



1ST LINE DEFENCE



Detailed Unexploded Ordnance (UXO) Risk Assessment

| | |
|-------------------------|---|
| Project Name | Croft Business Park |
| Client | e3p |
| Site Address | Croft Business Park, Carrock Road, Birkenhead, Wirral, CH62 3RA |
| Report Reference | DA7696-00 |
| Date | 10 th April 2019 |
| Originator | JMa |



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Executive Summary

Site Location and Description

The site is located in the town of Birkenhead, within the Metropolitan Borough of Wirral.

The proposed site boundary is bordered to the east and west by Welton Road, whilst Caldbeck Road bounds the site to the south. The northern and southern perimeters of the site boundary are lined by trees. To the north, the site is neighboured by a large car parking area associated with nearby commercial structures.

The site is currently predominantly occupied by open grassland.

It is approximately centred on the OS grid reference: **SJ 3502482821**.

Proposed Works

The exact scope of the proposed works was not available during the production of this report. However, a proposed development plan provided by e3p indicates that multi-storey commercial structures and adjoining car parking are to be constructed within the proposed site boundary.

Geology and Bomb Penetration Depth

It has not been possible to determine maximum bomb penetration capabilities at this stage due to the limited depth of site-specific geotechnical information available. An assessment of maximum bomb penetration depth can be made once such data becomes available, or by a UXO specialist during on-site support.

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

UXO Risk Assessment

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

- During the war, the site was situated within the Municipal Borough (M.B.) of Bebington. Home Office (HO) statistics suggest that this area sustained a low – moderate density of bombing with an average of 30 bombs dropped per 1,000 acres.
- No reference to bombing within or immediately adjacent to the site, was found within the available records. The closest recorded incident comprised of two bomb strikes approximately 220m south-east, according to bomb tracings for Merseyside. Another notable incident, recorded in the Mersey Home Guard War Diary, occurred approximately 292m east on the Stork Margarine Factory. These incidents are shown in an overlay, presented in **Annex M**. No incidents are recorded within or immediately adjacent to the area of works within the available record.
- The WWII-era photographs, presented in **Annex N**, indicate that the site remained largely unchanged from the pre-war condition presented in **Annex E**. The WWII-era photographs also do not show any visible signs of bomb damage. The photographs show that the site was particularly well-maintained and lacking in pockets of dense vegetation. Therefore, it is anticipated that the conditions present would have been relatively conducive to the observation of UXO.
- As the site was located within the grounds of a margarine works, within close proximity to New Chester Road, residential housing, and a sports ground it is anticipated that it would have been relatively well observed. The site's particularly well maintained condition also indicates that it received at least recurrent access. As the area did not sustain a high density of bombing, it is considered likely that incidents which happened on or near the site would have been reported and investigated.



UXO Risk Assessment

- Based on these conditions and the lack of evidence within any of the available bomb records to suggest that any bomb strikes fell specifically on or next to the site, the risk from UXO is considered to be low and has not been elevated above the 'background' level of risk for the region.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the Croft Business Park Site:

All Works

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

Glossary

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

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1st Line Defence Limited

Detailed Unexploded Ordnance (UXO) Risk Assessment

Site: Croft Business Park
Client: e3p

1. Introduction

1.1. Background

1st Line Defence has been commissioned by e3p to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for the proposed works at the proposed Croft Business Park site.

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

UXO in the UK can originate from three principal sources:

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

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

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

2. Method Statement

2.1. Report Objectives

The aim of this report is to conduct a comprehensive assessment of the potential risk from UXO at Croft Business Park. The report will also recommend appropriate site and work-specific risk mitigation measures to reduce the risk from explosive ordnance during the envisaged works to a level that is as low as reasonably practicable.

2.2. Risk Assessment Process

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

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

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

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

2.3. Sources of Information

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

- The National Archives and Merseyside Record Office.
- Historical mapping datasets.
- Historic England National Monuments Record.
- Relevant information supplied by e3p.
- Available material from 33 Engineer Regiment (EOD) Archive (now 28 Regt).
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published books and internet resources.

Research involved a visit to The National Archives.

3. Background to Bombing Records

3.1. General Considerations of Historical Research

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

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

3.2. German Bombing Records

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

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

3.3. Allied Records

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

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

4. UK Regulatory Environment and Guidelines

4.1. General

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

4.2. CDM Regulations 2015

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

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

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

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

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

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

4.4. CIRIA C681

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

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

4.5. Additional Legislation

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

5. The Role of Commercial UXO Contractors and The Authorities

5.1. Commercial UXO Specialists

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

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

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

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

5.2. The Authorities

The police have a responsibility to co-ordinate the emergency services in the event of an ordnance-related incident at a construction site. Upon inspection they may impose a safety cordon, order an evacuation, and call the military authorities Joint Services Explosive Ordnance Disposal (JSEOD) to arrange for investigation and/or disposal. In the absence of a UXO specialist, police officers will usually employ such precautionary safety measures, thereby causing works to cease, and possibly requiring the evacuation of neighbouring businesses and properties.

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

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

6. The Site

6.1. Site Location

The site is located in the town of Birkenhead, within the Metropolitan Borough of Wirral.

The proposed site boundary is bordered to the east and west by Welton Road, whilst Caldbeck Road bounds the site to the south. The northern and southern perimeters of the site boundary are lined by trees. To the north, the site is neighboured by a large car parking area associated with nearby commercial structures.

The site is approximately centred on the OS grid reference: **SJ 3502482821**.

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

6.2. Site Description

The site is currently predominantly occupied by open grassland.

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

7. Scope of the Proposed Works

7.1. General

The exact scope of the proposed works was not available during the production of this report. However, a proposed development plan provided by e3p indicates that multi-storey commercial structures and adjoining car parking are to be constructed within the proposed site boundary.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows that the bedrock of the site is comprised of the Helsby Sandstone Formation. No superficial deposits were recorded for the site area.

8.2. Site Specific Geology

Borehole data has been provided by E3P. See below for a brief description of the geology encountered within two example borehole positions.

| Borehole 1 | |
|-------------|--|
| Depth (m) | Description |
| 0.0 – 0.20 | Made ground – reinforced concrete |
| 0.20 – 0.60 | Made Ground – visually moist, dark brown/red silty sand, crushed brick and fragmented sandstone |
| 0.6 – 1.50 | Moist soft to firm/loose medium to dark brown, very silty, very sandy clay/clayey sand with much fine gravel. Some decayed ancient rootlets from 0.60m – 0.90m |
| 1.50 – 2.50 | Medium dense to dense reddish brown fined groined sand with much coarse gravel and sandstone fragments. |

| Borehole 2 | |
|-------------|--|
| Depth (m) | Description |
| 0.30 – 0.50 | Reddish brown friable sandy clay. |
| 0.50 – 3.00 | Reddish brown fine grained poorly cemented dense bunter sandstone. |

9. Site History

9.1. Introduction

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

9.2. Ordnance Survey Historical Maps

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

| WWI Period | | |
|-------------|---------|--|
| Date | Scale | Description |
| 1911 - 1912 | 1,2,500 | The map indicates that the site was occupied by open grass land. New Chester Road and multiple structures situated on it can be viewed to the west, beyond an area of open ground. Open ground can be viewed north, east, south. |

| Pre-WWII | | |
|----------|---------|---|
| Date | Scale | Description |
| 1936 | 1,2,500 | This map indicates that development occurred in the general area, however the site remains open grassland. To the west, the housing development on New Chester Road has expanded. Residential structures are now present approximately 120m north-west of the site. To the east, a sports area is now present approximately 50m south-east of the site. Further east, the Stork Margarine Works can be viewed approximately 292m from the site. |

| Post-WWII | | |
|-----------|---------|--|
| Date | Scale | Description |
| 1956 | 1,2,500 | This map shows more development in the general area. A playground became present to the north-west of the site. The sports area also expanded with a further tennis court. Multiple new residential structures also became present on New Chester Road. The site remains open and undeveloped. |

9.3. Historical Photographs of the Site

Historical photography has been consulted from the Aerofilms collection available from Britain From Above. This photograph provides a view of the site in 1934 (see **Annex E**). See below for a description of the photograph.

| Title of Photograph | Comments |
|---------------------|---|
| 1934 | This photograph confirms what was shown in the historic OS mapping. The site was occupied by open grassland. Two rows of residential structures can be viewed to the north-west whilst a sports area can be viewed south-east. The open ground, where the site was situated, appears to have been well-maintained. |

10. Introduction to German Aerial Delivered Ordnance

10.1. General

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

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

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

10.2. Generic Types of WWII German Aerial Delivered Ordnance

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

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

10.3. Failure Rate of German Aerial Delivered Ordnance

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

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

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

10.4. UXB Ground Penetration

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

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

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

10.4.1. The J-Curve Effect

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

10.4.2. WWII UXB Ground Penetration Studies

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

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

10.4.3. Site Specific Bomb Penetration Considerations

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

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

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

10.5. V-Weapons

Hitler's 'V-weapon' campaign began from mid-1944. It used newly developed unmanned cruise missiles and rockets. The V-1 known as the *flying bomb* or *pilotless aircraft* and the V-2, a long range rocket, were launched from bases in Germany and occupied Europe. A total of 9,251 V-1s and 1,115 V-2s were recorded in the United Kingdom.

Although these weapons caused considerable damage, their range was limited by their position of deployment across Europe and as a result the vast majority of V-weapon strikes were directed against targets in the south-east of England, predominantly in the London Boroughs and Home Counties. This limitation of capability meant targets in the north-west of England were generally too far to be considered for V-weapon strikes by the Luftwaffe.

The risk from V-weapons in Bebington is therefore considered negligible and will not be further addressed in this report.

11. The Likelihood of Contamination from German Aerial Delivered UXBs

11.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships as well as Gotha and Giant fixed-wing aircraft. A WWI map of air raids and naval bombardments across England is presented in **Annex I**. This source does not record any WWI bombing incidents to have affected the site.

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

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

The Luftwaffe's main objective for the attacks on Britain was to inhibit the country's economic and military capability. To achieve this they targeted airfields, depots, docks, warehouses, wharves, railway lines, factories, and power stations. As the war progressed the Luftwaffe bombing campaign expanded to include the indiscriminate bombing of civilian areas in an attempt to subvert public morale.

During WWII the site was located within the Municipal Borough (M.B.) of Bebington, which sustained an overall low-moderate density of bombing, as represented by bomb density data figures and maps in the following sections. The bombing of Bebington can largely be attributed to its position on the Wirral Peninsula, adjacent to the River Mersey, which contained a concentration of strategic Luftwaffe targets such as the docks at Liverpool, Wallasey and Birkenhead, as presented in Luftwaffe reconnaissance photography in **Annex J**. Furthermore the LMS railway line ran through Bebington, a line that provided a means transportation across the Wirral Peninsula and was a likely target of the Luftwaffe in an attempt to inhibit the logistical capabilities of an area populated by numerous docks key to the British war effort.

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

Records of bombing incidents for M.B. of Bebington are presented in the following sections.

11.3. WWII Home Office Bombing Statistics

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

| Record of German Ordnance Dropped on the Municipal Borough of Bebington | | |
|---|----------------------------------|---------------|
| Area Acreage | | 12,234 |
| Weapons | High Explosive bombs (all types) | 354 |
| | Parachute mines | 17 |
| | Oil bombs | 2 |
| | Phosphorus bombs | 0 |
| | Fire pots | 0 |
| | Pilotless aircraft (V-1) | 0 |
| | Long range rocket bombs (V-2) | 0 |
| Total | | 373 |
| Number of Items per 1,000 acres | | 30.5 |

Source: Home Office Statistics

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

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

11.4. Bomb Plot Tracings of Merseyside

Bomb tracings for the Merseyside were accessed at the National Archives. This record set is not considered comprehensive, with sporadic dates covered whilst some tracings do not contain any dates at all. It should also be noted that the scaling of the mapping is often inaccurate and the locations of incidents can only be considered approximate. A relevant tracing is detailed below and presented in **Annex K**.

| Bomb Plot Tracings of Liverpool | |
|---------------------------------|---|
| Date Range | Comments |
| Unknown | This tracing recorded two HE incidents within the vicinity of the site (one 50kg HE bomb and one 500kg HE bomb). The closest incident was approximately 220m to the south-east. |
| Unknown | This tracing recorded seven HE incidents within the vicinity of the site (six 50kg HE bombs and one 250kg HE bomb). The closest incident was approximately 250m north-west. |

11.5. Bomb Census Reports

Bomb census reports compiled by the Research and Experiments Branch of the Ministry of Home Security during WWII were consulted at The National Archives. These reports recorded information such as the date, time, type and damage caused by major bomb incidents in the north-west and are therefore not often comprehensive.

No references to the site or the immediate surrounding area could be found within these records.

11.6. Mersey Home Guard War Diaries

A war diary compiled by the Mersey Home Guard garrison was obtained from The National Archives. The documents records raids in the local area and notes the type of bomb, the damage caused and the number of casualties in the Mersey region between August 1940 and December 1941. However, some entries are vague and simply report bombs had fallen in a general area. A transcript of the associated written records for bombs that fell in the immediate site area is presented in the table below. An example of these entries is presented in **Annex L**.

| Mersey Home Guard War Diaries | |
|-------------------------------|---|
| Date Range | Comments |
| 10 th October 1940 | This record states that the Margarine Works, located approximately 292m east of the site, was subject to an air raid. |
| 23 rd October 1941 | 6 HEs were dropped on the 22 nd /23 rd in Birkenhead area, one unexploded. Casualties: 4 civilians reported killed and 3 injured. 1 HE in Wallasey area, 9 HE's in Bromborough area , 3 civilians injured. |
| 1 st November 1941 | 20 – 25 enemy aircraft operated in bright moonlight over the Merseyside area between the hours of 2110 and 2310. HE was reported from several places on the east of the Wirral Peninsula – notably Wallasey, Bebington and Bromborough . Damage was slight and casualties reported were 6 killed, 7 injured. |

11.7. Ian Boumphrey, Birkenhead at War 1939-1945, including surrounding areas & Bebington

Ian Boumphrey's book *Birkenhead at War 1939-1945* was consulted for the purposes of this report. The book documents bombing incidents and wartime activities across various areas in the vicinity of Birkenhead, such as Bebington, Bidston and Tranmere. The book presents bombing incidents which affected these areas in a diary format, noting the time, location and type of bomb which fell.

The book did not record any incidents within the site or within the immediate surrounding area.

11.8. WWII-Era Aerial Photography

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

| WWII-Era Aerial Photography | |
|------------------------------|---|
| Date | Description |
| 10 th August 1945 | There are no obvious indicators of significant bomb damage within the site in this photograph. There are no visible signs of cratering or ground disturbance within the site boundary. The photograph also indicates that the grassland which occupied the site remained in good condition. |
| 17 th May 1948 | This photograph is largely consistent with the previous photograph. No significant development can be viewed on the site. However, a footpath is now present to the north. |

11.9. Abandoned Bombs

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

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

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

11.10. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD) (now 29 Regt) is currently facing considerable delay. It has therefore not been possible to include any updated official information regarding bomb disposal/clearance tasks with regards to this site. A database of known disposal/clearance tasks has been referred to which does not make reference to such instances occurring within the site of proposed works. If any relevant information is received at a later date e3p will be advised.

11.11. Evaluation of German Aerial Delivered UXO Records

| Factors | Conclusion |
|--|---|
| <p>Density of Bombing</p> <p><i>It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High bombing density could allow for error in record keeping due to extreme damage caused to the area.</i></p> | <p>During the war, the site was situated within the Municipal Borough (M.B.) of Bebington. Home Office (HO) statistics suggest that this area sustained a low – moderate density of bombing with an average of 30 bombs dropped per 1,000 acres.</p> <p>Available records indicate that bombing incidents occurred within the general vicinity of the site. Bomb tracings for Merseyside recorded multiple incidents, with the closest approximately 220m south-east of the site boundary.</p> <p>Mersey Home Guard War Diaries state that the Stork Margarine Works, approximately 292m east, was targeted in an air raid.</p> <p>However, no reference to bombing sustained within or immediately adjacent to the site has been encountered within the available record sets.</p> |
| <p>Damage</p> <p><i>If buildings or structures on a site sustained bomb or fire damage any resulting rubble and debris could have obscured the entry holes of unexploded bombs dropped during the same or later raids. Similarly, a high explosive bomb strike in an area of open agricultural land will have caused soil disturbance, increasing the risk that a UXB entry hole would be overlooked.</i></p> | <p>WWII and post-WWII era photographs, presented in Annex N, do not show any visible signs of bomb damage. Areas of open ground were normally subject to cratering and ground disturbance when affected by bombing. However, none of these signs appear to be present.</p> |
| <p>Access Frequency</p> <p><i>UXO in locations where access was irregular would have a greater chance of passing unnoticed than at those that were regularly occupied. The importance of a site to the war effort is also an important consideration as such sites are likely to have been both frequently visited and subject to post-raid checks for evidence of UXO.</i></p> | <p>This site was occupied by open grassland within the grounds of a margarine works during wartime.</p> <p>Due to its location, there were several features within the proximity of the site which would have provided observance. For example New Chester Road to the west, residential housing north-west, and a sports ground east.</p> <p>As well as being close to these features, the site also appears to have been particularly well maintained. Therefore, it is anticipated that it would have been used for recreational purposes. This would have resulted in some access.</p> |
| <p>Ground Cover</p> <p><i>The nature of the ground cover present during WWII would have a substantial influence on any visual indication that may indicate UXO being present.</i></p> | <p>While open ground could serve to obscure evidence of UXO within shifting terrain, WWII-era aerial photographs, presented in Annex N, indicates that the grass which occupied the site was particularly well maintained and lacking in pockets of dense vegetation. Therefore, it is anticipated that the site would have been relatively conducive to the observation of UXO.</p> |
| <p>Bomb Failure Rate</p> | <p>There is no evidence to suggest that the bomb failure rate in the locality of the site would have been dissimilar to the 10% normally used.</p> |
| <p>Abandoned Bombs</p> | <p>1st Line Defence holds no records of abandoned bombs at or within the site vicinity.</p> |
| <p>Bombing Decoy sites</p> | <p>1st Line Defence could find no evidence of bombing decoy sites within the site vicinity.</p> |

| | |
|----------------------------|---|
| Bomb Disposal Tasks | 1 st Line Defence could find no evidence of bomb disposal tasks within the site boundary and immediate area. |
|----------------------------|---|

12. Introduction to Allied Explosive Ordnance

12.1. General

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

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

It should be highlighted that there is no evidence that the site formerly had any military occupation or usage that could have led to contamination with such items of Allied ordnance. Despite this, urban areas such as the location of the site, can however be at risk from buried unexploded anti-aircraft projectiles fired during WWII – as addressed below.

12.2. Defending the UK From Aerial Attack

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

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

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

12.2.1. Anti-Aircraft Artillery (AAA)

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

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

The closest recorded HAA to the site was located approximately 2.8km north-west of the site, however the range of a projectile can be up to 15km. The site would also have been in range of mobile light anti-aircraft guns.

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

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

13. The Likelihood of Contamination from Allied Ordnance

13.1. Introduction

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

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

13.2. Evaluation of Contamination Risk from Allied UXO

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

| Sources of Allied UXO Contamination | Conclusion |
|---|--|
| Military Camps <i>Military camps present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training.</i> | 1 st Line Defence could find no evidence of a military camp within the site. |
| Anti-Aircraft Defences <i>Anti-Aircraft defences were employed across the country. Proximity to anti-aircraft defences increases the chance of encountering AA projectiles.</i> | 1 st Line Defence could find no evidence of Anti-Aircraft defences such as a HAA or LAA gun emplacement occupying or bordering the site. The closest HAA was located approximately 2.8km north-west of the site, however the range of a projectile can be up to 15km. The conditions in which HAA or LAA projectiles may have fallen unnoticed within a site footprint are analogous to those regarding German aerial delivered ordnance. |
| Home Guard Activity <i>The Home Guard regularly undertook training and ordnance practice in open areas, as well as burying ordnance as part of anti-invasion defences.</i> | While the Home Guard are known to have been active in the general area, 1 st Line Defence has no evidence of any Home Guard activities immediately on or adjacent to the site. |
| Defensive Positions <i>Defensive positions suggest the presence of military activity, which is often indicative of ordnance storage, usage or disposal.</i> | There is no evidence of any defensive features formerly located on or bordering the site footprint. |
| Training or firing ranges <i>Areas of ordnance training saw historical ordnance usage in large numbers, often with inadequate disposal of expended and live items. The presence of these ranges significantly impact on the risk of encountering items of ordnance in their vicinity.</i> | There is no evidence of such features affecting the site. |



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

14. The Likelihood of UXO Contamination Summary

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

| UXO Contamination Summary | |
|---|---|
| Quality of the Historical Record | <p>The research has evaluated pre- and post-WWII Ordnance Survey maps, Luftwaffe reconnaissance imagery, Bomb Tracings for Merseyside, Mersey Home Guard War Diary, WWII-era aerial photography, Bomb Census Reports, and Ian Boumphrey's Birkenhead at War 1939-1945, including surrounding areas & Bebington.</p> <p>The record set is of generally satisfactory quality. The photography we have acquired has been able to provide an accurate view of the condition of the site both pre and post-WWII. We were also able to consult the comprehensive record of air raid incidents found within Ian Boumphrey's Birkenhead at War 1939-1945.</p> <p>Unfortunately, the Mersey Home Guard War Diary only covers incidents between August 1940 and December 1941. The Bomb Tracings for Merseyside are also not considered comprehensive in their overall coverage of air raid incidents.</p> |
| German Aerial Delivered Ordnance | <ul style="list-style-type: none"> • During the war, the site was situated within the Municipal Borough (M.B.) of Bebington. Home Office (HO) statistics suggest that this area sustained a low – moderate density of bombing with an average of 30 bombs dropped per 1,000 acres. • No reference to bombing within or immediately adjacent to the site, was found within the available records. The closest recorded incident comprised of two bomb strikes approximately 220m south-east, according to bomb tracings for Merseyside. Another notable incident, recorded in the Mersey Home Guard War Diary, occurred approximately 292m east on the Stork Margarine Factory. These incidents are shown in an overlay, presented in Annex M. No incidents are recorded within or immediately adjacent to the area of works within the available record. • The WWII-era photographs, presented in Annex N, indicate that the site remained largely unchanged from the pre-war condition presented in Annex E. The WWII-era photographs also do not show any visible signs of bomb damage. The photographs show that the site was particularly well-maintained and lacking in pockets of dense vegetation. Therefore, it is anticipated that the conditions present would have been relatively conducive to the observation of UXO. • As the site was located within the grounds of a margarine works, within close proximity to New Chester Road, residential housing, and a sports ground it is anticipated that it would have been relatively well observed. The site's particularly well maintained condition also indicates that it received at least recurrent access. As the area did not sustain a high density of bombing, it is considered likely that incidents which happened on or near the site would have been reported and investigated. • Based on these conditions and the lack of evidence within any of the available bomb records to suggest that any bomb strikes fell specifically on or next to the site, the risk from UXO is considered to be low and has not been elevated above the 'background' level of risk for the region. |
| Allied Ordnance | <ul style="list-style-type: none"> • There is no evidence that the site formerly had any military occupation or usage that could have led to contamination with items of Allied ordnance, such as LSA and SAA. The conditions in which HAA or LAA projectiles may have fallen unnoticed within the site boundary are however analogous to those regarding aerial delivered ordnance. |

15. The Likelihood that UXO Remains

15.1. Introduction

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

15.2. UXO Clearance

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

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

15.3. Post-war Redevelopment

Since WWII, the site has become incorporated within a retail park. It is understood that the site became occupied by a structure from around 1980. This structure then expanded from around 1990 before it was demolished in around 2006. Currently the site remains unoccupied.

The risk from deep-buried unexploded bombs is only considered mitigated at locations where post war piling or deep foundations have taken place.

16. The Likelihood of UXO Encounter

16.1. Introduction

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

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

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

16.2. Encountering Aerial Delivered Ordnance

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

17. The Likelihood of UXO Initiation

17.1. Introduction

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

17.2. Initiating Aerial Delivered Ordnance

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

In recent decades, there have been a number of incidents in Europe where Allied UXBs have detonated, and incidents where fatalities have resulted (some examples are presented in **Annex H2**). There have been several hypotheses as to the reason why the issue is more prevalent in mainland Europe – reasons could include the significantly greater number of bombs dropped by the Allied forces on occupied Europe, the preferred use by the Allies of mechanical rather than electrical fuzes, and perhaps just good fortune. The risk from UXO in the UK is also being treated very seriously in many sectors of the construction industry, and proactive risk mitigation efforts will also have affected the lack of detonations in the UK.

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

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

18. Consequences of Initiation/Encounter

18.1. Introduction

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

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

18.2. Consequences of Detonation

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

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

19. 1st Line Defence Risk Assessment

19.1. Risk Assessment Stages

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

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

19.2. Assessed Risk Level

1st Line Defence has assessed that there is an overall **Low Risk** from both German and Allied unexploded ordnance at the site of proposed works.

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

20. Proposed Risk Mitigation Methodology

20.1. General

The following risk mitigation measures are recommended to support the proposed works at the Croft Business Park Site:

| Type of Work | Recommended Mitigation Measure |
|--------------|---|
| All Works | <ul style="list-style-type: none"> • UXO Risk Management Plan It is recommended that a site-specific plan for the management of UXO risk be written for this site. This plan should be kept on site and be referred to in the event that a suspect item of UXO is encountered at any stage of the project. It should detail the steps to be taken in the event of such a discovery, considering elements such as communication, raising the alarm, nominated responsible persons etc. Contact 1st Line Defence for help/more information. • Site Specific UXO Awareness Briefings to all personnel conducting intrusive works. As a minimum precaution, all personnel working on the site should be briefed on the basic identification of UXO and what to do in the event of encountering a suspect item. This should in the first instance be undertaken by a UXO Specialist. Posters and information on the risk of UXO can be held in the site office for reference. |

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

1st Line Defence Limited

10th April 2019

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

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Site Location Maps



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Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Wirral**

Project: **Croft Business Park**

Ref: **DA7696-00**

Source: Google Maps

 **Approximate site boundary**





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Client: **Wirral**

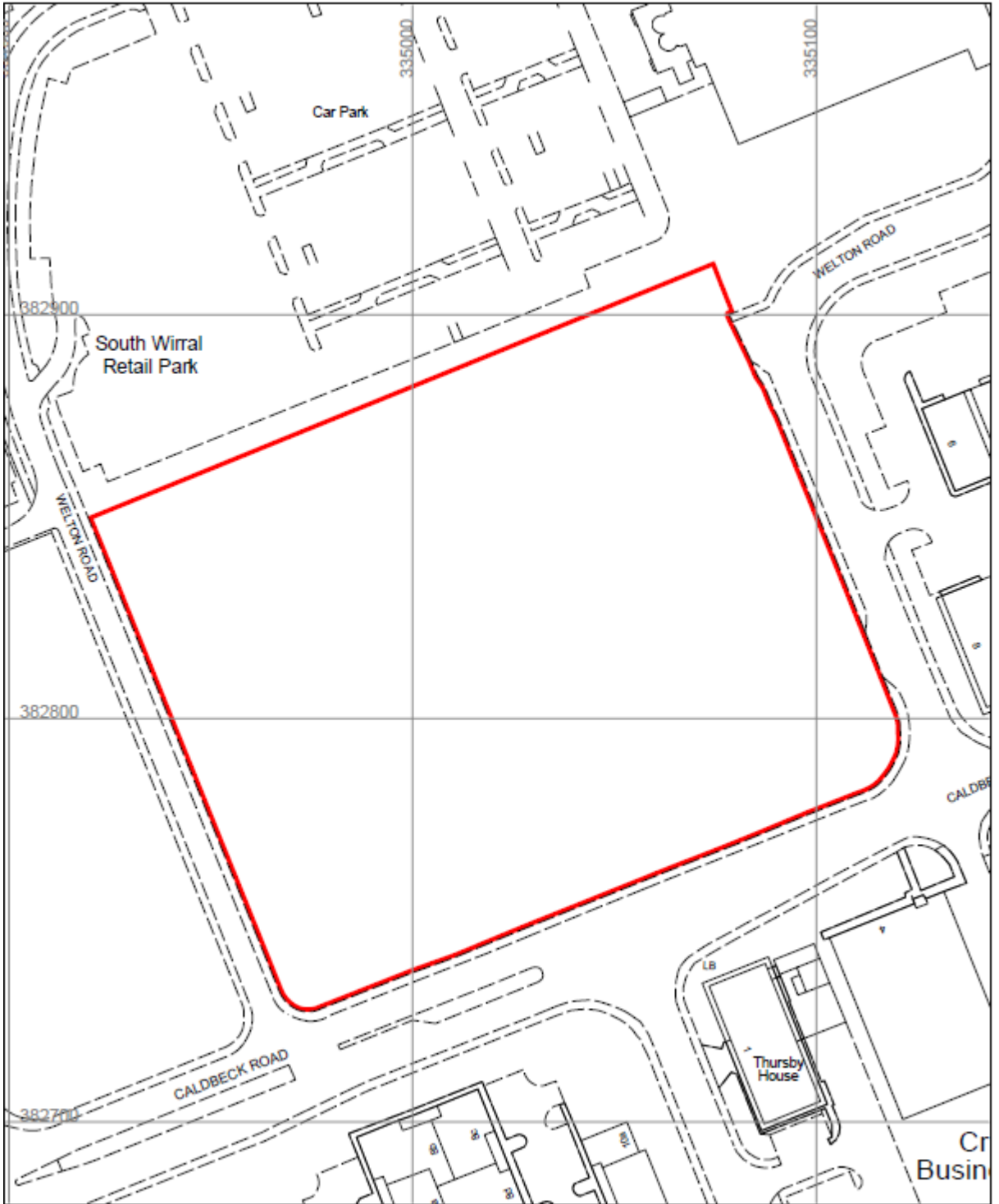
 **Approximate site boundary**



Project: **Croft Business Park**


Ref: **DA7696-00**

Source: Google Earth™ Mapping Services



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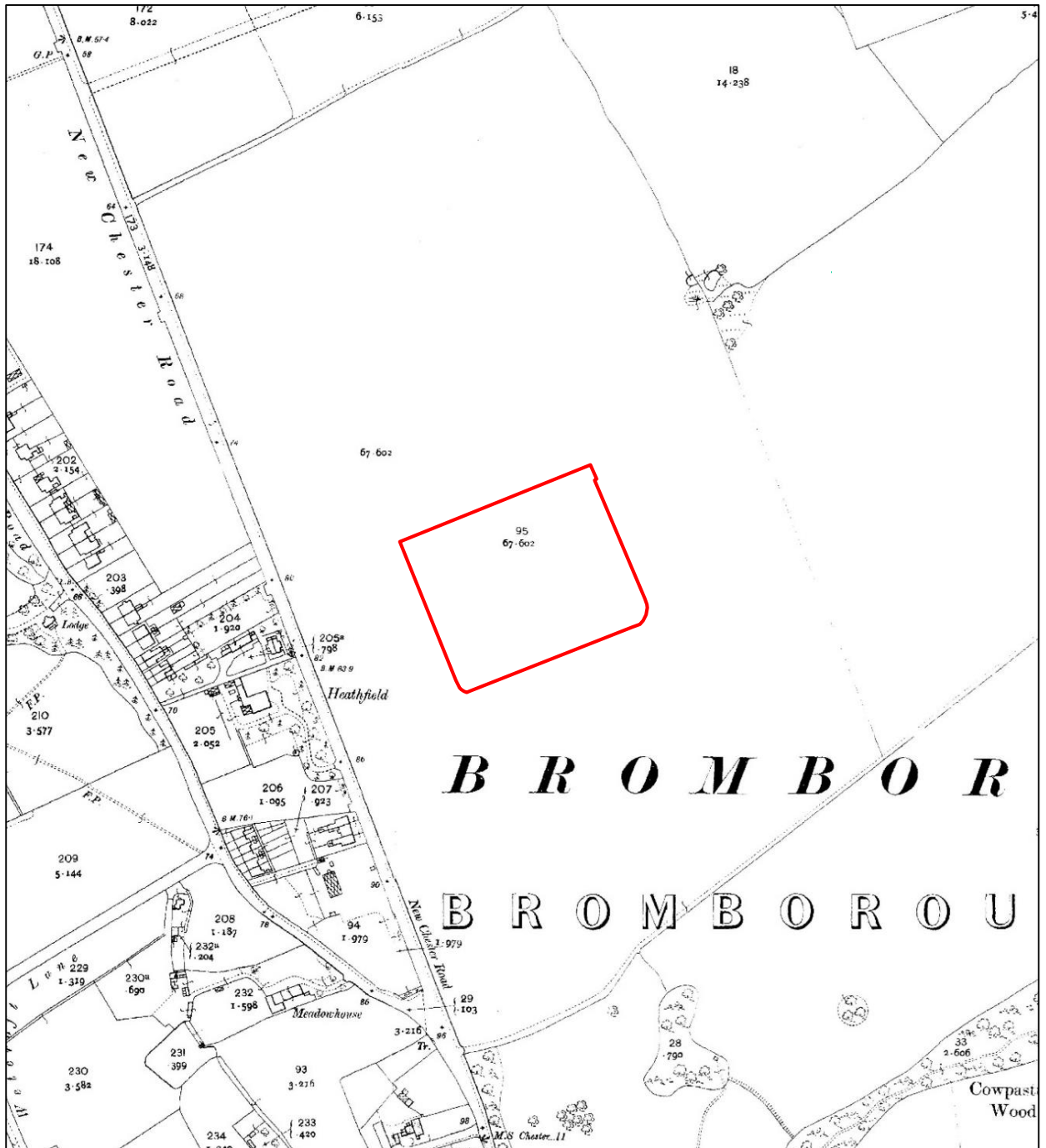
 **Approximate site boundary**



Project: **Croft Business Park**


Ref: **DA7696-00**

Source: e3p



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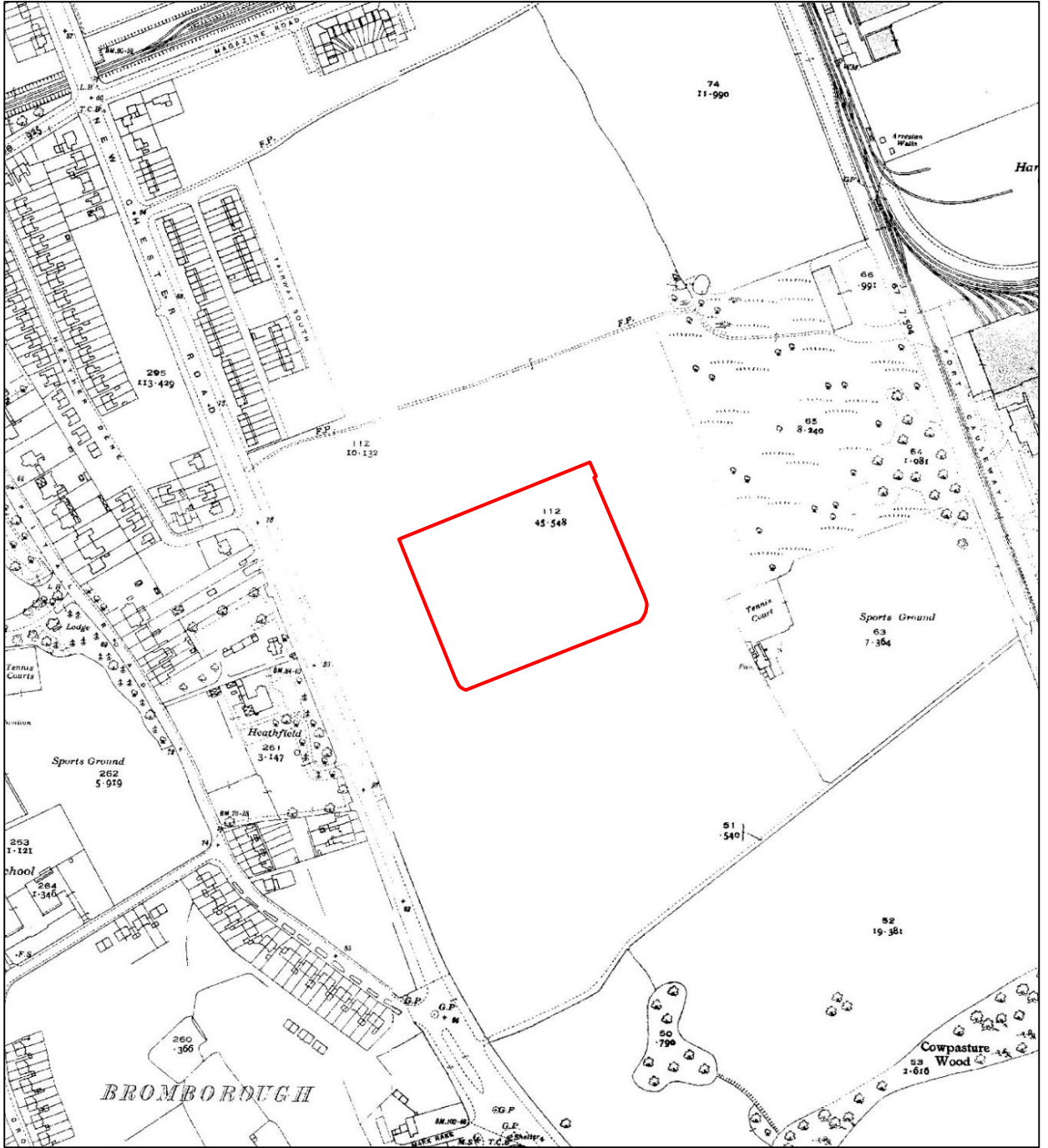


Project: **Croft Business Park**

Ref: **DA7696-00**

Source: Landmark Maps

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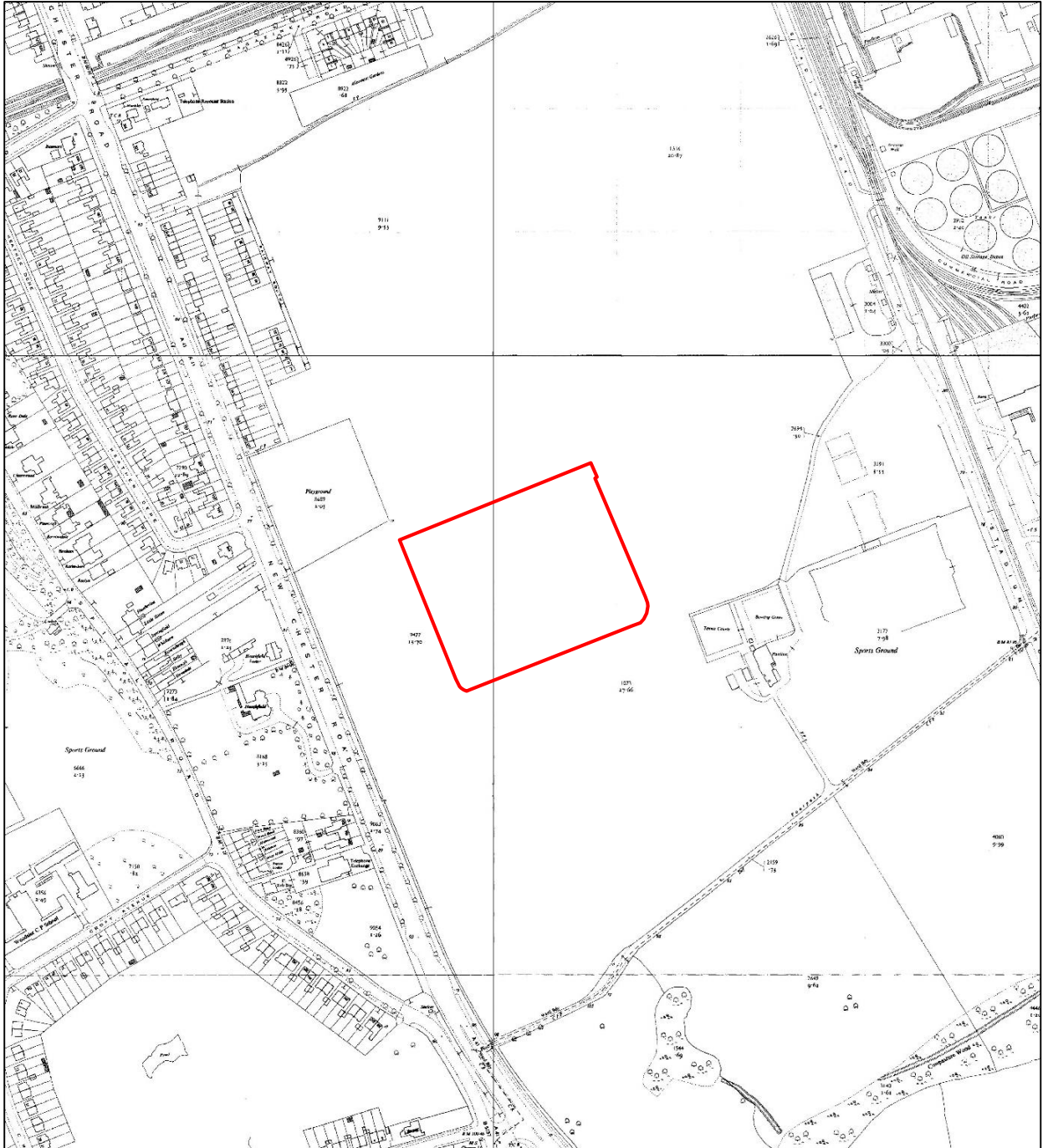
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Ref: **DA7696-00**

Source: Landmark Maps


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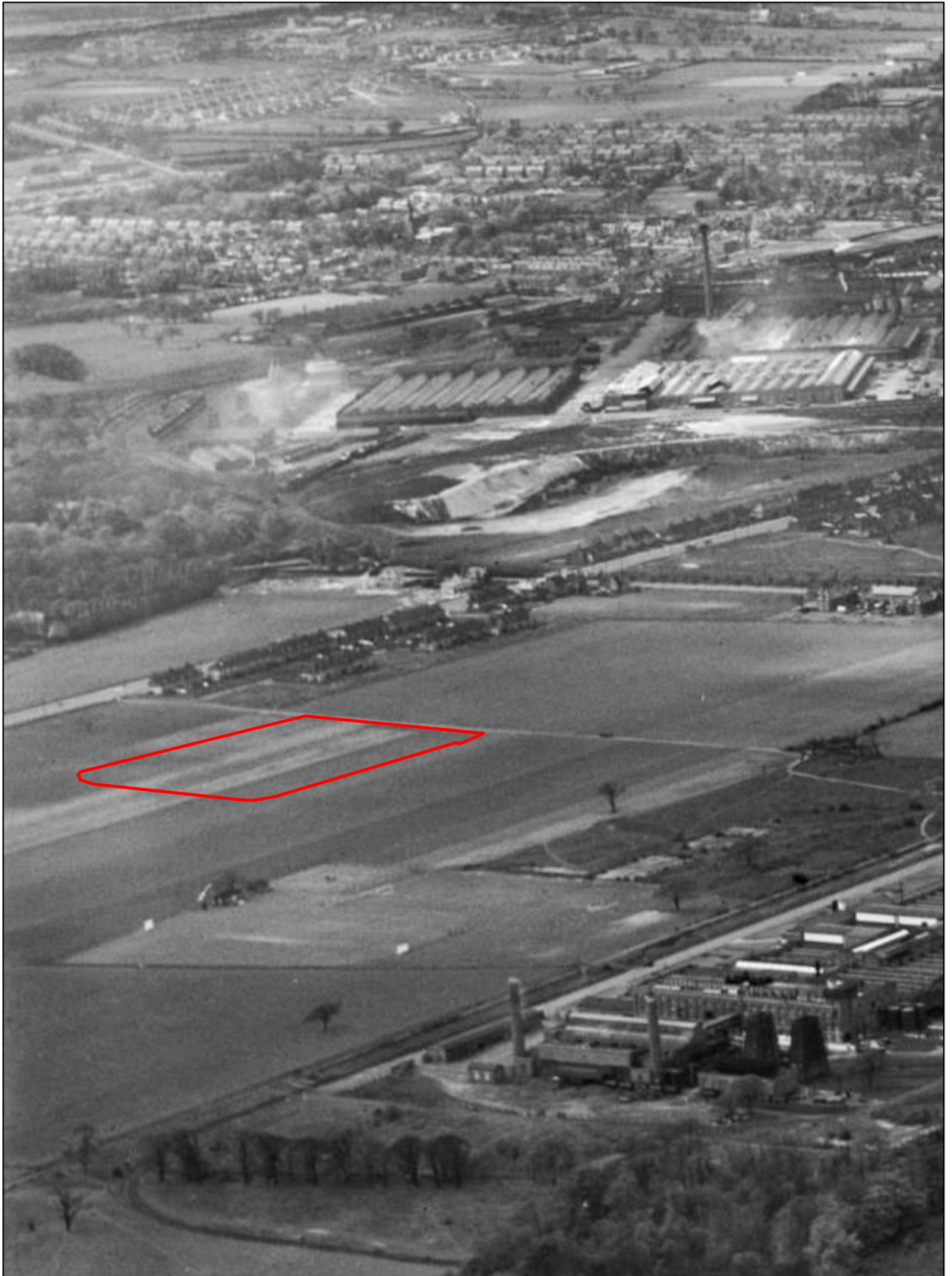
 **Approximate site boundary**



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Source: Landmark Maps



1ST LINE DEFENCE

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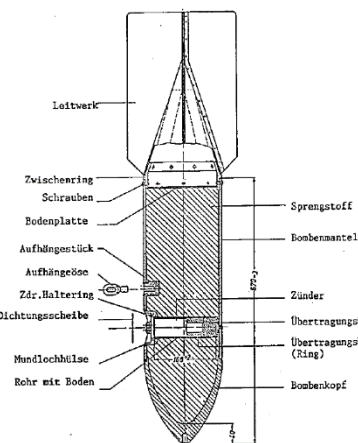
Source: Britain from Above

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Examples of German Air-Delivered Ordnance

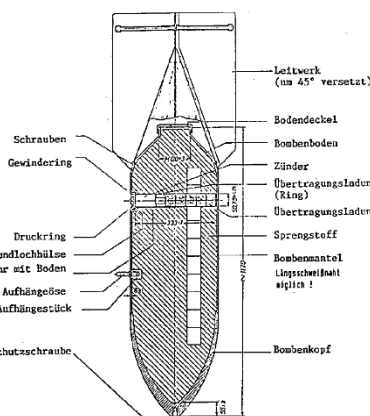
SC 50kg High Explosive Bomb

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



SC 250kg High Explosive Bomb

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

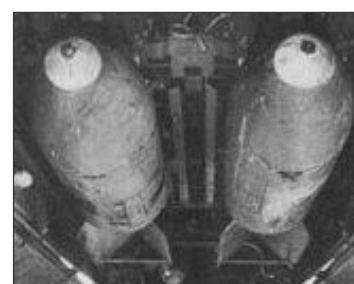
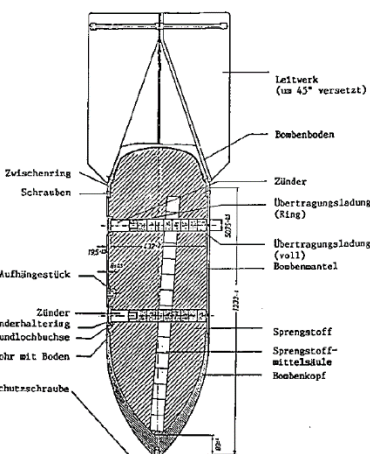


SC250 bomb being loaded onto German bomber



SC 500kg High Explosive Bomb

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



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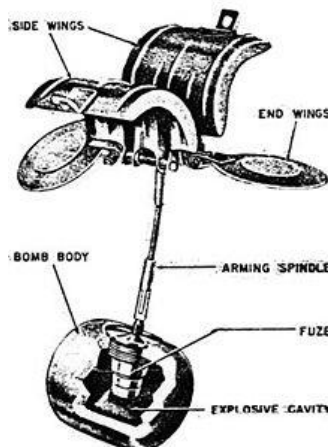
Ref: **DA7696-00**

Source: Various sources

Examples of German Air-Delivered Ordnance

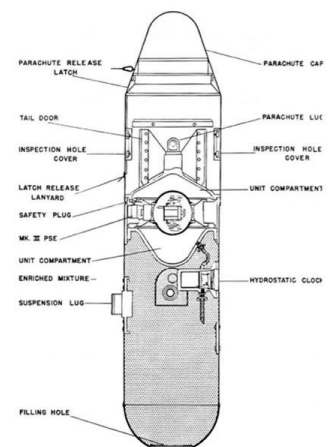
SD2 Anti-Personnel 'Butterfly Bomb'

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



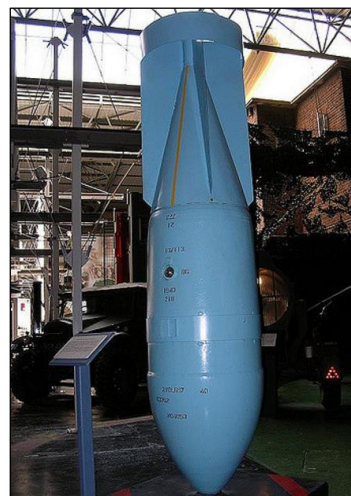
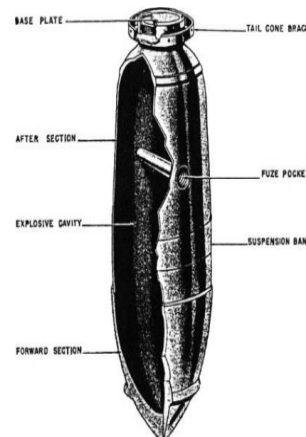
Parachute Mine (Luftmine B / LMB)

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



SC 1000kg

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



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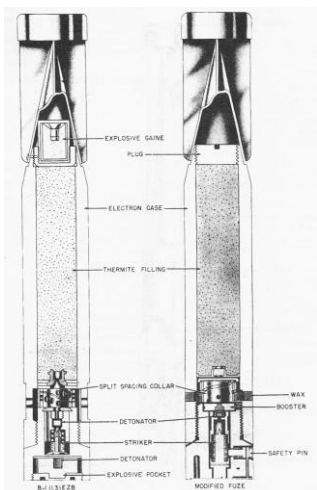
Ref: **DA7696-00**

Source: Various sources

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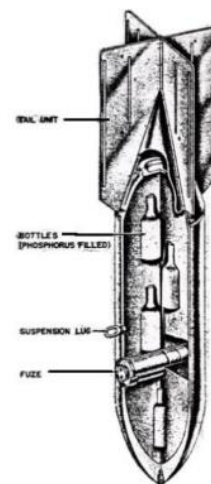
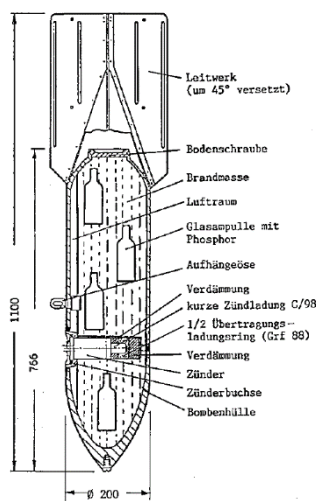
1kg Incendiary Bomb

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



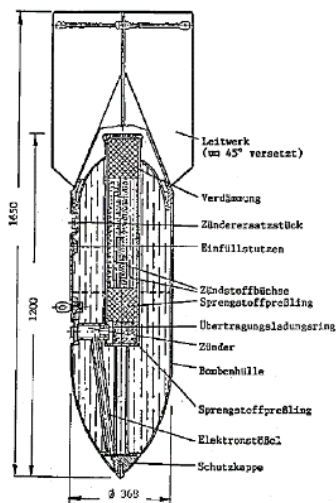
C50 A Incendiary Bomb

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



Flam C-250 Oil Bomb

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



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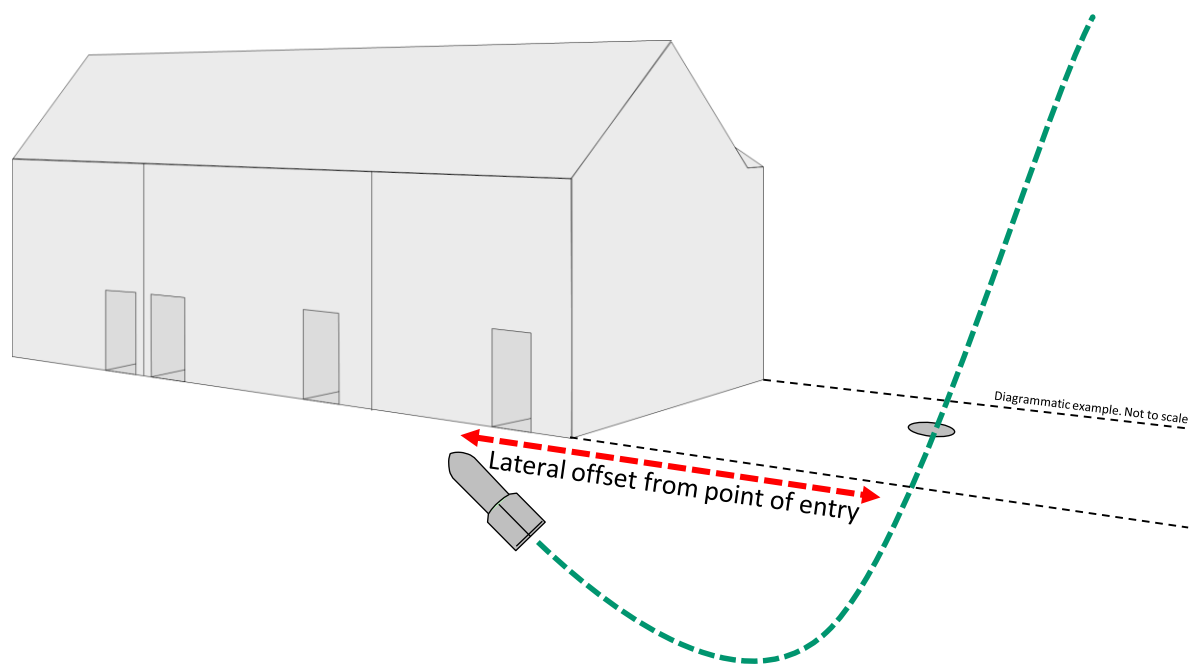
Client: **Wirral**

Project: **Croft Business Park**

Ref: **DA7696-00**

Source: Various sources

'J-Curve' Effect



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



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

BBC

NEWS

Bermondsey bomb: World War Two device safely removed



RUPERT FRERE

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

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

March 2015

BBC

NEWS

Bethnal Green WW2 bomb: Experts remove unexploded device



CROWN COPYRIGHT

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

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

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

August 2016

BBC

NEWS

Bath WW2 bomb scare: Device defused, police say



EPA

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

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

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

May 2016

BBC

NEWS

London City Airport reopens after WW2 bomb moved



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

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

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

May 2015



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Source: BBC News

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

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



BASF Provides Some Details

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

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

1st March 2013

WWII bomb injures 17 at Hattingen construction site



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

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

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

19th September 2013



World War II bomb kills three in Germany



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

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

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

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

2nd June 2010



June 2006

SPiegel ONLINE

Blast Kills One

World War II Bomb Explodes on German Motorway

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



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

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

23rd October 2006



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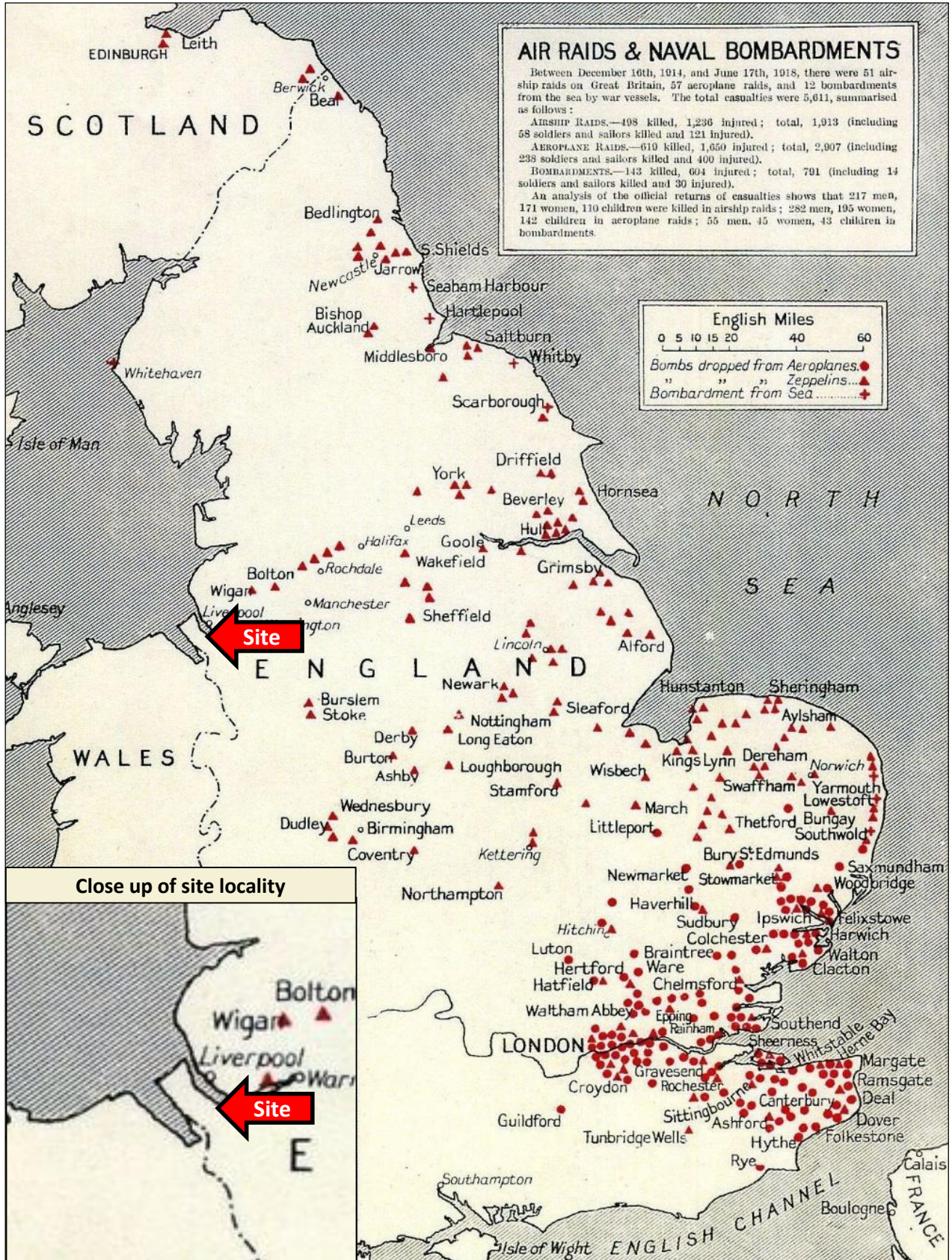
Client: **Wirral**

Project: **Croft Business Park**

Ref: **DA7696-00**

Source: Various news sources

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|-------------------------------------|---|--|
| Client: Wirral | | |
| Project: Croft Business Park | | |
| Ref: DA7696-00 | Source: J. Morris, <i>German Air Raids on Britain</i> | |



Dated 9th July, 1939



Above: Luftwaffe target photography of the Wallasey/Birkenhead Docks, dated 9th July 1943. The site is situated approximately 7km to the south of the docks.

Right: air raid statistics indicating the number of raids and metric tonnes of bombs dropped on Britain between September 1940 and May 1941.

| Target Area | Number of Major Raids | Metric Tonnes |
|----------------------------|-----------------------|---------------|
| London (entire period) | 71 | 18,800 |
| London (after November 14) | 14 | 5,140 |
| Liverpool-Birkenhead | 8 | 1,957 |
| Birmingham | 8 | 1,852 |
| Glasgow-Clydeside | 5 | 1,329 |
| Plymouth-Devonport | 8 | 1,228 |
| Bristol-Avonmouth | 6 | 919 |
| Coventry | 2 | 818 |
| Portsmouth | 3 | 687 |
| Southampton | 4 | 647 |
| Hull | 3 | 593 |
| Manchester | 3 | 578 |
| Belfast | 2 | 440 |
| Sheffield | 1 | 355 |
| Newcastle-Tyneside | 1 | 152 |
| Nottingham | 1 | 137 |
| Cardiff | 1 | 115 |

* Major attacks are those in which 100 tonnes or more of high-explosive were aimed. The table above, compiled from German statistics, does not take into consideration the weight of incendiary bombs aimed.

Above source: 'The Blitz: Then and Now'



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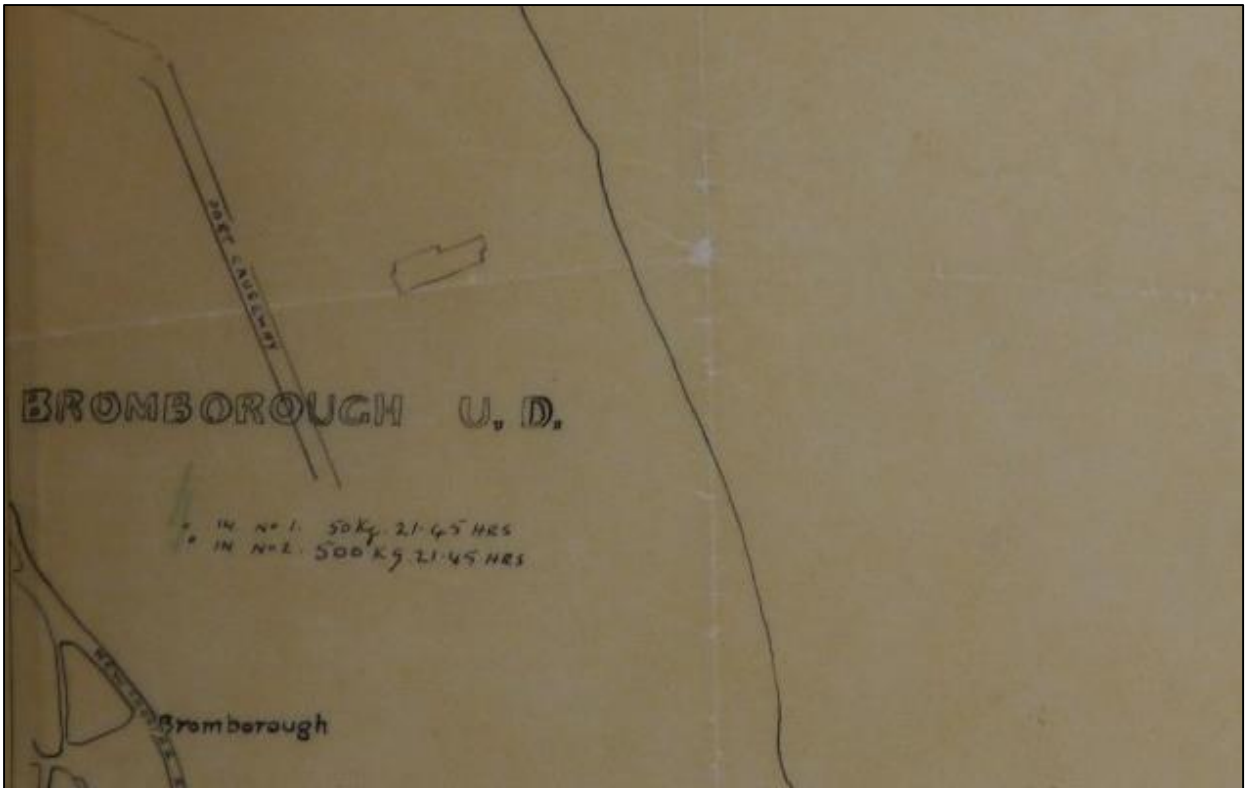
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Source: Nigel J. Clarke, "Adolf Hitler's Home Counties Holiday Snaps"

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 **Approximate site boundary**

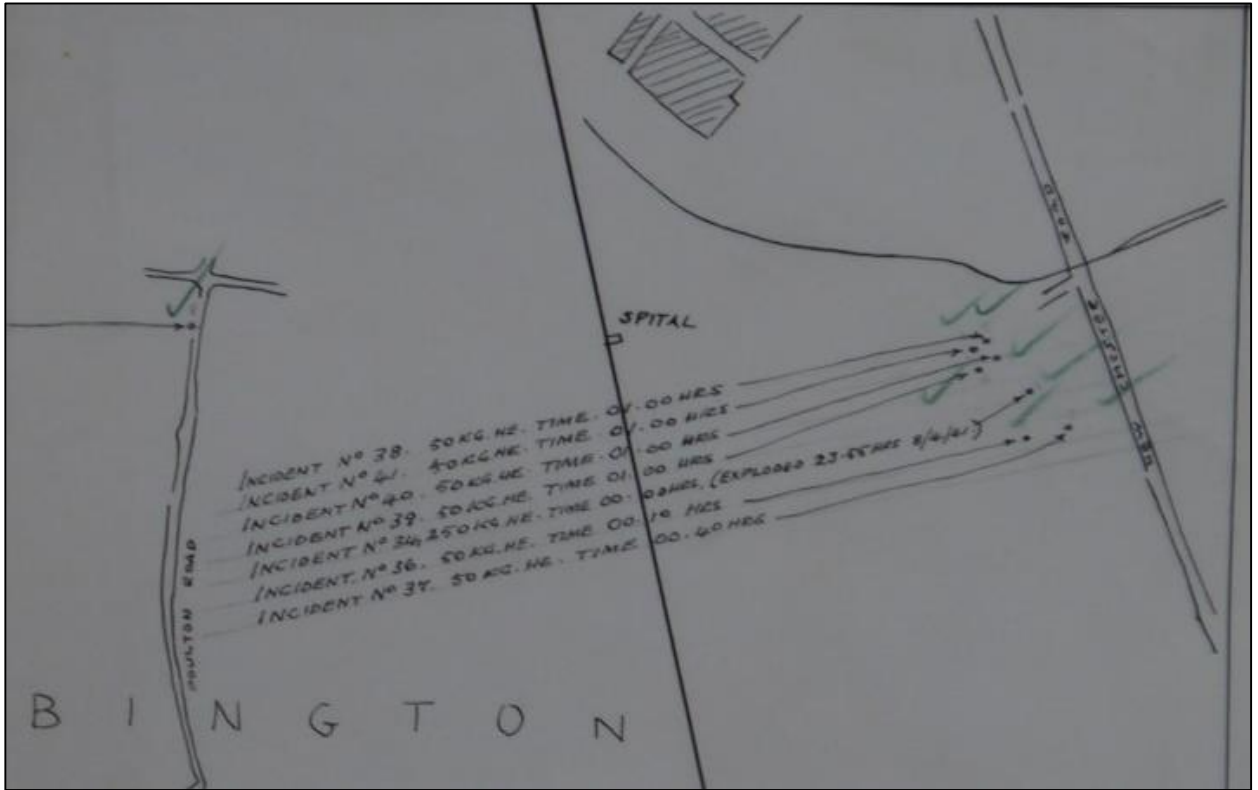


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Source: The National Archives, Kew

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— Approximate site boundary



Instructions regarding War Diaries and Intelligence Summaries are contained in F.S. Regs. Vol.1. and the Staff Manual respectively. Title pages will be prepared in manuscript.
 Month and Year.....

WAR DIARY
 or
~~INTELLIGENCE SUMMARY~~
 (Erase heading not required)

Unit, Mersey Garrison
 Commanding Officer, Brigadier T.T. Waddington, C.

| Place | Date | Hour | Summary of Events and information. | References to Appendices |
|-------|----------|------|--|--------------------------|
| | 10.10.40 | | <p><u>ENEMY ACTIVITY. (night 10th/11th Oct.)</u></p> <p>There were two raids during the night, the first taking place at <u>Rocks</u>, the apparent objectives were <u>Margarine Works at BROMBOROUGH</u>, <u>LeverBros Works at PORT SUNLIGHT</u>, <u>Oil Tanks at ELLESMERE PORT</u>, the <u>Eastham Locks by EASTHAM</u>, and <u>Napier's Factory</u>, certain main structural damage was caused to <u>Lever Bros. Works.</u></p> | |

Instructions regarding War Diaries and Intelligence Summaries are contained in F.S. Regs. Vol.1. and the Staff Manual respectively. Title pages will be prepared in manuscript.
 Month and Year.....

WAR DIARY
 or
~~INTELLIGENCE SUMMARY~~
 (Erase heading not required)

Commanding Officer

| Place | Date | Hour | Summary of Events and information. | References to Appendices |
|-------|------|------|---|--------------------------|
| | 21 | | <p><u>Victoria St. Birkenhead docks. One H.E. on foreshore in sea off Harrison Drive, in hallasey.</u></p> <p><u>Commander visited Salmon Barage 4th and a number of sites to advise on their ground defence. In the evening attended conference between military & Police re subject of co-operation at Chester</u></p> | |
| | 23rd | | <p><u>Telephone message received from 17th Bn H.G. that '6 para-chutists seen to land near LEDSHAM'. Message was checked back and found there was no confirmation of this report being true. Subsequently, further investigation was being made to find out how this report originated.</u></p> <p><u>6 H.E.'s were dropped during night of 22/23rd in Birkenhead Area, one unexploded. Casualties: 4 civilians reported killed and 3 injured.</u></p> <p><u>1 H.E. in hallasey Area</u></p> <p><u>9 H.E.'s in Bromborough Area, 3 civilians injured.</u></p> | |



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| Client: Wirral | |
| Project: Croft Business Park | |
| Ref: DA7696-00 | Source: The National Archives, Kew |

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WAR DIARY
OR
~~INTELLIGENCE SUMMARY~~
(Erase heading not required)

Army Form C. 2118
Unit Headquarters, Mersey Garrison
Commanding Officer Brigadier T.T. Waddington.
M.C.

Month and Year November, 1941.

| Place | Date | Hour | Summary of Events and Information | References to Appendices |
|------------|----------|------|---|--------------------------|
| LIVERPOOL. | 1.11.41 | | 20 - 25 enemy a/c operations in bright moonlight over the Merseyside area between the hours of 2110 and 2310. H.E. was reported from several places on the East of the WIRRAL Peninsula - notably WALLASEY, BEBBINGTON and BOMBOROUGH. Damage was slight and casualties reported were 6 killed, 7 injured. H.E. were also dropped at BABY, where cattle were killed and injured, HOYLAKE and CROXTETH PARK (LIVERPOOL). | |
| | 1.12.41. | | Exercise "FAZAKERLEY". A Defence Exercise was held to test the Fazakerley Defences (i.e. No.8 Ballonn Centre R.A.F. the factory of Messrs. NAPLERS Ltd. and the L.A.A. Sites in the vicinity). Troops engaged were:- (Enemy) 3 Platoons, 1 sec. carriers, det. engineers provided by No.19 I.T.C. (Defence) 1 Tp. L.A.A. (R.A.) No.8 Centre R.A.F. 73 Lances, H.G. 83 Lances, H.G. 86th Lances, H.G. | Appendix 'A' |
| | 3.12.41. | | Instructions were received from Headquarters, West Lancashire Area that the Subsectors of Mersey Garrison, formerly known as Subsectors 1, 2 and 3 will be called l.a.l.b. and l.c. respectively. | |

22793 Wt. 52096/1140 1.000m 12/40-Mec & Co. L16-31-8212 Form 02110/22



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Project: **Croft Business Park**

Ref: **DA7696-00**

Source: The National Archives, Kew



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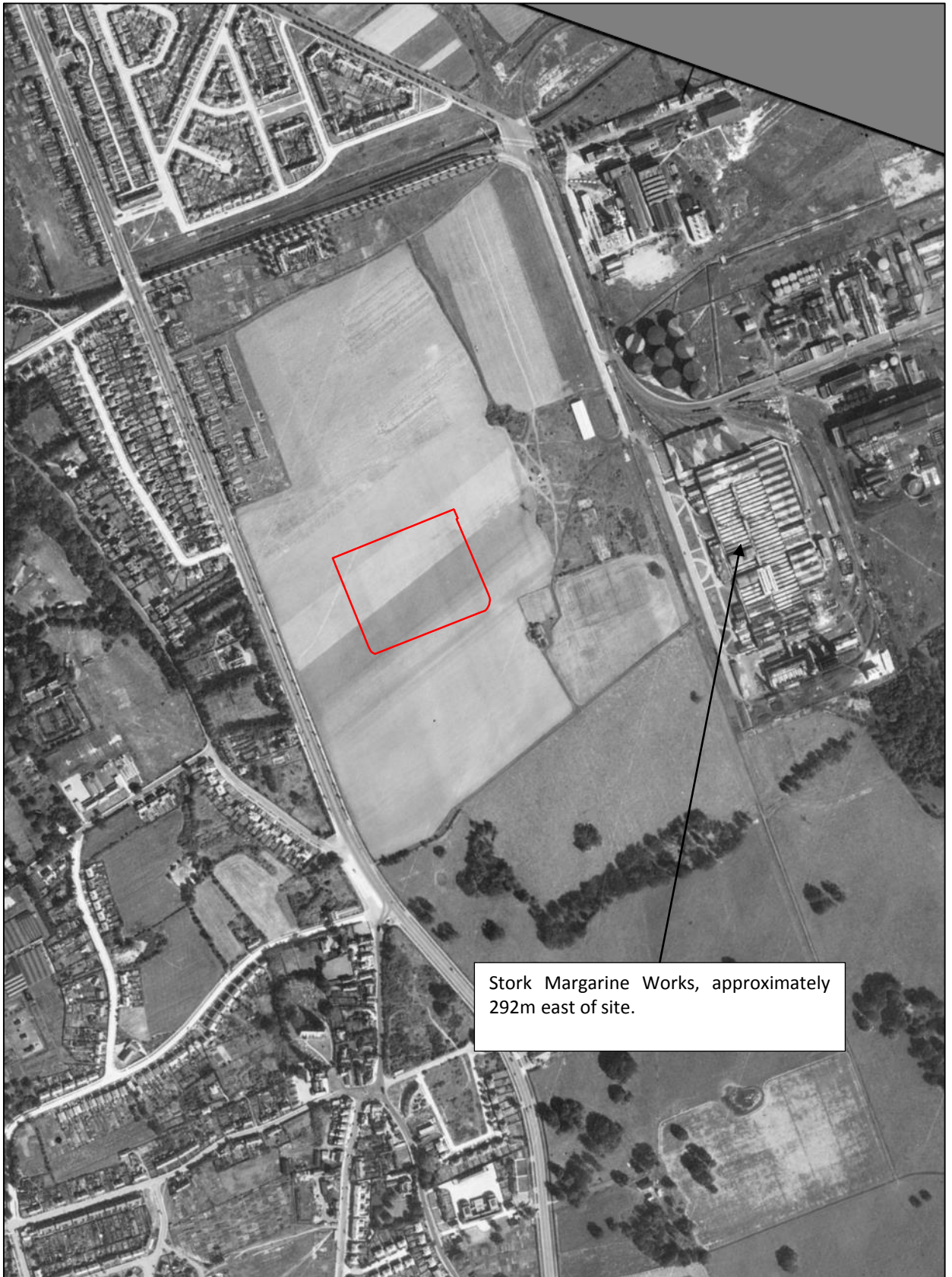


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Stork Margarine Works, approximately 292m east of site.



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Recorded HE Incident (Merseyside Bomb Tracings, Annex K)



Area targeted in air-raid (Mersey Home Guard War Diaries, Annex L)



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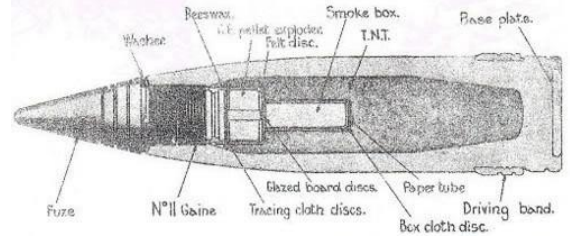
Source: 1st Line Defence

 **Approximate site boundary**



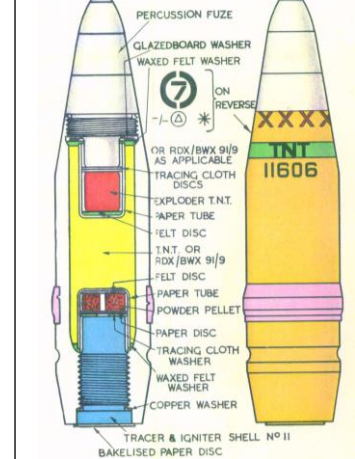
3.7 Inch QF Anti-Aircraft Projectile

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



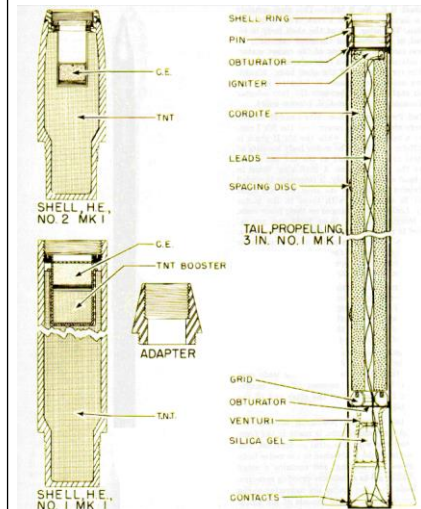
40mm Bofors Projectile

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



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

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



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Source: Various sources

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