



1ST LINE DEFENCE



Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	St Ann's Hospital
Client	Hill
Site Address	St Ann's Road, Tottenham, London, N15 3TH
Report Reference	DA5244a-00
Date	18 th August 2021
Originator	CB



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Executive Summary

Site Location and Description

The site is located in South Tottenham, in the London Borough of Haringey.

It is an approximately rectangular parcel of land that comprises the structures and grounds of St Ann's Hospital, as well as accompanying access roads and areas of open vegetation. It is bound to the north by St Ann's Road, with Hermitage Road situated to the east. To the south is a section of the London Overground railway, whilst residential properties facing out onto Warwick Gardens border the site to the west.

The site is approximately centred on the OS grid reference: **TQ 3242588555**.

Proposed Works

The exact scope of proposed works on site was not known when this report was written. It is believed that ground investigation works will take place on site prior to any construction occurring.

Geology and Bomb Penetration Depth

Site-specific geotechnical information was not available to 1st Line Defence at the time of the production of this report. An assessment of maximum bomb penetration depth can be made once such 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 predominantly a **Low Risk** that items of unexploded German aerial delivered and anti-aircraft ordnance could have fallen unrecorded within the site boundary, with a small section of the site in the west assessed to be of **Medium Risk**.

- The Municipal Borough of Tottenham was subject to a moderate density of bombing in comparison to other areas of London, with an average of 103.9 bombs recorded per 1,000 acres according to Home Office statistics. Bombing did however still occur on a regular basis throughout the blitz and can be largely attributed to targets in the locality such as the Tottenham Water Treatment Works, as well the borough's location north of the centre of London.
- London bomb census mapping and ARP incident records suggest that no bomb incidents took place directly within the site boundary. A number of bomb strikes are well recorded in the site's surroundings. These included HE bomb strikes and a V1 flying bomb surrounding Warwick Gardens, to the immediate west of the site, a UXB to the north-west of the site on St. Ann's Road and a UXAA projectile to the immediate south-east of the site, at the railway embankment near Hermitage Road. One bomb strike is recorded within the south-west of the site on one bomb census map edition, but when referenced with all other available evidence is anticipated to have been a misplot.
- There is no obvious sign of bomb damage within the site boundary; all structures have appeared to survive intact and in use in 1945 aerial imagery. However, an area of severe damage is visible immediately west of the site on Warwick Gardens road; three areas of clearance and an area of severe structural damage are noted. Whilst this damage can partially be attributed to the aforementioned V-weapon strike, in 1944, HE strikes are also recorded in the immediate locality in 1940. It has therefore not been possible to accurately determine to what extent this damage was already caused by HE bomb strikes prior to the V-weapon strike.
- This is of note, as this level of damage on the western boundary of the site could have created conditions whereby an item of UXO could have gone unnoticed and could have ended up within the site due to the 'J-curve' effect (see section 12.2) Volumes of rubble and debris and damaged structures, if present, are anticipated to have reduced access and to have been obstructive to post raid evidence of UXO, such as bomb entry holes. It is not possible to discount that such conditions could have had a direct impact on the far western section of the site area.
- The structures within the remainder of the site boundary do not appear to have sustained any obvious signs of damage. Furthermore, all available evidence, including anecdotal accounts and wartime hospital minutes, indicate that that hospital was in regular operation and subject to regular access and maintenance throughout the war. Whilst there is the potential that the ground cover in the open areas of the site can provide UXO a means to go unnoticed; it is considered a low probability in this instance. The urban location and anticipated access frequency would increase the detection probability of UXO in the area, as well as the lack of evidence to suggest that the site was subject to frequent heavy bombing raids.

**UXO Risk Assessment**

- Based on this criteria 1st Line Defence have assessed the majority of the site to be at **Low Risk**, with the far western section of the site at **Medium Risk**. A buffer zone has also been provided to take into account the 'J-curve' effect, whereby a bomb can move laterally underground and come to rest within adjoining ground away from its point of entry.
- 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 St Ann's Hospital site:

All Works

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

Medium Risk Areas**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.



Risk Map



For indicative purposes – not to scale.
Please note that this assessed risk map may not take into account all post-war redevelopment/excavations on site.



Low Risk



Medium Risk

Works in all Areas:

- Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works.

Works in Medium Risk Areas:

- Unexploded Ordnance (UXO) Specialist presence on site to support open intrusive works.
- Intrusive Magnetometer Survey of any borehole or pile locations/clusters down to an assessed maximum bomb penetration depth.



Glossary

Abbreviation	Definition
AA	Anti-Aircraft
AFS	Auxiliary Fire Service
AP	Anti-Personnel
ARP	Air Raid Precautions
AWAS	Air Warfare Analysis Section
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
LAA	Light Anti-Aircraft
LCC	London County Council
LRRB	Long Range Rocket Bomb (V-2)
LSA	Land Service Ammunition
MOL	Molotov (Incendiary Bomb)
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
SD1000	1,000kg high explosive bomb
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: St Ann's Hospital
Client: Hill

1. Introduction

1.1. Background

1st Line Defence has been commissioned by Hill to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for the proposed works at St Ann's Hospital.

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 St Ann's Hospital. 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 risk that the site was contaminated with UXO.
2. The risk that UXO remains on the site.
3. The risk that UXO may be encountered during the proposed works.
4. The risk 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, Kew, and Tottenham Archives.
- Historical mapping datasets.
- Historic England National Monuments Record.
- Relevant information supplied by Hill.
- Available material from 33 Engineer Regiment (EOD) Archive.
- 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 Tottenham Archives and The National Archives.

2.4. 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 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. Background to Bombing Records

During WWII, bombing records were gathered by the police, Air Raid Precaution (ARP) wardens and military personnel. Records were maintained in the form of local and regional written records, maps depicting the locations of individual strikes, and maps indicating the levels of damage sustained by structures. Records typically documented when, where and what types of bombs had fallen during an air raid. Records of bomb strikes were made either through direct observation or by post-raid surveys. The immediate priority was focused on assisting casualties and minimising damage. As a result, some records were incomplete and contradictory.

The quality, detail and nature of record keeping could vary considerably between boroughs and towns. 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. Many records were even damaged or destroyed in subsequent bombing 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. Furthermore, records of attacks on military or strategic targets were often maintained separately from the general records and have not always survived.

4. Background to Allied Records

During WWII, considerable areas of land were requisitioned by the army for the purpose of defence, training, and the construction of airfields and facilities for munitions production. 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 air and land defences. In rural locations, it may be possible to obtain plans of airfields and military establishments, as well as operational training logs, plans and personal memoirs.

5. UK Regulatory Environment

5.1. 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.

5.2. 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 within both the scope and purpose of the legislation. It is therefore implied that there is an obligation on 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.

5.3. 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.

5.4. 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.

6. Role of Commercial UXO Contractors and The Authorities

6.1. Commercial UXO Contractors

In the event that a risk of UXO contamination is detected at the proposed site, the support of a UXO specialist may be recommended. A UXO specialist may be able to avoid unnecessary call-outs to the authorities through the disposal or removal of low risk items. In addition, a specialist will assist in the swift recognition of high risk items, and will thereafter co-ordinate with the local authority with the objective of causing minimal levels of disruption to site operations, whilst putting in place safe and appropriate measures.

For more information on the role of commercial UXO specialists, see *CIRIA C681*.

6.2. 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 (JSEOD) to arrange for investigation and/or disposal. 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 JSEOD'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. The latter process is lengthy and may necessitate the establishment of additional cordons and evacuations.

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 JSEOD may not treat each occurrence as an emergency and will recommend the construction company put in place alternative procedures, such as the appointment of a commercial contractor to manage the situation.

7. The Site

7.1. Site Location

The site is located in South Tottenham, in the London Borough of Haringey.

It is bound to the north by St Ann's Road, with Hermitage Road situated to the east. To the south is a section of the London Overground railway, whilst residential properties facing out onto Warwick Gardens border the site to the west.

The site is approximately centred on the OS grid reference: **TQ 3242588555**.

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

7.2. Site Description

The site is an approximately rectangular parcel of land that comprises the structures and grounds of St Ann's Hospital, as well as accompanying access roads and areas of open vegetation.

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

8. Scope of the Proposed Works

8.1. General

The exact scope of proposed works on site was not known when this report was written. It is believed that ground investigation works will take place on site prior to any construction occurring.

9. Ground Conditions

9.1. General Geology

The British Geological Survey (BGS) map shows the bedrock geology of the site to be underlain by the London Clay Formation – clay, silt and sand, of the Palaeogene Period. No superficial deposits are recorded in this source.

9.2. Site Specific Geology

Site-specific geotechnical data was not available during the production of this report.

10. Site History

10.1. 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.

10.2. 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.

Post-WWI		
Date	Scale	Description
1920	1:10,560	This map is of relatively poor quality. It does however indicate the presence of the hospital buildings within the site boundary, as well as the presence of accompanying access roads and areas of open ground within the confines of the hospital. A <i>police station</i> is labelled immediately north-west of the site boundary. The hospital itself is labelled as a <i>Fever Hospital</i> .

Post-WWII		
Date	Scale	Description
1946	1:10,560	There is no significant change since the previous map edition. The site has remained occupied by the <i>Fever Hospital</i> and its associated grounds.
1955	1:2,500	This map edition indicates some changes within the site boundary; the structures in the east of the boundary have been cleared, with new structures built in their place. The hospital on site is now labelled as <i>St Ann's General Hospital</i> . In the surrounding area several houses to the west of the site appear to have been cleared and replaced by prefabricated structures. These areas are situated in the north and south of Warwick Gardens, just outside of the site's western boundary.
1967	1:10,560	This map is of poorer quality than the previous edition; however, there are no significant changes evident since the previous edition.

10.3. Goad Fire Insurance Mapping

1st Line Defence have inquired about obtaining pre and post-WWII fire insurance plans for the site. Unfortunately, no relevant records could be found during the production of this report.

11. Aerial Bombing Introduction

11.1. General

During WWI and WWII, many towns and cities across the UK were 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 report will concern German aerial delivered weapons dropped during WWII, although WWI bombing will also be considered.

11.2. Generic Types of WWII German Aerial-delivered Ordnance

An understanding of the type and characteristics of the ordnance used by the Luftwaffe during WWII allows an informed assessment of the hazards posed by any unexploded items that may remain in situ on a site.

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 F). Furthermore, ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. UXBs therefore present the greatest risk to present-day intrusive works.
Aerial or Parachute mines (PM)	There were deployed less frequently than HE and IBs due to size, cost and the difficulty of deployment.	If functioning correctly, PMs generally would 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.
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 have gone 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.
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.

Images and brief summaries of the characteristics of the above listed German aerial delivered ordnance are presented in **Annex E**.

11.3. 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 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 G1**.

11.4. 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. 2,419 V-1s and 517 V-2s were recorded in the London Civil Defence region alone, with an overall total of 9,251 V-1s and 1,115 V-2s recorded in the United Kingdom.

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 since even if the 1000kg warhead failed to explode, the weapons are so large that they would have been observed and the risk 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.

12. UXB Ground Penetration

12.1. General

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.

12.2. 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 up to 15m.

12.3. WWII UXB 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 made as to 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.

12.4. 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 – London Clay 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 lack of site specific borehole geotechnical information. An assessment can be made once such information becomes available or by an UXO Specialist on-site.

13. **Initiation of Unexploded Ordnance**

13.1. **General**

Unexploded ordnance does not spontaneously explode. All high explosive filling requires significant energy to create the conditions for detonation to occur. In the case of unexploded German bombs discovered within the construction site environment, there are a number of potential initiation mechanisms.

13.2. **UXB Initiation Mechanisms**

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 Clockwork Fuze	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.

Annex G2 details incidents where intrusive works have caused items of UXO to detonate, resulting in death or injury and damage to plant.

13.3. **Effects 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.

14. The Risk from German Air Delivered UXBs

14.1. World War I

During WWI London 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 H** for a WWI bomb plot map of London). This source does not show any bomb strikes at the site location.

WWI bombs were generally smaller than those used in WWII and were dropped from a lower altitude. 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.

14.2. World War II Bombing of Tottenham

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 Tottenham, which sustained a moderate density of bombing in comparison to other areas of London, as represented by bomb density data figures and maps, see **Annex I**. This was mainly due to its location on the periphery of north London, which avoided the majority of the bombing campaigns focused on the central and eastern areas of the capital. However Tottenham did still sustain regular bombing, with a number of industrial hubs identified in the wider area.

The Tottenham Water Treatment Works and Reservoir, situated approximately 1.6km northeast of the site boundary, is highlighted on Luftwaffe reconnaissance photography (see **Annex J**) which confirms its status as a target. The water treatment works and reservoir were part of the Lee Valley Reservoir chain, which provided London with water. (The River Lea was used by the Luftwaffe as a natural guide and navigation point, which is likely to have resulted in some of the bombing on the region.) Another potential target not identified on Luftwaffe reconnaissance photography was the Stoke Newington Reservoirs, situated approximately 1km south of the proposed site area. Neighbouring areas would often be affected by the presence of such targets, largely due to the inaccuracy of aerial bombing at this time, as well as the practice of Luftwaffe bomber aircraft deploying any remaining bombs on adjacent areas to avoid having to return to base with ordnance still on board – known as 'tip and run' raids. Much of the bombing on the region can be attributed to these potential targets and any bombing inflicted upon the civilian population.

Records of bombing incidents in the civilian areas of north 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 Tottenham are presented in the following sections.

14.3. 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 Tottenham between 1940 and 1945.

Record of German Ordnance Dropped on the Municipal Borough of Tottenham		
Area Acreage		3,013
Weapons	High Explosive bombs (all types)	283
	Parachute mines	4
	Oil bombs	18
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	5
	Long range rocket bombs (V-2)	3
Total		313
Number of Items per 1,000 acres		103.9

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 were not recorded, both types of item should not be overlooked when assessing the general risk to personnel and equipment.

14.4. London Civil Defence Region ARP Bomb Census Maps

During WWII, the ARP Department within the Research and Experiments Branch of the Ministry of Home Security produced consolidated, weekly and V-1 pilotless aircraft bomb census maps for the London Civil Defence Region. These maps collectively shows the approximate locations of bombs, mines and rockets. 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 **Annex K-L**.

London Consolidated Bomb Census Maps – Annex K1	
Date Range	Comments
Night Bombing up to 7 th October 1940	A bombing incident is recorded on the south-east boundary of the site, in close proximity to the railway line. No other strikes are recorded within the boundary in this map edition. There is sporadic bombing in the surrounding area; the closest recorded incident is situated approximately 150m southeast of the site boundary.
7 th October 1940 to 6 th June 1941	A bombing incident is recorded in the south-west of the site. No other strikes are recorded within the boundary in this map edition. There is sporadic bombing in the surrounding area; the closest recorded incident is situated approximately 50m north-west of the site boundary.

London Weekly Bomb Census Maps – Annex K2	
Date Range	Comments
27 th January to 3 rd February 1941	Five HE bombs are recorded immediately north of the site boundary on St Ann's Road. A UXB is also recorded approximately 60m north of the site boundary.

V-1 Pilotless Aircraft Bomb Census Map – Annex L	
Date Range	Comments
1944-45	One V-1 flying bomb fell on the western border of the proposed site. Four additional V-1 flying bombs were recorded in the surrounding area, however these are considered too far removed to have affected the site.

14.5. Tottenham ARP Bomb Map

A local bomb map compiled by Tottenham Council showing HE bomb, incendiary bomb and V-1 flying bomb strikes on the borough was obtained from Haringey Archives. The section showing the area of the site is described in the table below and presented in **Annex M**.

Tottenham Bomb Map	
Date Range	Comments
1940 – 1944	This map indicates that the site was not affected directly by any bombing incidents. Five separate incidents are however recorded immediately outside of the site boundary. These incidents are detailed in the corresponding ARP written records presented in section 14.7 of this report.

14.6. Tottenham Local Bomb Incident ARP Records

Bomb incident records specifically covering the Municipal Borough of Tottenham were obtained from Haringey Archives. This record was compiled by local Air Raid Precaution (ARP) personnel and volunteers during the war. A transcript of the only associated written record that fell in the immediate site area is presented in the table below. Imagery of the relevant entry is presented in **Annex N**.

Ministry of Home Security Bomb Census Reports		
Date	Type of bomb	Comments
23 rd September 1940	UXAA	On railway embankment off Hermitage Road.

14.7. Haringey Incident Records

Incident records covering the wider area of Haringey were also obtained from Haringey Archives and found to cover the site location. A transcript of the associated written records for bombs that fell in the site area is presented in the table below. Imagery of the relevant entries are presented in **Annex N**.

Tottenham Bomb Incident Records	
Date Range	Comments
23 rd September 1940	No.199 - Incident report records an unexploded HE bomb on railway embankment near bridge on Hermitage Road – later found to be unexploded AA shell.
18 th October 1940	No.347 - Incident report records a HE bomb on Warwick Gardens. 11 killed, 6 injured, 6 houses demolished, 77-87 others damaged, gas and water mains damaged.
5 th November 1940	No. 415 - Incident reports a HE bomb at Roseberry Gardens. 2 killed, 2 houses demolished, 2 partly demolished and several badly damaged.
5 th November 1940	No.416 - Incident report records an unexploded HE bomb on St Ann's Road outside Ever Ready Co. – damage to water, coal gas mains and sewers. Crater in road, house slightly damaged.
21 st January 1944	No.563 - Incident report records a UXAA on St Ann's Road, junction with Cornwall Road, damage to pavement. Crater in road.
4 th July 1944	No 603 - Incident report records a fly bomb – location not specified but assumed to be incident on Warwick Gardens – 6 seriously injured, however no damage reported.

14.8. Middlesex County Council War Damage Map

Map sheets compiled by Middlesex County Council (MCC) showing the extent of wartime bomb damage on the Municipal Borough of Tottenham were consulted at London Metropolitan Archives. The section showing the area of the site is described in the table below and presented in **Annex O**. It should be highlighted that this source only records the following damage categories: 'Total damage, building to be demolished', 'damaged beyond repair' and 'seriously damaged; doubtful if repairable'. The lesser damage categories such as seriously damaged but repairable at cost and general blast damage were not used.

MCC War Damage Map	
Date Range	Comments
1940-1945	The site was split across four sections of MCC bomb damage mapping. This record set did not cover the south-eastern area of the site. The section of mapping showing the northeast section of the site indicates no damage occurring within the site boundary. An area of category 3 damage – "seriously damaged; doubtful if repairable" is situated approximately 160m north of the site boundary. The section of mapping showing the south-western section of the site indicates no damage occurring within the site boundary. Several properties on Warwick Gardens and in its immediate surrounding area are shown as having suffered from damage varying from category 1 ("total damage, building to be demolished") to category 3 – this could be attributed to the HE bomb and V-1 flying bomb recorded on Warwick Gardens. The section of mapping showing the north-western section of the site indicates no damage occurring within the site boundary. Areas of damage ranging from category 1 to category 3 are situated to the north-west of the site; the closest area recorded is approximately 30m north of the site boundary.

14.9. WWII-Era Aerial Photography

A high-resolution scan of WWII-era aerial photography for the site area was obtained from the National Monuments Record Office (Historic England). This photograph provides a record of the potential composition of the site during the war, as well as its condition immediately following the war (see Annex P).

WWII-Era Aerial Photography	
Date	Description
21 st March 1945	This photograph indicates the hospital on site to have remained in use and in reasonably good condition immediately post-WWII. There are no obvious signs of structural damage within the site boundary, whilst there is no evidence of obvious signs of ground disturbance such as cratering within the open areas of the hospital. Wider views of the photograph are shown in Annexes P2 and P3. These highlight the existence of damage immediately west of the site boundary on Warwick Gardens; three areas of clearance are visible which indicates significant bomb damage. Isolated additional areas of damage are also notable in the wider surrounding area.

14.10. 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 were 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 would inevitably be UXBs that were never recorded.

1st Line Defence holds no records of officially registered abandoned bombs at or near the site of the proposed works.

14.11. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD) 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, Hill will be advised.

14.12. Evaluation of German Air Delivered UXB Risk

Factors	Conclusion
Density of Bombing <i>It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High levels of bombing density could allow for error in record keeping due to extreme damage caused to the area.</i>	The Municipal Borough of Tottenham was subject to a moderate density of bombing in comparison to other areas of London, with an average of 103.9 bombs recorded per 1,000 acres according to Home Office statistics. Bombing in the region did however still occur on a regular basis throughout the blitz and can be attributed to targets in such as the Tottenham Water Treatment Works and Reservoir, as well the borough's location north of the centre of London. No bomb strikes are recorded to have fallen directly within the site boundary, though a number of incidents are recorded in the surrounding area. London bomb census mapping and local ARP incident indicate the presence of both HE bomb incidents and a V1 incident to the immediate west of the site, surrounding Warwick Gardens. Additionally a UXB is recorded to the immediate north-west of the site, at St Ann's Road and a UXAA projectile to the immediate south-east of the site at the railway embankment at Hermitage Road.
Damage <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>	There is no obvious sign of bomb damage within the site boundary; all structures appear to survive intact on 1945 imagery. However, an area of severe damage is visible immediately west of the site on Warwick Gardens road; three areas of clearance and an area of severe structural damage are noted. Whilst this damage can partially be attributed to a V1 flying bomb, HE strikes are also recorded in the locality on London bomb census mapping and a local bomb map for the borough. As no pre V-weapon, strike photography was available to 1st Line Defence during the production of this report it is not possible to accurately determine to what extent this damage was caused by HE bomb strikes prior to the V-weapon strike.
Access Frequency <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>	All available evidence, including anecdotal accounts and wartime hospital minutes indicate that the hospital on site was in use throughout WWII. It is therefore anticipated that its grounds and structures would have received frequent and regular levels of access. The presence of St Ann's Road immediately north of the boundary and a section of railway immediately south would also increase access to the area immediately surrounding the site in question. The area of the site in close proximity to the damaged structures on Warwick Gardens may have had rubble and debris present should the damage have spilled over the boundary. Should this have occurred, access levels may have dropped in this particular area of the site.
Ground Cover <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>	The site was entirely occupied by the premises of St Ann's Hospital (known as the North-Eastern Fever Hospital during WWII) and its associated grounds during WWII. Whilst there is the potential that the ground cover in the open areas of the site can provide UXO a means to go unnoticed; it is considered a low probability in this instance. The urban location and anticipated access frequency would increase the detection probability of UXO in the area, as well as the lack of evidence to suggest that the site was subject to frequent heavy bombing raids.
Bomb Failure Rate	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.

Abandoned Bombs	1 st Line Defence holds no records of abandoned bombs at or within the site vicinity.
Bombing Decoy sites	1 st Line Defence could find no evidence of bombing decoy sites within the site vicinity.
Bomb Disposal Tasks	1 st Line Defence could find no evidence of bomb disposal tasks within the site boundary and immediate area.

15. The Risk from Allied Ordnance

15.1. General

The potential risk of encountering Allied ordnance on construction sites is particularly elevated in areas previously associated with military activity. This includes munitions deposited by military training exercises, dumped as a result of poor working practices, or deliberately placed to prevent adversary occupation and from other home defence activities. For example, contamination from items of Land Service (LSA) and Small Arms Ammunition (SAA) may result from historical occupation of an area or its use for military training.

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 however be at risk from buried unexploded Anti-Aircraft projectiles fired during WWII – as addressed below.

15.2. Defending the UK From Aerial Attack

During WWII, the Ministry of Defence 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
• Anti-aircraft gun emplacements to engage enemy aircraft. • Fighter aircraft to act as interceptors. • Rockets and missiles were used later during WWII.	• 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.

**15.2.1. 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 The closest HAA was located approximately 2km south of the site, however the range of a projectile can be up to 15km.			
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 conditions in which an HAA or LAA projectiles may have fallen unnoticed within a site area are analogous to those regarding aerial delivered ordnance. For detailed analysis on the ground conditions and access frequency within the proposed site, see the evaluation of German Bombing Records in, **Section 14**.

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

15.3. Evaluation of Allied Ordnance Risk

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

Sources of Contamination	Conclusion
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>	1st Line Defence could find no evidence of a military camp within the site. Note that an online account has been found to suggest that the hospital on site was requisitioned by the American Expeditionary Force (as Base Hospital No. 29) during WWI.¹ However reference to this occupation is relatively detailed and does not suggest that any military activity took place within the hospital's premises that could be associated with the storage or usage of items of ordnance. The hospital was officially decommissioned for military usage in March 1919.
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>	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 south 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.
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>	Evidence of Home Guard training areas and activities is difficult to obtain. 1st Line Defence has no evidence of any Home Guard activities on the site.
Defensive Positions <i>Defensive positions suggest the presence of military activity, which is often indicative of ordnance storage, usage or disposal.</i>	There is no evidence of any defensive features formerly located on or bordering the site footprint.
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>	There is no evidence of such features affecting the site.
Defensive Minefields <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>	There is no evidence of defensive minefields affecting the site.

¹ <http://ezitis.myzen.co.uk/stanns.html>



Ordnance Manufacture <i>Ordnance manufacture indicates an increased chance that items of ordnance were stored, or disposed of, within a location.</i>	No information of ordnance being stored, produced, or disposed of within the proposed site could be found.
Military Related Airfields <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>	The site was not situated within the perimeters or vicinity of a military airfield.

16. Ordnance Clearance and Post-WWII Ground Works

16.1. General

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.

16.2. UXO Clearance

1st Line Defence has no evidence that any official ordnance clearance operations have taken place on site. Note however that we have not received confirmation of this fact from 33 EOD Regiment.

16.3. Post-war Redevelopment

The usage of the site remains much the same today as it did during WWII; the hospital still occupies the entirety of the site boundary. However, some significant structural development has taken place post-war. The risk from UXO is considered to be mitigated at the location and down to the depths of post war foundations and excavations.

17. 1st Line Defence Risk Assessment

17.1. 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.

UXO Risk Assessment	
Quality of the Historical Record	The research has evaluated pre- and post-WWII Ordnance Survey maps, a WWI bomb plot map for London, a WWII bomb density map for London, Luftwaffe reconnaissance imagery, consolidated and weekly London bomb census mapping, London V-1 flying bomb mapping, a local bomb map for Tottenham, written ARP incident records, MCC (Middlesex County Council) bomb damage mapping and RAF high resolution WWII-era aerial photography. The record set is of generally good quality with sources often corroborative of one another. For example, an incident recorded on the southern border of the site is referenced across two sets of bomb mapping as well as two sets of written ARP incident records. One discrepancy is noted; an incident is recorded within the site boundary on consolidated London bomb census mapping. However, on a local bomb map for Tottenham as well as written ARP incident records the incident is recorded outside the boundary. As the structures within the hospital display no signs of damage it is therefore considered likely that the strike was misplotted on London bomb census mapping and did instead fall at Warwick Gardens, as implied by the local record sets.
The Risk that the Site was Contaminated with UXO	After considering the following facts, 1st Line Defence has assessed that there is a <u>Low Risk</u> that items of unexploded German aerial delivered ordnance could have fallen unrecorded across the majority of the site area, with a small section of the west of site assessed to be of <u>Medium Risk</u>. See Annex R for a risk map. • The Municipal Borough of Tottenham was subject to a moderate density of bombing in comparison to other areas of London, with an average of 103.9 bombs recorded per 1,000 acres according to Home Office statistics. Bombing did however still occur on a regular basis throughout the blitz and can be largely attributed to targets in the locality such as the Tottenham Water Treatment Works, as well the borough's location north of the centre of London. • London bomb census mapping and ARP incident records suggest that no bomb incidents took place directly within the site boundary. A number of bomb strikes are well recorded in the site's surroundings. These included HE bomb strikes and a V1 flying bomb surrounding Warwick Gardens, to the immediate west of the site, a UXB to the north-west of the site on St. Ann's Road and a UXAA projectile to the immediate south-east of the site, at the railway embankment near Hermitage Road. One bomb strike is recorded within the south-west of the site on one bomb census map edition, but when referenced with all other available evidence is anticipated to have been a misplot. • There is no obvious sign of bomb damage within the site boundary; all structures have appeared to survive intact and in use in 1945 aerial imagery. However, an area of severe damage is visible immediately west of the site on Warwick Gardens



	road; three areas of clearance and an area of severe structural damage are noted. Whilst this damage can partially be attributed to the aforementioned V-weapon strike, in 1944, HE strikes are also recorded in the immediate locality in 1940. It has therefore not been possible to accurately determine to what extent this damage was already caused by HE bomb strikes prior to the V-weapon strike. • This is of note, as this level of damage on the western boundary of the site could have created conditions whereby an item of UXO could have gone unnoticed and could have ended up within the site due to the 'J-curve' effect (see section 12.2) Volumes of rubble and debris and damaged structures, if present, are anticipated to have reduced access and to have been obstructive to post raid evidence of UXO, such as bomb entry holes. It is not possible to discount that such conditions could have had a direct impact on the far western section of the site area. • The structures within the remainder of the site boundary do not appear to have sustained any obvious signs of damage. Furthermore, all available evidence, including anecdotal accounts and wartime hospital minutes, indicate that that hospital was in regular operation and subject to regular access and maintenance throughout the war. Whilst there is the potential that the ground cover in the open areas of the site can provide UXO a means to go unnoticed; it is considered a low probability in this instance. The urban location and anticipated access frequency would increase the detection probability of UXO in the area, as well as the lack of evidence to suggest that the site was subject to frequent heavy bombing raids. • Based on this criteria 1st Line Defence have assessed the majority of the site to be at Low Risk, with the far western section of the site at Medium Risk. A buffer zone has also been provided to take into account the 'J-curve' effect, whereby a bomb can move laterally underground and come to rest within adjoining ground away from its point of entry. • 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.
The Risk that UXO Remains on Site	The usage of the site remains much the same today as it did during WWII; the hospital still occupies the entirety of the site boundary. However, some significant structural development has taken place post-war. The risk from UXO is considered to be mitigated at the location and down to the depths of post war foundations and excavations.
The Risk that UXO may be Encountered during the Works	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 risk of encountering will depend on the extent of the works, such as the numbers of boreholes/piles (if required) and the volume of the excavations. Any aerial delivered bombs may come to rest at any depth between just below ground level and its maximum penetration depth. Consequently, there is also a possibility that UXBs could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level. There is not considered to be any significant risk of encountering UXO during works planned within the footprint and down to the depth of any post-war buildings/excavations. Beyond these depths and away from these areas, a risk of encounter could remain.
The Risk that UXO may be Initiated	The risk that UXO could be initiated if encountered will depend on its condition, how it is found, and the energy with which it is struck. Certain construction activities such as piling and percussive drilling pose a greater risk of initiating UXO in comparison to machine excavation, where the force of impact is generally lower and the item is more likely to be observed.



	If a UXB is struck by piling or percussive drilling equipment, the force of the impact can be sufficient to detonate the main high explosive charge irrespective of the condition of the fuze or other components. Violent vibration might also impart enough energy to a chemical detonator for it to function, and there is a potential risk that clockwork fuzes could restart. If piling works are planned at St Ann's Hospital, there is a potential risk that a UXB, if present, could be initiated. The risk of initiation is assessed to be lower for any shallow intrusive works planned.
The Consequences of Encountering or Initiating Ordnance	The repercussions of the inadvertent detonation of items of UXO during intrusive ground works are potentially severe, 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. If appropriate risk mitigation measures are undertaken, the chances of initiating an item of UXO during ground works is comparatively low. The primary consequence of encounter of UXO will therefore be economic. This would be particularly notable in the case of sites with a high profile or where it is necessary to evacuate the public from the surrounding area. A site may be closed 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 items of UXO during intrusive works (if handled solely through the authorities), may also involve loss of production. Generally, the first action of the police in most cases will be to isolate the locale whilst awaiting military assistance, even if this becomes unnecessary.

**17.2. Assessed Risk Level**

Taking into consideration the findings of this study, 1st Line Defence has assessed that there is predominantly a **Low Risk** that items of unexploded German aerial delivered and anti-aircraft ordnance could have fallen unrecorded within the site boundary, with a small section of the site in the west assessed to be of **Medium Risk**.

Low Risk

This site was occupied by undamaged structures and displayed no obvious signs of ground disturbance. It is considered likely that this property and its surrounds would have been accessed throughout WWII based on its usage as a hospital and that regular checks would have been made for evidence of UXO.

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German Unexploded HE Bombs		✓		
German 1kg Incendiary Bombs		✓		
Anti-Aircraft Artillery Projectiles		✓		
Allied Military Land Service Ammunition (Grenades, Mortars etc.)	✓			

Medium Risk

The criteria described in the section above does not apply to the whole of the site. As immediately west of the site boundary are areas of clearance and significant damage, which are indicative of severe bombing raids occurring. Therefore there is the potential for the damage to have resulted in rubble and debris being present within the adjoining section of the site boundary, which would have potentially obscured any evidence of UXO entry holes from public view.

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German Unexploded HE Bombs			✓	
German 1kg Incendiary Bombs			✓	
Anti-Aircraft Artillery Projectiles			✓	
Allied Military Land Service Ammunition (Grenades, Mortars etc.)	✓			

18. Proposed Risk Mitigation Methodology

18.1. General

The following risk mitigation measures are recommended to support the proposed works at the St Ann's Hospital site:

Type of Work	Recommended Mitigation Measure
All Works	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 in Medium Risk Areas	Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works When on site the role of the UXO Specialist would include: - 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 in Medium Risk Areas	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

18th August 2021

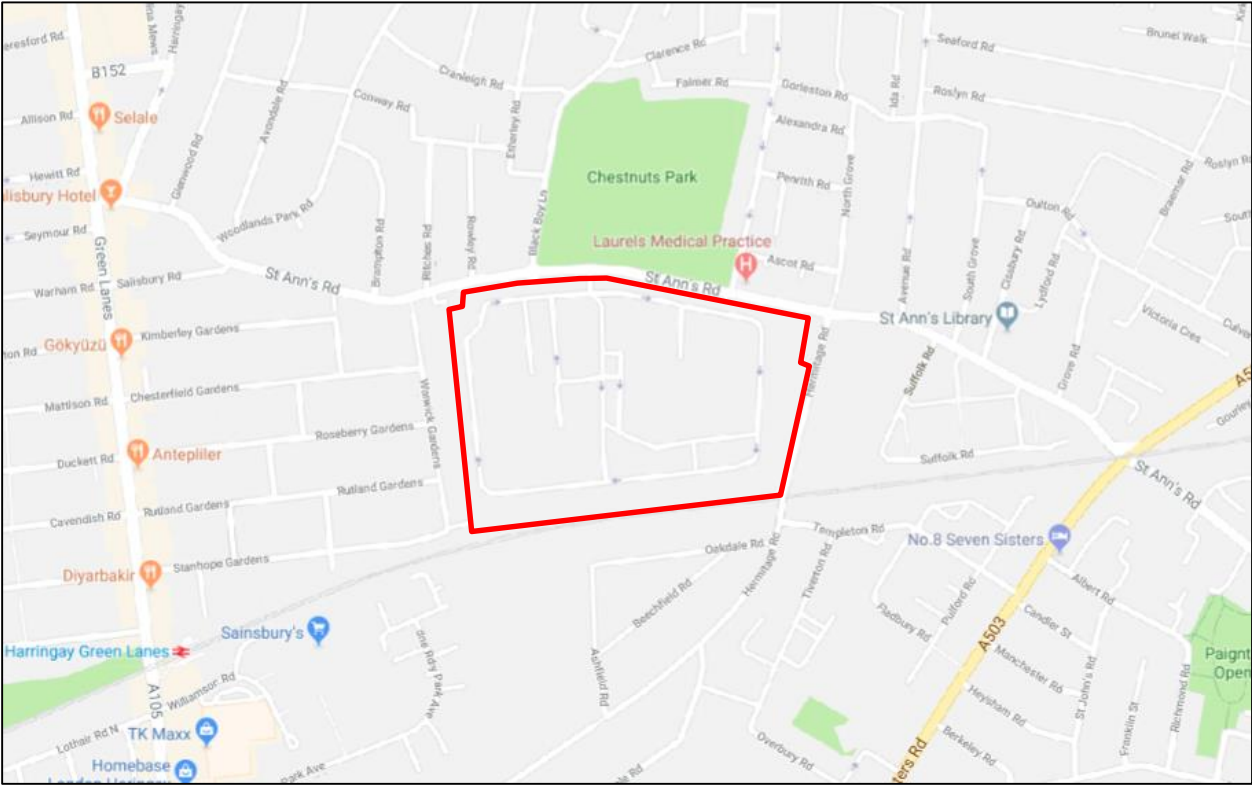
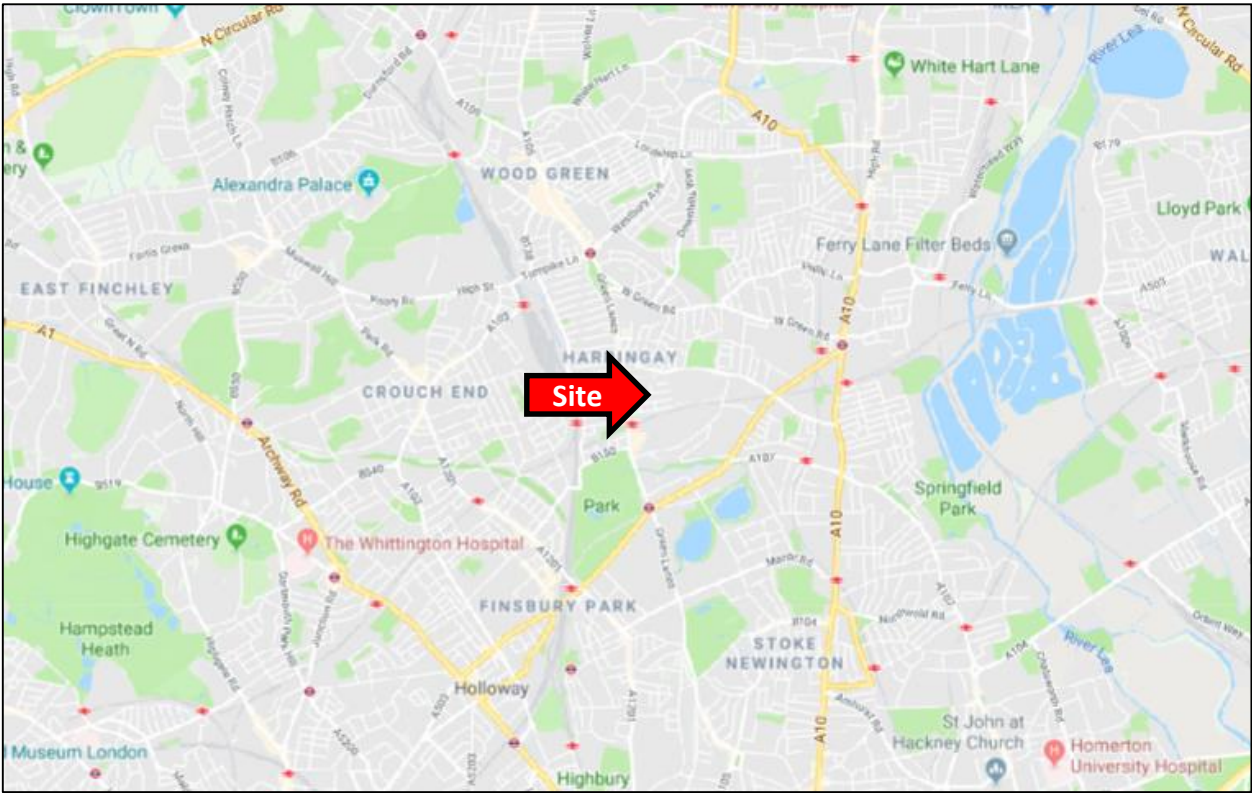
This Report has been produced in compliance with the Construction Industry Research and Information Association (CIRIA) C681 guidelines for the writing of Detailed UXO Risk Assessments.

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Client: **Hill**

Project: **St Ann's Hospital**

Ref: **DA5244a-00**

Source: Google Maps

 **Approximate site boundary**





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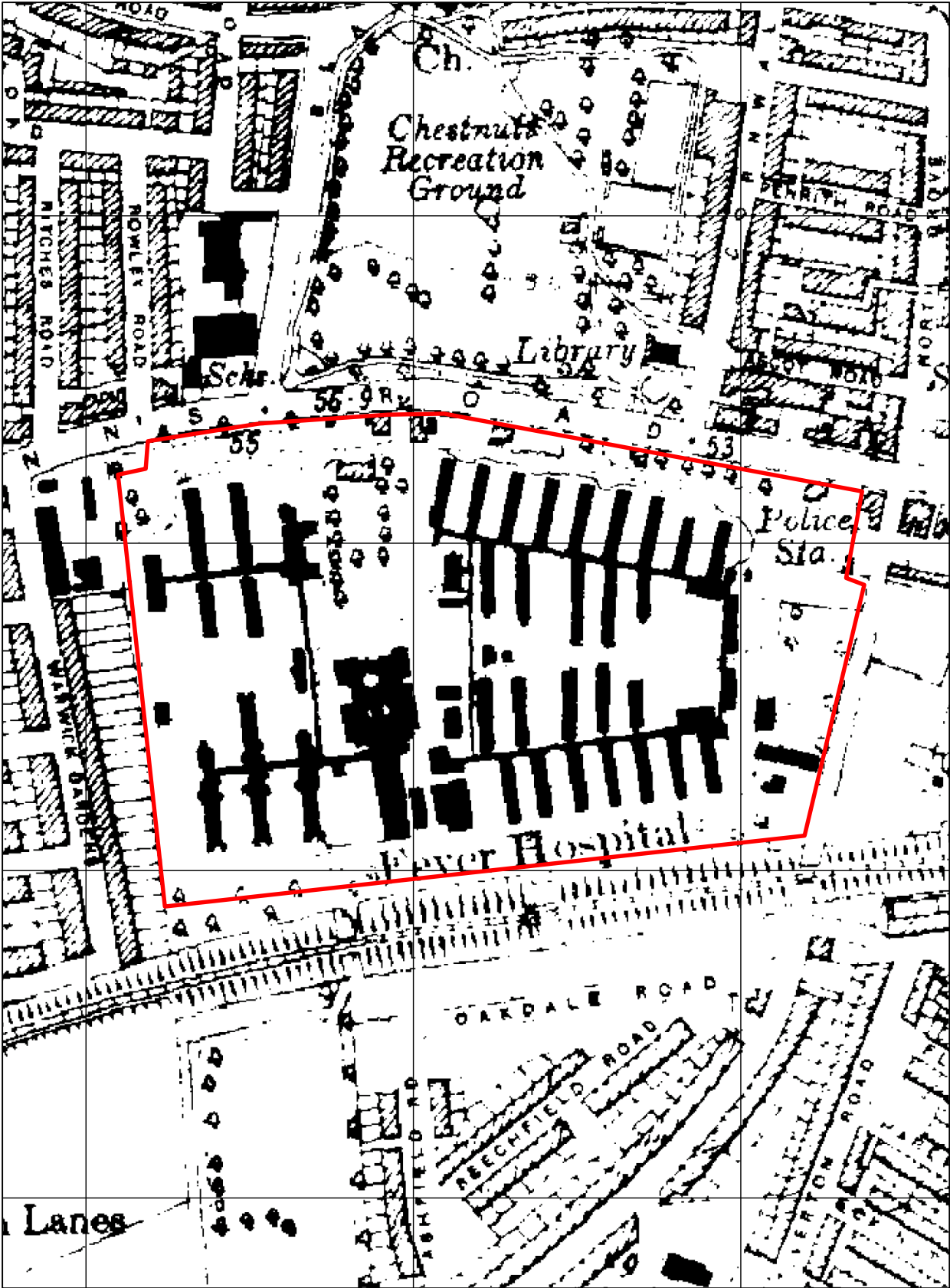
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 **Approximate site boundary**





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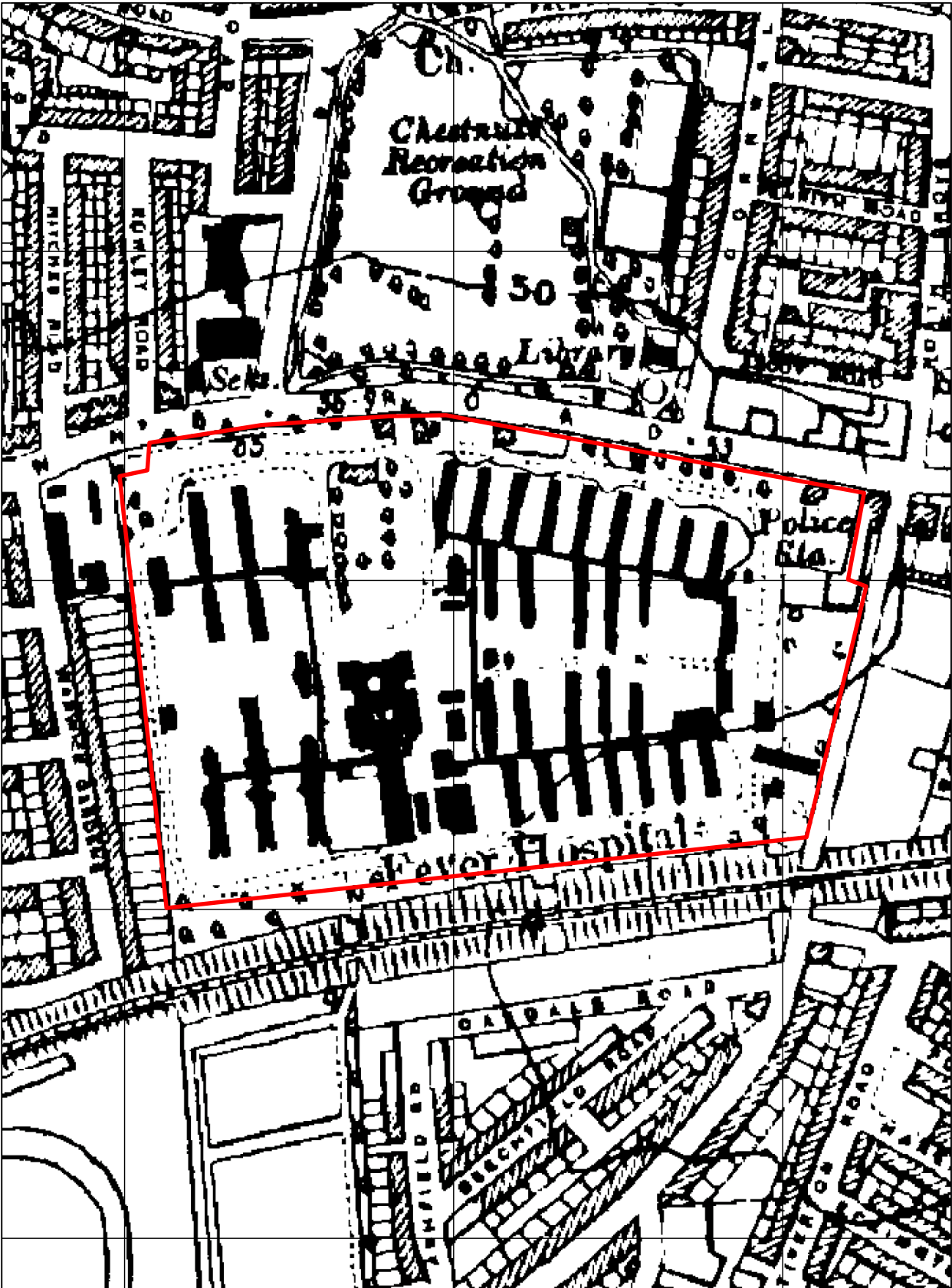
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Source: **Landmark Maps**

 **Approximate site boundary**





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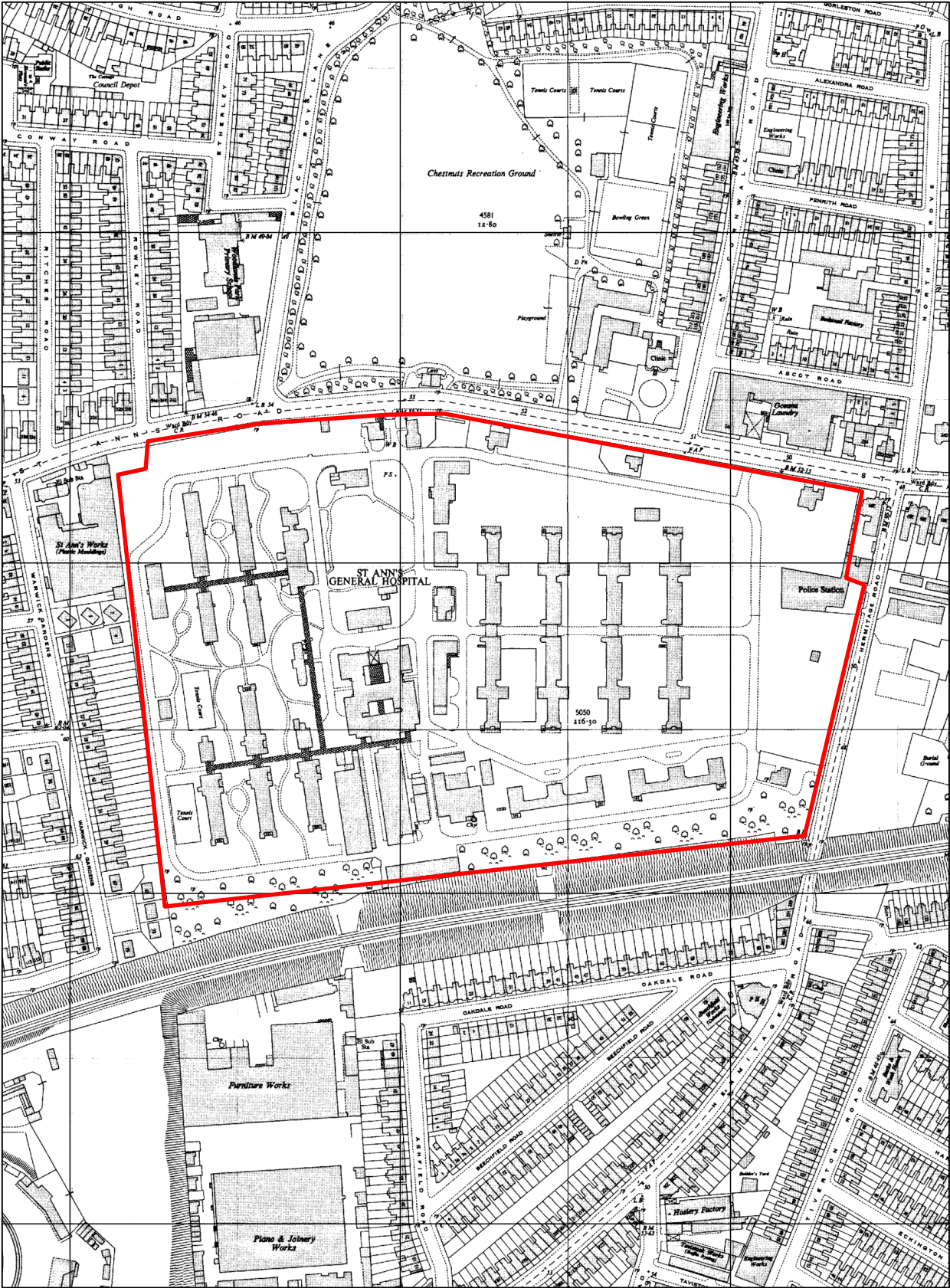
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 **Approximate site boundary**





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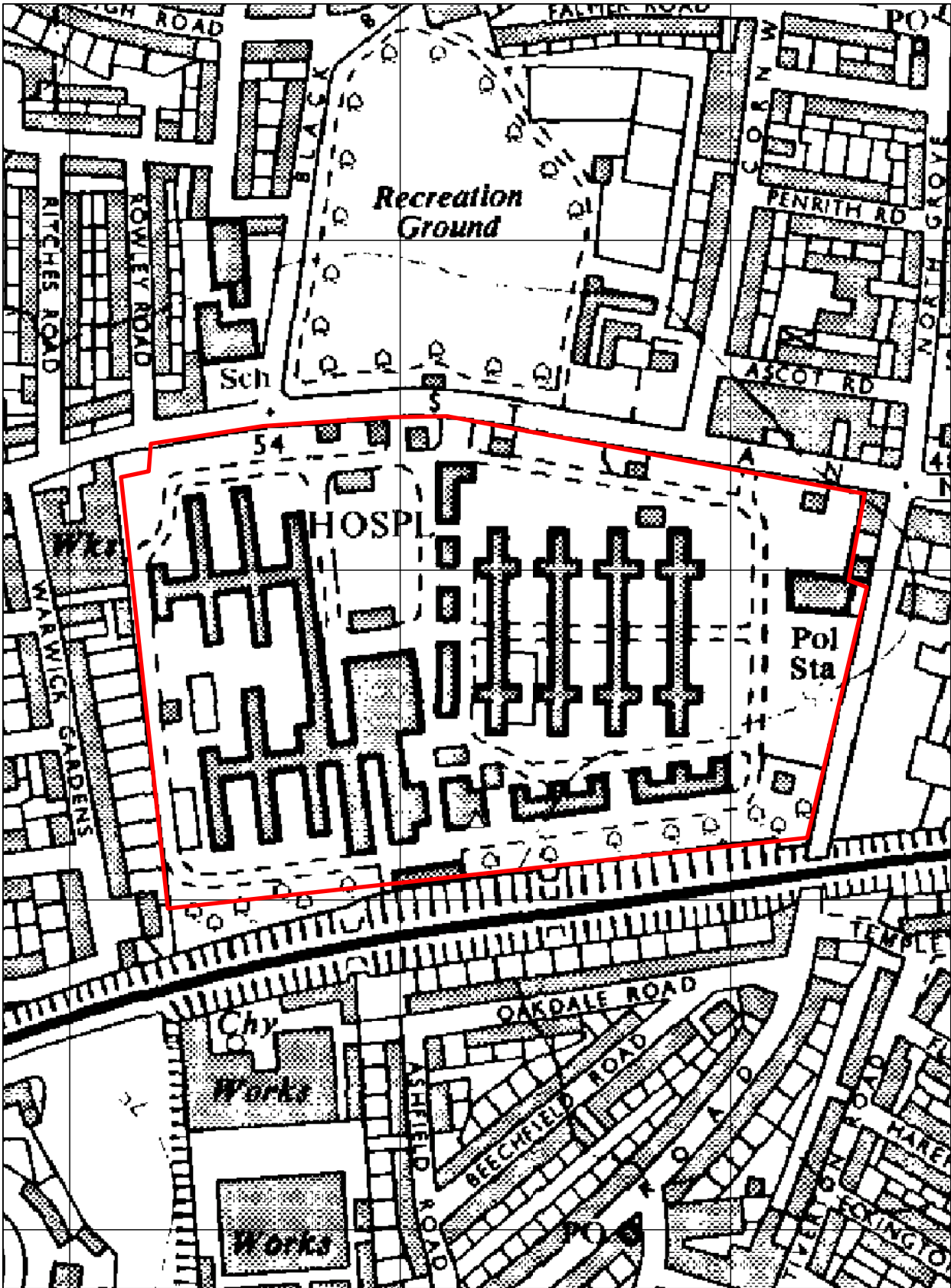
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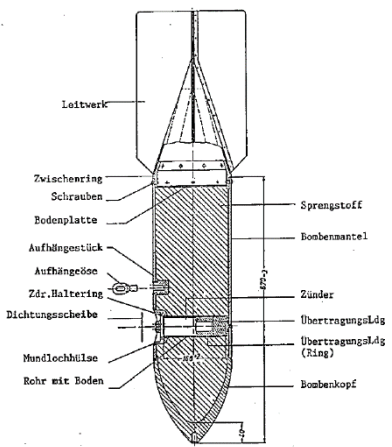
 **Approximate site boundary**



Examples of German Air-Delivered Ordnance

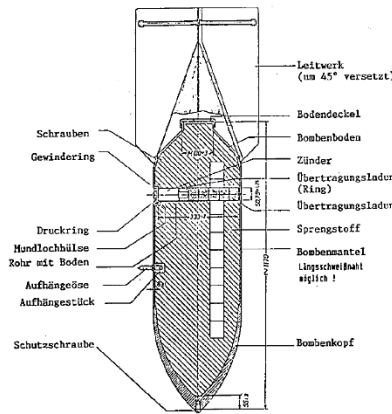
SC 50kg High Explosive Bomb

Bomb Weight	40-54kg (88-119lb)
Explosive Weight	c25kg (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).

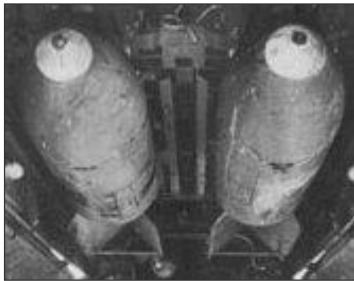
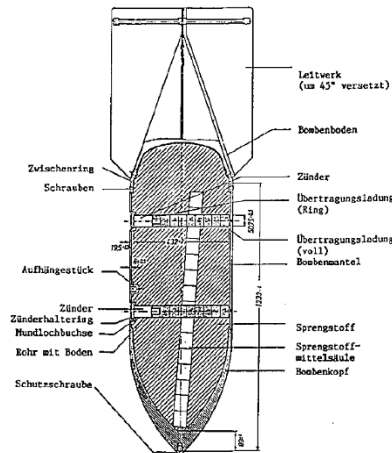


SC250 bomb being loaded onto German bomber



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, trialene. Bombs recovered with Trialene filling have cylindrical paper wrapped pellets 1-15/16 in. in length and diameter forming



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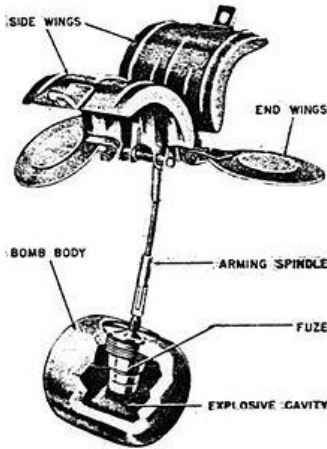
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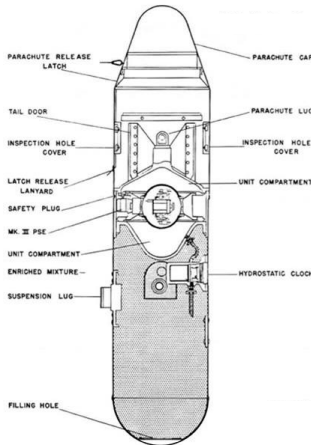
SD2 Anti-Personnel ‘Butterfly Bomb’

Bomb Weight	2kg (4.41lb)
Explosive Weight	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.



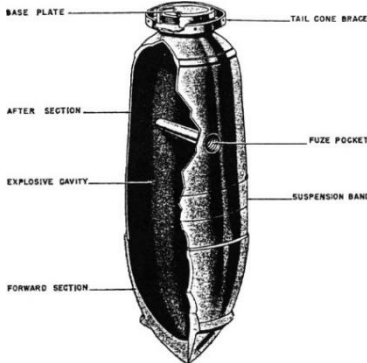
Parachute Mine (Luftmine B / LMB)

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 destroy a whole street of housing in a 100m radius.



SC 1000kg

Bomb Weight	993-1027kg (2,189-2,264lb)
Explosive Weight	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-shipping 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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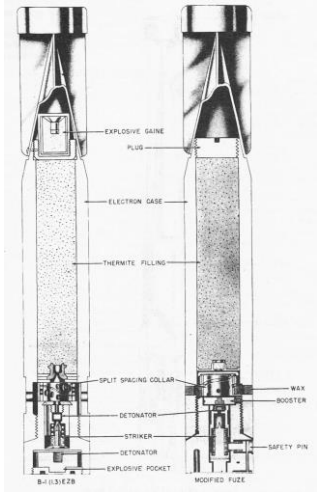
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German Incendiary Bombs

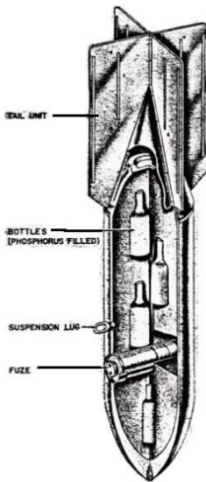
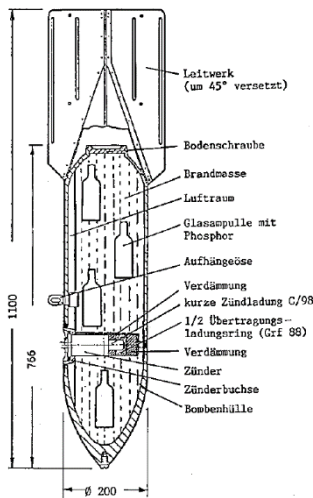
1kg Incendiary Bomb

Bomb Weight	1.0 and 1.3kg (2.2 and 2.9lb)
Explosive Weight	680g (1.3lb) 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 against 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.



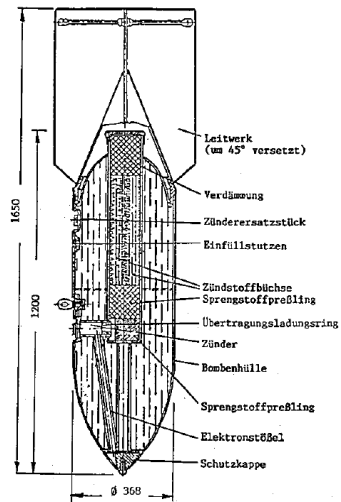
C50 A Incendiary Bomb

Bomb Weight	c41kg (90.4lb)
Explosive Weight	0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzene 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against all targets where an incendiary effect is required
Remarks	Early fill was a phosphorous/carbon disulphide incendiary mixture



Flam C-250 Oil Bomb

Bomb Weight	125kg (276lb)
Explosive Weight	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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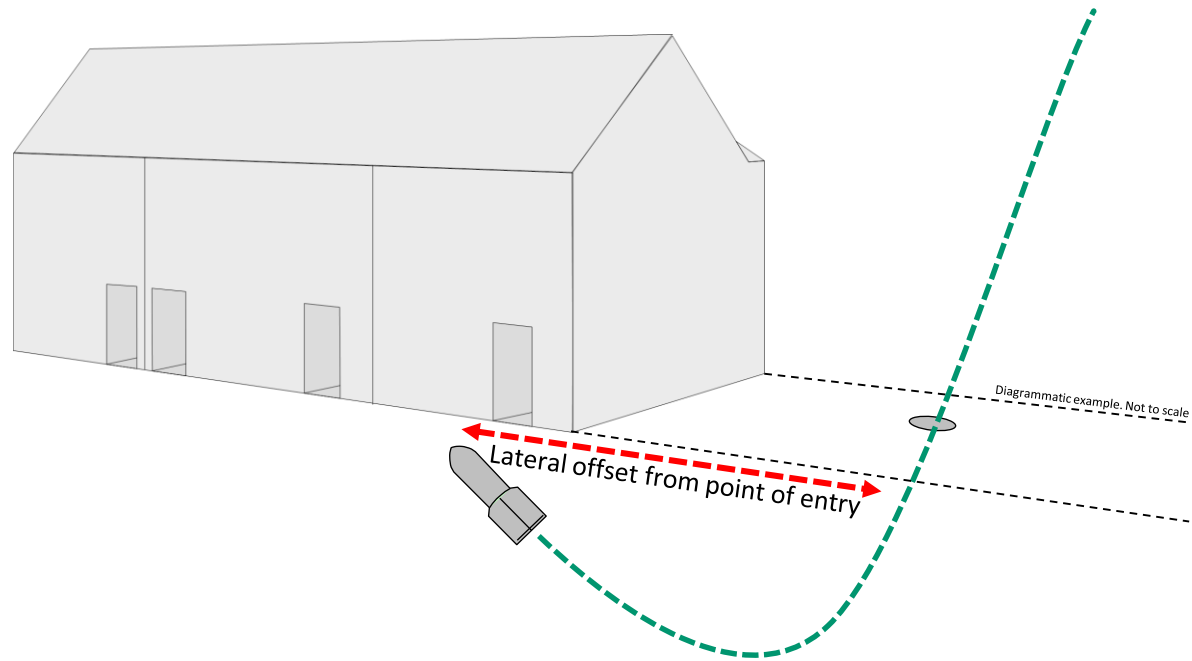
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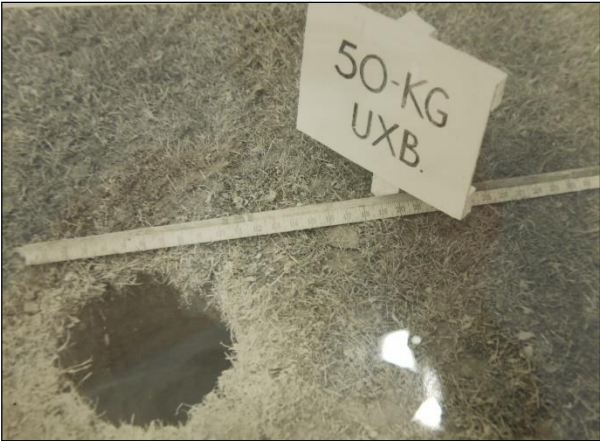
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Top: J-curve Effect - Due to angle of entry, unexploded bombs would often end their trajectory at a lateral offset from point of entry, often ending up beneath adjacent extant structures/sites.



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

Photograph **above** shows 250kg bomb found in Bermondsey pointing upwards, demonstrating 'J-curve'



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Bermondsey bomb: World War Two device safely removed

24 March 2015 | London

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RUPERT FRERE

The bomb measured about 5ft (1.5m) in length

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.

250kg HE bomb found in Bermondsey March 2015

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Bethnal Green WW2 bomb: Experts remove unexploded device

11 August 2015 | London

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CROWN COPYRIGHT

The MoD said the German WW2 air delivered bomb could have caused "mass destruction" if it had detonated

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.

250kg HE bomb found in Bethnal Green, Aug 2016

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Bath WW2 bomb scare: Device defused, police say

13 May 2016 | Somerset

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EPA

The bomb was found on the site of a former school on Thursday

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

250kg HE bomb found in Bath, May 2016

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Wembley WW2 live bomb posed 'risk to life'

22 May 2015 | London

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SERGEANT RUPERT FRERE RLC

A blast wall was put up around the bomb to minimise damage if it exploded

An unexploded World War Two bomb uncovered by builders near Wembley Stadium posed "a genuine risk to life", the Army has said.

50kg HE bomb found in Wembley, May 2015

1ST LINE DEFENCE Unit 3, Maple Park Essex Road, Hoddesdon, Hertfordshire. EN11 0EX Email: info@1stlinedefence.co.uk Tel: +44 (0)1992 245 020	Client: Hill		
	Project: St Ann's Hospital		
	Ref: DA5244a-00	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 is expanding their its Ludwigshafen location by expanding several plants and building a TDI plant, which was the site of an explosion on Tuesday (Feb. 26). One person was injured in the blast, which BASF believes was caused when excavation work detonated a bomb.

Early reports had speculated that excavation work had detonated a bomb from World War II. While the age of the bomb has not been confirmed, BASF has said that an explosive device was detonated.

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."

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.

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A cutting machine lies wrecked by the side of the A3 motorway next to a small crater left by the explosion.

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.

The A3 Autobahn linking the cities of Frankfurt and Würzburg has been blocked in both directions.

More than 60 years since the end of World War II, construction workers still frequently unearth unexploded bombs and it is not uncommon for whole city districts to be cordoned off and even evacuated while bomb disposal experts defuse them.

Indeed, just last week, some 22,000 people were evacuated from their homes in Hanover when three World War II bombs were discovered.

Allied pilots rained nearly 2 million tons of explosives on Germany during the war. Landmines, hand grenades, mortar bombs and anti-tank devices from the fighting on German soil at the end of the war are also found, and authorities say it will take decades before the country is cleared of duds.

Between 400 and 600 bombs are discovered a year in the state of North Rhine-Westphalia alone, where the heavily industrialized Ruhr region was a major target for Allied bombers.



WWII bomb injures 17 at Hattingen construction site

Published: 19 Sep 08 16:53 CET

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

- [Liberals grit teeth ahead of May state election](#) (17 Mar 12)
- [Nazi death camp guard Demjanjuk dies](#) (17 Mar 12)
- [Stupid stunt causes bomb scare chaos](#) (16 Mar 12)

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."



World War II bomb kills three in Germany

Three people have been killed and six injured trying to defuse a World War II bomb in central Germany.

Workers building a sports stadium had earlier unearthed the bomb in the town of Goettingen.

It was not immediately clear why the bomb, reportedly weighing 500kg (1,100lb), had detonated.

Unexploded WWII bombs dropped by Allied planes are frequently found in Germany, though it is unusual for them to explode unexpectedly.

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.



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Source: Various news sources

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News > London

Spitalfields bomb: Shoppers flee market after unexploded WW2 shell found

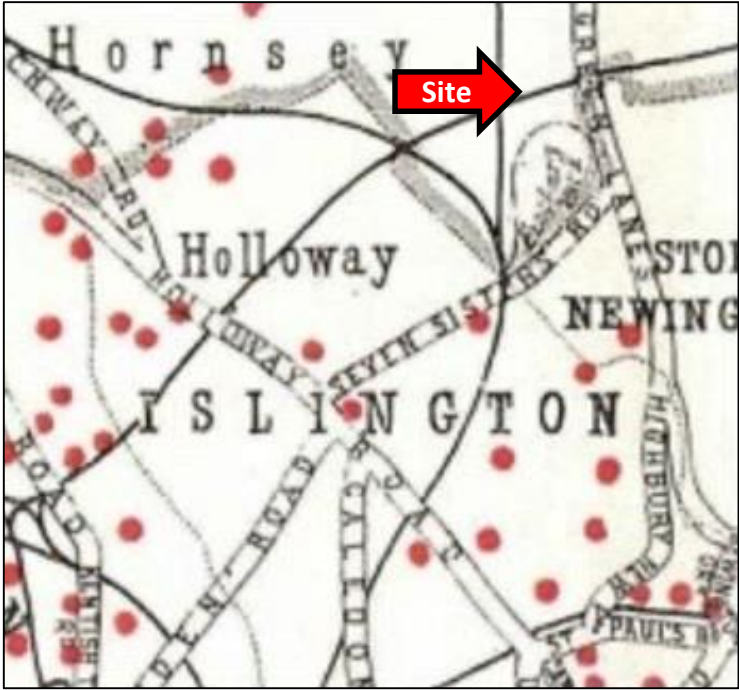
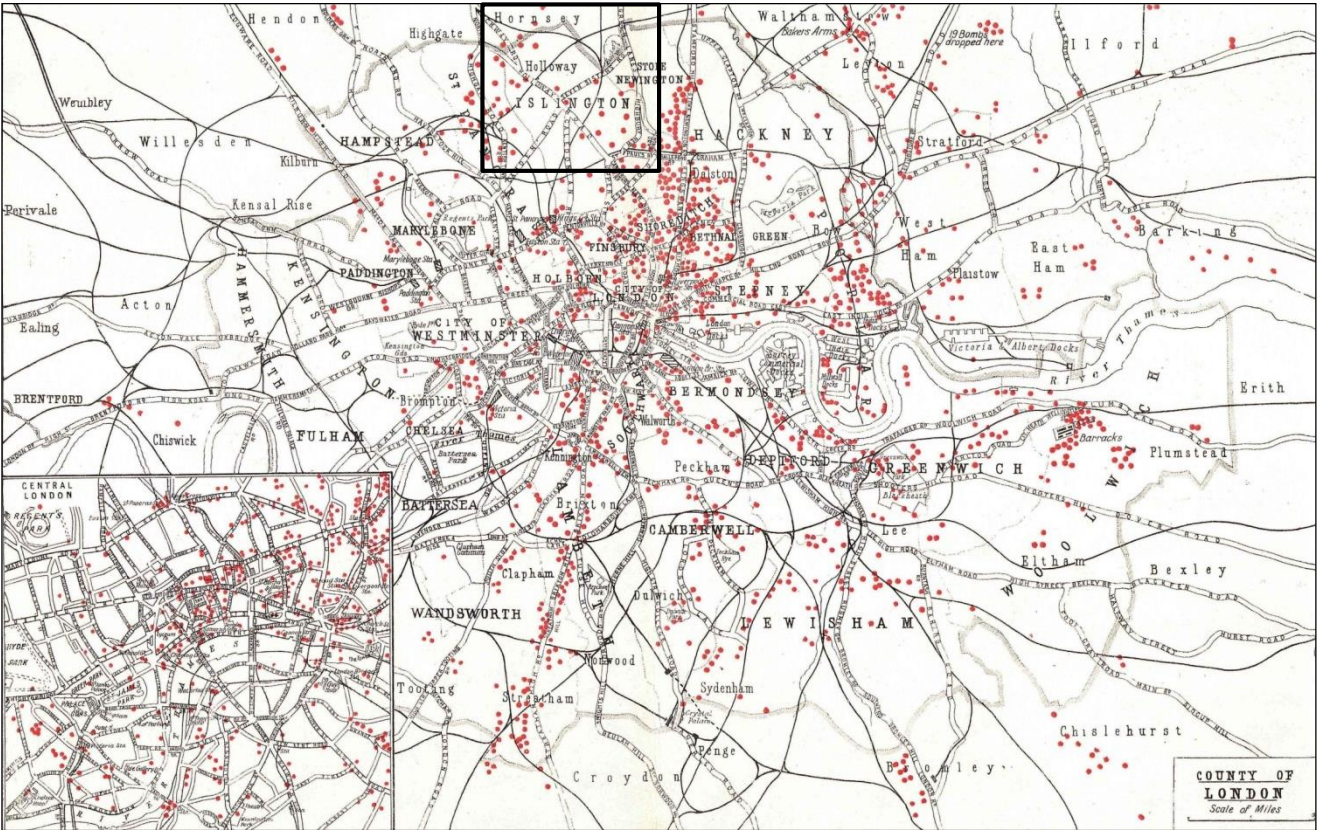
RAMZY ALWAKEEL, RACHEL BLUNDY | Thursday 12 November 2015 | 7 comments

Spitalfields Market was evacuated on Thursday morning after an unexploded bomb was discovered on a building site.

The shell was dug up at 9.44am on the site of the former Fruit and Wool Exchange, which is in the midst of a three-year development programme.

Bomb disposal experts managed to retrieve the device and take it away just before midday.

A construction worker at the site told the Standard the bomb had been discovered while workers were carrying out routine drilling at the site, which is being managed by contractor John F Hunt.



Examples of 50 and 100kg German WWI bombs



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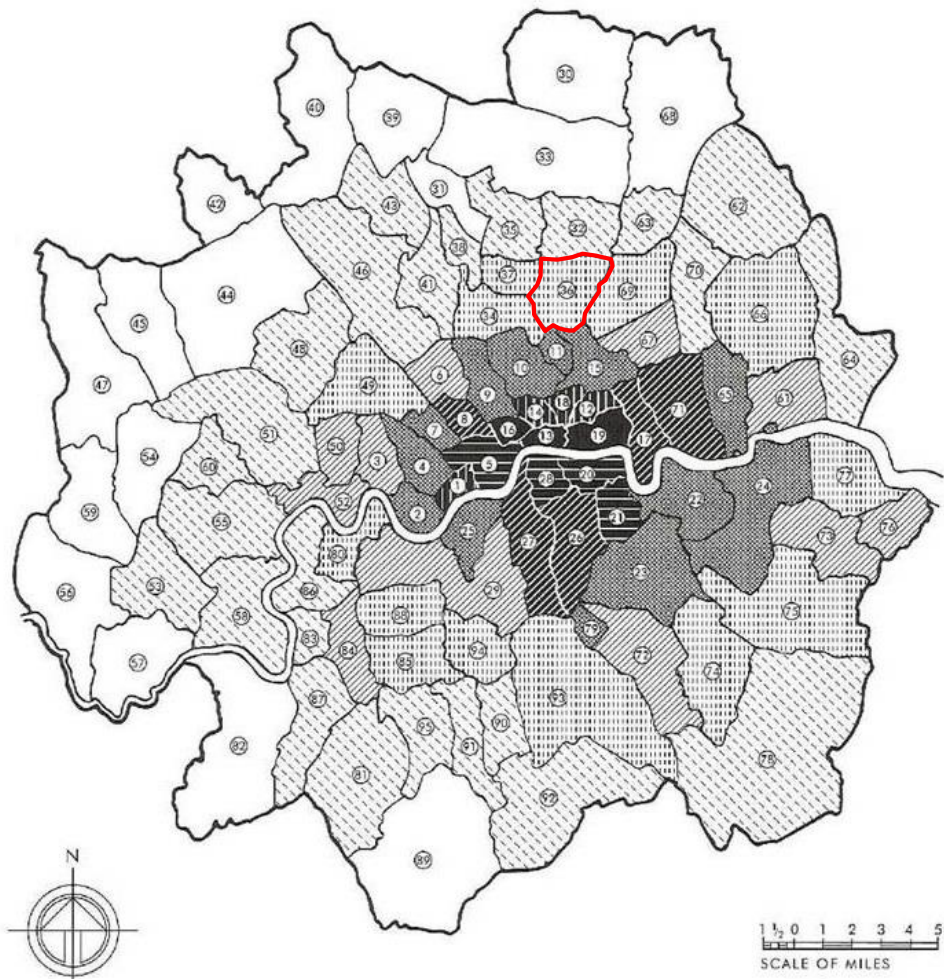
Client: Hill

Project: St Ann's Hospital

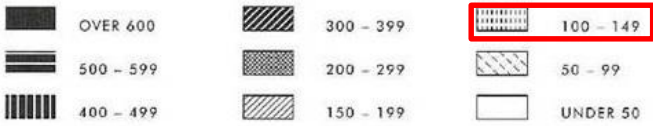
Ref: DA5244a-00

Source: The National Archives, Kew





No. OF BOMBS PER 1,000 ACRES



- | | | | |
|--------------------|--------------------------|------------------------------|------------------------------|
| 1 Chelsea | 25 Battersea | 49 Willesden | 72 Beckenham |
| 2 Fulham | 26 Camberwell | 50 Acton | 73 Bexley |
| 3 Hammersmith | 27 Lambeth | 51 Ealing | 74 Bromley |
| 4 Kensington | 28 Southwark | 52 Brentford and Chiswick | 75 Chislehurst and Sidcup |
| 5 Westminster | 29 Wandsworth | 53 Feltham | 76 Crayford |
| 6 Hampstead | 30 Cheshunt | 54 Hayes and Harlington | 77 Erith |
| 7 Paddington | 31 East Barnet | 55 Heston and Isleworth | 78 Orpington |
| 8 St. Marylebone | 32 Edmonton | 56 Staines | 79 Penge |
| 9 St. Pancras | 33 Enfield | 57 Sunbury | 80 Barnes |
| 10 Islington | 34 Hornsey | 58 Twickenham | 81 Epsom and Ewell |
| 11 Stoke Newington | 35 Southgate | 59 Yiewsley and West Drayton | 82 Esher |
| 12 Bethnal Green | 36 Tottenham | 60 Southall and Norwood | 83 Kingston on Thames |
| 13 City of London | 37 Wood Green | 61 Barking | 84 Malden and Coombe |
| 14 Finsbury | 38 Friern Barnet | 62 Chigwell | 85 Merton and Morden |
| 15 Hackney | 39 Potters Bar | 63 Chingford | 86 Richmond |
| 16 Holborn | 40 Elstree | 64 Dagenham | 87 Surbiton |
| 17 Poplar | 41 Finchley | 65 East Ham | 88 Wimbledon |
| 18 Shoreditch | 42 Bushey | 66 Ilford | 89 Banstead |
| 19 Stepney | 43 Barnet U.D. | 67 Leyton | 90 Baddington and Wallington |
| 20 Barmadsey | 44 Harrow | 68 Waltham Holy Cross | 91 Carshalton |
| 21 Deptford | 45 Ruislip and Northwood | 69 Walthamstow | 92 Coulsdon and Purley |
| 22 Greenwich | 46 Hendon | 70 Wanstead and Woodford | 93 Croydon |
| 23 Lewisham | 47 Uxbridge | 71 West Ham | 94 Mitcham |
| 24 Woolwich | 48 Wembley | | 95 Sutton and Cheam |



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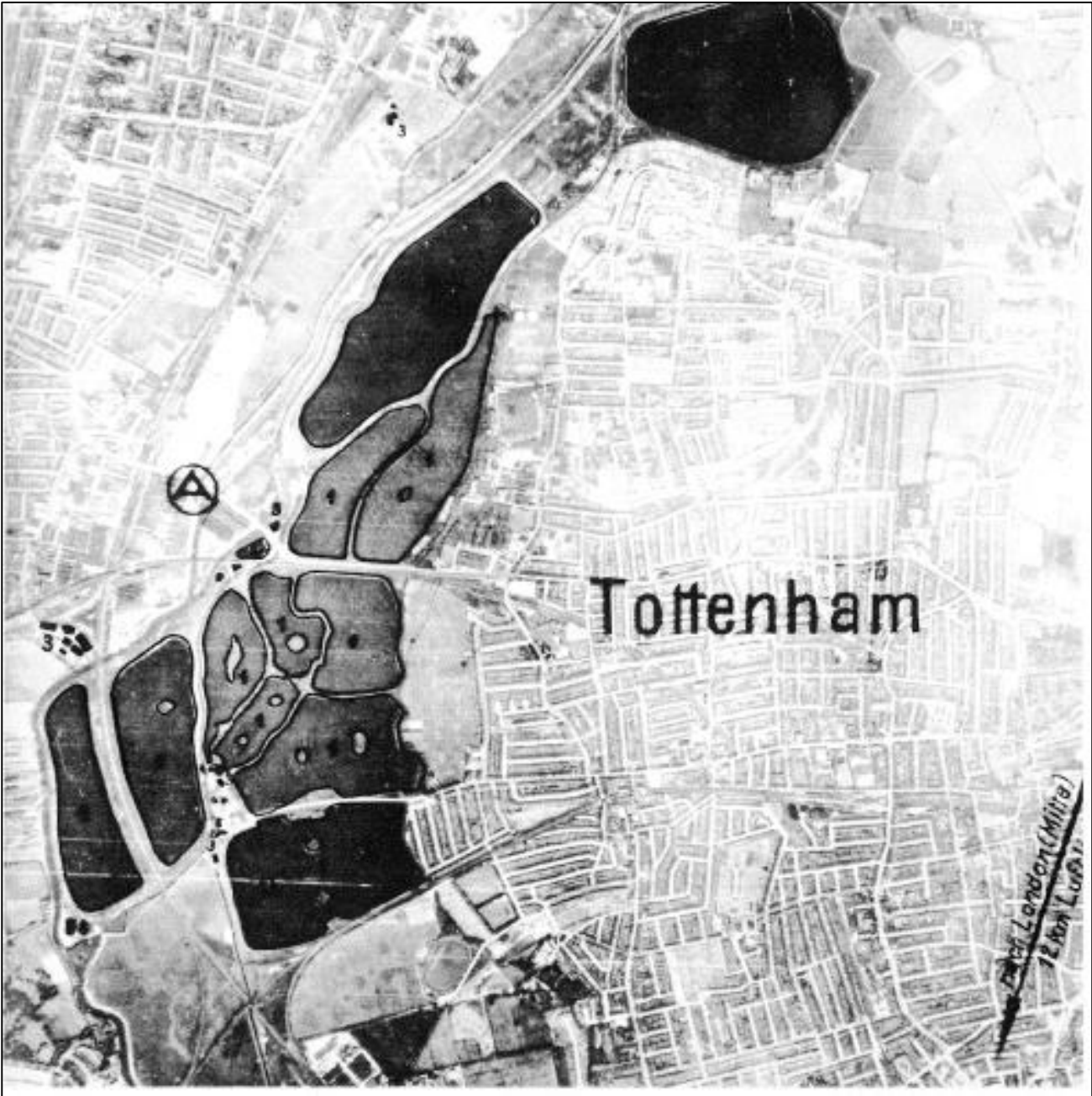
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Source: The London Metropolitan Archives





London – Tottenham
A. Tottenham Water Treatment Works and Reservoir.

The site located approximately 1.6km south-west of Tottenham Water Treatment Works and Reservoir.



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Source: Nigel J. Clarke, “Adolf Hitler’s Home Counties Holiday Snaps”

 **Approximate site boundary**



Night Bombing up to 7th October 1940



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



●● Recorded bomb strike



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Source: The National Archives, Kew

— Approximate site boundary



Night Bombing – 27th January to 3rd February 1941



- Recorded HE bomb strike
- Recorded UXB strike
- Recorded incendiary bomb shower
- Recorded oil bomb strike
- Colour refers to day of the week.





V-1 flying bomb



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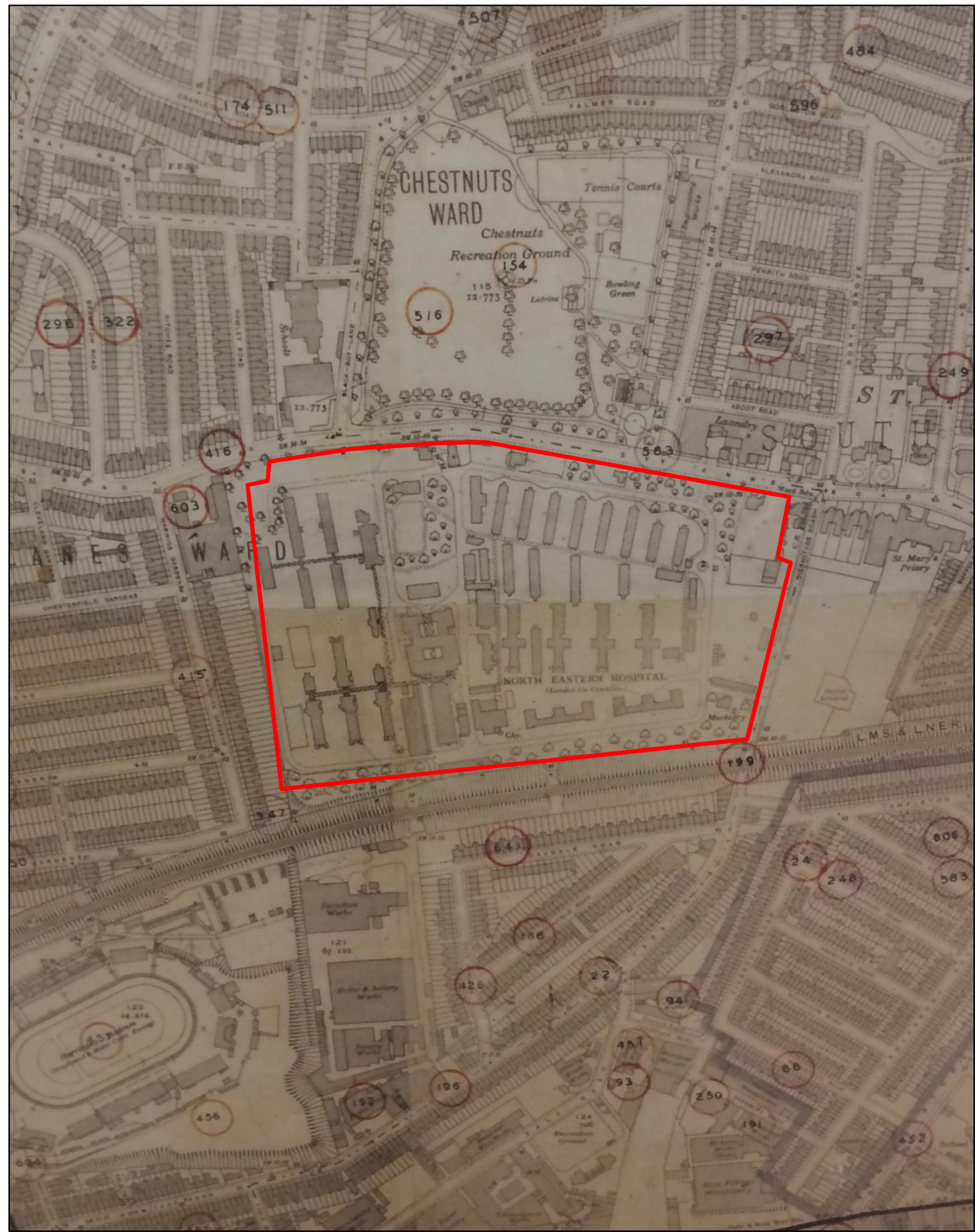
Project: **St Ann's Hospital**

Ref: **DA5244a-00**

Source: The National Archives, Kew

 **Approximate site boundary**





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Source: Haringey Archives

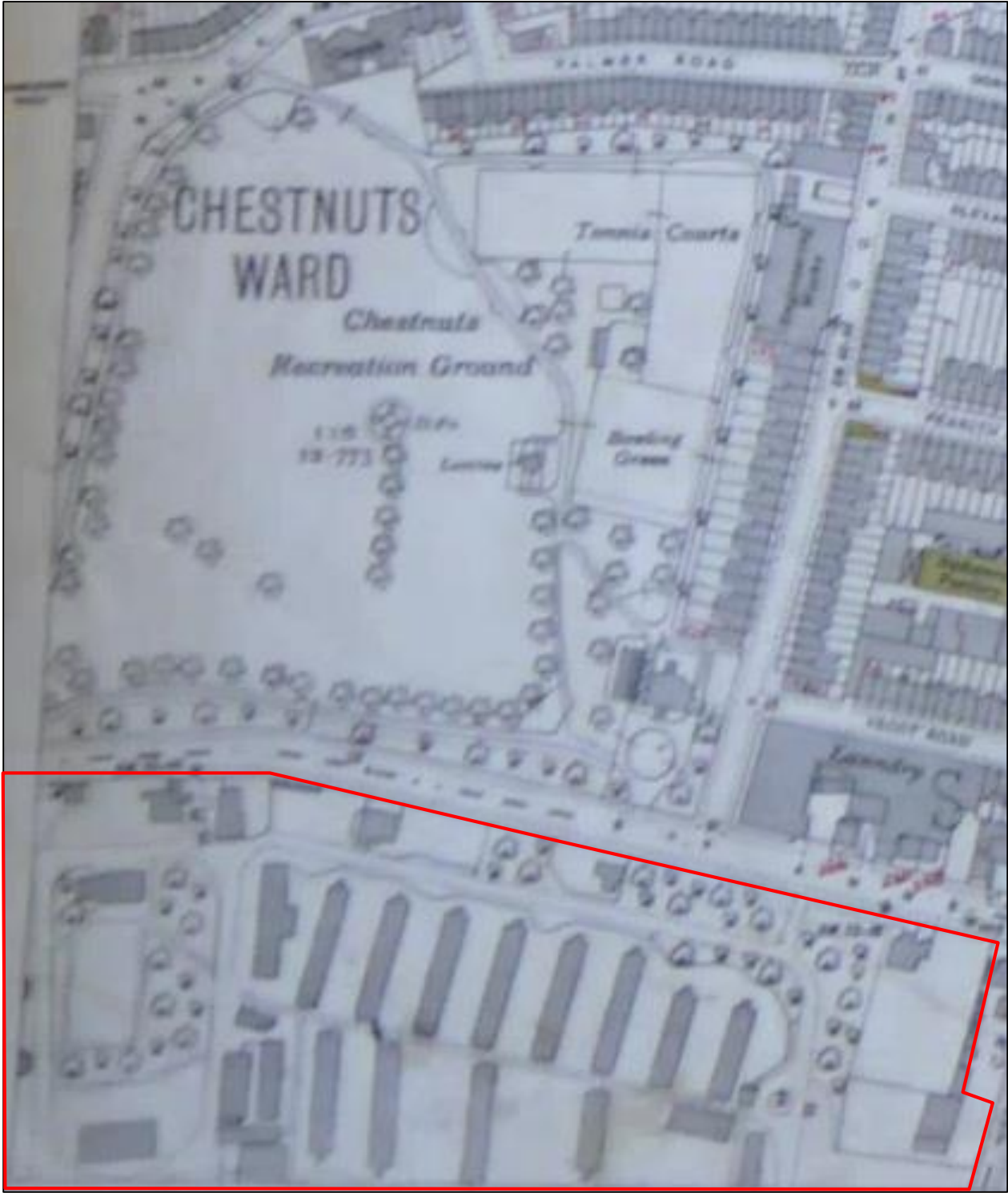
— Approximate site boundary

Tottenham ARP written incident records

228. Hermitage Road on r/way embankment	UX AA (report @) as	-/ HE 05.15 23/09/40
229. Gt Cambridge Road (Roundway east end)		UXB 13.25 23/09/40

Haringey Archives – Local incident records

199	Reported 1325 Unexploded H.E.	On Railway embankment, Nr. Bridge in Hermitage Road		Church and vicarage slightly damaged.
				30.9.40. Found to be unexploded AA shell
347	2005 Unexploded H.E.	Warwick Gardens	NIL	Removed 22.10.4
348	Reported		11 killed 6 injured	6 houses demolished (Nos. 77-87), others damaged. Gas and water mains damaged.
415	0420 H.E.	Roseberry Gardens	2 killed 11 seriously injured. 8 slightly	2 houses completely demolished. 2 partly demolished and several badly damaged. Damage to water mains.
416	0420 Unexploded H.e.	St. Ann's Road outside ever Ready Co.		Damage to water, coal gas mains and sewers. Crater in road.
417	0415 Unexploded	48. Sandringham Road	NIL	House slightly damaged.
416	0420 Unexploded H.e.	St. Ann's Road outside ever Ready Co.		Damage to water, coal gas mains and sewers. Crater in road.
417	0415 Unexploded	48. Sandringham Road	NIL	House slightly damaged.
563	0614 UX.AA	St. Anns Road, Junc. Cornwall Road.	NIL	Windows at 100, 102 & 104. Fences at 102, 104.
Saturday January 2nd, 1944 to Friday January 28th, 1944.			NIL	Pavement and Gutter.
Thursday June 29th, 1944 to Monday July 3rd, 1944.			NIL.	Stamford Road, etc.
Friday 4.7.44	/	1937 Fly.	6 serious	No damage reported in Tottenham.
Wednesday July 5th to Saturday July 8th, 1944.			NIL.	



- Category 1 - "Total damage, building to be demolished."
- Category 2 - "Some repairs possible, but could become Cat 1."
- Category 3 - "Border line areas, uncertain whether repairs possible, might have to be demolished."

- V-1 Flying Bomb
- V-2 Long Range Rocket



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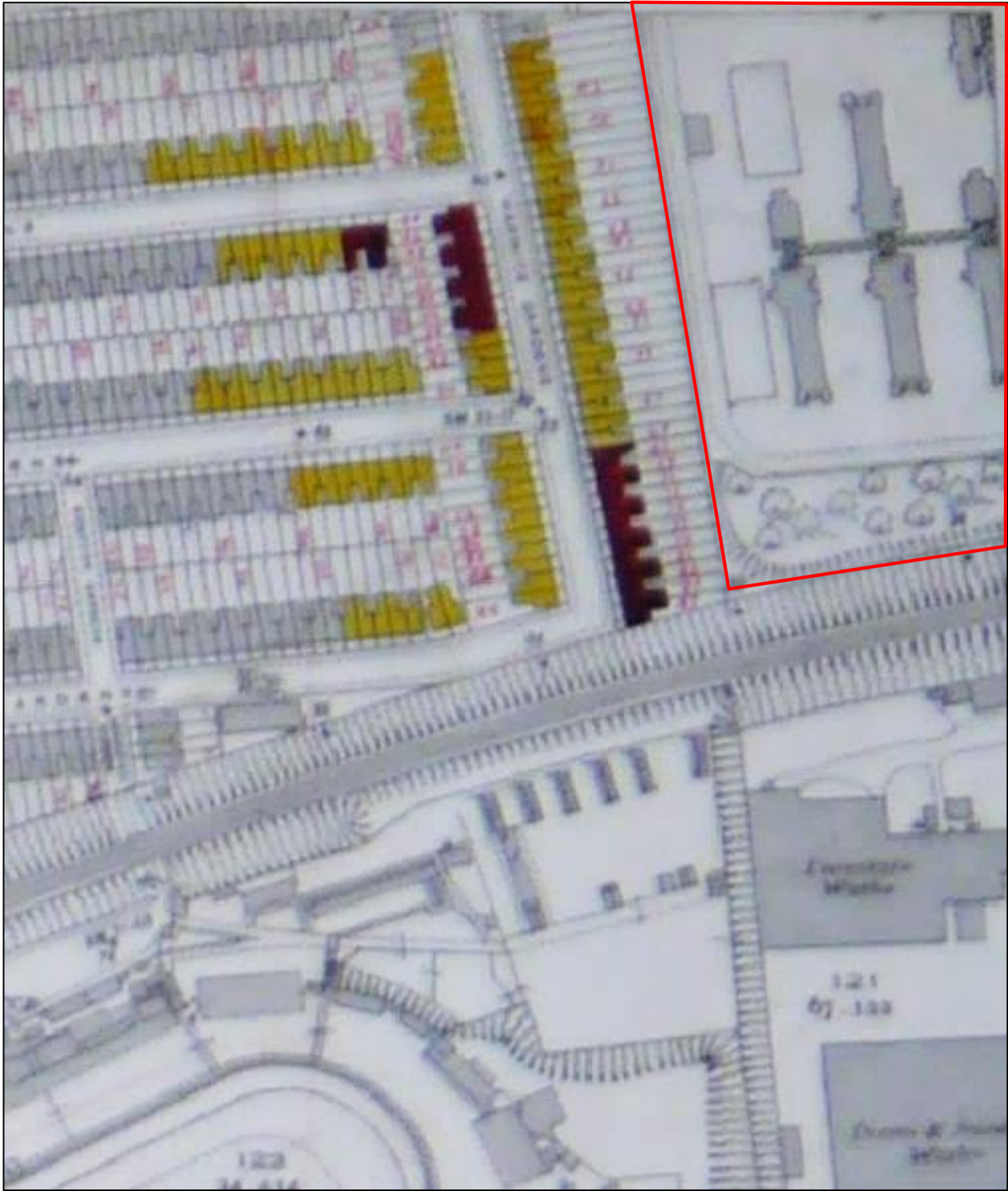
Project: St Ann’s Hospital

Ref: DA5244a-00

Source: London Metropolitan Archives

Approximate site boundary





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Source: National Monuments Record Office (Historic England)

 **Approximate site boundary**





Cleared Ground

Serious Damage

Prefabricated Housing



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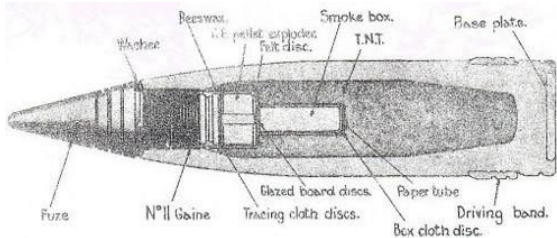
Approximate site boundary



Examples of Anti-Aircraft Projectiles

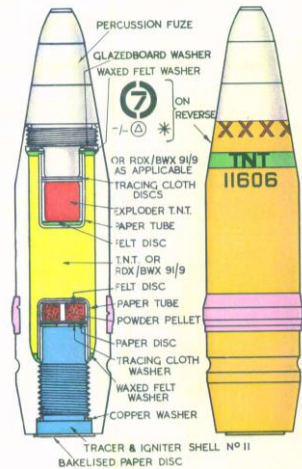
3.7 Inch QF Anti-Aircraft Projectile

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 Mk 1-3 were the standard Heavy Anti-Aircraft guns of the British Army.
Ceiling	30,000ft to 59,000ft



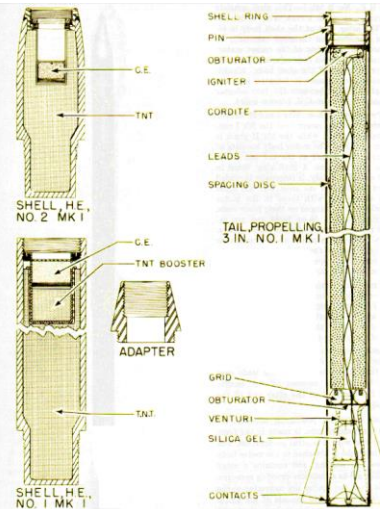
40mm Bofors Projectile

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 fuzeing
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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-  Low Risk
-  Medium Risk

- Low and Medium Risk Areas:**
- Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works
- Medium Risk Area:**
- Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works
 - Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth

For indicative purposes – not to scale



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