

BRIMSTONE

DETAILED UXO RISK ASSESSMENT

STAGE 2 DETAILED UXO RISK ASSESSMENT

Client:	XXXXX	
Project Ref:	XXXX01R	
Site Name:	Wimbledon Common DRA Example	
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EXECUTIVE SUMMARY

RESULT: Brimstone concludes that unexploded ordnance (UXO) poses a **MODERATE RISK** to the proposed works.

THE SITE: The Site is located in Wimbledon, within the London Borough of Merton, approximately 1.8km west of Wimbledon Park station. It is bound in all directions by parcels of open ground, mature vegetation and hardstanding footpaths within Wimbledon Common.

The Site entirely comprises an area of undeveloped ground within Wimbledon Common. Footpaths intersect the Site intermittently throughout.

Grid Reference: TQ 23219 72307 **What3Words:** handed.admiral.living

THE PROPOSED WORKS: SI works on Site will comprise 12 window sample boreholes to an anticipated maximum depth of 20m bgl.

Development works will comprise a five-storey residential development. A basement level to 3m bgl will be constructed, while piled foundations to 20m bgl will be required.

UXO RISK ASSESSMENT:

German UXO:

- During WWII, the Site was located in the Municipal Borough of Wimbledon, which experienced a moderate-to-high bombing density, the result of 99.9 bombs / 1,000 acres. It was also located approximately 320m south-east of the administrative border of the Metropolitan Borough of Wandsworth, which experienced 170.1 bombs / 1,000 acres, a high bombing density. A railway engine repair shed, approximately 2km east of the Site, was identified as a primary bombing target by the Luftwaffe, and it is possible the military infrastructure on Site, such as the AA battery, provided an easily identifiable target of opportunity.
- Indeed, London bomb census mapping records 18 'iron' bombs, three UXBs, two 1,000kg UXBs and one incendiary bomb shower within an approximate 300m radius of the Site. Of these, four HE bomb strikes and two 1,000kg UXBs are recorded within the Site boundary. Additionally, a Wimbledon specific bomb plot map records 12 HE bomb strikes, five UXBs, 11 IB clusters and two AA shell strikes within the same approximate 300m radius. Of these, two HE bombs, one UXB and four IB clusters are recorded within the Site boundary. The fact that these sources record different levels of bombing highlights the difficulty in wartime record keeping and raises the possibility that additional bomb strikes (potential UXBs) fell in the area unnoticed and unrecorded.
- Analysis of WWII-era aerial photography does not identify any obvious signs of bomb damage within the Site boundary itself. Two large craters are, however, visible approximately 40m and 180m south-west of the Site in aerial photography dated 1941. It is possible that subsequent bomb damage to the open ground was obscured by the time the post-war image was taken (1946), with any cratering filled in and obscured from sight. Indeed, craters visible in 1941 imagery are no longer visible by this date, evidencing the fact that they would have been filled in.
- Furthermore, areas of the Site are anticipated to have experienced infrequent levels of access during WWII. Sections of the Site had no obvious purpose during the war, comprising poorly maintained open ground with no immediately obvious military usage. However, it is likely that the known military activity may have provided a degree of monitor to the entire Site, although the period and extent of this cannot be confirmed given that the operational dates of the encampment are unknown.

- In conjunction with varying levels of access, the ground cover across much of the Site was likely unconducive to the visual detection of UXBs. WWII-era photography indicates that the open ground was poorly maintained, and so a UXB strike could have easily gone unnoticed, its entry hole obscured by vegetation / shifting environmental conditions and filling in over time. Whilst a UXB strike to any hardstanding on Site would be instantly recognisable, any UXB strike to the open ground could have gone unnoticed and potentially come to rest beneath the hardstanding owing to the J-curve effect (see ***Section 6.3.2***).
- In summary, evidence of significant bombing within the study area has been identified within available records, including four HE bomb strikes and two UXBs on Site. In addition, conditions in areas of the Site are anticipated to have been largely unconducive to the visual detection of UXBs, although the military presence may have led to more conducive conditions in certain areas. As such, it is entirely possible that a UXB strike affecting the Site may have gone unnoticed and unrecorded, and a **Moderate Risk** of encountering a German UXB has been assessed across the Site.

British / Allied UXO:

- During the late 19th century, the Site occupied the north-western periphery of the Wimbledon Range Complex. These SAA ranges were first established in 1859 and had been cleared by the 1890s. In total, four firing points were located on Site, with a further two just beyond the southern boundary. An overlay of the range footprints in the area is presented at **FIGURE 6**.
- Any unwanted / faulty SAA could have been discarded near the range shooting positions, becoming buried over time. This is particularly significant as pre-WWI practices and regulations may not have been strictly adhered to as 21st century protocols, and there was a prevalent 'out of sight, out of mind' attitude, especially as the ranges were used by volunteers, who potentially lacked the discipline of military personnel. It therefore cannot be ruled out that sections of the Site, particularly those surrounding the firing points, were utilised for the disposal of unwanted / malfunctioning ammunition.
- During WWII, an AA battery was present in the south-west of the Site. This battery is clearly visible in 1941 aerial photography, where four gun emplacements and a command post / ammo shelter are evident. A radar tower is also visible to the east of the main battery, and a large encampment is present in the north-west of the Site. Additionally, small trenches are visible approximately 180m south-west of the Site, potentially being an indicator of additional defensive features / training. This image is presented at **FIGURE 3.**
- Recent WWII-era Allied UXO finds in England indicate an ill disciplined 'out of sight, out of mind' culture in the army during WWII. It would appear that surplus, faulty or partially spent ammunition was sometimes buried or discarded in areas near to their garrison / posting. If discarded, the UXO could then become buried over time and potentially remain in-situ today. It cannot be ruled out that this took place in the open ground surrounding the HAA battery, which would have seen no civilian access and presented ideal conditions for the discreet disposal of ordnance i.e. undeveloped, vegetated land.
- Such personnel often carried out training and manoeuvres in open ground within close proximity to their garrison or barracks. Official records of day-to-day activities of troops at Wimbledon Common are not available and so details about the type of training which took part during busy wartime periods are scarce. However, as an area of open ground adjacent to a military installation, likely with very little civilian access, the unused open ground on Site could have been considered an ideal location for training and feasibly have been used for training with live ordnance.

- Indeed, potential practice trenches are visible in WWII-era aerial photography. A cluster of trenches are present approximately 180m south-west of the Site, whilst another ground disturbance resembling a trench is visible in the east of the Site. Whilst it is not possible to confirm the nature of the ground disturbance on Site, it is possible this provides evidence of training activities occurring. Given that the Site was accessed by armed personnel, there is the potential for ordnance to have been disposed of within the Site boundary, in an unauthorized and haphazard manner i.e. the burial of surplus or faulty ordnance in nearby open ground.
- This is evidenced by two recent hand grenade discoveries at Wimbledon Common, near 'The Windmill'. As The Windmill is present approximately 60m north-west of the Site, these finds suggest that live ordnance was present and disposed of in the locality. It therefore cannot be entirely ruled out that additional items of UXO are present in situ in the area. As a result, the Site has been assessed as **Moderate Risk** from items of Allied UXO.
- 25 permanent HAA batteries were active within range of the Site during WWII, including the battery within the Site boundary. LAA guns likely defended vulnerable points within the borough. Luftwaffe activity was frequent and intense over the wider area and therefore these guns would have expended a vast quantity of ammunition. Consequently, there is an elevated likelihood of unexploded AA shells striking the Site and penetrating to a shallow depth. As a result, the risk of encountering an unexploded AA shell on Site has been assessed as **Moderate**.

Likelihood of UXO Remaining and UXO Encounter:

- The risk associated with any shallow or deep buried German UXBs will likely not have been mitigated at all across the Site. The risk associated with any very shallow buried UXO will have been partially mitigated with the clearing of WWII-era features and subsequent maintenance of the open ground.
- Please note, the risk of a UXO encounter can be considered mitigated in the exact locations and down to the exact depths of any post-WWII intrusive works.

RECOMMENDED RISK MITIGATION MEASURES: The measures detailed below are recommended to mitigate the risk to ALARP level.

Risk Mitigation Measure	Recommendation
UXO Safety Awareness Briefings	Prior to all intrusive works commencing.
Intrusive Magnetometer Probe Survey	Of all pile positions.
EOD Engineer - On Site Supervision	Watching brief of all open excavations.
Non-Intrusive Magnetometer Survey	Open excavations on greenfield land.

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FIGURE 2: Historical OS Mapping

FIGURE 3: Historical Aerial Photography

FIGURE 4: London Bomb Census Mapping / V1 Mapping

FIGURE 5: Wimbledon Bomb Map Overlay

APPENDICES

APPENDIX 1: Recent UXO Incidents and Historical Analysis

APPENDIX 2: Data Sheets - German WWII Air-Delivered Munitions

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QUALITY POLICY

Brimstone Site Investigation Ltd (Brimstone) delivers specialist unexploded ordnance (UXO) risk mitigation services, including the safe location, identification, and disposal of explosive ordnance, to clients in the UK and internationally. Since incorporation in 2016, our purpose has been to provide unbiased, technically rigorous UXO risk mitigation that meets each client's requirements in accordance with relevant national and international standards.

Quality, for Brimstone, means delivering the right outcome safely, on time, and in a form the client can rely on. Our quality management system is independently certified to ISO 9001:2015 by the British Standards Institution (BSI) and carries the BSI Kitemark. The Kitemark goes beyond standard certification by requiring ongoing independent surveillance, product and process testing, and demonstrable performance against the standard, rather than self-declared conformance. The system applies to every part of the business, from desk-based risk assessment through to on-site intrusive works and platform-delivered intelligence products.

Our approach is underpinned by four core commitments:

- **Integrity.** We provide honest, evidence-based advice. Where the data does not support a conclusion, we say so. We do not shape findings to suit a commercial outcome.
- **Professionalism.** Our people are competent, accountable, and properly equipped for the work they undertake. Standards of conduct and delivery are consistent across every engagement.
- **Knowledge.** We invest in the technical development of our staff and in the proprietary data, tools, and platforms that allow us to deliver better-informed risk advice than any peer in our sector.
- **Innovation.** We continually develop new methods, technologies, and products that improve the accuracy, efficiency, and value of UXO risk mitigation for our clients.

We operate a Plan-Do-Check-Act cycle to set, monitor, and review quality objectives. Performance against those objectives is reviewed by the senior leadership team, and the outputs of those reviews drive corrective action and continual improvement of the management system.

This policy applies to all Brimstone personnel, including the Managing Director, and to all subcontractors and suppliers acting on Brimstone's behalf. Every member of the team is responsible for the quality of their own work, for identifying opportunities to improve, and for raising concerns where standards are not being met. Customer satisfaction is measured and acted on, and we are committed to meeting or exceeding the requirements of ISO 9001:2015 in everything we do.

This policy is reviewed annually, or sooner if business circumstances change.

Aaron Florence
Founder
Brimstone Site Investigation Ltd.

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1 INTRODUCTION

1.1 Background

XXXXX (the Client) has commissioned Brimstone to carry out a Stage 2 Detailed Unexploded Ordnance Risk Assessment (DRA) of the proposed works at the Wimbledon Common DRA Example site (the Site).

1.2 Legislation

There are no regulations that specifically govern the UXO risk mitigation industry in the UK. However, there are two pieces of legislation that require consideration. It is industry best practice (and common sense) to frame your site in the context of UXO, and to put in place measures to protect people from risks. In 2009, CIRIA published Unexploded Ordnance (UXO) - A Guide for the Construction Industry C681. This publication, though not legally binding, provides the gold-standard framework to which UXO and construction companies operate.

1.2.1 Construction Design and Management Regulations (CDM) 2015

The regulations identify the client, the CDM coordinator, the designer, and the principal contractor as responsible parties. Under the regulations, responsible parties are held accountable for the way a construction project is managed and for the health and safety of workers. Responsible parties must:

- Provide an appropriate assessment of potential UXO risks, or ensure an assessment is completed by another party.
- Put in place appropriate risk mitigation measures if necessary.
- Supply all parties with information relevant to the risks.
- Ensure the preparation of an emergency response plan.

1.2.2 The Health and Safety at Work Act 1974

The Health and Safety at Work Act 1974 had a transformative impact on health and safety, saving thousands of lives since its enactment. Employers must consider their employees, workers not in their employment, and members of the public. The act places a duty on every employer ‘as far as is reasonably practicable’ to protect workers from risks. It also says that information must be provided about aspects of health and safety that affect their role.

1.3 Commercial Contractor and the Authorities

1.3.1 Commercial Contractors

If your site has been given a moderate or high-risk rating, then control measures will be recommended. The measures will be specific to the scope of works on site, usually in relation to the depth and extent of excavations, piling and similar activities. There are a range of different methods at Brimstone’s disposal, including:

- Non-intrusive surveying (including drone surveying)
- Intrusive surveying
- Search and clear
- Watching brief
- Support to geotechnical investigations
- Target investigation
- Site-specific training packages
- Site safety briefings

Our UXO Engineers can assess suspicious items on site when they are found. This will avoid unnecessary site

evacuations. If our engineer(s) decide the item is UXO, they will coordinate with the authorities, manage disruptions, and advise on control measures, such as evacuations and a cordon.

1.3.2 UK Authorities

If Brimstone is not on site and a suspicious item is found, the local police must be immediately called on the non-emergency number. Police will visit the site. They will then inform the Joint Services Explosive Ordnance Disposal (JSEOD) office, which will coordinate the callout of an army or navy response team.

A precautionary cordon will initially be put into effect, with possible evacuation of homes and businesses, road and rail closures. The cordon may be extended following the advice from JSEOD's response team.

To manage their resources, JSEOD triages incidents. A consideration of the type, size and location of the UXO is made. If an incident is not given a high priority rating, a team may not be available for up to two days following the initial report.

The use of JSEOD is under the Military Aid to Civil Authorities (MACA) framework, therefore the budget and personnel is limited, and there are no statutory obligations made of the MOD. Often the MOD will recommend involvement of a commercial UXO contractor to manage the ongoing risk – this is especially true of former airfields and training areas where contact with land service ammunition can be frequent.

1.4 UXO Risk in the UK

Fortunately, to the best of our knowledge, there has not been a single post-war incident in the UK where a construction worker has been killed or injured because of an item of UXO exploding. There have been cases in mainland Europe where UXO had been struck and then exploded, killing workers. In 2019, a WWII general purpose bomb spontaneously detonated in a field north of Frankfurt, Germany.

However, the incident in Frankfurt is not comparable to the UK, due to the way different countries manufactured ordnance. Bombs made in different countries have different associated hazards. British WWII bombs, for example, have a fuzing system which uses chemicals which makes them very unsafe. Please see **APPENDIX 1** for recent examples of UK UXO incidents.

Between 2013 and 2016 JSEOD responded to 7,500 callouts. These callouts range from falsely identified objects, inert objects, small items of UXO and large WWII German unexploded bombs (UXBs). Each year the construction industry inadvertently unearths UXO; often this goes unreported. UXO contamination comes from three main sources:

- **Enemy action:** during WWI and WWII the air forces of Germany, and to a lesser extent Italy, bombed targets throughout the UK. The German navy bombarded several coastal targets in eastern England during WWI and then in WWII German long-range artillery on the French coast bombarded parts of Kent.
- **Allied military activity:** during WWI and WWII several Allied nations used the UK as a staging area for military action in the European Theatre; predominantly the US and Canada.
- **UK military activity:** domestic British Army, Royal Air Force (RAF) and Royal Navy (RN) training activities during peacetime and conflict as well as anti-aircraft gun and rocket batteries during WWI and WWII.

1.5 UXO Detonations

A detonation is a violent chemical reaction which creates a huge volume of gas. This reaction appears to happen instantaneously – the velocity of the shockwave moving is up to 9,000m per second. This chemical reaction is started using a small amount of very sensitive explosives called primary explosives. These types of explosives are highly sensitive to shock, friction, heat, and spark. As the explosive charge undergoes high order decomposition (detonation), the brisance, or shattering effect, causes the casing to splinter, projecting razor-sharp shrapnel across long distances.

The blast wave effect and the shrapnel effect can cause significant damage. Calculating safety distances is a

complex process. As a rule of thumb, in open ground, a 250kg explosive charge (as would be found inside a typical 500kg bomb) would require an omnidirectional safety distance of at least 1.6km.

Bombs work by amplifying the explosive charge from the sensitive primary explosive through to the main charge or fill of the item. This process is called an explosive train, if any link in that chain is broken, the item will fail to function as intended. This can be due to mechanical, electrical, or manufacturing tolerances or faults. Amongst other reasons, detonation of UXO could occur under the following circumstances:

- **UXO body impact:** A substantial impact onto the main body of a UXO; borehole rigs, piling rigs, jack hammers and mechanical excavator buckets.
- **Fuse impact:** Environmental conditions during decades of burial can result in the primary explosives located in the fuse pocket to crystallise and become shock sensitive. It would then take a relatively small impact or friction impact to cause the fuse to function and detonate the UXO.
- **Re-starting a timer:** A small proportion of German WWII bombs used clockwork fuses. In 2002, an Army EOD Engineer reported that the clockwork fuse in a UXB re-started. Decades of burial causes substantial corrosion in WWII German UXBs and therefore an incident such as this is extremely rare.

2 ASSESSMENT METHODOLOGY

2.1 Introduction

This assessment has been produced in accordance with the relevant CIRIA guidelines; *Unexploded Ordnance (UXO) - A Guide for the Construction Industry C681* (published in 2009). CIRIA C681 is a publication which originated from round table best practice discussions from industry leaders.

2.2 Source, Pathway, Receptor, Consequence Risk Model

The Source, Pathway, Receptor, Consequence (SPRC) risk model can be applied to buried UXO as follows:

- **Sources:** UK and Allied UXO sources include military firing ranges, bases, storage depots, munitions factories, anti-aircraft batteries, amongst others. There are many wartime causes of UXO contamination. The source for enemy contamination is overwhelmingly from WWII German air raids.
- **Pathways:** the pathway describes how the UXO reaches receptors. Usually, UXO is buried and therefore pathways can be any activity which involve breaking ground. Examples include ground investigation works, site enabling works and excavations.
- **Receptors:** receptors are the people, assets and infrastructure that can be adversely affected by UXO exposure. This includes site personnel, plant, equipment, buildings, the general public, and the environment.
- **Consequence:** the consequences of an inadvertent UXO detonation are catastrophic. They include injury and loss of life, as well as damage to property. Fortunately, the likelihood of UXO detonating is low, even when it is uncovered during works. However, another consequence to consider is delays to works, which itself can be a risk.

2.3 Assessment Structure

In accordance with CIRIA C681 this assessment addresses the following considerations in the appropriate order:

- The likelihood that the site was contaminated with UXO.
- The type of UXO that could have contaminated the site, and their associated hazards.
- The likelihood that UXO remains on the site.
- Theoretical bomb penetration depths.
- The likelihood that UXO will be uncovered during the proposed works.
- Risk rating and risk mapping (as appropriate).
- Risk mitigation recommendations.

2.4 Information Sources

To complete this risk assessment, Brimstone has gathered information from a wide range of sources. Brimstone's research team has completed detailed historical research, including access of original archived records. The list below is a general list of information sources that are consulted during the research process. For Site-specific sources consulted for this risk assessment, please refer to **APPENDIX 5**.

- The National Archives,
- Local archive centres,
- Ministry of Defence,
- The Council for British Archaeology,
- Groundsure mapping services,
- Historical aerial photography (Historic England, Britain from Above, NCAP),
- Google open-source mapping,
- The British Geological Survey,
- Open sources; published book, articles, web resources,
- Site-specific information supplied by the Client,
- Brimstone's library and historical database, and
- Brimstone's former armed forces employees.

2.5 As Low as Reasonably Practicable Principle

The ALARP (as low as reasonably practicable) principle corresponds to the actions that should be taken to reduce risks. The term 'ALARP' is in the Health and Safety at Work Act 1974, which says that risks must be controlled in a reasonable way.

Infinite time, effort and money could be spent trying to eliminate risk entirely. HSE uses the example that spending £1m to prevent five employees bruising their knees is disproportionate, whereas spending the same amount to prevent an explosion which could kill 150 people is proportionate.

Using this principle, Brimstone aims to reduce client costs by recommending strategies that are proportionate to the assessed risks, if any elevated risk is found at all.

2.6 Risk Tolerances

The Brimstone risk assessment process divides UXO risk into two tolerances:

- **Tolerable:** Low Risk and Low-Moderate Risk ratings are tolerable. Where the risk cannot be completely discounted, it may be a useful strategy to opt for a low-cost measure, such as a UXO safety briefing from a qualified UXO engineer.
- **Intolerable:** Moderate, Moderate-High, and High-Risk ratings are intolerable. Proactive risk mitigation measures should be put in place. Various strategies are at Brimstone's disposal to meet your project-specific needs.

2.7 Mapping/Imagery Accuracy Disclaimer

The information presented in any drawings, maps, or images has been compiled from a variety of sources, where possible, and is provided for general reference only. While Brimstone makes every effort to ensure the accuracy and completeness of this information, it may contain errors or omissions and should not be relied upon as definitive. Brimstone disclaims any liability for the misuse or misinterpretation of the information and makes no warranties or representations, express or implied, regarding its accuracy, completeness, or suitability for any particular purpose. Please contact Brimstone for further information regarding a map or image and further information can be provided where possible.

2.8 Reliance and Limitations

This report has been prepared using published information and information provided by the Client. Brimstone is not liable for any information which has become available following the publication of this report. No third-party liability or duty of care is extended. Any third-party using information contained in this assessment do so at their own risk.

3 THE PROJECT

3.1 The Site

The Site is located in Wimbledon, within the London Borough of Merton, approximately 1.8km west of Wimbledon Park station. It is bound in all directions by parcels of open ground, mature vegetation and hardstanding footpaths within Wimbledon Common.

The Site entirely comprises an area of undeveloped ground within Wimbledon Common. Footpaths intersect the Site intermittently throughout.

Grid Reference: TQ 23219 72307 **What3Words:** handed.admiral.living

FIGURE 1: Site Location Maps

3.2 The Proposed Works

SI works on Site will comprise 12 window sample boreholes to an anticipated maximum depth of 20m bgl.

Development works will comprise a five-storey residential development. A basement level to 3m bgl will be constructed, while piled foundations to 20m bgl will be required.

4 SITE HISTORY

4.1 Site Introduction

Site-specific history can be assessed by reviewing historical mapping, historical aerial photography and by carrying out additional Site-specific research where appropriate. Below are descriptions of a selection of records relevant to the Site:

4.2 Mapping

The below table describes the composition of the Site, structural changes in pre- and post-WWII Ordnance Survey (OS) editions, and relevant points of interest. All maps were retrieved from National Library of Scotland (NLS) online database and the Landmark Promap OS database.

Period	Map Date	Map Scale	Review
Pre-WWI	1865	1:10,560	A majority of the Site comprises undeveloped ground within Wimbledon Common. It is located on the north-eastern periphery of the Wimbledon Camp rifle range complex. This facility contained over 20 rifle ranges of varying lengths, from 120yds to 1,000yds. Four firing points are recorded directly within the Site boundary, all belonging to different ranges. Additional firing points are present directly south and south-west of the Site. The nearest targets / stop butts are recorded approximately 310m west of the Site boundary. This facility will be discussed further in ***Section 7.2***.
	1893-1894	1:2,500	The rifle range complex has been cleared and re-located, leaving the Site as unused open ground within Wimbledon Common.
WWI	1914	1:2,500	**FIGURE 2:** No significant changes appear to have taken place on Site.
Pre-WWII	1938	1:10,560	Although this map is of small scale and lacks detail, it can be said that no significant changes have occurred on Site.
Post-WWII	1952	1:2,500	**FIGURE 2:** No significant developments appear to have taken place on Site. A small copse is now recorded in the central extent; however, it remains wholly undeveloped. No structures in the wider area have been recorded as 'ruins', and no structural clearance is visible.

4.3 Photography/Aerial Photography

The below table describes the composition of the Site visible in post-WWII aerial photography, including areas of possible structural clearance, damage and other possible features of note. All photographs were retrieved from Historic England's (HE) Royal Air Force (RAF) Photography Archive.

Period	Photo Date	Review
WWII	**18th June 1941**	**FIGURE 3.1:** This vertical photography, displaying the entire Site and its surrounds, was taken during the early years of WWII. The Site has been requisitioned for military use; a camp has been constructed in the north-western extent, with an anti-aircraft battery and associated radar station visible in the southern extent. The camp comprises multiple rows of Nissen huts, and the anti-aircraft battery is set in a typical configuration, with four concrete gun emplacements facing south-west to protect the south-westerly approach to central London. A command bunker is present in the centre of the emplacements, with a radar visible to the east. Anti-landing obstacles, comprising trenches and poles, are visible in a crosshatch pattern across the wider area, including amongst the battery. Smaller excavations are visible in the south-east of the image, approximately 60m south of the Site boundary; these are likely small trenches dug for defensive or training purposes. Two large ground disturbances are visible approximately 40m and 180m south-west of the Site. These are generally consistent with the appearance of German bomb craters, i.e. roughly circular with raised edges. No other evidence of bombing in the area is visible.
Post-WWII	**23rd March 1946**	**FIGURE 3.2:** This vertical image, displaying the entire site in higher resolution than the image discussed above, was taken approximately one year after the conclusion of WWII. The anti-aircraft battery, anti-landing obstacles and small trenches are no longer visible; however, the camp remains extant in the north-eastern extent. Three small bunded structures are visible on Site; their exact purpose is unknown, although they likely comprise air raid shelters / remaining infrastructure from the AA battery. No immediately obvious evidence of additional German bomb damage, i.e. cratering in the open ground or structural clearance / ruins, is visible on Site or in the surrounds. The craters mentioned above are no longer visible.

4.4 Additional Site-Specific History

Some sites will have been occupied by landmarks or significant buildings historically and in such cases specific written histories including significant wartime details are occasionally available in the public domain. No such information was available.

5 UXO RISK - GERMAN BOMBING

5.1 WWI Bombing History

5.1.1 Britain during WWI

During World War I (WWI), an estimated 9,000 German bombs were dropped on London, Eastern England and South-Eastern England during some 51 Zeppelin airship raids and 52 fixed-wing aircraft raids. London suffered the worst of the bombing with an estimated 250 tonnes of HE and incendiary bombs recorded across the Capital, over half of which fell on the City of London district.

The WWI bombing campaign waged by Germany was on a far smaller scale than the WWII campaign, in terms of the number of raids, the weight of ordnance dropped during each attack and the size of the bombs used. When coupled with the fact that most WWI-bombed locations have since been redeveloped, German WWI UXB finds are extremely rare. Furthermore, most air raids took place during daylight hours and as it was the first time Britain had experienced strategic aerial bombardment, the raids often attracted public interest and even spectators, increasing the chances of any UXBs being reported.

5.1.2 Site Specific

A collection of written reports describing each air raid in the region was reviewed.[1] Whilst London as a whole experienced numerous air raids during WWI, only one bomb was dropped on Wimbledon. This landed in the King's College School playing field, approximately 1.7km south of the Site, and failed to explode. Therefore WWI-era bombing does not pose a significant UXO risk on Site today and will not be discussed further.

5.2 WWII Bombing History

5.2.1 London

In the summer and autumn of 1940, the Luftwaffe targeted the RAF's airfields and support network with the intention of achieving air supremacy prior to a planned amphibious invasion of south-east England. The resulting Battle of Britain campaign (July to October) resulted in many air raids across England, although these were mainly concentrated in the south-east. During this period, a few small-scale raids affected the outer London boroughs.

In early September 1940, the Luftwaffe changed their tactics and commenced an indiscriminate carpet-bombing campaign against London. The resulting nine-month Blitz began on 7th September 1940 and ended on 12th May 1941 - the heaviest raid of the Blitz. The vast majority of the Luftwaffe units based in occupied Europe were then redeployed to the Russian front.

During 1943, a number of small-scale fighter bomber raids were carried out against the Capital, then in 1944, the Luftwaffe commenced Operation Steinbock. This campaign comprised 31 major raids against London and other southern England targets, executed by inexperienced Luftwaffe crews, between January and May. However, poor navigation and improved defences resulted in unsustainable Luftwaffe losses, many formations being broken up by the RAF over the Home Counties. The final large-scale Luftwaffe raid on the Capital took place during May 1944, with all air raids ceased by the end of June.

Between 1940 and 1944, there were a total of 71 major air raids on Greater London resulting in some 190,000 bombs being dropped, killing over 29,000. In total some 50,000 tonnes of HE bombs and 110,000 tonnes of incendiary bombs (mainly of the 1kg type) were dropped during the Blitz over Britain. The army BDUs successfully dealt with approximately 40,000 UXBs during the war.

Immediately following the final air raids on London, the Luftwaffe launched the V Weapons campaign, commencing in June 1944. The V1 (Flying Bomb or Doodlebug) and later the V2 (Long Range Rocket) were

[1] https://www.iancastlezeppelin.co.uk/

launched from occupied Europe. 2,419 of the former and 517 of the latter were recorded in the London Civil Defence region.

Both carried a large 1,000kg HE warhead and were constructed of thin sheet steel, rather than the thick steel used on the Luftwaffe's free fall bombs. V Weapons were designed to detonate on the surface (like parachute mines), as opposed to free fall bombs which were designed to have some penetration ability through multi-storey buildings.

Consequently, any V Weapons which failed to detonate broke up on impact, resulting in an easily identifiable debris field. Although there is a negligible risk from unexploded V Weapons on land today, they caused widespread destruction throughout London and therefore, at V Weapon impact sites, the assessment of pre-1944 UXB risk can be hampered.

5.2.2 Luftwaffe Targets

Prior to the outbreak of- and throughout WWII, the Luftwaffe produced thousands of target dossiers to facilitate the tactical bombing of important industrial, infrastructural and military sites within Britain ('primary targets'). Luftwaffe aircraft often conducted targeted air raids against primary targets, resulting in elevated bombing densities in their locality. These target dossiers are held by the Imperial War Museum (IWM) and National Archives and Records Administration (NARA) and have been consulted by Brimstone to determine if any primary targets for tactical bombing were identified within a close proximity to the Site.

The nearest identifiable target for which the Luftwaffe produced a target dossier was a railway engine repair shed and associated sidings, approximately 2km east of the Site. The military infrastructure on Site, including the camp, AA battery and radar, may have comprised viable targets of opportunity.

5.2.3 Bombing Decoy Sites

In mid-1940 bombing decoys were introduced. Decoys were intended to deceive Luftwaffe aircraft in the hope that they would incorrectly identify the decoy as their target area and deploy their payload harmlessly over open country. If a decoy is located within close proximity to a Site area, their presence can often result in an elevated density of bombing locally. These decoys used either:

- A system of lighting to simulate an urban area or a military airfield's runway,
- Deliberately started fires to simulate a previously bombed target,
- Dummy buildings and vehicles to simulate a military facility.

792 static decoy sites were built at 593 locations in Britain. They were estimated to have drawn at least 5% of the total weight of bombs away from their intended targets. No decoys were operational within a significant radius of the Site during WWII. The closest was approximately 2.7km to the north-west.

5.3 WWII Bombing Records

5.3.1 Introduction

The bomb census recorded the location and type of bomb strikes to help with intelligence gathering and planning. It was compiled using information recorded by ARP wardens. These records were gathered by the Ministry of Home Security to calculate bombing density within administrative areas.

The bomb census was unreliable in the early stages of the war, though by 1941 procedures had been standardised. The quality of the census records also depended on where in the UK the records were produced. Some records are held at the National Archives and some are held at local borough archives.

Relevant records held at the National Archives; the London Metropolitan Archives and Merton Heritage & Local Studies Archives were obtained for this risk assessment.

5.3.2 Bombing Density Statistics

The table below records the Ministry of Home Security's bombing density calculation for the Municipal Borough of Wimbledon. It gives a breakdown of the types of large German bombs reported and is understood to not include UXBs.

Admin Area	Wimbledon
Area Acreage	3,213
High Explosive Bombs (all types/weights)	305
High Explosive Parachute Mines	0
Flam (Oil) Bombs	11
40kg Phosphorus Incendiary Bombs (IBs)	5
40kg 'Fire Pot' IBs	0
V1 Flying Bomb	34
V2 Long Range Rocket	0
Total (excluding V-Weapons and 1kg / 2kg IBs)	321
Bombs Per 1,000 Acres	**99.9**

1kg / 2kg incendiary bombs and 2kg anti-personnel (AP) bombs were often too numerous to record accurately and therefore are not included in the above figures. The latter were not dropped on London. Small IBs were however dropped in vast numbers (>100,000) over the capital.

5.3.3 Bomb Census Maps

Brimstone has reviewed a collection of original consolidated and weekly bomb census maps for the wider study area. These small-scale maps cover the entire bombing campaign and record all types of bomb. An overlay plotting bomb strikes recorded in these maps is presented at **FIGURE 4**.

- Approximately 18 x 'iron' bombs, five UXBs (including three unexploded 1,000kg HE bombs) and one incendiary bomb shower are plotted within an approximate 300m radius of the Site.
- Four HE bomb strikes (consolidated mapping) and two unexploded 1,000kg HE bombs (weekly mapping) are recorded within the Site boundary.
- Two potential bomb sticks have been identified in the study area. One of these comprised the two 1,000kg UXBs, whilst the other consisted of three HE bomb strikes approximately 110m east of the Site.
- One 1kg / 2kg IB showers is plotted within approximately 300m of the Site; this was recorded over the northern extent of the Site. Note, no weekly plot maps are available for the 7th September to 7th October 1940 period and therefore it is not known whether IB showers affected the Site during this month.

5.3.4 Wimbledon Bomb Map

Brimstone has obtained a copy of an original bomb plot map for Wimbledon, sourced from a local history publication (Plastow, N. 2010). This map is considered to provide a relatively comprehensive account of bombing in Wimbledon during WWII, and records HE bombs, UXBs, IB clusters, oil bombs, AA shells and V1 rockets. An overlay plotting bomb strikes recorded in these maps is presented at **FIGURE 5.**

- 12 HE bomb strikes, five UXBs, 11 IB clusters and two AA shell strikes are recorded within an approximate 300m radius of the Site.

- Of these, two HE bombs, one UXB and four IB clusters are recorded within the Site boundary. Due to the lack of information regarding the dates of the bomb strikes, it has not been possible to plot potential bomb sticks within this source.

5.3.5 V Weapons

Brimstone has reviewed a collection of original consolidated V1 Bomb Plot Maps, including the Wimbledon bomb map mentioned above, as well as a contemporary plot map of V2 Rocket incidents, produced using collections of original written incident reports.

No V1 or V2 strikes are plotted within or adjacent to the Site boundary. The closest V1 strike (date unknown) is plotted in the Wimbledon Bomb Map approximately 340m to the south, and the closest V2 strike (15th March 1945) occurred 2.8km to the north-west.

Neither of these incidents occurred in close proximity to the Site. Furthermore, as a majority of the Site comprised open ground, it is less likely to be affected by the large blast wave from a V1 impact, compared with a more developed area. Due to their light-body construction and design, V1 rockets were typically unable to penetrate the ground and broke up on impact. As such, there is negligible risk from unexploded V Weapons today.

5.3.6 Abandoned Bomb Register

Due to the overstretched bomb disposal units during WWII, many bombs were intentionally left undisturbed. UXBs were triaged based on where they were and how big they were. If they didn't pose a significant risk, they were 'abandoned'. The locations of these bombs were recorded on the abandoned bomb register.

The abandoned bomb register is a public record document held at the Parliamentary Archives of the House of Commons, from which Brimstone has obtained a copy. The register should not be relied on for completeness or accuracy. The closest abandoned bomb is recorded approximately 3km south-east of the Site.

5.3.7 Secondary Source / Anecdotal Evidence

A search of online resources, as well as a review of local history publications was carried out with the intention of locating any eyewitness accounts of local bombing incidents. Wimbledon at War, 1939-1945 (by Norman Plastow) was checked for references to the wider study area (approximate 300m radius of the Site). The following excerpt was found:

- 24th February 1944 – "*Suspected unexploded bomb fallen in the anti-aircraft camp Site near the Windmill (on Site)… A second crater was found on the perimeter of the camp".* It is subsequently noted that due to the size of the craters these were established to be unexploded 1,000kg HE bombs.

It should be noted that despite containing 12 references to Wimbledon Common, the above entry was the only incident recording bomb strikes within an approximate 300m radius of the Site. Given the large number of bombs recorded within the same radius in other sources, it can be said that this source is far from a comprehensive record of the entire Luftwaffe bombing campaign.

5.4 Likelihood of UXB Contamination

Where detailed bombing records exist, it is possible to predict whether any UXBs could be found on a site. This likelihood is discussed in the following table:

Density of Bombing	
Number of Air Raids in the Vicinity:	A comparison of the bombing incident records confirms that at least seven air raids affected the study area. Note, this number is almost certainly higher as central London was bombed many times during the first month of the Blitz, for which weekly plot maps are unavailable.
Intensity of these Air Raids:	A majority of the bombs dropped locally were likely part of large-scale indiscriminate carpet-bombing raids, which were carried out at night.
Bomb Strike Positions	
Closest Bomb Strikes	HE bombs: On Site. 1kg / 2kg IBs: On Site.
Alignment of recorded Bomb Strikes:	For districts with a very high bombing density, such as that within which the Site was situated, accurate analysis for the alignment of bomb strikes is not always possible. Indeed, only two bomb sticks have been identified; one of these comprises the two 1,000kg UXBs on Site, whilst the other was located approximately 110m east of the Site. Given the high level of bombing experienced by the study area, it is highly likely that additional bomb sticks would have been present in the area, potentially intersecting the Site. However, as it has not been possible to identify the majority of bomb sticks over the Site and given the severity of bombing locally, there may have been multiple occasions during which a UXB (unobserved and unplotted) could have been released over and landed within the Site boundary. For most small IB spreads (covering a wide area) it is impossible to correctly identify the aircraft's flightpath and thus bomb-stick alignment. Furthermore, such bombs were significantly affected by the wind, further hampering analysis.
Bomb Failure Rate	
Evidence to suggest that the generally accepted failure rate of 10% differs in the vicinity of the Site:	None.
UXBs recorded in close proximity to the Site:	On Site.

5.5 Likelihood of Subsequent UXB Detection

A range of circumstances determine whether a UXB strike location would have been identified, during and after the war. This is discussed in the following table. This includes level of access to the Site during WWII, bomb damage, as well as the ground cover during WWII. This is discussed in the following tables.

Historic Access
A UXB falling on a site which was frequently accessed would have had a better chance of being found. ARP Wardens actively searched for UXBs in heavily bombed residential areas. The importance of a site or nearby buildings and infrastructure was also a factor. Many industrial facilities had fire watchers tasked with extinguishing incendiary bombs and reporting UXBs.
A majority of the air raids in the immediate vicinity likely occurred during the hours of darkness. During raids at these times, there is a greater probability that any UXB strike to the Site could have occurred unobserved as residents / employees were inside. This factor decreases the likelihood that any UXB fall would have been witnessed and reported. However, after the Site was requestioned for use by the military, it likely experienced a more frequent level of access, particularly due to the presence of anti-aircraft infrastructure which will have been active during air raids. However, areas of undeveloped ground were present throughout the Site and do not appear to have had an obvious use, such as the eastern extent away from the military facility. Therefore, despite the military presence in the area, it is conceivable that these sections were less frequently accessed and the likelihood of a UXB falling unnoticed in such an area is considered greater.

Bomb Damage
As the bombing campaign continued, damaged areas became vulnerable to unreported UXBs. Bomb site wreckage or soil disturbance at a bomb crater could obscure evidence of a subsequent UXB strike.
No immediately obvious evidence of bomb damage within the Site itself has been identified within available photography. The military structures appear to survive WWII externally intact, whilst the disturbances identified on Site can likely be attributed to Allied activity. Two large potential bomb craters have, however, been identified approximately 40m and 180m south-west of the Site.

Ground Cover Type
A UXB which falls on open field could easily go unnoticed, whereas a UXB dropped on a hard-surfaced car park would have been easily observed.
Any UXB strike to the military structures / infrastructure on Site would have caused incontrovertible evidence of its incidence as it passed through the structures and into the ground beneath. The same can be said for the majority of neighbouring structures and roads to the north-east and north-west, where (assuming no cratering) a HE UXB entry hole would have been persistent and easily recognisable. Grassy areas were present on Site during WWII. It is entirely possible that these became overgrown / unmaintained at some point during the war, creating conditions unconducive to visual UXB detection. Over time, changing environmental conditions could have caused a UXB entry hole to infill, erasing any evidence of a UXB. Note: the diameter of the smallest German HE bomb (which was also the most commonly deployed over Britain) was 20cm, creating a small easily obscured entry hole.

6 WWII GERMAN BOMBS

6.1 Bombs Dropped on the UK

Nazi Germany used different types of ordnance against the UK for different effects. Some types were designed to cause fires, others for their destructive blast effect and other for their penetration capability. Each type of ordnance was fitted with at least one fuze. For some bombs multiple fuzes were used. Many different types of fuzes were available for use – each with its own set of associated hazards.

Data sheets on those bombs most likely to be encountered today are included at **APPENDIX 2**.

- **HE bombs** – **moderate NEQ (net explosive quantity):** the most common types of HE bombs dropped were the SC (general purpose - GP) and SD (semi-armour piercing - SAP) series of bombs. The NEQ is between 30-50%. SAP bombs are engineered to attack light fortifications, whereas GP bombs are used in a mixed destructive blast and anti-personnel fragmentation role. 70% of bombs dropped on the UK were the 50kg type.
- **HE bombs** – **high NEQ:** blast bombs and parachute mines have bodies made of thin steel, allowing for larger HE charges. These were designed to detonate above ground, maximising the blast effect. Parachute mines were weapons slowed by parachutes and designed to detonate without penetrating the ground. Although, in some marshland areas, partially buried parachute mines have been observed. Consequently, it is highly unlikely that any unexploded blast bombs remain buried in the UK today.
- **HE bombs** – **low NEQ:** The PC series were armour piercing bombs used against heavy fortifications and reinforced bunkers. They were not commonly used over the UK.
- **Small incendiary bombs:** The 1kg and 2kg incendiaries were the most dropped bomb. Up to 620 x 1kg incendiaries could be packed into the largest container unit, which opened at a pre-determined height scattering its payload over a wide area. These small bombs could fully penetrate soft ground due to their small diameter. Variants of the 1kg and 2kg incendiary bombs contained a small HE charge designed for an anti-personnel role, and to increase its incendiary effect.
- **Large incendiary bombs - Thick skinned:** The C50 has a thick body and contained a mixture of incendiary liquids and white phosphorus. Another version of the C50 had a white phosphorus fill. The C50 'firepot' contained thermite incendiary containers (aka firepots) and a small HE charge.
- **Large incendiary bombs - Thin skinned:** The Flam 250 and Flam 500 models had thin steel bodies designed to break up on impact, spreading their oil-incendiary mixture, which was ignited by a small HE charge. Consequently, it is highly unlikely that any unexploded Flam bombs remain buried in the UK today. Their unreliability meant withdrawal from frontline use by January 1941.
- **Submunitions:** The SD2 'butterfly' bomb was a 2kg submunition dropped on several British cities and towns. It contained a 225gram HE charge. SD2s had no ground penetration ability so the vast majority were recovered at the time. However, SD2s are still found across Britain today.
- **V1 flying bombs and V2 rockets:** In the final year of WWII Germany began using pilotless weapons against England. Both V Weapons had 1,000kg HE warheads. Due to their light-body construction, they had no penetration ability, and any impact left a noticeable debris field. As such, there is negligible risk from unexploded V Weapons today.

6.2 Bomb Failures

Records from September 1940 to July 1941 show that an average of 84 UXBs were dropped on civilian targets each day. Around 8% of these were time delay bombs – designed to strike the ground and start a predetermined countdown which could last days.

There is a generally accepted 10% failure rate for WWII German HE bombs. This is estimated from records gathered by bomb disposal units. These statistics do not account for UXBs that went by unnoticed.

Failures can happen for different reasons, including:

- Equipment or human error in arming the bombs before release,
- Failure of a mechanism within the fuze (out of tolerance),
- Jettisoning payloads if the bomber was under attack or crashing, or
- Partially functioned bombs (e.g. cracks in the cast TNT).

6.3 Bomb Ground Penetration

6.3.1 Introduction

Using data gathered during WWII by the Ministry of Home Security, estimations can be made about how deep a bomb is likely to penetrate the ground. Over one thousand incidents were reported by the bomb disposal units to support this research. Further tests were carried out, dropping bombs of different sizes into chalk and measuring the depths they reached. This research is held at the National Archives. The estimates are:

Bomb weight (kg)	Ground Type (m)									
	Sand		Gravel		Chalk		Clay		Sandstone	
	Average	Max.	Average	Max.	Average	Max.	Average	Max.	Average	Max.
50	2.8	7.8	2.8	7.8	3.5	7.7	4.0	9.1	2.7	6.0
250	4.8	13.7	4.8	13.7	6.0	13.1	6.8	15.8	4.6	10.4
500	6.0	17.3	6.0	17.3	7.6	16.4	8.7	19.8	5.8	13.1
1,000	7.6	21.9	7.6	21.9	9.6	20.7	10.9	24.9	7.3	16.5

Different layers of geology affect penetration depths. For example, 1m of made ground, then 1m of gravel before reaching clay – as is many areas of London – is not easily calculated from the data above.

When calculating how deep a bomb could have reached, we must make three assumptions:

- **Impact velocity:** German bombing raids were carried out at altitudes in excess of 5,000m. The velocity of impact is roughly 313ms^{-1} (not accounting for resistance). It is the same velocity regardless of mass.
- **Impact angle:** strike angles of 10 to 15 degrees to the vertical. It must be assumed that the bomb was stable at the moment of ground penetration.
- **Bomb design:** Some larger German bombs were occasionally fitted with 'kopfrings' - a metal ring, triangular in cross section, fitted around the nose of the bomb to help prevent penetration. It must be assumed that no 'kopfrings' were fitted.

6.3.2 The J-Curve Effect

During WWII, Bomb Disposal Units (BDUs) reported that most buried UXBs were found horizontal or upturned. This observation confirmed the 'J-curve effect'. As an HE bomb penetrates the ground, slightly offset from the vertical, its passage underground creates a 'J' shape.

This is relevant because the J-curve effect results in a horizontal offset between the buried UXB and its point of entry. This distance is estimated to be one third of the theoretical penetration depth. A low altitude attack, meaning a low impact angle, could produce an even greater offset, of up to 15m.

6.3.3 Site Specific Geology

BGS Mapping	**Superficial Deposits:** Black Park Gravel Member (Sand and Gravel)	**Bedrock Deposits:** Claygate Member (Sand, Silt and Clay)
SI Data	No recent SI data was provided by the Client. However, local BGS borehole logs were available. The closest BGS SI through the same mapped geology as the Site is located approximately 500m south of the Site (BGS ID: 15993876). This SI (October 1962) encountered the following ground conditions: - 0.53m of topsoil - 0.61m of made ground - 4.57m of stiff brown and grey clay - 2.21m of stiff blue / grey silty clay - 7.16m of stiff blue / grey clay	

6.3.4 Site Specific Maximum Bomb Penetration Depth

During WWII, the Luftwaffe dropped many different types of HE bomb. The SC (general purpose) series was by far the most numerous and of this series, the SC 500 model (weighing 500kg) was the largest of the most commonly deployed and therefore this will be used as the benchmark weapon for the Site-specific bomb penetration depth calculations.

In order to calculate the most likely maximum depth to which a bomb would penetrate, Brimstone has taken the average of the average and maximum figures for the predominant Site-specific geology (clay) in the table above. This gives a likely maximum bomb penetration depth of 14.25m below WWII ground level for a 500kg bomb.

Note, the Ministry of Home Security data indicates that the maximum bomb penetration depth could be down to 19.8m for a 500kg bomb, or 24.9m for a 1,000kg bomb; however, in line with the ALARP principle, it is not considered to be a likely scenario that a bomb would penetrate so deeply. Furthermore, while evidence indicates that a 1800kg HE bomb could penetrate to over 30m, these types of bombs were not dropped frequently. For example, War Office statistics confirm that between October 1940 and May 1941 the majority of HE UXBs (>90%) were either 50kg or 250kg, with the 500kg bombs making up most of the remaining 10%.

7 UXO RISK - BRITISH/ALLIED ACTIVITY

7.1 Introduction

The table below lists potential sources of UXO (excluding enemy action). Those which are potentially relevant to the Site are discussed in the subsequent section(s).

Potential UXO Source	Potentially Significant
Army or RAF training areas / ranges	✓
Military bases and other installations	×
Munitions and explosives factories	×
Military storage depots	×
Defensive fortifications	×
Wartime site requisitions	✓
WWII defensive mining (landmines)	×
WWII Home Guard activity	×
Wartime anti-aircraft fire	✓

7.2 Potential Sources of UXO

7.2.1 Introduction

As referenced throughout this assessment, research has identified wartime military usage occurring on Site. Multiple potential Allied UXO risk contamination pathways stem from this usage. These are discussed in the following sections.

7.2.2 19th Century Ranges

Analysis of historical OS mapping has identified a complex of rifle ranges at Wimbledon Common, and on Site, in the 19th century. This range complex was established in 1859 by volunteer riflemen and the National Rifle Association (NRA) in response to fears of a French invasion and the perceived need for a home defence force. These ranges would be heavily used by the volunteers and for shooting competitions, notably the annual NRA Meeting including the Queen's Prize. An overlay of the footprints of the ranges on Site / in the immediate surrounds is presented at **FIGURE 6**.

It is highly likely that all weapons fired on the rifle range will have utilised SAA i.e. solid-shot (low hazard) ammunition. This included late rifled musket ammunition and the .303 rounds used by Enfield rifles. Any faulty SAA could have been discarded near the range shooting positions, becoming buried over time. Each range appears to have only one firing point, and four of these were located directly within the Site boundary, with another along the southern boundary. This is particularly significant as pre-WWI practices and regulations may not have been strictly adhered to as 21st century protocols, and there was a prevalent 'out of sight, out of mind' attitude, especially as the ranges were used by volunteers, who potentially lacked the discipline of military personnel. It therefore cannot be ruled out that sections of the Site, particularly those surrounding the firing points, were utilised for the disposal of unwanted / malfunctioning ammunition.

7.2.3 WWII-era Anti-Aircraft Camp

An AA battery was present in the south-west of the Site during WWII. This battery is clearly visible in 1941 aerial photography, where four gun emplacements and a command post / ammo shelter are visible. A radar tower is also visible to the east of the main battery. This image is presented at **FIGURE 3**.

This battery was established as part of a ring of AA defences protecting central London. The installation on Site formed part of the protection of the south-western approach to the city. This is likely why particularly large radio / radar capabilities are visible in 1941 imagery, to give advanced warning to the city's other defences of an impending raid. As London was by far the most heavily bombed British city during WWII, these guns would likely have been active frequently and the battery would have needed to store a large volume of ammunition.

As the battery was on Site, the risk of UXO contamination stems from improper disposal of AA ammunition stored at the battery rather than shells fired from the guns at enemy aircraft (the associated risk from this pathway will be discussed in ***Section 7.2.5***). The disposal of superfluous / malfunctioning ordnance is known to have taken place around defensive features during WWII, rather than disposing of such items via the proper channels, which could be time consuming. This is more likely to have occurred during periods of heavy bombing, when defences were constantly in use and manpower was stretched thin.

The disposal of ordnance in this manner is more likely to have taken place in the area containing the AA battery and associated camp. As this section of Wimbledon Common was requisitioned for military use, it would have likely had no civilian access, and the open ground would have provided ideal conditions to bury unwanted ordnance.

7.2.4 Military Training

As previously mentioned, the section of Wimbledon Common encompassing the Site was requisitioned for military use during WWII. Indeed, a relatively large camp and AA battery are visible in the north-west and south-west of the Site respectively. Therefore, a number of military personnel would have been present within the Site boundary throughout the conflict.

Such personnel often carried out training and manoeuvres in open ground within close proximity to their garrison or barracks. Official records of day-to-day activities of troops at Wimbledon Common are not available and so details about the type of training which took part during busy wartime periods are scarce. However, as an area of open ground adjacent to a military installation, likely with very little civilian access, the unused ground on Site could have been considered an ideal location and feasibly have been used for training utilising live ordnance.

Indeed, potential practice trenches are visible in WWII-era aerial photography; a cluster of these are present approximately 180m south-west of the Site, whilst another ground disturbance, potentially resembling a trench, is visible in the east of the Site. Whilst it is not possible to confirm the exact nature of the latter, the ground disturbances in this area do not resemble any known agricultural practices and given the known military / Home Guard presence in the area, it is possible these were the result of training activities.

Given that the Site was utilised by armed personnel, there is the potential for ordnance to have been disposed of within the Site boundary in an unauthorized and haphazard manner i.e. the burial of surplus or faulty ordnance in nearby open ground. This may have consisted of land service ammunition (LSA), as well as small arms ammunition (SAA) utilised by the weapons mentioned above.

Post-WWII UXO finds in other defended areas confirm that such situations did occur in areas manned by armed personnel, remaining in-situ today. This is evidenced by two recent hand grenade discoveries at Wimbledon Common, near 'The Windmill'. As The Windmill is present approximately 60m north-west of the Site, these finds

suggest that live ordnance was present and disposed of in the surrounds. It therefore cannot be entirely ruled out that additional buried items of UXO are present in the area.

7.2.5 WWII Anti-Aircraft Fire

Anti-Aircraft (AA) Command was a British Army command established in 1939 to defend the UK during the anticipated German bombing campaign. It controlled the Territorial Army AA artillery and searchlight units. From 1940 to 1945 BDUs dealt with 7,000 unexploded AA shells in Britain. There were three main types of AA battery used for home defence (see below). Data sheets on these AA defences are included at **APPENDIX 3**.

- **Heavy Anti-Aircraft (HAA):** large-calibre guns (3.7" and 4.5") for engaging high-altitude bomber formations. Hundreds of permanent batteries were constructed in and around major cities and military bases during the 1930s. Some 2,000 of these guns were available during the Blitz. Each gun could fire between 10 and 20 rounds per minute and consequently HAA batteries could expend large quantities of shells during each engagement.

  British time fuses were poorly manufactured during WWII, and this led to high failure rate for HAA shells, up to 30%. Unexploded HAA shells had the potential to land up to 27km from their battery, although more typically landed within a 15km radius.

- **Light Anti-Aircraft (LAA):** smaller calibre guns for engaging dive bombers and low altitude intruders. As such, they were mostly used to defend specific industrial and military targets which were subject to precision bomber attack. LAA guns were either .303" calibre machine guns or 20mm and 40mm calibre cannon. The latter were fitted with simple impact fuses and small incendiary or HE bursting charges.

  The 40mm Bofors gun could fire 120 x HE shells / minute to a ceiling of 1,800m. Each shell was designed to self-destruct if it didn't strike an aircraft, however, inevitably some failed and fell back to earth.

- **Z (Rocket) Batteries**: a Z-Battery comprised a grid formation of 64 rocket projectors which fired 2" and later 3" Unrotated Projectile (UP) rockets to a maximum altitude of 5,800m; a ground range of some 9,000m. They were deployed in cities all around the UK from 1941 and proved to be an effective addition to the existing AA guns.

  The rockets measured 0.9m (2") and 1.8m (3") in length with four stabilising fins at the base and were fitted with 3.5kg or 8.2kg HE warheads. The larger warhead had an effective airborne blast radius of up to 20m. Some variants deployed a form of aerial mine described as a "small yellow bomb" which was designed to detach from the rocket at height and descend on a parachute with the objective of becoming snagged on target aircraft and then detonating.

Unlike bombs which were designed to strike the ground, AA projectiles and rockets were designed to function in the air. Due to their shape, and centre of gravity they would often not strike the ground nose first. This coupled with the lower mass of AA UXO resulted in shallower ground penetration depths, compared to UXBs. Although, in very soft conditions, unexploded AA projectiles have been found deeper than 1.5m bgl.

25 permanent HAA batteries were active within range of the Site during WWII, including the battery within the Site boundary. LAA guns likely defended vulnerable points within the borough. Luftwaffe activity was frequent and intense over the wider area and therefore these guns would have expended a vast quantity of ammunition. Consequently, there is an elevated likelihood of unexploded AA shells striking the Site, with any such shells penetrating to a shallow depth and potentially remaining in situ.

8 UXO RISK MITIGATING CIRCUMSTANCES

8.1 Introduction

Works on a UXO contaminated site could result in the partial or complete removal of UXO risk. Construction or earthworks may have uncovered any UXO contamination, which would then have been reported and removed by the authorities. A site may have been subject to an explosive ordnance clearance (EOC) task conducted by the armed forces. EOC tasks involve surveying, subsequent target investigation and removal of UXO. Although the effectiveness of historic EOC tasks will have often been unsatisfactory.

8.2 Explosive Ordnance Clearance Tasks

The division of EOC tasks has been complex throughout British military history. It used to be the case that anything under the water level would be dealt with by navy units, and anything on land would be dealt with by army units. In recent years, RAF Explosive Ordnance Disposal (EOD) capability has been discontinued, and now only the Royal Navy and the British Army have EOD units. In the army, the Royal Logistics Corps and Royal Engineer EOD units have been amalgamated to form 29 EOD & Search Group. Often taskings are assigned to either the naval or army elements based on where in the country the threat is and the nature of the threat.

Brimstone has access to a database of historic EOC tasks. This database is only complete up until the early 2000s and therefore does not include recent EOC tasks. No such database for the RAF and Royal Navy EOD units is easily accessible. A search of this database has not resulted in any Army EOC tasks in the vicinity of the Site.

UXO encounters on civilian land are often reported in the media and therefore a web search of local media outlets was also carried out. On 29th March 2012, metal detectorists found a WWII-era hand grenade at an undisclosed location 'near the Windmill' on Wimbledon Common. The Windmill is located approximately 60m north-west of the Site.[2] Subsequently, on 18th September 2026, an additional hand grenade was found on Windmill Road, approximately 10m north of the Site. This grenade was disposed of in a controlled detonation.[3] Both of these incidents indicate that military activity resulting in UXO contamination took place in the study area during WWII.

8.3 Ground Works

The Site appears to have undergone limited development post-WWII. All of the WWII-era infrastructure on Site was cleared by 1951, and the Site has remained undeveloped since.

The clearance of these features, alongside general maintenance of the open ground, has likely disturbed ground to very shallow (<1m bgl) depths only on Site. No evidence of substantial post-WWII ground intrusions to shallow (1-2m bgl) or deep (>2m bgl) depths has been identified.

8.4 Deductions

The risk associated with any shallow or deep buried German UXBs will likely not have been mitigated at all across the Site. The risk associated with any very shallow buried UXO will have been partially mitigated with the clearing of WWII-era features and subsequent maintenance of the open ground.

Please note, the risk of a UXO encounter can be considered mitigated in the exact locations and down to the exact depths of any post-WWII intrusive works.

[2] https://www.yourlocalguardian.co.uk/news/9618440.explosive-find-for-wimbledon-treasure-hunters/

[3] https://www.london-now.co.uk/news/26568026.wimbledon-common--historic-grenade-discovery-sparks-evacuations/

9 CONCLUSION

9.1 Accuracy of Historical Records

Occasionally, the accuracy of some historical records can prove to be poor when compared with other sources of information. One significant consequence of this can be the possibility of unrecorded German bomb strikes in the study area. In this case, the London-wide bomb census mapping and a Wimbledon specific bomb plot map record differing numbers of bomb strikes within the Site boundary. This highlights the difficulty in wartime record keeping, particularly during periods of intense bombing, and raises the possibility that additional bomb strikes (potential UXBs) fell in the area unrecorded.

9.2 The Risk of UXO Contamination on Site

9.2.1 Key Findings – German UXO Risk

- During WWII, the Site was located in the Municipal Borough of Wimbledon, which experienced a moderate-to-high bombing density, the result of 99.9 bombs / 1,000 acres. It was also located approximately 320m south-east of the administrative border of the Metropolitan Borough of Wandsworth, which experienced 170.1 bombs / 1,000 acres, a high bombing density. A railway engine repair shed, approximately 2km east of the Site, was identified as a primary bombing target by the Luftwaffe, and it is possible the military infrastructure on Site, such as the AA battery, provided an easily identifiable target of opportunity.
- Indeed, London bomb census mapping records 18 'iron' bombs, three UXBs, two 1,000kg UXBs and one incendiary bomb shower within an approximate 300m radius of the Site. Of these, four HE bomb strikes and two 1,000kg UXBs are recorded within the Site boundary. Additionally, a Wimbledon specific bomb plot map records 12 HE bomb strikes, five UXBs, 11 IB clusters and two AA shell strikes within the same approximate 300m radius. Of these, two HE bombs, one UXB and four IB clusters are recorded within the Site boundary. The fact that these sources record different levels of bombing highlights the difficulty in wartime record keeping and raises the possibility that additional bomb strikes (potential UXBs) fell in the area unnoticed and unrecorded.
- Analysis of WWII-era aerial photography does not identify any obvious signs of bomb damage within the Site boundary itself. Two large craters are, however, visible approximately 40m and 180m south-west of the Site in aerial photography dated 1941. It is possible that subsequent bomb damage to the open ground was obscured by the time the post-war image was taken (1946), with any cratering filled in and obscured from sight. Indeed, craters visible in 1941 imagery are no longer visible by this date, evidencing the fact that they would have been filled in.
- Furthermore, areas of the Site are anticipated to have experienced infrequent levels of access during WWII. Sections of the Site had no obvious purpose during the war, comprising poorly maintained open ground with no immediately obvious military usage. However, it is likely that the known military activity may have provided a degree of monitor to the entire Site, although the period and extent of this cannot be confirmed given that the operational dates of the encampment are unknown.
- In conjunction with varying levels of access, the ground cover across much of the Site was likely unconducive to the visual detection of UXBs. WWII-era photography indicates that the open ground was poorly maintained, and so a UXB strike could have easily gone unnoticed, its entry hole obscured by vegetation / shifting environmental conditions and filling in over time. Whilst a UXB strike to any hardstanding on Site would be instantly recognisable, any UXB strike to the open ground could have gone unnoticed and potentially come to rest beneath the hardstanding owing to the J-curve effect (see ***Section 6.3.2***).

- In summary, evidence of significant bombing within the study area has been identified within available records, including four HE bomb strikes and two UXBs on Site. In addition, conditions in areas of the Site are anticipated to have been largely unconducive to the visual detection of UXBs, although the military presence may have led to more conducive conditions in certain areas. As such, it is entirely possible that a UXB strike affecting the Site may have gone unnoticed and unrecorded, and a **Moderate Risk** of encountering a German UXB has been assessed across the Site.

9.2.2 Key Findings - British UXO Risk

- During the late 19th century, the Site occupied the north-western periphery of the Wimbledon Range Complex. These SAA ranges were first established in 1859 and had been cleared by the 1890s. In total, four firing points were located on Site, with a further two just beyond the southern boundary. An overlay of the range footprints in the area is presented at **FIGURE 6**.
- Any unwanted / faulty SAA could have been discarded near the range shooting positions, becoming buried over time. This is particularly significant as pre-WWI practices and regulations may not have been strictly adhered to as 21st century protocols, and there was a prevalent 'out of sight, out of mind' attitude, especially as the ranges were used by volunteers, who potentially lacked the discipline of military personnel. It therefore cannot be ruled out that sections of the Site, particularly those surrounding the firing points, were utilised for the disposal of unwanted / malfunctioning ammunition.
- During WWII, an AA battery was present in the south-west of the Site. This battery is clearly visible in 1941 aerial photography, where four gun emplacements and a command post / ammo shelter are evident. A radar tower is also visible to the east of the main battery, and a large encampment is present in the north-west of the Site. Additionally, small trenches are visible approximately 180m south-west of the Site, potentially being an indicator of additional defensive features / training. This image is presented at **FIGURE 3.**
- Recent WWII-era Allied UXO finds in England indicate an ill disciplined 'out of sight, out of mind' culture in the army during WWII. It would appear that surplus, faulty or partially spent ammunition was sometimes buried or discarded in areas near to their garrison / posting. If discarded, the UXO could then become buried over time and potentially remain in-situ today. It cannot be ruled out that this took place in the open ground surrounding the HAA battery, which would have seen no civilian access and presented ideal conditions for the discreet disposal of ordnance i.e. undeveloped, vegetated land.
- Such personnel often carried out training and manoeuvres in open ground within close proximity to their garrison or barracks. Official records of day-to-day activities of troops at Wimbledon Common are not available and so details about the type of training which took part during busy wartime periods are scarce. However, as an area of open ground adjacent to a military installation, likely with very little civilian access, the unused open ground on Site could have been considered an ideal location for training and feasibly have been used for training with live ordnance.
- Indeed, potential practice trenches are visible in WWII-era aerial photography. A cluster of trenches are present approximately 180m south-west of the Site, whilst another ground disturbance resembling a trench is visible in the east of the Site. Whilst it is not possible to confirm the nature of the ground disturbance on Site, it is possible this provides evidence of training activities occurring. Given that the Site was accessed by armed personnel, there is the potential for ordnance to have been disposed of within the Site boundary, in an unauthorized and haphazard manner i.e. the burial of surplus or faulty ordnance in nearby open ground.

- This is evidenced by two recent hand grenade discoveries at Wimbledon Common, near 'The Windmill'. As The Windmill is present approximately 60m north-west of the Site, these finds suggest that live ordnance was present and disposed of in the locality. It therefore cannot be entirely ruled out that additional items of UXO are present in situ in the area. As a result, the Site has been assessed as **Moderate Risk** from items of Allied UXO.
- 25 permanent HAA batteries were active within range of the Site during WWII, including the battery within the Site boundary. LAA guns likely defended vulnerable points within the borough. Luftwaffe activity was frequent and intense over the wider area and therefore these guns would have expended a vast quantity of ammunition. Consequently, there is an elevated likelihood of unexploded AA shells striking the Site and penetrating to a shallow depth. As a result, the risk of encountering an unexploded AA shell on Site has been assessed as **Moderate**.

9.3 Site-Specific UXO Hazards

Different types of UXO pose differing types of hazard, depending on their structural design, Net Explosive Quantity (NEQ), fill type and likely contamination depth. The table below lists the main types of UXO most often encountered on urban UK sites and their relative hazard levels.

UXO Type	NEQ (NEQ Range)	Likely Burial Depth	Hazard Posed
WWII German General Purpose HE Bombs	25kg - 220kg (most commonly deployed bomb weights)	Deep burial (>2m)	**HIGH**
WWII British Heavy Anti-Aircraft Shells (HAA Shells)	1.1kg - 1.7kg	Shallow burial (1-2m)	**MODERATE-HIGH**
WWII British Land Service Ammunition (LSA)	<2kg	Shallow burial (1-2m)	
WWII German 2kg Incendiary / HE Bombs (IBs)	680g incendiary hazard + ~500g explosive hazard	Shallow burial (1-2m)	
WWII German 1kg IBs	680g (incendiary, not explosive hazard)	Shallow burial (1-2m)	**MODERATE**
WWII British Light Anti-Aircraft Shells (LAA Shells)	4g - 70g	Very shallow burial (<1m)	**LOW-MODERATE**
Small Arms Ammunition (SAA)	<1g	Very shallow burial (<1m)	**LOW**
Inert/Practice Item	0g	Very shallow burial (<1m)	

9.4 The Likelihood of UXO Encounter

9.4.1 Introduction

This report assesses the risk of UXO in relation to the proposed works, not simply the risk that UXO remains buried on Site. The likelihood of UXO encounter during intrusive ground works will vary depending on the type of UXO and the type of construction methods employed during the project. With increased soil disturbance i.e. more excavations, the likelihood of encountering UXO increases.

Within an area of elevated UXO contamination likelihood, the sub-surface volume of potential UXO contamination will comprise the natural soil / geology in between WWII ground level and the maximum bomb penetration depth. Therefore, any intrusions into this layer will be at risk of UXO encounter.

Any post-WWII fill material deposited on a site is unlikely to be contaminated with UXO and therefore the risk of encountering UXO on such a site could vary with depth.

In the wake of the initial nine-month Blitz, many cities and towns were left with vast quantities of bomb site rubble that required removal and relocation. This material was put to use for in a variety of ways, for example >750,000 tons of London's rubble was used to build runways for new RAF and USAAF airfields and much of Liverpool's rubble was used to create and maintain sea / flood defences throughout Merseyside.

It is quite possible that unexploded British AA projectiles and German 1kg incendiaries were overlooked during removal, resulting in UXO contaminated fill material ending up on otherwise low UXO risk sites, possibly many miles from any high bombing density areas.

9.4.2 German UXBs

Although most German UXBs came to rest several metres below WWII ground level, these weapons can be found at any level between just below WWII ground level and the maximum bomb penetration depth. There are a number of reasons why these heavy bombs might be found at surprisingly shallow depths.

- **Tip and run:** When enemy aircraft had to take evasive action to escape RAF fighter intercepts or AA defences, they often dropped their bomb loads from a reduced height, potentially resulting in extreme J-curve effect.
- **Deflection:** the shape of German bomb nose sections meant they were susceptible to deflection when striking surface or shallow sub-surface obstacles, occasionally resulting in shallow burial or even UXBs skidding across hardstanding.
- **Aircraft Crash Site:** if an aircraft was unable to dump its bomb load before impacting the ground, due to mechanical fault, any externally fitted bombs could have become buried on impact.

German 1kg / 2kg incendiaries were cylindrical and approximately 50mm in diameter. They had tail sections, and so landed nose first. Within soft ground this could result in full penetration of the bomb below the surface. Such UXBs are usually found close to the surface.

9.4.3 British / Allied UXO

The nature of British/Allied military activity involving LSA and SAA and the smaller size of these munitions (in relation to German HE bombs) indicates that any resulting UXO contamination on a site will be limited to shallow depths, usually within 1.5m of the surface, notwithstanding added material to raise the ground level.

Domestic military LSA and SAA contamination will either be the result of expending blinds (dud ammunition) which bury into the ground on impact or munitions purposefully buried, for a number of reasons. Either way, these types of UXO are all found at shallow depth.

9.4.4 Deductions

An elevated likelihood of UXO contamination (British and German) and likelihood of that UXO remaining up to the present day has been identified across the entire Site. Therefore, all the proposed works are considered to be exposed to a UXO encounter.

10 OVERALL RISK RATING

Ratings for the likelihood of UXO contaminating the Site, remaining within the Site up to the present day and being encountered during the proposed works, inform the overall risk rating. Please refer to the UXO hazard table presented in ***Section 9.3*** for a breakdown of the most common hazards and their associated risk. The colour of each respective type of hazard indicates the associated risk, as defined within the aforementioned table. The UXO risk to the proposed works has been assessed as **Moderate.**

Risk Table					
Risk Zone	**UXO Type (Hazard)**	**Likelihood of UXO Contamination**	**Likelihood of UXO Remaining**	**Likelihood of UXO Encounter**	**Overall Risk Rating**
Moderate	**WWII German GP HE Bombs**	Moderate	Moderate-High	Moderate	**MODERATE**
	HAA Shells	Moderate	Moderate	Moderate-High	
	LSA	Low	Moderate	Moderate-High	
	German 2kg IBs	Low	n/a		**LOW**
	German 1kg IBs	Low	n/a		
	LAA Shells	Low	n/a		
	SAA	Low	Moderate	Moderate-High	**MODERATE**

11 RISK MITIGATION RECOMMENDATIONS

Brimstone has identified an elevated UXO risk to the proposed works. The measures detailed below are recommended to mitigate the risk to ALARP level.

Risk Mitigation Measure	Recommendation
UXO Safety Awareness Briefings: To all personnel conducting intrusive works on Site. An essential part of the Health & Safety Plan for a site. Conforms to the requirements of CDM2015.	Prior to all intrusive works commencing.
EOD Engineer - On Site Supervision: Watching brief for open excavations below WWII ground level. Portable magnetometer instruments for clearing ground ahead of borehole positions and shallow excavations (where / when appropriate). Positive identification of suspicious (non UXO) objects. Liaison during confirmed UXO incidents. Provision of additional UXO Safety Awareness Briefings.	Watching brief of all open excavations and magnetometer survey of borehole locations.
Intrusive Magnetometer Probe Survey: A range of intrusive magnetometer methodologies can be deployed to survey the ground (down to the maximum bomb penetration depth) prior to deep intrusive works; pile foundations. The appropriate technique is governed by a number of factors, the most important being the site-specific ground conditions.	Of all / any pile positions.
Non-Intrusive Magnetometer Survey: A range of non-intrusive magnetometer methodologies can be deployed to survey large areas of land to a limited depth. Such surveys can typically detect a 50kg WWII bomb at a depth of 4.5m, in “clean” ground. This survey is only appropriate for greenfield land where “magnetic noise” is negligible. To extend survey range, a reduced dig and secondary survey can be carried out.	Open excavations on greenfield land.

FIGURES: 1 - 6

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DRA-XX-XXXX

Project: Wimbledon Common DRA Example

Client: XXXXX

Source: XXXX

Legend:

- Site Location
- Site Boundary

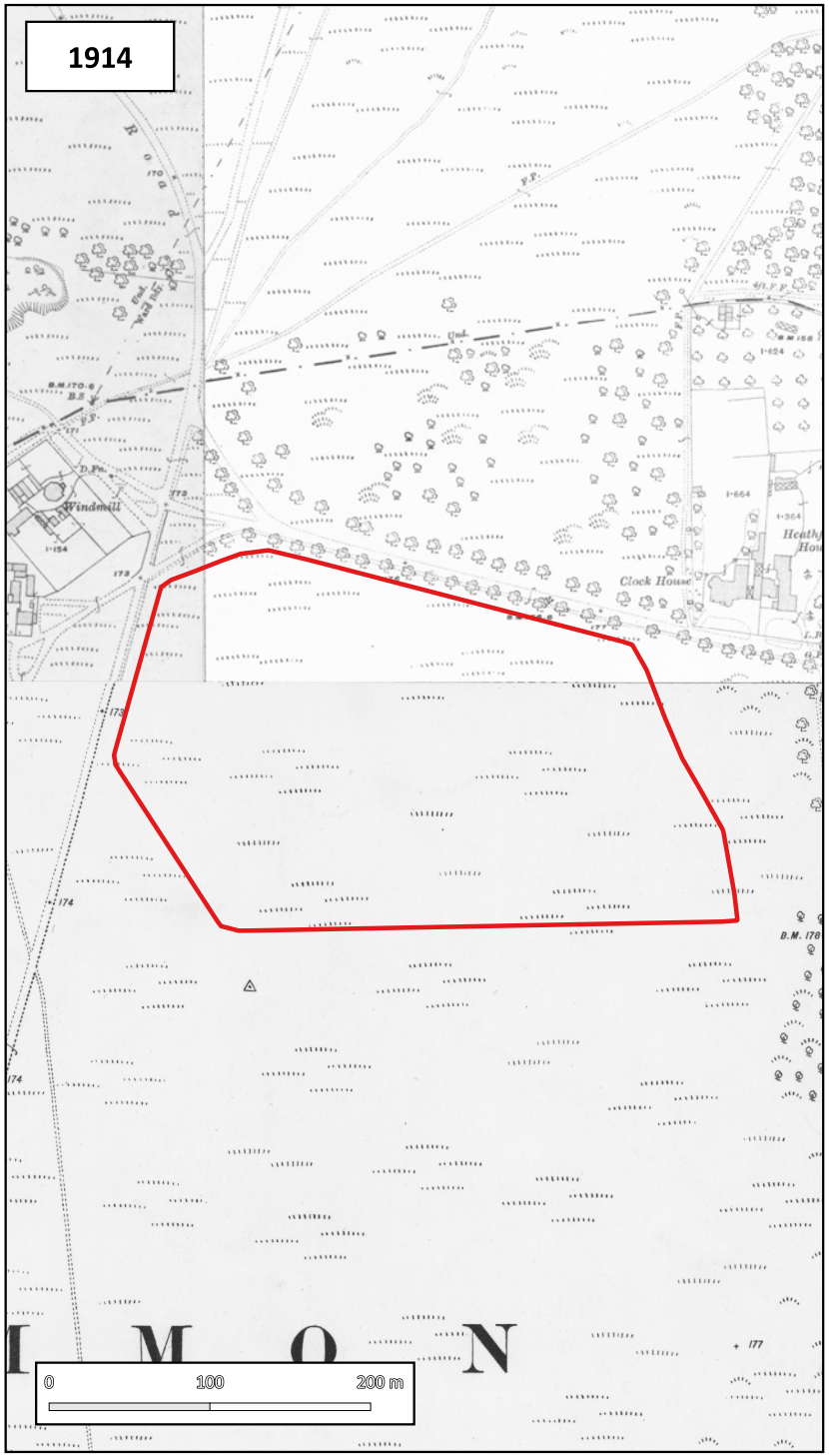
Notes:

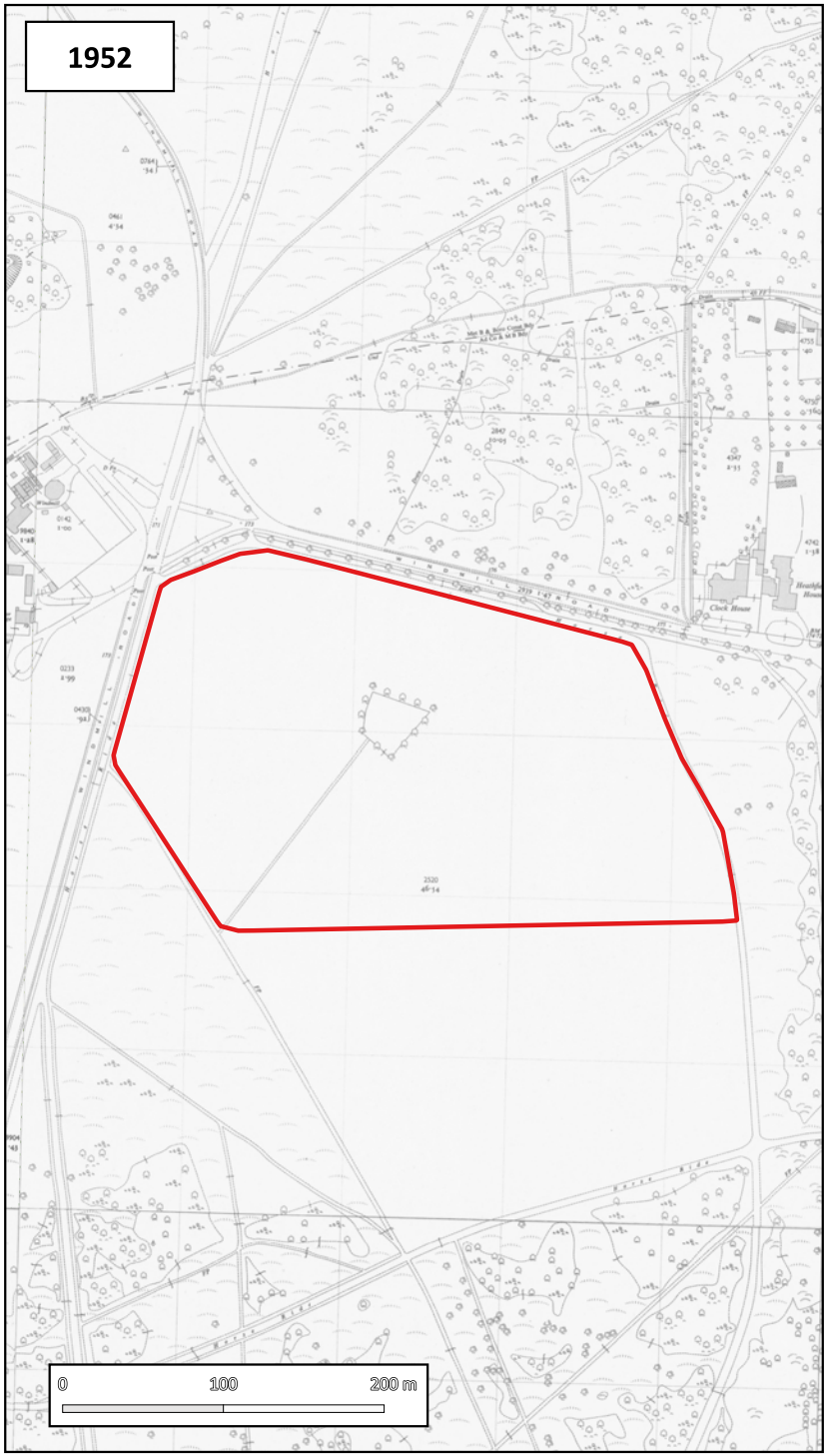
Site Location

FIGURE: 1

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Project: Wimbledon Common DRA Example

Client: XXXXX

Source: XXXX

Legend:

Site Boundary

Notes:

Historical OS Mapping

FIGURE: 2

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Project: Wimbledon Common DRA Example

Client: XXXXX

Source: XXXX

Legend:

Site Boundary

Notes:

Historical Aerial Photography

FIGURE: 3.1

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Project: Wimbledon Common DRA Example

Client: XXXXX

Source: XXXX

Legend:

Site Boundary

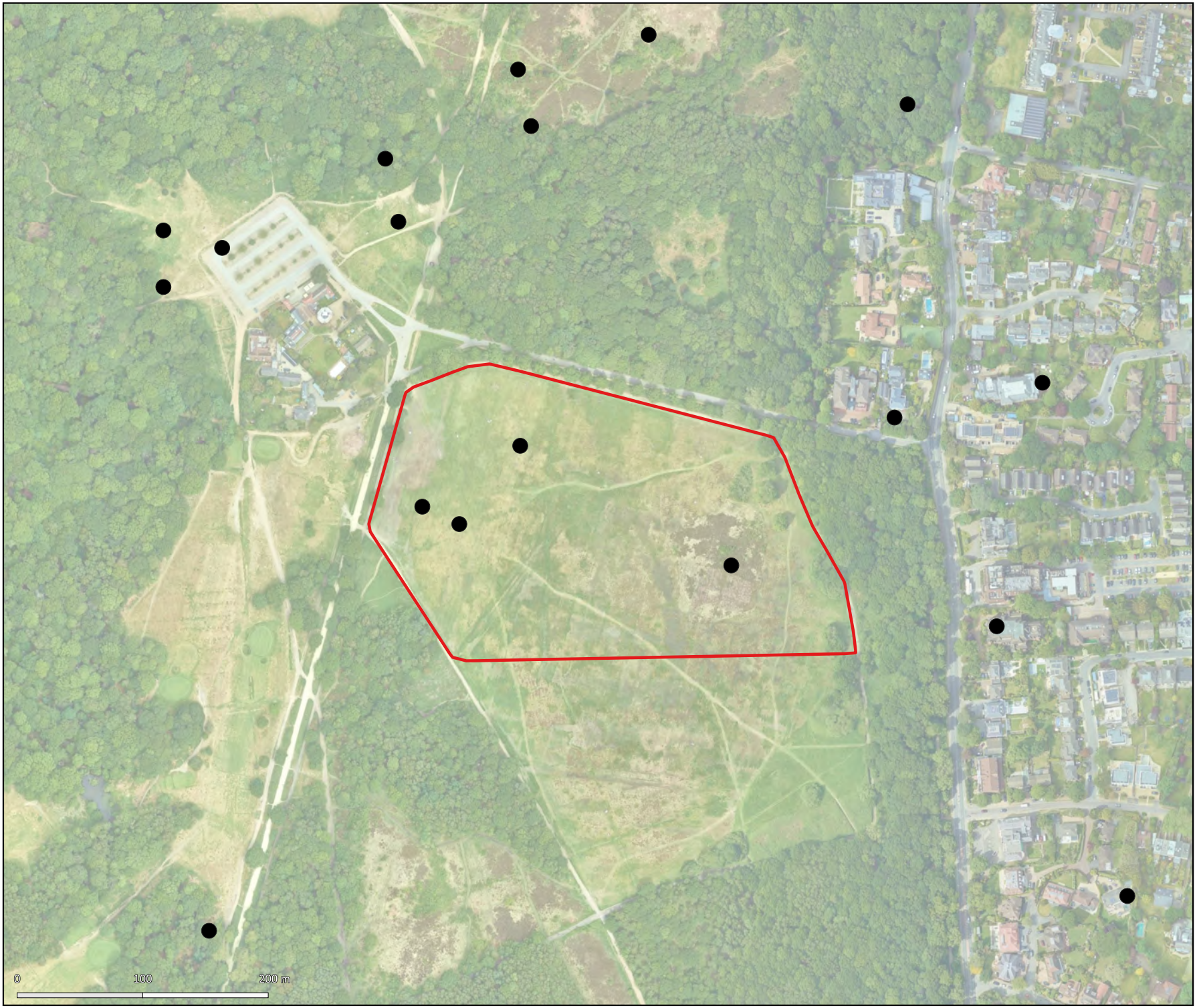
Notes:

Historical Aerial Photography

FIGURE: 3.2

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Project: Wimbledon Common DRA Example

Client: XXXXX

Source: XXXX

Legend:

- Site Boundary
- HE Bomb Strike

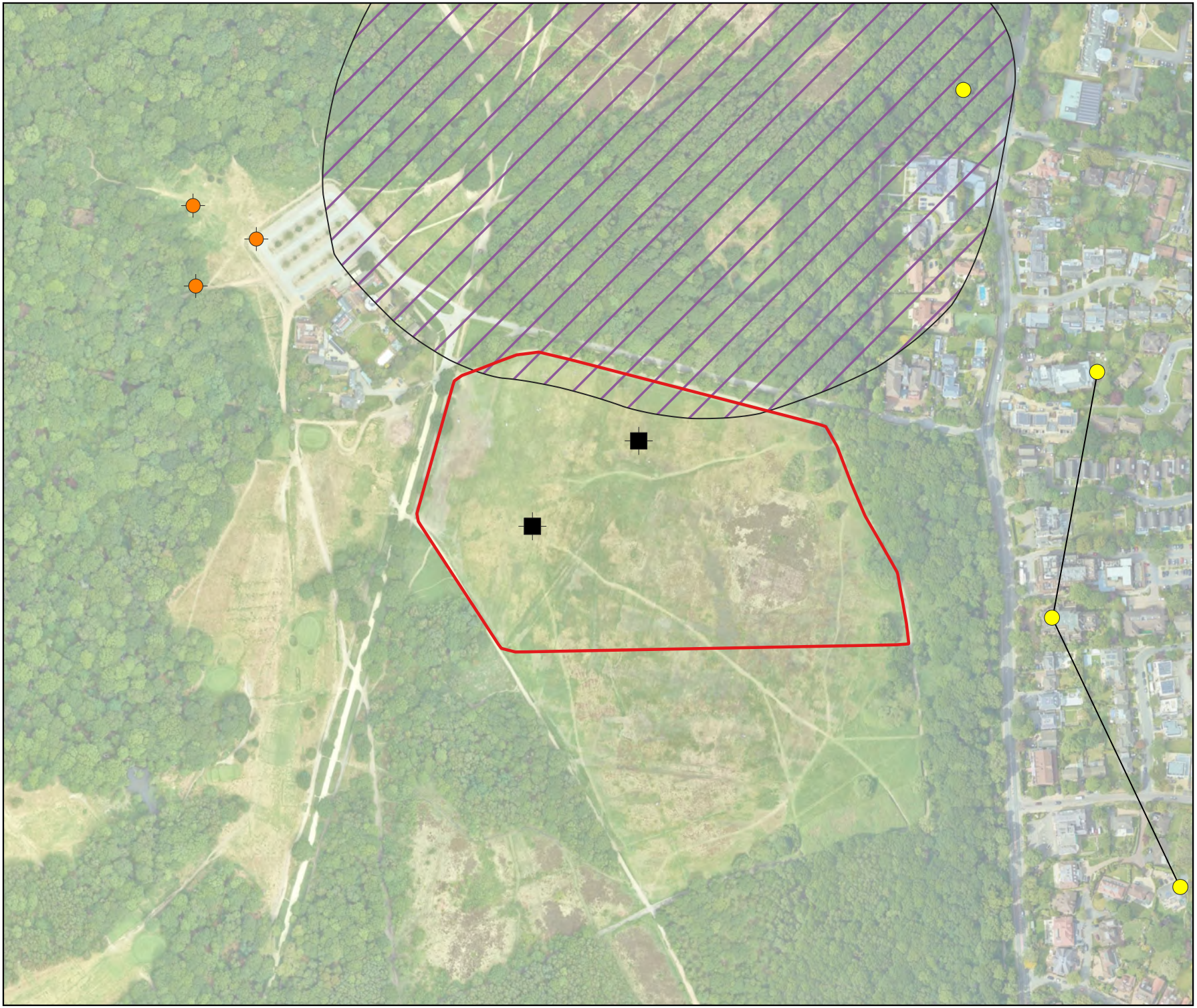
Notes:

Consolidated Bomb Mapping Overlay

FIGURE: 4.1

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Project: Wimbledon Common DRA Example

Client: XXXXX

Source: XXXX

Legend:

Site Boundary

04-11 November 1940

HE Bomb Strike - Weekly

Potential Bomb Stick

17-24 February 1941

IB Shower

03-10 March 1941

UXB Strike

21-27 February 1944

1000kg UXBs

Notes:

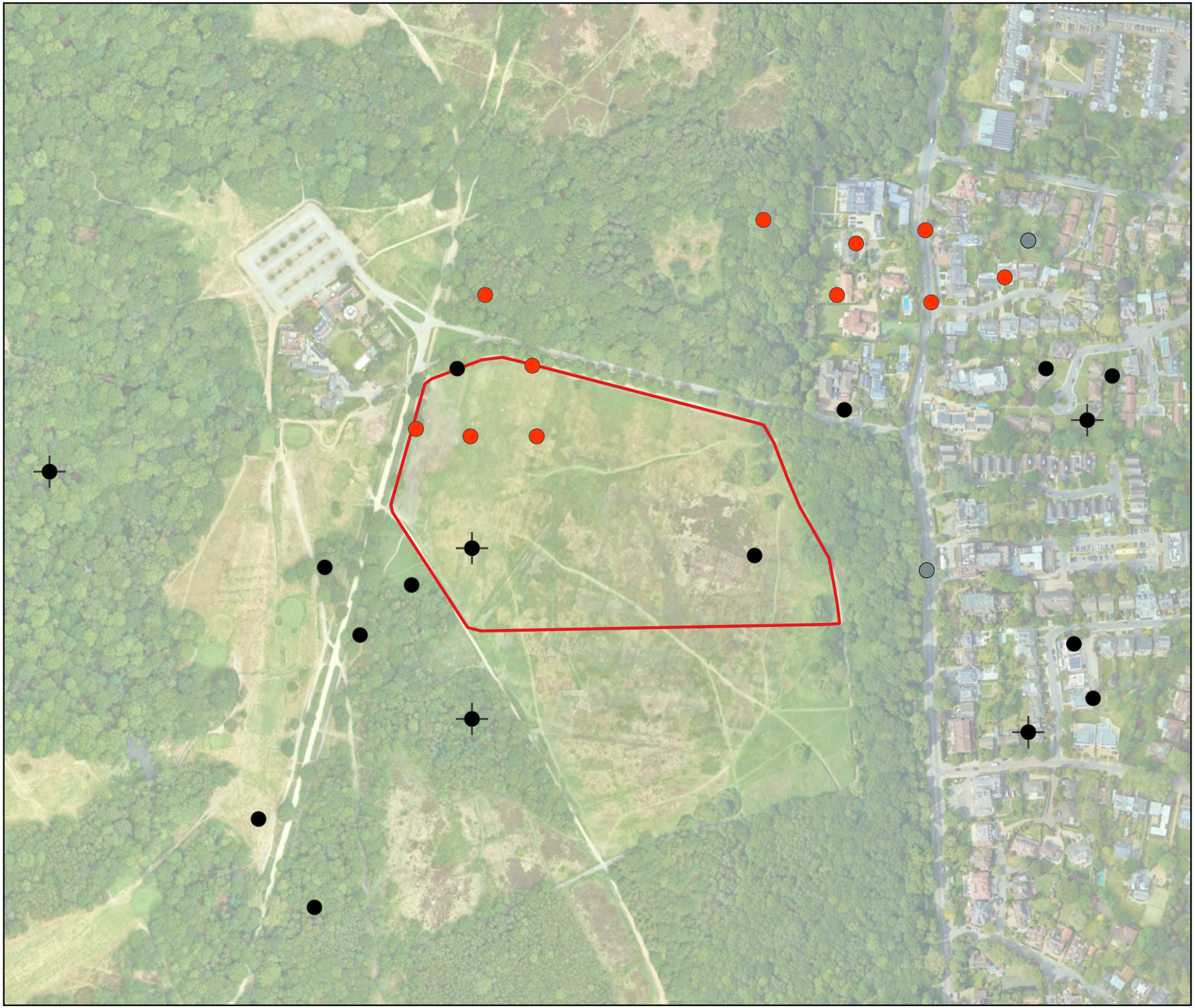
Weekly Bomb Census Mapping Overlay

FIGURE: 4.2

N

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Project: Wimbledon Common DRA Example

Client: XXXXX

Source: XXXX

Legend:

Site Boundary

Wimbledon Bomb Map

- High Explosive
- UX High Explosive
- Incendiary Bomb
- AA Shell

Notes:

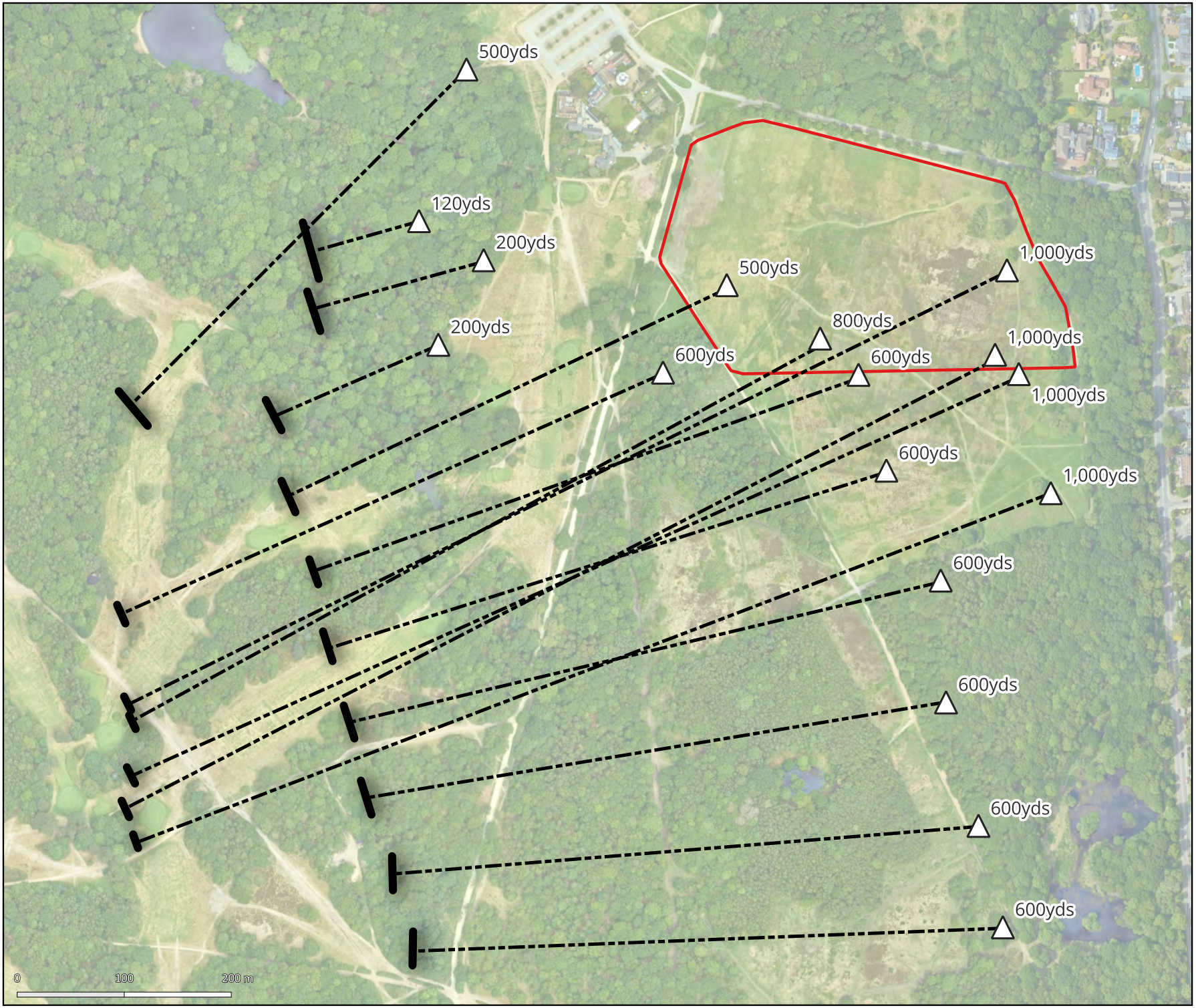
Wimbledon Bomb Map Overlay

FIGURE: 5

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Project: Wimbledon Common DRA Example

Client: XXXXX

Source: XXXX

Legend:

- Site Boundary
- Firing Point
- Stop Butts
- Range Alignment

Notes:

19th Century Rifle Range Overlay

FIGURE: 6

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APPENDICES: 1 - 7

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Recent German UXB Finds in the UK + Historical Analysis

The Ministry of Defence (MOD) says that bomb disposal teams around the UK deal with approximately 60 German WWII-era UXBs per year.

- ***20th February 2024*** – An SC500 (standard 500kg HE bomb) was found during shallow excavations in a residential garden in Keyham, Plymouth. *Historical Analysis: The UXB landed in a small residential back garden belonging to an undamaged terraced house. It came to rest at approximately 1 to 2m bgl.*
- ***10th February 2023 –*** An SC250 (standard 250kg HE bomb) was dredged out of the River Yare in Great Yarmouth. The UXB detonated unexpectedly in situ during an attempt to disarm it. *Historical Analysis: The UXB landed in the River Yare; the precise location of its initial impact is unknown. UXBs in water are often affected by migration, whereby the item can travel along the riverbed.*
- ***26th February 2021 –*** An SC1000 (standard 1,000kg HE bomb) was discovered during shallow excavations in Exeter, adjacent to the University of Exeter. The item was detonated in situ and caused structural damage to nearby properties, leaving some inhabitable. *Historical Analysis: The UXB landed in undeveloped land of no obvious significance. It came to rest at approximately 2 to 3m bgl with its nose facing upwards, highlighting the potential of J-curve occurring.*
- ***23rd May 2019*** - An SC250 (standard 250kg HE bomb) was found during shallow excavations at a building site in Kingston upon Thames, London. *Historical Analysis: The UXB landed in a small residential back garden belonging to an undamaged terraced house. It came to rest approximately 3 to 4m bgl.*
- ***11th February 2018*** – An SC500 (standard 500kg bomb) was discovered in George V Dock in London during planned work at London City Airport. *Historical Analysis*: *George V Dock was identified as a primary target by the Luftwaffe during WWII and was bombed on multiple occasions.*
- ***15th May 2017 -*** An SC250 (standard 250kg HE bomb) was found during shallow excavations at a building site in Aston, Birmingham. *Historical Analysis: The UXB landed in a small back garden belonging to a terraced house, part of a row. It J-Curved under a neighbouring garden and came to rest at just 1.4m bgl. NB: These houses had not sustained bomb damage.*
- ***2nd March 2017 -*** A 250kg HE bomb was found during deep excavations at a building site in Brondesbury Park, London. *Historical Analysis: UXB landed in a large residential back garden. A single storey building was built on top of the UXB post-WWII.*

Recent Allied UXB finds in Europe

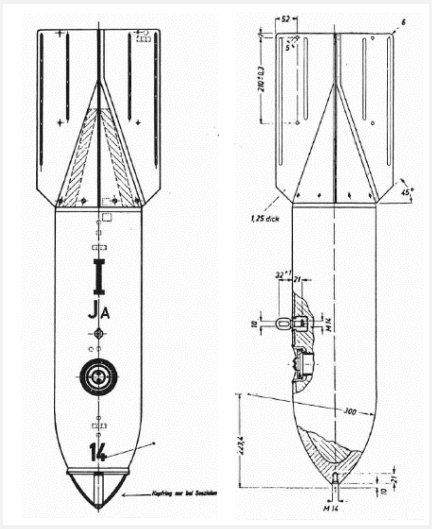
- ***27th June 2024*** – A 250kg HE UXB of Allied origin was discovered in a wooded area in Gruenheide (Germany).
- ***26th April 2024*** – A 500kg American HE UXB was discovered during construction work in Mainz (Germany), nearby the MEWA Arena stadium.
- ***3rd April 2024 –*** A 500kg UXB of Allied origin was discovered during construction work on a shipping channel in Deutz, Cologne (Germany). The device was defused in situ.
- ***28th March 2024*** – A 500lb American HE UXB was discovered during construction work in Aachen (Germany). The device was defused in situ.
- ***11th August 2023 –*** A 250kg HE UXB of Allied origin was discovered in Lublin (Poland). The device was discovered in an area where an aircraft factory had been located prior to WWII.
- ***8th August 2023*** – An unexploded "one-tonne shell" (1000kg HE UXB) of anticipated Allied origin was discovered near Dusseldorf city zoo (Germany).
- ***5th July 2023*** – A UXB of unspecified origin and calibre (alleged to have been Russian but no confirmation) was discovered on a construction site in Hohenschönhausen, Berlin (Germany). The device was defused in situ.
- ***17th March 2022*** – A farmer ploughing a field discovered a British INC30 (incendiary) bomb, which contained phosphorous, in Viersen (Germany). The plough became embedded in the device, which did not explode.

NB: Domestic UXO finds in the UK are too numerous to list. Between 2006 and 2009, over 15,000 items of British / Allied UXO (excluding small arms ammunition) were found on UK construction sites (CIRIA).

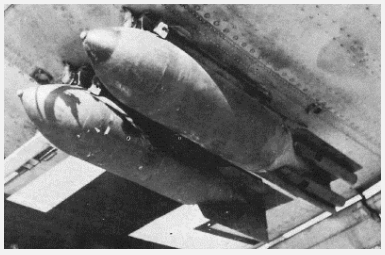
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SC 50

Bomb Weight:	40-54kg (110-119lb)
Explosive Weight:	25kg (55lb)
Filling:	TNT, Amatol or Trialen
Charge/Weight Ratio:	46%
Fuse Type:	Electrical impact fuse or mechanical delayed action fuse
Body Dimensions:	1,100mm length x 200mm diameter
Appearance:	Bomb body and tail painted grey/green with a yellow stripe on the tail unit. Steel construction.
Variants:	8 x variants. Additional fittings: Kopfring nose for limited penetration and Stabbo nose for dive-bombing.

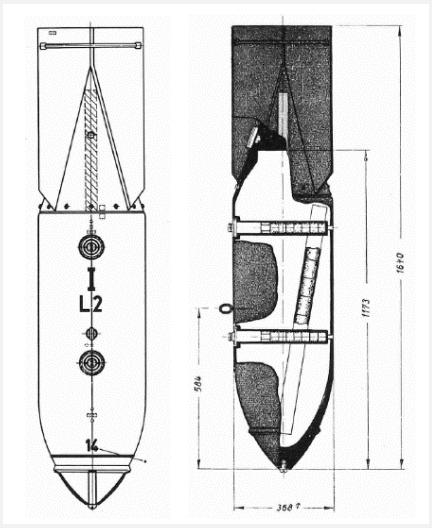






SC 250

Bomb Weight:	245-256kg (540-564lb)
Explosive Weight:	125-130kg (276-287lb)
Filling:	TNT, Amatol and Trialen mix
Charge/Weight Ratio:	44%
Fuse Type:	1 or 2 electrical impact fuse(s) or mechanical delayed action fuse(s)
Body Dimensions:	1,173mm length x 368mm diameter
Appearance:	Bomb body and tail painted grey/green with a yellow stripe on the tail unit. Steel construction.
Variants:	8 x variants. Kopfring nose for limited penetration. Stabbo nose for dive-bombing.

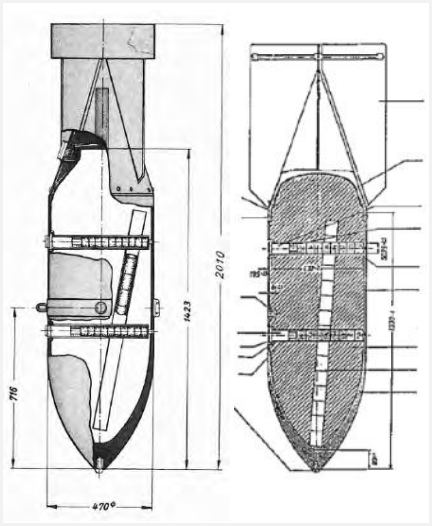






SC 500

Bomb Weight:	480-520kg (1,058-1,146lb)
Explosive Weight:	220kg (485lb)
Filling:	TNT, Amatol and Trialen mix
Charge/Weight Ratio:	44%
Fuse Type:	2 electrical impact fuses or mechanical delayed action fuses
Body Dimensions:	1,423mm length x 470mm diameter
Appearance:	Bomb body and tail painted grey/green or buff with a yellow stripe on the tail unit. Steel construction.
Variants:	3 x variants. Kopfring nose for limited penetration.





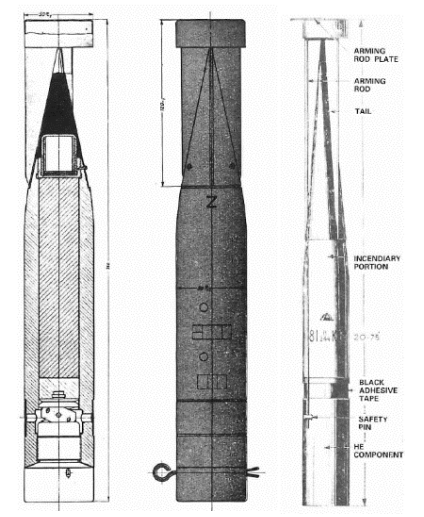


Project:	**Wimbledon Common DRA Example**
Client:	**XXXXX**
Report Ref:	**DRA-XX-XXXX**
Info Source:	*W, Ramsey.1988 / various news sources*

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B-1E Sub-Munition

Bomb Weight:	1-1.3kg (2.2-2.87lb)
Incendiary Weight:	680g (1.4lb)
Filling:	Thermite
Fuse Type:	Simple impact fuse
Body Dimensions:	247mm length x 50mm diameter
Appearance:	Grey body and dark green painted tail unit. Magnesium alloy case.
Operation:	Small percussion charge ignites Thermite (>1,000°C burn).
Variants:	Most common variant: B 2EZ (2kg) included a small HE charge
Remarks:	Drop containers varied in size. The smallest cluster bomb held 36 x B-1Es and the largest 620 x B-1Es.

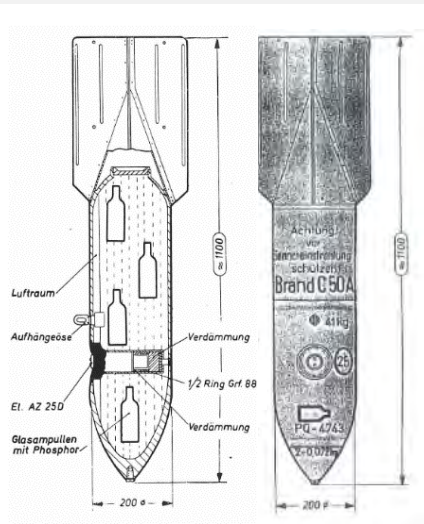






Brand C50

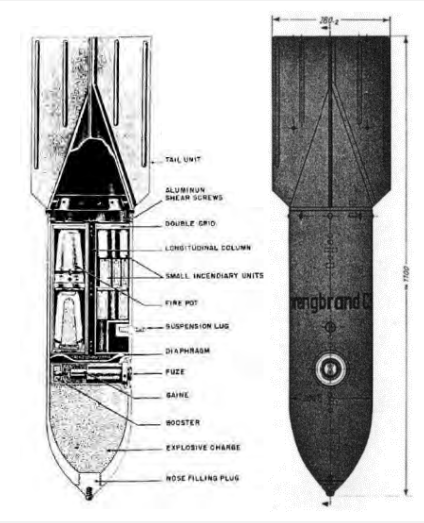
Bomb Weight:	41kg (90.4lb)
Incendiary Weight:	13kg (30lb)
Filling:	Main fill (86% Benzine, 10% Rubber) plus 4% Phosphorus in glass bottles
Fuse Type:	1 x electrical impact fuse
Bomb Dimensions:	762mm length x 203mm diameter
Appearance:	bomb body and tail painted grey or green with the rear of the bomb painted red and a red band around the centre of the body.
Variants:	C 50 B: 77% White Phos fill C 250 A: 87.7% Petroleum, 11.7% Polystyrene, 0.5% White Phos (185kg version)

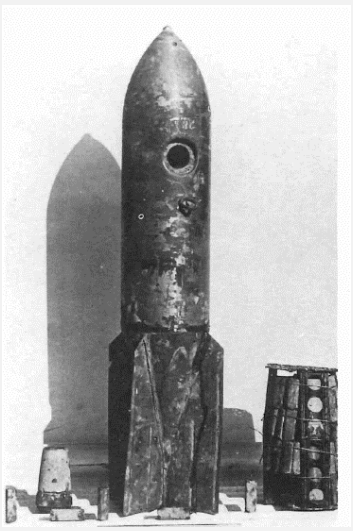




Spreng-Brand C50 - *Fire Pot*

Bomb Weight:	34kg (75lb)
Explosive Weight:	9kg (20lb)
Filling:	TNT burster charge, 6 x Thermite containers (fire pots) and 67 x small triangular incendiary elements.
Fuse Type:	1 x electrical impact fuses or aerial burst fuse
Bomb Dimensions:	711mm length x 203mm diameter
Appearance:	Bomb body and tail painted grey/green or pale blue with red base plug and red or green incendiary markings. Steel construction.
Operation:	A charge blows off the base plate, firing a plume of incendiary mixture 100 yds. Approx 1 second later the HE charge detonates.





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.303

In service: 1888 – 1970s

Common Weapons used:
Lee Enfield Rifle
Bren light machine gun
Vickers machine gun

40524979



Left: Pre-WWI .303
Right: WWII .303

7.62mm

In service: 1950s – present

Common Weapons used:
L1A1 SLR
M14
L85A1
L7A2 GPMG



.30-06

In Service: 1906 - 1957

Common Weapons used:
M1 Grand
Browning machine gun
Springfield rifle
BAR



Left: .30.06
Right: .303

5.56mm

In service: 1980 - present

Common Weapons used:
M16
L85A2
L85A3



Left: 7.62mm
Right: 5.56mm

Ammunition finds





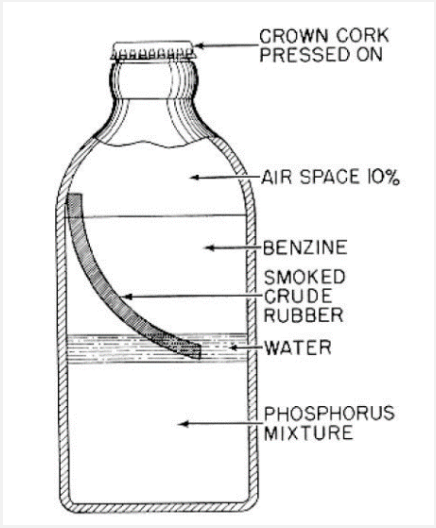
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No. 76 Self Igniting Grenade (SIP)

Construction:	Glass bottle and metal stopper
Weight:	0.59kg
Dimensions:	152mm x 63mm
Hazardous Fill:	White Phosphorus and Benzene
Fuse:	n/a
Appearance:	White / off yellow milk bottle
Hazards:	Choking fumes of Phosphorus Pentoxide and Sulphur Dioxide, as well as heat. Severe burns if comes into contact with skin.
Remarks:	By August 1941 well over 6,000,000 of these grenades were available and mainly issued to the Home Guard.

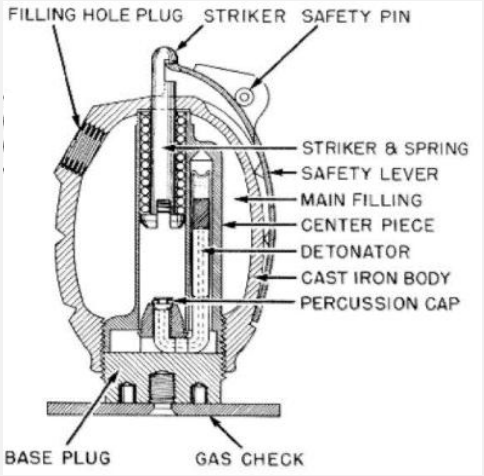




No. 36 Hand Grenade (Mills Bomb)

Construction:	Metal
Dimensions:	95mm x 61mm
Weight:	760g
Fill weight:	71g
Hazardous Fill:	Baratol
Fuse:	Percussion cap and 4 second time delay fuse
Hazards:	Blast, fragmentation. ~30m effective range.
Remarks:	>70 million were produced between 1915 and the 1980s

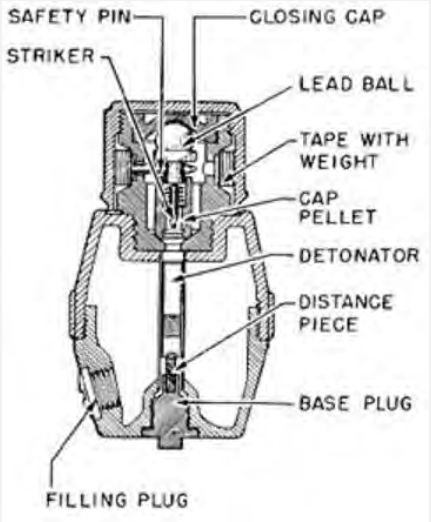




No. 69 (Blast) Hand Grenade

Construction:	Bakelite (plastic)
Dimensions:	114mm x 60mm
Weight:	383g
Fill weight:	92g
Hazardous Fill:	Baratol, Amatol or Lyddite
Fuse:	'All-Ways' Impact fuse
Hazards:	Blast effect. <20m effective range.
Remarks:	Green bands around the grenade signified a HE fill





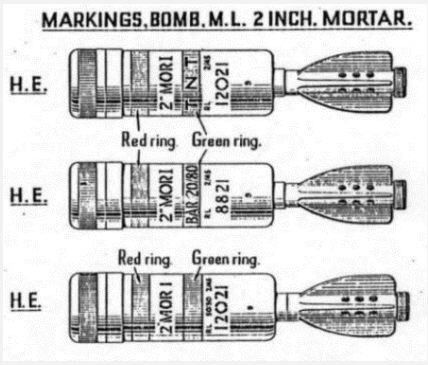
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2” ML Mortar - High Explosive

Weight:	1.02kg
Dimensions:	51mm x 290mm
Hazardous Fill:	200g of RDX/TNT
Fuse:	Impact fuse
Appearance:	Cylindrical shape. Brown body, green and red bands, five finned tail
Variants:	Several smoke, inert practice and parachute illumination versions were manufactured
Remarks:	Common anti-personnel weapon in use with British Army throughout
WWII. >12.5 million	HE rounds were produced in 1942 alone





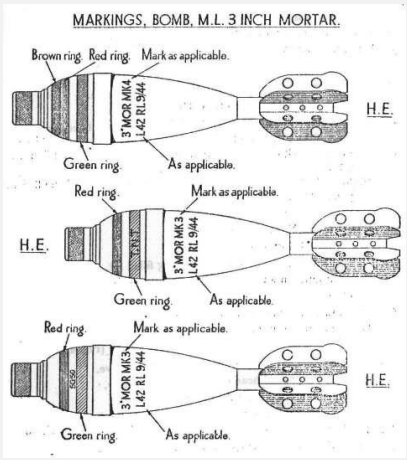


3” ML Mortar - High Explosive

Weight:	4.5kg
Dimensions:	81mm x 490mm
Hazardous Fill:	882g of RDX/TNT
Fuse:	Impact fuse
Appearance:	Pear-drop shape. Brown body, green and red bands, five finned tail
Variants:	Several smoke, white Phosphorus, inert practice and parachute illumination versions were manufactured
Remarks:	Common anti-personnel weapon in use with British Army throughout
WWII. >6.5 million	HE rounds were produced in 1942 alone





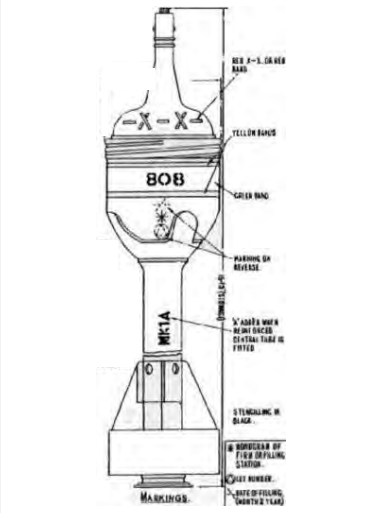


PIAT Anti-Tank Weapon

Projectile Type:	HEAT - shaped charge
Projectile Dimensions:	400mm x 90mm
Hazardous Fill:	Hollow HE charge and small solid propellant charge
Fill Weight:	1.13kg (charge)
Fuse:	Impact fuse
Remarks:	115,000 launchers were produced in Britain during WWII and the PIAT was used by most Allied armies during this conflict





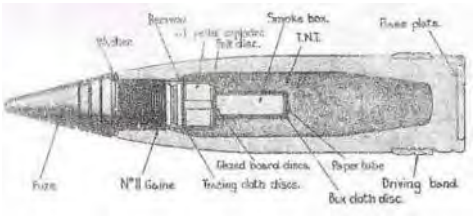


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HAA Battery - 3.7" QF Shell

Shell Weight:	12.7kg
Shell Dimensions:	94mm x 438mm
Fill Weight:	1.1kg
Fill Type:	TNT
Fuse Type:	Mechanical Time Delay fuse
Appearance:	Grey body, copper driving bands, brass neck
Rate of Fire:	10 - 20 rpm
Ceiling:	9,000 - 18,000m
Variants:	HE or shrapnel shells. Note, the 4.5" gun was also used in an HAA role throughout the UK.

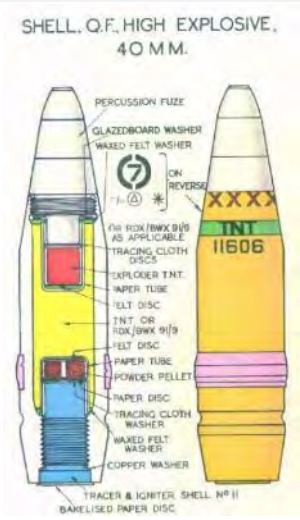






LAA Battery - 40mm Bofors Shell

Shell Weight:	0.84kg
Shell Dimensions:	40mm x 180mm
Fill Weight:	70g
Fill Type:	TNT
Fuse Type:	Impact fuse
Appearance:	Grey body, copper driving bands, brass neck
Rate of Fire:	120 rpm
Ceiling:	7,000m
Variants:	HE or AP shells. Both with rear tracer compartment



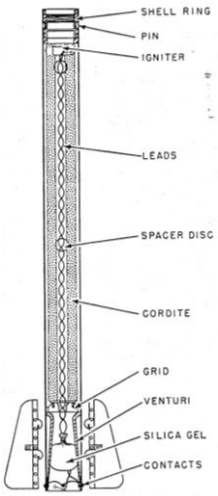






Z Battery - 3" U.P Rocket

Rocket Weight:	24.5kg
Warhead Weight:	1.94kg
Filling:	TNT warhead. Black Powder solid fuel rocket motor.
Fuse Type:	Mechanical Time Delay fuse
Rocket Dimensions:	1,930mm x 76mm
Ceiling:	6,770m
Operation:	Fired from single, tandem and (later) 36 x rail launchers (Z Batteries). Limited use throughout the UK.





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AA	*Anti-Aircraft (defences)*
AFS	*Auxiliary Fire Service*
AP	*Anti-Personnel*
ARP	*Air Raid Precautions*
ASW	*Anti-Submarine Warfare*
BDU	*Bomb Disposal Unit (historic term for EOD)*
Bgl	*Below Ground Level*
EOC	*Explosive Ordnance Clearance*
EOD	*Explosive Ordnance Disposal*
FP	*Fire Pot (German bomb)*
GI	*Ground Investigation*
HAA	*Heavy Anti-Air (gun battery)*
Ha	*Hectare (10,000m2)*
HE	*High Explosive*
IB	*Incendiary Bomb*
Kg	*Kilogram*
LAA	*Light Anti Air (gun battery)*
LCC	*London County Council*
LRRB	*Long Range Rocket Bomb (V2)*
LSA	*Land Service Ammunition*
Luftwaffe	*German Air Force*
OB	*Oil Bomb (German bomb)*
PM	*Parachute Mine (German bomb)*
RAF	*Royal Air Force*
RFC	*Royal Flying Corps*
RN	*Royal Navy (British)*
RNAS	*Royal Naval Air Service*
ROF	*Royal Ordnance Factory*
SAA	*Small Arms Ammunition*
SD2	*2kg AP bomb (German bomb)*
SI	*Site Investigation*
U/C	*Unclassified (German) bomb*
UP	*Unrotating Projectile (British 3" AA rocket)*
USAAF	*United States Army Air Force*
UX	*Unexploded*
UXB	*Unexploded Bomb*
UXO	*Unexploded Ordnance*
V1	*German Flying (pilotless) bomb - "Doodlebug"*
V2	*German LRRB - "Big Ben"*
WAAF	*Women's Auxiliary Air Force*
WWI	*World War One*
WWII	*World War Two*

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The National Archives

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- **HO 193/50**: Ministry of Home Security (1944-1945) *Pilotless Aircraft Bomb Census Maps: London Area*
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