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Explosive Ordnance Threat Assessment in respect of Spitfire Road, Speke

for
LK Consult Limited

5831TA

9th January 2015

BACTEC

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This Report has been produced in compliance with the Construction Industry Research and Information Association guidelines for the preparation of Detailed Risk Assessments in the management of UXO risks in the construction industry.

Glossary of Terms

AAA	Anti-Aircraft Artillery
ARP	Air-raid Precautions
BDO	Bomb Disposal Officer
EOD	Explosive Ordnance Disposal (current term for "bomb" disposal)
HE	High Explosive
HG	Home Guard
IB	Incendiary Bomb
kg	Kilogram
LCC	London County Council
LM	Land Mine
LSA	Land Service Ammunition (includes grenades, mortars, etc.)
Luftwaffe	German Air Force
m bgl	Metres Below Ground Level
MoD	Ministry of Defence
OB	Oil Bomb
PM	Parachute Mine
RAF	Royal Air Force
SI	Site Investigation
SAA	Small Arms Ammunition (small calibre cartridges used in rifles & machine guns)
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	"Doodlebug" the first cruise type missile, used against London from June 1944. Also known as 'Flying Bomb'.
V-2	The first ballistic missile, used against London from September 1944
WWI	First World War (1914 -1918)
WWII	Second World War (1939 – 1945)

Executive Summary

The Site: The site, centred on the approximate OS Grid Reference: 341632, 384512, is located between Speke and Garston, approximately 610m south-east of Liverpool South Parkway Railway Station. It is bound to the north by Spitfire Road, to the south by a railway line and to the east by an industrial estate. It is exclusively occupied by bare earth with some unmaintained vegetation at its peripheries.

Proposed Works: A Site Investigation involving boreholes has been carried out over a small part of the site. This is expected to be continued across the entire study area in due course. Following this work, the site is to be redeveloped for commercial units. Note however a detailed scope of the proposed works, including maximum depths of intrusive works, was not available within the timeframe of this report.

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

Explosive Ordnance Risk Assessment: BACTEC concludes that the site is at **Medium Risk** from encountering UXO. This is based on the following:

German UXO

- During WWII Liverpool was subjected to over 300 bombing raids, mainly due to the presence of the city's vital dock facilities, and by the end of the war it was the second most heavily bombed city in Britain.
- The site was situated several kilometres to the south of these primary Luftwaffe targets and therefore occupied an area of moderate bombing density. Note however RAF Speke and a neighbouring aircraft factory were situated just south of the site and both facilities are known to have been targeted during the Battle of Britain.
- Although not heavily bombed, RAF Speke (420m south of the site) was subjected to several raids and a fairly heavy raid was reported over Garston, 700m to the west. The latter resulting in many UXBs in the wider area.
- A bomb damage map does not highlight any damage close to the site, however the undeveloped nature of the area suggests any bombing in close proximity would not be recorded on this map, as no damage would be sustained. Also noteworthy is that two small pre-WWII buildings directly adjacent to the eastern site boundary, were demolished between 1936 and 1953; possibly the result of bombing.
- During WWII the site was undeveloped / relatively isolated and does not appear to have had any apparent use. Therefore access to the majority of the site will have been very limited and it is conceivable that parts were neglected for the duration of the war. Note however several allotment gardens at the western extent will have been subject to some level of access, depending on the season.
- Therefore it is possible that a UXB could have fallen unobserved on site, especially since the majority of raids in the region occurred at night. In addition, ARP wardens are unlikely to have accessed the study area for post-raid UXO checks, due to its undeveloped nature and lack of importance.
- Furthermore, had such an incident occurred the resulting evidence could have remained undetected. Note that the entry hole of an unexploded SC 50 (the most commonly deployed German HE bomb) may have been as little as 20cm in diameter and therefore easily obscured in vegetation.

British UXO

- During the period of anticipated invasion, several Home Guard units were active in Liverpool. One of which was attached to RAF Speke, just to the south of the site. Two pillboxes in the vicinity also indicate a Home Guard defensive presence.
- The house-keeping of less disciplined Home Guard personnel during WWII is known to have been poor with unwanted, faulty or expended items of land service and small arms ammunition often burnt, buried or discarded on civilian land.
- Although no evidence could be found to indicate that the site had any historical military use, it is known that the Home Guard often carried out training in unused open ground, on the edge of urban areas and therefore (although unlikely), the possibility that the site was used for training (which could have led to land service / small arms ammunition contamination) cannot be entirely discounted.

The site does not appear to have been subject to any significant post-WWII intrusive work or development and therefore the risk from both shallow buried UXO (1kg German incendiaries, British AAA shells, LSA and SAA) and deep buried German HE UXBs will not have been mitigated to any significant degree.

Bomb Penetration Assessment: It has been assessed that a 500kg bomb would have had a maximum bomb penetration depth of up to **8m** below WWII ground level, or shortly after impact with the Mudstone layer, whichever is sooner. Penetration depth could potentially have been greater if the UXB was larger (though only 4% of German bombs used in WWII over Britain were of that size). Note that UXBs may be found at any depth between just below the WWII ground level and the maximum penetration depth. This assessment has been made using generic geological information.

Risk Mitigation Measures: The following risk mitigation measures are recommended to support the proposed intrusive works:

All Works

- Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works.
- The provision of Unexploded Ordnance Site Safety Instructions.

Shallow Intrusive Works

- Non-Intrusive Magnetometer Survey and subsequent Target Investigation, if necessary.
- Explosive Ordnance Disposal (EOD) Engineer presence on site to support shallow intrusive works.

Deep Intrusive Works

- Intrusive Magnetometer Survey of any borehole and pile locations down to a maximum bomb penetration depth.

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Explosive Ordnance Threat Assessment

In Respect of

Spitfire Road, Speke

1. Introduction

1.1. Background

During October 2014, BACTEC provided EOD Engineer supervision to LK Consult Limited Site Investigation works within part of the Spitfire Road site, Speke, Liverpool.

LK Consult Limited has since commissioned BACTEC International Ltd to conduct an Explosive Ordnance Threat Assessment for the proposed redevelopment works of the entire Spitfire Road site.

Unexploded Ordnance (UXO) presents a significant threat to construction projects in parts of the UK as a result of enemy actions during the two 20th Century World Wars and historic British and Allied military activity.

One of the legacies of these conflicts is buried unexploded air-dropped bombs or anti-aircraft projectiles resulting from the failure of a proportion of the weapons to function as designed. It is commonly accepted that the failure rate of these munitions was approximately 10% and, depending on their shape, weight, velocity and ground conditions many penetrated the ground and came to rest at depth.

Intensive efforts were made during and after the war to locate and render safe all UXO but, unsurprisingly, not all were found and dealt with. This is evidenced by the regular, on-going discoveries of unexploded ordnance during construction-related intrusive ground works.

In addition, it is estimated that over 20% of the UK landmass has been used for military training at some point and between 2006 and 2009, over 15,000 items of ordnance (excluding small arms ammunition) were found on UK construction sites (CIRIA).

As a result of a generally increased risk awareness amongst professionals involved in ground engineering works and proactive health and safety measures, the threat to life and limb from unexploded ordnance has been minimised. However even the simple discovery of a suspected device during on-going works can cause considerable disruption to production and cause unwanted delays and expense.

Such risks can be more fully controlled by a better understanding of the site-specific threat and the implementation of appropriate risk mitigation measures.

2. Construction Industry Duties and Responsibilities

2.1. The UK Regulatory Environment

There is no specific legislation covering the management and control of the UXO risk in the UK construction industry but issues regarding health and safety are addressed under a number of regulatory instruments, as outlined below.
In practice the regulations impose a responsibility on the construction industry to ensure that they discharge their obligations to protect those engaged in ground-intrusive operations (such as archaeology, site investigation, drilling, piling or excavations) from any reasonably foreseeable UXO risk.

2.2. The Health and Safety at Work Act, 1974

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

2.3. Construction (Design and Management) Regulations 2007

This legislation defines the responsibilities of all parties (primarily the Client, the CDM Co-ordinator, the Designer and the Principal Contractor) involved with works.

Although UXO issues are not specifically addressed the regulations effectively place obligations on all these parties to:

- Ensure that any potential UXO risk is properly assessed
- Put in place appropriate risk mitigation measures if necessary
- Keep all parties affected by the risk fully informed
- Prepare a suitably robust emergency response plan

2.4. Other Legislation

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

3. The Role of the Authorities and Commercial Contractors

3.1. The Authorities

The Police have the responsibilities for co-ordinating the emergency services in the case of an ordnance-related incident on a construction site. They will make an initial assessment (i.e. is there a risk that the find is ordnance or not?) and if they judge necessary impose a safety cordon and/or evacuation and call the military authorities (JSEODOC - Joint Services Explosive Ordnance Disposal Operations centre) to arrange for investigation and/or disposal. In the absence of an EOD specialist on site many Police Officers will use the precautionary principle, impose cordon(s)/evacuation and await advice from the JSEODOC.

The priority given to the request by JSEODOC will depend on their judgement of the nature of the threat (ordnance, location, people and assets at risk) and the availability of resources. They may respond immediately or as resources are freed up. Depending on the on-site risk assessment the item of ordnance may be removed or demolished (by controlled explosion) in-situ. In the latter case additional cordons and/or evacuations may be necessary.

Note that the military authorities will only carry out further investigations or clearances in very high profile or high risk situations. If there are regular ordnance finds on a site the JSEODOC may not treat each occurrence as an emergency and will encourage the construction company to put in place alternative procedures (i.e. the appointment of a commercial contractor) to manage the situation and relieve pressure from the JSEODOC disposal teams.

3.2. Commercial Contractors

In addition to pre-construction site surveys and clearances a commercial contractor is able to provide a reactive service on construction sites. The presence of a qualified EOD Engineer with ordnance recognition skills will avoid unnecessary call-outs to the authorities and the Contractor will be able to arrange for the removal and disposal of low risk ordnance. If high risk ordnance is discovered actions will be co-ordinated with the authorities with the objective of causing the minimum possible disruption to site operations whilst putting immediate, safe and appropriate measures in place.

4. This Report

4.1. Aims and Objectives

The aim of this report is to examine the possibility of encountering any explosive ordnance during any intrusive works at the Spitfire Road site. Risk mitigation measures will be recommended, if deemed necessary, to reduce the threat from explosive ordnance during the envisaged works. The report follows the CIRIA Guidelines.

4.2. Risk Assessment Methodology

The following issues will be addressed in the report:

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

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

4.3. Approach

In preparing this Explosive Ordnance Threat Assessment Report, BACTEC has considered general and, as far as possible, site specific factors including:

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

4.4. Sources of Information

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

Material from the following sources has been consulted:

- The National Archives, Kew.
- Liverpool Record Office, Liverpool.
- The Britain From Above Project.
- Landmark Maps.

- The RAF Museum, Hendon.
- Relevant information supplied by LK Consult Limited.
- Available material from 33 Engineer Regiment (EOD) Archive.
- BACTEC's extensive archives built up over many years of research and hands-on Explosive Ordnance Disposal activities in the UK.
- Open sources such as published books, local historical records and the internet.

4.5. Reliability of Historical Records

4.5.1. General Considerations

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

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

4.5.2. Bombing Records

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

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

5. The Site

5.1. Site Location

The site is located between Speke and Garston, approximately 610m south-east of Liverpool South Parkway Railway Station. It is bound to the north by Spitfire Road, to the south by a railway line and to the east by an industrial estate.

The site is centred on the approximate OS Grid Reference: 341632, 384512

Site location maps are presented in Annex A.

5.2. Site Description

The study area is exclusively occupied by bare earth with some unmaintained vegetation at its peripheries.

A recent aerial photograph showing the site boundary is presented in Annex B.

6. Scope of any intrusive Works

A Site Investigation involving boreholes has been carried out over a small part of the site. This is expected to be continued across the entire study area in due course. Following this work, the site is to be redeveloped for commercial units. Note however a detailed scope of the proposed works, including maximum depths of intrusive works, was not available within the timeframe of this report.

A Current Site Plan showing the site boundary is presented in Annex C.

7. Ground Conditions

Borehole log data for a Site Investigation carried out on site in October 2014 was provided by LK Consult Limited. The following geological sequence was recorded:

- 4m of Made Ground – mainly sand, silty sand and clay with some gravel near the surface.
- 2.5m of stiff brown clay.
- 2.7m of dense brown silty sand.
- 2m of very stiff brown slightly sandy slightly gravelly clay
- 1.24m of red sandstone

8. Site History

8.1. General

Pre and post WWII historical OS maps[1] were obtained for the site from Landmark Maps. These are presented in Annex D.

8.2. Pre-WWII

The 1936 (1:2,500 scale) OS map shows the site to be entirely undeveloped and mostly occupied by an unmarked field. A stream passes through the eastern extent, a pond is situated at the northernmost corner and the western periphery encroaches on a large area of *Allotment Gardens*.

The immediate surrounding area is a mixture of significant railway infrastructure, in the form of numerous sidings, immediately to the south and open ground (possibly agricultural) to the north. Note that a *Locomotive Shed* close to the south-western boundary and a *Varnish & Colour Works* to the east.

8.3. Post-WWII

The 1953 (1:2,500 scale) OS map shows no changes to the study area. Note however that immediately east of the site, a *Sports Ground Pavilion* and an adjacent unlabelled structure have been demolished.

Note that such observations on early post-WWII OS maps are often indicative of bomb damage in areas historically subjected to German bombing.

[1] Latest pre-war and earliest post-war

9. The Threat from Aerial Bombing

9.1. General Bombing History of Merseyside

9.1.1. First World War

The UK suffered aerial bombardment during WWI, beginning with indiscriminate night raids by Zeppelin airships. However as British defensive measures became more effective and aircraft development progressed, the German military switched to daylight raids by fixed-wing aircraft in June 1917.

Historical sources indicate that Liverpool was targeted by Zeppelins during WWI, however the city escaped bombing due to navigational errors. Therefore the threat from WWI German UXBs is considered negligible and will not be further addressed in this report.

9.1.2. Second World War

At the start of WWII, the Luftwaffe planned to destroy key military installations, including RAF airfields and Royal Navy bases, during a series of daylight bombing raids in the south and east of Britain.

After the Battle of Britain these tactics were modified to include both economic and industrial sites across the entire country, including Merseyside. Targets included dock facilities, railway infrastructure, power stations, weapon manufacturing plants, gas works, etc. As a result of aircraft losses, daylight raids were reduced in favour of attacking targets under the cover of darkness.

As the war progressed the strategy changed to one of attempting to destroy the morale of the civilian population by the "carpet bombing" of major UK cities including Liverpool. However by May 1941, concentrated attacks ceased as the Luftwaffe was diverted east to prepare for 'Operation Barbarossa', the invasion of the Soviet Union.

Some minor raids carried on into early 1942, however the last bombs fell in the region not long after.

9.2. Aerial Delivered Ordnance in the Second World War

9.2.1. Generic Types of WWII German Air-delivered Ordnance

The nature and characteristics of the ordnance used by the Luftwaffe allows an informed assessment of the hazards posed by any unexploded items that may remain today. Detailed illustrations of German air delivered ordnance are presented at Annex E.

- HE Bombs: In terms of weight of ordnance dropped, HE bombs were the most frequent weapon deployed. Most bombs were 50kg, 250kg or 500kg (overall weight, about half of which was the high explosive) though large bombs of up to 2000kg were also used. HE bombs had the weight, velocity and shape to easily penetrate the ground intact if they failed to explode. Post-raid surveys would not always have spotted the entry hole or other indications that a bomb penetrated the ground and failed to explode and contemporary ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. Unexploded HE bombs therefore present the greatest risk to present–day intrusive works.
- Blast Bombs/ Parachute Mines: Blast bombs generally had a slow rate of descent and were extremely unlikely to have penetrated the ground. Non-retarded mines would have shattered on most ground types, if they had failed to explode. There have been extreme cases when these items have been found unexploded, but this was where the ground was either very soft or where standing water had reduced the impact. BACTEC does not consider there to be a significant threat from this type of munition on land.
- Large incendiary bombs: This type of bomb ranged in size from 36kg to 255kg and had a number of inflammable fill materials (including oil and white phosphorus), and a small explosive charge. They were designed to explode and burn close to the surface but their shape and weight meant that they did have penetration capability. If they penetrated the

ground complete combustion did not always occur and in such cases they remain a risk to intrusive works.

- 1 kg Incendiary Bombs (IB): These bombs, which were jettisoned from air-dropped containers, were unlikely to penetrate the ground and in urban areas would usually have been located in post-raid surveys. However, if bombs did not initiate and fell in water or dense vegetation, or became mixed with rubble in bomb damaged areas they could have been overlooked. Some variants had explosive heads and these present a risk of detonation during intrusive works.
- Anti-personnel (AP) Bomblets: AP bombs had little ground penetration ability and should have been located by the post-raid survey unless they fell into water, dense vegetation or bomb rubble.
- Specialist Bombs (smoke, flare, etc): These types do not contain high explosive and therefore a detonation consequence is unlikely. They were not designed to penetrate the ground.

9.2.2. German Air-delivered Ordnance Failure Rate

It has been estimated that 10% of the German HE bombs dropped during WWII failed to explode as designed. This estimate is probably based on the statistics of wartime recovered UXBs and therefore will not have taken account of the unknown numbers of UXBs that were not recorded at the time, and is probably an underestimate.

The reasons for failures include:

- Fuze or gaine malfunction due to manufacturing fault, sabotage (by forced labour) or faulty installation.
- Clockwork mechanism failure in delayed action bombs.
- Failure of the bomber aircraft to arm the bombs (charge the electrical condensers which supplied the energy to initiate the detonation sequence) due to human error or equipment defect.
- Jettison of the bomb before it was armed or from a very low altitude. Most likely if the bomber was under attack or crashing.

War Office Statistics document that a daily average of 84 bombs which failed to function were dropped on civilian targets in Great Britain between 21st September 1940 and 5th July 1941. 1 in 12 of these (probably mostly fitted with time delay fuzes) exploded sometime after they fell - the remainder were unintentional failures.

From 1940 to 1945 bomb disposal teams dealt with a total of 50,000 explosive items of 50 kg and over (i.e. German bombs), 7000 AAA shells and 300,000 beach mines. These operations resulted in the deaths of 394 officers and men. However, unexploded ordnance is still regularly encountered across the UK (see recent press articles, Annex F-1).

9.2.3. UXB Ground Penetration

9.2.3.1. General Considerations

The actual penetration depth of aerial delivered bombs into the ground will have been determined by the mass and shape of the bomb, the velocity and angle of the bomb on impact (dependent on the height of release) and the nature of the ground and ground cover; the softer the ground, the greater the potential penetration. Peat, alluvium and soft clays are easier to penetrate than gravel and sand. Bombs are brought to rest or are commonly deflected by bedrock or large boulders.

9.2.3.2. The "j" Curve Effect

An air-dropped bomb falling from normal bombing altitude (say 5000m) into homogeneous ground will continue its line of flight but turn in an upwards curve towards the surface as it comes to rest. This offset from vertical is generally thought to be about one third of the penetration depth, but can be up to 15m depending on ground conditions or the bomb's angle of impact.

9.2.3.3. Second World War Bomb Penetration Studies

During WWII the Ministry of Home Security undertook a major study on actual bomb penetration depths, carrying out statistical analysis on the measured depths of 1328 bombs as reported by Bomb Disposal, mostly in the London area. They then came to conclusions as to the likely average and maximum depths of penetration of different sized bombs in different geological strata.

The median penetration of 430 x 50kg German bombs in London Clay was 4.6m and the maximum penetration observed for the SC50 bomb was 9m.

They concluded that the largest common German bomb, 500kg, had a likely penetration depth of 6m in sand or gravel but 8.7m in clay. The maximum observed depth for a 500kg bomb was 10.2m and for a 1000kg bomb 12.7m. Theoretical calculations suggested that significantly greater penetration depths were probable.

9.2.4. Initiation of Unexploded Bombs

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

- Direct impact onto the main body of the bomb: 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) to initiate a buried iron bomb. Such violent action can cause the bomb to detonate.
- Re-starting the clock timer in the fuze: Only a small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion has taken place within the fuze mechanism over the last 60 years that would prevent clockwork mechanisms from functioning, nevertheless it was reported that the fuze in a UXB dealt with by 33 EOD Regiment in Surrey in 2002 did re-commence.
- Induction of a static charge, causing a current in an electric fuze: The majority of German WWII bombs employed electric fuzes. It is probable that significant corrosion has taken place within the fuze mechanism over the last 60 years such that the fuze circuit could not be activated.
- Friction impact initiating the (shock-sensitive) fuze explosive: This is the most likely scenario resulting in the bomb detonating.

Annex F-2 details UXB incidents where intrusive works have caused UXBs to detonate, resulting in death or injury and damage to plant.

9.3. Second World War Bombing of Liverpool and Speke

During WWII Liverpool docks was the most important port outside London; a total of 74,000 aircraft and 4.7 million troops passed through the city. By early 1941 it represented a major naval base and headquarters for Britain's North Atlantic Campaign. Once London's port facilities were immobilised, following an intense bombing campaign, Liverpool became even more important to the British war effort. Furthermore, 100 warships were built at the Cammell Laird shipyards in the city.

German bombing over Liverpool was sporadic in the autumn of 1940, however the raids grew in intensity towards the end of the year. By 23rd October Liverpool had suffered 200 air raids, increasing to 300 by 12th December 1940.

The most intense periods of bombing were the 'Christmas Raids' of December 1940 and the week-long 'May Blitz' of 1941. The latter of which brought the most devastation with 500 roads closed and one third of the houses in Liverpool damaged or destroyed.

The heaviest raid over the city took place during the night of the 3rd May 1941 which coincidently saw the largest explosion on Merseyside during the war when the ammunition ship *SS Malakand* in Huskisson Dock No.2 exploded. The vessel contained 1,000 tonnes of bombs/shells and the resulting explosion destroyed several acres of the surrounding docks.

By the end of the 1941 Blitz, 69 out of 144 cargo berths within the Liverpool/Bootle docks were closed. The final raid on Liverpool occurred on the 10th January 1942.

A Luftwaffe target map (presented in Annex G) shows that the nearest docks to the site, The Stalbridge Docks 1.5km to the west, were earmarked for attack.

This annex also includes an aerial Luftwaffe reconnaissance photograph, highlighting an aircraft factory, approximately 1.4km to the south-east of the site. Note also that this facility is associated with RAF Speke airfield. This military base is also known to have been targeted by German aircraft during The Battle of Britain and is situated just 420m south of the study area.

Records of bombing incidents in the civilian areas of Liverpool were collected by the Air Raid Precautions wardens and collated by the Civil Defence Office, although some other organisations, such as the docks, maintained separate records. However it is understood that such records for Liverpool were destroyed by enemy action during WWII.

9.3.1. Second World War Bombing Statistics

The following table summarises the quantity of German bombs (excluding 1kg incendiaries and anti-personnel bombs) falling on the County Borough of Liverpool between 1940 and 1945. It does not include UXO found during or after WWII.

Record of German Ordnance Dropped on the County Borough of Liverpool	
Area Acreage	27,321
High Explosive Bombs (all types)	2,332
Parachute Mines	117
Oil Bombs	50
Phosphorus Bombs	0
Pilotless Aircraft (V1 Bomb)	0
Fire Pot	0
Total	2,499
Items Per 1,000 Acres	**91.5**

Source: Home Office Statistics

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. However it is estimated that during the seven consecutive nights Blitz in May 1941, approximately 112,000 1kg incendiaries were dropped over the city and surrounding area.

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

9.4. Site Specific WWII Bombing Records

9.4.1. Anecdotal Reports

Although official ARP written reports for Liverpool did not survive the war, BACTEC has found references to local bombing incidents within two publications[2]. The table below details those incidents in the vicinity of the site during WWII.

[2] Johnson, A., Merseyside's Secret Blitz Diary, Trinity Mirror Merseyside. 2005 and Hughes, J., Port in a Storm: The Air Attacks on Liverpool and its Shipping in the Second World War, 1993

Date	Weapon	Location	Remarks
n/k	HE Bombs	Garston L.M.S Timber Yard	None
15/09/1940	HE Bombs	RAF Speke	HE Bombs reported on Speke Airport field
17/09/1940	HE Bombs	Speke	HE's dropped near Roote's Aircraft Factory, Speke. Dwelling houses damaged.
12/10/1940	n/a	RAF Speke	Three Dorniers attacked by 611 Squadron during German sortie to bomb RAF Speke. One of the raiders forced to ditch in Cardigan Bay; second plane set alight but managed to return to base, badly damaged. third bomber crashed into the Irish Sea.
21/10/1940	HE Bombs	Speke	HE's dropped near Roote's Aircraft Factory, Speke, causing slight damage to overhead wires.
28/11/1940	IBs	Garston Docks	Areas of sheds at Garston Docks attacked, extensive fires reported.
29/11/1940	Unexploded Parachute Mine	Garston Gas Works	Mine fell in No.1 Gas Holder without exploding. The Mine was not rendered safe until 03/12/1940, until which time all access to the LMS Railways Garston Docks was blocked.
13/03/1941	2 x HE Bombs	Garston	Bombs fell on the "Cast Iron" shore at Garston. Several casualties
8/04/1941	IBs	Garston	150 IBs dropped over Garston area.
15/04/1941	HE Bombs, UXBs & IBs	Garston	Recorded as a heavy attack, lasting several hours. Works in Garston were hit including Blackwell's Metalurgical Works, Speke Road (where thermite is among the products); Bryant & May's Factory, (where there was a small fire); J Rawlinson's works, joiners and timber merchants; some houses were also struck in the same area. Many UXBs also reported to the area.

No incidents are recorded as having fallen on site, however the several bombs are reported within 1km of the study area. Note that this is not considered to be a comprehensive list of all bombing incidents in the area during WWII, as only anecdotal evidence was available.

9.4.2. RAF Battle of Britain Diaries

The complete RAF diaries of day to day activities and incident on RAF facilities during the Battle of Britain (July to October 1940) was obtained and reviewed.

As well as those incidents described above, the following also occurred at RAF Speke, just south of the study area.

- 29th August 1940 - Roote's Aircraft Factory attacked, Speke
- 27th September 1940 – Ineffective air raid on RAF Speke
- 7th October 1940 - Speke Aerodrome attacked at 23:50 hours
- 29th October 1940 – At 21:00 hours incendiary bombs caused some fires at the Speke Station railway sidings, approximately 1.48km east of the site.

9.4.3. Liverpool HE Bomb Damage Map

A HE bomb damage map for Liverpool was also obtained from Liverpool Record Office and is presented in Annex H. The closest reported damage is plotted approximately 940 south-west of the site.

Note that this is not a bomb plot map and only records locations damage. Therefore it is possible that bombs could have landed in open ground (causing no damage) in closer proximity to the site.

9.4.4. Second World War Era Aerial Photography

WWII-era aerial photography of the site was obtained from the Britain From Above Project. One oblique image of the study area dated 1947 is presented in Annex I.

This photograph, taken approximately five years after the last air raid over Liverpool, shows the site as it appears on historical OS mapping. The ground cover appears to be maintained grass; possibly a grazing field.

No significant bomb damage to buildings or railway sidings in the vicinity is apparent, however a possible HE bomb crater in a field a few hundred metres north-east of the site has been highlighted.

9.4.5. 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 were encountered, Bomb Disposal Officer teams would normally have been requested to attempt to locate, render safe and dispose of the bomb. Occasionally evidence of UXBs was discovered but due to a relatively benign position, access problems or a shortage of resources the UXB could not be exposed and rendered safe. Such an incident may have been recorded and noted as an Abandoned Bomb.

Given the inaccuracy of WWII records and the fact that these bombs were 'abandoned', their locations cannot be considered definitive, nor 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.

BACTEC holds no records of officially registered abandoned bombs at or near the site of any intrusive works.

9.4.6. Site Specific Bomb Penetration Considerations

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

- Geology – 4m of Made Ground (mainly sand, silty sand and clay with some gravel near the surface), 2.5m of stiff brown clay, 2.7m of dense brown silty sand, 2m of very stiff brown slightly sandy slightly gravelly clay, 1.24m of red sandstone
- Impact Angle and Velocity – 80-90^{O} from horizontal and 267 metres per second.
- Bomb Mass and Configuration – The 500kg SC (General Purpose) HE bomb, without retarder units or armour piercing nose. This was the largest of the common bombs used against Britain.

Taking into account the above-mentioned factors it has been assessed that a 500kg bomb would have had a maximum bomb penetration depth of up to **8m** below WWII ground level. Penetration depth could potentially have been greater if the UXB was larger (though only 4% of German bombs used in WWII over Britain were of that size). Note that UXBs may be found at any depth between just below the WWII ground level and the maximum penetration depth.

9.5. Likelihood of Post-raid UXO Detection

Utilising the above information, it is possible to make an assessment of the likelihood that evidence of unexploded ordnance would have been noted on a site during the war and the incident dealt with or recorded at the time. Factors such as bombing density, frequency of access, ground cover, damage and failure rate have been taken into consideration.

9.5.1. Density of Bombing

Bombing density is an important consideration for assessing the possibility that UXBs remain in an area. A very high density of bombs can for example result in increased levels of damage sustained to structures, greater likelihood of errors in record keeping and a higher risk that UXBs fell over the area.

Official bombing statistics for the city of Liverpool indicate a high bombing density. However this density was locally lower in Speke, due to its distance from the primary Luftwaffe target area, the city Docks.

Several raids are however known to have occurred over RAF Speke, 420m south of the site and over Garston to the west. A fairly heavy raid over the latter is also known to have resulted in many UXBs in the wider area.

9.5.2. Frequency of Access

Unexploded ordnance at sites where human access was infrequent would have a higher chance of being overlooked than at those sites which were subject to greater occupancy. The importance of a site or facility to the war effort is also an important consideration as such sites are likely to have been both frequently accessed and are also likely to have been subject to post-raid checks for evidence of UXO.

During WWII the site was undeveloped / relatively isolated and does not appear to have had any apparent use. Therefore access to the majority of the site will have been very limited and it is conceivable that parts were neglected for the duration of the war. Note however the allotment gardens at the western extent will have been subject to some level of access, depending on the season.

Therefore it is possible that a UXB could have fallen unobserved on site, especially since the majority of raids in the region occurred at night. Furthermore, ARP wardens are unlikely to have accessed the study area for post-raid UXO checks, due to its undeveloped nature and lack of importance.

9.5.3. Ground Cover

The degree and type of groundcover present during WWII would have had a significant effect on the visual evidence at ground level which may have indicated the presence of buried UXO.

During WWII the site was mainly occupied by a grass field. In addition there was some denser vegetation associated with the allotment gardens in the west and the stream in the east, whilst a pond encroached on the northern site boundary.

Consequently a UXB strike on site could conceivably have become obscured and remained undetected. Note that the entry hole of an SC 50 (the most commonly deployed German HE bomb) may have been as little as 20cm in diameter and therefore easily obscured in vegetation.

Furthermore, it should be noted that 1kg incendiary sub-munitions (known to be dropped in the vicinity) were also capable of significant penetration into soft soil (see Annex J) and therefore the possibility that such items remain in situ cannot be discounted.

9.5.4. Damage

If structures on a site have been subject to significant bomb or fire damage, rubble and debris are likely to have been present; similarly a HE bomb strike on open ground is likely to have resulted in a degree of soil disturbance. Under such conditions there is a greater risk of the entry holes of unexploded bombs dropped during subsequent raids being obscured and going unnoticed.

No buildings, to which damage could be ascribed, were located on site and no evidence of cratering was identified either.

9.5.5. Bomb Failure Rate

There is no evidence to suggest that the bomb failure rate in the vicinity of the site would have been different from the "approximately 10%" figure normally used.

10. The Threat from Allied Military Ordnance

10.1. General

BACTEC has found evidence to suggest that the surrounding area of the site had former military use which could have led to ordnance contamination.

The following potential military uses have been considered:

- Anti-Aircraft Defences
- Home Guard
- Training or firing ranges or the storage of ammunition
- Military bases
- Defensive minefields (including pipemines)
- Defensive Positions
- Manufacture of explosives or ordnance

The most likely source of Allied ordnance is from anti-aircraft fire and Home Guard activity, as discussed in the following sections.

10.1.1. Anti-Aircraft Artillery and Projectiles

At the start of the war two types of AAA guns were deployed: Heavy Anti-Aircraft Artillery (HAA), using large calibre weapons such as the 3.7" QF (Quick Firing) gun and Light Anti-Aircraft Artillery (LAA) using smaller calibre weapons such as 40mm Bofors gun.

During the early war period there was a severe shortage of AAA available and older WWI 3" and modified naval 4.5" guns were deployed alongside those available 3.7" weapons. The maximum ceiling height of fire at that time was around 11,000m (for the 3.7" gun and less for other weapons). As the war progressed improved variants of the 3.7" gun were introduced and, from 1942, large 5.25 inch weapons began to be brought into service. These had significantly improved ceiling heights of fire reaching over 18,000m.

The LAA batteries were intended to engage fast low flying aircraft and were typically deployed around airfields or strategic installations. These batteries were mobile and could be moved to new positions with relative ease when required. The most numerous of these was the 40mm Bofors gun which could fire up to 120 x 40mm HE shells per minute to over 1800m.

The HAA projectiles were high explosive shells, usually fitted with a time delay or barometric pressure fuze to make them explode at a pre-determined height. Before the war all the clockwork fuses used by the Royal Artillery had come from Switzerland. When that source of supply was cut off, Britain had been forced to make its own. After four years of war, the country still lacked the engineering skills to produce a reliable fuse. This resulted in a considerable number of AA projectiles either exploding prematurely, killing the gunners or failing to explode at all; falling to the ground as UXBs. In January 1944 more people in London were killed by HAA shells than by German bombs. Details of the most commonly deployed WWII AAA projectiles are shown below:

Gun type	Calibre	Shell Weight	Shell Dimensions
3.0 Inch	76mm	7.3kg	76mm x 356mm
3.7 Inch	94mm	12.7kg	94mm x 438mm
4.5 Inch	114mm	24.7kg	114mm x 578mm
40mm	40mm	0.9kg	40mm x 311mm

Although the larger unexploded projectiles could enter the ground they did not have great penetration ability and are therefore likely to be found close to WWII ground level. These shells are frequently mistakenly identified as small German air-delivered bombs, but are differentiated by the copper driving band found in front of the base. With a high explosive fill and fragmentation hazard these items of UXO present a significant risk if encountered. The smaller 40mm projectiles are similar in appearance and effect to small arms ammunition and, although still dangerous, present a lower risk.

Numerous unexploded AAA shells were recovered during and following WWII and are still occasionally encountered on sites today. Illustrations of anti-aircraft projectiles and rockets are presented at Annex K.

Three HAA batteries were located within 5km of the site. With four guns per battery firing several rounds per minute, HAA batteries could expel numerous shells in even the shortest engagements. Unexploded AA projectiles could land several kilometres from their batteries and therefore, due to the undeveloped nature of the study area, the risk of unexploded AA shell contamination is elevated.

10.1.2. Home Guard Activity

The Home Guard (HG) was a defence organisation of the British Army, operational between 1940 and 1944. It comprised 1.5 million local volunteers, otherwise ineligible for military service, and acted as a secondary defence force, in case of enemy invasion. The HG guarded the coastal areas of Britain and other important facilities such as airfields, factories and explosives stores. They were also very active in towns, villages and countryside, within the most at-risk coastal areas, such as Merseyside.

Records confirm that several individual HG battalions were based in the County Borough of Liverpool during WWII. On such unit, the 1st/8th Battalion, had a platoon detachment based at RAF Speke. This No.7 Platoon was given the task of defending Speke Aerodrome. Their main fortified position being a collection of four permanently manned machine guns near Rose Cottage[3].

Furthermore, information taken from the Council for British Archaeology's study of the WWII anti-invasion landscape of England, (mapping the locations and types of existing defences around the country) records two pillboxes in the wider area, approximately 690m to the south and 880m to the north of the site.

Thousands of these concrete fortifications were strategically positioned around the UK during the period of anticipated invasion in 1940 and they would have been manned by HG personnel, issued with weapons and ammunition during 1940 and 1941.

While no records of HG activity specifically on site could be located, official records were rarely kept by the HG and therefore any present day evidence is usually anecdotal. It is known however that HG personnel often carried out training in open countryside on the outskirts of cities and towns, and therefore the possibility cannot be completely discounted that such activity occurred on site, especially since the site was undeveloped and does not appear to have had any specific use.

Today, items of ordnance related to the HG and the military are occasionally encountered by members of the public and the construction industry in the British countryside. Experience has shown that the 'housekeeping' of less disciplined/voluntary HG personnel during WWII, was often poor with items of faulty/surplus UXO often burnt, buried, misplaced or otherwise discarded on civilian land.

[3] http://www.bbc.co.uk/history/ww2peopleswar/stories/84/a1124984.shtml

11. Ordnance Clearance and Post-WWII Ground Works

11.1. General

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

11.2. EOD Bomb Disposal and Clearance Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD) is currently facing considerable delay. It has therefore not been possible to include any official information regarding bomb disposal/clearance tasks on this site. A search of the BACTEC EOD clearance tasks database has not identified any EOD activity on or close to the site.

11.3. Post-War Redevelopment

Additional post-WWII OS mapping suggests that the study area has remained undeveloped. An aerial photograph dated December 2000 shows that the site was previously occupied by unmaintained, mixed vegetation. This has since been cleared, leaving the site in its current state.

12. The Overall Explosive Ordnance Threat Assessment

12.1. General Considerations

Taking into account the quality of the historical evidence, the assessment of the overall threat to any intrusive works from unexploded ordnance must evaluate the following risks:

- That the site was contaminated with unexploded ordnance
- That unexploded ordnance remains on site
- That such items could be encountered during any intrusive works
- That ordnance may be activated by the works operations
- The consequences of encountering or initiating ordnance

12.2. The Risk that the Site was Contaminated with Unexploded Ordnance

For the reasons discussed in Sections 9 and 10 BACTEC believes that there is a risk that unexploded ordnance contaminated the study area.

German UXO

- During WWII Liverpool was subjected to over 300 bombing raids, mainly due to the presence of the city's vital dock facilities, and by the end of the war it was the second most heavily bombed city in Britain.
- The site was situated several kilometres to the south of these primary Luftwaffe targets and therefore occupied an area of moderate bombing density. Note however RAF Speke and a neighbouring aircraft factory were situated just south of the site and both facilities are known to have been targeted during the Battle of Britain.
- Although not heavily bombed, RAF Speke (420m south of the site) was subjected to several raids and a fairly heavy raid was reported over Garston, 700m to the west. The latter resulting in many UXBs in the wider area.
- A bomb damage map does not highlight any damage close to the site, however the undeveloped nature of the area suggests any bombing in close proximity would not be recorded on this map, as no damage would be sustained. Also noteworthy is that two small pre-WWII buildings directly adjacent to the eastern site boundary, were demolished between 1936 and 1953; possibly the result of bombing.

- During WWII the site was undeveloped / relatively isolated and does not appear to have had any apparent use. Therefore access to the majority of the site will have been very limited and it is conceivable that parts were neglected for the duration of the war. Note however several allotment gardens at the western extent will have been subject to some level of access, depending on the season.
- Therefore it is possible that a UXB could have fallen unobserved on site, especially since the majority of raids in the region occurred at night. In addition, ARP wardens are unlikely to have accessed the study area for post-raid UXO checks, due to its undeveloped nature and lack of importance.
- Furthermore, had such an incident occurred the resulting evidence could have remained undetected. Note that the entry hole of an unexploded SC 50 (the most commonly deployed German HE bomb) may have been as little as 20cm in diameter and therefore easily obscured in vegetation.

British UXO

- During the period of anticipated invasion, several Home Guard units were active in Liverpool. One of which was attached to RAF Speke, just to the south of the site. Two pillboxes in the vicinity also indicate a Home Guard defensive presence.
- The house-keeping of less disciplined Home Guard personnel during WWII is known to have been poor with unwanted, faulty or expended items of land service and small arms ammunition often burnt, buried or discarded on civilian land.
- Although no evidence could be found to indicate that the site had any historical military use, it is known that the Home Guard often carried out training in unused open ground, on the edge of urban areas and therefore (although unlikely), the possibility that the site was used for training (which could have led to land service / small arms ammunition contamination) cannot be entirely discounted.

12.3. The Risk that Unexploded Ordnance Remains on Site

The site does not appear to have been subject to any significant post-WWII intrusive work or development and therefore the risk from both shallow buried UXO (1kg German incendiaries, British AAA shells, LSA and SAA) and deep buried German HE UXBs will not have been mitigated to any significant degree.

12.4. The Risk that Ordnance may be Encountered during the Works

The most likely scenarios under which a 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.

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

12.5. The Risk that Ordnance may be Initiated

The risk that UXO could be initiated if encountered will depend on its condition, how it is found and the energy with which it is struck. The most violent activity on most construction sites is percussive piling.

As a result items that are shallow buried present a lower risk than those that are deep buried, since the force of impact is usually lower and they are more likely to be observed – when immediate mitigating actions can be taken.

12.6. The Consequences of Encountering or Initiating Ordnance

Clearly the consequences of an inadvertent detonation of UXO during construction operations would be catastrophic with a serious risk to life, damage to plant and a total site shutdown during follow-up investigations.

Since the risk of initiating ordnance is comparatively low if appropriate mitigation measures are undertaken, the most important consequence of the discovery of ordnance will be economic. This would be particularly so in the case of high profile locations and could involve the evacuation of the public. The unexpected discovery of ordnance may require the closing of the site for any time between a few hours and a week with a potentially significant cost in lost time. Note also that the suspected find of ordnance, if handled solely through the authorities, may also involve loss of production since the first action of the Police in most cases will be to isolate the locale whilst awaiting military assistance, even if this turns out to have been unnecessary.

12.7. BACTEC's Assessment

Taking into consideration the findings of this study, BACTEC considers the risk from encountering UXO on site to be **Medium.**

	Level of Risk			
Type of Ordnance	**Negligible**	**Low**	**Medium**	**High**
German High Explosive Bombs			✓	
German 1kg Incendiary Bombs		✓		
British Anti-Aircraft Shells		✓		
British Land Service / Small Arms Ammunition		✓		

13. Proposed Risk Mitigation Methodology

13.1. General

BACTEC believes the following risk mitigation measures should be deployed to support any intrusive works at the Spitfire Road site.

13.2. Recommended Risk Mitigation Measures

All Works

- ***Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works:*** A specialised briefing is always advisable when there is a possibility of explosive ordnance contamination. It is an essential component of the Health & Safety Plan for the site and conforms to requirements of CDM Regulations 2007. All personnel working on the site should be instructed on the identification of UXB, actions to be taken to alert site management and to keep people and equipment away from the hazard. Posters and information of a general nature on the UXB threat should be held in the site office for reference and as a reminder.

- ***The provision of Unexploded Ordnance Site Safety Instructions:*** These written instructions contain information detailing actions to be taken in the event that unexploded ordnance is discovered. They are to be retained on site and will both assist in making a preliminary assessment of a suspect object and provide guidance on the immediate steps to be taken in the event that ordnance is believed to have been found.

Shallow Intrusive Works

- ***Non-Intrusive Magnetometer Survey and target investigation*** – This survey is carried out using caesium vapour magnetometers linked to a data logger. Data is interpreted using advanced proprietary software which is capable of modelling the magnetic anomalies for mass, depth and location, thus providing information which can be used to locate discrete buried objects that may be ordnance.

The system will typically locate buried ordnance to a depth of 4m for a 50kg bomb (the smallest HE bomb used by the Luftwaffe) and deeper for larger bombs. Additionally the survey will locate any buried services with a magnetic signature, will indicate areas of gross magnetic "contamination" (which may indicate unknown underground obstructions) and provide information on archaeological features.

In locations where this technique is impaired due to high levels of magnetic 'noise' in the ground or impossible due to restricted access, the following alternative measure is recommended:

- ***Explosive Ordnance Disposal (EOD) Engineer presence on site to supervise shallow intrusive works:*** When on site the role of the EOD Engineer would include; monitoring works using visual recognition and instrumentation and immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site; providing Explosive Ordnance Safety and Awareness briefings to any staff that have not received them earlier and advise staff of the need to modify working practices to take account of the ordnance threat, and finally to aid Incident Management which would involve liaison with the local authorities and Police should ordnance be identified and present an explosive hazard.

Deep Intrusive Works

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

BACTEC International Limited 9th January 2015

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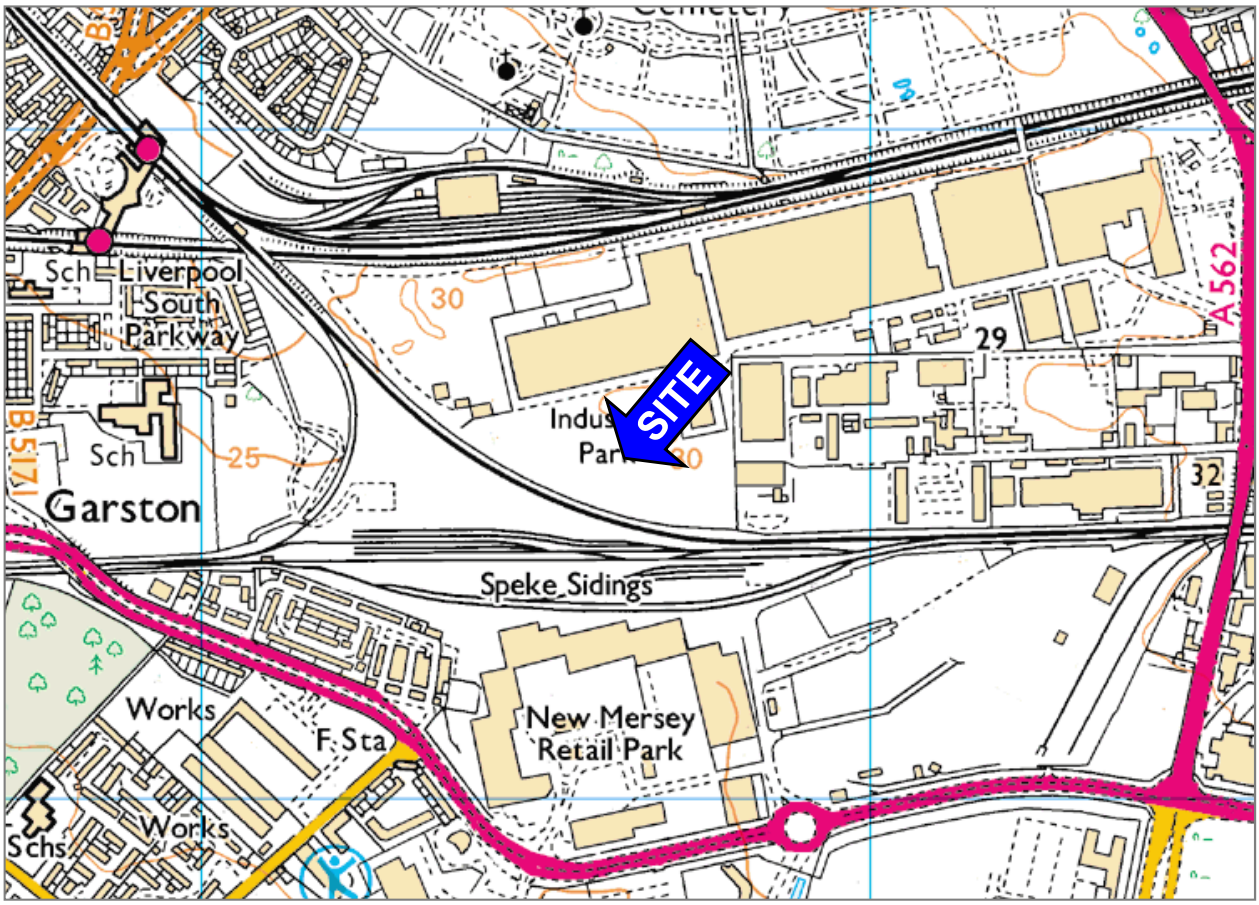
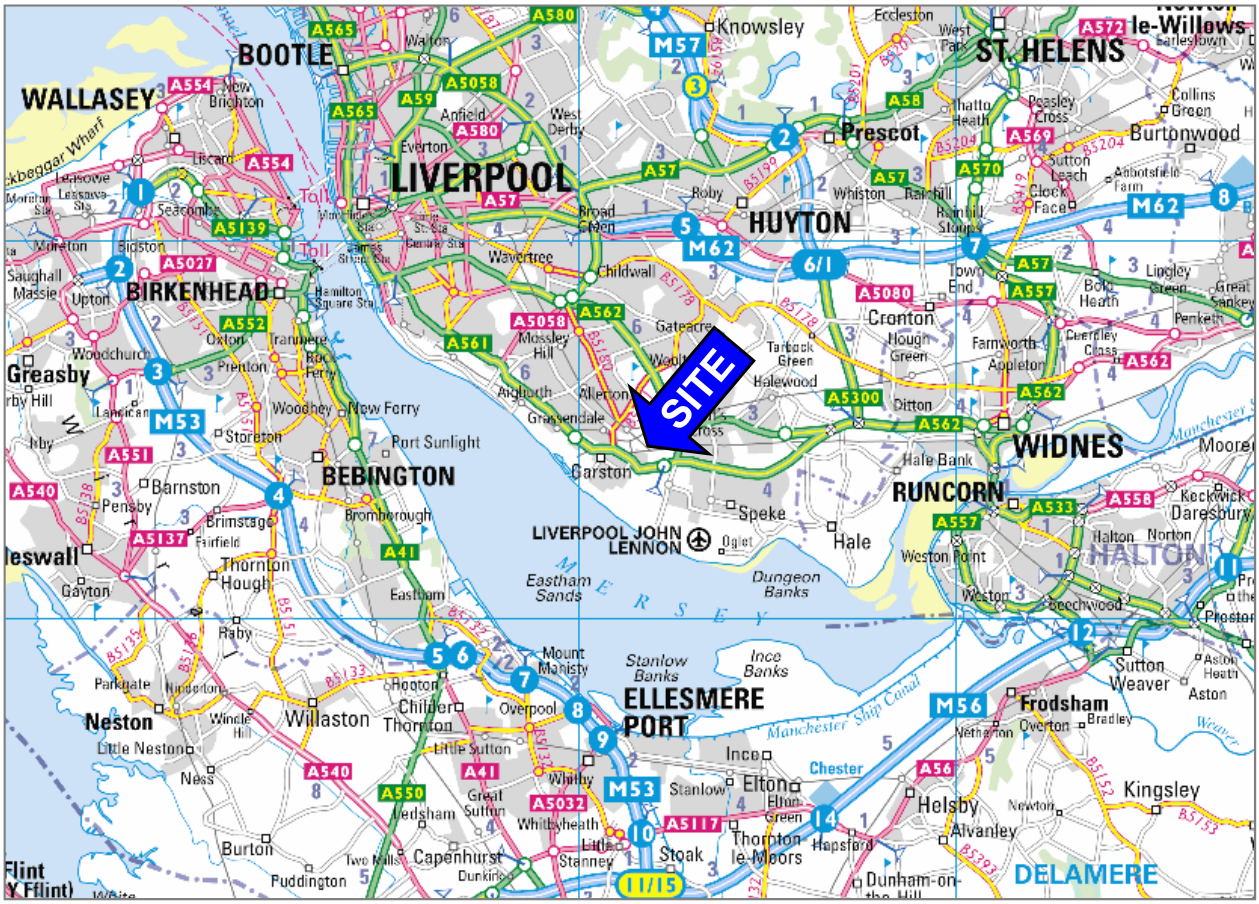
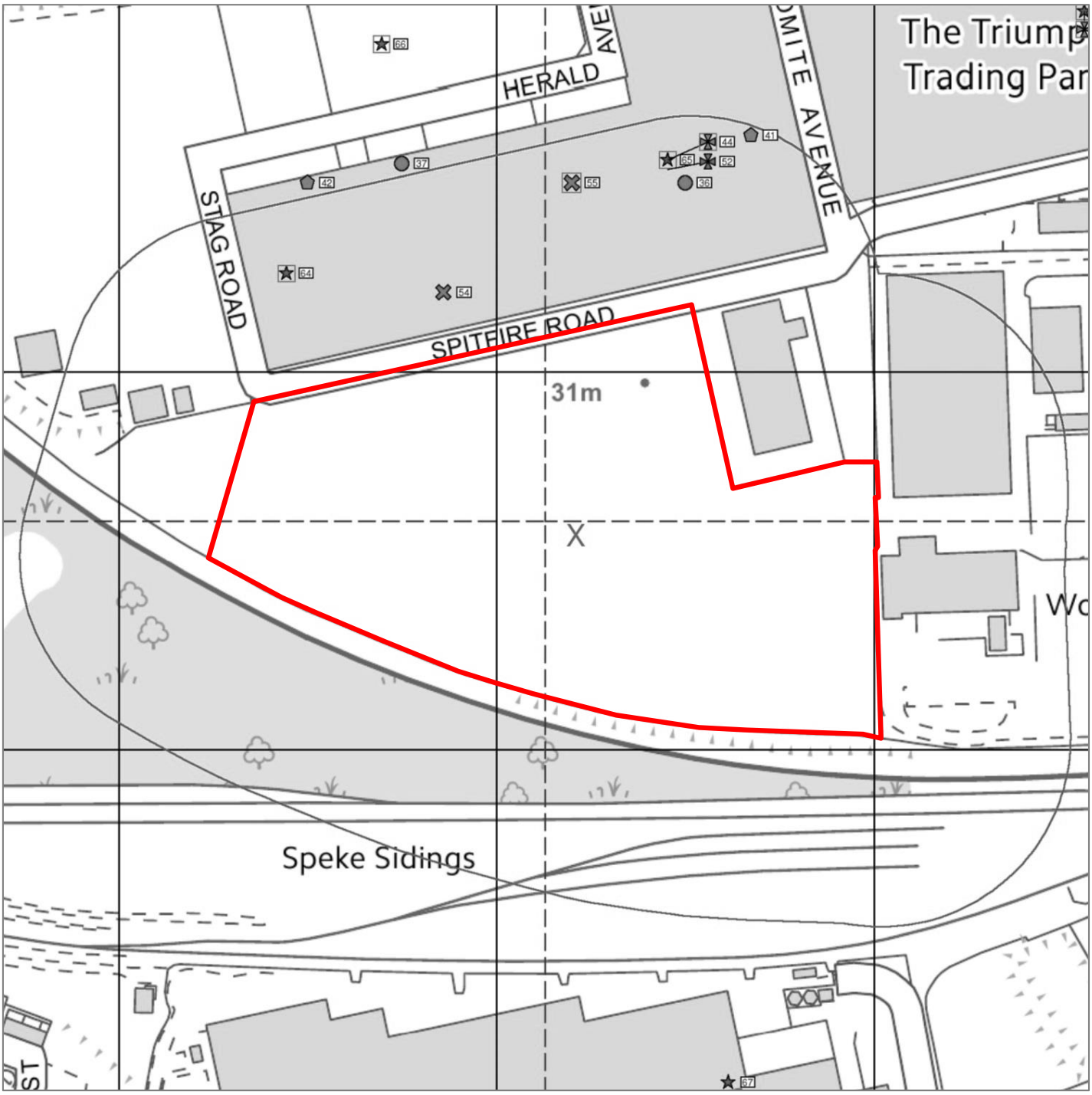




Report Reference:	Client:	
5831TA	LK Consult Limited	BACTEC
	Project: Spitfire Road, Speke	

Approximate site boundary

North

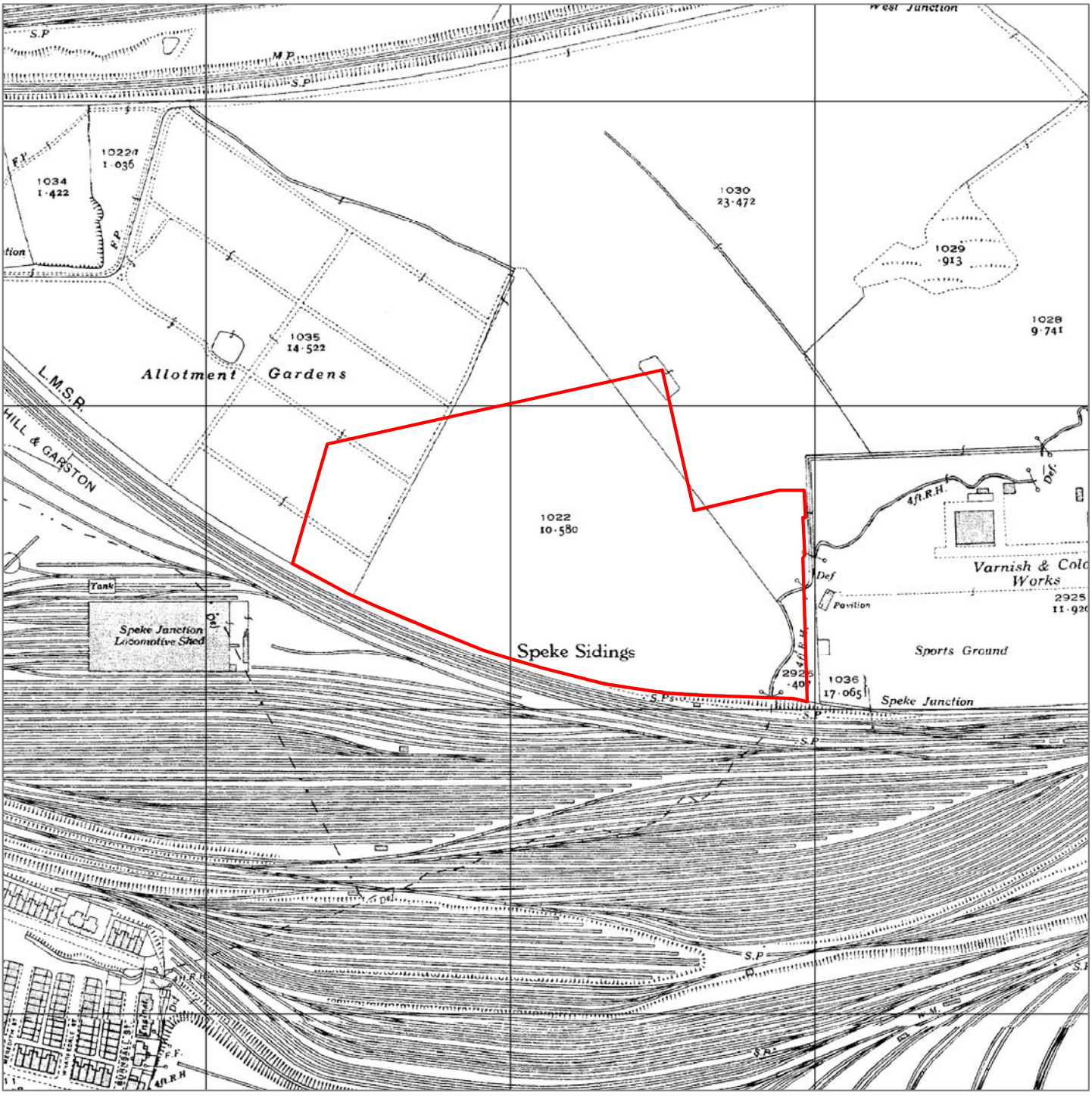


Site boundary

Report Reference:	Client:	
5831TA	LK Consult Limited	BAC TEC
	Project: Spitfire Road, Speke	

Source: LK Consult Limited

North



Approximate site boundary

Report Reference:	Client:	
5831TA	LK Consult Limited	BACTEC
	Project: Spitfire Road, Speke	

Source: Landmark Maps

North

Approximate site boundary

Cleared buildings

Report Reference:	Client:	
5831TA	LK Consult Limited	BACTEC
	Project: Spitfire Road, Speke	

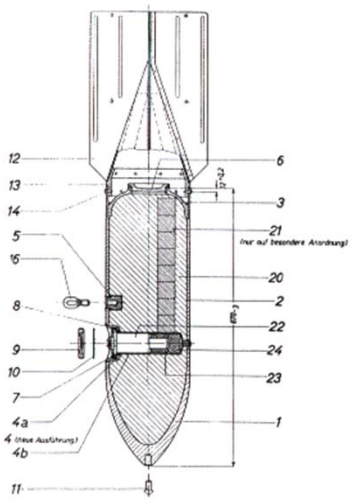
Source: Landmark Maps

SC 50

Bomb Weight:	40-54kg (110-119lb)
Explosive Weight:	c25kg (55lb)
Fuze Type:	Impact fuze/electro-mechanical time delay fuze
Bomb Dimensions:	1,090 x 280mm (42.9 x 11.0in)
Body Diameter:	200mm (7.87in)
Use:	Against lightly damageable materials, hangars, railway rolling stock, ammunition depots, light bridges and buildings up to three stories.
Remarks:	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.

50kg bomb, London Docklands

Minus tail section

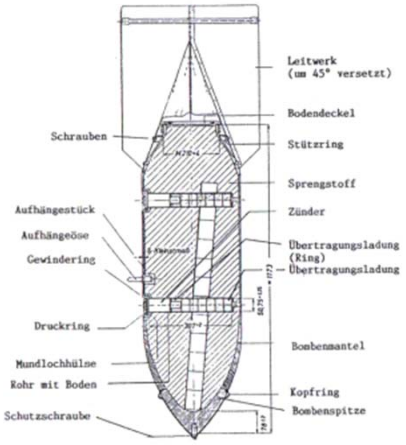


SC-50 JA (Güteklasse 1)

SC 250

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.

250kg bomb, Hawkinge

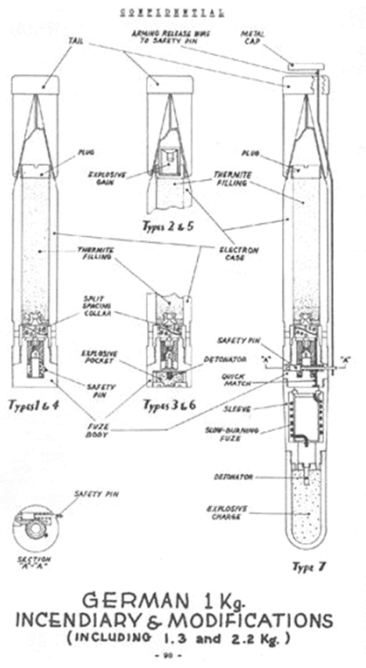


SC-250 JA (Güteklasse I)

1kg Incendiary Bomb

Bomb weight:	1.0 and 1.3kg (2.2 and 2.87lb)
Filling:	680gm (1.3lb) Thermite
Fuze type:	Impact fuze
Bomb dimensions:	350 x 50mm (13.8 x 1.97in)
Body diameter:	50mm (1.97in)
Use:	As incendiary – dropped in clusters against towns and industrial complexes
Remarks:	Jettisoned from air-dropped containers. Magnesium alloy case. Sometimes fitted with high explosive charge

1. Scaffold pipe
2. Incendiary 1kg bomb
3. Incendiary bomb recently found on site in UK



GERMAN 1 Kg. INCENDIARY & MODIFICATIONS (INCLUDING 1.3 and 2.2 Kg.)

Source: BACTEC International Limited and various historical sources

1st September 2012 News – **Unexploded World War II Device** detonated on Bournemouth beach
An unexploded World War II device has been detonated on Bournemouth beach, according to Dorset Police. The discovery was made on Friday at 19:11 BST near the junction of East Overcliff Drive and Manor Road.
http://www.bbc.co.uk/news/uk-england-dorset-19445172

31st August 2012 News – **Suspected Unexploded Weapon** found on Cornwall's Porthmeor beach
Lifeguards have found what is believed to be a section of an unexploded weapon on a Cornish beach.The object, which witnesses have said looks like a corroded depth charge - an anti-submarine warfare weapon - has been found at Porthmeor Beach, in St Ives, Falmouth Coastguard has said.
http://www.bbc.co.uk/news/uk-england-cornwall-19440291

11th August 2012 News – **Unexploded Bomb** uncovered by workmen in Carlisle
Army bomb disposal experts have been called to Carlisle after what is thought to be an unexploded bomb was dug up. Workmen on a building site at Trinity School uncovered the device earlier. Cumbria Police said a cordon had been put in place and the sports centre on Strand Road had been evacuated as a precaution. A bomb disposal unit from Catterick Garrison, in North Yorkshire, attended the scene.
http://www.bbc.co.uk/news/uk-england-cumbria-19224152

28th July 2012 News – Alert over **'unexploded shells'** in Sheerness Harbour
Thirty-nine people were evacuated from two vessels in Kent after suspected unexploded shells were found. A 100m exclusion zone was also put around Sheerness Harbour on Saturday afternoon after two separate calls. The first call came from a catamaran which had an 18in by 5in shell on its deck at about 14:00 BST. At 15:30 BST, a 90m cable layer reported having a 12in by 4in shell on board. The shells were later declared safe by Royal Navy experts.
http://www.bbc.co.uk/news/uk-england-kent-19034493

10th July 2012 News – **Unexploded WWII Bomb** safely detonated off Kent coast
An unexploded wartime German bomb found off the coast of Kent has been safely detonated, coastguards have said. The 500lb (226kg) device was discovered by a dredger in Dover harbour on Monday but it could not be made safe as the tidal conditions were not right. Dover Coastguard worked with a four-man Royal Navy bomb disposal team from Portsmouth to move it to a remote area. A spokeswoman said it was detonated at 08:45 BST, three-and-a-half miles (5.6km) east of Deal Pier. The World War II explosive was 3.3ft (1m) in length and was said to have had fins which had rusted off.
http://www.bbc.co.uk/news/uk-england-kent-18765547

8th April 2012 News – Huge explosion as experts detonate **large WWII Mine**
Water and ash were propelled more than 120m (390ft) into the air when Royal Navy experts detonated a German mine in the Thames estuary. The 750kg (1,650lb) unexploded World War II (WWII) weapon was placed on the sea bed after it was caught in the nets of a fishing boat earlier in the week. Divers brought it to the surface and then took it to a spot off Kent, during a "delicate" seven-hour operation.
http://www.bbc.co.uk/news/uk-england-kent-17652116

5th March 2012 News – Beach open after **WWII shell found**
A beach in County Londonderry has reopened after an unexploded World War II shell was found on Sunday. The device was discovered lying near the water on Benone beach by a member of the public. The beach was evacuated just before 16:00 GMT, and a controlled explosion was carried out by army bomb experts
http://www.bbc.co.uk/news/uk-northern-ireland-foyle-west-17255505

21st February 2012 News – **Two WWII bombs** detonated near Lincolnshire village
Bomb disposal experts have carried out a controlled explosion on two devices found near Manby in Lincolnshire. Anglian Water found the unexploded World War II shells near the former RAF Manby airfield, opposite the Motorplex building, on Monday. The area was cordoned off and police remained at the scene until experts from the Ministry of Defence explosive ordnance disposal team arrived.
http://www.bbc.co.uk/news/uk-england-lincolnshire-17111021

9th January 2012 News – County Durham road reopens after **WWII shell uncovered**
A road in County Durham was closed after an unexploded WWII shell was found. The shell was found on land at Slaidburn Road, Stanley, near the A693 Chester Road. Durham Police advised people to avoid the area, closing Chester Road and evacuating a local bus depot and nearby garage as a precaution. Catterick's bomb squad carried out a controlled explosion and all cordons have now been lifted.
http://www.bbc.co.uk/news/uk-england-tyne-16473968

13th October 2011 News – **WWII grenades** found near Gatwick Airport
Unexploded World War II hand grenades have been discovered close to Gatwick Airport. Network Rail staff found the explosives while working near Gatwick Airport railway station in West Sussex. A bomb disposal team was called in to carry out a controlled explosion at about 10:50 BST, Sussex Police said. The bomb disposal team found three hand grenades, one four-inch mortar and a smoke grenade in a metal container and identified them as World War II explosives, he added. Outgoing flights from the airport and rail services were halted as a precaution for about 15 minutes but have since resumed. The alert affected train services run by Gatwick Express, Southern, First Capital Connect and First Great Western.
http://www.bbc.co.uk/news/uk-england-sussex-15292719

SKY NEWS Website of the Year — FIRST FOR BREAKING NEWS

M62 Motorway Closed For Detonation Of World War Two Bomb

5:04pm UK, Friday January 04, 2008
A busy motorway has been closed to allow for a wartime bomb to be detonated nearby.


The controlled explosion

Army expertsdestroyed the huge Second World War device in a controlled explosion near the M62.

The motorway was shut in both directions between junctions 37 and 38 as a safety precaution.

The "deeply buried" bomb had lain dormant in an East Yorkshire field for almost 64 years.

The device was discovered by a metal detecting enthusiast on New Year's Eve in a field near the B1230 at Balkholme, near Howden, which was also closed.

An Army bomb disposal team travelled up from Essex to join police, ambulance and fire services and utility companies at the scene.

Captain Tim Ives, of 33 Engineer Regiment, earlier said 10 soldiers would be employed to "reduce the effects of the controlled explosion by packing sand around the device".

Page last updated at 14:45 GMT, Friday, 22 May 2009 15:45 UK
E-mail this to a friend Printable version

Building site WWII bomb exploded

Building site WWII bomb exploded

A controlled explosion has been carried out on a World War II bomb found on a building site in East Sussex.

The 110lb (50kg) SC50 bomb, thought to have been dropped from a German aircraft in 1940 or 1941, was found at the Hollenden House site in Bexhill.

Children at St Peter and St Paul Primary School next door in Buckhurst Road were sent home early after the discovery on Thursday.

Police said a 160ft (50m) cordon was put round the site during the blast.

BBC 14:23 GMT, Thursday, 5 June 2008 15:23 UK
E-mail this to a friend Printable version

Unexploded bomb 'started to tick'

An unexploded World War II bomb started to tick and ooze liquid as experts tried to defuse it, police have said.

The large bomb was found in a river at Sugar House Lane, near Bromley-by-Bow Tube station in east London, on Monday.

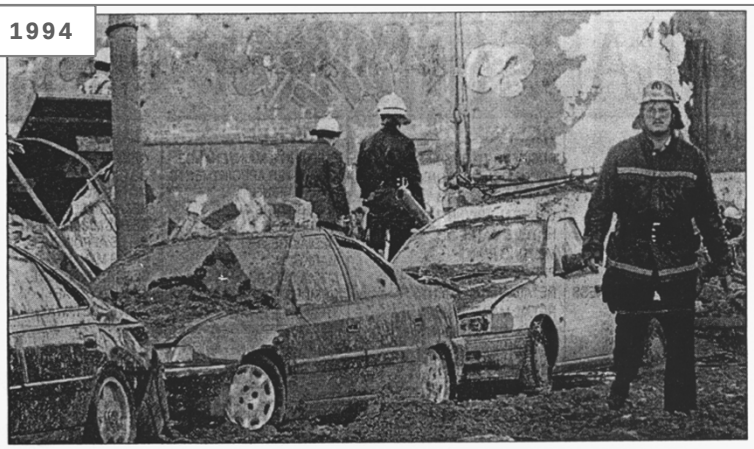
Rush-hour travel was disrupted as overnight work to make the bomb safe continued into Thursday morning.

Police commander Simon O'Brien said: "It started to tick and ooze some pretty horrible substances." It stopped ticking when doused with liquid.

'Hero colleague'

"It measures approximately the size and length of a man, and weighs around 1,000kg (2,200lb).

1994



RESCUE workers search for survivors after a Second World War bomb exploded at a building site in Berlin, killing three people and injuring at least eight others.
A fire brigade spokesman said he feared the final death toll could be higher. One worker was still missing, believed to be trapped under a machine. "We've found human remains 100 metres away but we can't tell if they belong to the dead already found," the spokesman said.
The blast, set off by drilling work on Frankfurter Allee, one of east Berlin's busiest avenues, trapped workers under building machinery and sent huge chunks of concrete tumbling through the air.
A large office block was being built on the site of the explosion which sent shoppers scrambling for shelter and paralysed dense afternoon traffic. One eyewitness said: "There was a bang, then silence, and then it started raining stones and dirt."
Dozens of cars within a 250-metre radius were wrecked and the top two floors of a nearby apartment block caved in.
Radio reports claimed that the total number of injured stood at 14.

Blown up by history

2008

2006

World War II bomb kills three in Germany

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

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

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

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

2010

2006

WW2 bomb blast kills digger driver in Germany

The bomb went off as the machine lifted up earth and debris

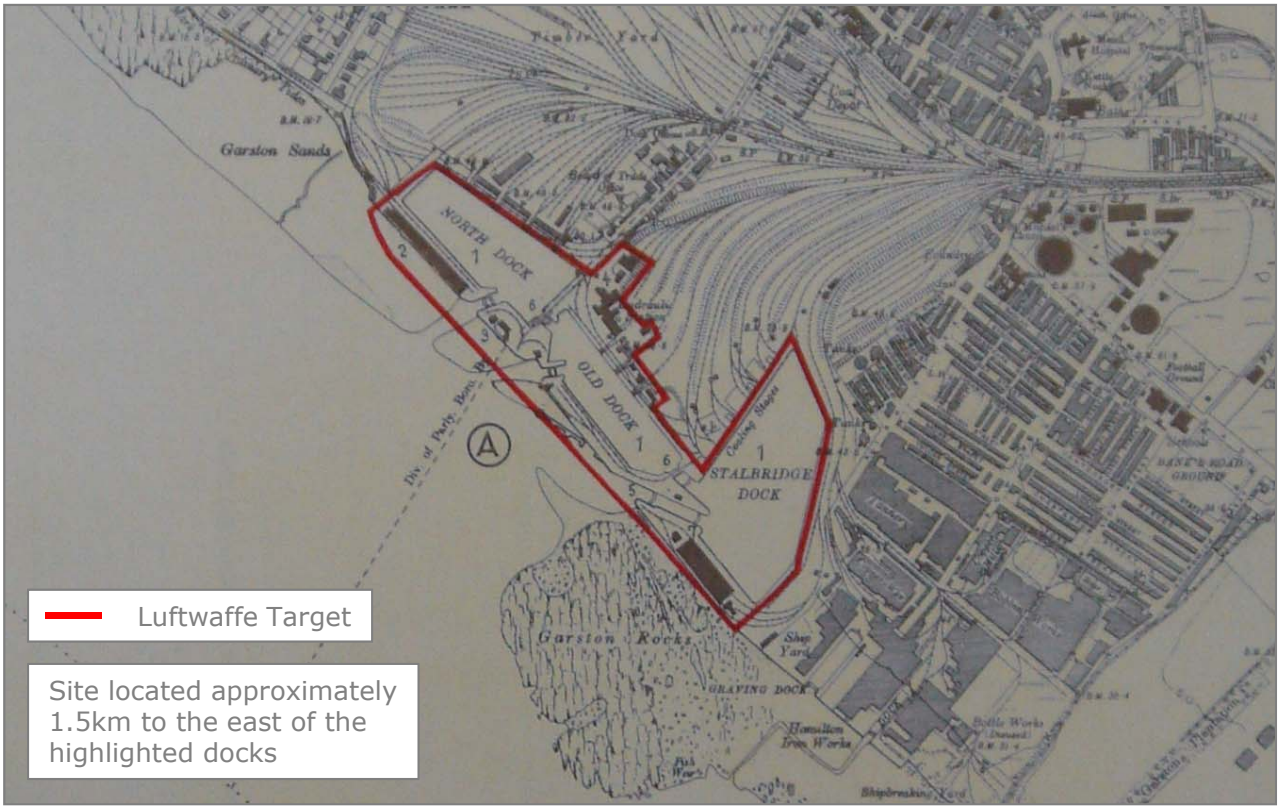
A World War Two bomb has exploded at a construction site near a west German town, killing a man and injuring eight others, police say.

The explosion occurred after a digger accidentally struck the device during excavation work in Euskirchen in the state of North Rhine-Westphalia.

The machine's operator died on the spot. Two of those hurt were critically wounded, the dpa news agency reports.

2014

Top Left: WWII bomb killed 3 and injured 8 in Berlin – 1994.
Middle Left: WWII bomb killed 3 in Goettingen, Germany – 2010.
Bottom Left: Excavator operator killed by WWII bomb in Euskirchen, Germany – 2014.
Top Right: WWII bomb injures 17 at construction site in Hattingen, Germany - 2008.
Middle Right: A highway construction worker in Germany accidentally struck a WWII bomb, killing himself and wrecking several passing cars - 2006.
Bottom Right: Destroyed piling rig and dump truck after detonation of WWII UXB in Austria - 2006.



Report Reference:	Client:	
5831TA	LK Consult Limited	BACTEC
	Project: Spitfire Road, Speke	

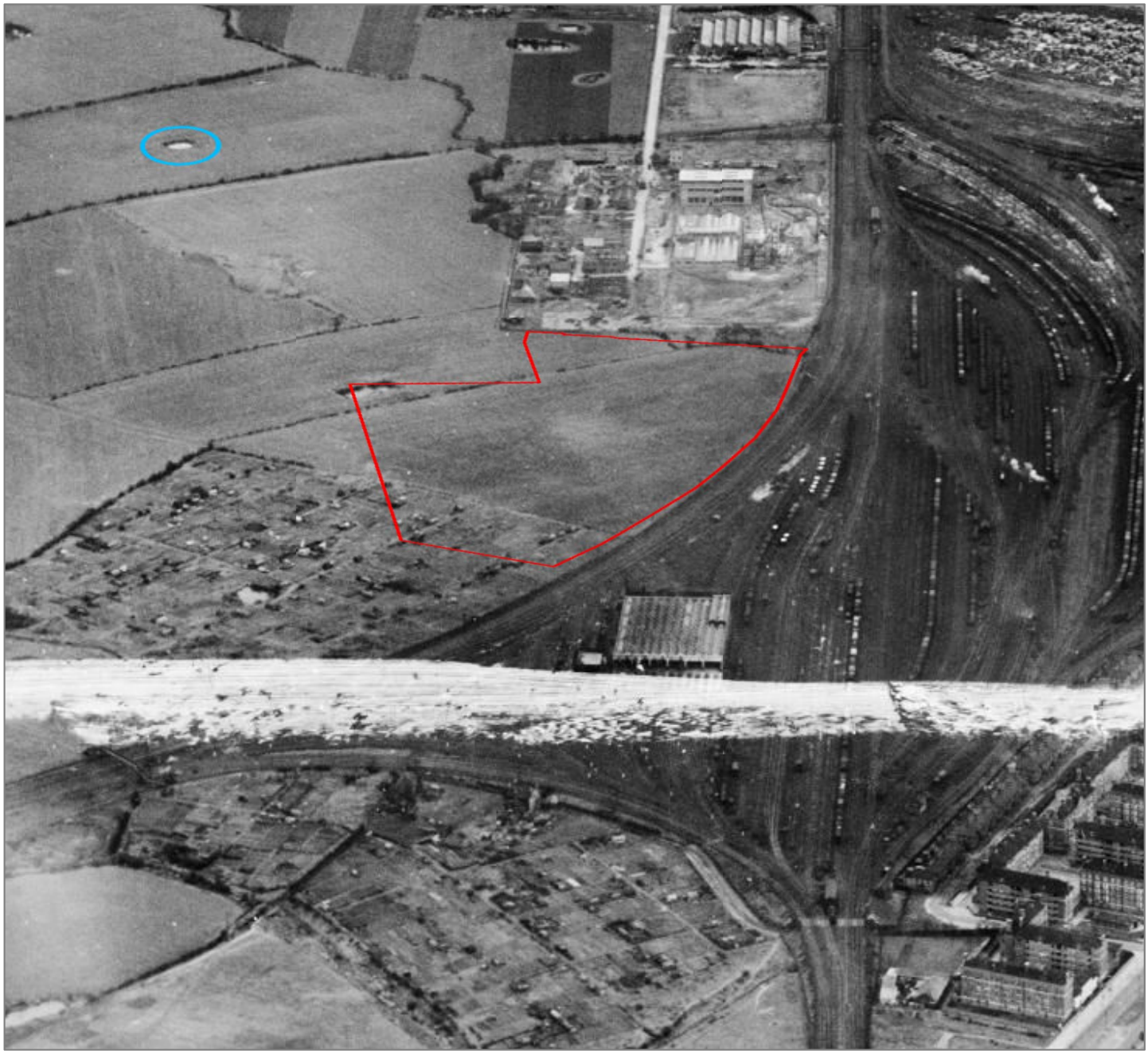
Source: Liverpool Record Office

North

- Approximate site boundary
- Serious HE bomb damage
- Serious fire damage

Report Reference:	Client:	
5831TA	LK Consult Limited	BACTEC
	Project: Spitfire Road, Speke	

Source: Liverpool Record Office



Approximate site boundary

Possible HE bomb crater

Report Reference:	Client:	
5831TA	LK Consult Limited	BAC TEC
	Project: Spitfire Road, Speke	

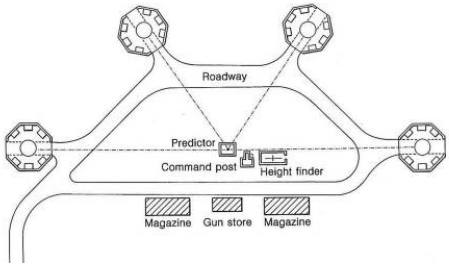
Source: Britain From Above

1kg German Incendiary Bomb next to a 30cm ruler

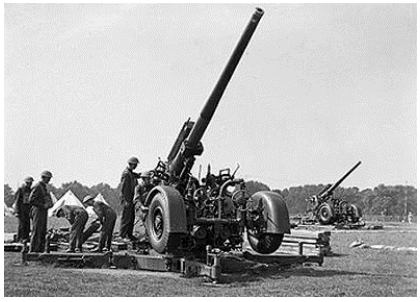
3.7 inch Anti-Aircraft Projectile

Weight:	12.7kg (28lb)
Dimensions:	94 x 360mm (3.7 x 14.7in)
Carriage:	Mobile and Static Versions
Rate of Fire:	10-20 rounds per minute
Ceiling:	9-18,000m (29-59,000ft)
Muzzle Velocity:	792m/s (2,598ft/s)
Remarks:	4.5 inch projectiles were also commonly utilised

Slade Green's HAA battery, Dartford showing typical size and layout of the installation.



Layout plan for a typical HAA battery site.

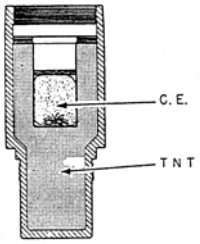


Hyde Park 1939 3.7 Inch QF gun on mobile mounting

3.7 inch AA Projectile Minus Fuze

Rockets / Unrotated Projectiles

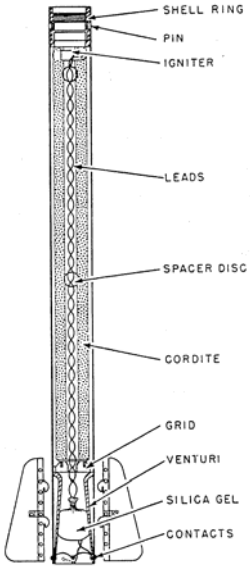
Weight:	Overall: 24.5kg (54lb) Warhead: 1.94kg (4.28lb)
Dimensions:	1930mm x 82.6mm (76 x 3.25in)
Carriage:	Mobile – transported on trailers
Ceiling:	6770m (22,200ft)
Maximum Velocity:	457mps (1,500 fps)



MK II HE Shell (3.5kg)

Rocket Battery in action

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



2" U.P AA Rocket

40mm Bofors Gun Projectile

Weight:	0.86kg (1.96lb)
Dimensions:	40mm x 310mm (1.6in x 12.2in)
Rate of Fire:	120 rounds per minute
Ceiling:	23,000ft (7000m)
Muzzle Velocity:	2,890 ft/s (881m/s)
Remarks:	Mobile batteries – normally few records of where these guns were located

Unexploded 40mm Bofors projectile recovered from a marine environment

40mm Bofors gun and crew at Stanmore in Middlesex, 28 June 1940.

Report Reference: 5831TA	Client: LK Consult Limited	BACTEC
	Project: Spitfire Road, Speke	

Source: BACTEC International Limited and various historical sources

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