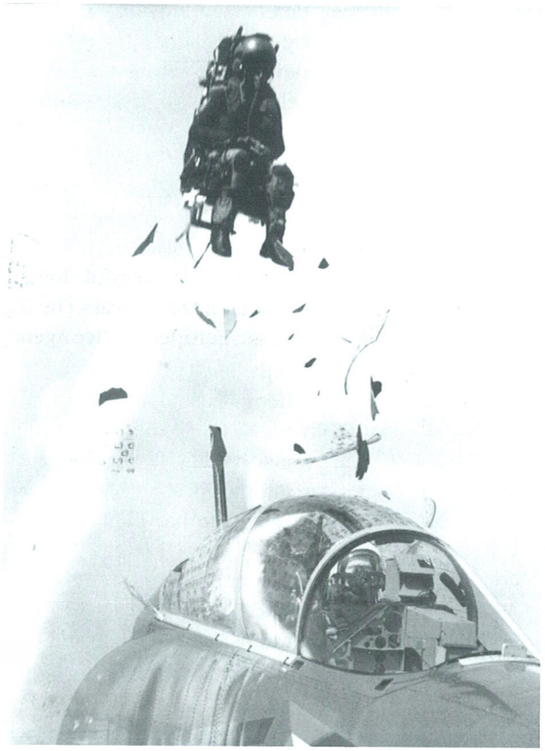

Ejecting from a jet aircraft cockpit. The ejector seats manufactured by the Martin Baker Company, using propellants developed at Waltham Abbey, have saved the lives of countless airmen.

Abbey scientists, along with their sister establishments had quietly developed the Skylark rocket that was first successfully launched from the rocket range at Woomera, Australia in February 1957. The Skylark had been designed to carry out a range of scientific experiments in the upper atmosphere to understand the significance of such phenomena as ultraviolet, X-ray, gamma and infrared radiation. A greater knowledge of these subjects helped pave the way for the exploration of space.

The power cartridges used for the Sky Flash missile launcher on the Tornado aircraft were developed at PERME, Waltham Abbey.

As technological requirements of the military changed, work on liquid rocket propellants transferred to the Rocket Propulsion Establishment (RPE) at Wescott, and Waltham Abbey began work on new composite propellants and materials, which included those for safely blasting ejector seats from aircraft. In 1973 Waltham Abbey and Wescott were merged, followed, in 1977, with further structural changes, as Waltham Abbey became the Propellants, Explosives and Rocket Motor

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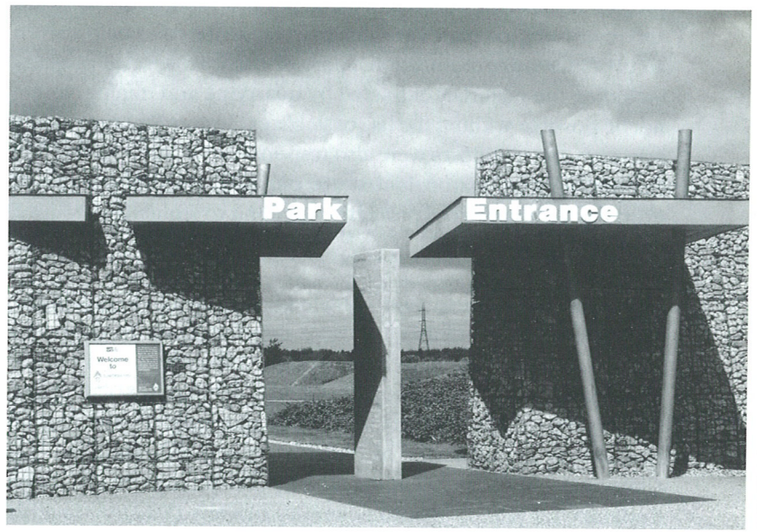
Establishment (PERME). This new set-up continued until 1984 when the government decided to privatise the Royal Ordnance factories and Waltham Abbey became divided between the old north site and the south site then became Royal Ordnance plc.

Although the government stopped funding the Skylark programme in 1977, believing that the American Space Shuttle would carry out future research, there was still a future for the project. Skylark was taken over by British Aerospace and later by Matra Marconi Space and became one of the most successful long-term rocket programmes in history, lasting almost fifty years. The final launch, its 441st, under the auspices of the European Space Agency, took place from Sweden in May 2005.

Waltham Abbey was also at the forefront of other research developing a range of propellants for ship-to-air missiles and those used in the mine-clearance system 'Giant Viper', successfully employed in Campaign Desert Storm during the Gulf War. Another highly secret area of research was the investigation of 'Whiskers' technology. This resulted in the development of new fibre-enhanced metals of exceptional strength and durability that are now used extensively by the aerospace and other industries.

In 1991, the Waltham Abbey north site, owned by the Ministry of Defence (MOD), was decommissioned. The south site, as previously mentioned, had already been privatised in 1984. Visitors to the Lee Valley Park today can now enjoy a picnic or a leisurely stroll across



Developed by the Lee Valley Regional Park Authority, the new Country Park, the Gunpowder Park, occupies what was once the "south site" of the Waltham Abbey Royal Gunpowder Mills.

the ground that once formed part of the south site and is now named Gunpowder Park, a new country park.

The attractive entrance to the Royal Gunpowder Mills Visitor Exhibition Centre and the "Ignite your Imagination" theatre built on the former "north site" at Waltham Abbey.

After a massive decontamination and rebuilding programme, the Waltham Abbey Gunpowder Mills (the north site) reopened as a visitor attraction in May 2001. The Mills still retain much of their unique dual-level canal system that was once used to transport dangerous materials around the site. Also onsite there are in excess of 300 different structures of which English Heritage have listed over 20.

It should not be forgotten that the success of the Skylark and the many other research programmes was the result of investigations carried out by that early team of talented scientists and engineers at Waltham Abbey and her sister establishments. The peacetime developments and products that came from these early experiments have changed the way we live our lives today. Imagine a world where we could not undertake major civil-engineering projects such as the building of roads, bridges, tunnels, canals, docks and reservoirs, to create the infrastructure required to help sustain an ever-increasing population. Some of these large-scale projects, including the materials extracted by quarrying and mining, would not be possible without the use of stable explosives. Waltham Abbey scientists and engineers were also responsible for investigating and developing new materials that are currently used in a range of everyday products from protective clothing to some that are used in medical procedures.

Visitors to the site can gain knowledge and also experience the significance of a number of these developments through the various displays that have been designed to inform and excite. These are housed in the recently created exhibition building and also in some of the other restored buildings around the site. Visitors can also enjoy, either by walking at leisure or riding on the Gunpowder Mill's land train, the seventy-one hectares that has been designated a Site of Special Scientific Interest (SSSI) by English Nature, with the largest heronry in Essex and some of the largest flocks of siskin (a small yellow-green bird not too dissimilar to a greenfinch) in the UK. There is also the opportunity for the visitors to explore and discover for themselves the profusion of wildlife that lives within the thickly wooded areas where at least two species of deer roam free. Afterwards, perhaps over a cup of tea and a scone in the onsite café, the visitor might like to ponder the question, how did the manufacture and development of a range of explosive materials create such a natural haven for so much wildlife?

REFERENCES

Author unknown, "Explosives – OHMS Bicentenary", booklet to commemorate 200 years (1787–1987) of Government ownership of the Royal Gunpowder Mills (Waltham Abbey).

Congreve, William, *The Details of the Rocket System*, London, 1814.

Cooper, Roger, *Rocket Man*, Navtech Systems Limited, Sulby, 2006.

Knapp, Trevor, (Chairman of the Royal Gunpowder Mills Trustees), Interview July 2007.

Lewis, Jim, "The Lea Valley and Britain's Forgotten Greatness", *Electrotechnology*, December 1997/January 1998.

National Archive, Kew: WO1/1120, WO1/1123.

Page, William (ed.), *The Victoria History of the County of Essex*, Vol. 2.

Note 1

The Royal Gunpowder Mills is open as an attraction between April and September and potential visitors should either telephone (01992 707370) or check the website www.royalgunpowdermills.com for further details.

Note 2

Skylark and other rockets like Skura and Petrel were called Sounding Rockets as they 'sounded' the upper atmosphere rather like the term sounding the ocean's depths.

Note 3

The author should like to take the opportunity to thank Roger Cooper of Navtech Systems Limited for generously providing photographs and also for giving advice regarding the Skylark programme. Roger was Senior Experimental Officer with the University of Leicester Space Research Group, and while working as a "Rocket Man" for fifteen years was attached to the British National Space Programme.



6. FROM GUNPOWDER TO TOURISM – THE PEACEFUL EXPLOSION

The Royal Gunpowder Mills at Waltham Abbey, which occupy some 190 acres towards the northern end of the Lea Valley, were in continuous government use from 1787 to 1991. Before this, gunpowder had been produced on the site by the Walton family and before them by the Hudsons. Until steam was introduced in the 1850s, water from the River Lea powered the machinery and charged the site's dual-level canal system. In the twentieth century, the development and manufacture of a range of chemical propellants and explosives, particularly Tetryl and RDX (used in the "Dambusters" raid) helped the Allied Forces win two world wars. The site, now decommissioned, contains over 300 structures, over 20 of which are listed.

The experimental, development and production work carried out at Waltham Abbey has, over the centuries, provided employment and brought economic and social prosperity to the area. Neither was this work for entirely military purposes. The peaceful use of explosives in civil engineering has speeded the construction of roads, bridges, railways, canals and harbours and made the extraction of essential raw materials considerably easier in the mining and quarrying industries. Due to the quality of Waltham Abbey's products, which were recognised internationally, new export markets were opened up to Britain.

J. Farmer's engraving (1735) of John Walton's Gunpowder Mills at Waltham Abbey, Essex.

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In the centre of the picture is a gunpowder barge resting in a dried-up canal. On the right is a protective blast wall. Picture taken autumn 1996.

With the closure of the Mills, economic hardship came to the locality. The question then had to be addressed as to whether any commercial alternatives could be put in place. Solutions to such problems often depend upon a site's particular heritage and accessibility to transport. If a stricken industry or place of manufacture has an interesting historic past, then there is the possibility of developing a long-term strategy based on aspects of that heritage.

Waltham Abbey for many reasons is truly a jewel in the tourism and heritage crown, the site being recognised by English Heritage as "the most important to the history of explosives manufacture in Europe". While the Royal Commission on the Historical Monuments of England (RCHME) has written that the Gunpowder Mills are "the most complex industrial site yet surveyed by the commission". There are also at least thirty-eight A4 pages of references to individual historical documents on the Waltham Abbey Mills located at the National Archive, Kew. As those who seriously study history will know, such a wealth of quality documented evidence is extremely rare.

Because the site had remained in government hands for so long (over two hundred years) and because of the highly secret nature of the work, the place took on the mantle of a forbidden

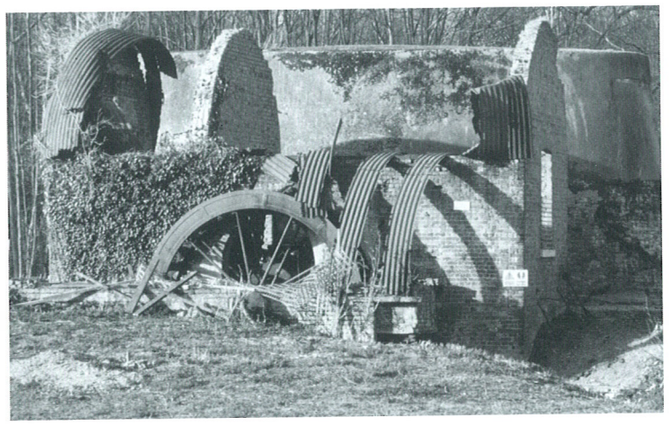
Powder barges on the dual-level canal system at the Royal Gunpowder Mills at Waltham Abbey. These barges were used for transporting explosive material around the site and not for shipping gunpowder, via the River Lea, to the powder magazines located along the River Thames and elsewhere.

wai-0102-05 wasc-0459-05

Archaeologists recording details of a powder barge during excavation work at the Royal Gunpowder Mills at Waltham Abbey, circa 1996.

city. External contractors for repair and maintenance were seldom used, the work being carried out internally by a highly skilled workforce who had to comply with the rigours of the Official Secrets Act. These were major factors in the conservation of the site which have clearly helped to guard the integrity of the artefacts.

When a particular source of power for the site's machinery became obsolete, or outlived its useful life, it was replaced with the latest technology. The abandoned technology was then discarded and allowed to fall slowly into a state of decay. This has provided a unique opportunity to trace, study and record the technological changes to the energy sources which drove the various pieces of processing plant, from water through steam to electricity. Apart



Remains of mid-nineteenth-century water-powered gunpowder press house on the site of the Royal Gunpowder Mills, Waltham Abbey, Essex.

from the obvious educational and academic benefits to be derived from such work, much can be learned from studying the past and making comparisons with evolving present-day industrial and technological developments. By a careful analysis of the results, it is often possible to learn important lessons, thus avoiding the repetition of costly mistakes.

The northern end of the Gunpowder Mills site has been designated a Site of Special Scientific Interest (SSSI) by English Nature. Planted in the seventeenth century with alder trees to provide charcoal for the production of gunpowder, the wood now supports the largest heronry in Essex and one of the biggest flocks of siskin (a small yellow-green bird, not unlike the greenfinch) in the UK. In seclusion, and protected by the dense vegetation, live a variety of mammals such as deer, foxes and otters. Here, by man's deliberate interference with nature, we have been accidentally provided with a priceless environmental asset over two hundred years later which as tourists we can all enjoy.

After an extensive programme of decontamination, with the cost of £16 million being met by the Ministry of Defence, a Charitable Trust has been formed to own, conserve and manage the Gunpowder Mills for the benefit of the public. A further role for the Trust is to formulate a strategy for the creation of a large visitor attraction. This will be done by exploiting the site's heritage through the promotion of a plan which will interpret the various processes used in the manufacture of gunpowder. This initiative is well under way, boosted by a grant (in 1997) of £6.5 million from the Heritage

Listed incorporating mills at the Royal Gunpowder Mills, Waltham Abbey, Essex. Picture taken in autumn 1996.

Bridge over a section of the dual-level canal system at the Royal Gunpowder Mills, Waltham Abbey, Essex, with barge quay on the left.

Lottery Fund. Since the opening of the site to the public, several new displays have been set up within the listed buildings including one on small arms and also a firework exhibition. During the summer months several events take place, including themed weekends and re-enactments by specialist groups. These have become increasingly popular as family outings.

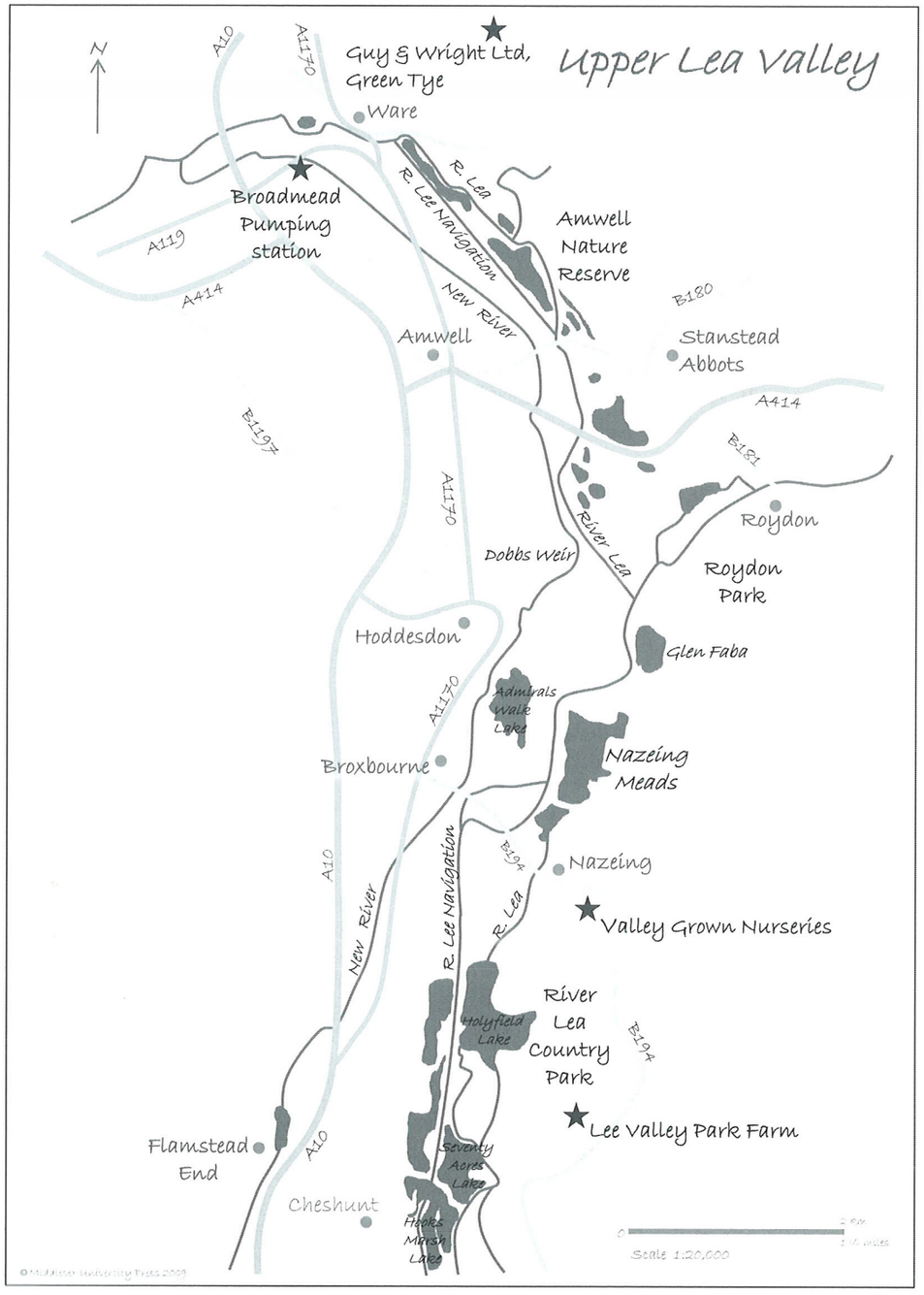
While the change of emphasis from manufacturing to tourism will not necessarily bring instant economic benefit for the region, there is the hope that in the longer term the sensitive restoration of many

treasured sites within the Lea Valley will create a focus of attention which will encourage new job-creating industries back to the area. After all, we have the model of Ironbridge Gorge and Coalbrookdale, where the unique industrial heritage of the region helped secure considerable manufacturing investment, particularly from abroad, in the nearby town of Telford.

REFERENCES

Bone, Daniel, "The Royal Gunpowder Mills", publicity brochure, Civix, London, September 1992.

Lewis, Jim, "The Lea Valley and Britain's Forgotten Greatness", *Electrotechnology*, December 1977/January 1978.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R. Lee Navigation
Broadmead Pumping station
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A414
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New River
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Amwell
Stanstead Abbots
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B1197
A1170
B181
River Lea
Roydon
Dobbs Weir
Roydon Park
Hoddesdon
Glen Faba
A1170
Admirals Walk Lake
Broxbourne
Nazeing Meads
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New River
R. Lee Navigation
R. Lea
Valley Grown Nurseries
River Lea Country Park
Holyfield Lake
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Lee Valley Park Farm
Flamstead End
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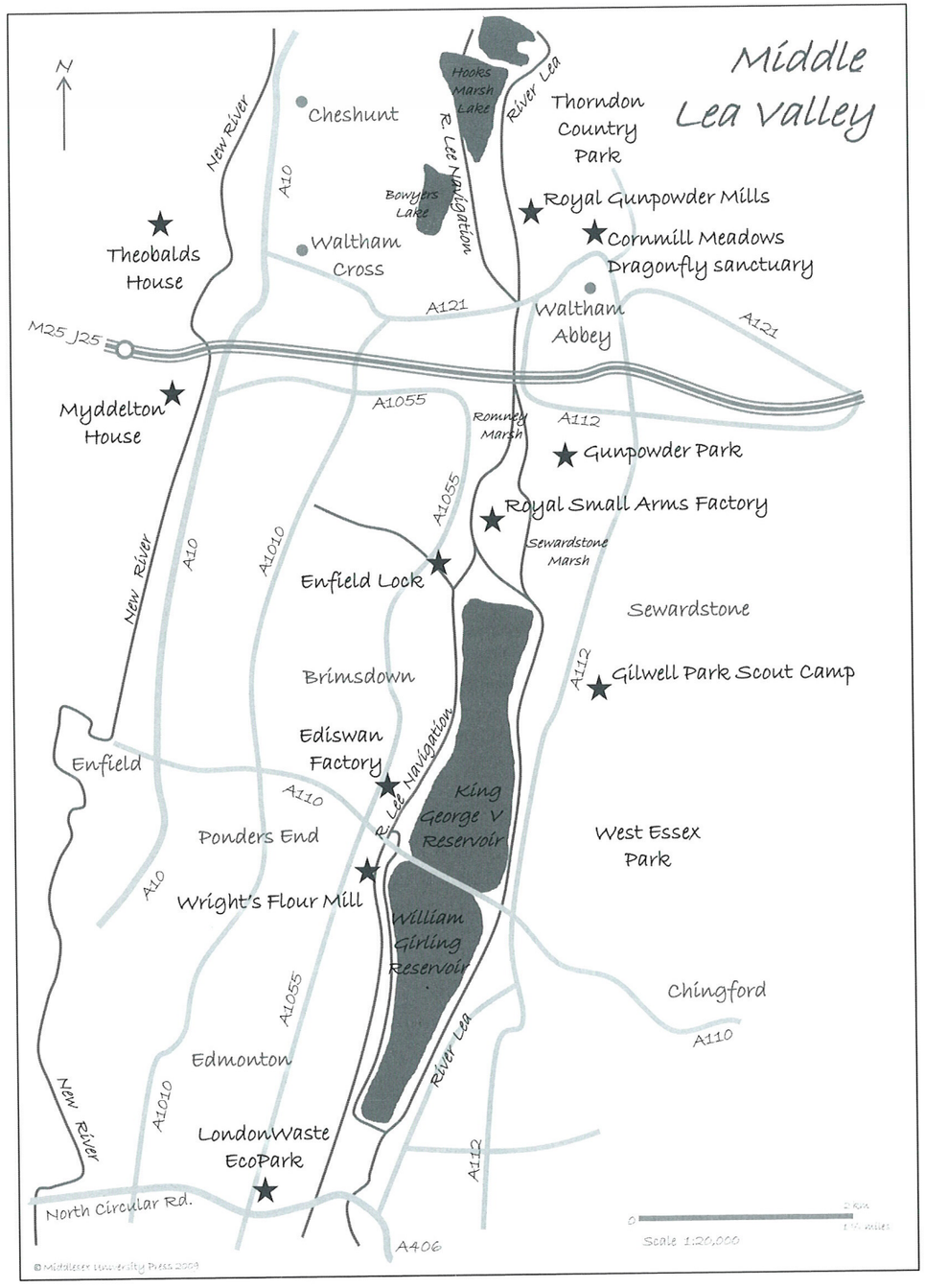
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Bowyers Lake
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Cornmill Meadows Dragonfly sanctuary
Theobalds House
Waltham Cross
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Waltham Abbey
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Myddelton House
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Romney Marsh
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Gunpowder Park
Royal Small Arms Factory
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Gilwell Park Scout Camp
Ediswan Factory
Lee Navigation
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King George V Reservoir
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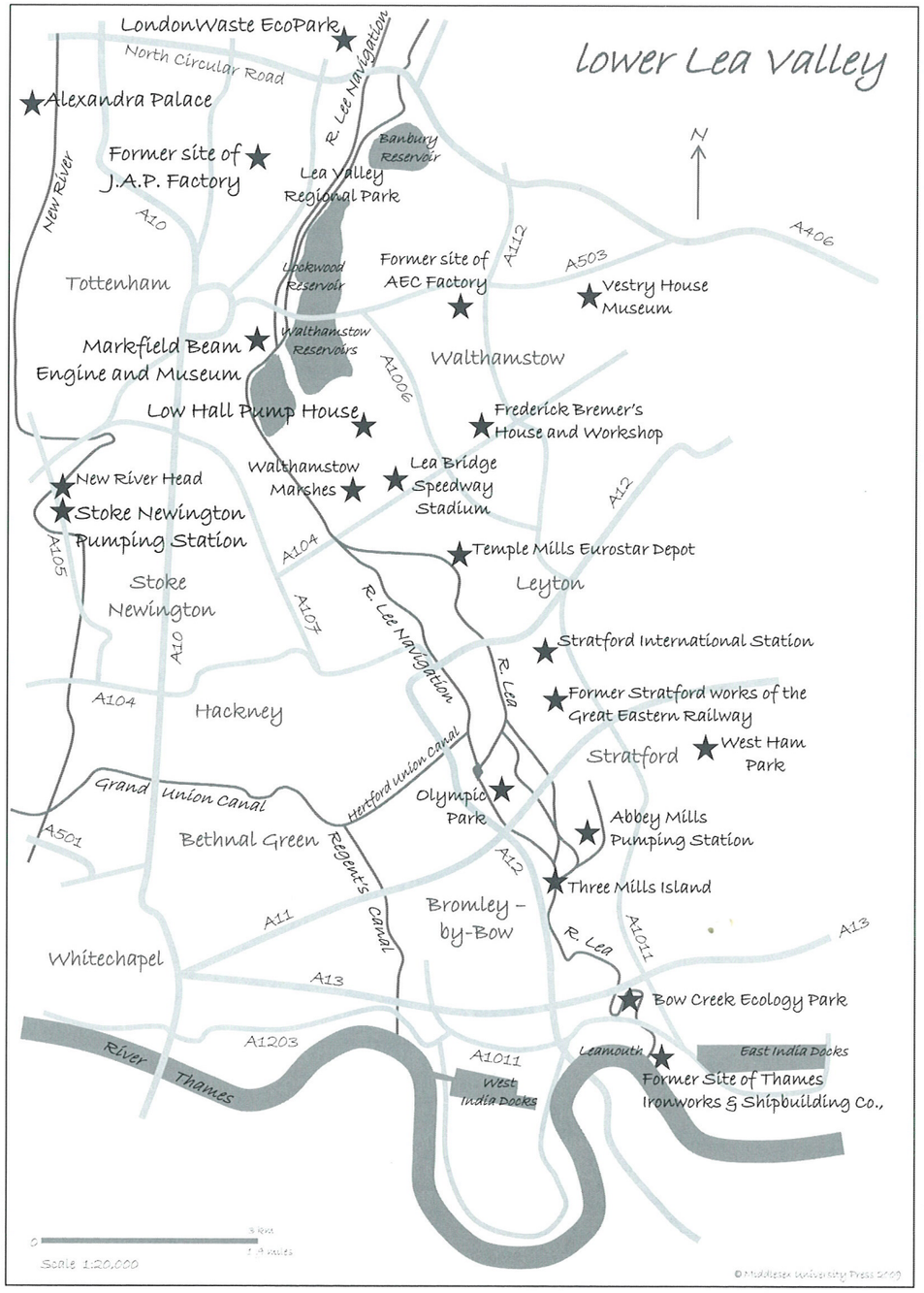
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Banbury Reservoir
Lea Valley Regional Park
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Tottenham
Lockwood Reservoir
Former site of AEC Factory
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A503
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Vestry House Museum
Markfield Beam Engine and Museum
Walthamstow Reservoirs
Walthamstow
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Low Hall Pump House
Frederick Bremer's House and Workshop
New River Head
Stoke Newington Pumping Station
Walthamstow Marshes
Lea Bridge Speedway Stadium
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Temple Mills Eurostar Depot
Stoke Newington
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R. Lee Navigation
Stratford International Station
R. Lea
Former Stratford works of the Great Eastern Railway
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Regent's Canal
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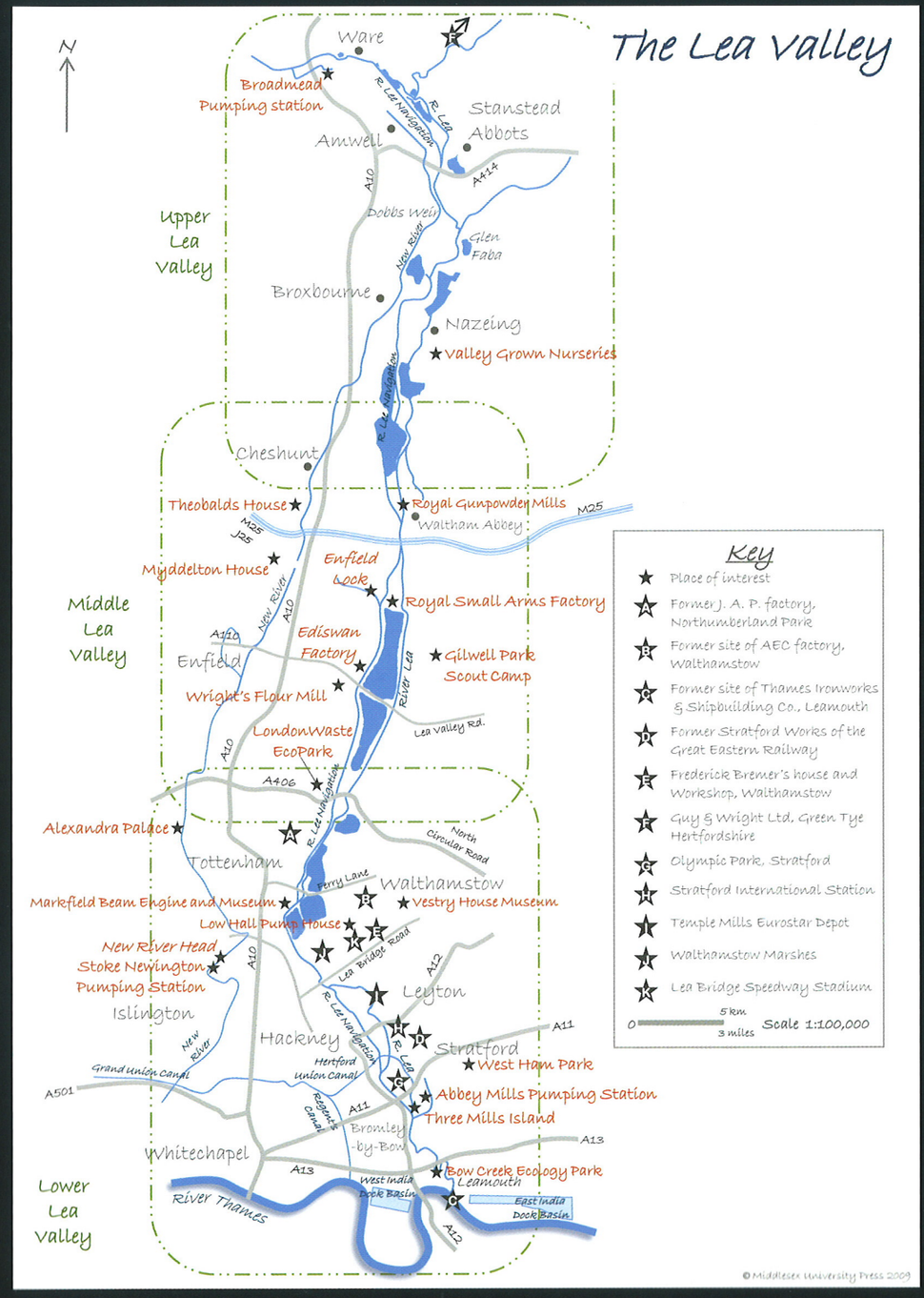
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West India Dock Basin
East India Dock Basin
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Key
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