



1ST LINE DEFENCE



Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	S. Norton & Sons, River Road, Barking
Client	WML Consulting
Site Address	River Road, Barking, London, IG11 0DS
Report Reference	DA10683-00
Date	1 st April 2020
Originator	CB



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Executive Summary

Site Location and Description

The site is located in Barking, east London. Recent aerial photography indicates the site footprint to currently comprise the premises of S. Norton & Sons, a metal recycling company, consisting of a large open hard surfaced yard area containing some small structures and several large piles of metal waste. It is bound to the north by a waste recycling plant on River Road, to the east by a hard surfaced yard area of a presumed industrial nature, to the south by the River Thames and to the west by open ground of both a hard surfaced and grassland nature.

The site is approximately centred on the OS grid reference: **TQ 45825 81667**.

Proposed Works

The proposed works are understood to involve the construction of 2no commercial/industrial units and a weighbridge.

Geology and Bomb Penetration Depth

The British Geological Survey (BGS) map shows the site area to be underlain by a combination of the following:

- Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated) – chalk, of the Cretaceous Period.
- Thanet Formation – sand, of the Palaeogene Period.

Superficial deposits are indicated to comprise Alluvium – clay, silt, sand and peat, of the Quaternary Period.

Site-specific geotechnical data provided by WML Consulting confirmed 0.4m of concrete underlain by made ground (6F2) to 2.6m bgl. The made ground was underlain by soft clay to 6.2m bgl, peat to 7.4m bgl and medium dense sand and gravel interbedded with firm clay to 16m bgl where the nodular chalk was encountered. However, due to the limitations of the data available, a maximum bomb penetration depth could not be assessed. An assessment of maximum bomb penetration depth can be made once more data becomes available, or by a UXO specialist during on-site support.

It should be noted that the maximum depth that a bomb could reach may vary across a site and will be largely dependent on the specific underlying geological strata and its density.

UXO Risk Assessment

1st Line Defence has assessed that there is a **Medium Risk** from items of German aerial delivered UXO and Allied UXO across the site. This assessment is based on the following factors:

- During WWII, the site area was situated within the Municipal Borough of Barking. A borough of 3,877 acres, Barking sustained an overall very high density bombing campaign; an average of 156.8 items of ordnance were recorded per 1,000 acres, according to Home Office statistics. This bombing density can be attributed to the presence of a number of Luftwaffe bombing targets in the vicinity, including the Beckton Gas Works and Barking Power Station. The site itself was an industrial facility in a prominent position on the banks of the Thames – it may in itself have constituted an obvious and viable target from the air.
- The site was occupied by the Lawes Chemical Works and a section of the River Thames during WWII. The chemical works consisted of a large structure in the centre of the site area, several smaller structures, open hard surfaced ground and a wharf.
- London bomb census mapping and local bomb plot mapping both record incidents within and immediately adjacent to the site area, including HE bomb strikes in the centre of the boundary and to the immediate north and north-west. An anti-aircraft shell is also recorded on the north-western border. However, whilst analysing available written records, no references to incidents occurring within the site area were found. It should be noted that the available written records were often ambiguous regarding the locations of incidents.
- Aerial photography taken in 1941 does not identify any obvious areas of structural clearance or significant damage within the site footprint. However, when comparing with post-WWII photography taken in 1946, whilst the general composition of the site area does not alter, there is evidence suggesting that structures present on site sustained bomb damage i.e. repairs to roofing. However, given the limitations of the available record set, the exact extent of any damage is unknown.
- At the outset of WWII, the land based area of the site is likely to have experienced frequent and regular levels of access due to its occupation by an industrial feature. Furthermore, the ground cover present should have been largely conducive to the visual detection of UXO i.e. structures, hard surfaced ground at the outset of WWII. However, following the recorded bombing incidents, there is the potential for conditions unconducive to the detection of UXO to have been



UXO Risk Assessment

created i.e. rubble and debris. This will also have potential resulted in a decrease in access levels for a period. Items of UXO are considered more likely to fall unnoticed in areas occupied by rubble and debris and poorly accessed areas such as the disturbed ground in the eastern section of the site

- During WWII, the southern section of the site was occupied by open water and an area of mud/foreshore. It is considered very unlikely that any UXO falling within these areas would have been noted and reported at the time as there would have been little if any evidence of their presence left. These sections of the site are considered to be at a somewhat greater risk of contamination. It is noted that some of this southern section of the site has been subject to infill post-war. Whilst there is not considered to be any significant risk of contamination within the levels of post-war fill, below these levels a risk of encountering UXO would still remain.
- There is no evidence that the site formerly had any military occupation or usage that could have led to contamination with items of Allied ordnance, such as LSA and SAA. The conditions in which HAA or LAA projectiles may have fallen unnoticed within the site boundary are however analogous to those regarding aerial delivered ordnance.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the S. Norton & Sons site in Barking:

All Works

- UXO Risk Management Plan
- Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.

Open Intrusive Works (trial pits, service pits, open excavations, shallow foundations etc.)

- UXO Specialist On-site Support

Boreholes and Piled Foundations

- Intrusive Magnetometer Survey of all borehole and pile locations/clusters down to maximum bomb penetration depth.

Glossary

Abbreviation	Definition
AA	Anti-Aircraft
AFS	Auxiliary Fire Service
AP	Anti-Personnel
ARP	Air Raid Precautions
DA	Delay-action
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
FP	Fire Pot
GM	G Mine (Parachute mine)
HAA	Heavy Anti-Aircraft
HE	High Explosive
IB	Incendiary Bomb
JSEODOC	Joint Services Explosive Ordnance Disposal Operation Centre
LAA	Light Anti-Aircraft
LCC	London County Council
LRRB	Long Range Rocket Bomb (V-2)
LSA	Land Service Ammunition
NFF	National Filling Factory
OB	Oil Bomb
PAC	Pilotless Aircraft (V-1)
PB	Phosphorous Bomb
PM	Parachute Mine
POW	Prisoner Of War
RAF	Royal Air Force
RCAF	Royal Canadian Air Force
RFC	Royal Flying Corps
RNAS	Royal Naval Air Service
ROF	Royal Ordnance Factory
SA	Small Arms
SAA	Small Arms Ammunition
SD2	Anti-personnel "Butterfly Bomb"
SIP	Self-Igniting Phosphorous
U/C	Unclassified bomb
UP	Unrotated Projectile (rocket)
USAAF	United States Army Air Force
UX	Unexploded
UXAA	Unexploded Anti-Aircraft
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	Flying Bomb (Doodlebug)
V-2	Long Range Rocket
WAAF	Women's Auxiliary Air Force
X	Exploded



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1st Line Defence Limited

Detailed Unexploded Ordnance (UXO) Risk Assessment

Site: S. Norton & Sons, River Road, Barking
Client: WML Consulting

1. Introduction

1.1. Background

1st Line Defence has been commissioned by WML Consulting to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for the works proposed at the S. Norton & Sons site on River Road, Barking.

Buried UXO can present a significant risk to construction works and development projects. The discovery of a suspect device during works can cause considerable disruption to operations as well as cause unwanted delays and expense.

UXO in the UK can originate from three principal sources:

1. Munitions resulting from wartime activities including German bombing in WWI and WWII, long range shelling, and defensive activities.
2. Munitions deposited as a result of military training and exercises.
3. Munitions lost, burnt, buried or otherwise discarded either deliberately, accidentally, or ineffectively.

This report will assess the potential factors that may contribute to the risk of UXO contamination. If an elevated risk is identified at the site, this report will recommend appropriate mitigation measures, in order to reduce the risk to as low as is reasonably practicable. Detailed analysis and evidence will be provided to ensure an understanding of the basis for the assessed risk level and any recommendations.

This report complies with the guidelines outlined in *CIRIA C681*, 'Unexploded Ordnance (UXO) A Guide for the Construction Industry.'



2. Method Statement

2.1. Report Objectives

The aim of this report is to conduct a comprehensive assessment of the potential risk from UXO at the S. Norton & Sons site on River Road, Barking. The report will also recommend appropriate site and work-specific risk mitigation measures to reduce the risk from explosive ordnance during the envisaged works to a level that is as low as reasonably practicable.

2.2. Risk Assessment Process

1st Line Defence has undertaken a five-step process for assessing the risk of UXO contamination:

1. The likelihood that the site was contaminated with UXO.
2. The likelihood that UXO remains on the site.
3. The likelihood that UXO may be encountered during the proposed works.
4. The likelihood that UXO may be initiated.
5. The consequences of initiating or encountering UXO.

In order to address the above, 1st Line Defence has taken into consideration the following factors:

- Evidence of WWI and WWII German aerial delivered bombing as well as the legacy of Allied occupation.
- The nature and conditions of the site during WWII.
- The extent of post-war development and UXO clearance operations on site.
- The scope and nature of the proposed works and the maximum assessed bomb penetration depth.
- The nature of ordnance that may have contaminated the proposed site area.

2.3. Sources of Information

Every reasonable effort has been made to ensure that relevant evidence has been consulted and presented in order to produce a thorough and comprehensible report for the client. To achieve this the following, which includes military records and archive material held in the public domain, have been accessed:

- The National Archives and Barking & Dagenham Archives.
- Historical mapping datasets.
- Historic England National Monuments Record.
- Relevant information supplied by WML Consulting.
- Available material from 33 Engineer Regiment (EOD) Archive (now 28 Regt).
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published books and internet resources.

Research involved a visit to The National Archives and Barking & Dagenham Archives.



3. Background to Bombing Records

3.1. General Considerations of Historical Research

This desktop assessment is based largely upon analysis of historical evidence. Every reasonable effort has been made to locate and present significant and pertinent information. 1st Line Defence cannot be held accountable for any changes to the assessed risk level or risk mitigation measures, based on documentation or other data that may come to light at a later date, or which was not available to 1st Line Defence during the production of this report.

It is often problematic and sometimes impossible to verify the completeness and accuracy of WWII-era records. As a consequence, conclusions as to the exact location and nature of a UXO risk can rarely be quantified and are, to a degree, subjective. To counter this, a range of sources have been consulted, presented and analysed. The same methodology is applied to each report during the risk assessment process. 1st Line Defence cannot be held responsible for any inaccuracies or the incompleteness in available historical information.

3.2. German Bombing Records

During WWII, bombing records were generally gathered locally by the police, Air Raid Precaution (ARP) wardens and military personnel. These records typically contained information such as the date, the location, the amount of damage caused and the types of bombs that had fallen during an air raid. This information was made either through direct observation or post-raid surveys. The Ministry of Home Security Bomb Census Organisation would then receive this information, which was plotted onto maps, charts, and tracing sheets by regional technical officers. The collective record set (regional bomb census mapping and locally gathered incidents records) would then be processed and summarised into reports by the Ministry of Home Security Research and Experiments Branch. The latter were tasked with providing the government 'a complete picture of air raid patterns, types of weapons used and damage caused- in particular to strategic services and installations such as railways, shipyards, factories and public utilities.'¹

The quality, detail and nature of record keeping could vary considerably between provincial towns, boroughs and cities. No two areas identically collated or recorded data. While some local authorities maintained records with a methodical approach, sources in certain areas can be considerably more vague, dispersed, and narrower in scope. In addition, the immediate priority was mostly focused on assisting casualties and minimising damage at the time. As a result, some records can be incomplete and contradictory. Furthermore, many records were even damaged or destroyed in subsequent air raids. Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are therefore not always reliable. Whereas records of attacks on military or strategic targets were often maintained separately and have not always survived.

3.3. Allied Records

During WWII, considerable areas of land were requisitioned by the War Office for the purpose of defence, training, munitions production and the construction of airfields. Records relating to military features vary and some may remain censored. Within urban environments datasets will be consulted detailing the location of munition production as well as wartime air and land defences. In rural locations it may be possible to obtain plans of military establishments, such as airfields, as well as training logs, record books, plans and personal memoirs. As with bombing records, every reasonable effort will be made to access records of, and ascertain any evidence of, military land use. However, there are occasions where such evidence is not available, as records may not be accessible, have been lost/destroyed, or simply were not kept in the first place.

¹ <http://www.nationalarchives.gov.uk/help-with-your-research/research-guides/bomb-census-survey-records-1940-1945/>.

4. UK Regulatory Environment and Guidelines

4.1. General

There is no formal obligation requiring a UXO risk assessment to be undertaken for construction projects in the UK, nor is there any specific legislation stipulating the management or mitigation of UXO risk. However, it is implicit in the legislation outlined below that those responsible for intrusive works (archaeology, site investigation, drilling, piling, excavation etc.) should undertake a comprehensive and robust assessment of the potential risks to employees and that mitigation measures are implemented to address any identified hazards.

4.2. CDM Regulations 2015

The Construction (Design and Management) Regulations 2015 (CDM 2015) define the responsibilities of parties involved in the construction of temporary or permanent structures.

The CDM 2015 establishes a duty of care extending from clients, principle co-ordinators, designers, and contractors to those working on, or affected by, a project. Those responsible for construction projects may therefore be accountable for the personal or proprietary loss of third parties, if correct health and safety procedure has not been applied.

Although the CDM does not specifically reference UXO, the risk presented by such items is both within the scope and purpose of the legislation. It is therefore implied that there is an obligation for parties to:

- Provide an appropriate assessment of potential UXO risks at the site (or ensure such an assessment is completed by others).
- Put in place appropriate risk mitigation measures if necessary.
- Supply all parties with information relevant to the risks presented by the project.
- Ensure the preparation of a suitably robust emergency response plan.

4.3. The 1974 Health and Safety at Work etc. Act

All employers have a responsibility under the Health and Safety at Work etc. Act 1974 and the Management of Health and Safety at Work Regulations 1999, to ensure the health and safety of their employees and third parties, so far as is reasonably practicable and conduct suitable and sufficient risk assessments.



4.4. CIRIA C681

In 2009, the Construction Industry Research and Information Association (CIRIA) produced a guide to the risk posed by UXO to the UK construction industry (CIRIA C681). CIRIA is a neutral, independent and not-for-profit body, linking organisations with common interests and facilitating a range of collaborative activities that help improve the industry.

The publication provides the UK construction industry with a defined process for the management of risks associated with UXO from WWI and WWII aerial bombardment. It is also broadly applicable to the risks from other forms of UXO that might be encountered. It focuses on construction professionals' needs, particularly if there is a suspected item of UXO on site, and covers issues such as what to expect from a UXO specialist. The guidance also helps clients to fulfil their legal duty under CDM 2015 to provide designers and contractors with project specific health and safety information needed to identify hazards and risks associated with the design and construction work. This report conforms to this CIRIA guidance and to the various recommendations for good practice referenced therein. It is recommended that this document is acquired and studied where possible to allow a better understanding of the background to both the risk assessment process and the UXO issue in the UK in general.

4.5. Additional Legislation

In the event of a casualty resulting from the failure of an employer/client to address the risks relating to UXO, the organisation may be criminally liable under the Corporate Manslaughter and Corporate Homicide Act 2007.



5. The Role of Commercial UXO Contractors and The Authorities

5.1. Commercial UXO Specialists

The role of a UXO Specialist (often referred to as UXO Consultant or UXO Contractor) such as 1st Line Defence, is defined in CIRIA C681 as the provision of expert knowledge and guidance to the client on the most appropriate and cost-effective approach to UXO risk management at a site.

The principal role of UXO Specialists is to provide the client with an appropriate assessment of the risk posed by UXO for a specific project, and identify and carry out suitable methodology for the mitigation of any identified risks to reduce them to an acceptable level.

The requirement for a UXO Specialist should ideally be identified in the initial stages of a project, and it is recommended that this occur prior to the start of any detailed design. This will enable the client to budget for expenditure that may be required to address the risks from UXO, and may enable the project team to identify appropriate techniques to eliminate or reduce potential risks through considered design, without the need for UXO specific mitigation measures. The UXO Specialist should have suitable qualifications, levels of competency and insurances.

Please note 1st Line Defence has the capability to provide a complete range of required UXO risk mitigation services, in order to reduce a risk to as low as reasonably practicable. This can involve the provision of both ground investigation, and where appropriate, UXO clearance services.

5.2. The Authorities

The police have a responsibility to co-ordinate the emergency services in the event of an ordnance-related incident at a construction site. Upon inspection they may impose a safety cordon, order an evacuation, and call the military authorities Joint Services Explosive Ordnance Disposal Operation Centre (JSEODOC) to arrange for investigation and/or disposal. Within the Metropolitan Police Operational Area, SO15 EOD will be tasked to any discovery of suspected UXO. The request for Explosive Officer (Expo) support is well understood and practiced by all Metropolitan Boroughs. The requirement for any additional assets will then be coordinated by the Expo if required.

In the absence of a UXO specialist, police officers will usually employ such precautionary safety measures, thereby causing works to cease, and possibly requiring the evacuation of neighbouring businesses and properties.

The priority given to the police request will depend on the EOD team's judgement of the nature of the UXO risk, the location, people and assets at risk, as well as the availability of resources. The speed of response varies; authorities may respond immediately or in some cases it may take several days for the item of ordnance to be dealt with. Depending on the on-site risk assessment the item of ordnance may be removed from the site and/or destroyed by a controlled explosion.

Following the removal of an item of UXO, the military authorities will only undertake further investigations or clearances in high-risk situations. If there are regular UXO finds on a site the JSEODOC may not treat each occurrence as an emergency and will recommend the construction company puts in place alternative procedures, such as the appointment of a commercial contractor to manage the situation.

6. The Site

6.1. Site Location

The site is located in Barking, east London. It is bound to the north by a waste recycling plant on River Road, to the east by a hard surfaced yard area of a presumed industrial nature, to the south by the River Thames and to the west by open ground of both a hard surfaced and grassland nature.

The site is approximately centred on the OS grid reference: **TQ 45825 81667**.

Site location maps are presented in **Annex A**.

6.2. Site Description

Recent aerial photography indicates the site footprint to currently comprise the premises of S. Norton & Sons, a metal recycling company, consisting of a large open hard surfaced yard area containing some small structures and several large piles of metal waste.

A recent aerial photograph and site plan are presented in **Annex B** and **Annex C** respectively.

7. Scope of the Proposed Works

7.1. General

The proposed works are understood to involve the construction of 2no commercial/industrial units and a weighbridge.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows the site area to be underlain by a combination of the following:

- Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation (undifferentiated) – chalk, of the Cretaceous Period.
- Thanet Formation – sand, of the Palaeogene Period.

Superficial deposits are indicated to comprise Alluvium – clay, silt, sand and peat, of the Quaternary Period.

8.2. Site Specific Geology

Site-specific geotechnical data provided by WML Consulting confirmed 0.4m of concrete underlain by made ground (6F2) to 2.6m bgl. The made ground was underlain by soft clay to 6.2m bgl, peat to 7.4m bgl and medium dense sand and gravel interbedded with firm clay to 16m bgl where the nodular chalk was encountered.



9. Site History

9.1. Introduction

The purpose of this section is to identify the composition of the site pre and post-WWII. It is important to establish the historical use of the site, as this may indicate the site's relation to potential sources of UXO as well as help with determining factors such as the land use, groundcover, likely frequency of access and signs of bomb damage.

9.2. Summary of the Historical Background of the Site

During WWII, the site was occupied by the Lawes Chemical Company. Founded in 1857, the main factory and workmen's cottages were built at Barking Creek, Essex at some point prior to 1875. The business was purchased from Lawes in 1872 and incorporated as Lawes Chemical Manure Co. Ltd, to manufacture artificial fertilisers, sulphuric acid and other chemical fertilisers. The company became Lawes Chemical Co. Ltd. in 1935 and went into liquidation in 1969, the business continuing to trade under the name of Seabright Chemicals Ltd.

Between the 1920s and 1940s, the structures on site appear to have been locally modified, prior to being developed into a smaller unnamed works sometime prior to 1944. Sometime between the late 1980s and the late 1990s the site was redeveloped into its current configuration as S. Norton & Sons metal recyclers.

9.3. Ordnance Survey Historical Maps

Relevant historical maps were obtained for this report and are presented in **Annex D**. See below for a summary of the site history shown on acquired mapping.

Pre-WWII		
Date	Scale	Description
1916	1:2,500	<p>This map edition indicates the site area to have been primarily occupied by a large industrial structure, known to have been the premises of the Lawes Chemical Company. Some smaller structures situated in the west and north-west of the boundary are assumed to be associated with the chemical works.</p> <p>To the immediate south of the chemical works is an embankment labelled to consist of <i>mud</i>. Features in this area of the site include two <i>cranes</i>, a <i>wharf</i> and a <i>pier</i>. The boundary also comprises part of the River Thames.</p> <p>The site's immediate surrounds are defined by workmen's cottages to the north-west, a further part of the chemical works to the east and the River Thames to the south.</p>

Post-WWII		
Date	Scale	Description
1958 – 1962	1:1,250	<p>The larger structure previously present on site is indicated to have been cleared and replaced with a number of smaller structures; these structures are known to still comprise the chemical works. The <i>cranes</i> and <i>pier</i> are no longer labelled in the south of the boundary.</p> <p>Clearance has also occurred to the immediate north-west of the boundary; the workmen's cottages are no longer present. It should be noted however that the date of this map is dated around fifteen years post-war, and any structural changes noted may not be indicative of bomb damage.</p>

9.4. Historical Photography of the Site

Historical photography has been obtained from the Aerofilms collection available from *Britain From Above*. This imagery provides a view of the site in 1921 and 1931 (see **Annex E**). See below for a description:

Title of Photograph	Comments
EPW006139 – Lawes Chemical Manure Co Ltd, Creekmouth, 1921	This image portrays the site area and its immediate surrounds from the south-east. A large warehouse structure defines the majority of the site footprint.
EPW006140 – Lawes Chemical Manure Co Ltd, Creekmouth, 1921	This image portrays the site area and its immediate surrounds from the south on the adjacent side of the Thames. The chemical works is shown to extend eastwards out of the site footprint. The area to the immediate north of the boundary is defined entirely by open ground.
EPW036779 – The Lawes Chemical Co Works, the Barking Guano Works and environs, Creekmouth, from the south-east, 1931	This image portrays the site area and its immediate surrounds from the south-east. The chemical works is shown to have been reduced in size; the section of the works formerly situated immediately east of the boundary is now occupied by open hard surfaced ground.
EPW036783 – The Lawes Chemical Co Works, pylons running across the Dagenham Marshes and environs, Creekmouth, from the south-west, 1931	This image portrays the site area and its immediate surrounds from the south-west.

10. Introduction to German Aerial Delivered Ordnance

10.1. General

During WWI and WWII, the UK was subjected to bombing which often resulted in extensive damage to city centres, docks, rail infrastructure and industrial areas. The poor accuracy of WWII targeting technology and the nature of bombing techniques often resulted in neighbouring areas to targets sustaining collateral damage.

In addition to raids which concentrated on specific targets, indiscriminate bombing of large areas also took place. This occurred most prominently in the London 'Blitz', though affected many other towns and cities. As discussed in the following sections, a proportion of the bombs dropped on the UK did not detonate as designed. Although extensive efforts were made to locate and deal with these UXBs at the time, many still remain buried and can present a potential risk to construction projects.

The main focus of research for this section of the report will concern German aerial delivered ordnance dropped during WWII, although WWI bombing will also be considered.

10.2. Generic Types of WWII German Aerial Delivered Ordnance

To provide an informed assessment of the hazards posed by any items of unexploded ordnance that may remain in situ on site, the table below provides information on the types of German aerial delivered ordnance most commonly used by the Luftwaffe during WWII. Images and brief summaries of the characteristics of these items of ordnance are listed in **Annex F**.

Generic Types of WWII German Aerial Delivered Ordnance		
Type	Frequency	Likelihood of detection
High Explosive (HE) bombs	In terms of weight of ordnance dropped, HE bombs were the most frequently deployed by the Luftwaffe during WWII.	Although efforts were made to identify the presence of unexploded ordnance following an air raid, often the damage and destruction caused by detonated bombs made observation of UXB entry holes impossible. The entry hole of an unexploded bomb can be as little as 20cm in diameter and was easily overlooked in certain ground conditions (see Annex G). Furthermore, ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded smaller bomb. UXBs therefore present the greatest risk to present-day intrusive works.
1kg Incendiary bombs (IB)	In terms of the number of weapons dropped, small IBs were the most numerous. Millions of these were dropped throughout WWII.	IBs had very limited penetration capability and in urban areas would often have been located in post-raid surveys. If they failed to initiate and fell in water, on soft vegetated ground, or bombed rubble, they could easily go unnoticed.
Large Incendiary bombs (IB)	These were not as common as the 1kg IBs, although they were more frequently deployed than PMs and AP bomblets.	If large IBs did penetrate the ground, complete combustion did not always occur and in such cases they could remain a risk to intrusive works.
Aerial or Parachute mines (PM)	These were deployed less frequently than HE and IBs due to size, cost and the difficulty of deployment.	If functioning correctly, PMs would generally have had a slow rate of descent and were very unlikely to have penetrated the ground. Where the parachute failed, mines would have simply shattered on impact if the main charge failed to explode. There have been extreme cases when these items have been found unexploded. However, in these scenarios, the ground was either extremely soft or the munition fell into water.
Anti-personnel (AP) bomblets	These were not commonly used and are generally considered to pose a low risk to most works in the UK.	SD2 bomblets were packed into containers holding between 6 and 108 submunitions. They had little ground penetration ability and should have been located by the post-raid survey unless they fell into water, dense vegetation or bomb rubble.



10.3. Failure Rate of German Aerial Delivered Ordnance

It has been estimated that 10% of WWII German aerial delivered HE bombs failed to explode as designed. Reasons for why such weapons might have failed to function as designed include:

- Malfunction of the fuze or gain mechanism (manufacturing fault, sabotage by forced labour or faulty installation).
- Many were fitted with a clockwork mechanism that could become immobilised on impact.
- Failure of the bomber aircraft to arm the bombs due to human error or an equipment defect.
- Jettisoning the bomb before it was armed or from a very low altitude. This most likely occurred if the bomber aircraft was under attack or crashing.

From 1940 to 1945, bomb disposal teams reportedly dealt with a total of 50,000 explosive items of 50kg, over 7,000 anti-aircraft projectiles and 300,000 beach mines. Unexploded ordnance is still regularly encountered across the UK, see press articles in **Annex H1**.

10.4. UXB Ground Penetration

An important consideration when assessing the risk from a UXB is the likely maximum depth of burial. There are several factors which determine the depth that an unexploded bomb will penetrate:

- Mass and shape of bomb.
- Height of release.
- Velocity and angle of bomb.
- Nature of the ground cover.
- Underlying geology.

Geology is perhaps the most important variable. If the ground is soft, there is a greater potential of deeper penetration. For example, peat and alluvium are easier to penetrate than gravel and sand, whereas layers of hard strata will significantly retard and may stop the trajectory of a UXB.

10.4.1. The J-Curve Effect

J-curve is the term used to describe the characteristic curve commonly followed by an aerial delivered bomb dropped from height after it penetrates the ground. Typically, as the bomb is slowed by its passage through underlying soils, its trajectory curves towards the surface. Many UXBs are found with their nose cone pointing upwards as a result of this effect. More importantly, however, is the resulting horizontal offset from the point of entry. This is typically a distance of about one third of the bomb's penetration depth, but can be higher in certain conditions (see **Annex G**).

10.4.2. WWII UXB Ground Penetration Studies

During WWII the Ministry of Home Security undertook a major study on actual bomb penetration depths, carrying out statistical analysis on the measured depths of 1,328 bombs as reported by bomb disposal (BD) teams. Conclusions were drawn predicting the likely average and maximum depths of penetration of different sized bombs in different geological strata.

For example, the largest common German bomb (500kg) had a likely concluded penetration depth of 6m in sand or gravel but 11m in clay. The maximum observed depth for a 500kg bomb was 11.4m and for a 1,000kg bomb 12.8m. Theoretical calculations suggested that significantly greater penetration depths were probable.



10.4.3. Site Specific Bomb Penetration Considerations

When considering an assessment of the bomb penetration at the site of proposed works the following parameters have been used:

- WWII geology – the Lewes Nodular Chalk Formation, Seaford Chalk Formation and Newhaven Chalk Formation and the Thanet Formation
- Impact angle and velocity – 10-15° from vertical and 270 metres per second.
- Bomb mass and configuration – The 500kg SC HE bomb, without retarder units or armour piercing nose (this was the largest of the common bombs used against Britain).

It has not been possible to determine maximum bomb penetration capabilities at this stage due to the limitations of site-specific geotechnical information currently available. An assessment can be made once further information becomes available or by an UXO Specialist on-site.

10.5. V-Weapons

Hitler's 'V-weapon' campaign began from mid-1944. It used newly developed unmanned cruise missiles and rockets. The V-1, known as the *flying bomb* or *pilotless aircraft*, and the V-2, a long range rocket, were launched from bases in Germany and occupied Europe. A total of 2,419 V-1s and 517 V-2s were recorded in the London Civil Defence region alone.

Although these weapons caused considerable damage, their relatively low numbers allowed accurate records of strikes to be maintained. These records have mostly survived. There is a negligible risk from unexploded V-weapons on land today. Even if the 1000kg warhead failed to explode, the weapons are so large that they would have been observed and dealt with at the time. Therefore, V-weapons are referenced in this report not as a viable risk factor, but primarily in order to help account for evidence of damage and clearance reported.



11. The Likelihood of Contamination from German Aerial Delivered UXBs

11.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships, as well as Gotha and Giant fixed-wing aircraft. An estimated 250 tons of ordnance (high explosive and incendiary bombs) was dropped on Greater London, more than half of which fell on the City of London (see **Annex I** for a WWI bomb plot map of London). This source does not record any WWI bombing incidents to have affected the site.

WWI bombs were generally smaller and dropped from a lower altitude than those used in WWII. This resulted in limited UXB penetration depths. Aerial bombing was often such a novelty at the time that it attracted public interest and even spectators to watch the raids in progress. For these reasons there is a limited risk that UXBs passed undiscovered in the urban environment. When combined with the relative infrequency of attacks and an overall low bombing density, the risk from WWI UXBs is considered low and will not be further addressed in this report.

11.2. World War II Bombing of the Municipal Borough of Barking

The Luftwaffe's main objective for the attacks on London was to inhibit the capital's commercial output. To achieve this they targeted the docks, warehouses, wharves, railway lines, factories and power stations. As the war progressed this strategy gradually changed to the indiscriminate bombing of civilian areas in an attempt to subvert public morale.

During WWII the site was located within the Municipal Borough of Barking, which sustained a very high density of bombing, as represented by bomb density data figures and maps, see **Annex J**. This was mainly due to its location in London and its proximity to key Luftwaffe targets such as Barking Power station and the Beckon Gas Works (shown in Luftwaffe reconnaissance photography in **Annex K**).

Records of bombing incidents in the civilian areas of London were collected by the Air Raid Precautions wardens and collated by the Civil Defence Office. Some other organisations, such as port and railway authorities, maintained separate records. Records would be in the form of typed or hand written incident notes, maps and statistics. Bombing data was carefully analysed, not only due to the requirement to identify those parts of the country most needing assistance, but also in an attempt to find patterns in the Germans' bombing strategy in order to predict where future raids might take place.

Records of bombing incidents for Municipal Borough of Barking are presented in the following sections.

11.3. WWII Home Office Bombing Statistics

The following table summarises the quantity of German aerial delivered bombs (excluding 1kg incendiaries and anti-personnel bombs) dropped on the Municipal Borough of Barking between 1940 and 1945.

Record of German Ordnance Dropped on the Municipal Borough of Barking		
Area Acreage		3,877
Weapons	High Explosive bombs (all types)	484
	Parachute mines	26
	Oil bombs	12
	Phosphorus bombs	11
	Fire pots	15
	Pilotless aircraft (V-1)	40
	Long range rocket bombs (V-2)	20
Total		608
Number of Items per 1,000 acres		156.8

Source: Home Office Statistics

This table does not include UXO found during or after WWII.

Detailed records of the quantity and locations of the 1kg incendiary and anti-personnel bombs were not routinely maintained by the authorities as they were frequently too numerous to record. Although the risk relating to IBs is lesser than that relating to larger HE bombs, they were similarly designed to inflict damage and injury. Anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous. Although Home Office statistics did not record these types of ordnance, both should not be overlooked when assessing the general risk to personnel and equipment.

11.4. London Civil Defence Region Bomb Census Maps

During WWII, the ARP Department within the Research and Experiments Branch of the Ministry of Home Security produced both consolidated and weekly bomb census maps for the London Civil Defence Region, as well as census mapping of V-1 pilotless aircraft. These maps collectively show the approximate locations of bombs, mines and rockets dropped in the region. The site area was checked on each available map sheet. Those showing bomb incidents on and in the immediate vicinity of the site are discussed below and are presented in **Annexes L-M**.

Consolidated London Bomb Census Maps – Annex L1	
Date Range	Comments
Night Bombing up to 7 th October 1940	An incident is recorded within the site footprint. A further incident is plotted approximately 200m to the north-west.
7 th October 1940 to 6 th June 1941	An incident is plotted to the immediately north of the boundary in the confines of the chemical works. Several further incidents are recorded in the site's immediate and wider surrounds; the closest is plotted approximately 30m to the east of the boundary.

Weekly London Bomb Census Maps – Annex L2-L4	
Date Range	Comments
7 th to 14 th October 1940	A HE incident is recorded on the site's northern boundary. This incident is part of a stick which fell to the north-west of the boundary; however, it is not visible on the map.
25 th November to 2 nd December 1940	No incidents are recorded within the site footprint during this week. However, a UXB strike is plotted on the <i>Guano Works</i> approximately 200m east of the site footprint.
6 th to 13 th January 1941	An incendiary bomb 'shower' is recorded over the site footprint during this week.
17 th to 23 rd January 1944	No incidents are recorded within the site footprint during this week. However, a phosphorous bomb is recorded approximately 300m north-east of the boundary to the immediate north of the <i>Guano Works</i> .
24 th to 30 th January 1944	A 500kg HE bomb is recorded to the immediate south-east of the site footprint in the River Thames.

V-1 Pilotless Aircraft Bomb Census Map – Annex M	
Date Range	Comments
1944-45	No V-1 incidents are recorded within the site boundary or its immediate surrounds. The closest recorded incident is plotted approximately 360m to the north-east of the site area.

11.5. London Bomb Census Reports

Bomb census reports compiled by the Research and Experiments Branch of the Ministry of Home Security during WWII were consulted at The National Archives. These reports recorded information such as the date, time, type and damage caused by bomb incidents for a selected time period in the region and are therefore not often comprehensive. No relevant records for the site area could be identified during the production of this report.

11.6. Barking ARP Bomb Mapping

Bomb mapping for the Municipal Borough of Barking was obtained from the Barking and Dagenham Archives and Local Studies Service. These were mostly compiled by the Borough engineers and surveyors department, and were labelled as ‘Bomb Investigation Record’. Other maps do not appear to be compiled by the Borough Engineers and this will be noted. The section of these map editions showing the area of the site is presented in **Annexes N-Q**.

Barking Bomb Maps	
Date	Comments
AA Shell mapping likely September 1939 – December 1940 (Annex N)	This map is noted to be a copy of a map sent to a Group Engineer on the 17 th December 1940. The date range of this map is likely from the start of the war to December 1940. An anti-aircraft (AA) shell is recorded to the immediate north-west of the site area.
Consolidated up until October 1940 (Annex O)	This bomb census map is based on a 1938 Landmark map of the area, with bomb strikes overlaid. This map covers the area of the London Borough of Barking and Dagenham, and was apparently compiled for a school project that was not finished, and the map only covers strikes pre-October 1940. This map does not differentiate between exploded and unexploded bombs. This map records two HE bomb strikes to the immediate north and north-west of the site area. Several HE bomb strikes are recorded in the site’s wider surrounds; however, these are considered too far removed to have been of note.
29 th January 1944 (Annex P)	This map appears to be compiled by Group Engineers. It records a HE bomb strike to the immediate east of the boundary on the banks of the Thames. There are no incidents recorded within the site footprint during this time period.
V-1 Flying Bomb Map likely 1944-1945 (Annex Q)	This bomb map appears to be based on the same map as the AA Shell mapping, but there are no annotations as to the date or who compiled this map. The only annotation shows ‘Fly Bombs’ which means this bomb plot map corresponds to V1 weapon strikes within Barking. No incidents are recorded within the site footprint; the closest recorded incident is plotted approximately 350m to the north-east of the boundary.

11.7. Barking Register of Air Raids

Bomb incident records were obtained from the Barking and Dagenham Archives. A transcript of the associated written records for bombs which fell in the site area is presented in the table below. It should be noted that that the locations of these strikes are approximate.

Barking Register of Air Raid Incidents		
Date Range	Location	Type of bomb
17 th October 1940	East side River Road, Creekmouth End.	High Explosive Bomb
3 rd March 1943	In River Thames (three incidents recorded)	High Explosive Bomb

11.8. WWII-Era Aerial Photography

WWII-era aerial photography for the site area was obtained from the National Monuments Record Office (Historic England). This photography provides a record of the potential composition of the site during the war, as well as its condition immediately following the war (see Annexes R-S).

WWII-Era Aerial Photography	
Date	Description
18 th June 1941	<p>This image shows the boundary to have been occupied by the premises of Lawes Chemical Works at the outset of WWII, consisting of the main works building, smaller outbuildings associated with the works and open hard surfaced ground. The River Thames occupied the southern area of the boundary. No obvious evidence of structural clearance or significant structural damage to properties within the land based area of the site and its immediate surrounds is visible in this image.</p> <p>A wider view of the image is presented in Annex R2. Potential bomb craters are visible approximately 100m east of the boundary in the vicinity of an access road off River Road and approximately 260m to the north of the boundary in open ground north of River Road.</p>
1 st May 1946	<p>Whilst the image does not indicate any significant alterations to the general composition of the site area from the previous edition, there is evidence to suggest that the chemical works sustained structural damage during WWII. Areas of roofing appear to have undergone repair works. The exact extent of any damage sustained is unknown.</p> <p>Furthermore, the open area of land to immediate east of the works encompassed by the site boundary displays characteristics consistent with ground disturbance sustained by bombing incidents.</p> <p>Damage and structural clearance is also noted to the immediate north-west of the boundary; please see Annex S2 for a wider view of the image.</p>



11.9. Abandoned Bombs

A post air-raid survey of buildings, facilities, and installations would have included a search for evidence of bomb entry holes. If evidence of an entry hole was encountered, Bomb Disposal Officer Teams would normally have been requested to attempt to locate, render safe, and dispose of the bomb. Occasionally, evidence of UXBs was discovered but due to a relatively benign position, access problems, or a shortage of resources the UXB could not be exposed and rendered safe. Such an incident may have been recorded and noted as an 'abandoned bomb'.

Given the inaccuracy of WWII records, and the fact that these bombs were 'abandoned', their locations cannot be considered definitive or the lists exhaustive. The MoD states that 'action to make the devices safe would be taken only if it was thought they were unstable'. It should be noted that other than the 'officially' abandoned bombs, there will inevitably be UXBs that were never recorded.

An abandoned bomb is officially registered approximately 500m north of the site area in the vicinity of a coal dump at Barking Power Station. However, 1st Line Defence holds no records of officially registered abandoned bombs at the site of the proposed works.

11.10. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD) (now 29 Regt) is currently facing considerable delay. It has therefore not been possible to include any updated official information regarding bomb disposal/clearance tasks with regards to this site. A database of known disposal/clearance tasks has been referred to which does not make reference to such instances occurring within the site of proposed works. If any relevant information is received at a later date, WML Consulting will be advised.

11.11. Evaluation of German Aerial Delivered UXO Records

Factors	Conclusion
<p>Density of Bombing</p> <p><i>It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High bombing density could allow for error in record keeping due to extreme damage caused to the area.</i></p>	<p>During WWII, the site area was situated within the Municipal Borough of Barking. A borough of 3,877 acres, Barking sustained an overall very high density bombing campaign; an average of 156.8 items of ordnance were recorded per 1,000 acres, according to Home Office statistics. This bombing density can be attributed to the presence of a number of Luftwaffe bombing targets in the vicinity, including the Beckton Gas Works and Barking Power Station.</p> <p>London bomb census mapping and local bomb plot mapping both record bombing incidents within and immediately adjacent to the site area; including HE bomb strikes in the centre of the boundary and to the immediate north and north-west and an AA shell on the north-western border. However, whilst analysing available written records, no references to incidents occurring within the site area were found. It should be noted that the available written records were often ambiguous in regards to locations of incidents.</p>
<p>Damage</p> <p><i>If buildings or structures on a site sustained bomb or fire damage, any resulting rubble and debris could have obscured the entry holes of unexploded bombs dropped during the same or later raids. Similarly, a high explosive bomb strike in an area of open agricultural land will have caused soil disturbance, increasing the risk that a UXB entry hole would be overlooked.</i></p>	<p>Whilst the general composition of the site area does not alter significantly when comparing aerial photography taken in 1941 and 1946, there is evidence to suggest that the structures present on site sustained bomb damage; areas of roofing appear to have undergone repair works. However, the exact extent of any damage sustained is unknown. It should be noted that given the site's industrial nature, any damage may have been repaired swiftly and therefore is not visible in the photography.</p> <p>Due to the southern area of the site's occupation by the River Thames, it is not considered possible to accurately identify areas of damage from available sources.</p> <p>Evidence of damage and clearance is noted to the immediate north-west of the boundary in post-war aerial photography from 1946; this can be attributed to bombing incidents in the vicinity.</p>
<p>Ground Cover</p> <p><i>The nature of the ground cover present during WWII would have a substantial influence on any visual indication that may indicate UXO being present.</i></p>	<p>The ground cover present in the land based area of the site is considered to have been largely conducive to the visual detection of UXO i.e. structures, hard surfaced ground, at the outset of WWII. However, following the recorded bombing incidents, there is the potential for conditions unconducive to the detection of UXO to have been created i.e. rubble and debris. UXO entry holes could be as small as 20cm in diameter and could easily go undetected in such conditions.</p> <p>During WWII, the southern section of the site was occupied by open water and an area of mud/foreshore. Whilst the site only encompasses a small portion of the river, it is still considered a risk that an item of UXO may have fallen unnoticed and unrecorded within the site area.</p> <p>It is considered very unlikely that any UXO falling within these areas would have been noted and reported at the time as there would have been little if any evidence of their presence left.</p>



<p>Access Frequency</p> <p><i>UXO in locations where access was irregular would have a greater chance of passing unnoticed than at those that were regularly occupied. The importance of a site to the war effort is also an important consideration as such sites are likely to have been both frequently visited and subject to post-raid checks for evidence of UXO.</i></p>	<p>At the outset of WWII, the land based area of the site is likely to have experienced frequent and regular levels of access due to its occupation by an industrial feature. However, following bombing incidents and any subsequent damage occurring, the site area is likely to have experienced a decrease for a period. Items of UXO are more likely to fall unnoticed in infrequently accessed areas.</p> <p>Regarding the marine based area of the site, the possibility of UXO falling unnoticed within this part of the site cannot be discounted due to the inability to frequently access bodies of water.</p>
<p>Bomb Failure Rate</p>	<p>There is no evidence to suggest that the bomb failure rate in the locality of the site would have been dissimilar to the 10% normally used.</p>
<p>Abandoned Bombs</p>	<p>1st Line Defence holds no records of abandoned bombs at or within the site vicinity.</p>
<p>Bombing Decoy sites</p>	<p>1st Line Defence could find no evidence of bombing decoy sites within the site vicinity.</p>
<p>Bomb Disposal Tasks</p>	<p>1st Line Defence could find no evidence of bomb disposal tasks within the site boundary and immediate area.</p>

12. Introduction to Allied Explosive Ordnance

12.1. General

Many areas across the UK may be at risk from Allied UXO because of both wartime and peacetime military use. Typical military activities and uses that may have led to a legacy of military UXO at a site include former minefields, home guard positions, anti-aircraft emplacements, training and firing ranges, military camps, as well as weapons manufacture and storage areas.

Although land formerly used by the military was usually subject to clearance before returned to civilian use, items of UXO are sometimes discovered and can present a potential risk to construction projects.

Chemical works were often requisitioned during WWII for military purposes and were often converted in order to produce munitions. However, in this case, it should be highlighted that there is no evidence that the site formerly had any military occupation or usage that could have led to contamination with such items of Allied ordnance. Despite this, urban areas, such as the location of the site, can be at risk from buried unexploded anti-aircraft projectiles fired during WWII – as addressed below.

12.2. Defending the UK From Aerial Attack

During WWII the War Office employed a number of defence tactics against the Luftwaffe from bombing major towns, cities, manufacturing areas, ports and airfields. These can be divided into passive and active defences (examples are provided in the table below).

Active Defences	Passive Defences
<ul style="list-style-type: none"> • Anti-aircraft gun emplacements to engage enemy aircraft. • Fighter aircraft to act as interceptors. • Rockets and missiles were used later during WWII. 	<ul style="list-style-type: none"> • Blackouts and camouflaging to hinder the identification of Luftwaffe targets. • Decoy sites were located away from targets and used dummy buildings and lighting to replicate urban, military, or industrial areas. • Barrage balloons forced enemy aircraft to greater altitudes. • Searchlights were often used to track and divert adversary bomber crews during night raids.

Active defences such as anti-aircraft artillery present a greater risk of UXO contamination than passive defences. Unexploded ordnance resulting from dogfights and fighter interceptors is rarely encountered and difficult to accurately qualify.



12.2.1. Anti-Aircraft Artillery (AAA)

During WWII three main types of gun sites existed: heavy anti-aircraft (HAA), light anti-aircraft (LAA) and 'Z' batteries (ZAA). If the projectiles and rockets fired from these guns failed to explode or strike an aircraft they would descend back to land. The table below provides further information on the operation and ordnance associated with these type of weapons.

Anti-Aircraft Artillery				
Item	Description			
HAA	These large calibre guns such as the 3.7" QF (Quick Firing) were used to engage high flying enemy bombers. They often fired large HE projectiles, which were usually initiated by integral fuzes, triggered by impact, area, time delay or a combination of aforementioned mechanisms.			
LAA	These mobile guns were intended to engage fast, low flying aircraft. They were typically rotated between locations on the perimeters of towns and strategically important industrial works. As they could be moved to new positions with relative ease when required, records of their locations are limited. The most numerous of these were the 40mm Bofors gun which could fire up to 120 x 40mm HE projectiles per minute to over 1,800m.			
Variations in HAA and LSA Ammunition	Gun type	Calibre	Shell Weight	Shell Dimensions
	3.0 Inch	76mm	7.3kg	76mm x 356mm
	3.7 Inch	94mm	12.7kg	94mm x 438mm
	4.5 Inch	114mm	24.7kg	114mm x 578mm
	40mm	40mm	0.9kg	40mm x 311mm
Z-AA	The three inch unrotated rocket/projectile known as the UP-3 had initially been developed for the Royal Navy. The UP-3 was also used in ground-based single and 128-round launchers known as "Z" batteries. The rocket, containing a high explosive warhead was often propelled by cordite.			

The closest recorded HAA to the site was located approximately 2km east of the site, however the range of a projectile can be up to 15km. The site would also have been in range of mobile light anti-aircraft guns.

The conditions in which anti-aircraft projectiles may have fallen unnoticed within a site area are analogous to those regarding aerial delivered ordnance. Unexploded anti-aircraft projectiles could essentially have fallen indiscriminately anywhere within range of the guns. The chance of such items being observed, reported and removed during the war depends on factors such as land use, ground cover, damage and frequency of access – the same factors that govern whether evidence of a UXB is likely to have been noted. More information about these factors with regards to this particular site can be found in the German Aerial Delivered Ordnance section of this report.

Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at Annex T.

13. The Likelihood of Contamination from Allied Ordnance

13.1. Introduction

There are several factors that may serve to either affirm, increase, or decrease the level of risk within a site with a history of military usage. Such factors are typically dependent upon the proximity of the proposed area of works to training activities, munition productions and storage, as well as its function across the years.

This section will examine the history of the proposed site and assess to what degree, if any, the site could have become contaminated as a result of the military use of the surrounding area.

13.2. Evaluation of Contamination Risk from Allied UXO

1st Line Defence has considered the following potential sources of Allied ordnance contamination:

Sources of Allied UXO Contamination	Conclusion
<p>Military Camps <i>Military camps present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training.</i></p>	<p>1st Line Defence could find no evidence of a military camp within the site.</p>
<p>Anti-Aircraft Defences <i>Anti-Aircraft defences were employed across the country. Proximity to anti-aircraft defences increases the chance of encountering AA projectiles.</i></p>	<p>1st Line Defence could find no evidence of Anti-Aircraft defences such as a HAA or LAA gun emplacement occupying or bordering the site. The closest HAA was located approximately 2km east of the site, however the range of a projectile can be up to 15km. The conditions in which HAA or LAA projectiles may have fallen unnoticed within a site footprint are analogous to those regarding German aerial delivered ordnance.</p>
<p>Home Guard Activity <i>The Home Guard regularly undertook training and ordnance practice in open areas, as well as burying ordnance as part of anti-invasion defences.</i></p>	<p>1st Line Defence has no evidence of any Home Guard activities on the site.</p>
<p>Defensive Positions <i>Defensive positions suggest the presence of military activity, which is often indicative of ordnance storage, usage or disposal.</i></p>	<p>There is no evidence of any defensive features formerly located on or bordering the site footprint.</p>
<p>Training or firing ranges <i>Areas of ordnance training saw historical ordnance usage in large numbers, often with inadequate disposal of expended and live items. The presence of these ranges significantly impact on the risk of encountering items of ordnance in their vicinity.</i></p>	<p>There is no evidence of such features affecting the site.</p>



<p>Defensive Minefields</p> <p><i>Minefields were placed in strategic areas to defend the country in the event of a German invasion. Minefields were not always cleared with an appropriate level of vigilance.</i></p>	<p>There is no evidence of defensive minefields affecting the site.</p>
<p>Ordnance Manufacture</p> <p><i>Ordnance manufacture indicates an increased chance that items of ordnance were stored, or disposed of, within a location.</i></p>	<p>No information of ordnance being stored, produced, or disposed of within the proposed site could be found.</p>
<p>Military Related Airfields</p> <p><i>Military airfields present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training or bombing practice.</i></p>	<p>The site was not situated within the perimeters or vicinity of a military airfield.</p>



14. The Likelihood of UXO Contamination Summary

The following table assesses the likelihood that the site was contaminated by items of German aerial delivered and Allied ordnance. Factors such as the risk of UXO initiation, remaining, and encountering will be discussed later in the report.

UXO Contamination Summary	
Quality of the Historical Record	<p>The research has evaluated pre- and post-WWII Ordnance Survey maps, pre-WWII oblique imagery, Luftwaffe reconnaissance imagery, London bomb census mapping, London V-1 pilotless aircraft mapping, an AA shell map for Barking, bombing raid maps for Barking, V-1 pilotless aircraft mapping for Barking, 1941 & 1946 high-resolution RAF aerial photography, and relevant in-house data.</p> <p>The record set is of an adequate quality. A number of sources are available; however, they are not all corroborative of one another. For example, the location of bombing incidents on London bomb census mapping and local bomb plot mapping do not match one another. Furthermore, the incident records available are vague in terms of exact locations, meaning it has not proved possible to accurately establish the amount and extent of any bombing incidents within the site footprint and its immediate surrounds.</p>
German Aerial Delivered Ordnance	<ul style="list-style-type: none"> • During WWII, the site area was situated within the Municipal Borough of Barking. A borough of 3,877 acres, Barking sustained an overall very high density bombing campaign; an average of 156.8 items of ordnance were recorded per 1,000 acres, according to Home Office statistics. This bombing density can be attributed to the presence of a number of Luftwaffe bombing targets in the vicinity, including the Beckton Gas Works and Barking Power Station. The site itself was an industrial facility in a prominent position on the banks of the Thames – it may in itself have constituted an obvious and viable target from the air. • The site was occupied by the Lawes Chemical Works and a section of the River Thames during WWII. The chemical works consisted of a large structure in the centre of the site area, several smaller structures, open hard surfaced ground and a wharf. • London bomb census mapping and local bomb plot mapping both record incidents within and immediately adjacent to the site area, including HE bomb strikes in the centre of the boundary and to the immediate north and north-west. An anti-aircraft shell is also recorded on the north-western border. However, whilst analysing available written records, no references to incidents occurring within the site area were found. It should be noted that the available written records were often ambiguous regarding the locations of incidents. • Aerial photography taken in 1941 does not identify any obvious areas of structural clearance or significant damage within the site footprint. However, when comparing with post-WWII photography taken in 1946, whilst the general composition of the site area does not alter, there is evidence suggesting that structures present on site sustained bomb damage i.e. repairs to roofing. However, given the limitations of the available record set, the exact extent of any damage is unknown. • At the outset of WWII, the land based area of the site is likely to have experienced frequent and regular levels of access due to its occupation by an industrial feature. Furthermore, the ground cover present should have been largely conducive to the visual detection of UXO i.e. structures, hard surfaced ground at the outset of WWII. However, following the recorded bombing incidents, there is the potential for conditions unconducive to the detection of UXO to have been created i.e. rubble and debris. This will also have potential resulted in a decrease in access levels for a period. Items of UXO are considered more likely to fall unnoticed in areas occupied by rubble and debris and poorly accessed areas such as the disturbed ground in the eastern section of the site



	<ul style="list-style-type: none">During WWII, the southern section of the site was occupied by open water and an area of mud/foreshore. It is considered very unlikely that any UXO falling within these areas would have been noted and reported at the time as there would have been little if any evidence of their presence left. These sections of the site are considered to be at a somewhat greater risk of contamination. It is noted that some of this southern section of the site has been subject to infill post-war. Whilst there is not considered to be any significant risk of contamination within the levels of post-war fill, below these levels a risk of encountering UXO would still remain.
Allied Ordnance	<ul style="list-style-type: none">There is no evidence that the site formerly had any military occupation or usage that could have led to contamination with items of Allied ordnance, such as LSA and SAA. The conditions in which HAA or LAA projectiles may have fallen unnoticed within the site boundary are however analogous to those regarding aerial delivered ordnance.



15. The Likelihood that UXO Remains

15.1. Introduction

It is important to consider the extent to which any explosive ordnance clearance (EOC) activities or extensive ground works have occurred on site. This may indicate previous ordnance contamination or reduce the risk that ordnance remains undiscovered.

15.2. UXO Clearance

1st Line Defence has found no evidence in the public domain or within internal records that any official ordnance clearance operations have taken place on site. Note however that we have not received confirmation of this fact from the 33 EOD Regiment Archive (now part of 29 Regt). It should also be noted that in addition to 29 Regt archival information, 1st Line Defence also do not currently have access to data that may be relevant including 5131(BD)SQN Archive, SD Training Technical Advisory Section (TAS) and MACA Records (bomb disposal callouts).

If such information is available at a later date, it is recommended that it be reviewed as it will assist with understanding both levels and types of contamination likely to be present, and may indicate risk reduction in certain areas.

15.3. Post-War Redevelopment

Post-war redevelopment has consisted of the clearance of all surviving post-war structures, the redevelopment of the Lawes Chemical Works as evidenced in post-war OS mapping and the later clearance of the redeveloped chemical works. The site is currently shown to be occupied by a metal recycling works. The risk of UXO remaining is considered to be mitigated at the location of and down to the depth of any post-war redevelopment on site.

Within the footprints of post-WWII redevelopments, the risk from shallow-buried UXO (especially 1kg German incendiaries and British AA projectiles) should have been encountered/removed during initial excavations. However, the risk from deep-buried German UXBs will only have been mitigated within the volumes of any post-war pile foundations or deep excavations for basement levels. The risk will remain within virgin geology below and amongst these post-war works, down to the maximum bomb penetration depth.



16. The Likelihood of UXO Encounter

16.1. Introduction

For UXO to pose a risk at a site, there should be a means by which any potential UXO might be encountered on that site.

The likelihood of encountering UXO on the site of proposed would depend on various factors, such as the type of UXO that might be present and the intrusive works planned on site. In most cases, UXO is more likely to be present below surface (buried) than on surface.

In general, the greater the extent and depth of intrusive works, the greater the risk of encountering. The most likely scenarios under which items of UXO could be encountered during construction works is during piling, drilling operations or bulk excavations for basement levels. The overall risk will depend on the extent of the works, such as the numbers of boreholes/piles (if required) and the volume of the excavations.

Generally speaking, the risk of encountering any type of UXO will be minimal for any works planned within the footprint and down to the depth of post-war foundations and excavations.

16.2. Encountering Aerial Delivered Ordnance

Since an aerial delivered bomb may come to rest at any depth between just below ground level and its maximum penetration depth, there is a chance that such an item (if present) could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level as well as at depth.

17. The Likelihood of UXO Initiation

17.1. Introduction

UXO does not spontaneously explode. Older UXO devices will require an external event/energy to create the conditions for detonation to occur. The likelihood that a device will function can depend on a number of factors including the type of weaponry, its age and the amount of energy it is struck with.

17.2. Initiating Aerial Delivered Ordnance

Unexploded bombs do not spontaneously explode. All high explosive filling requires significant energy to create the conditions for detonation to occur.

In recent decades, there have been a number of incidents in Europe where Allied UXBs have detonated, and incidents where fatalities have resulted.. There have been several hypotheses as to the reason why the issue is more prevalent in mainland Europe – reasons could include the significantly greater number of bombs dropped by the Allied forces on occupied Europe, the preferred use by the Allies of mechanical rather than electrical fuzes, and perhaps just good fortune. The risk from UXO in the UK is also being treated very seriously in many sectors of the construction industry, and proactive risk mitigation efforts will also have affected the lack of detonations in the UK.

There are certain construction activities which make initiation more likely, and several potential initiation mechanisms must be considered:

UXB Initiation	
Direct Impact	Unless the fuze or fuze pocket is struck, there needs to be a significant impact e.g. from piling or large and violent mechanical excavation, onto the main body of the weapon to initiate a buried iron bomb. Such violent action can cause the bomb to detonate.
Re- starting the Clock	A small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion would have taken place within the fuze mechanism over the last 70+ years that would prevent clockwork mechanisms from functioning. Nevertheless, it was reported that the clockwork fuze in a UXB dealt with by 33 EOD Regiment in Surrey in 2002 did re-start.
Friction Impact	The most likely scenario resulting in the detonation of a UXB is friction impact initiating the shock-sensitive fuze explosive. The combined effects of seasonal changes in temperature and general degradation over time can cause explosive compounds to crystallise and extrude out from the main body of the bomb. It may only require a limited amount of energy to initiate the extruded explosive which could detonate the main charge.



18. Consequences of Initiation/Encounter

18.1. Introduction

The repercussions of the inadvertent detonation of UXO during intrusive ground works, or if an item or ordnance is interfered with or disturbed, are potentially profound, both in terms of human and financial cost. A serious risk to life and limb, damage to plant and total site shutdown during follow-up investigations are potential outcomes. However, if appropriate risk mitigation measures are put in place, the chances of initiating an item of UXO during ground works is comparatively low.

The consequences of encountering UXO can be particularly notable in the case of high-profile sites (such as airports and train stations) where it is necessary to evacuate the public from the surrounding area. A site may be closed for anything from a few hours to a week with potentially significant cost in lost time. It should be noted that even the discovery of suspected or possible item of UXO during intrusive works (if handled solely through the authorities), may also involve significant loss of production

18.2. Consequences of Detonation

When considering the potential consequences of a detonation, it is necessary to identify the significant receptors that may be affected. The receptors that may potentially be at risk from a UXO detonation on a construction site will vary depending on the site specific conditions but can be summarised as follows:

- People – site workers, local residents and general public.
- Plant and equipment – construction plant on site.
- Services – subsurface gas, electricity, telecommunications.
- Structures – not only visible damage to above ground buildings, but potentially damage to foundations and the weakening of support structures.
- Environment – introduction of potentially contaminating materials.

19. 1st Line Defence Risk Assessment

19.1. Risk Assessment Stages

Taking into account the quality of the historical evidence, the assessment of the overall risk from unexploded ordnance is based on the following five considerations:

1. That the site was contaminated with unexploded ordnance.
2. That unexploded ordnance remains on site.
3. That such items will be encountered during the proposed works.
4. That ordnance may be initiated by the works operations.
5. The consequences of encountering or initiating ordnance.

19.2. Assessed Risk Level

1st Line Defence has assessed that there is an overall **Medium Risk** from German and anti-aircraft unexploded ordnance at the site of proposed works. There is also an assessed **Negligible Risk** from Allied ordnance.

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German Unexploded HE Bombs			✓	
German 1kg Incendiary Bombs			✓	
Allied Anti-Aircraft Artillery Projectiles			✓	
Allied Land Service and Small Arms Ammunition	✓			

This report has been undertaken with due diligence, and all reasonable care has been taken to access and analyse relevant historical information. By necessity, when dealing historical evidence, and when making assessments of UXO risk, various assumptions have to be made which we have discussed and justified throughout this report. Our reports take a common-sense and practical approach to the assessment of risk, and we strive to be reasonable and pragmatic in our conclusions.

It should however be stressed that if any suspect items are encountered during the proposed works, 1st Line Defence should be contacted for advice/assistance, and to re-assess the risk where necessary. The mitigation measures outlined in the next section are recommended as a minimum precaution to alert ground personnel to the history of the site, what to look out for, and what measures to take in the event that a suspect item is encountered. It should also be noted that the conclusions of this report are based on the scope of works outlined in the 'Proposed Works' section of this report. Should the scope of works change or additional works be proposed, 1st Line Defence should be contacted to re-evaluate the risk.

20. Proposed Risk Mitigation Methodology

20.1. General

The following risk mitigation measures are recommended to support the proposed works at the S. Norton & Sons site in Barking:

Type of Work	Recommended Mitigation Measure
All Works	<ul style="list-style-type: none"> • UXO Risk Management Plan It is recommended that a site-specific plan for the management of UXO risk be written for this site. This plan should be kept on site and be referred to in the event that a suspect item of UXO is encountered at any stage of the project. It should detail the steps to be taken in the event of such a discovery, considering elements such as communication, raising the alarm, nominated responsible persons etc. Contact 1st Line Defence for help/more information. • Site Specific UXO Awareness Briefings to all personnel conducting intrusive works. As a minimum precaution, all personnel working on the site should be briefed on the basic identification of UXO and what to do in the event of encountering a suspect item. This should in the first instance be undertaken by a UXO Specialist. Posters and information on the risk of UXO can be held in the site office for reference.
Shallow Intrusive Works/Open Excavations	<ul style="list-style-type: none"> • Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works When on site the role of the UXO Specialist would include: <ul style="list-style-type: none"> • Monitoring works using visual recognition and instrumentation, including immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site. • Providing UXO awareness briefings to any uninformed staff and advise staff of the need to modify working practices to take account of the ordnance risk. • To aid incident management which would involve liaison with the local authorities and police should ordnance be identified and present an explosive hazard.
Borehole/Piles	<ul style="list-style-type: none"> • Intrusive Magnetometer Survey of all borehole and pile locations down to a maximum bomb penetration depth: 1st Line Defence can deploy a range of intrusive magnetometer techniques to clear pile locations. The appropriate technique is influenced by a number of factors, but most importantly the site's ground conditions. The appropriate survey methodology would be confirmed once the enabling works have been completed.

In making this assessment and recommending these risk mitigation measures, if known, the works outlined in the 'Scope of the Proposed Works' section were considered. Should the planned works be modified or additional intrusive engineering works be considered, 1st Line Defence should be consulted to see if a re-assessment of the risk or mitigation recommendations is necessary.

1st Line Defence Limited

1st April 2020

This Report has been produced in compliance with the Construction Industry Research and Information Association (CIRIA) C681 guidelines for the writing of Detailed UXO Risk Assessments.



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Client: **WML Consulting**

 **Approximate site boundary**



Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: Google Maps



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Source: Google Earth™ Mapping Services

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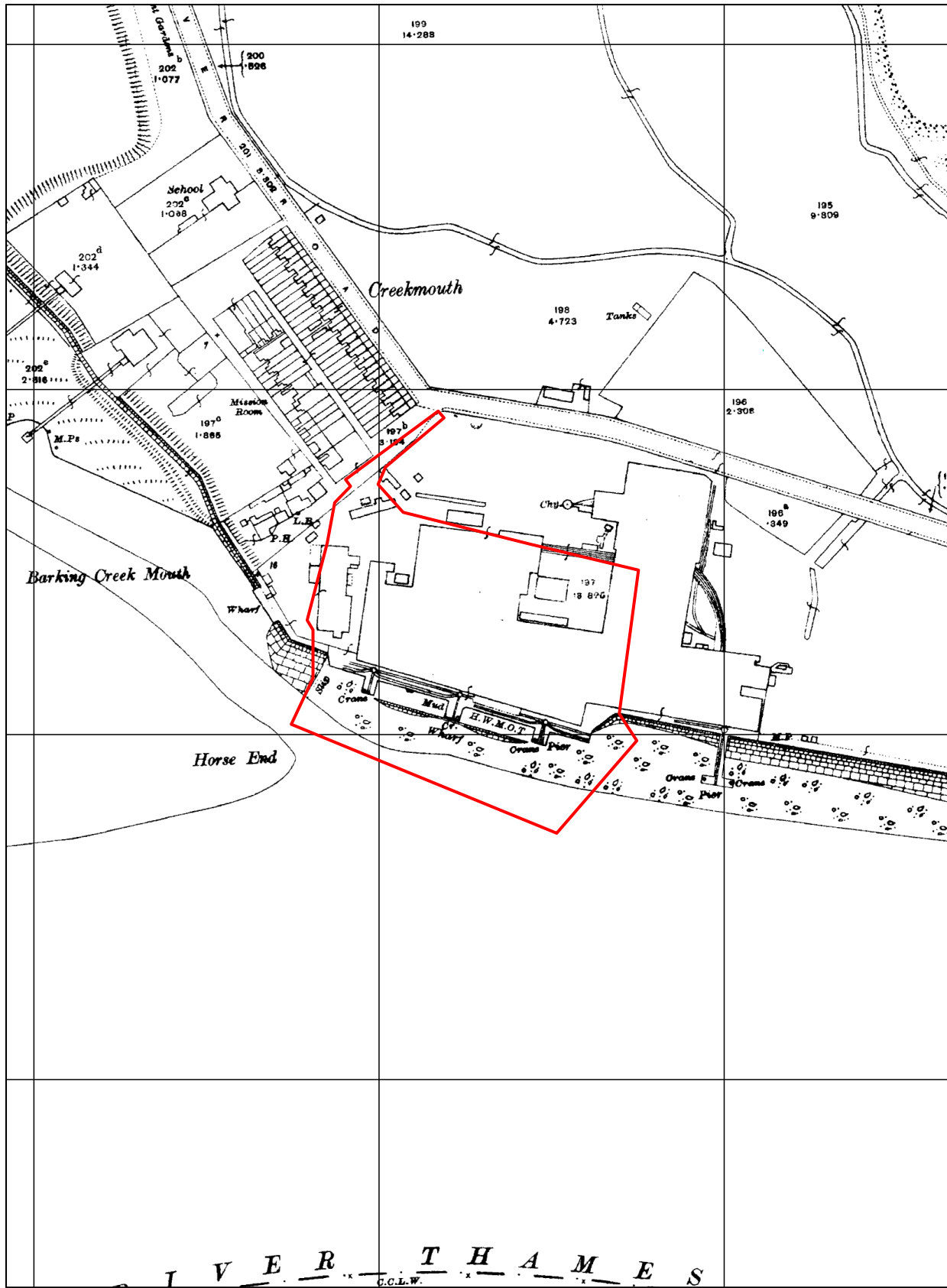
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Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: The Client



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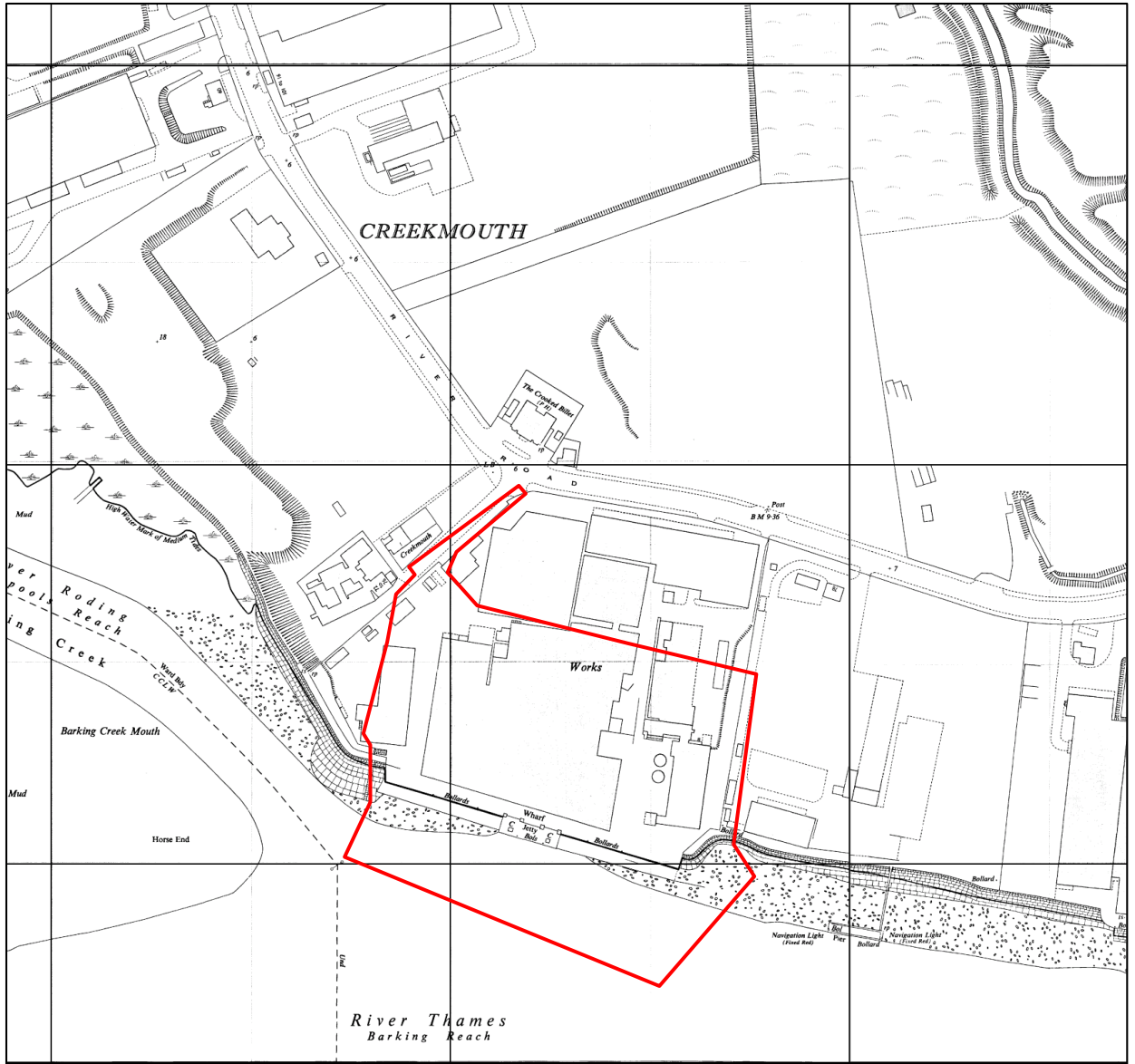
Approximate site boundary



Project: **S. Norton & Sons, River Road, Barking**

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Source: Landmark Maps

EPW006139 – Lawes Chemical Manure Co Ltd, Creekmouth, 1921



EPW006140 – Lawes Chemical Manure Co Ltd, Creekmouth, 1921



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EPW036779 – The Lawes Chemical Co Works, the Barking Guano Works and environs, Creekmouth, from the south-east, 1931



EPW036783 – The Lawes Chemical Co Works, pylons running across the Dagenham Marshes and environs, Creekmouth, from the south-west, 1931



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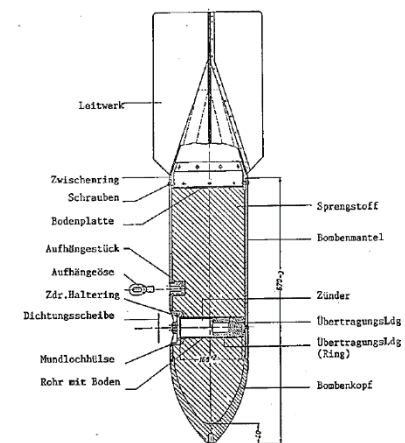
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Examples of German Air-Delivered Ordnance

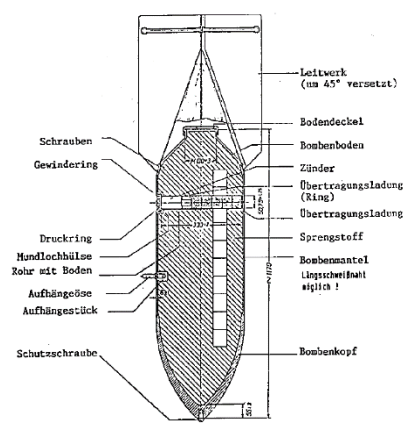
SC 50kg High Explosive Bomb

Bomb Weight	40-54kg (88-119lb)
Explosive Weight	25kg (55lb)
Fuze Type	Impact fuze/electro-mechanical time delay fuze
Bomb Dimensions	1,090 x 280mm (42.9 x 11.0in)
Body Diameter	200mm (7.87in)
Use	Against lightly damageable materials, hangars, railway rolling stock, ammunition depots, light bridges and buildings up to three stories.
Remarks	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.



SC 250kg High Explosive Bomb

Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground installations.
Remarks	It could be carried by almost all German bomber aircraft, and was used to notable effect by the Junkers Ju-87 Stuka (Sturzkampfflugzeug or dive-bomber).

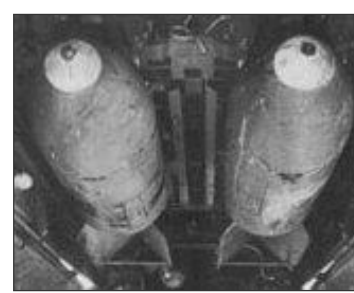
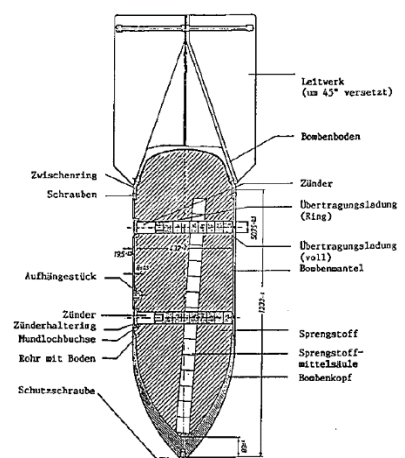


SC250 bomb being loaded onto German bomber



SC 500kg High Explosive Bomb

Bomb Weight	480-520kg (1,058-1,146lb)
Explosive Weight	250-260kg (551-573lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1957 x 640mm (77 x 25.2in)
Body Diameter	470mm (18.5in)
Use	Against fixed airfield installations, hangars, assembly halls, flyovers, underpasses, high-rise buildings and below-ground installations.
Remarks	40/60 or 50/50 Amatol TNT, trionalene. Bombs recovered with Trialen filling have cylindrical paper wrapped pellets 1-15/16 in. in length and diameter forming



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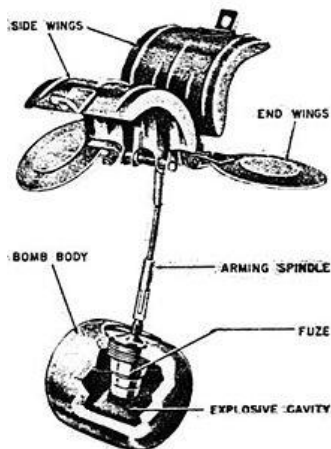
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Examples of German Air-Delivered Ordnance

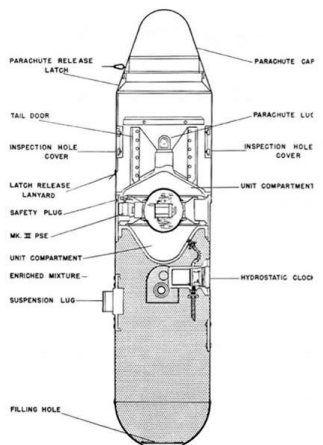
SD2 Anti-Personnel 'Butterfly Bomb'

Bomb Weight	Approx. 2kg (4.41lb)
Explosive Weight	Approx. 7.5oz (225 grams) of Amatol surrounded by a layer of bituminous composition.
Fuze Type	41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuze (anti-handling device)
Body Diameter	3in (7.62 cm) diameter, 3.1in (7.874) long
Use	Designed as an anti-personnel/ fragmentation weapon. They were delivered by air, being dropped in containers of 23-144 sub-munitions that opened at a predetermined height, thus scattering the bombs.
Remarks	Very rare. First used against Ipswich in 1940, but were also dropped on Kingston upon Hull, Grimsby and Cleethorpes in June 1943, amongst various other targets in UK. As the bombs fell the outer case flicked open by springs which caused four light metal drogues with a protruding 5 inch steel cable to deploy in the form of a parachute & wind vane which armed the device as it span.



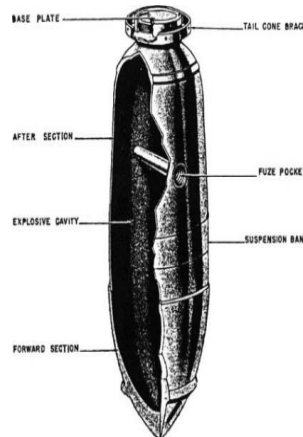
Parachute Mine (Luftmine B / LMB)

Bomb Weight	Approx. 990kg (2176lb)
Explosive Weight	Approx. 705kg (1,554lb)
Fuze Type	Impact/ Time delay / hydrostatic pressure fuze
Dimensions	2.64m x 0.64m (3.04m with parachute housing)
Use	Against civilian, military and industrial targets. Used as blast bombs and designed to detonate above ground level to maximise damage to a wider area.
Remarks	Deployed a parachute when dropped in order to control its descent. Had the potential to cause extensive damage in a 100m radius.



SC 1000kg

Bomb Weight	Approx. 993-1027kg (2,189-2,264lb)
Explosive Weight	Approx. 530-620kg (1168-1367lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Filling	Mixture of 40% amatol and 60% TNT, but when used as an anti-shiping bomb it was filled with Trialen 105, a mixture of 15% RDX, 70% TNT and 15% aluminium powder.
Bomb Dimensions	2800 x 654mm (110 x 25.8in)
Body Diameter	654mm (18.5in)
Use	SC type bombs are General Purpose Bombs used primarily for general demolition work. Constructed of parallel walls with comparatively heavy noses. They are usually of three piece welded construction



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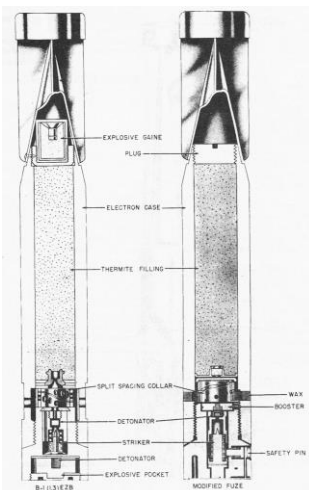
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Source: Various sources

German Incendiary Bombs

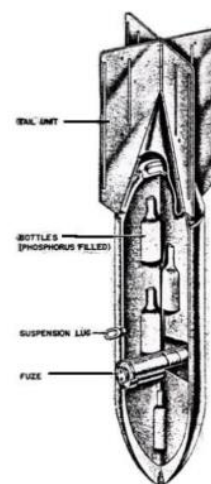
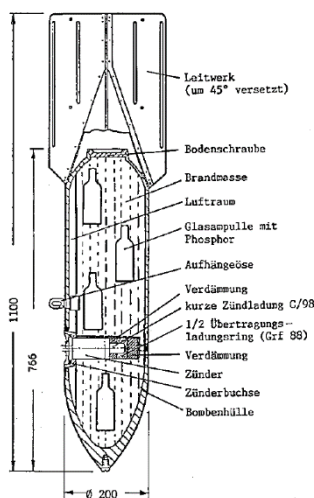
1kg Incendiary Bomb

Bomb Weight	Approx. 1.0 - 1.3kg (2.2 and 2.9lb)
Explosive Weight	Approx. 680g (1.5lb) Thermite 8-15gm Explosive Nitropenta
Fuze Type	Impact fuze
Bomb Dimensions	350 x 50mm (13.8 x 1.97in)
Body Diameter	50mm (1.97in)
Use	As incendiary – dropped in clusters on towns and industrial complexes
Remarks	Magnesium alloy case. Sometimes fitted with high explosive charge. The body is a cylindrical alloy casting threaded internally at the nose to receive the fuze holder and fuze.



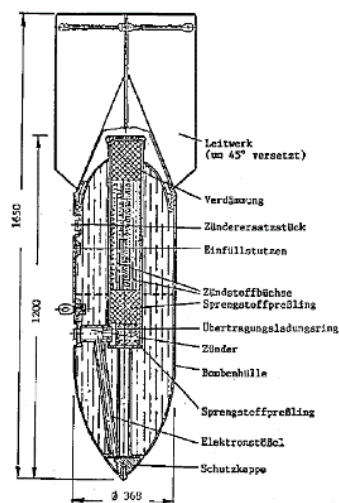
C50 A Incendiary Bomb

Bomb Weight	Approx. 41kg (90.4lb)
Explosive Weight	Approx. 0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against any targets where an incendiary effect is required
Remarks	Early fill was a phosphorus/carbon disulphide incendiary mixture



Flam C-250 Oil Bomb

Bomb Weight	Approx. 125kg (276lb)
Explosive Weight	Approx. 1kg (2.2lb)
Fuze Type	Super-fast electrical impact fuze
Filling	Mixture of 30% petrol and 70% crude oil
Bomb Dimensions	1,650 x 512.2mm (65 x 20.2in)
Body Diameter	368mm (14.5in)
Use	Often used for surprise attacks on ground troops, against troop barracks and industrial installations. Thin casing – not designed for ground penetration



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Client: **WML Consulting**

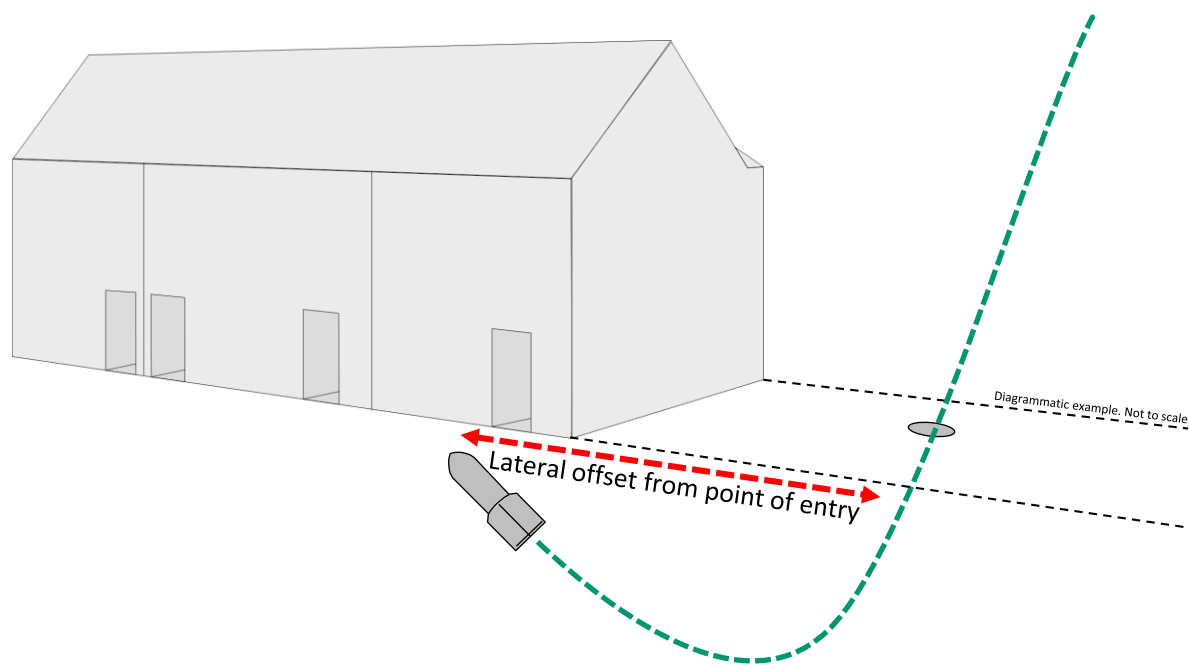
Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: Various sources

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'J-Curve' Effect



Top: J-curve Effect - Due to angle of entry, unexploded bombs would often end their trajectory at a lateral offset from point of entry, often ending up beneath adjacent extant structures/sites. The photograph above shows 250kg bomb found in Bermondsey pointing upwards, demonstrating 'J-curve'



One of the most common scenarios for UXO going unnoticed was when a UXB fell into a 'bomb site' (such as the area shown **Top Left**), the entry hole of the bomb obscured by any debris and rubble present. Note that the entry hole of a 50kg UXB could be as little as 20cm in diameter (**Left**).

BBC

NEWS

Bermondsey bomb: World War Two device safely removed



RUPERT FRERE

An unexploded World War Two bomb found in south London has been driven away safely under police and Army escort.

The 500lb (250kg) device was found on a building site in Grange Walk, Bermondsey on Monday.

March 2015

BBC

NEWS

Bethnal Green WW2 bomb: Experts remove unexploded device



CROWN COPYRIGHT

An unexploded World War Two bomb that prompted the evacuation of 700 people in east London has been made safe and removed by the military.

Families spent the night in a school hall after the 500lb bomb was found in the basement of a building site on Temple Street, in Bethnal Green, on Monday afternoon.

A 200m (650ft) exclusion zone was set up around the device.

August 2016

BBC

NEWS

Bath WW2 bomb scare: Device defused, police say



EPA

A 500lb World War Two bomb found on the site of a former school in Bath has been defused and made safe.

The discovery of the bomb on Thursday led to the evacuation of hundreds of homes and many road closures in the Lansdown area of the city.

A cordon around the site was lifted on Friday evening, more than 24 hours after residents were asked to leave their homes.

May 2016

BBC

NEWS

London City Airport reopens after WW2 bomb moved



London City Airport has reopened after an unexploded 500kg World War Two bomb was safely moved from the area.

The device was discovered at the King George V Dock on Sunday during planned work at the east London airport.

All flights were cancelled on Monday after an exclusion zone was put in place, with the closure affecting up to 16,000 passengers and nearby residents being evacuated from their homes.

May 2015



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Source: BBC News

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BASF has confirmed that an explosive device, most likely a World War II-era bomb, caused the blast that left one person injured Tuesday at a plant construction site in Germany.

The explosion was reported at BASF's Ludwigshafen toluene diisocyanate (TDI) plant, which recently broke ground for a 300,000 metric tons per year TDI production plant and other construction to expand its facilities.



BASF Provides Some Details

Responding to a request from *PaintSquare News* for more information on Wednesday (Feb. 27), BASF's manager of media relations and corporate communications Europe, Ursula von Stetten, wrote in an email, "So here [are] the facts: The detonation took place at 10:00 a.m. One person was injured; the injury is not serious. He will be kept in the hospital for some days.

"Cause of the detonation was an explosive device, presumably a bomb deriving from the Second World War. The device detonated when grounding work was done. No details on [a] delay [are] available. At the moment, the exact circumstances of the incident are [being] evaluated."

1st March 2013

WWII bomb injures 17 at Hattingen construction site



Seventeen people were injured on Friday when a construction crew unwittingly detonated a buried World War II-era bomb in Hattingen.

An excavator apparently drove over a 250-kilogramme (550 pound) American bomb, damaging surrounding buildings. Most of the injured suffered auditory trauma from the blast, and the excavator operator suffered injuries to his hands, police in the German state of **North Rhine-Westphalia** said.

"The hole was astoundingly small for such a large bomb full of so many explosives," Armin Gebhard, head of the Arnsberg department for military ordnance removal, told *The Local*. "But of course it damaged all the surrounding buildings too. We are really happy it wasn't worse."

19th September 2013



World War II bomb kills three in Germany



A special commission is investigating the causes of the explosion, while prosecutors are considering whether the team leader should face charges of manslaughter through culpable negligence, the BBC's Oana Lungescu reports from Berlin.

The blast happened an hour before the defusing operation was due to start.

Officials said the three men who died were experienced sappers, or combat engineers, who over 20 years had defused up to 700 bombs.

More than 7,000 people were immediately evacuated when the 500kg bomb was found. Several schools, a kindergarten and local companies remain closed.

2nd June 2010



June 2006

SPiegel ONLINE

Blast Kills One

World War II Bomb Explodes on German Motorway

A highway construction worker in Germany accidentally struck an unexploded World War II bomb, causing an explosion which killed him and wrecked several passing cars.



A World War II bomb has exploded during construction work on a German highway, killing one worker and injuring several motorists who were driving past, police said.

The worker had been cutting through the road surface near the south-western town of Aschaffenburg when his machine struck the bomb and triggered it. Police said they weren't sure yet what type of bomb it was. "The explosion seems to have been too small for it to have been an aircraft bomb," a police spokesman said.

23rd October 2006




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Ref: DA10683-00	Source: Various news sources
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London City airport closed until Tuesday after WWII bomb found

 theguardian.com/uk-news/2018/feb/12/london-city-airport-closed-after-wwii-bomb-found-in-thames

Patrick Greenfield

February 12, 2018

London City airport will reopen on Tuesday after an unexploded second world war bomb that was found in the river Thames near the runway was safely removed.

An exclusion zone around George V dock in east London near the airport has been lifted after Royal Navy technicians and the Metropolitan police safely removed a 500kg tapered end shell measuring about 1.5 metres that was discovered on Sunday morning during pre-planned building work.

The airport was closed all day yesterday as authorities worked to remove the device. Police and navy divers had to wait for the tide to change on Monday evening before the bomb could be brought to the surface and moved out of the dock.

Evacuated residents have been told they can return to their homes, and normal services at London City airport will resume on Tuesday .

Specialist Met police officers and Royal Navy technicians confirmed the nature of the device after it was discovered just after 5am on Sunday. The exclusion zone was implemented at 10pm the same day to ensure public safety, police said.

"Following the discovery of a world war two ordnance in King George V dock as part of planned development works, a 214-metre exclusion zone has been implemented as a precaution by the Met police. As a result, London City airport is currently closed," a spokesperson for the airport said on Sunday..

In an updated statement on Monday, a spokesperson for the airport said: "The World War Two ordnance discovered in King George V Dock has been safely removed by the Royal Navy and Met Police. As a result, the exclusion zone has now been lifted and the airport will be open as normal on Tuesday."



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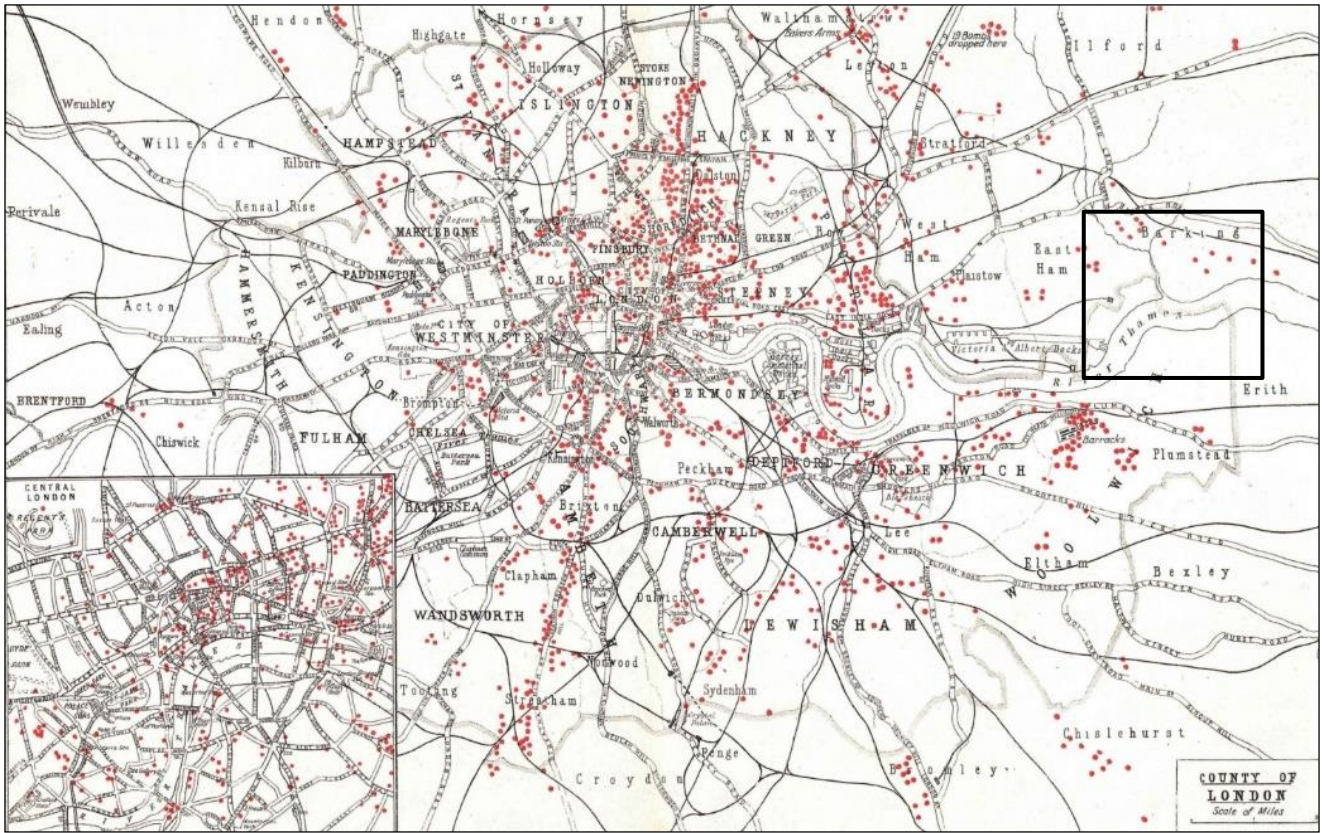
Client: **WML Consulting**

Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: The Guardian

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Examples of 50 and 100kg German WWI bombs



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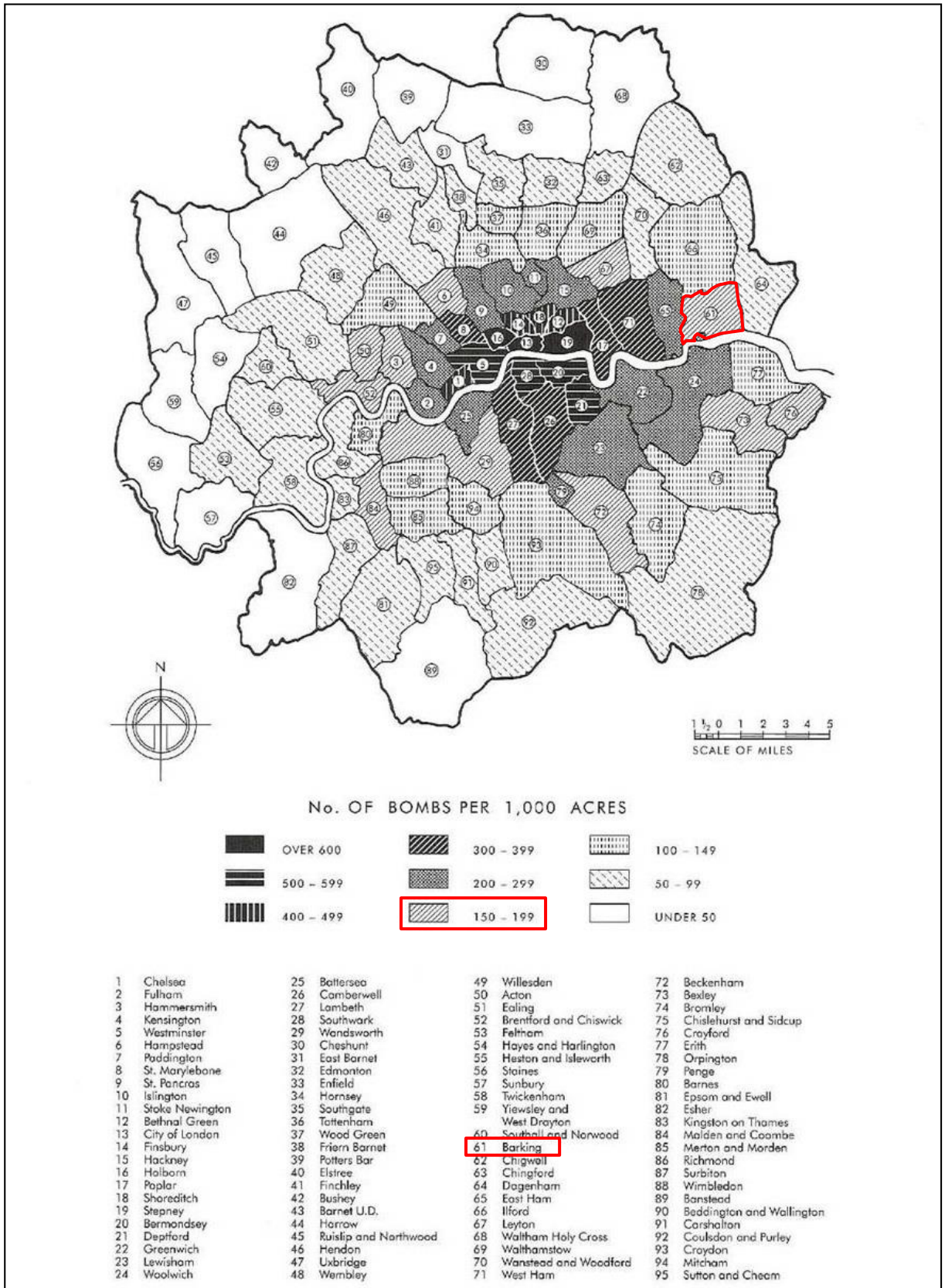
Client: **WML Consulting**

Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: The National Archives, Kew





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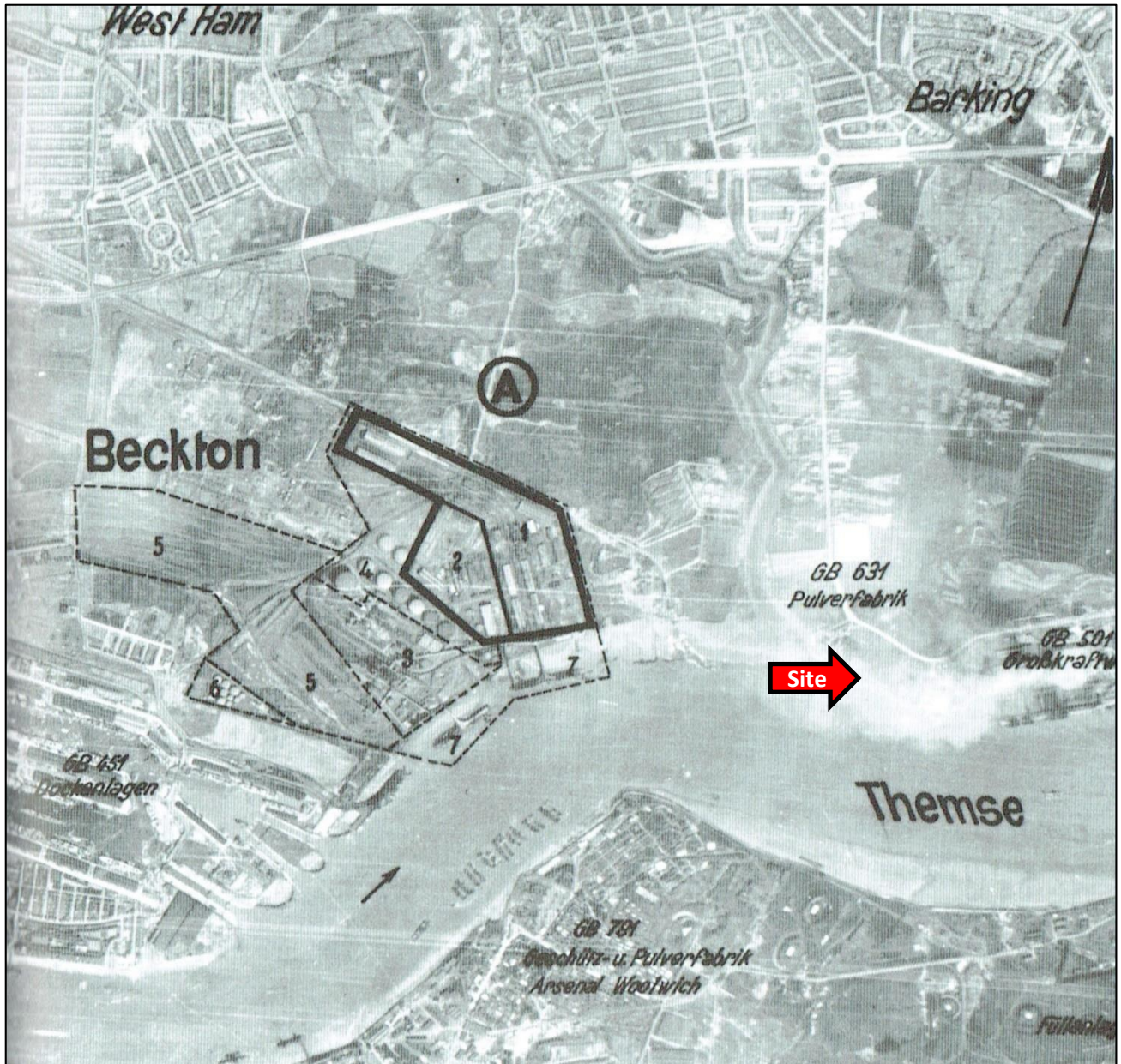
Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: The London Metropolitan Archives



Luftwaffe Photograph, 24th May 1939



London – Beckton/Barking

A - The Beckon Gas Works

GB 451 – Dockenlagen – Docklands GB

GB 501 – Grobkraften – Power Station

631 – Pulberfabrik – Powder Factory

GB 781 – Geschuiz – u. Pulverfabrik – Woolwich Arsenal



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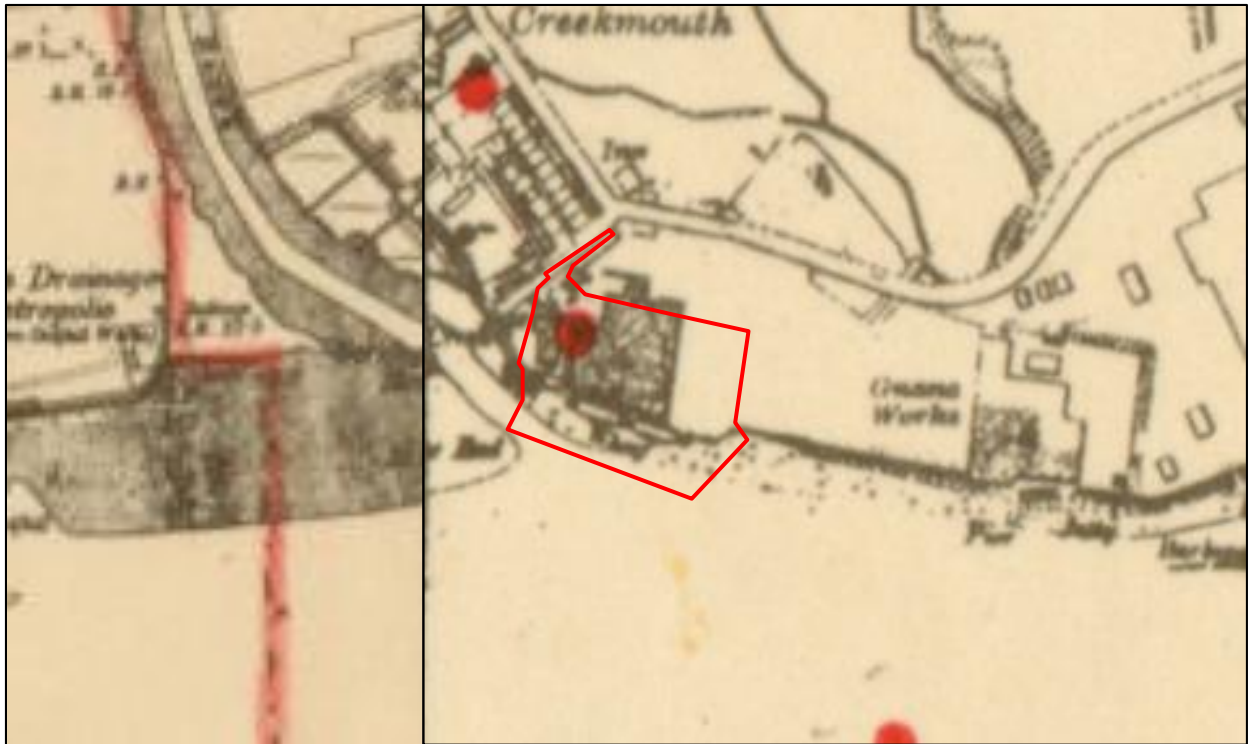
Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: Nigel J. Clarke, "Adolf Hitler's Home Counties Holiday Snaps"



Night Bombing up to 7th October 1940



Night Bombing - 7th October 1940 to 6th June 1941



●● Recorded bomb strike



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— Approximate site boundary

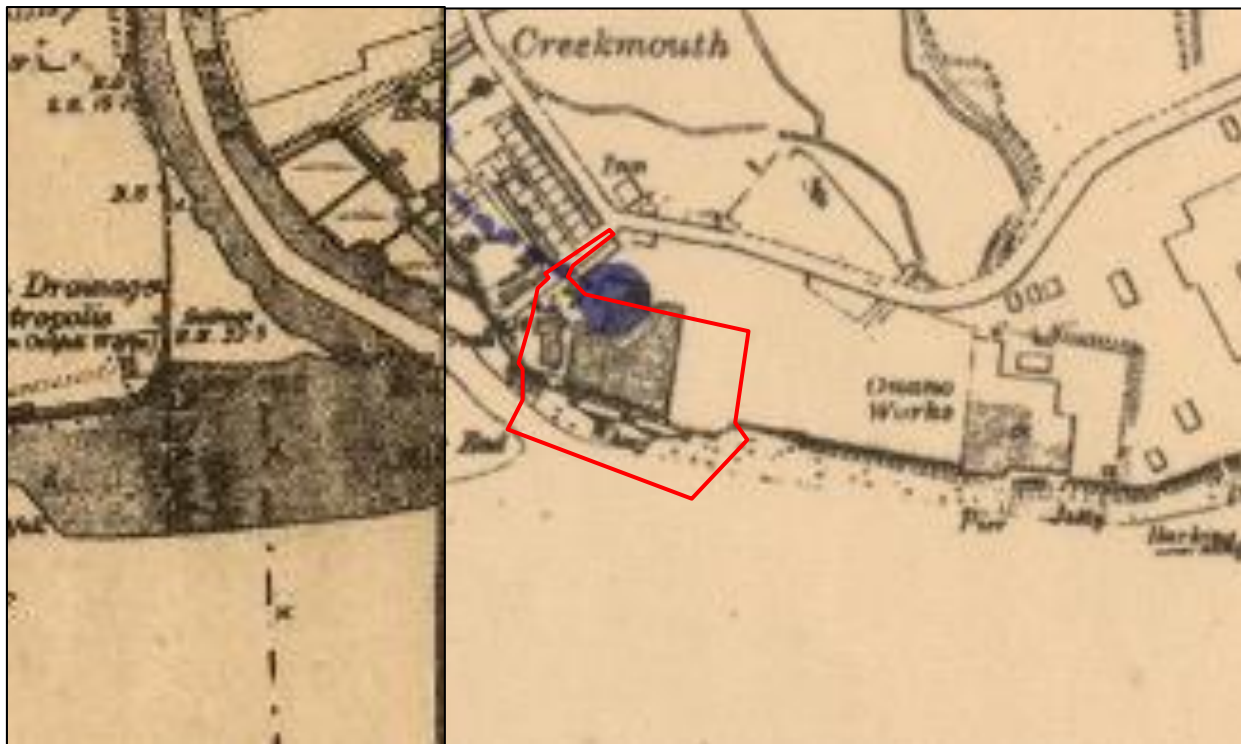


Project: **S. Norton & Sons, River Road, Barking**

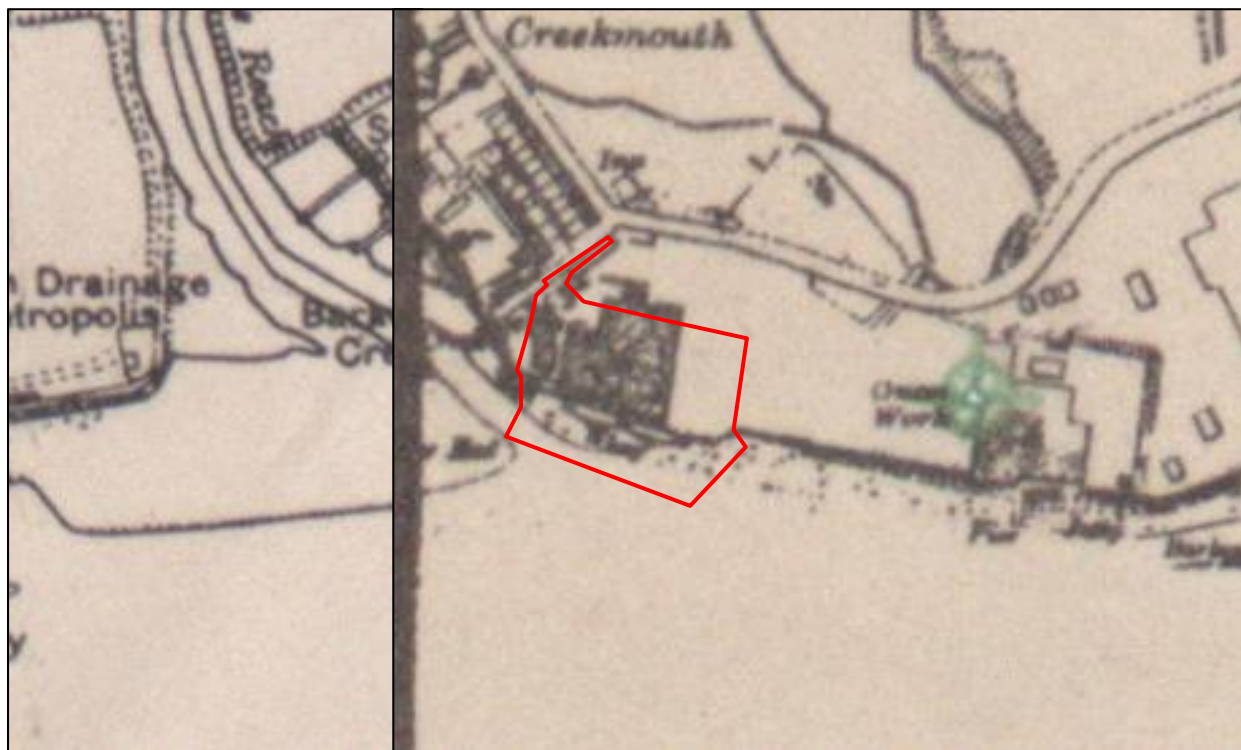
Ref: **DA10683-00**

Source: The National Archives, Kew

Night Bombing – 7th to 14th October 1940



Night Bombing - 25th November to 2nd December 1940



- Recorded HE bomb strike
- ☩ Recorded incendiary bomb shower
- ⊙ Recorded UXB strike
- Recorded oil bomb strike

Key to weekly map symbol colours
 Monday - Brown Friday - Green
 Tuesday - Vermilion Saturday - Violet
 Wednesday - Blue Sunday - Yellow
 Thursday - Black



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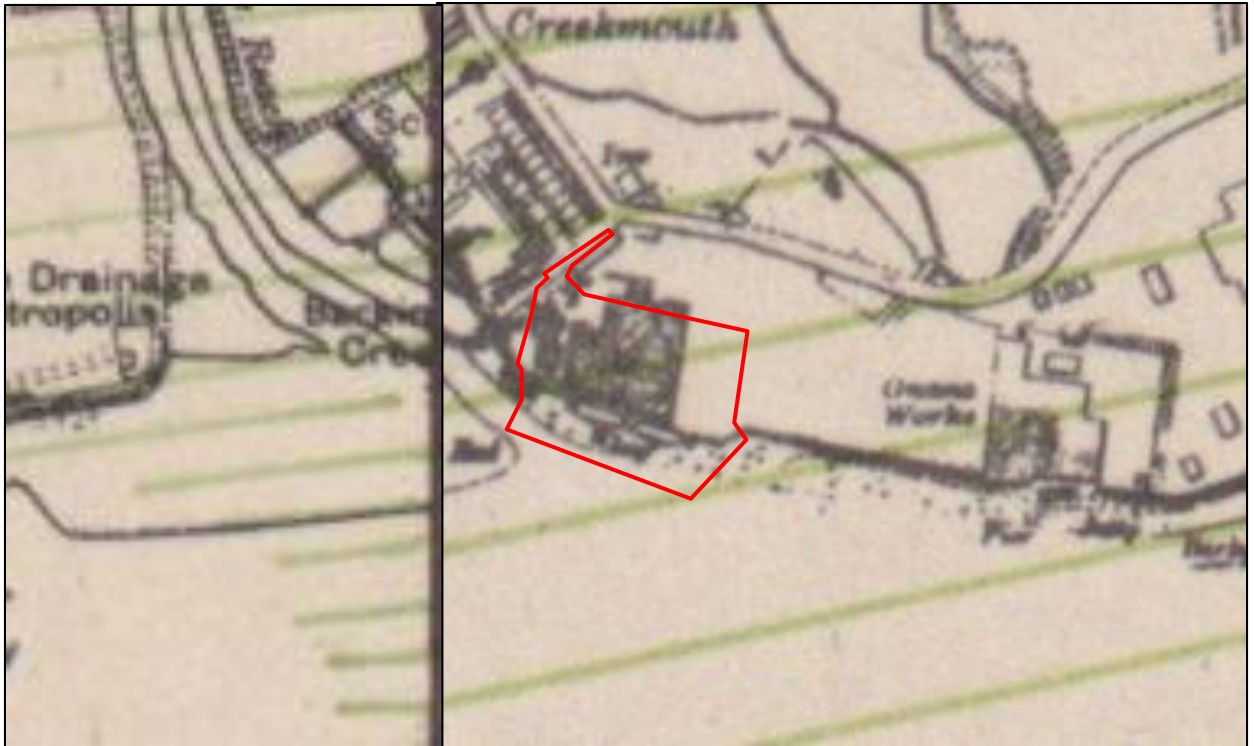
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Source: The National Archives, Kew

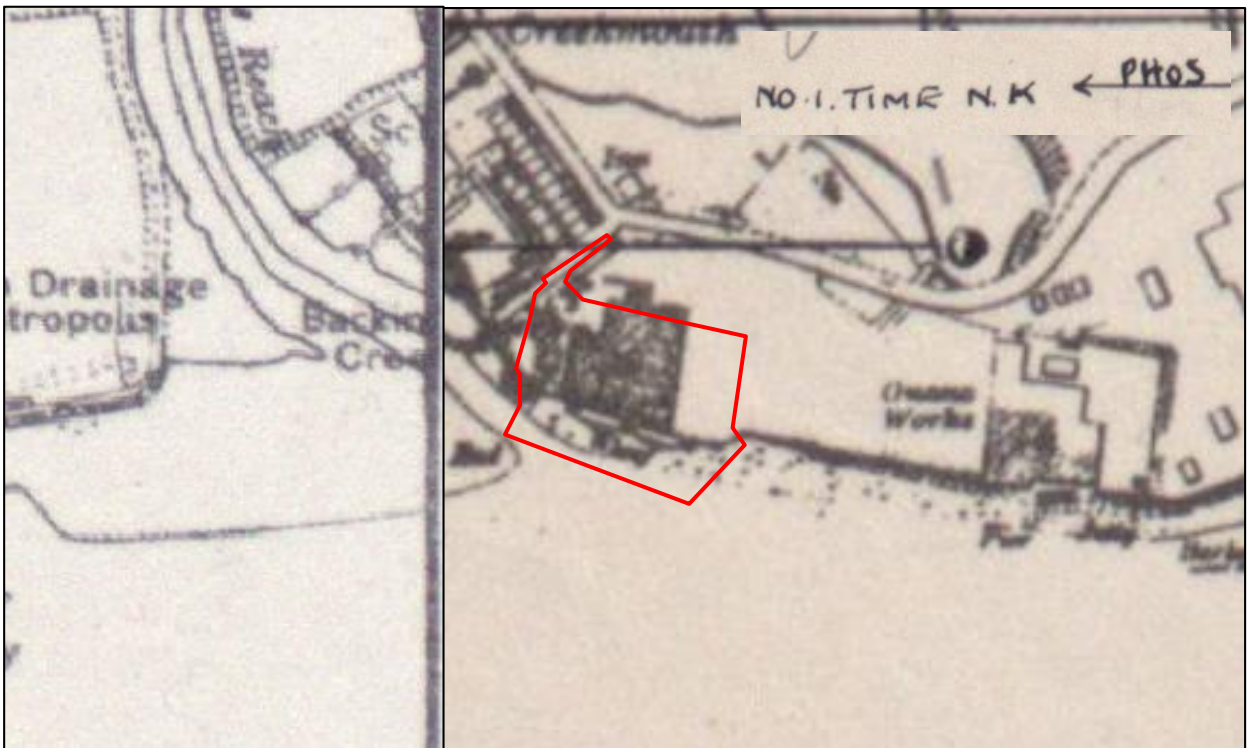
Approximate site boundary



Night Bombing – 6th to 13th January 1941



Night Bombing – 17th to 23rd January 1944



- Recorded HE bomb strike
- ⊙ Recorded UXB strike
- ▨ Recorded incendiary bomb shower
- Recorded oil bomb strike

Key to weekly map symbol colours

- Monday - Brown
- Tuesday - Vermilion
- Wednesday - Blue
- Thursday - Black
- Friday - Green
- Saturday - Violet
- Sunday - Yellow

— Approximate site boundary



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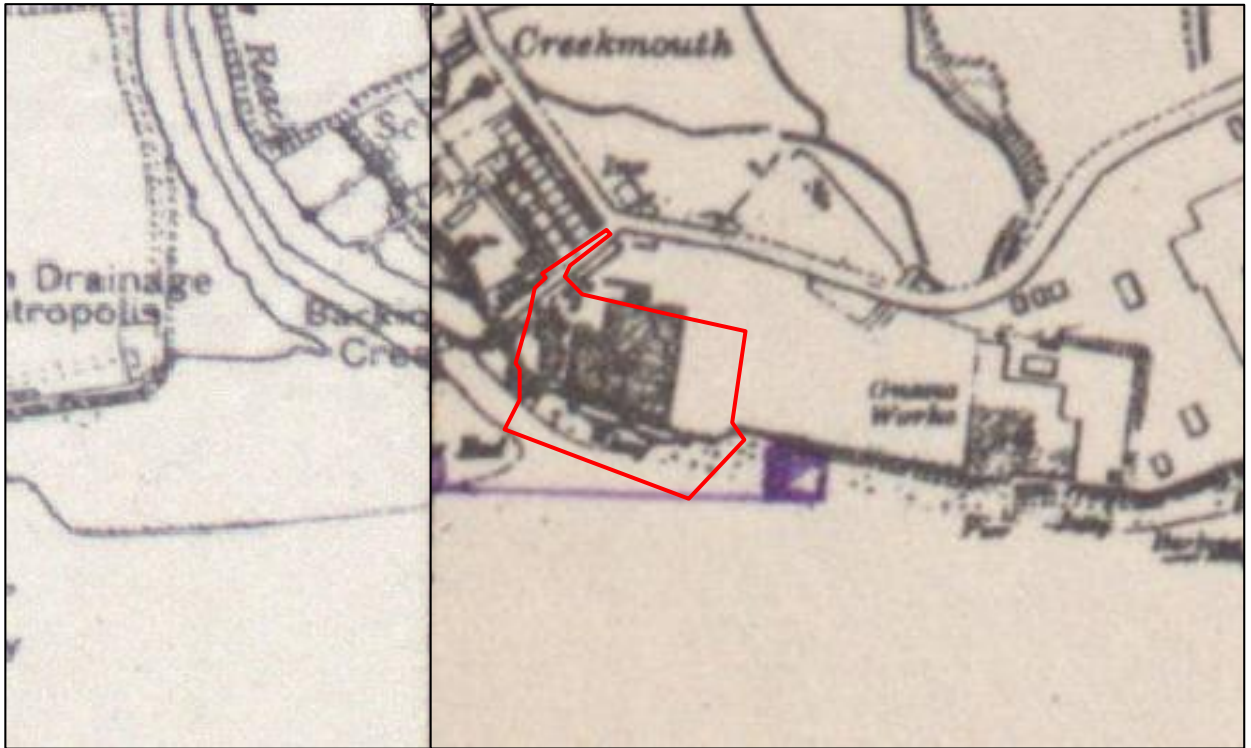
Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: The National Archives, Kew



Night Bombing – 24th to 30th January 1941



- Recorded HE bomb strike
- ⦿ Recorded UXB strike
- ▨ Recorded incendiary bomb shower
- Recorded oil bomb strike

Key to weekly map symbol colours

- Monday - Brown
- Tuesday - Vermilion
- Wednesday - Blue
- Thursday - Black
- Friday - Green
- Saturday - Violet
- Sunday - Yellow

Approximate site boundary



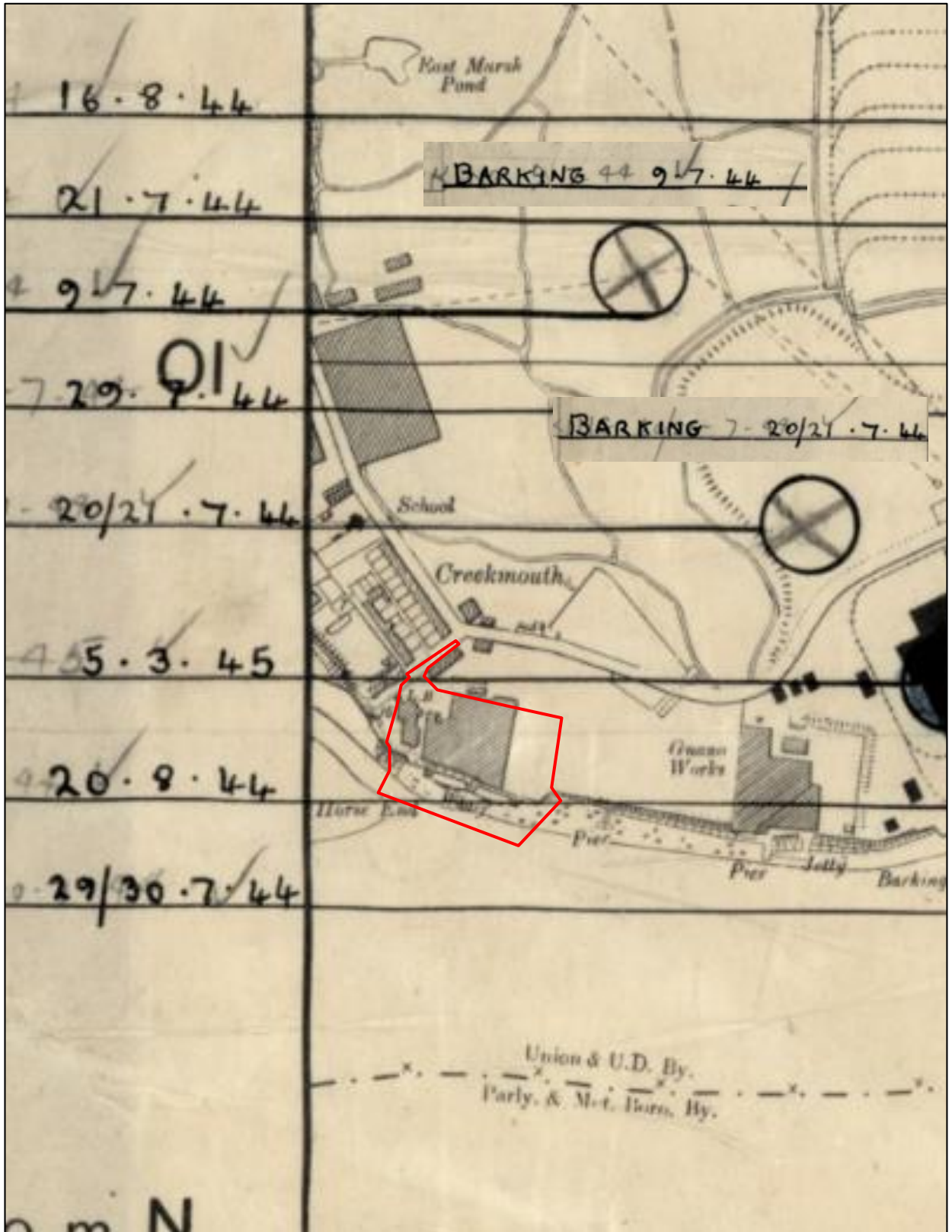
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Source: The National Archives, Kew



 V-1 flying bomb



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 **Approximate site boundary**


Project: **S. Norton & Sons, River Road, Barking**



Ref: **DA10683-00**

Source: The National Archives, Kew



 Recorded AA Shell



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Client: **WML Consulting**

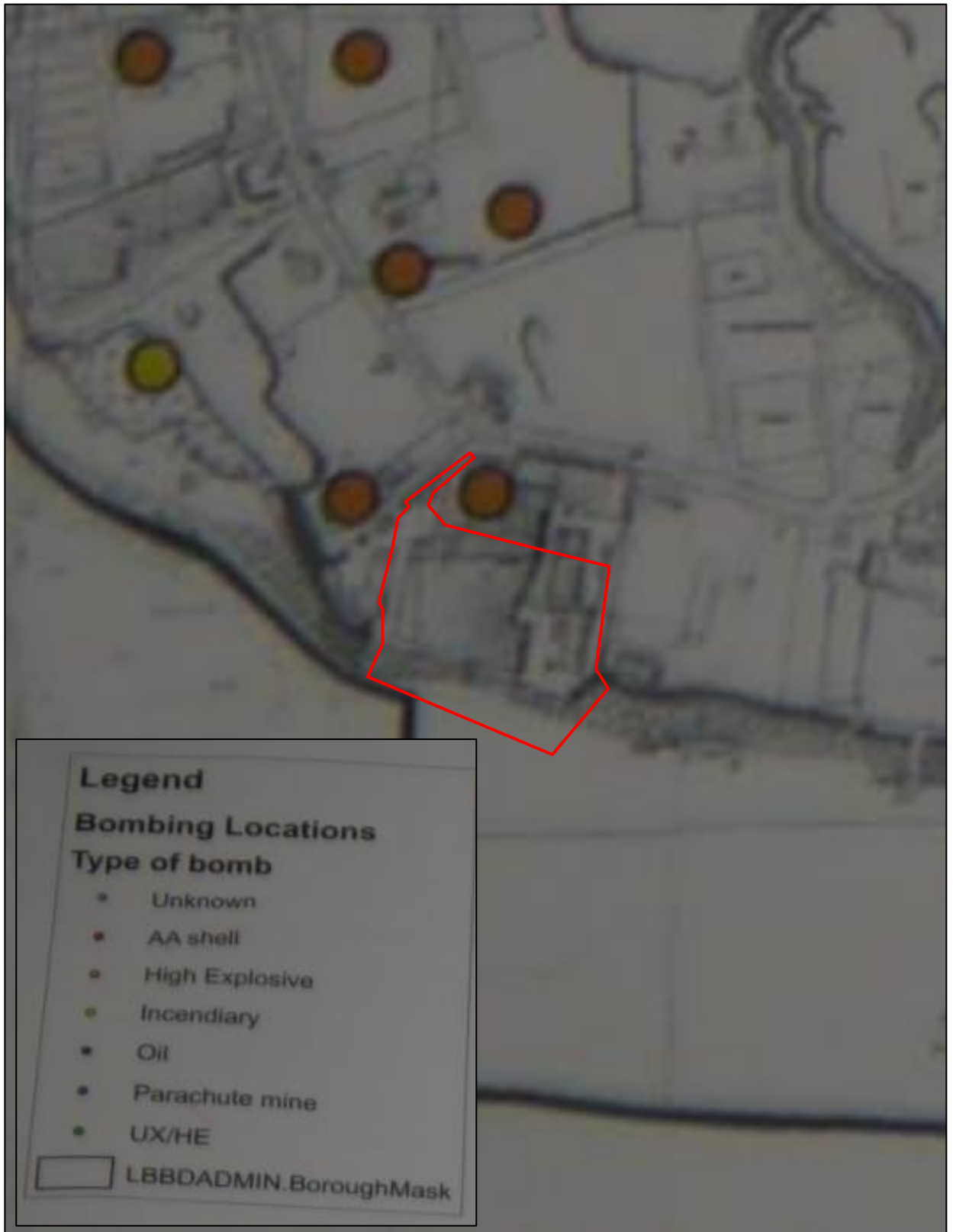
 **Approximate site boundary**



Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: Barking and Dagenham Archives



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 **Approximate site boundary**

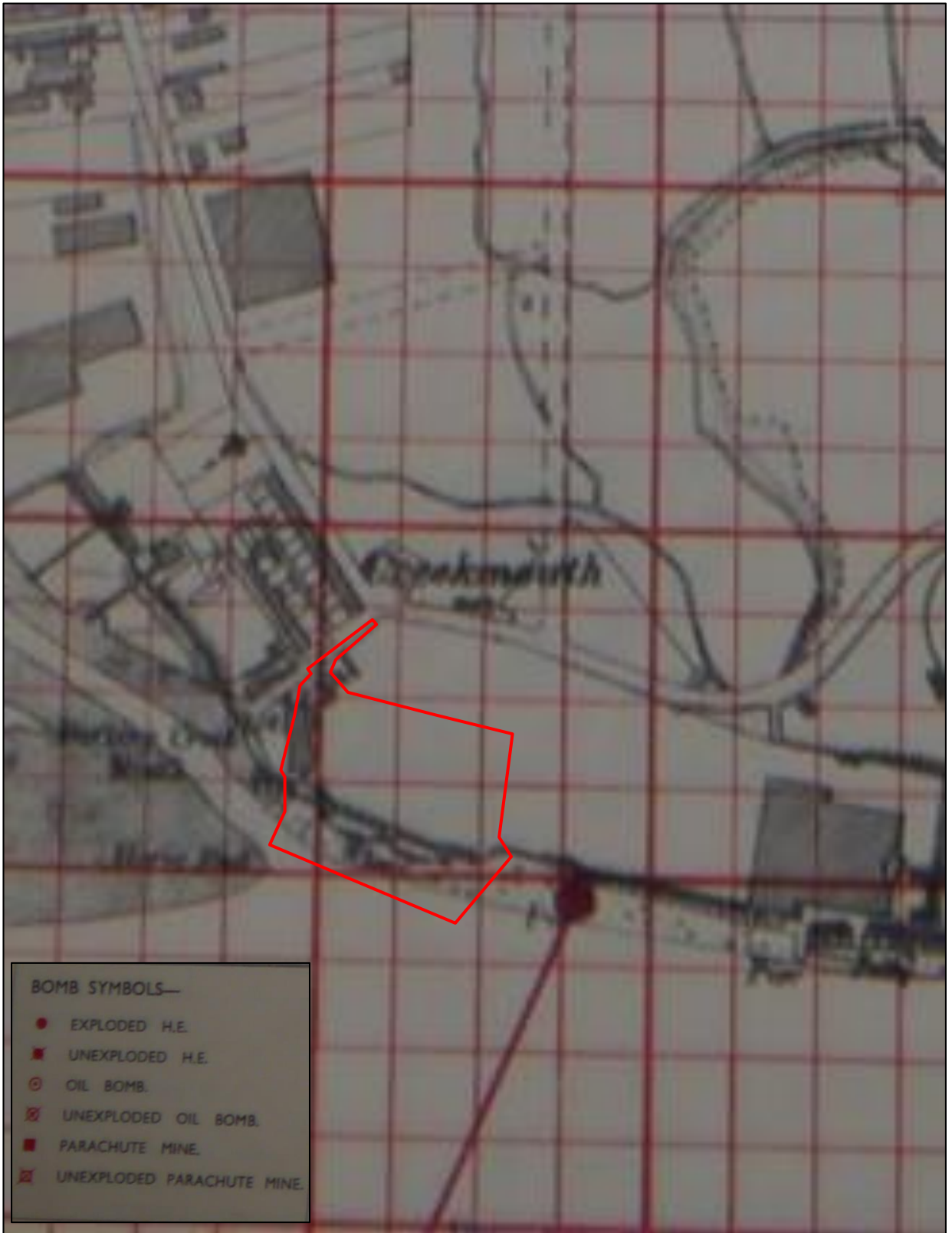


Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: The National Archives, Kew

29th January 1944



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Tel: +44 (0)1992 245 020

Client: **WML Consulting**

 **Approximate site boundary**



Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: Barking and Dagenham Archives



● Recorded V-1 Pilotless Aircraft strike



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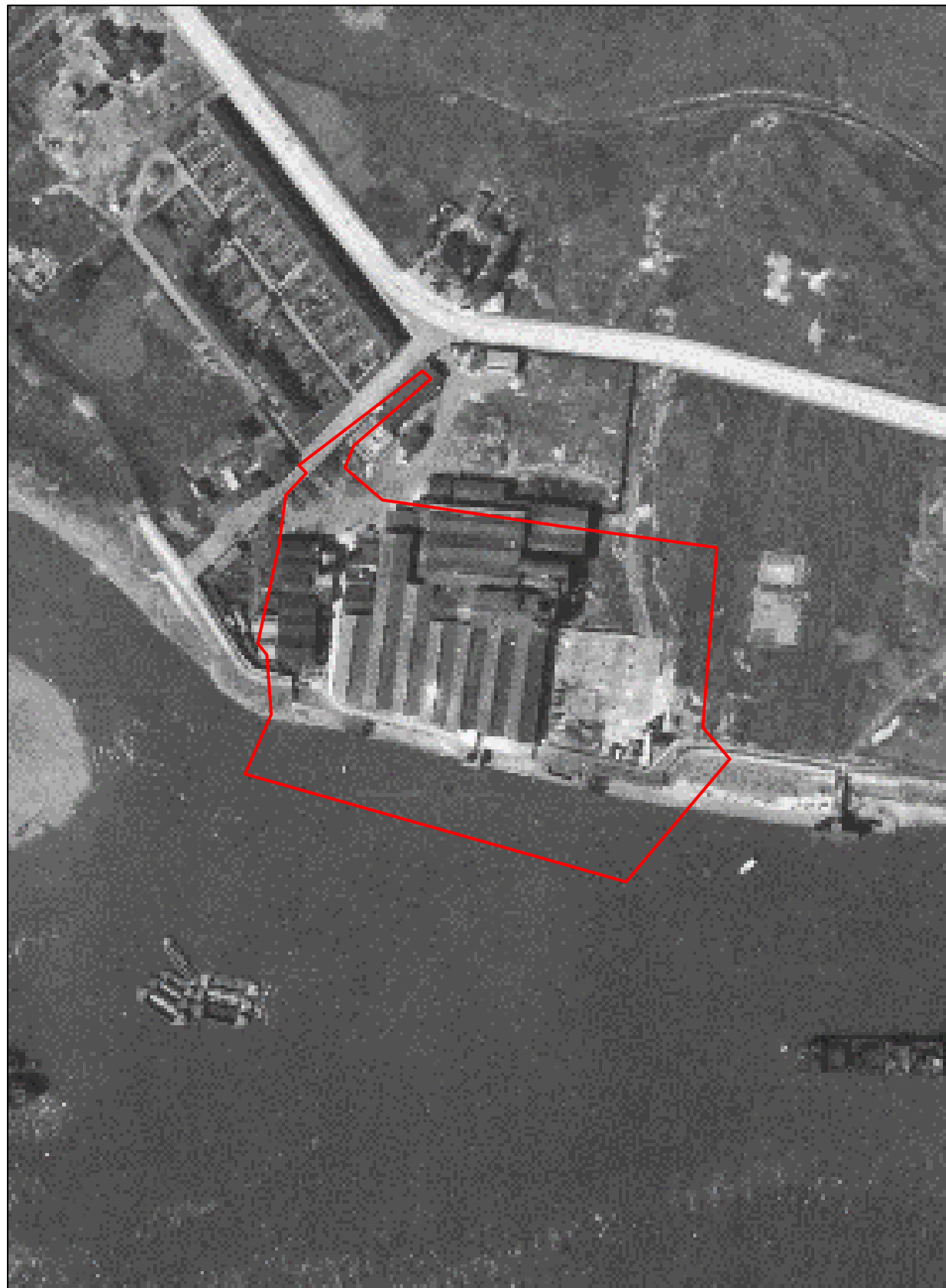
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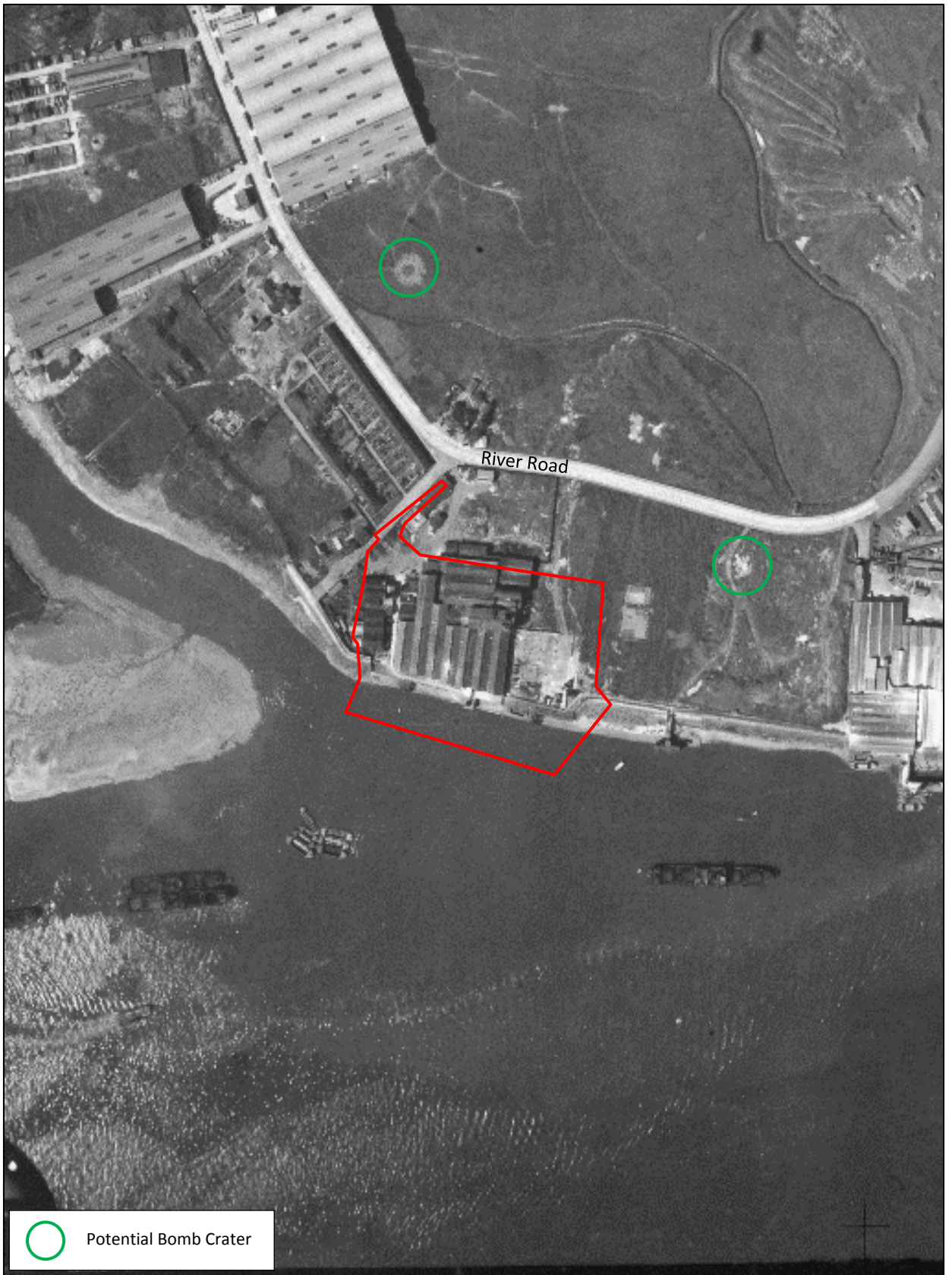


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Source: National Monuments Record Office (Historic England)

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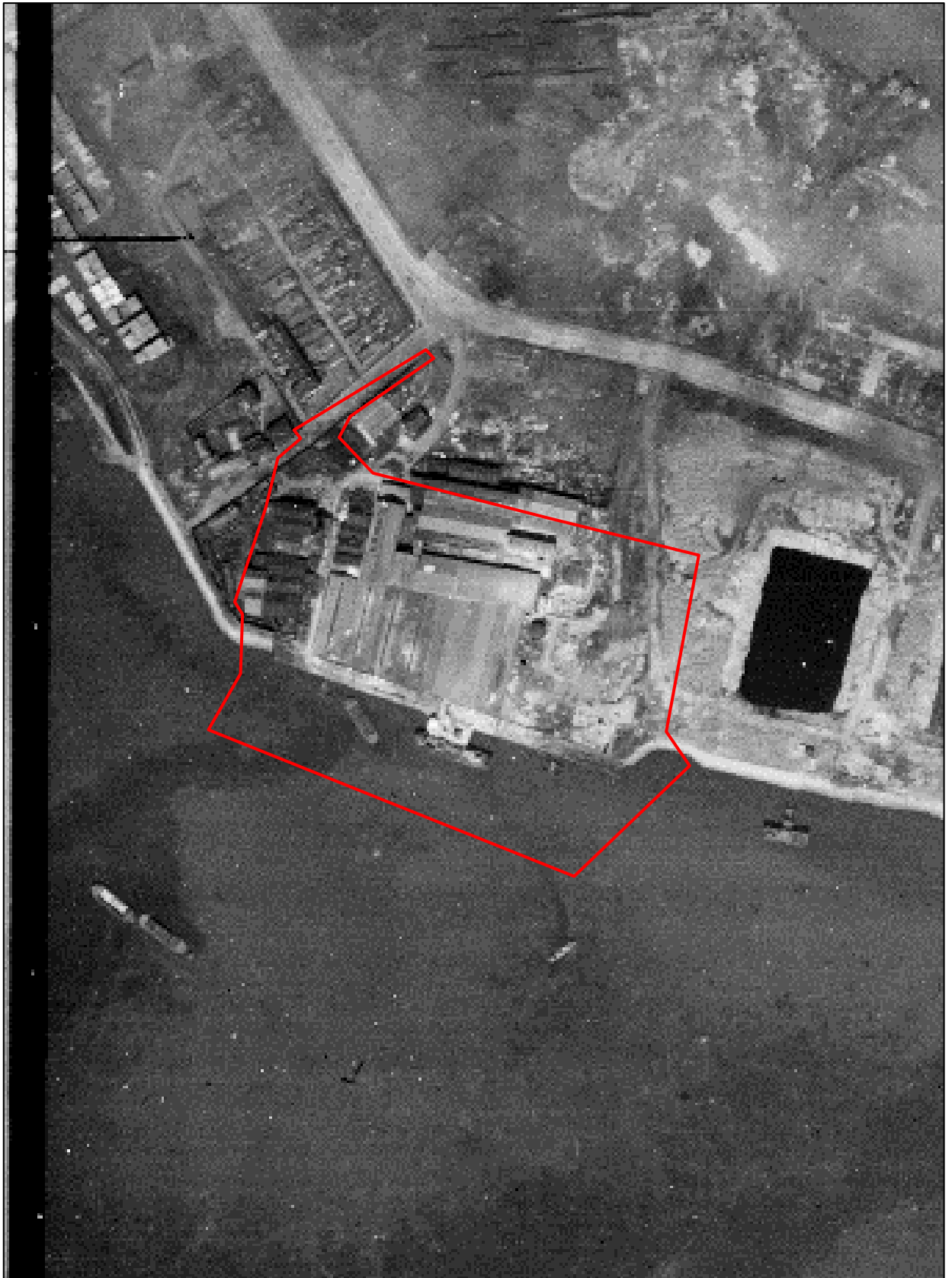


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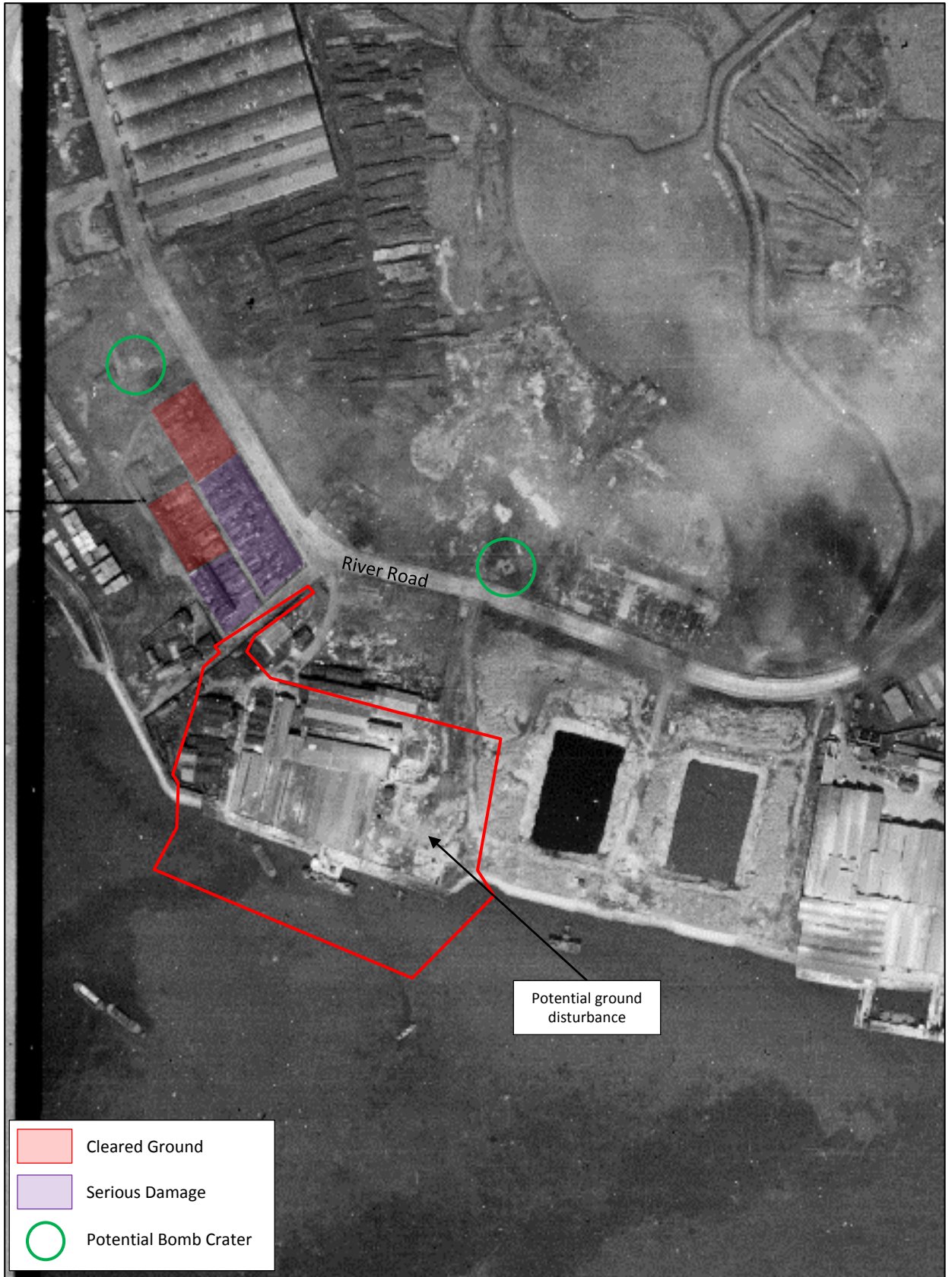
 **Approximate site boundary**



Project: **S. Norton & Sons, River Road, Barking**

Ref: **DA10683-00**

Source: National Monuments Record Office (Historic England)



	Cleared Ground
	Serious Damage
	Potential Bomb Crater



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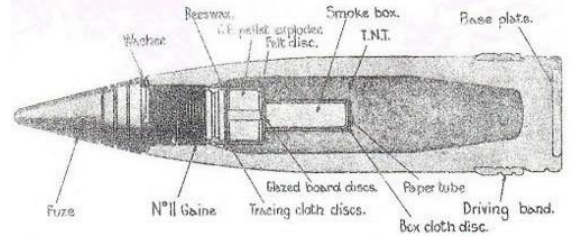
Source: National Monuments Record Office (Historic England)

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Examples of Anti-Aircraft Projectiles

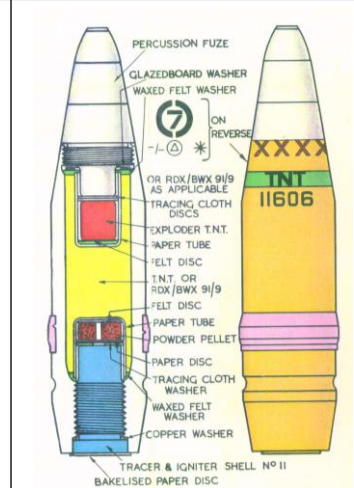
3.7 Inch QF Anti-Aircraft Projectile

Projectile Weight	28lb (12.6 kg)
Explosive Weight	2.52lbs
Fuze Type	Mechanical Time Fuze
Dimensions	3.7in x 14.7in (94mm x 360mm)
Rate of Fire	10 to 20 rounds per minute
Use	The 3.7in AA Mks 1-3 were the standard Heavy Anti-Aircraft guns of the British Army.
Ceiling	30,000ft to 59,000ft



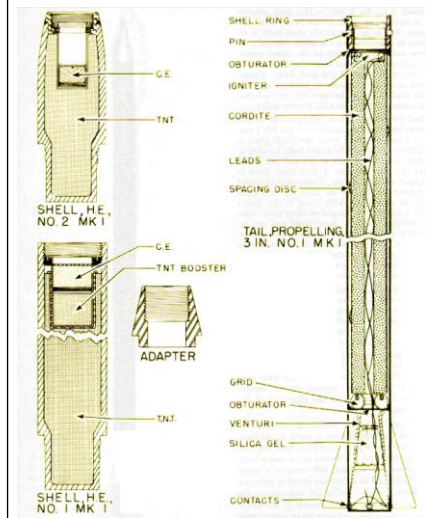
40mm Bofors Projectile

Projectile Weight	1.96lb (0.86kg)
Explosive Weight	300g (0.6lb)
Fuze Type	Impact Fuze
Rate of Fire	120 rounds per minute
Projectile Dimensions	40 x 180mm
Ceiling	23,000ft (7000m)
Remarks	Light quick fire high explosive anti-aircraft projectile. Each projectile fitted with small tracer element. If no target hit, shell would explode when tracer burnt out. Designed to engage aircraft flying below 2,000ft



3in Unrotated Projectile (UP) Anti-Aircraft Rocket ("Z" Battery)

HE Projectile Weight	3.4kg (7.6lb)
Explosive Weight	0.96kg (2.13lb)
Filling	High Explosive – TNT. Fitted with aerial burst fuzing
Dimensions of projectile	236 x 83mm (9.29 x 3.25in)
Remarks	As a short range rocket-firing anti-aircraft weapon developed for the Royal Navy. It was used extensively by British ships during the early days of World War II. The UP was also used in ground-based single and 128-round launchers known as Z Batteries. Shell consists of a steel cylinder reduced in diameter at the base and threaded externally to screw into the shell ring of the rocket motor



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Client: **WML Consulting**
Project: **S. Norton & Sons, River Road, Barking**
Ref: **DA10683-00** Source: Various sources

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