



Detailed Unexploded Ordnance Risk Assessment

Cliffe Hall Farm, Markfield

10621 RA



Unit 3, The Courtyard Campus Way, Gillingham Business Park, Gillingham, Kent, ME8 0NZ



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Distribution

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Report Summary

Project Site Information	
Project site address	Old House Lane, Markfield, Hinckley and Bosworth, Leicestershire, England, LE67 9QB, United Kingdom
NGR Centre Point	SK 48211 11451
Scope of proposed works	The proposed works comprises the construction of 6no. industrial units with a total floor area of approximately 700,000 square feet. This will be paired with the development of access roads, car parking regions and ancillary infrastructure. Due to the existing topography of the site, works will also be required to plateau certain areas.

Overall Risk Rating
LOW

Risk Rating Summary		
Hazard	Average Depth of Hazard	Risk Rating
German HE bombs	<12m bgl ¹	Low
German 1kg IBs	<1m bgl	Low
Anti-Aircraft Projectiles	<5m bgl	Low
Land Service Ammunition	<2m bgl	Low
Small Arms Ammunition	<1m bgl	Low

Possibility that UXO Could Remain on Site
The threat of UXO contaminating the site has been assessed as minimal and therefore the likelihood of UXO remaining on site is also minimal.

In accordance with CIRIA guidelines this assessment has carried out research, analysed the evidence and considered the likelihood that the site has been contaminated with unexploded ordnance; that such items remained on site; the risk that they could be encountered during any intrusive works and the consequences that could result. Appropriate risk mitigation measures have been proposed.

¹ See Section 7.6. A site-specific maximum bomb penetration depth is assumed between 10-12m below WWII ground level.



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Glossary of Terms

AAA	Anti-Aircraft Artillery
ALARP	As Low As Reasonably Practicable
AP	Anti-Personnel
ARP	Air-raid Precautions
BDO	Bomb Disposal Officer
BPD	Bomb Penetration Depth
EOD	Explosive Ordnance Disposal (current term for “bomb” disposal)
HAA	Heavy Anti-Aircraft
HE	High Explosive
HG	Home Guard
IB	Incendiary Bomb
LAA	Light Anti-Aircraft
LM	Land Mine
LSA	Land Service Ammunition (includes grenades, mortars, etc.)
Luftwaffe	German Air Force
m bgl	Metres Below Ground Level
MoD	Ministry of Defence
NGR	National Grid Reference
OB	Oil Bomb
PM	Parachute Mine
RAF	Royal Air Force
SI	Site Investigation
SAA	Small Arms Ammunition (small calibre cartridges used in rifles & machine guns)
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	“Doodlebug” the first cruise type missile, used against London from June 1944. Also known as ‘Flying Bomb’
V-2	The first ballistic missile, used against London from September 1944
WWI	First World War (1914 -1918)
WWII	Second World War (1939 – 1945)



Detailed Unexploded Ordnance Risk Assessment

In respect of

Cliffe Hill Farm, Markfield

1. Introduction

Caddick Developments Ltd (“the client”) has commissioned Igne to conduct a Detailed Unexploded Ordnance Risk Assessment of Cliffe Hill Farm, Markfield (“the site”).

Unexploded Ordnance (UXO) poses significant risks to UK construction projects due to past conflicts and military activity. Buried unexploded air-dropped bombs and anti-aircraft projectiles, with an estimated failure rate of 10%, can be found at various depths depending on their characteristics and the ground conditions. Furthermore, it is estimated that over 20% of the UK land mass has been utilised by the military.

Despite efforts to locate and render safe UXO, ongoing discoveries during construction-related ground works continue to occur.

Increased risk awareness and proactive safety measures have reduced the risk to personnel. However, even the discovery of a suspected device can disrupt production and lead to delays and expenses. Site-specific risk understanding and appropriate mitigation measures can help address these risks effectively.

2. Construction Industry Duties and Responsibilities

2.1 The UK Regulatory Environment

The construction industry is not legally required to control and mitigate UXO risk. However, CIRIA (C681): Unexploded Ordnance (UXO) A Guide for the Construction Industry provides guidelines for good practice and information on managing UXO risk. These guidelines include a process for risk assessment and implementation of site-specific mitigation strategies. While there is no specific legislation for UXO risk, health and safety regulations address the responsibility of the construction industry to protect workers engaged in ground-intrusive operations from foreseeable UXO risks.

2.2 The Health and Safety at Work Act, 1974

The Act places a duty of care on an employer to put in place safe systems of work to address, as far as is reasonably practicable, all risks (to employees and the general public) that are reasonably foreseeable.

2.3 Construction (Design and Management) Regulations 2015

CDM 2015 ensures that health and safety within the construction industry is continually improved:

- Works are sensibly planned and managed.
- Competent staff are engaged in the works.



- Risks are identified and managed.
- All parties cooperate and coordinate activities.
- Communication flows to those who require it.
- Workers are consulted and engaged about risks and how they are being managed.

In line with CDM 2015 legislation, Igne are able to assist parties in their discharge of CDM duties as follows:

- Assist Principal Designers with pre-construction information and risk assessments.
- Assist the Designer with the Designer's Risk Assessment.
- Issue UXO risks as have been identified and manage risks accordingly.
- Assist the Principal Contractor with the construction phase information, in particular risk assessments and mitigation strategies.
- Plan, manage and monitor survey and clearance works under Igne's control.

2.4 Other Legislation

Other relevant legislation includes the "Management of Health and Safety at Work Regulations 1999" and "The Corporate Manslaughter and Corporate Homicide Act 2007".

3. The Role of the Authorities and Commercial Contractors

3.1 The Authorities

The Police coordinate emergency services in ordnance-related incidents on construction sites. They assess the risk and may establish a safety cordon, evacuate the area, and contact the military authorities (JSEODOC – Joint Services Explosive Ordnance Disposal Operations Centre) for investigation or disposal. If no EOD specialist is present, the Police impose precautions and away JSEODOC advice.

The response time from JSEODOC depends on the assessed risk and resource availability. They may remove or dispose of the ordnance on site if deemed necessary, potentially requiring additional cordons and evacuations. In routine cases, JSEODOC may not treat each occurrence as an emergency and may advise the construction company to engage a commercial contractor for managing the situation and reducing pressure on JSEOD disposal teams.

3.2 Commercial Contractors

In addition to pre-construction site surveys and follow-on clearance work, a commercial contractor is able to provide a reactive service on construction sites. The presence of a qualified EOD Engineer with ordnance recognition skills will avoid unnecessary callouts to the authorities and the contractor will be able to arrange for the removal and disposal of low-risk ordnance. If high risk ordnance is discovered actions will be co-ordinated with the authorities with the objective of causing the minimum



possible disruption to site operations whilst putting immediate, safe and appropriate measures in place.

4. This Report

4.1 Aims and Objectives

The aim of this report is to examine the probability of encountering and detonating any explosive ordnance during any intrusive works at the site. Risk mitigation measures will be recommended in line with the CIRIA C681 guidelines, to reduce the risk of detonating UXO, and the subsequent risk of harm / damage during the envisaged works to as low as reasonably practicable (ALARP).

This report is a live document and should be updated if any new information comes to light after issue.

4.2 Risk Assessment Methodology

The following issues will be addressed in the report:

- The probability that the site was contaminated with unexploded ordnance.
- The probability that unexploded ordnance remains on site.
- The probability that ordnance may be encountered during any intrusive works.
- The probability that ordnance may be detonated.
- The consequences of detonating or encountering ordnance.

Risk mitigation measures, appropriate to the assessed level of risk and site conditions, will be recommended.

4.3 Approach

In preparing this Unexploded Ordnance Risk assessment, Igne has considered general and, as far as possible, site-specific factors including:

- Evidence of German bombing and delivery of UXBs.
- Site history, occupancy and conditions during WWII.
- The legacy of Allied military activity.
- Details of any known EOD clearance activity.
- The extent of any post war redevelopment.
- Scope of the current proposed works.

4.4 Sources of Information

Igne has carried out detailed historical research for this Unexploded Ordnance Risk Assessment including accessing military records and archived material held in the public domain and in the MoD.



Material from a range of sources has been consulted, including but not limited to:

- The National Archives.
- Britain From Above.
- Historic England.
- Landmark Maps.
- Relevant information supplied by the client.
- Igne's extensive archives built up over many years of research and hands-on Explosive Ordnance Disposal activities in the UK.
- Open sources such as published books, local historical records and the internet.

4.5 Reliability of Historical Records

4.5.1 General Considerations

This report is based upon research of historical evidence. Whilst every effort has been made to locate all relevant material Igne cannot be held responsible for any changes to the assessed level of risk or risk mitigation measures based on documentation or other information that may come to light at a later date.

The accuracy and comprehensiveness of wartime records is frequently difficult or impossible to verify. As a result, conclusions as to the exact location, quantity and nature of the ordnance risk can never be definitive but must be based on the accumulation and careful analysis of all accessible evidence. Igne cannot be held responsible for inaccuracies or gaps in the available historical information.

4.5.2 Bombing Records

During WWII, considerable efforts were expended in recording enemy air raids. Air Raid Precautions (ARP) wardens were responsible for making records of bomb strikes either through direct observation or by post-raid surveys. However, their immediate priority was to deal with casualties and limit damage, so it is to be expected that records are often incomplete and sometimes contradictory. Record keeping in the early days of bombing was not comprehensive and details of bombing in the early part of the war were sometimes destroyed in subsequent attacks. Some reports may cover a single attack, others a period of months or the entire war.

Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are not always reliable; records of attacks on military or strategic targets were often maintained separately from the general records and have not always survived.



5. The Site and Scope of Proposed Works

Details for the site and the proposed works are presented in the following table.

Site Address	Old House Lane, Markfield, Hinckley and Bosworth, Leicestershire, England, LE67 9QB, United Kingdom	
OS National Grid Reference	SK 48211 11451	
Site Description	The site comprises open agricultural fields located adjacent to the M1 to the west and the A50 to the south, approximately 1km north-west of Markfield. Whitwick Road forms the site's eastern boundary, while Old House Lane lies to the north. Several fields within the site are subdivided by established tree lines. Structures are present in some of the site's peripheral areas; a small area of hardstanding is present in the south-western extent. Moreover, the site's topography slopes from north to south by approximately 20m.	
Proposed Works	The proposed works comprises the construction of 6no. industrial units with a total floor area of approximately 700,000 square feet. This will be paired with the development of access roads, car parking regions and ancillary infrastructure. Due to the existing topography of the site, works will also be required to plateau certain areas.	
References	Site Location Maps	Figure 1.0
	Recent Aerial Photograph	Figure 2.0
	Proposed Site Plan	Figure 3.0

6. WWII Site Conditions

Available mapping and photography were sought for the site, in order to assess site conditions pre, during and post-wartime.

6.1 Pre and Post-WWII OS Mapping

The following historic OS mapping for the site was obtained and reviewed.

	Date	Observations	Reference	Source
Pre-WWII	1929	- The site encompasses rural fields related to <i>White Hill</i>. - A road encroached into the southern extent of the site. - A <i>F.P</i> (footpath) crosses the site from south to the eastern boundary.	Figure 4.1	Landmark Maps
Post-WWII	1959-60	- The site remains mostly consistent with early Pre-war OS mapping. - A pond now occupies the centre of the site. - No signs of clearance or redevelopment indicative of bomb damage are evident across the site.	Figure 4.2	



6.2 WWII-era RAF Aerial Photography

The following WWII-era aerial photography was obtained and reviewed.

Date	4 th December 1940	
Source	Historic England	
Image quality	High resolution, large scale, partial coverage, oblique	
Observations	- The image depicts two howitzers and associated military personnel on Old House Lane (located to the north of the site). - Due to the scale of the imagery, it is difficult to assess whether these weapons were facing towards the study area. - However, it does indicate that some level of training occurred in proximity of the site (see Section 8.2 for further details).	
Reference		Public resource ²

Date	18 th April 1944	
Source	Historic England	
Image quality	High resolution, small scale, partial coverage	
Observations	- The site conditions appear similar to those observed in historical post-war OS mapping. - The eastern extent of the site appears to have been covered by the aerial photography. - A small area of ground disturbance, resembling a crater, can be identified within the open ground adjacent to Old House Lane and Whitwick Road. - Further areas of ground disturbance resembling craters can be identified adjacent to Poulney Wood (1.2km north-east of the site) and at Lea Wood (1.7km south-east of the site).	
Reference		Public resource ³

² https://historicengland.org.uk/images-books/archive/collections/aerial-photos/record/RAF_613H_HHO_09

³ https://historicengland.org.uk/images-books/archive/collections/aerial-photos/record/us_7ph_gp_loc280_v_5025



7. The Threat from Aerial Bombing

7.1 General Bombing History of Leicestershire

7.1.1 First World War

During WWI, multiple towns and cities across England and Scotland were targets by aircraft and Zeppelins, and naval bombardment. Available evidence and mapping (not attached) does not record any bombing or bombardment on or in close proximity to the site.

WWI bombs were generally smaller and dropped from lower altitudes, leading to shallow UXB penetration. Aerial bombing was a novelty that attracted public interest and spectators. Due to these factors, the risk of undiscovered WWI UXBs is limited. With infrequent attacks and low bombing density, the overall risk is considered low and will not be discussed further in this report.

7.1.2 Second World War

At the beginning of WWII, the Luftwaffe planned daylight bombing raids targeting military installations and later expanded to include economic and industrial sites. Aircraft losses led to a shift to nighttime attacks.

Markfield appears to hold no nearby industrial, infrastructure, or military areas that may have been a target for the Luftwaffe.

However, as the site was located within the agricultural rural district of Market Bosworth, 11km west of Leicester, the surrounding area may have been at risk from 'tip and run' bombing incidents. These incidents occurred when enemy aircraft under heavy AA fire or fighter interception would prematurely / indiscriminately jettison their bomb loads in order to escape the combat zone. These apparently random incidents also occurred when pilots became lost / disorientated over enemy territory.

7.2 Generic Types of WWII German Air-delivered Ordnance

The nature and characteristics of the ordnance used by the Luftwaffe allows an informed assessment of the hazards posed by any unexploded items that may remain today.

HE Bombs	In terms of weight of ordnance dropped, HE bombs were the most frequent weapon deployed. Most bombs were 50kg, 250kg or 500kg (overall weight, about half of which was the high explosive) though large bombs of up to 2,000kg were also used. HE bombs had the weight, velocity and shape to easily penetrate the ground intact if they failed to explode. Post-raid surveys would not always have spotted the entry hole or other indications that a bomb penetrated the ground and failed to explode, and contemporary ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. Unexploded HE bombs therefore present the greatest risk to present-day intrusive works.
Blast Bombs / Parachute Mines	Blast bombs generally had a slow rate of descent and were extremely unlikely to have penetrated the ground. Non-retarded mines would have shattered on most ground types if they had failed to explode. There have been extreme cases when these items have been found unexploded, but this was where the ground was either very soft or where standing water had reduced the impact. Igne does not consider there to be a significant risk from this type of munition on land.
Large incendiary bombs	This type of bomb ranged in size from 36kg to 255kg and had a number of inflammable fill materials (including oil and white phosphorus), and a small explosive charge. They were designed to explode and burn close to the surface, but their shape and weight meant that they did have penetration capability. If they penetrated the ground, complete combustion did not always occur, and, in such cases, they remain a risk to intrusive works.
1kg Incendiary Bombs (IB)	These bombs, which were jettisoned from air-dropped containers, were just over 30cm in size and therefore highly likely to go unnoticed. They had the potential to penetrate soft ground and left a very small entry hole. Furthermore, if bombs did not initiate and fell in water or dense vegetation or became mixed with rubble in bomb damaged areas, they could have remained hidden to this day. Some variants had explosive heads, and these present a risk of detonation during intrusive works, particularly due to their shape, which leads them to often be misidentified.
Anti-personnel (AP) Bomblets	AP bombs had little ground penetration ability and should have been located by the post-raid survey unless they fell into water, dense vegetation or bomb rubble.
Specialist Bombs (smoke, flare, etc)	These types do not contain high explosive and therefore a detonation consequence is unlikely. They were not designed to penetrate the ground.
Examples of the most commonly deployed German bombs are presented at Appendix 1.	

7.3 Second World War Bombing Statistics

The following table summarises the quantity of German bombs (excluding 1kg incendiaries and anti-personnel bombs) falling on the Rural Districts of Market Bosworth and Barrow upon Soar between 1940 and 1945.

Record of Ordnance Dropped Over the Area										
Districts	Area Acres	HE bombs (all)	Para- chute Mines	Oil Bombs	Phos. Bombs	Fire Pots	V1	V2	Total	Items per 1000 acres
R.D Market Bosworth	25,902	159	2	-	-	-	-	-	161	2.5
R.D Barrow upon Soar	22,196	84	3	-	-	-	-	-	87	1.6

Source: Home Office Statistics

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

Detailed records of the quantity and locations of the 1kg incendiary and anti-personnel bombs were not routinely maintained by the authorities as they were frequently too numerous to record.

Although the incendiaries are not particularly significant in the risk they pose, they nevertheless are items of ordnance that were designed to cause damage and inflict injury and should not be overlooked in assessing the general risk to personnel and equipment. The anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous.

7.4 Site Specific WWII Bombing Records

7.4.1 Leicestershire Incidents Map

A consolidated map of all known German bombing activity in the surrounding area was obtained from Birds Eye Wartime: Leicestershire and shown in **Figure 5.0**.⁴ Please note that the areas covered by plotted bombs are exaggerated due to the small scale of the map; therefore, the incidents shown must be considered approximate and interpreted with caution.⁵

⁴ Terrence C. Cartwright, *Birds Eye Wartime: Leicestershire 1939-45*. (T.C.C Publications 2002).

⁵ A description of the map highlights that most of the bombs recorded landed on open farmland and apart from damage to livestock, barns, and crops, little damage was done.

Weapon	Quantity	Details
HE bomb	7no.	Nearest strike was recorded ~900m south-east.
Unexploded bomb	2no.	Nearest incident was recorded ~1.3km north-east.
Plane crash	1no.	Nearest incident was recorded ~800m south-east (see Section 8.2 for further details).

7.4.2 Original ARP Bombing Incident Records

Throughout WWII, records of bombing incidents were kept by the ARP and Civil Defence Office. These records were kept in the form of typed or hand-written notes and/or presented on bomb plot maps. Some other organisations, such as port authorities and railways, maintained separate records. None covering the site were found during the timeframe of this report.

7.4.3 Home Office Intelligence Reports

The Home Office Intelligence reports document enemy action on British domestic soil and were prepared twice a day for the Home Security War Room. The summaries were prepared by intelligence staff, who compiled reports received from the twelve civil defence regions.

However, available records only document time and general location of attack and numbers of casualties. The intelligence officials generally only recorded locations on municipal level (town, village, or city), rarely providing specific addresses.

Date	Location	Details
28-29/08/1940	Coalville, Leicester	Night raid – no casualties.
03-04/12/1940	Coalville, Leicester	Night raid – no casualties.
15-16/12/1940	Coalville, Leicester	Night raid – no casualties.
16-17/12/1940	Woodhouse Eaves	Night raid – no casualties.
12-13/08/1941	Markfield, Leicester	Night raid – no casualties.

7.4.4 Secondary Source / Anecdotal Evidence

Anecdotal evidence of local bombing incidents was sought from publications and web resources. No references to incidents on site or in the surrounding area were found during the timeframe of this report.

7.4.5 Bombing Decoy Sites

In July 1940, a national decoy authority led by Colonel John Fisher Turner was established. Urban lighting decoys, known as “Civil” sites, were set up following earlier experiments in Glasgow and Sheffield. These sites, designated as “QL” for urban lighting simulation and “QF” for dummy fires, used electrical and pyrotechnical apparatus to imitate various sources of light and flare. Additional sites simulated small fires caused by incendiary bombs, including special “SF” sites known as

“Starfish” sites that attracted enemy bombers away from populated areas and defence installations. Decoy sites were quite successful, with airfield decoys receiving 359 attacks compared to 358 attacks on real airfields by the end of 1941.

A bombing decoy site was established in close proximity to the site

x

7.4.6 Abandoned Bombs

After an air raid, a survey would be conducted to search for bomb entry holes. If evidence was found, Bomb Disposal Officer teams would be called to locate and dispose of the bomb. However, sometimes UXBs were discovered but could not be accessed or rendered safe due to various reasons. These incidents could be recorded as Abandoned Bombs. Due to inaccurate records and the nature of these abandoned bombs, their locations are not definitive, and the lists may not be exhaustive. The MoD would only take action to make the devices safe if they were deemed unstable. It should be noted that aside from officially abandoned bombs, there may be unrecorded UXBs.

Igne holds records of officially registered abandoned bombs at or near the site

x

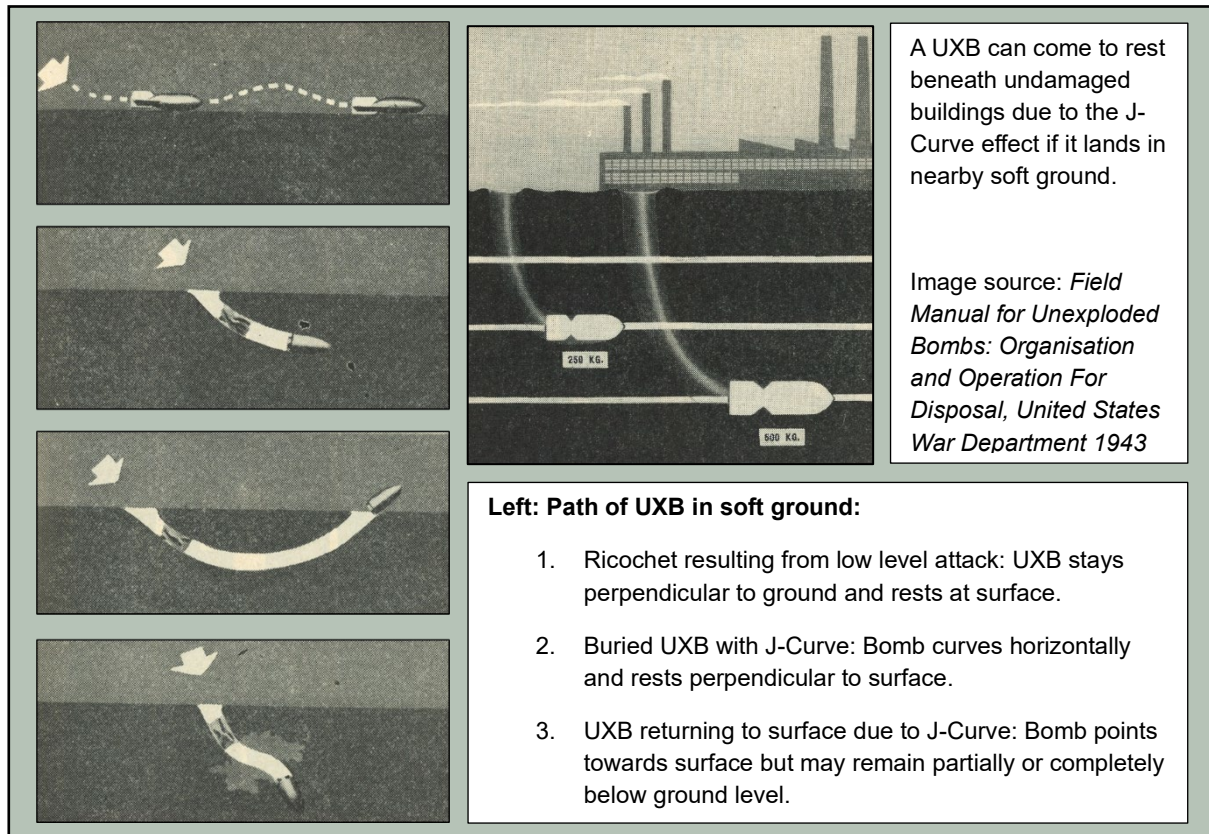
7.5 UXB Ground Penetration

7.5.1 General Considerations

The depth bombs penetrate the ground depends on factors such as their mass, shape, velocity, angle of impact, and the characteristics of the ground cover. Softer ground allows for greater penetration, with peat, alluvium and soft clays being easier to penetrate compared to gravel and sand. Bedrock or large boulders can bring bombs to a stop or cause deflection.

7.5.2 The “J” Curve Effect

When an air-dropped bomb is released from a normal bombing altitude (approximately 5,000m), it can reach a terminal velocity of 350-400 ms⁻¹. The bomb enters the earth at an angle or approximately 15° from the perpendicular, making its exact path hard to trace. As the bomb travels through the ground, it undergoes an upward curve due to energy transfer. The slower nose of the bomb experiences more drag/friction compared to the faster-moving rear. This causes the bomb’s location to be offset from the entry hole. The offset is generally one-third of the penetration depth but can reach up to 15m (50’) depending on ground conditions and the bomb’s angle of impact. The J-Curve effect illustrated below demonstrates not UXBs can come to rest beneath undamaged buildings in homogeneous ground.



7.5.3 Second World War Bomb Penetration Studies

During WWII, the Ministry of Home Security undertook a major study on actual bomb penetration depths, carrying out statistical analysis on the measured depths of 1,328 bombs as reported by Bomb Disposal, mostly in the London area. They then came to conclusions as to the likely average and maximum depths of penetration of different sized bombs in different geological strata.

The table below presents the maximum and average penetration depths observed during this survey. Note, the table includes the most commonly dropped HE bomb sizes, from 50kg to 1000kg.

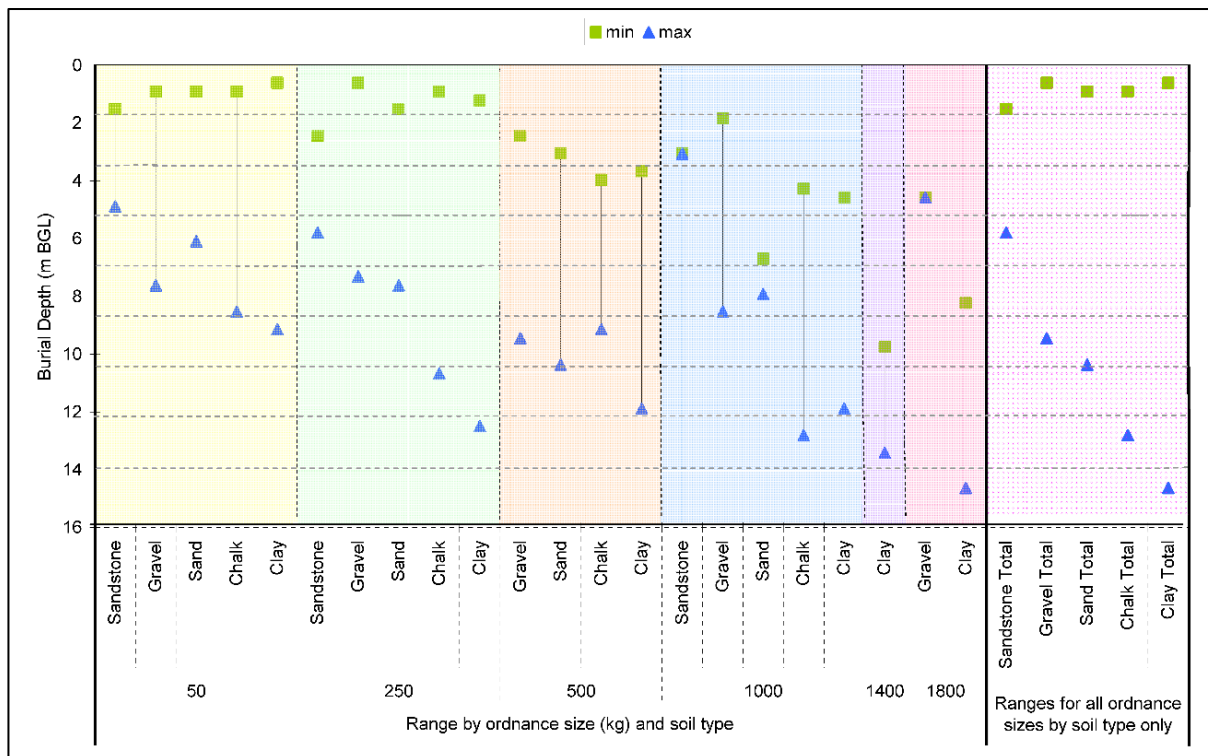
		Bomb penetration depth							
		Max.	Av.	Max.	Av.	Max.	Av.	Max.	Av.
HE bomb size		50kg		250kg		500kg		1000kg	
Ground Type	Sandstone	6.1m	2.7m	10.4m	4.6m	13.1m	5.8m	16.5m	7.3m
	Gravel	7.8m	2.8m	13.7m	4.8m	17.3m	6.0m	21.9m	7.6m
	Sand	7.8m	2.8m	13.7m	4.8m	17.3m	6.0m	21.9m	7.6m
	Chalk	7.7m	3.5m	13.1m	6.0m	16.4m	7.6m	20.7m	9.6m
	Clay	9.1m	4.0m	15.8m	6.8m	19.8m	8.7m	24.9m	10.9m

Note, theoretical calculations suggested that significantly greater penetration depths were probable.

7.5.4 CIRIA Bomb Penetration Depth Specifications

As stated within C681, the ground conditions at any individual site are likely to be highly variable and this results in a large range of burial depths for each different size bomb.

The chart to below shows the observed variation in burial depths of various sizes of air-delivered UXO for different ground conditions.



7.5.5 Site Specific Bomb Penetration Considerations

When considering an assessment of the bomb penetration at the site, the following parameters would be used:

Parameter		Details	
Geology	British Geological Survey Borehole	Borehole Reference	SK41SE11
		Location	M1 ~100m west of the site.
		Date	12/07/1961
		Recorded Shallow Geology	0.15m – TOPSOIL (silty). 1.83m – SILT (sandy, with rock fragments). 0.46m – TUFF. 0.96m – GEMSTONES.⁶

⁶ Ineligible, unlikely to be gemstones.

Parameter	Details		
			0.77m – TUFF. 3.35m – TUFF (fine grained bands of grit). 5.18m – SILTSTONE and TUFF.
	British Geological Survey Mapping	Superficial Deposits	- Oadby Till Member-Diamicton. - Head-Clay, silt, sand and gravel.
		Bedrock	- Gunthorpe Member - Mudstone. - Bradgate Formation-Volcaniclastic - siltstone. - Beacon Hill Formation-Volcaniclastic - siltstone.
	Client Provided Data	BWB Phase 2 Report	Borehole CP102: 0.20m – TOPSOIL (grass over sandy clay). 4.00m – CLAY (gravelly). 4.38m – CLAY (silty, gravelly).
Impact Angle and Velocity	80-90° from horizontal and 267 metres per second		
Bomb Mass and Configuration	The 500kg SC (General Purpose) HE bomb, without retarder units or armour piercing nose. This was the largest of the common bombs used against Britain.		

7.5.6 Deductions

Based on WWII-era studies, a 500kg bomb could have penetrated up to approximately 19.8m below ground level (bgl), with an average depth of around 8.7m bgl. However, considering the varied strata and limited data, it is estimated that the bomb's maximum bomb penetration depth (BPD) during that era was likely between 10-12m bgl, as per CIRIA guidelines. Note, due to the variety of geological strata across the site, the average bomb penetration depth is also likely to vary greatly.

The current ground level should be evaluated to determine its impact on the BPD. If the UXB is larger, the BPD could potentially be greater, although only 4% of German bombs used in WWII over Britain were of that size.

UXBs can be found at any depth between just below WWII ground level and the maximum BPD. It should be noted that ground conditions can vary significantly on site, and these guidelines may change once on-site conditions are assessed prior to any necessary mitigation works.

7.6 Likelihood of Post-Raid UXO Detection

Utilising the available historical bombing records as reviewed in Section 7.5, it is possible to make an assessment of the likelihood that evidence of UXO would have been noted on a site during the war and the incident dealt with or recorded at the time. Factors such as bombing density, frequency of access, ground cover, damage and failure rate have been taken into consideration.

Factor	General Considerations	Site Specific Considerations
Density of bombing	Bombing density impacts the likelihood of UXBs remaining in an area. A high density of bombs increases the chance of record-keeping errors, due to overwhelmed civil defence and emergency response personnel. It also raises the total number of actual UXBs in a given area. The type and location of recorded bomb strikes are significant factors. If a stick of bombs is plotted in line with or straddling a side, it suggests the possibility of an unrecorded UXB from the same stick hitting that site.	• Low bombing density. • Home Office Statistics show bombing at nearby towns Markfield, Coalville, and Woodhouse Eaves. • Small scale bomb plot mapping of the region shows strikes within 900m of the site. • No evidence of bombing on site.
Bomb damage	In Blitzed cities and towns across Britain, bomb sites were often left uncleared until after the war. Mid-war repairs were focused on vital facilities, while buildings with upper floor damage had their ground floor damage reported and dealt with at the time. HE bomb strikes on open ground created visible craters and soil disturbance. Subsequent UXB strikes in disturbed ground would go unnoticed without identifiable entry holes. The German V1 and V2 campaigns caused widespread devastation in London and south-east England. However, damage from these weapons does not necessarily indicate increased risk of Luftwaffe freefall UXB contamination, as they were used after significant Luftwaffe air raids. Damage from earlier Luftwaffe raids may have been erased by subsequent V weapon strikes.	• Some areas of ground disturbance can be identified on site on historical aerial photography; these are sometimes indicative of bomb damage. • However, there is no historical photograph covering the entire site, therefore a completely accurate assessment of the ground conditions cannot be made. • As such it is possible that further ground disturbance, indicative of bomb damage could have been identified across the site.
Ground conditions	The entry hole of a 50kg UXB (common German HE bomb) could be as small as 20cm in diameter. Records confirm that even small 1kg German incendiary bombs could penetrate soil, leaving tiny entry holes (5cm) or burying completely. During WWII, the quantity and type of ground cover affected the visibility of buried UXBs. Dense vegetation, soft ground, rubble, railway ballast or stockpiled material could obscure evidence. UXB strikes in waterlogged areas or open water would be hidden beneath the waterline. Tidal mudflats or river banks would temporarily cover entry holes with water and sediment. Elevated risk ground cover could cause UXBs to end up beneath neighbouring undamaged buildings or hardstanding due to the "J Curve" Effect. UXB strikes on intact or superficially damaged buildings and hardstanding would cause significant damage or leave easily identifiable entry holes. Well-maintained lawns or gardens are less likely to overlook an HE UXB entry hole, with such incidents reported and the UXB removed.	• The site was occupied predominantly by agricultural fields. • In these conditions, a UXB strike may have been obscured by vegetation. • Roadways also crossed the site. • A UXB strike to a hard-standing road will have left an identifiable entry hole and likely been noticed at the time.
Frequency of access	A UXB strike in a site with infrequent human access would have a lower chance of being observed, reported and recorded compared to a developed site with regular access. Strikes during nighttime raids are also more	• The site will have experienced seasonal access. • Football at night (when most raids occurred) was unlikely.

Factor	General Considerations	Site Specific Considerations
	likely to go unnoticed compared to daytime attacks when German aircraft could be detected more easily. In frequently bombed cities / towns, ARP Wardens searched for UXBs in recently bombed residential areas and schools. Important facilities had dedicated ARP teams or Fire Watchers responsible for observing air raids and reporting UXB strikes. However, anecdotal evidence suggests that Fire Watchers were not always present, so their activities cannot be assumed without specific evidence. Less important buildings damaged by bombs would be abandoned until the German bombing campaign ceased, reducing access to those sites. Schools closed due to evacuations were often used as First Aid posts and reception centres, increasing access to those locations.	Roads are likely to have seen frequent access.
German air-delivered ordnance failure rate	Empirical evidence suggests that approximately 10% of German HE bombs dropped during WWII failed to explode as intended. This estimate, based on recovered UXB statistics, likely underestimates the true number as unrecorded UXBs were not accounted for at the time. The reasons for failures include: - Fuze or gaine malfunction due to manufacturing fault, sabotage (by forced labour) or faulty installation. - Clockwork mechanism failure in delayed action bombs. - Failure of the bomber aircraft to arm the bombs (charge the electrical condensers which supplied the energy to initiate the detonation sequence) due to human error or equipment defect. - Jettison of the bomb before it was armed or from a very low altitude. Most likely if the bomber was under attack or crashing. According to War Office statistics, an average of 84 malfunctioning bombs were dropped on civilian targets in Britain per day from 21/09/1940 to 05/07/1941. About 1 in 12 of these bombs, likely those with time delay fuzes, exploded after landing, while the rest unintentionally failed to detonate. From 1940 to 1945 bomb disposal teams dealt with a total of 50,000 explosive items of 50kg and over (German bombs), 7,000 AAA shells and 300,000 beach mines. These operations resulted in the deaths of 394 officers and men. However, UXO is still regularly encountered across the UK. Note, due to manufacturing fault or failure of the bomber crew to correctly arm their munitions, whole bomb loads often failed to detonate. Therefore, the presence of reported UXBs increases the likelihood of an additional unrecorded UXB in the vicinity.	No evidence has been found to suggest the ordnance failure rate in this area was higher than 10%.



8. The Threat from Allied Military Ordnance

The following potential historical and modern sources of UXO contamination on site or in the surrounding area have been considered:

- Army, Navy & RAF bases & installations
- Military training areas & weapons ranges
- Ordnance / explosives factories & storage depots
- Sites requisitioned for military use
- Sites used or occupied by the Home Guard
- Military fortifications & coastal defences
- Locations of Army Explosive Ordnance Clearance (EOC) tasks
- WWII heavy and light anti-aircraft batteries
- WWII pipe-mined locations and beach minefields

The risk of contamination from Allied UXO on site is discussed below.

8.1 Land Service and Small Arms Ammunition (LSA/SAA)

It is estimated that around 20% of the UK's landmass has been used by the military at some point. As such, a large proportion of sites can remain at risk from military related UXO, through training, testing, storage, disposal or manufacture.

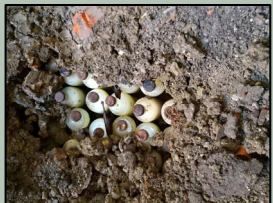
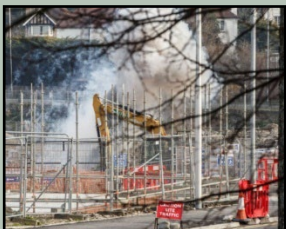
8.1.1 Defensive Fortifications

After the defeat at Dunkirk in May 1940, Britain rushed to establish defences against the imminent invasion. Coastlines and inland areas were fortified with anti-tank obstacles, ditches, pillboxes and gun emplacements. The goals of these defences were to prevent enemy landings at sea or by aircraft, protect ports and harbours, stop armoured columns from advancing, and safeguard vulnerable locations. Stop lines were created to halt German armoured units, with anti-tank obstacles and pillboxes strategically positioned. The defences were manned by Home Guard and military personnel.

8.1.2 Home Guard Activity

The Home Guard (HG) was a British Army defence organisation active from 1940-44. Comprising 1.5 million local volunteers ineligible for military service, it served as a secondary defence force against enemy invasion. The HG protected coastal areas, important facilities and urban centres. Official records were scarce, making present-day evidence mostly anecdotal. HG personnel conducted training, including weapons training, in rural areas near towns and cities. Present-day discoveries of HG-related ordnance indicate a culture of lax discipline regarding live ammunition. HG members purposefully buried caches of weapons and ammunition in strategic locations for future use, some of

which were forgotten and have been found as UXO in recent years. The table below provides several examples:⁷

Home Guard UXO Finds:	
	Live unexploded WWII grenade found in a residential garden, Devon – March 2023
	A cache of phosphorous grenades found buried underneath a school during construction works in Swindon – November 2022
	Unexploded Spigot Mortar Round, used by the Home Guard in WWII, found and disposed of in Hayle, Cornwall – January 2021
	24 x WWII grenades found buried in a field in Sibton, Suffolk – May 2019
	A cache of 80 phosphorous grenades buried by the Home Guard found in Eastbourne – September 2015
	Home Guard Phosphorous Grenades found buried beneath a bridge in Herne Bay – July 2015

8.1.3 Generic Types of WWII British / Allied UXO (LSA/SAA)

The nature and characteristics of the ordnance used by the military allows an informed assessment of the hazards posed by any unexploded items that may remain today.

⁷ Various News Sources

Hazard Type	Description		
Land Service Ammunition	The term Land Service Ammunition covers all items of ordnance that are propelled, placed or thrown during land warfare. They may be filled or charged with explosives, smoke, incendiary or pyrotechnics. They can be broken into five main groups: 1. Mortars 2. Grenades 3. Projectiles 4. Rockets 5. Landmines	Mortars	A mortar bomb is a fin-stabilised munition with a nose fuze and its own propelling charge. Additional propellant can be added to increase range. They come in HE or Carrier types and are typically tear-dropped in shape (though older variants may have parallel sides) with a finned ‘spigot tube’ at the rear housing the propellant. Detonation of a mortar relies on the striker hitting a detonator, which may already be in contact, requiring only slight pressure for initiation. Discarded augmenting charges are commonly found near mortar firing areas/bases.
		Grenades	A grenade is a short-range weapon that can be thrown by hand, fired from a rifle, or launched from a specialised grenade launcher. There are two categories: HE and carrier (typically smoke). Like mortars, a grenade’s striker may either be in close contact with the detonator or held by a tensioned spring, so shock can cause it to function. Grenades have an explosive range of 15-20m. Older variants often have a classic “pineapple” shape, while modern grenades are usually smooth-sided.
	Unexploded or partially unexploded Mortars and Grenades are among the most common items of UXO encountered in the UK. They are commonly encountered in areas used by the military for training and are often found discarded on or near historic military bases.		
Small Arms Ammunition	The most likely type of ordnance to be encountered on site are items of SAA (bullets), especially .303” ammunition which was the standard British and Commonwealth military cartridge from 1889 until the 1950s. However even if an item such as this functioned, the explosion would not be contained within a barrel and detonation would only result in local overpressure and very minor fragmentation from the cartridge case. Some LAA guns and RAF fighter cannons in use with British forces during WWII utilised the 20mm round. These bullets had a small fuse and a ~4gram HE or incendiary charge. Although small, this fill quantity still has the potential to cause serious injury.		
Examples of the most commonly used British / Allied ordnance types are presented in Appendix 2.			

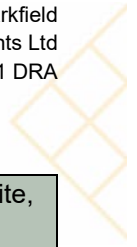
8.1.4 Site Specific Threat from LSA / SAA

The following table discusses site-specific potential UXO contamination from military activity.

Potential Source	Details
Defensive features within the vicinity	No defensive features were recorded within 1km of the site.
Home Guard Activity on site	8th Leicestershire (Market Bosworth) Battalion were the closest operating Home Guard Battalion to the site. - It is likely that a smaller company operated in the nearby Markfield. However, the location of their headquarters could not be found within timeframe of this report - Photographic evidence of possible Home Guard / Military training adjacent to the site (See Section 6.1).⁸ - The image shows two howitzers set up on the road possibly facing the fields on site, with soldiers measuring. - The below photo shows the 8th Battalion in a training exercise within rural Leicestershire. The precise location of this activity has not been disclosed, but it is possible this would have occurred in or around the site. Given there is evidence of training within proximity of the site already disclosed, it cannot be ruled out this image was taken on Old House Lane.⁹  Source: Leicestershire Live - Home Guard and military personnel are known to have purposefully buried caches of ammunition / grenades in tactical locations to be exhumed in case of an invasion.

⁸ https://historicengland.org.uk/images-books/archive/collections/aerial-photos/record/RAF_613H_HHO_09

⁹ <https://www.leicestermercury.co.uk/news/history/role-dads-army-frustrate-advance-1798828>



	No precise evidence of live fire exercises could be found to have occurred on site, although, as cautioned, this possibility that they did occur cannot be ruled out.
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8.2 Aircraft Crashes

8.2.1 Aircraft Crashes

Aircraft crashes were frequent at WWII airfields due to short pilot training programs. Limited flying hours on small trainers before transitioning to bombers or fighters compounded this. Heavy weapon and fuel loads on bombers, especially during take-off, led to numerous crashes. In the Allied bombing campaign over Europe, damaged aircraft often crash-landed, notably near coastal airfields close to occupied territories.

High-speed crashes could bury heavy objects like engines, bombs and rocket warheads deeply. After such incidents, salvage was not usually a priority, potentially leaving Allied ordnance buried at crash sites.

8.2.2 Site Specific Threat

Potential Source	Details
Threat to the site from aircraft crashes	28/08/1940 – A Tiger Moth reportedly crashed near Markfield, further details on the specific location could not be found within the timeframe of this report.¹⁰ - This incident is considered too far from the site to result in contamination.

8.3 Anti-Aircraft Gun Batteries

At the war's outset, two types of AAA guns were used: Heavy Anti-Aircraft (HAA) and Light Anti-Aircraft (LAA). LAA batteries targeted fast, low-flying aircraft near airfields and strategic sites. These mobile batteries, equipped with four guns each, could rapidly fire multiple rounds. Unexploded AAA shells from WWII are still occasionally found today.

Initially, the maximum firing height was about 11,000m. However, improved versions of the 3.7" gun and larger 5.25" weapons with higher firing ceilings (over 18,000m) were introduced from 1942.

The 3.7" AA gun was said to have a maximum firing range of around 5.6km when fired horizontally or 12km when fired at an angle. The 5.25" AA gun had a potential maximum firing range of 14.2km, with naval versions capable of reaching up to 22km. Other types, like the 4.5" AA gun and the Bofors 40mm, had a maximum range of approximately 12.5km.

When Switzerland stopped supplying clockwork fuses, Britain had to produce its own. Due to a lack of engineering expertise, many AA shells prematurely detonated, causing casualties or becoming UXBs. In January 1944, more people in London were killed by HAA shells than by German bombs.

¹⁰ Terrence C. Cartwright, *Birds Eye Wartime: Leicestershire 1939-45*. (T.C.C Publications 2002).

Unexploded AA shells are frequently found across the UK. The table below provides several examples:¹¹

Anti-Aircraft Artillery UXO Finds:	
	AA shell found in a canal, Ashton-under-Lyne, June 2022.
	AA shell found in the River Great Ouse, Bedford town centre, July 2021.
	Several AA shells found during construction in Somersham, November 2017.
	AA shell found in a residential garden, Potters Bar, October 2015.
	AA shell found on a construction site, Waltham Abbey, May 2015.

¹¹ Various News Sources

8.3.1 Generic Types of WWII British / Allied Unexploded Ordnance (Artillery)

The nature and characteristics of the ordnance used by the military allows an informed assessment of the hazards posed by any unexploded items that may remain today.

Hazard Type	Description				
Anti-Aircraft Shells	At the start of WWII, two types of AAA guns were used: HAA with large calibre weapons like the 3.7" QF gun, and LAA with smaller calibre weapons like the 40mm Bofors gun. The Bofors gun could fire up to 120 shells per minute. Due to AAA shortages, older WWI guns were also deployed. These shells, often mistaken for German bombs, can be identified by the copper driving band. Unexploded larger projectiles are found close to ground level and pose a significant risk due to their HE fill and fragmentation. Smaller 40mm projectiles resemble SAA and present a lower risk. Details of the most commonly deployed WWII AAA projectiles are shown below:				
	Gun type	Calibre	Shell Dimensions	Shell Weight	HE Fill Weight
	3.7 Inch	94mm	94mm x 438mm	12.7kg	1.1kg
	4.5 Inch	114mm	114mm x 578mm	24.7kg	1.7kg
	40mm	40mm	40mm x 311mm	0.84kg	70g
Examples of the most commonly used British / Allied ordnance types are presented in Appendix 2.					

8.3.2 Site-Specific Threat from Anti-Aircraft Artillery

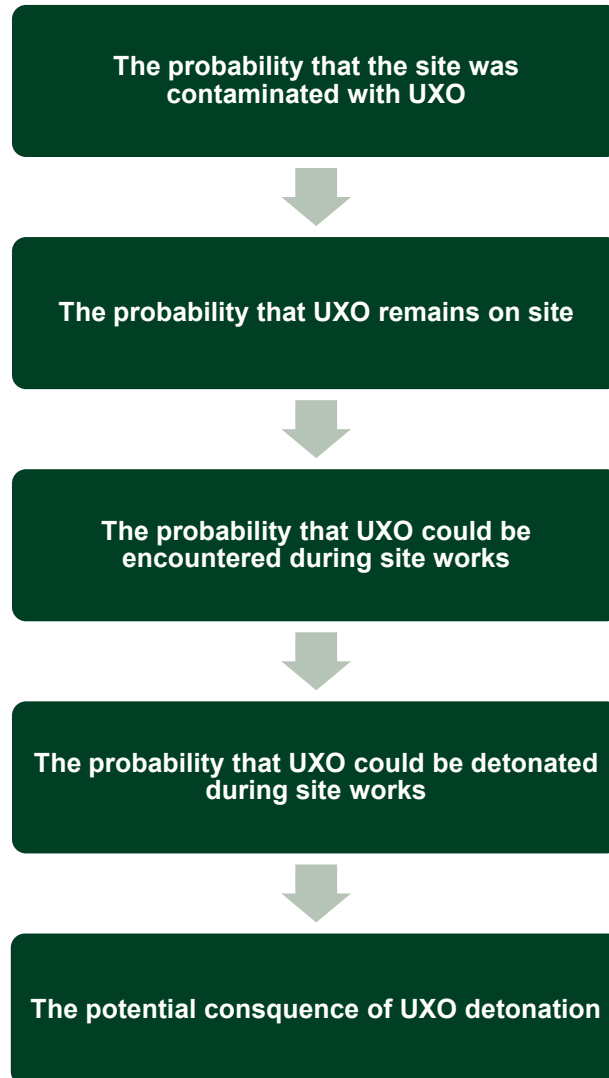
The following table discusses site-specific potential UXO contamination from anti-aircraft artillery.

Potential Source	Details
Threat to the site from unexploded AA shells	- Whilst no recorded HAA batteries were present in the surrounding area during WWII. It is likely that additional emplacements would have been present within the vicinity of site. - During the war, the site was mostly occupied by soft open ground. In such ground cover, it is conceivable that an unexploded AA shell or a rocket strike that had landed in the ground would have gone unnoticed. - However, due to the overall low bombing density in the surrounding area, the volume / frequency of AA fire over the site is unlikely to have been high. As such, the possibility of an unexploded AA shell landing on site is considered to be relatively low.



9. Overview of UXO Risk Assessment Methodology

Taking into account the quality and nature of the historical evidence, the assessment of the overall risk to any intrusive works from UXO must evaluate the following factors:



Each of these steps will be evaluated in the following sections in order to conclude the total risk from UXO to the proposed works to be undertaken within the project site.

9.1 The Probability of UXO Contamination on Site

9.1.1 Contamination Factors

The table below presents generalised factors used to determine the probability that the site was contaminated with unexploded ordnance. Note that additional site-specific information can adjust UXO risk beyond these criteria:

	Probability of Contamination Definitions	
	German Air-Delivered Ordnance / Allied Anti-Aircraft Shells	British / Allied Land Service or Small Arms Ammunition
Probable	- High local bombing density or evidence of bombing / bomb damage on or adjacent to the site. Confirmed finds of WWII UXB. - Ground conditions that would have immediately and completely obscured the existence of UXB. - Site may be completely obscured from view or subject to very infrequent access.	- Evidence of weapons testing or disposal on or adjacent to the site. - Evidence of UXO finds on or in the vicinity of the site.
Possible	- Moderate to High local bombing density or evidence of bombing / bomb damage on or close to the site. - Ground conditions that allow for bomb penetration. - Site located in an area that was infrequently observed or accessed, with a low likelihood that a UXB strike would have been noticed.	- Clear evidence of military training activity on site involving live ammunition / munitions. - Military sites which have not undergone clearance operations or redevelopment since use. - Evidence of weapons storage on site. - Open or unmaintained ground that may have been used for disposal or caching of munitions.
Unlikely	- No evidence of bombing / bomb damage on site coupled with low local bombing density. - Ground conditions that would prevent UXB penetration or lead to easily identifiable entry holes. - Site was occupied and accessed fully throughout the bombing campaign.	- No evidence of Allied military activity on or near the site. Or - Military sites which have been cleared / redeveloped since their use Or - Military-owned sites which have not been used for training with live munitions. - Developed areas that are unlikely to have been used for military exercises.

The following sections assess the probability of contamination from German UXO and British / Allied UXO, based on the evidence discussed in the previous sections.

9.1.2 The Probability of Contamination from German UXO

The following table discusses the overall probability of contamination from German UXO, based on the evidence discussed in **Section 7**.

Overview of the Potential Sources of German Air-Delivered UXO		Overall Probability of Contamination
Bombing density	- Low bombing density. - Home Office Statistics show bombing at nearby towns Markfield, Coalville, and Woodhouse Eaves. - Small scale bomb plot mapping of the region shows strikes within 900m of the site. - No evidence to suggest an elevated risk of German Air-Delivered ordnance on site.	Unlikely
Bomb Damage	- Ground disturbance on site. - However, there is overall limited evidence of bomb damage on site.	
Ground Conditions	- Agricultural open ground on site. - A UXB may have been obscured in the open ground on site. - Note, the diameter of a 50kg HE bomb (the most common type of bomb deployed during WWII) was approx. 20cm. - Roads cross the site.	
Frequency of Access	- Seasonal access to agricultural land. - Frequent access to roadways.	
J-Curve Effect	Had any UXB landed within the soft ground on site, it could have come to rest beneath the adjacent undamaged roadways / unconsolidated ground.	
Other considerations	n/a	

9.1.3 The Probability of Contamination from British / Allied UXO

The following table discusses the overall probability of contamination from British / Allied UXO, based on the evidence discussed in **Section 8**.

Overview of the Potential Sources of British / Allied UXO		Overall Probability of Contamination
Land Service Ammunition / Small Arms Ammunition	- Photographic evidence of a howitzer on Old House Lane. - Possible training within proximity of the site. However, there is limited evidence to corroborate live fire training on site. - Moreover, there is no corroboratory evidence to support the training on Old House Lane. - As such, there is insufficient evidence to suggest that contamination from LSA / SAA impacts the site, although the possibility cannot be completely ruled out.	Unlikely
Anti-Aircraft Projectiles	Whilst no recorded HAA batteries were present in the surrounding area during WWII.	Unlikely

	- An AA shell landing on site may have been obscured by the agricultural open ground. - However, due to the overall low bombing density in the surrounding area, the volume / frequency of AA fire over the site is unlikely to have been high. - As such, the possibility of an unexploded AA shell landing on site is considered to be relatively low.	
Aircraft Crashes	While a crash was reported to have occurred in the Markfield area, there is no evidence to corroborate whether it occurred within vicinity of the site.	Unlikely

9.2 The Probability that UXO Remains on Site

9.2.1 General

The extent to which any ordnance clearance activities have taken place on site or extensive ground works have occurred is relevant, since they may indicate previous ordnance contamination but also may have reduced the risk that ordnance remains undiscovered.

9.2.2 EOD Bomb Disposal, Clearance Tasks and UXO Finds

Post-WWII UXO finds are vital, as they can tell us locations where UXO was dropped or buried, the types of munitions used and the numbers that went unnoticed for years after the war ended.

Igne holds a number of official records of explosive ordnance disposal operations during and following WWII, obtained from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD), British Army.

Igne have also sought news articles, publications, anecdotal records and local Igne projects to determine post-WWII UXO encounters on or near to the site. No UXO discoveries could be found within proximity of the site during the timeframe of this report.

9.2.3 Post War Redevelopment

The nature of post-WWII ground works, redevelopment and construction has been considered. Significant structural redevelopment on site can, in some cases, provide a level of mitigation, particularly from shallow buried items. However, if a site has not undergone any extent of redevelopment, the likelihood of UXO remaining within its boundaries can remain.

Redevelopment Details
No known redevelopment appears to have occurred on site; the agricultural fields are likely to have been subject to shallow intrusive works such as ploughing / tilling. Information provided by the client has suggested that the site has experienced localised areas of deep excavation.



9.2.4 Site-Specific Analysis

The following table discusses the likelihood that UXO could remain on site, following any post-WWII activity.

Mitigating factors during post-WWII period	The available evidence suggests that majority of the site has been subject only to shallow ground works since the end of WWII. With client information suggesting areas of deep intrusive works within localised areas.
Further comments	The threat of UXO contaminating the site has been assessed as minimal and therefore the likelihood of UXO remaining on site is also minimal.

9.3 The Probability that UXO may be Encountered during the Works

UXO may be encountered during constructions works, particularly piling, drilling or bulk excavations. The risk depends on the extent of the works, such as the number of boreholes / piles, and excavation volume. Shallow excavations near the original WWII ground level may also pose a risk. If the works are within post-WWII fill material, the risk of encountering WWII UXBs is lower. However, the risk significantly increases if the works are below the WWII ground level. The probability of encounter can be determined using the table below.

Probability of Encounter	
1	Rare
2	Unlikely
3	Possible
4	Probable
5	Highly Probable

9.4 The Probability that UXO may be Detonated

Items of ordnance do not become inert or lose their effectiveness with age. Time can indeed cause items to become more sensitive and less stable. This applies equally to items submerged in water or embedded in silts, clays or similar materials. The greatest risk occurs when an item of ordnance is struck or interfered with. This is likely to occur when mechanical equipment is used or when unqualified personnel pick up munitions.

9.4.1 Detonation of Unexploded Bombs

In the case of unexploded German bombs discovered within the construction site environment, there are a number of potential initiation mechanisms:

Direct Impact onto the main body of the bomb	Unless the fuze or fuze pocket is struck, there needs to be a significant impact to initiate a buried HE bomb.
Re-starting the clock timer in the fuze	Only a small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion has taken place within the fuze since the end of WWII that would prevent clockwork mechanisms from functioning, nevertheless it was reported that the fuze in a UXB dealt with by 33 EOD Regiment in Surrey in 2002 did recommence.
Induction of a static charge, causing a current in an electric fuze	The majority of German WWII bombs employed electric fuzes. It is probable that significant corrosion has taken place within the fuze mechanism since the end of WWII such that the fuze circuit could not be activated.
Friction impact initiating the (shock-sensitive) fuze explosive	This is the most likely scenario resulting in the bomb detonating.

9.4.2 Activities that may Result in the Detonation of UXO

Unexploded bombs do not spontaneously explode. All high explosive requires significant energy to create the conditions for detonation to occur. The risk that UXO could be initiated if encountered will depend on its condition, how it is found and the energy with which it is struck. However certain activities pose a greater risk than others.

Percussive piling or deep mechanical excavations	The most violent activity on most construction sites is percussive piling or deep mechanical excavations. If an item is struck with a significant enough impact, be it direct or through friction/vibration, it risks detonation.
Shallow excavation	Soil levelling and shallow excavation such as trial pits can pose a similar risk to deeper excavations, since UXO can be found at any depth between ground level and the maximum bomb penetration depth. In addition to risk of initiation by violent impact or vibration, detonation can also occur if discovered items are mishandled by unqualified personnel. This is particularly common when onsite personnel are not trained in the recognition of ordnance.
Non-intrusive works	In the case of non-intrusive planned works, little risk is posed by items of UXO that are buried beneath the ground. However, risk can arise from unburied munitions,

particularly items of ordnance discarded in periphery areas of military sites. These items are frequently discovered by onsite personnel and remain live and liable to activate if mishandled.

9.4.3 The Consequences of Encountering or Detonating UXO

An inadvertent detonation of UXO during construction operations would have catastrophic consequences, including a serious risk to life, damage to equipment and a complete site shutdown for subsequent investigations. Appropriate mitigation measures can significantly reduce the risk of initiating ordnance, but the most significant consequence of ordnance discovery is economic, especially in high-profile locations that may require a public evacuation. The unsuspected discovery of ordnance can lead to site closure for a period ranging from a few hours to a week, resulting in substantial lost time costs. Additionally, involving authorities for handling suspected ordnance may further disrupt production, as the police would typically isolate the area while waiting for military assistance, even if it proves unnecessary.

The following table details several recent UK-based UXO incidents:

Recent UK-Based UXO Incidents	
	February 2021-March 2023 – A WWII-era German 1000kg HE UXB was discovered in Exeter, Devon, February 2021. Consequences to the project included: • Halt to construction works while 400m cordon was implemented. • Approximately 2600 properties in the vicinity were evacuated for 2 days. • Structural damage within blast radius during in-situ disposal. • Insurance claim was declined by insurers (March 2023).
	February 2023 – A WWII UXB unexpectedly exploded at the site of a construction project in Great Yarmouth, Norfolk. Consequences to the project included: • Resulted in a 4-day major incident. • Minor damage to the road, and damage to the river wall.
	February 2018 – WWII UXB found in King George V dock, London. Consequences to the project included: • 214m exclusion zone implemented. • Closure of London City Airport with all flights cancelled.
	March 2017 – Construction workers found a WWII UXB in Brondesbury Park, London. Consequences to the project included: • Evacuation of residents and 2 schools. • Halt to construction and delays to project.



10. UXO Risk Analysis and Risk Rating

10.1 Risk Analysis Methodology

In order to identify appropriate risk ratings and recommended risk mitigation measures, a semi-quantitative assessment has been undertaken, using all available information discussed in this report.

This risk assessment is designed to determine the level of risk associated with the planned works / actions on site. Igne will identify the hazards and investigate the potential receptor that could be affected. The pathway to the hazard will determine the risk on site. This relationship is usually described as Source – Pathway – Receptor.

Source (or Hazard): Based on the information discussed throughout the report, the most likely potential sources of hazard include:

- HE bombs
- Incendiary bombs
- AA Projectiles
- Land Service Ammunition
- Small Arms Ammunition

Pathway: this is defined as the route in which a hazard could reach the receptor. This will usually include any intrusive ground works.

Receptors: Taking into account the proposed project details, potential receptors could include:

- Personnel (people, workers, engineers, public)
- Equipment & infrastructure
- Environment
- Reputation

An evaluation of the risk rating on site will be determined by several factors; the probability of UXO to remain on site, the probability that it could be encountered / initiated during the proposed works, and the consequences of an accidental detonation. A total risk rating for the site will be determined by considering these factors.

The final risk rating is based upon:

Probability of Encounter (pE) x Consequence of Detonation (cD)

using the definitions below:

Probability of Encounter (pE)		Consequence of Detonation (cD)	
1	Rare	1	Insignificant or Very Low
2	Unlikely	2	Minor or Low
3	Possible	3	Moderate or Medium
4	Probable	4	Major or High
5	Highly Probable	5	Catastrophic or Very High

Consequence Level	Potential Consequences				
	Personnel	Assets and Equipment		Environment	Reputation
		Plant & Equipment	Infrastructure		
1	Minor injury, first aid required	No noticeable impact	No noticeable impact	Minor disturbance	No noticeable impact
2	Injury with time lost (<3 days)	Slight superficial damage	Slight superficial damage	Significant disturbance	Minor impact
3	Serious injury, hospital treatment required	Minor component repair or replacement required	Non-structural repairs required	Moderate damage to habitats	Moderate impact
4	Localised fatalities	Significant component repair or placement required	Structural repairs required	Moderate damage to habitats with minor long-term impact	Major impact
5	Fatalities over a substantial area	Irreparable damage or loss of unit	Localised structural destruction, collapse or failure	Localised destruction of habitats with moderate long-term impact	Significant Impact

10.2 Risk Matrix

Using the classifications presented in section 10.1, the risk matrix below will be utilized to determine the final risk rating for the site.

		Consequence of Detonation (cD)				
		1	2	3	4	5
Probability of Encounter (pE)	1	1	2	3	4	5
	2	2	4	6	8	10
	3	3	6	9	12	15
	4	4	8	12	16	20
	5	5	10	15	20	25

Risk Ratings Definitions	
High (16-25)	Significant or unacceptable risk. Action required to mitigate the risk before works commence to prevent a significant incident.
Medium (6-15)	Tolerable level of risk if controls lower the risk to ALARP. Workers should proceed with extra caution. Increased monitoring and evaluation required.
Low (1-5)	Acceptable risk. Minimum proactive risk mitigation measures are recommended on site prior to further site works.



10.3 Final Risk Rating & Recommended Risk Mitigation Measures

10.3.1 Risk Rating

The following table discusses the risk rating across the entire site:

Hazard	Average Depth of Hazard	pE	cD	Risk Analysis (pE x cD)	Risk Rating
HE bombs	<12m bgl	1	5	5	Low
IB (1kg)	<1m bgl	1	4	4	Low
AA	<5m bgl	1	4	4	Low
LSA	<2m bgl	1	4	4	Low
SAA	<1m bgl	1	2	2	Low

10.3.2 Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended in order to lower the overall risk during the proposed works to ALARP. Additional information regarding these methods can be found in Section 10.4. In the event of significant additions or alterations to the proposed scope of works, please refer to Section 10.4 for a comprehensive list of risk mitigation details. Furthermore, in the event of any such changes to the proposed works on site, Igne should be contacted to ensure correct mitigation methods are applied based on specific scope of works.

Pathway	Risk Rating	Recommended Risk Mitigation Measure(s)
All	Low	- Site Specific Explosive Ordnance Safety and Awareness Briefings (UXO Toolbox Briefing) to all personnel conducting intrusive works - Site Specific Safety Instructions (SSSI) Training Course



10.4 Risk Mitigation Overview

An overview of Risk Mitigation Measures is presented below.

Site-Specific Proposed Works	Risk Mitigation Measures	Further Detail
All	Site Specific Explosive Ordnance Safety and Awareness Briefings (UXO Toolbox Briefing) to all personnel conducting intrusive works	These briefings are intended to make site operatives aware of the nature of explosive ordnance that may be encountered on their project site. - Delivered by a specialist Explosive Ordnance Disposal Engineer. - Provides information on the site-specific explosive ordnance risk. - Basic ordnance identification. - What to do in the event of an encounter with a suspicious object. - Provide UXO response procedures.
All	Site Specific Safety Instructions (SSSI) Training Course	For longer term projects that require Explosive Ordnance Safety and Awareness Briefings as part of the Explosive Ordnance Risk Mitigation measures for the project, SSSIs can be provided to allow nominated site representatives to deliver these briefings after initial training. 2/3-hour presentation and training course. - Delivered by a fully qualified senior EOD Engineer. - Suitable for Project Site Manager HSE representative and supervisors. - Includes briefing pack. This provides a cost-effective solution to ensure that the Explosive Ordnance Safety and Awareness Briefings can be delivered effectively and efficiently to the required standard.
Open excavation Shallow intrusive works	Explosive Ordnance Disposal (EOD) Engineer On-Site Support (Watching Brief)	In areas where the risk posed by the potential presence of explosive ordnance is low or where the conditions are not suitable for pro-active survey, EOD On-Site Support can provide a reactive response to any suspicious object that may be encountered during open excavation works. The presence of the EOD Engineer (sometimes referred to as 'high risk dig wardens') on-site in support of shallow intrusive work allows for a direct monitoring of works using visual recognition and instrumentation and provides an immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by ground workers. Igne EOD personnel on-site also have the additional benefit of providing Explosive Ordnance Safety and Awareness briefings (UXO TBB) to any staff that have not received them earlier and can advise staff of the need to modify working practices to take account of the ordnance threat. The EOD Engineer will also aid potential incident management which would involve liaison with the local

Site-Specific Proposed Works	Risk Mitigation Measures	Further Detail
		authorities and police should ordnance that presents an explosive hazard be identified. • Specialist Explosive Ordnance Disposal Engineer. • Maintains a watching brief over all excavations. • Provides safety and awareness briefings to construction personnel as required. • Provides immediate identification of any suspicious item that is encountered. • Identifies whether any UXO item is live or inert. • Provides liaison assistance with the relevant authorities when dealing with any live UXO. Avoids on site delays which can be caused by the incorrect identification of a suspect item being potential UXO.
Boreholes	Support to Borehole Drilling	For cost effective risk mitigation for site investigation work, the site operative can conduct intrusive surveys for borehole and window sample locations working in conjunction with the site investigation team. The On-Site Support will also provide a reactive response to any suspicious object that may be encountered during open excavation works. • Works in conjunction with the drilling team to survey all borehole and window sample locations in real-time using a staged drilling and magnetometer survey procedure. • Avoids on site delays which can be caused by the incorrect identification of a suspect item being potential UXO. <i>Technical Information</i> 1. In optimum ground conditions each survey using the borehole technique will have a 1 metre look ahead capability. 2. Any steel casing used for borehole surveys will need to be retracted by 3 metres to allow the magnetometer survey to be conducted. Non-ferrous pipe will be required to support the borehole during the survey minimum diameter 60mm (to be supplied by the client).
Shallow intrusive works (max. 2m bgl)	Search & Clear	Where a non-intrusive magnetometer survey is not possible (e.g. wooded areas) Igne can deploy a two-man Explosive Ordnance Disposal Engineer team using handheld magnetometer equipment who will proactively survey either in search lanes or boxes, investigating each reading with the support of an operated excavator. The survey is suited to detecting suspicious ferro-magnetic buried objects that may be munitions and/or explosive ordnance related. All Igne personnel involved with the Search and Clearance Works will be former military personnel who have gained formal NATO Military Explosive Ordnance Disposal Qualifications, having completed training at the Defence Explosive Ordnance Disposal

Site-Specific Proposed Works	Risk Mitigation Measures	Further Detail
		School (DEODS) Chattenden, Kent or similar establishment throughout their military service. The client will be responsible for: • Demarcating the areas to be searched. • Providing services clearance and permit to dig. • Providing operated excavator to access deeper targets if required (Igne can provide this service at additional cost). • Providing coordinates of positions where debris have been identified (if information required in report). • Providing storage for recovered debris. Output will depend upon terrain and contamination (number of readings to be investigated).
Shallow intrusive works (max. 2m bgl)	Non-Intrusive Magnetometer Survey and Target Investigation (greenfield land only)	<i>Non-Intrusive Survey</i> This survey type is designed for use on magnetically 'clean' land commonly referred to as 'greenfield'. Brownfield land is often described as that which has had previous industrial or commercial use. In this context it specifically encompasses sites which are underlain by 'made ground' which may contain metallic contamination. Non-intrusive magnetometry or electromagnetic equipment which is used in the search for buried UXO relies upon the detection of small changes between clear ground and that containing UXO. The technique operates very successfully in environments where there is minimal ground contamination from other sources such as fired bricks, reinforced concrete, discarded scrap metal and buried services. There are also man-made ambient effects on magnetic and electromagnetic non-intrusive survey systems which include moving plant vehicles, power cables, electric trains etc. Non-Intrusive survey is carried out using either total-field or gradiometer magnetometry, dependent upon site conditions. Data is recorded and then interpreted using advanced AGSPRoc software in order to map magnetic fields and model discrete magnetic anomalies (variations in the Earth's magnetic field caused by ferro-magnetic objects electrical fields or geology). The location of such anomalies is determined, and mathematical modelling used to estimate their mass and depth. The survey will also locate any buried services with a magnetic signature and indicate any areas of gross magnetic "contamination" which may indicate the

Site-Specific Proposed Works	Risk Mitigation Measures	Further Detail
		presence of unknown obstructions. Additionally, the survey can provide information on archaeological features. The system can detect the magnetic field from a 50kg WWII air-dropped bomb at a depth of 4m and smaller items such as Land Service Ammunition to depths of up to 1.5m in ground with a low ambient magnetic field. In the case of soft geology, it should be noted that a 50kg high explosive bomb may be buried greater than 4 metres below ground level and therefore may not be detected by the survey. In this instance intrusive surveys may be required. The non-intrusive survey system will be deployed utilising the pedestrian survey frame. The output for the pedestrian frame is estimated at up to 2Ha per day. <i>Technical information:</i> • Client to clearly demarcate area to be surveyed prior to start and highlight any known services/underground obstructions. • Ground must be level, free of obstacles / obstructions and clear of undergrowth. Height of any crops should be no more than 400mm and where crops are present Igne would require written approval from the landowner or client to walk over the site area. • When working adjacent to existing infrastructure the survey may be ineffective due to the ferro magnetic interference caused by passing vehicles and the presence of underground buried services. A site visit may be recommended prior to commencement. • Note: the survey will be ineffective on Brownfield sites due to the magnetic nature of building rubble, which typically masks the weaker magnetic signatures of buried objects. If parts of the site are contaminated, then alternative risk mitigation measures may need to be considered. <i>Target Investigation</i> If a buried anomaly is detected that cannot be discounted as a potential UXO / UXB then the object will need to be investigated to positively identify the item. The process will include; • Specialist two-man Explosive Ordnance Disposal Team. • Combination of manual and mechanical excavation techniques. • Excavator shafting, shoring and dewatering equipment can be provided by Igne if required. • Excavation techniques will be defined and agreed prior to the commence. A factual report with clearance certificate will be issued on completion of the investigation.

Site-Specific Proposed Works	Risk Mitigation Measures	Further Detail
Piling	Intrusive Magnetometer Survey of all pile locations down to the maximum bomb penetration depth	Igne can deploy a range of intrusive magnetometry techniques to clear ahead of all the pile locations. The appropriate technique is governed by a number of factors, but most importantly the site's ground conditions. The appropriate survey methodology would be confirmed once the enabling works have been completed. A site meeting would be required between Igne and the client to determine the methodology suitable for this site. Target investigation or avoidance will be recommended as appropriate.

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Figures



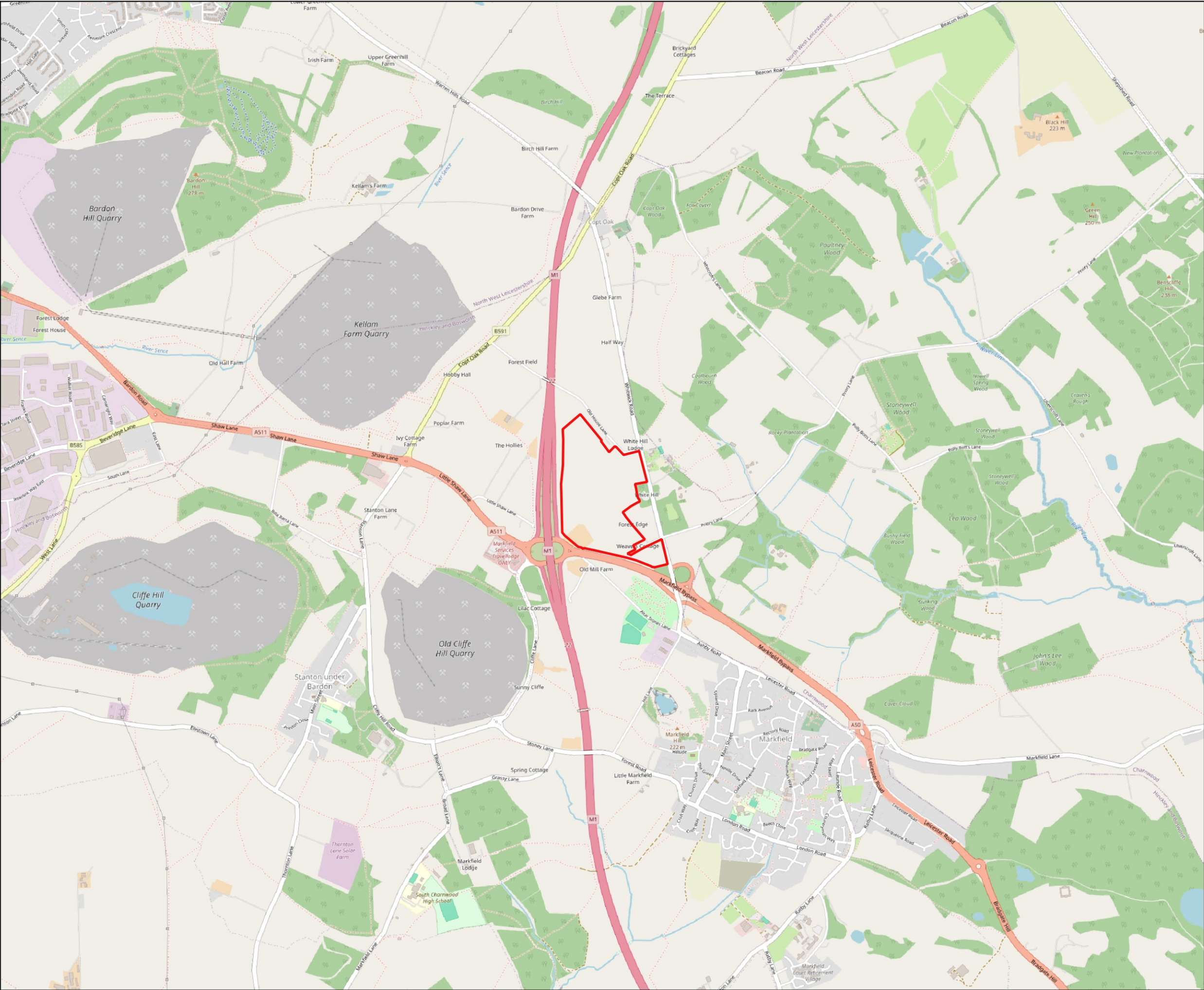
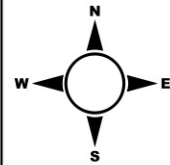
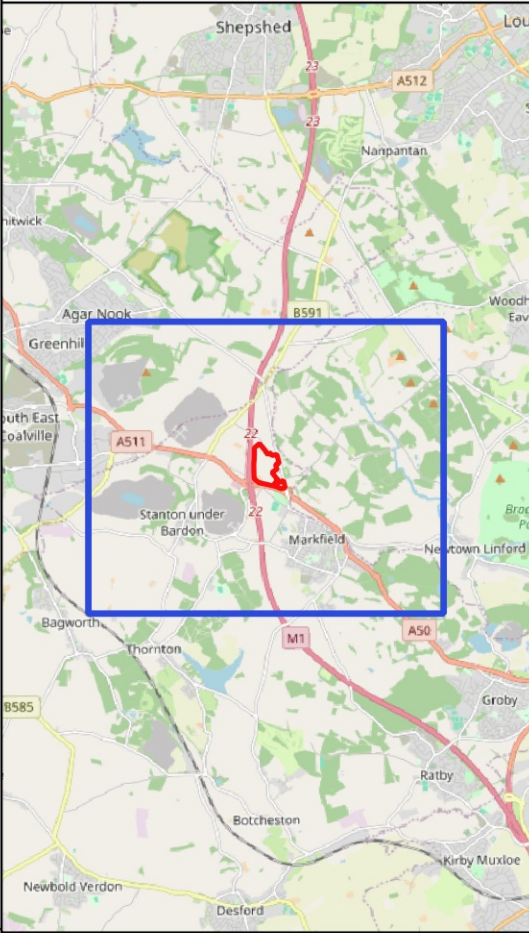


Figure 1.0

Site Location Maps

Key

Site boundary 



Source:
OpenStreetMap

Document Reference: 10621





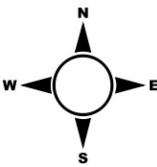
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Figure 2.0

Recent Aerial Photograph

Key

Site boundary



Notes:

Source:
Google Earth Mapping Services

Document Reference: 10621

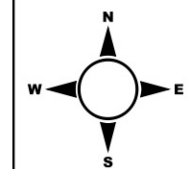


Figure 3.0

Site Plan

Key

Site boundary



Notes:

Source:
Caddick Developments Ltd

Document Reference: 10621



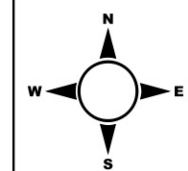
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Figure 4.1

1929 OS Map

Key

Site boundary



Notes:

Source:
Landmark Maps

Document Reference:10621

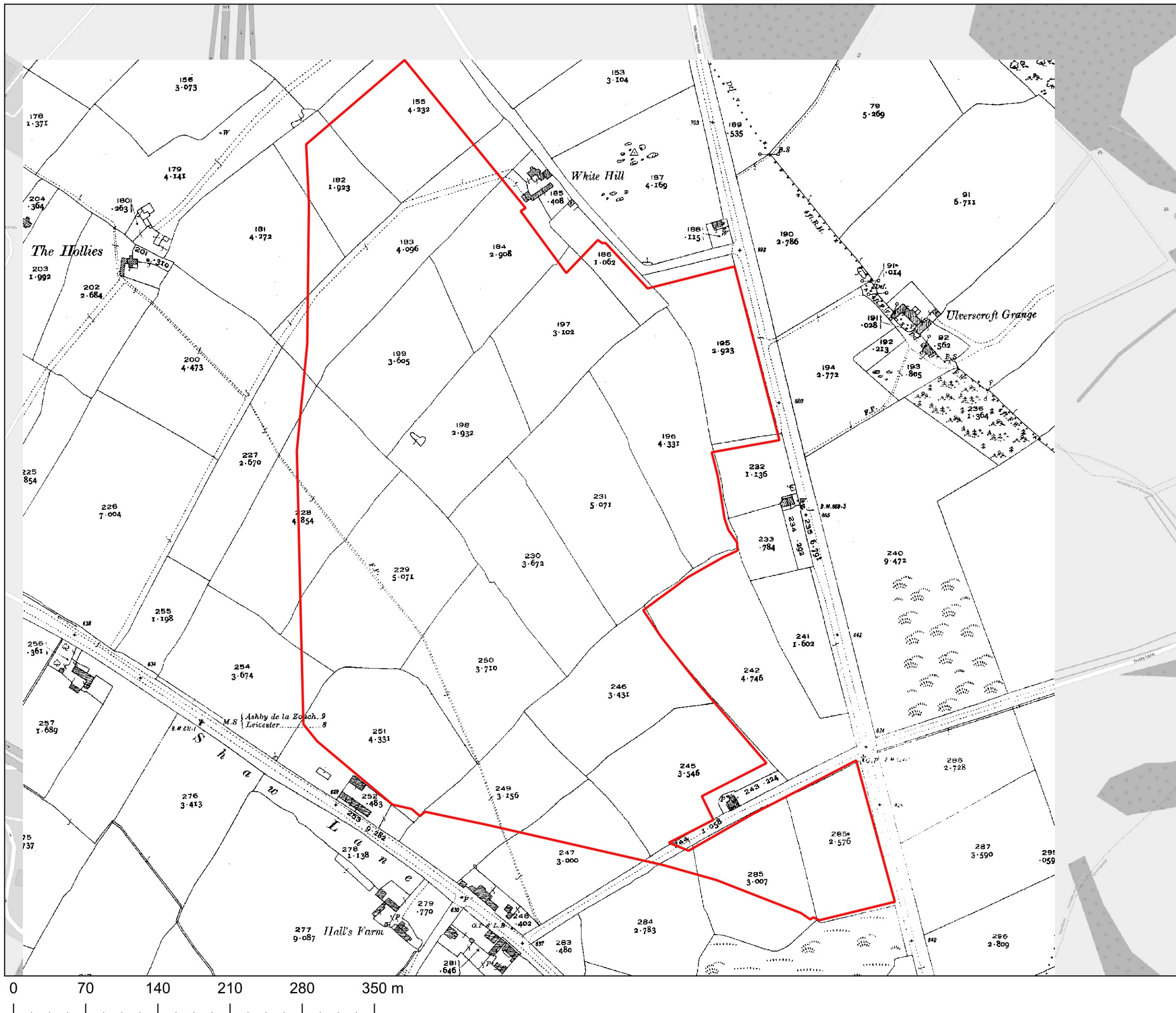


Figure 4.2

1959-60 OS Map

Key

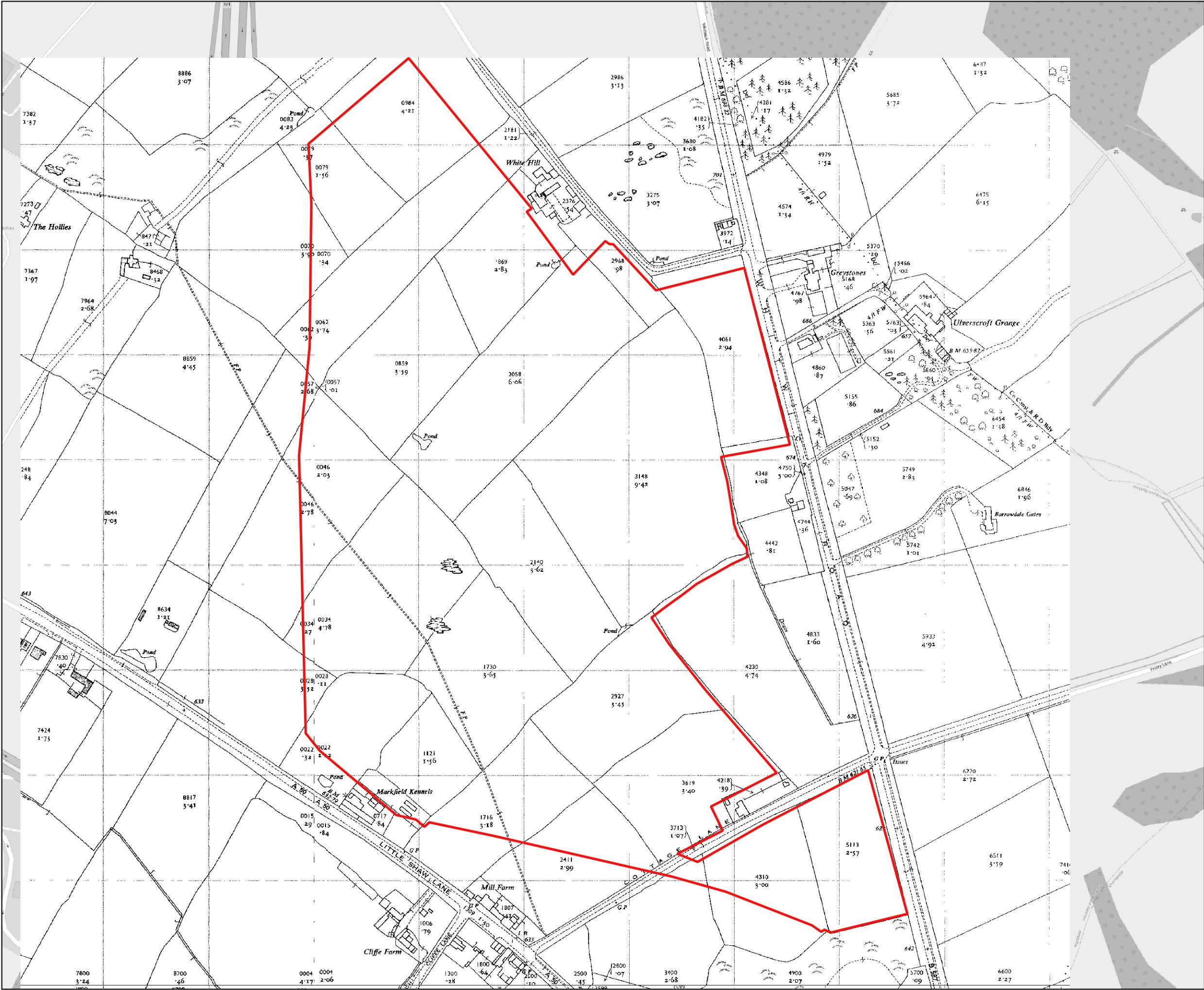
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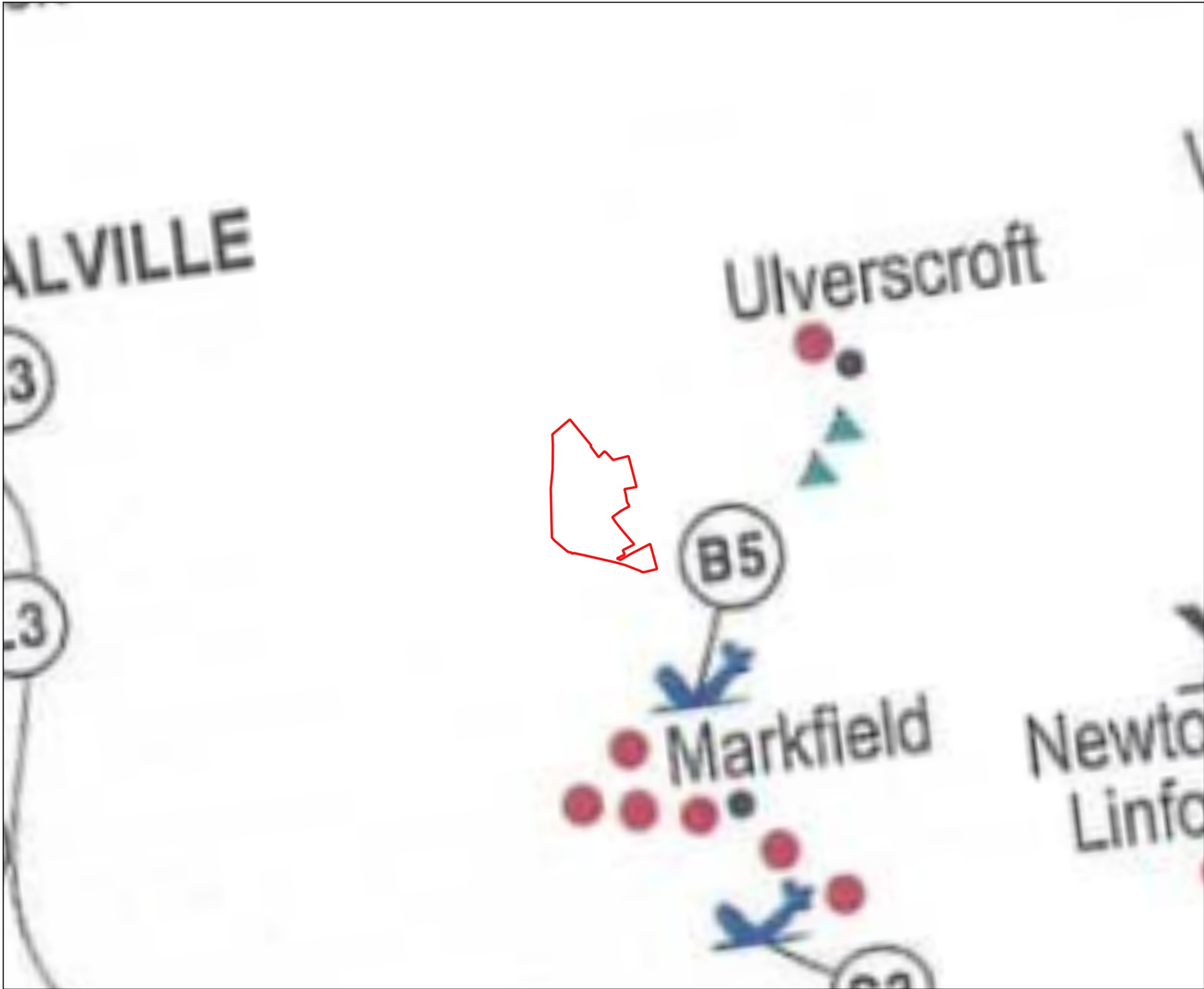


Figure 5.0

Leicestershire Incidents Map

Key

Site boundary

- Parachute Mine (Landmine)
- Unexploded Parachute Mine
- Heavy high explosive bombs
- High explosive bombs
- Oil bombs
- Unexploded bombs
- Clusters of Incendiary bombs
- Exploding Incendiary bombs
- V1 Flying bomb
- Area machine gunned
- Site of plane crash (approx.)



Notes:

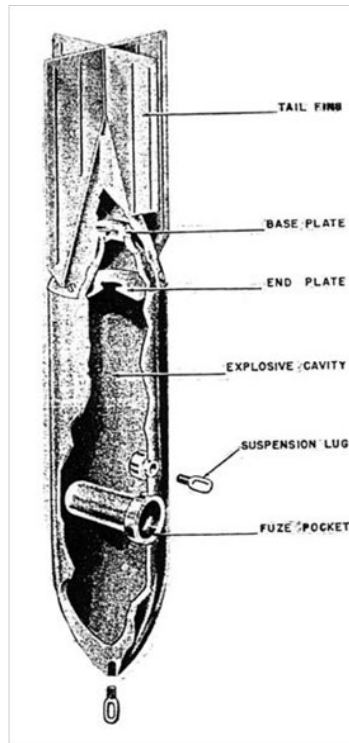
Source:
Birds Eye Wartime, Cartwright

Document Reference: 10621



Appendices

Sprengbombe Cylindrisch 50 (SC50)



Bomb weight: 40-54kg

Fuze Type: Impact fuze / electro-mechanical time delay fuze

Bomb Dimensions: 1090 x 280mm

Body Diameter: 200mm

Use: Used against lightly damageable materials, hangars, railway rolling stock, ammunition depots, light bridges and buildings up to 3-storeys.

Remarks: The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.

SC50 found on site

In May 2015, an SC50 was found at a building site on Empire Way, Wembley, London. (Image source: *The Guardian*)



Appendix 1.1

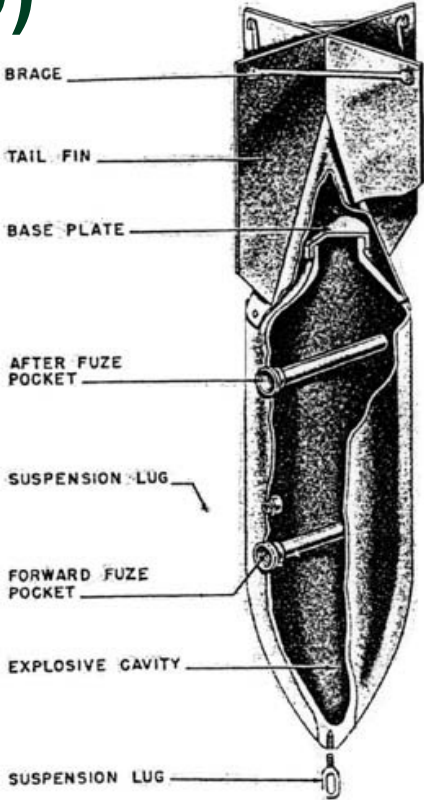
Generic Types of German Air-Dropped Ordnance

Additional Notes:

Sources:
Various news sources
Open source images

Sprengbombe Cylindrisch 250 (SC250)

Bomb weight: 245-256k
Explosive Weight: 125-130kg
Fuze Type: Electrical impact / mechanical time delay fuze
Bomb Dimensions: 1640x512mm
Body Diameter: 368mm
Use: Used against railway installations, embankments, flyovers, underpasses, large buildings and below-ground installations



Appendix 1.2

Generic Types of German Air-Dropped Ordnance

Additional Notes:
The images show SC250 bombs facing upwards in the ground, illustrating the J-Curve Effect.

Sources:
Various news sources
Open source images

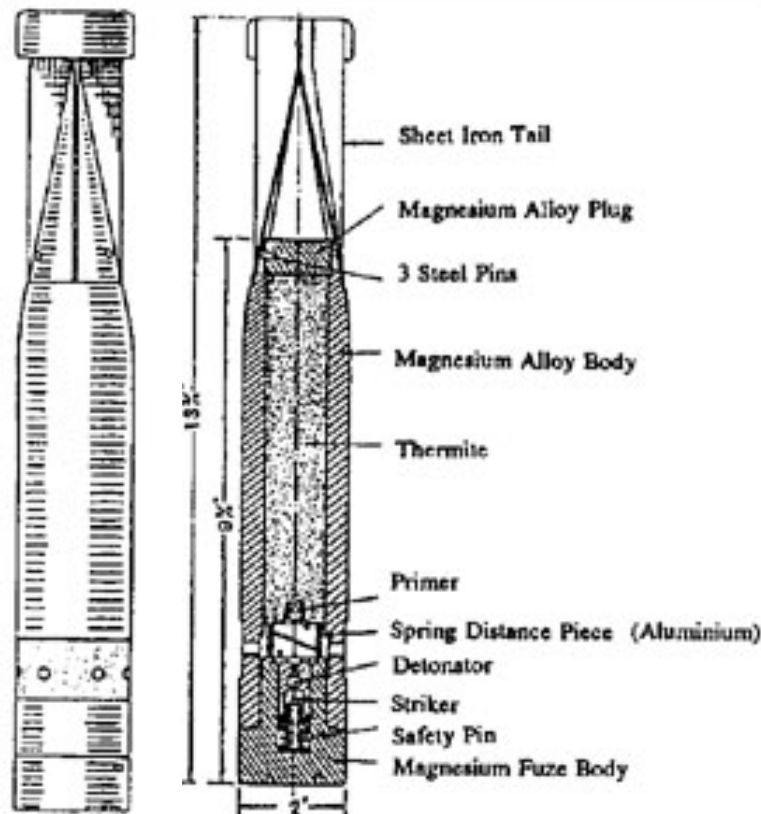


SC250 found on site
In 2000, Igne discovered an SC250 whilst supervising construction work at Hawkinge, Kent.



SC250 found on site
In 2015, a 250kg HE bomb was found on a construction site in Bermondsey, London.

1kg Incendiary Bomb (IB)



Bomb weight: 1.0 & 1.3kg
Filling: 680g Thermite
Fuze Type: Impact fuze
Body Dimensions: 350 x 50mm
Body Diameter: 50mm
Use: As incendiary – dropped in clusters against towns and industrial complexes
Remarks: Jettisoned from air-dropped containers. Magnesium alloy case. Sometimes filled with high explosive charge.



Left: ordinary scaffold pipe
Centre: 1kg incendiary bomb
Right: incendiary bomb found on site in UK

Appendix 1.3

Generic Types of German Air-Dropped Ordnance

Additional Notes:

Sources:
Various news sources
Open source images

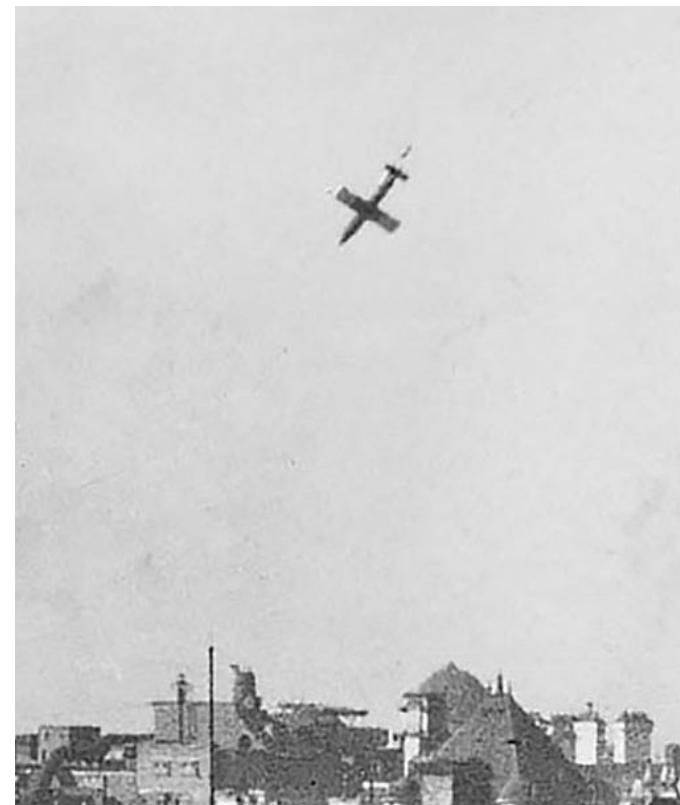
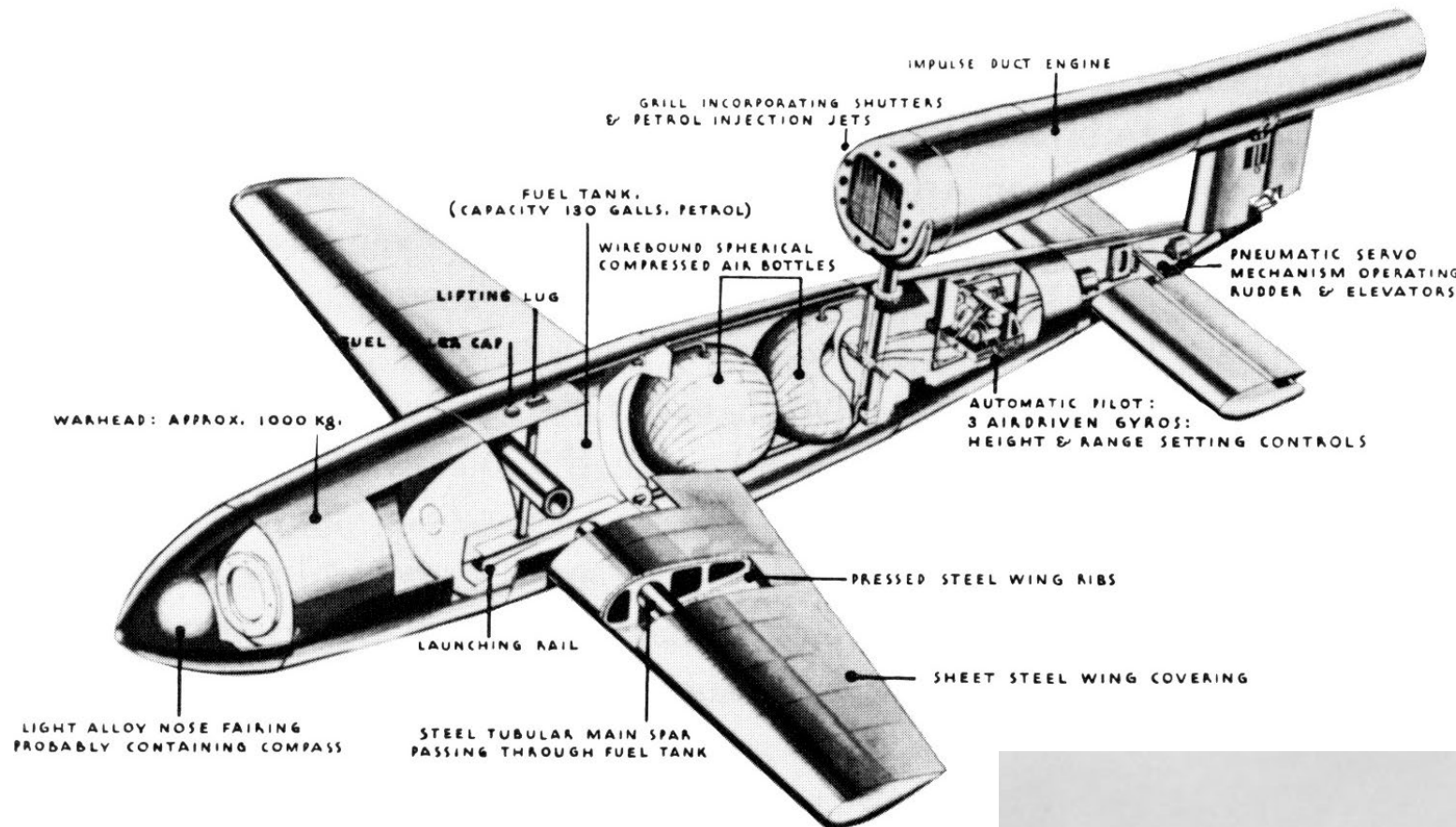
Vergeltungswaffe 1 (V1) “Fly” Bomb

Appendix 1.4

Generic Types of German Air-Dropped Ordnance

Additional Notes:

Sources:
Various news sources
Open source images



A V-1 ‘Fly’ Bomb, captured over London, seconds before impacting

Missile Weight: 2,150kg

Fuze Type: Electric Impact Fuze

Missile Length: 8.32m

Width: 5.37m

Range: 250km

Use: Pulsejet-powered guided cruise missile, designed to attack Allied cities.

Remarks: Armed with an 850kg warhead, around 10,000 V-1 flying bombs were fired at England, causing significant damage and killing approximately 6,000 people. There is a negligible risk from unexploded V-1s today, since the remains would have left incontrovertible evidence of the impact.

Vergeltungswaffe 2 (V2) Rocket

Rocket Weight: 12,500kg

Fuze Type: Electric Impact Fuze

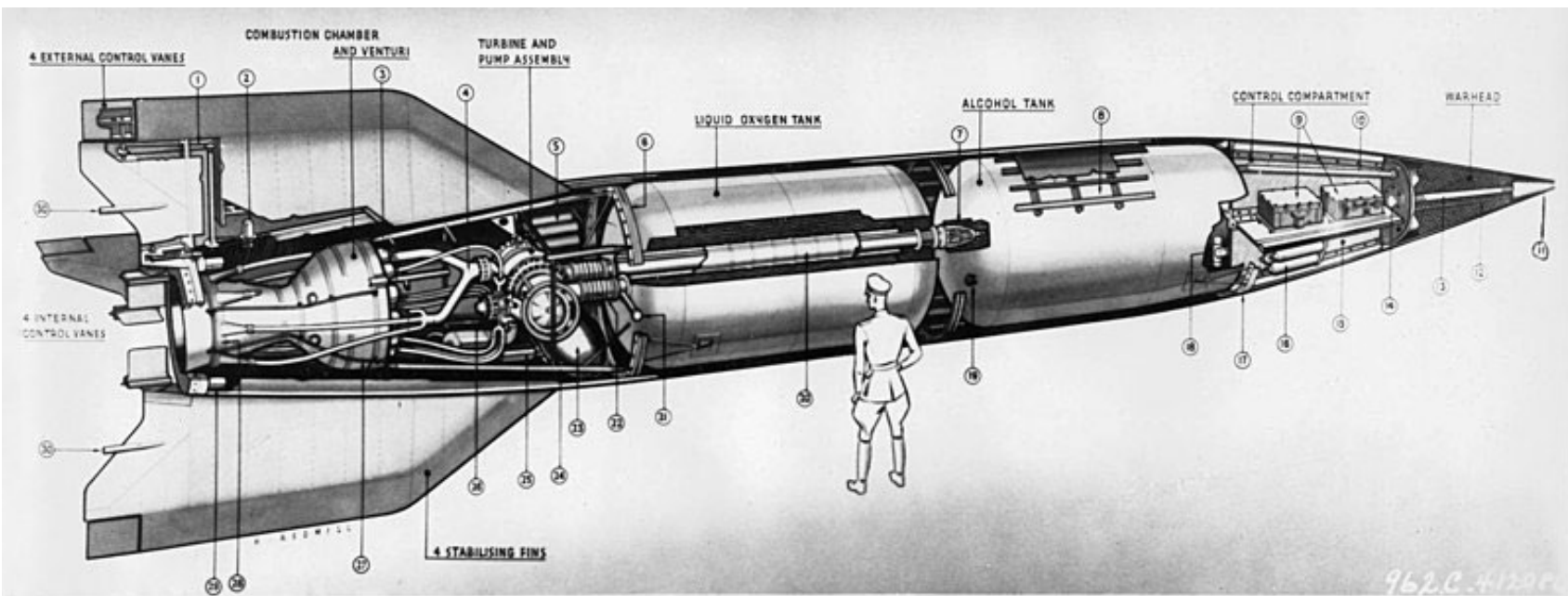
Rocket Length: 14m

Body Diameter: 1.65m

Range: 320km

Use: Long-range ballistic missile, designed to attack Allied cities.

Remarks: Armed with a 975kg warhead and travelling at three times the speed of sound, the V-2 could cause widespread destruction. There is a negligible risk from unexploded V-2s today, since the remains would have left incontrovertible evidence of the impact.



- 1 CHAIN DRIVE TO EXTERNAL CONTROL VALVE
- 2 ELECTRIC MOTOR
- 3 BURNER CUPS
- 4 ALCOHOL SUPPLY FROM PUMP
- 5 AIR BOTTLES
- 6 REAR JOINT RING AND STRONG POINT FOR TRANSPORT
- 7 SERVO-OPERATED ALCOHOL OUTLET VALVE
- 8 ROCKET SHELL
- 9 RADIO EQUIPMENT
- 10 PIPE LEADING FROM ALCOHOL TANK TO WARHEAD

- 11 NOSE PROBABLY FITTED WITH NOSE SWITCH, OR OTHER DEVICE FOR OPERATING WARHEAD FUZE
- 12 CONDUIT CARRYING WIRES TO NOSE OF WARHEAD
- 13 CENTRAL EXPLODER TUBE
- 14 ELECTRIC FUZE FOR WARHEAD
- 15 PLYWOOD FRAME
- 16 NITROGEN BOTTLES
- 17 FRONT JOINT RING AND STRONG POINT FOR TRANSPORT
- 18 PITCH AND AZIMUTH GYROSCOPE
- 19 ALCOHOL FILLING POINT
- 20 DOUBLE WALLED ALCOHOL DELIVERY PIPE TO PUMP

- 21 OXYGEN FILLING POINT
- 22 CONCERTINA CONNECTIONS
- 23 HYDROGEN PEROXIDE TANK
- 24 TUBULAR FRAME HOLDING TURBINE AND PUMP ASSEMBLY
- 25 PERMANGANATE TANK (GAS GENERATOR UNIT BEHIND THIS TANK)
- 26 OXYGEN DISTRIBUTOR FROM PUMP
- 27 ALCOHOL PIPES FOR SUBSIDIARY COOLING
- 28 ALCOHOL INLET TO DOUBLE WALL
- 29 ELECTRO-HYDRAULIC SERVO MOTORS
- 30 AERIAL LEADS

Appendix 1.5

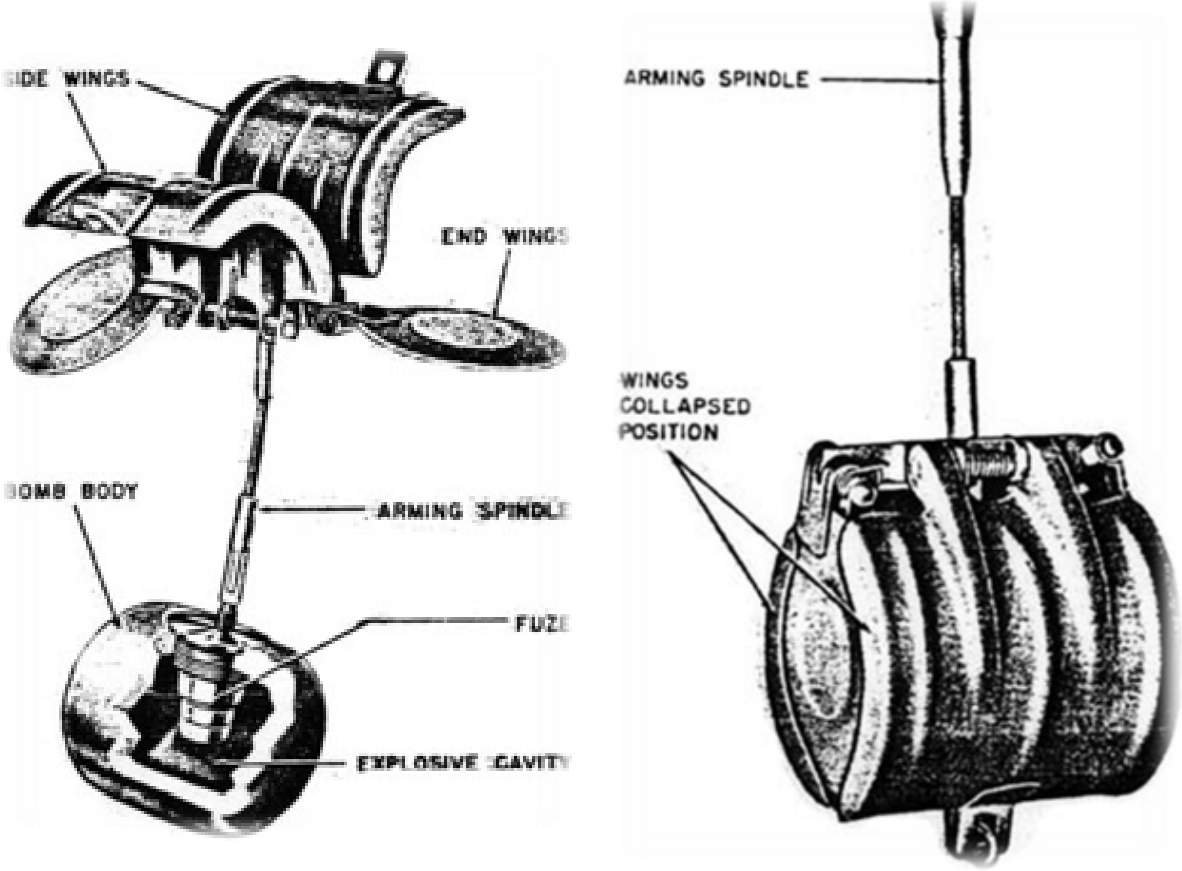
Generic Types of German Air-Dropped Ordnance

Additional Notes:

Sources:
Various news sources
Open source images

SD-2 & SD-2 B “Butterfly Bomb”

Bomb Weight: 2.0kg
Explosive Weight: 0.225kg
Explosive Filling: 225g of TNT
Fuze Type: Mechanical (41) clockwork fuze only in SD-2
Bomb Dimensions: 200x76mm with cable attachment but without brake airscrews
Bomb Diameter: 76mm
Use: Against living targets and with Störzänder (deterrent fuze) as mine
Remarks: Jettisoned from air-dropped containers. Generally lethal to anyone within a radius of 25m and could injure people as far away as 150m.



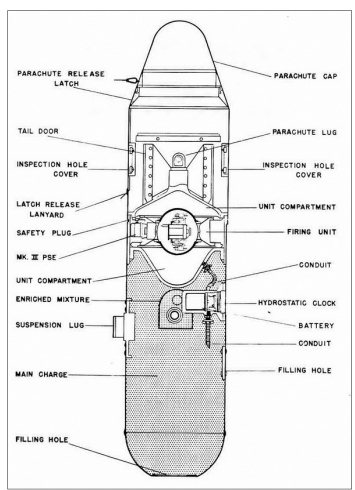
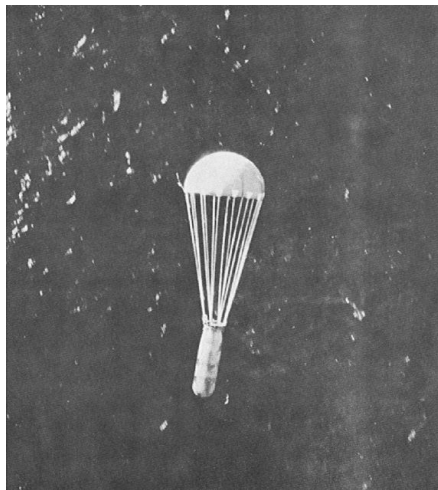
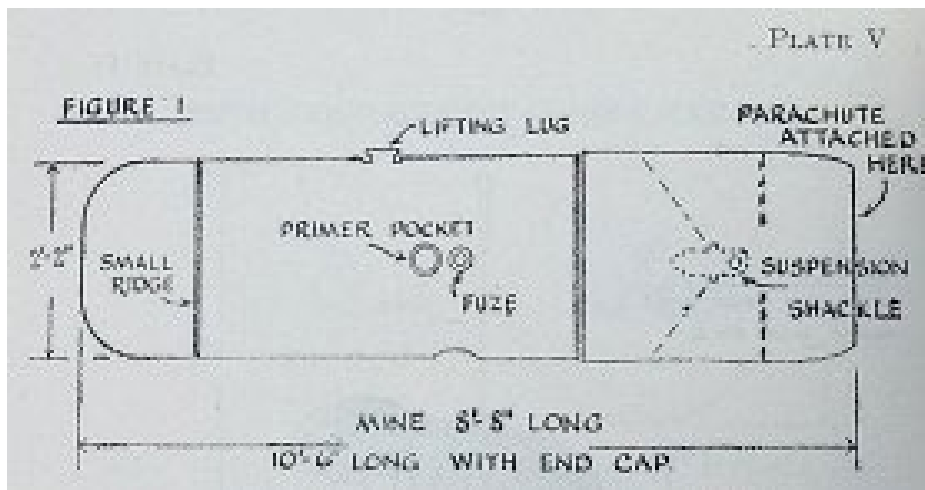
Appendix 1.6

Generic Types of German Air-Dropped Ordnance

Additional Notes:

Sources:
Various news sources
Open source images

Luftmine A/B “Parachute Mine”



Bomb Weight: A- 500kg, B – 1000kg
Fuze Type: Mechanical clockwork fuze
Bomb Dimensions: A – 1768mm, B – 2682mm
Use: Capable of creating severe blast damage in built-up areas
Remarks: Parachute mines were standard German sea mines fitted with a suitable detonator. They were widely used against British cities.

Appendix 1.7

Generic Types of German Air-Dropped Ordnance

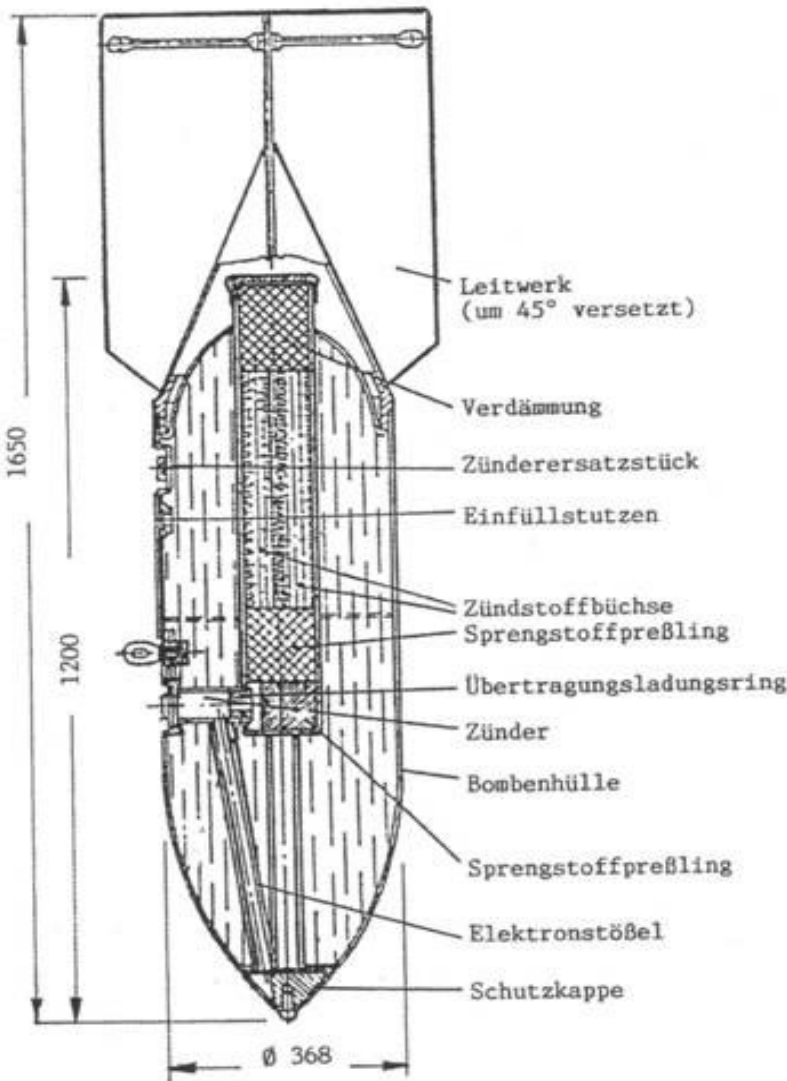
Additional Notes:

Sources:
Various news sources
Open source images



Flam C-250 “Oil Bomb”

Bomb Weight: 125kg
Explosive Weight: 1kg
Flammable Weight: 74kg
Filling: Mixture of 30% petrol and 70% crude oil
Fuze Type: Super-fast electrical impact fuze
Bomb Dimensions: 1650 x 512.2mm
Body Diameter: 368mm
Use: Often used for surprise attacks on living targets, against troop barracks and industrial installations
Remarks: Thin casing – not designed for ground penetration



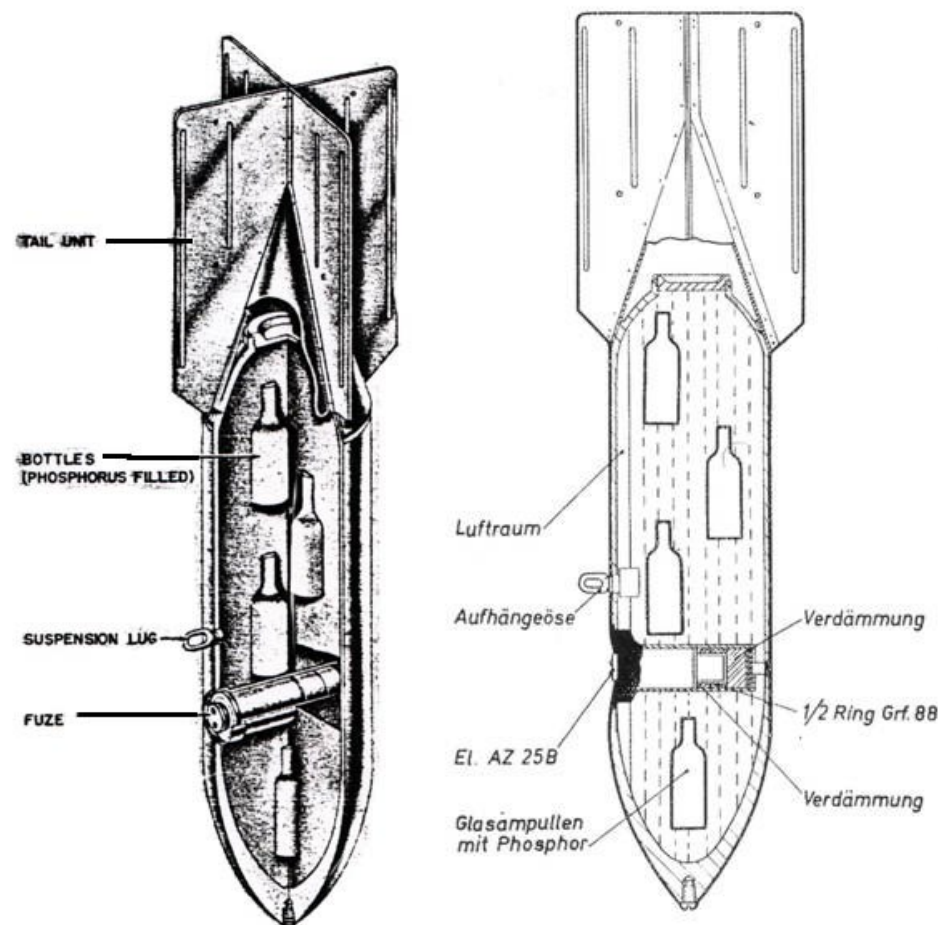
Appendix 1.8

Generic Types of German Air-Dropped Ordnance

Additional Notes:

Sources:
Various news sources
Open source images

C-50 A Phosphorous Bomb



Bomb Weight: c.41kg
Explosive Weight: 0.03kg
Incendiary Filling: 12kg liquid filling with phosphor igniters in glass phials
Fuze Type: Electrical impact fuze
Bomb Dimensions: 1100 x 2800mm
Body Diameter: 200mm
Use: Against all targets where an incendiary effect is to be expected
Remarks: Early fill was a phosphorus / carbon disulphide incendiary mixture

Appendix 1.9

Generic Types of German Air-Dropped Ordnance

Additional Notes:

Sources:
Various news sources
Open source images



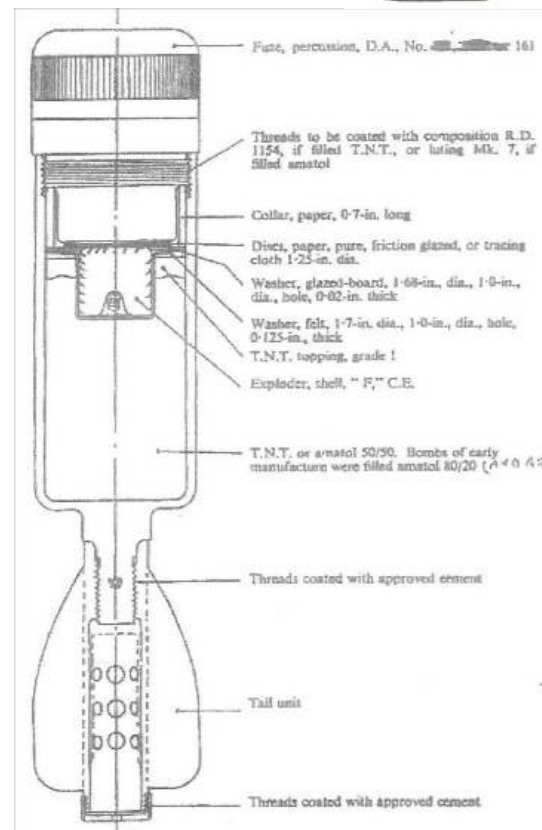
Typical 2" High Explosive Mortar

Bomb weight: 1.02kg

Fuze Type: High Explosive

Bomb Dimensions: 51 x 290mm **Filling:** 200g RDX/TNT

Remarks: Fitted with an impact fuze which detonates the fuze booster charge (exploder) and, in turn, the high explosive charge. The main charge shatters the mortar bomb body, producing near optimum fragmentation and blast effect at the target.



Appendix 2.1

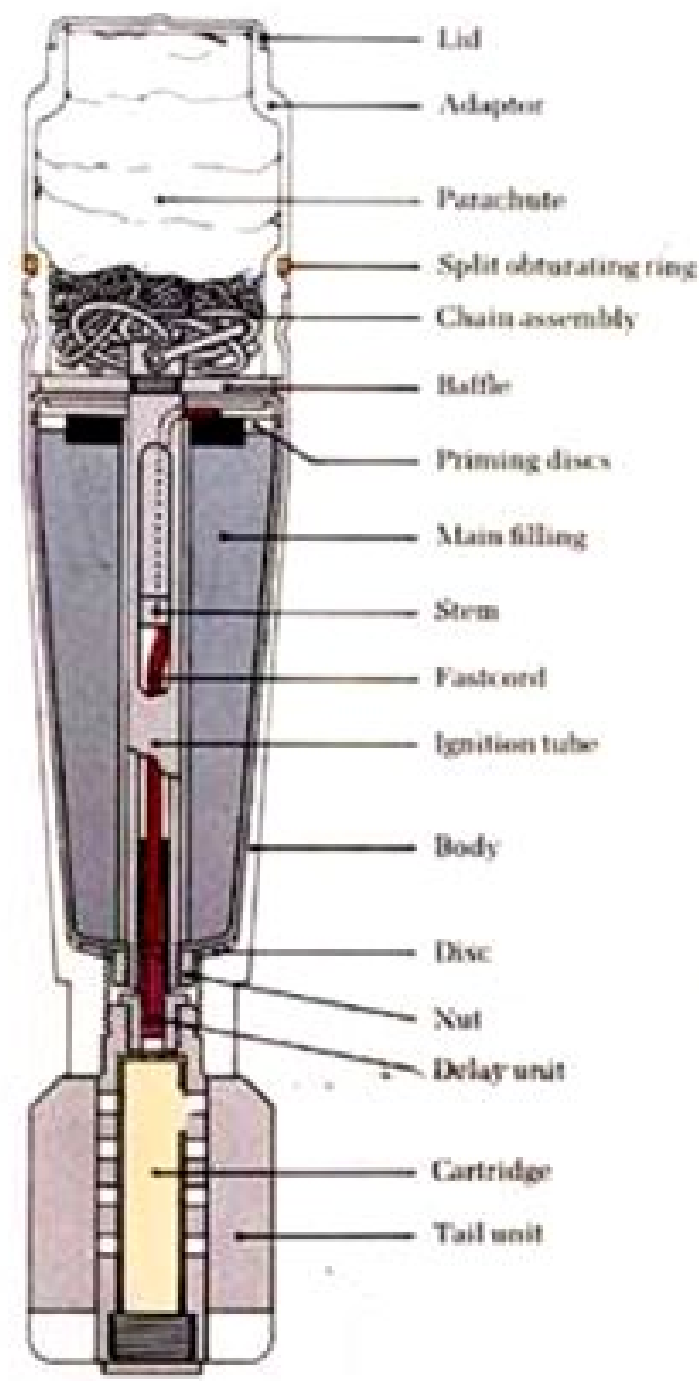
Generic Types of British / Allied Land Service Ammunition

Additional Notes:

Sources:
Various news sources
Open source images

Typical 2” Illuminating Mortar

Fuze Type:
Illuminating
Bomb
Dimensions: 51
x 290mm
Filling: Various
Remarks: The
expulsion
charge ignites
and ejects the
candle
assembly. A
spring ejects the
parachute from
the tail cone.
The parachute
opens, slowing
the descent of
the burning
candle which
illuminates the
target.



Appendix 2.2

Generic Types of British / Allied Land Service Ammunition

Additional Notes:

Sources:
Various news sources
Open source images

Typical 3” Smoke Mortar

Fuze Type: Smoke Bomb

Dimensions: c.490 x 76mm

Filling: Typically, white phosphorus

Remarks: On impact, the fuze functions and initiates the bursting charge. The bursting charge ruptures the mortar bomb body and disperses the white phosphorous filler. The white phosphorous produces smoke upon exposure to the air.



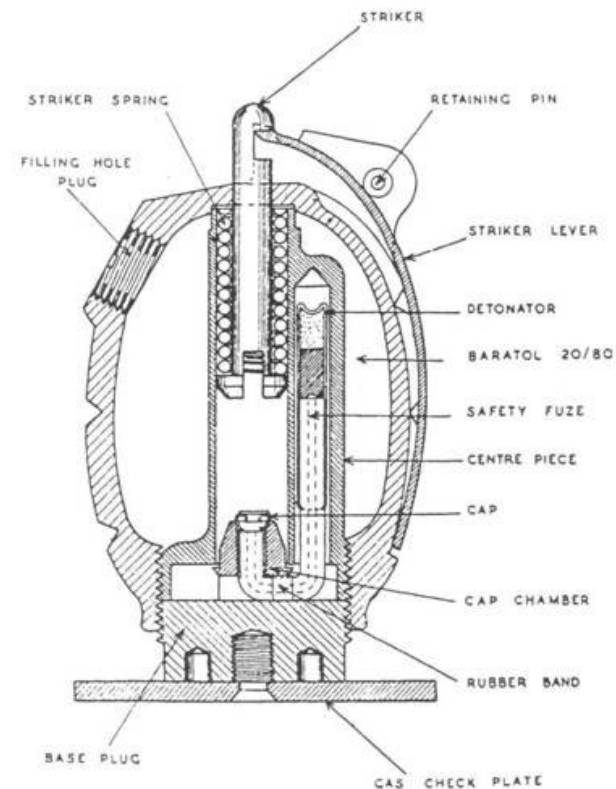
Appendix 2.3

Generic Types of British / Allied Land Service Ammunition

Additional Notes:

Sources:
Various news sources
Open source images

No. 36 “Mills” Grenade



Grenade, .303 inch rifle, No. 36M, Mark I.



Weight: 0.7kg filled
Type: Hand or discharger, fragmentation
Dimensions: 95 x 61mm
Filling: Alumatol, Amatol 2 or TNT
Remarks: 4 second hand-throwing fuze with approximate range of 30m. First introduced May 1918.

Appendix 2.4

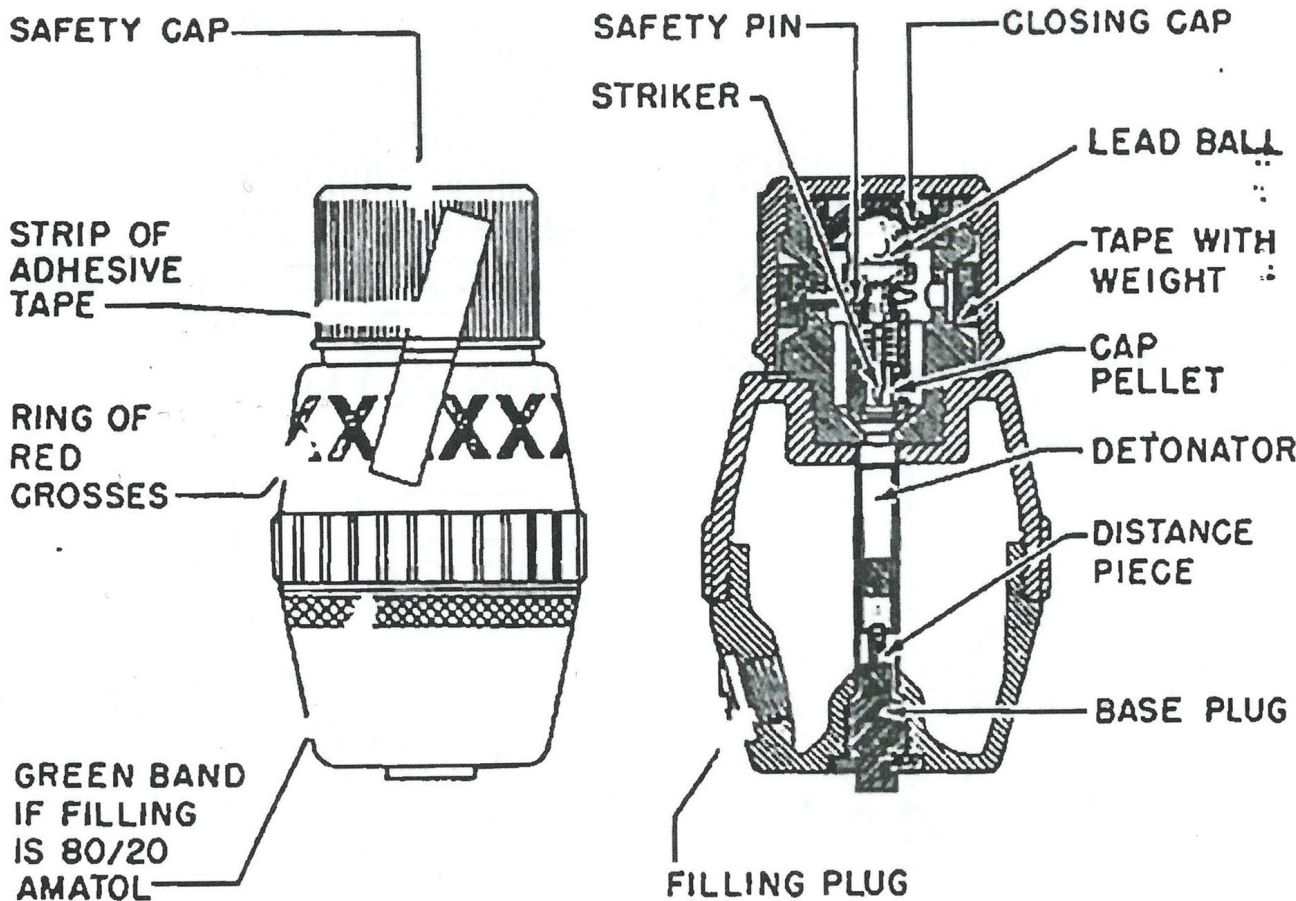
Generic Types of British / Allied Land Service Ammunition

Additional Notes:

Sources:
Various news sources
Open source images

No. 69 Grenade

Weight: 038kg filled
Type: Percussion / Blast
Date Introduced: December 1940
Remarks: Black Bakelite body. Blast rather than fragmentation type. After unscrewing the safety cap, a tape is held when throwing the grenade releasing the safety bolt in the throwing motion. Detection is problematic due to its very low metal content.



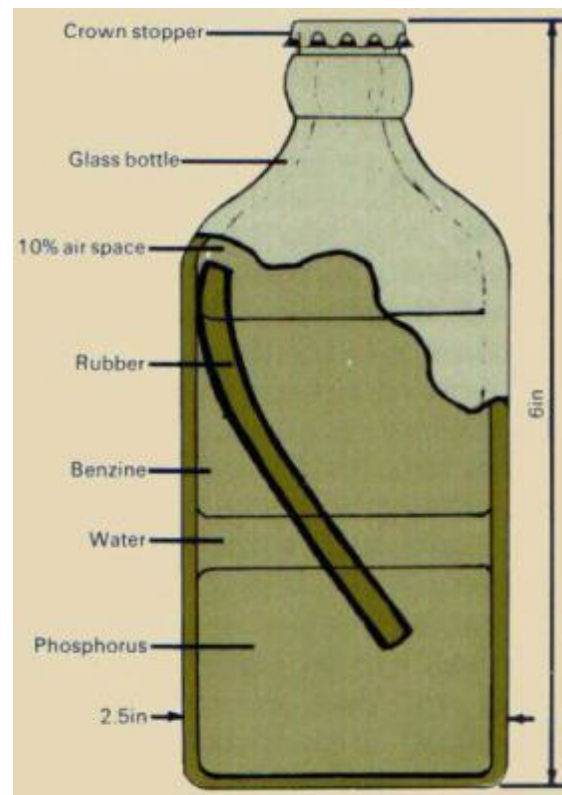
Appendix 2.5

Generic Types of British / Allied Land Service Ammunition

Additional Notes:

Sources:
Various news sources
Open source images

Self-Igniting Phosphorous (SIP) Grenade



Sometimes called the “A&W (Albright & Wilson)” grenade.

The grenade comprised a glass bottle with a total volume of approximately 1 pint. It was filled with white phosphorous, benzene, a piece of rubber and water. Over time, the rubber dissolved to create a sticky fluid which would self-ignite when the bottle broke.

Fired by hand or Northover Projector.



Appendix 2.6

Generic Types of British / Allied Land Service Ammunition

Additional Notes:

Sources:
Various news sources
Open source images

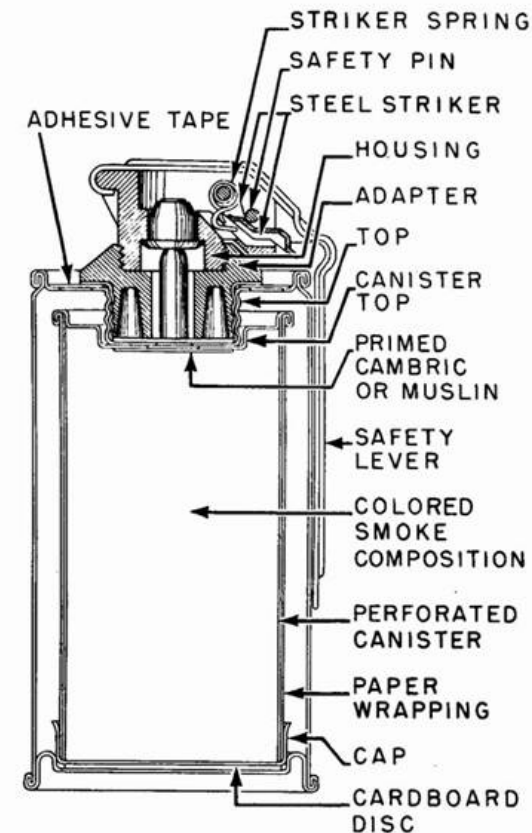
Typical Smoke Grenade

Dimensions: Approx. 65 x 115mm

Type: Smoke

Date Introduced: Current MoD issue

Remarks: Smoke grenades are used as ground-to-ground or ground-to-air signalling devices, target or landing zone marking devices, and screening devices for unit movement.



Appendix 2.7

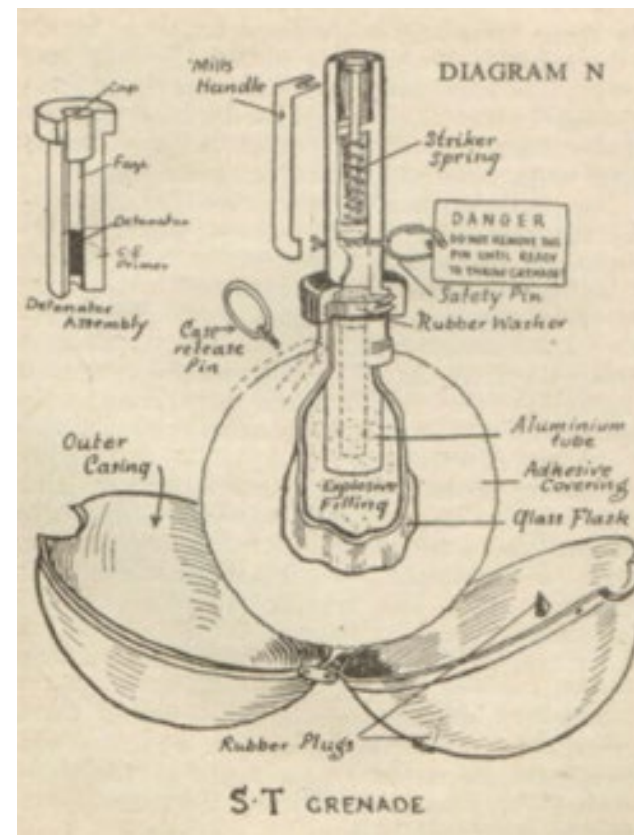
Generic Types of British / Allied Land Service Ammunition

Additional Notes:

Sources:
Various news sources
Open source images

No. 74 Grenade (“Sticky Bomb”)

Designed as an anti-tank grenade and used by the Home Guard. The grenade consisted of a glass ball on the end of a Bakelite (plastic) handle. Inside the glass ball was an explosive filling whilst on the outside was a very sticky adhesive covering. Until used, this adhesive covering was encased in a metal outer casing.



Appendix 2.8

Generic Types of British / Allied Land Service Ammunition

Additional Notes:

Sources:
Various news sources
Open source images

Rockets / Un-rotating Projectiles

Weight: 24.5kg

Bomb Dimensions: 94 x 360mm

Carriage: Typically, white phosphorus

Rate of Fire: 10-20 rounds per minute

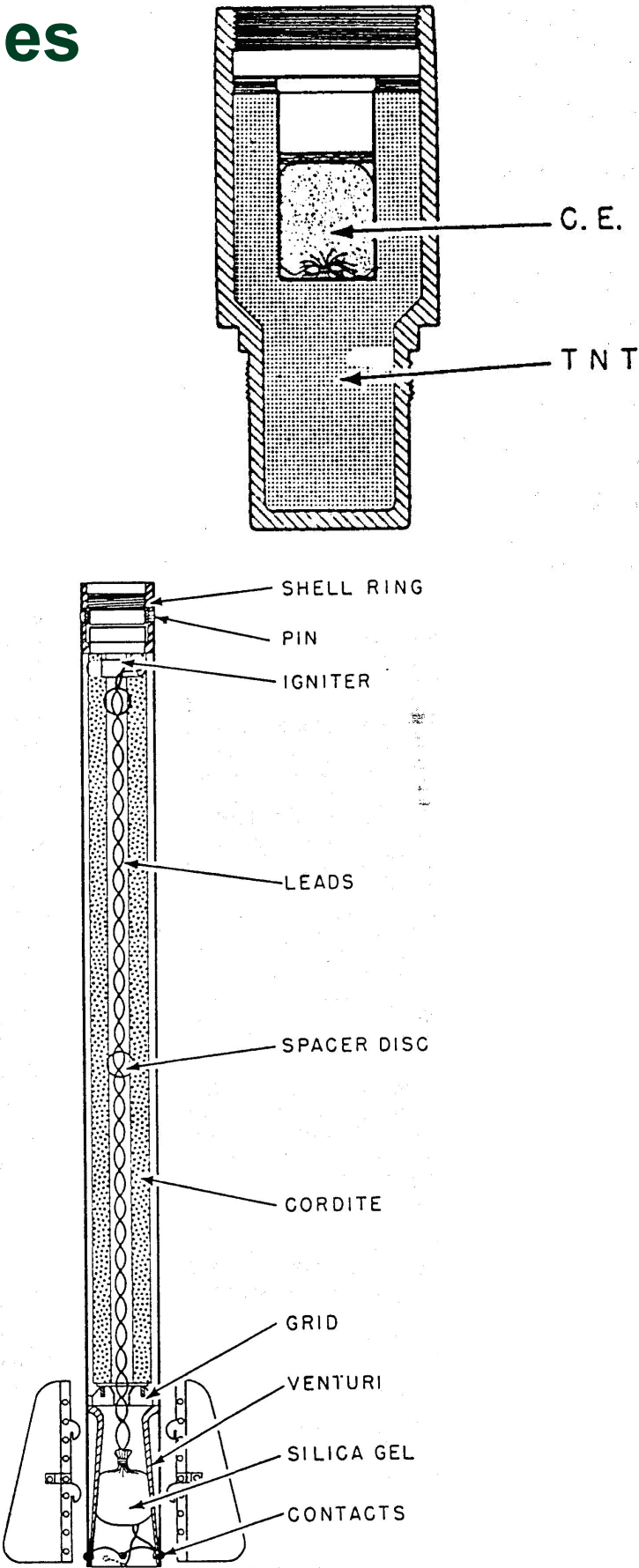
Ceiling: 9,000-18,000m

Muzzle Velocity: 72m/s

Remarks: 4.5" projectiles were also commonly utilized.



Home Guard soldiers load an anti-aircraft rocket at a 'Z' Battery



Appendix 2.9

Generic Types of British / Allied Anti-Aircraft Ordnance

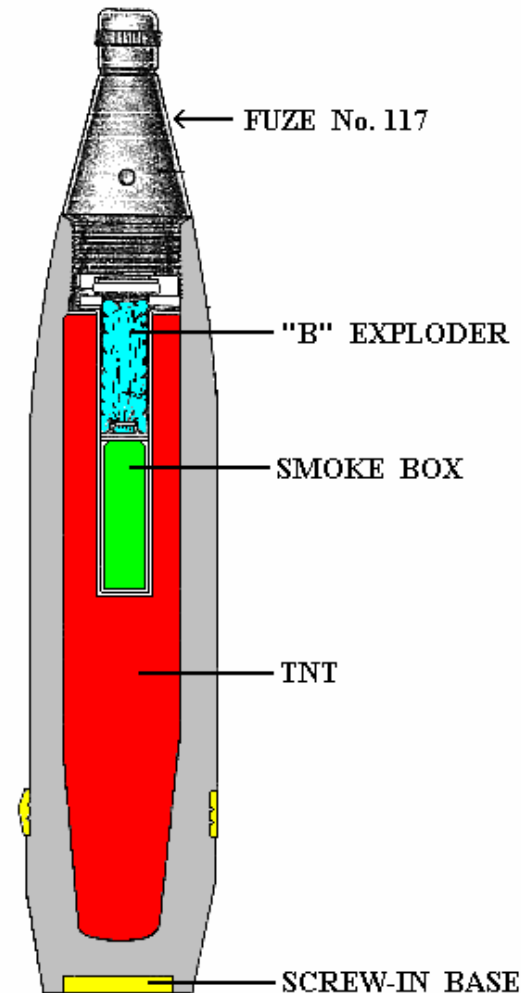
Additional Notes:

Sources:
Various news sources
Open source images

High Explosive Projectile: Fragmentation & Blast

Features:

- a) Long, pointed ogival nose and streamlined body.
- b) Square or tapered base. Boat tailed/streamlined.
- c) One-piece body construction.
- d) Base plate screwed or welded to the base, occasionally of one piece construction.
- e) Copper driving band near the base of the projectile.
- f) Body construction normally thin.
- g) Low charge to weight ratio.
- h) Fuzed with point-initiating and/or base-detonating fuze.
- i) If no driving band is present, it may use two bourrelets.



4in HE Projectile



2in HE Projectile

Appendix 2.10

Generic Types of British / Allied Land Service Ammunition

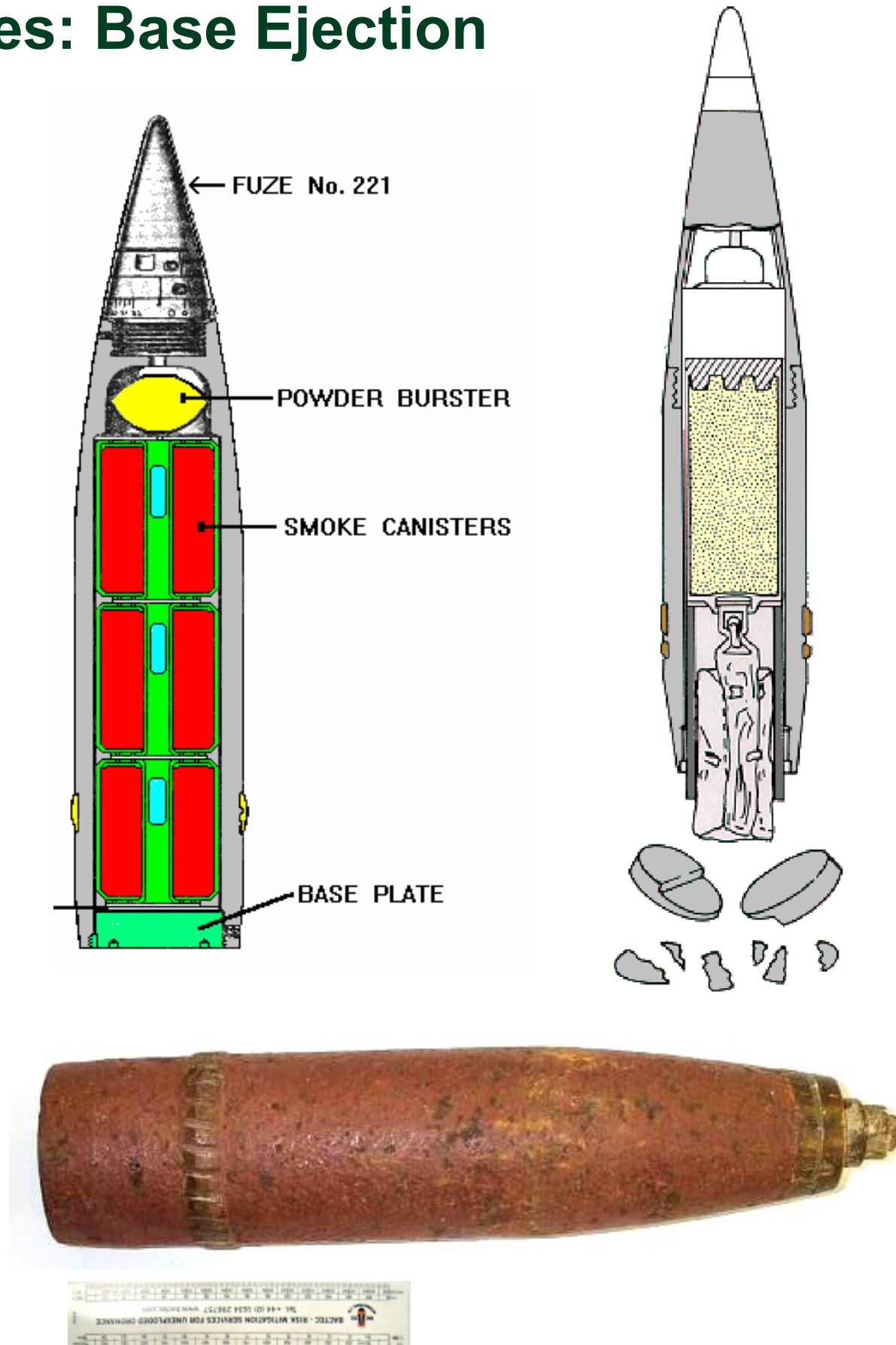
Additional Notes:

Sources:
Various news sources
Open source images

Carrier Projectiles: Base Ejection

Features:

- a) Ogival streamlined nose.
- b) Nose/Time fuzed.
- c) Parallel sides (on older items).
- d) Square or tapered base.
- e) One or two-piece body construction.
- f) Base plate held in place by weakened PVC ring or shear pins.
- g) Copper driving band may be fitted.
- h) Base plate ejected if the munition has functioned.
- i) Contains a small low explosive burster/expulsion charge.



Appendix 2.11

Generic Types of British / Allied Land Service Ammunition

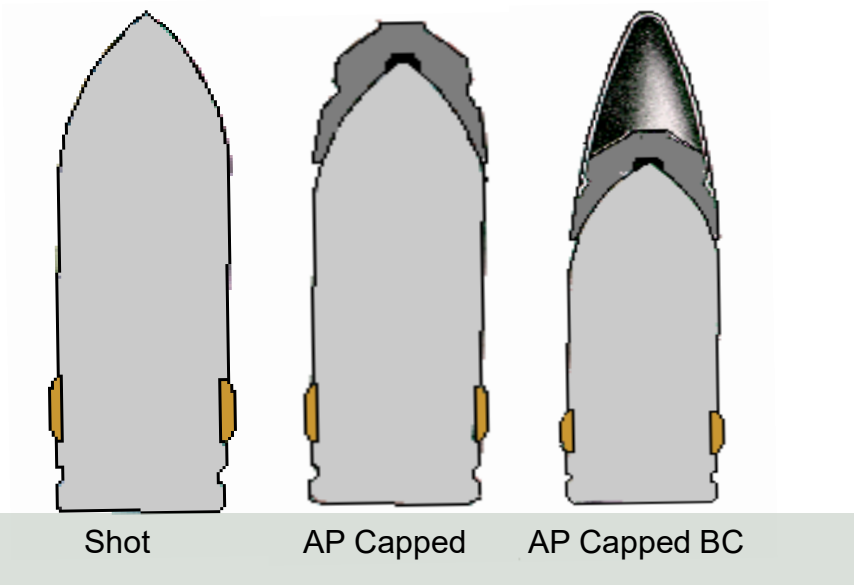
Additional Notes:

Sources:
Various news sources
Open source images

Shot Projectiles

Features:

- a) Driving bands (early designs) or obturators (current designs).
- b) Tracer pockets common.
- c) Ballistic caps and piercing caps (current designs).
- d) Early shot projectiles were made of hard high grade steel. Current designs use tungsten carbide or Depleted Uranium (DU) cores or penetrators.
- e) Most current shot projectiles now use discarding sabots, either of the post or petal type
- f) Proof shot projectiles have flat heads and are used to test guns.
- g) No fuzes are present.



4in Solid Shot

Appendix 2.12

Generic Types of British / Allied Land Service Ammunition

Additional Notes:

Sources:
Various news sources
Open source images



.303" Ammunition

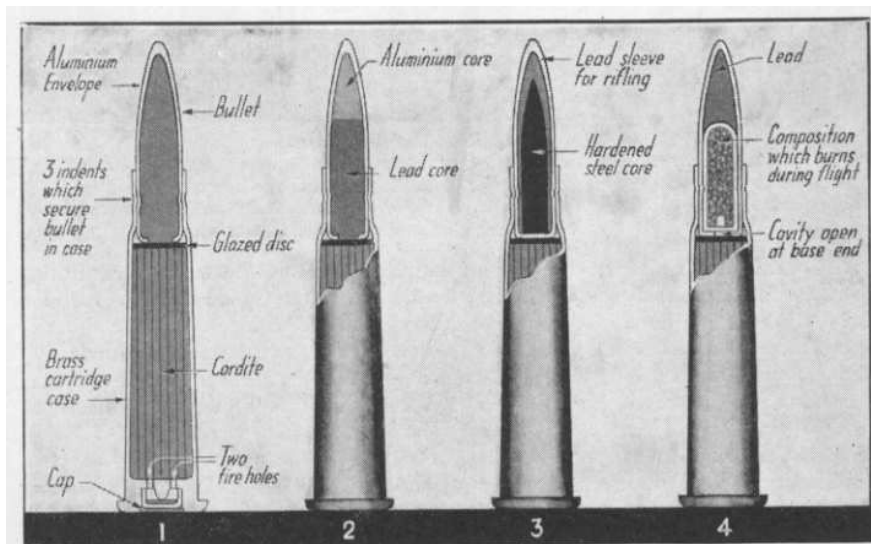
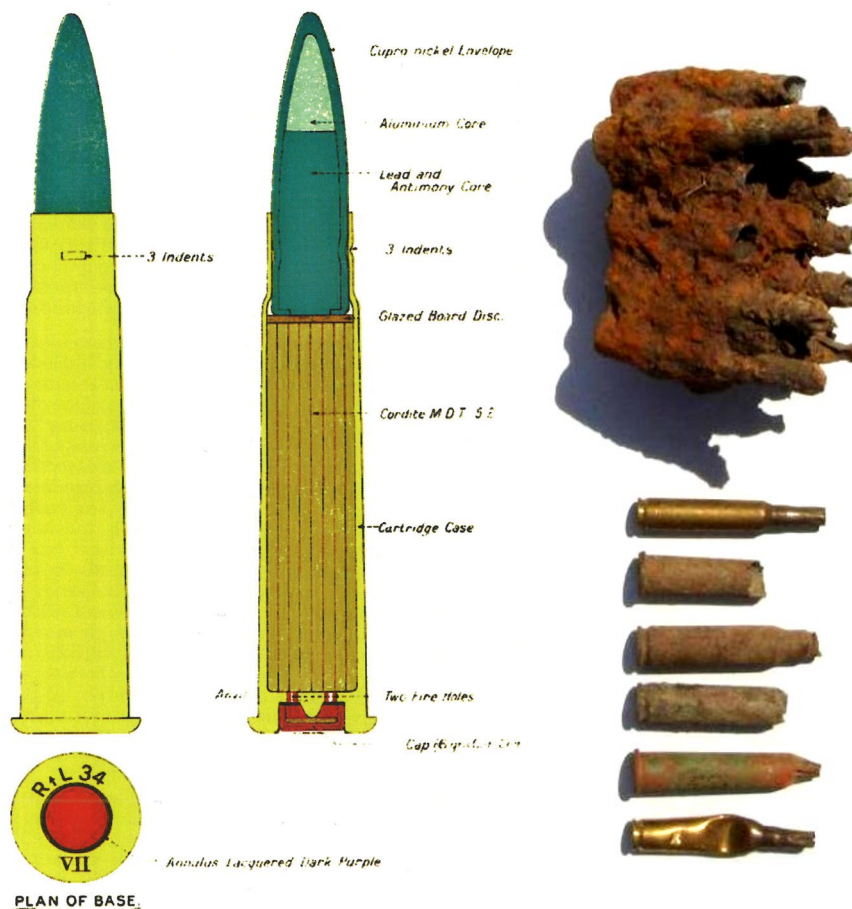


Fig. 1. Four types of ammunition used by modern infantry. 1 and 2 are ball cartridges, 3 is an armour-piercing bullet, and 4 a tracer bullet which burns and makes its flight visible.



Type: Rifle / machine gun round

Markings: Regular round – none. Tracer round – red primer

Bullet Weight: 150 – 180g

Dimensions: Total cartridge / projectile length – 182mm

Filling: Regular round – none. Tracer round – small incendiary fill

Threat: Explosive cordite within unspent cartridge

Deployment: Royal Navy, RAF and British Army Light Anti-Aircraft guns, machine guns and rifles. Standard British and Commonwealth military cartridge from 1889 until the end of the 1950s.

Remarks: Cartridges are belted or supplied loose in cartons

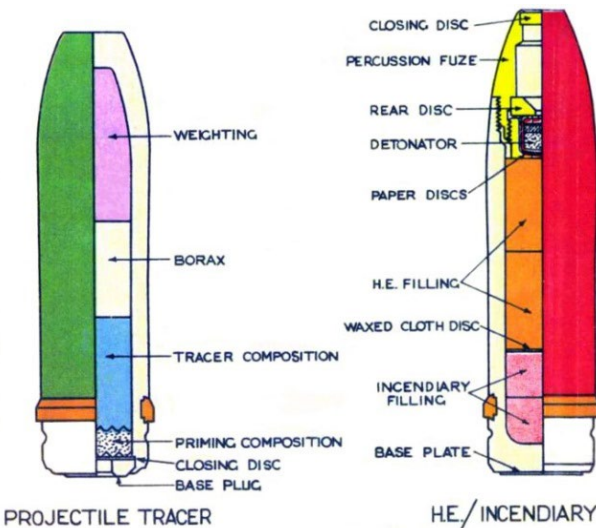
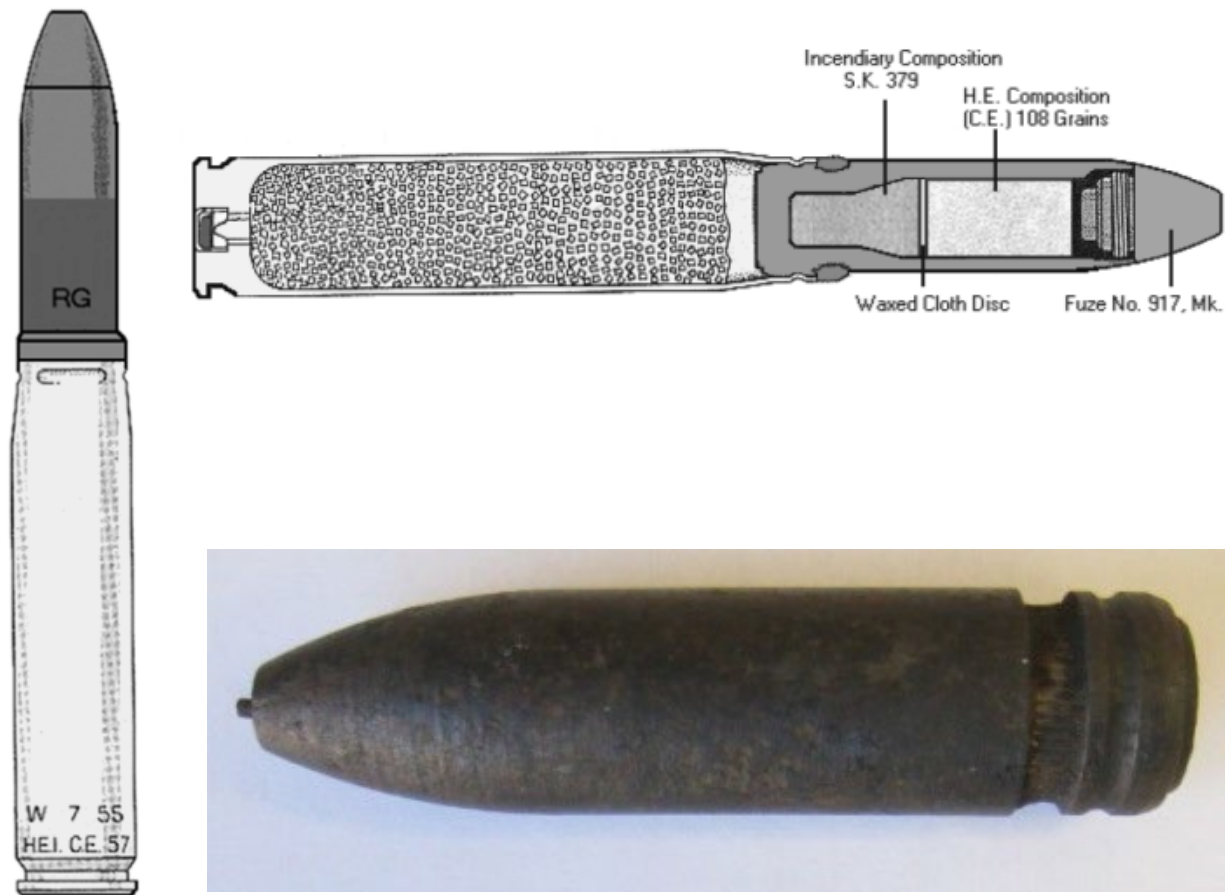
Appendix 2.13

Generic Types of British / Allied Small Arms Ammunition

Additional Notes:

Sources:
Various news sources
Open source images

200mm Hispano HEI Ammunition



COLOUR IDENTIFICATION		
BRITISH		
NATURE OF SHELL	H.E.FILLING	COLOUR
H.E. TRACER	T.N.T.	Blue
H.E.	T.N.T.	Orange
PROJ. PRACTICE		Pink
PROJ. TRACER		Green
H.E. INCENDIARY	T.N.T.	Red
H.E. INCENDIARY TRACER	T.N.T.	Green

Type: Live cannon round
Markings: Upper half of projectile painted “buff” colour, lower half is red
Cartridge Weight: 256g
Dimensions: Total cartridge / projectile length – 182mm
Fuze: Contact fuze – No. 253, No. 254 or No. 917
Filling: 108 grains of contact explosive & 68 grains of SR. 379 incendiary composition
Threat: Explosives within unspent cartridge as well as the projectile
Deployment: Royal Navy, RAF and British Army Light Anti-Aircraft guns, and RAF aircraft cannons.
Remarks: Cartridges are belted or supplied loose in cartons.

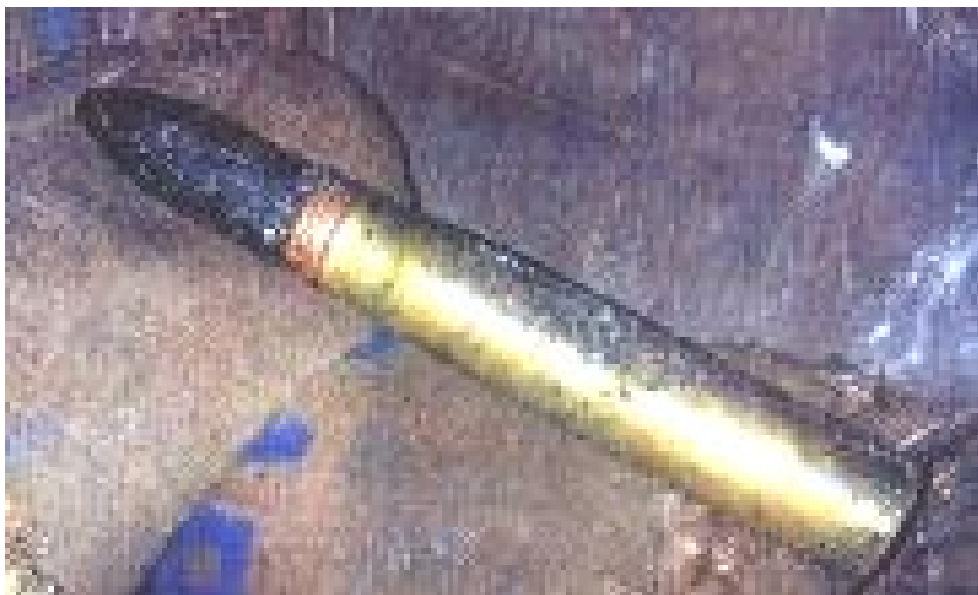
Appendix 2.14

Generic Types of British / Allied Small Arms Ammunition

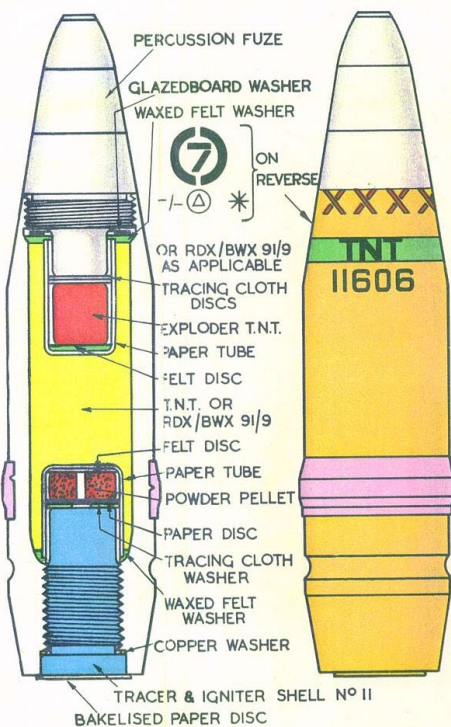
Additional Notes:

Sources:
Various news sources
Open source images

40mm Bofors Gun Projectile



SHELL, Q.F., HIGH EXPLOSIVE,
40 MM.



Weight: 0.86kg
Bomb

Dimensions:

40mm x 310mm

Rate of Fire: 120
rounds per min

Ceiling: 7,000m

Muzzle Velocity:
881m/s

Remarks: Mobile
batteries – normally
few records of
where these guns
were located

Appendix 2.15

Generic Types of British /
Allied Anti-Aircraft Ordnance

Additional Notes:

Sources:
Various news sources
Open source images

3.7” Anti-Aircraft Projectile

Weight: 12.7kg (28lb)

Dimensions: 94 x 360mm (3.7 x 14.7in)

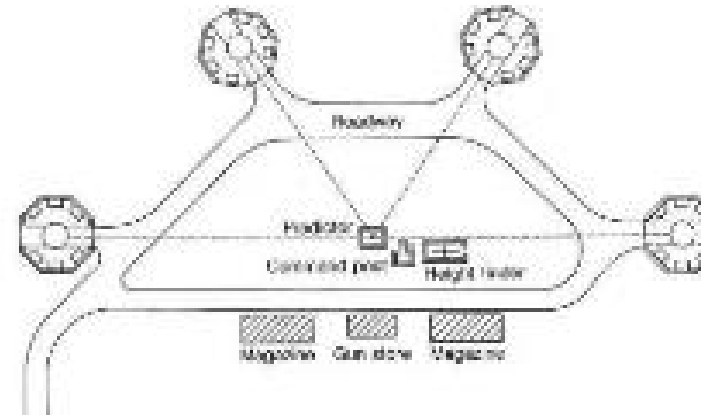
Carriage: Mobile and Static Versions

Rate of Fire: 10-20 rounds per minute

Ceiling: 9-18,000m (29-59,000ft)

Muzzle Velocity: 792m/s (2,598ft/s)

Remarks: 4.5 inch projectiles were also commonly utilised



Layout plan for a typical HAA battery site.



3.7 inch AA Projectile, Minus Fuze.



This AA shell was uncovered on a construction site in North London in February 2009.



Hyde Park 1939 3.7 Inch QF gun on mobile mounting.

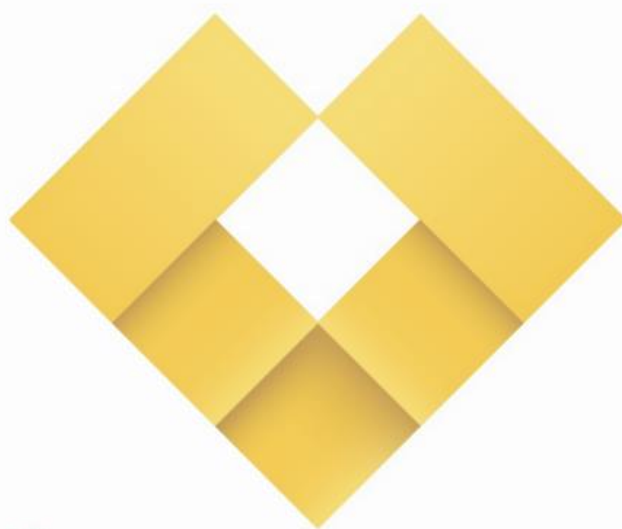
Appendix 2.16

Generic Types of British / Allied Anti-Aircraft Ordnance

Additional Notes:

Sources:
Various news sources
Open source images

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