Heckington Fen Solar Park

ENO10123

Environmental Statement | Volume 3: Technical Appendices

Appendix 18.1: UXO Risk Assessment

Applicant: Ecotricity (Heck Fen Solar) Limited

Document Reference: 6.3.18.1

Pursuant to: APFP Regulation 5(2)(a)

February 2023

Planning Act 2008

1ST LINE DEFENCE

Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	Heckington Fen
Client	Ecotricity (Heck Fen Solar) Ltd
Site Address	Heckington Fen, Lincolnshire
Report Reference	DA16024-01
Date	09/09/22
Originator	ER

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Executive Summary

Site Location and Description

The site is situated within the Borough of Boston and North Kesteven District, Lincolnshire. It is bound by open land/fields and several small roadways.

The site is divided into two areas: the Energy Park Area (Site A) in the north and the Grid Connection Routes Area (Site B) in the centre and south. Both site areas are occupied by open land/fields. An electricity substation and wind turbines are located in the southern section of Site B. The South Forty Foot Drain and railway tracks also run through the north of Site B.

The northern point of the site is approximately centred on the OS grid reference: **TF 19976 46722**.

The central point of the site is approximately centred on the OS grid reference: **TF 20816 42652**.

The southern point of the site is approximately centred on the OS grid reference: **TF 19569 38313**.

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

Proposed Works

Information provided by the client indicates that the proposed works on site will include the construction of ground-mounted solar panels, an energy storage facility, a below-ground grid cable connection to Bicker Fen Substation and associated infrastructure works.

Geology and Bomb Penetration Depth

The British Geological Survey (BGS) map shows the site to be underlain by the West Walton Formation – mudstone and siltstone of the Jurassic Period. The superficial deposits are described as Tidal Flat Deposits – clay and silt of the Quaternary Period.

Although site-specific geotechnical information has been provided by the client, due to the lack of an 'N' value – which indicates the density of an area's subsurface geology – it has not been possible to determine maximum bomb penetration capabilities at this stage of the report. An assessment can be made once further information becomes available or by an UXO Specialist on-site. 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 an overall **Low Risk** from German and anti-aircraft unexploded ordnance at the site of proposed works. The risk from Allied unexploded ordnance is not considered to be homogenous. The central section of the site has been elevated to **Medium Risk**, due to the presence of a WWII-era Home Guard Auxiliary base in this approximate location. The remainder of the site is considered to be of **Low Risk**, although it cannot be completely discounted that Home Guard activity also affected this area.

German Aerial Delivered Ordnance

- During WWII, the site was located within the Rural District of East Kesteven and the Rural District of Boston. The Rural District of Spalding was also located adjacent to the south of the site boundary. According to official Home Office bombing statistics, these districts each sustained an overall very low density of bombing, with an average of less than 3 bombs per 1,000 acres recorded in each. This is mainly due to the rural environment of the local area and the lack of significant Luftwaffe targets nearby. Nevertheless, the towns of Boston and Sleaford are known to have suffered sporadic bombing raids during the war.
- The site area was primarily occupied by open land/fields. East Heckington was located in northern section of the site (the southern section of Site A) and the *GNR* railway and *South Forty Foot Drain* ran through/adjacent to the centre of the site (the northern section of Site B).
- Several anecdotal accounts recorded isolated bomb incidents in the local area, including at a field near to East Heckington, the *GNR* railway and Swineshead (located approximately 750m east of Site B). Incidents were also recorded in the civil parishes of Heckington, Great Hale, Little Hale, South Kyme and Helprignham, all of which bordered the site boundary to the west.
- The ground cover across almost the entire site would not have been particularly conducive to the detection of signs of UXO. For example, the entry hole of an unexploded bomb could have been as little as 20cm in diameter and therefore overlooked in certain ground conditions, especially large areas of open land. Similarly, the level of access across most of the site is not thought to have been frequent, with the exception being sections of the site occupied by railway lines or

UXO Risk Assessment

features associated with East Heckington. Both of these factors are however considered to be less of a concern on this occasion due to the limited level of bombing in the region.

- When taking the overall very-low density of bombing recorded in the region and the lack of any significant urban, industrial or military targets in the locality (the surrounding area was largely agricultural land) the risk of UXO contamination is not considered to be elevated above the 'background level' of risk for this section of the UK.
- Subsequently, although a number of incidents are recorded in the locality, the quantity of these is not considered unusual considering the large size of the site area and as a result, these incidents are not considered to significantly elevate the risk of UXO on site.
- While the possibility of UXO falling unnoticed and remaining today within the site area cannot be entirely dismissed, due to the site's size and open nature, no definitive evidence could be identified to suggest that the site area in particular is at an increased risk of encounter of UXO. For this reason, the site has been deemed to be at a **Low Risk** from items of unexploded German air-delivered ordnance.
- *It should be noted however that the while risk from UXO is not considered significant enough to warrant active UXO risk mitigation measures, within any section of the site area, it is certainly recommended that ground personnel are given UXO safety and awareness briefings to make them aware of the history of the site, what to look out for, and what to do in the event that a suspect item is encountered.*

Military Ordnance

- An Auxiliary Unit (AU) operational base was recorded at Royalty Farm/Swineshead Bridge, near to the *GNR* railway and the *South Forty Foot Drain*, the former location understood to be situated within the northern section of Site B. AUs were small bands of local volunteers tasked with conducting guerrilla activities behind German lines in the event of a potential German invasion of Britain. As such, these small scale bases were typically stored with items of Land Service Ammunition (LSA) and Small Arms Ammunition (SAA), explosives, rifles, fuses, detonators and sticky bombs. Indeed, one member of the local Swineshead AU stated: 'we were issued with an amazing set of supplies – revolvers and Sten guns, hand grenades, knives and plastic explosives'. It is unknown if this base has been cleared post-WWII.
- The Swineshead Auxiliary Unit is understood to have trained in the local area and conducted mock attacks on nearby villages with plastic explosives. The British Army is also understood to have taken part in these exercises. A member of the local Swineshead Patrol further stated: 'We trained using real explosives, brought down trees and that sort of thing. No one from the surrounding area took much notice of a few extra explosions going off'. Three more Auxiliary Unit bases were recorded between 2km and 5km of the site boundary, suggesting that the local area was used for training by several such units.
- The local area in and around Swineshead is also understood to have been used for training by a local Home Guard unit, who also manned a pillbox in the area during exercises.
- An anti-aircraft searchlight is understood to have been located adjacent to the central eastern border of Site B, although it is unknown if this searchlight was defended with weaponry.
- In summary, an Auxiliary Unit operational base was recorded on/adjacent to the northern section of Site B. These bases were typically stored with items of LSA, SAA and explosives. The local Swineshead Auxiliary Unit is also understood to have trained in the local area and took part in mock attacks on nearby villages with the British Army. It is also unknown if this base was cleared after WWII. Considering the presence of this unit and the operational base, this part of the northern section of Site B has been assessed to be at **Medium Risk** of military ordnance. See risk mapping of the site on **Annex G.**
- While much of the site area was not located near to the Auxiliary Base, it cannot be completely discounted that the open land/fields around the base were used for associated training or the storage/disposal of ordnance by the Home Guard. Thus, whilst there is no positive evidence that there was a military presence within the rest of the site area and the risk is assessed to be low, awareness briefings or a site specific safety package should be considered as a minimum precaution for these areas.

Post-War Redevelopment

- There has been little significant post-WWII development across the site, as it is still almost entirely occupied by open land/fields. Two substations and a wind farm comprising 13 turbines have been built in the south of Site B.
- The risk of UXO remaining is considered to be mitigated at the location of and down to the depth of any post-war redevelopment on site. For example, the risk from deep buried UXO will only have been mitigated within the volumes of any post-war pile foundations or deep excavations for basement levels. The risk will however remain within virgin geology below and amongst these post-war works, down to the maximum bomb penetration depth.

Recommended Risk Mitigation Measures

A combination of the following risk mitigation measures are recommended to support the proposed works at the Heckington Fen site:

All Works

- UXO Risk Management Plan
- Site Specific UXO Awareness Briefings to all personnel conducting intrusive works.
- Provision of Site Specific Safety Package (SSSP) – training to allow the client to undertake basic safety and awareness briefings.

Medium Risk Area

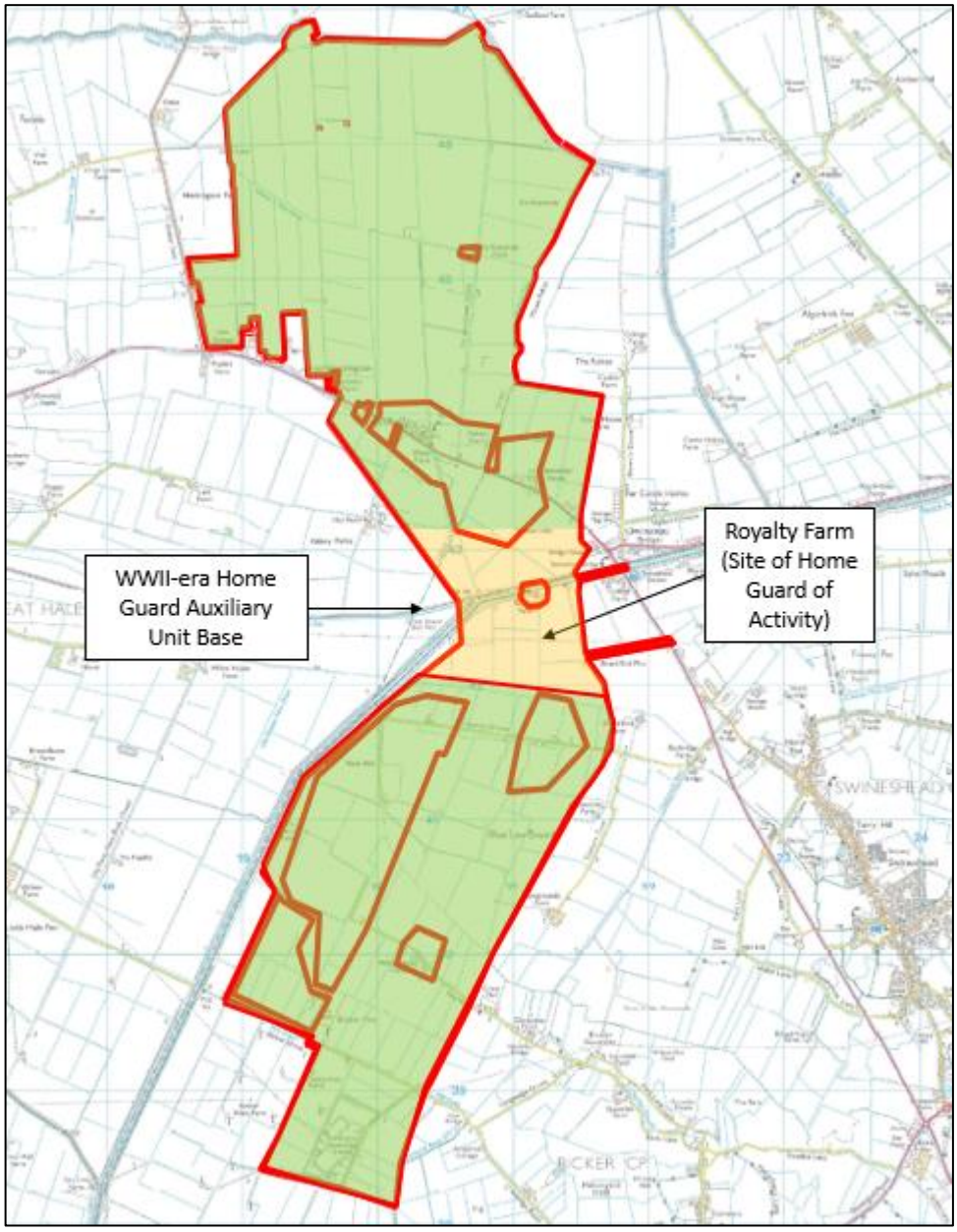
Open Intrusive Works (trial pits, service pits, open excavations, shallow foundations etc.)

- Non-Intrusive UXO Magnetometer Survey and Target Investigation.

  Where this type of survey is not practical (due to for example terrain or ground conditions), the following is recommended to support shallow intrusive works
- UXO Specialist On-site Support

Note – the above risk mitigation measures are not considered necessary for any works, including trial pits or ground investigation works, taking place at the location of and at the depths of any post-war development present. The risk will however remain within virgin geology below and amongst these post-war developments down to the maximum bomb penetration density.

Allied UXO Risk Map



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

Low Risk

Medium Risk

1st Line Defence Risk Mitigation Services:

All Areas of the Site:

- Site Specific Unexploded Ordnance Awareness Briefings – a service recommended to all personnel conducting intrusive works.
- UXO Risk Management Plan

Medium Risk Areaa of the site:

Open Intrusive Works (trial pits, service pits, open excavations, shallow foundations etc.)

- Non-Intrusive UXO Magnetometer Survey and Target Investigation.

  Where this type of survey is not practical (due to for example terrain or ground conditions), the following is recommended to support shallow intrusive works
- UXO Specialist On-site Support

Glossary

Abbreviation	Definition
AA	Anti-Aircraft
AFS	Auxiliary Fire Service
AP	Anti-Personnel
ARP	Air Raid Precautions
AU	Auxiliary Unit
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
JSEODOC	Joint Services Explosive Ordnance Disposal Operation Centre
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: Heckington Fen
Client: Ecotricity

1. Introduction

1.1. Background

1st Line Defence has been commissioned by Ecotricity to conduct a Detailed Unexploded Ordnance (UXO) Risk Assessment for the works proposed at Heckington Fen, including an underground cable to Bicker Fen Substation.

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 Heckington Fen. 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 air 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.
- Historical mapping datasets.
- Historic England National Monuments Record.
- Relevant information supplied by Ecotricity.
- Available material from 33 Engineer Regiment (EOD) Archive (part of 29 Explosive Ordnance and Disposal and Search Group).
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published books and internet resources.

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 for 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 the risk posed by UXO to 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 air 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 Operation Centre (JSEODOC) to arrange for investigation and/or disposal. Within the Metropolitan Police Operational Area, SO15 EOD will be tasked to any discovery of suspected UXO. The request for Explosive Officer (Expo) support is well understood and practiced by all Metropolitan Boroughs. The requirement for any additional assets will then be coordinated by the Expo if required.

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 the EOD teams' 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 JSEODOC 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 situated within the Borough of Boston and North Kesteven District, Lincolnshire. It is bound by open land/fields and several small roadways.

The northern point of the site is approximately centred on the OS grid reference: **TF 19976 46722**.
The central point of the site is approximately centred on the OS grid reference: **TF 20816 42652**.
The southern point of the site is approximately centred on the OS grid reference: **TF 19569 38313**.

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

6.2. Site Description

The site is divided into two areas: the Energy Park Area (Site A) in the north and the Grid Connection Routes Area (Site B) in the centre and south. Both site areas are occupied by open land/fields. An electricity substation and wind turbines are located in the southern section of Site B. The South Forty Foot Drain and railway tracks also run through the north of Site B.

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

Information provided by the client indicates that the proposed works on site will include the construction of ground-mounted solar panels, an energy storage facility, a below-ground grid cable connection to Bicker Fen Substation and associated infrastructure works.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows the site to be underlain by the West Walton Formation – mudstone and siltstone of the Jurassic Period. The superficial deposits are described as Tidal Flat Deposits – clay and silt of the Quaternary Period.

8.2. Site Specific Geology

Site-specific borehole data was obtained from the British Geological Survey. See below for a brief example description showing the geology typically encountered.

Example Borehole	
Depth (ft)	**Description**
0 – 1.6	Soil
1.6 – 2.6	Grey sand
2.6 – 3.6	Sand and gravel
3.6 – 240	Grey clay

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.

Pre-WWII		
Date	**Scale**	**Description**
1903-06	1:2,500	The site was occupied by open land/fields. Part of *East Heckington* was located in the south of Site A. *South Forty Foot Drain* and the *GNR Grantham, Sleaford and Boston* railway ran through the north of Site B.

Post-WWII		
Date	**Scale**	**Description**
1946-51	1:2,500	There was little significant change on site, as it was still occupied by open land/fields.

10. Introduction to German Air 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 air delivered ordnance dropped during WWII, although WWI bombing will also be considered.

10.2. Generic Types of WWII German Air 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 air 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 **Appendices i-iii**.

Generic Types of WWII German Air 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 **Appendix iv**). 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)	These were deployed less frequently than HE and IBs due to size, cost and the difficulty of deployment.	If functioning correctly, PMs would generally 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 Air Delivered Ordnance

It has been estimated that 10% of WWII German air 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, over 7,000 anti-aircraft projectiles and 300,000 beach mines. Unexploded ordnance is still regularly encountered across the UK, see press articles in **Appendices v – viii**.

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 Principle

J-curve is the term used to describe the characteristic curve commonly followed by an air 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 **Appendix iv**).

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 drawn predicting 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 should be used:

- WWII geology – West Walton 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).

Although site-specific geotechnical information has been provided by the client, due to the lack of an 'N' value – which indicates the density of an area's subsurface geology – it has not been possible to determine maximum bomb penetration capabilities at this stage of the report. 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 Lincolnshire were generally too far to be considered for V-weapon strikes by the Luftwaffe. The risk from V-weapons is therefore considered negligible and will not be further addressed in this report.

11. The Likelihood of Contamination from German Air 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. The objective of these raids was to unnerve the British public, to destroy strategic targets and to ultimately attempt to coerce Britain's capitulation from the war. A WWI map of air raids and naval bombardments across the UK was consulted, see **Appendix ix**. This source showed a nearby incident to the south-east of Sleaford.

11.1.1. World War I Bombing of Swineshead

According to Ian Castle's *Britain's First Blitz* project, the nearby village of Swineshead – located approximately 750m east of the site – was bombed by Zeppelin L 23 on 2nd/3rd September 1916. A relevant passage has been transcribed below:

> Zeppelin L 23 approached the Norfolk coast over The Wash. […] Another HE bomb dropped, landing at Kirton Holme, then two landed at Swineshead before L 23 turned south and released another that fell at Gosberton. There was no recorded damage.[2]

11.1.2. Evaluation

An isolated WWI bombing incident has been identified in the site's wider vicinity, however no WWI bombing has been identified directly on-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. 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.

[2] Ian Castle, Britain's First Blitz.

11.2. World War II Bombing of East Kesteven, Boston and Spalding

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 Site A was located within the Rural District of East Kesteven and most of Site B was located within the Rural District of Boston. The Rural District of Spalding was also located adjacent to the south of Site B (see **Annex E**). These districts sustained an overall very low density of bombing, as represented by bomb density data figures, see Section 11.4. This is mainly due to the rural environment of the local area and the lack of significant Luftwaffe targets nearby. Nevertheless, the towns of Boston – located approximately 7km east of the site – and Sleaford – located approximately 10km west of the site – are known to have suffered sporadic bombing raids during the war.

Records of bombing incidents in the civilian areas of East Kesteven and Boston were typically collected by Air Raid Precautions wardens and collated by Civil Defence personnel. 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 are presented in the following sections.

11.3. WWII Home Office Bombing Statistics

The following tables summarise the quantity of German air delivered bombs (excluding 1kg incendiaries and anti-personnel bombs) dropped on the Rural Districts of East Kesteven, Boston and Spalding between 1940 and 1945.

Record of German Ordnance Dropped on the Rural District of East Kesteven		
Area Acreage		**123,406**
Weapons	High Explosive bombs (all types)	296
	Parachute mines	2
	Oil bombs	2
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	0
	Long range rockets (V-2)	0
Total		**300**
Number of Items per 1,000 acres		**2.4**

Record of German Ordnance Dropped on the Rural District of Boston		
Area Acreage		**84,398**
Weapons	High Explosive bombs (all types)	215
	Parachute mines	0
	Oil bombs	4
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	0
	Long range rockets (V-2)	0
Total		**219**
Number of Items per 1,000 acres		**2.6**

Record of German Ordnance Dropped on the Rural District of Spalding		
Area Acreage		**87,758**
Weapons	High Explosive bombs (all types)	65
	Parachute mines	2
	Oil bombs	1
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	0
	Long range rockets (V-2)	0
Total		**68**
Number of Items per 1,000 acres		**0.8**

Source: Home Office Statistics
These tables do 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 did not record these types of ordnance, both should not be overlooked when assessing the general risk to personnel and equipment.

11.4. Report on Enemy Attack in Boston

A written report which recorded details of a bombing raid in Boston on 22nd/23rd August 1942 was obtained from the National Archives. A relevant passage, presented in **Annex F**, is transcribed below:

> 'Bomb numbers 9-12, all UXBs, fell in a long stick in open fields to the south-west of Boston. Numbers 9 and 10 straddled the Boston-Grantham Railway.'

However, despite the reference to the *GNR* railway which ran through the site boundary, due to the distance of the site from Boston, this incident is not thought to have affected the site.

11.5. *Sleaford Gazette* Bombing Report

A bombing report produced by the *Sleaford Gazette* on 3rd November 1944 was obtained online. A relevant passage has been transcribed below:

> 'The village of Heckington was bombed by the Luftwaffe on three occasions and bombs are recorded to have fallen twice at Helpringham and Little Hale. The Germans confined themselves to dropping bombs only once at Great Hale and South Kyme. When Sleaford people realise how close they have been to the focal point of many raids they can be thankful that the Luftwaffe, in the earlier years of the war, were inaccurate.'[3]

The villages referenced above were situated at least 3km from the site, to the west/north west of the site boundary. Whilst these incidents are not thought to have affected the site boundary, they do provide context to bombing in the wider area.

11.6. BBC *WW2 People's War*

Several accounts of bombing in the local area were obtained from the BBC's online history project *WW2 People's War*. One account, from an individual who lived in Swineshead during the war, has been transcribed below:

> 'The nearest any German bombs dropped to where I lived was half a mile away. They woke us all up about 7.20 am; it was still dark. The house shook and windows rattled.'[4]

Another account, from an individual who lived in East Heckington – part of which was located in the south of Site A – has also been transcribed below:

'In 1940, I remember German planes flying over the house, down Side Bar Lane [*located on/adjacent to the west of Site A*] at East Heckington. A searchlight battery division was stationed and we could see planes in the beams. One dropped a bomb which landed in a field ¾ mile from where we lived. It was obviously aiming for the GNR railway. Two land mines dropped in the farmyard, one exploded shattering the windows of the cottage I lived in.'[5]

[3] Sleaford Gazette.
[4] BBC, WW2 People's War.
[5] Ibid.

11.7. 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.

An abandoned bomb is recorded at a field in the village of Bicker approximately 2km south-east of the site, although the exact location of this bomb is unknown.

11.8. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (now part of 29 EOD & Search Group) no longer processes commercial requests for information. 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, Ecotricity will be advised.

Despite the lack of information available from the EOD, a bomb disposal task was recorded in Bicker in October 2010 (see local UXO incident on **Appendix viii**). This UXO was said to have comprised a 'WWII-era nose cone of a plane-mounted bomb'. A Ministry of Defence report on UXO finds further stated that an unexploded practice bomb had been found in Bicker in October 2010.[6]

11.9. Evaluation of German Air Delivered UXO Records

Factors	Conclusion
Density of Bombing *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.*	During WWII, Site A and a small area of Site B were located within the Rural District of East Kesteven and the rest of Site B was located within the Rural District of Boston. The Rural District of Spalding was also located adjacent to the south of Site B. According to official Home Office bombing statistics, these districts each sustained an overall very low density of bombing, with an average of less than 3 bombs per 1,000 acres recorded in each. This is mainly due to the rural environment of the local area and the lack of significant Luftwaffe targets nearby. Nevertheless, the towns of Boston and Sleaford are known to have suffered sporadic bombing raids during the war. Several anecdotal accounts record isolated bomb incidents in the local area, including at a field near to East Heckington (which was situated in the south/west of Site A), the GNR railway (part of which ran through the north of Site B) and Swineshead. Incidents were also recorded in the villages of Heckington, Great Hale, Little Hale, South Kyme and Helprignham, the civil parishes which these villages resided in border the site boundary to the west.

[6] Ministry of Defence.

Damage *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.*	As the site was occupied by open land, neither OS mapping nor official/anecdotal bombing reports would have attributed any damage to the site area, if sustained. No evidence has been found to suggest that the site did sustain any damage, although its exact condition and composition during wartime could not be confirmed.
Ground Cover *The nature of the ground cover present during WWII would have a substantial influence on any visual indication that may indicate UXO being present.*	The ground cover across almost the entire site would not have been particularly conducive to the detection of signs of UXO. For example, the entry hole of an unexploded bomb could have been as little as 20cm in diameter and therefore easily overlooked certain ground conditions, especially large areas of open land. Where the site was intersected by railway lines, or occupied by features associated with the village of East Heckington, it is expected groundcover would have been more conducive to UXO detection.
Access Frequency *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.*	Considering the rural environment of the site and the local area, the level of access across most of the site is not thought to have been frequent. Infrequent access would have decreased the likelihood of obvious signs of UXO being noticed, reported and dealt with, although this potential concern is considered to be mitigated on this occasion by the low density of bombing recorded in the locality.
Bomb Failure Rate	There is no evidence to suggest that the bomb failure rate in the locality of the site would have been dissimilar to the 10% normally used.
Abandoned Bombs	An abandoned bomb is recorded at a field in the village of Bicker approximately 2km south-east of the site.
Bombing Decoy sites	1st Line Defence could find no evidence of bombing decoy sites within the site vicinity.
Bomb Disposal Tasks	A bomb disposal task was recorded approximately 2km south-east of the site in Bicker in October 2010. This UXO was said to have comprised a 'WWII-era nose cone of a plane-mounted bomb' and potentially a practice bomb.

12. Introduction to Allied 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 was usually subject to clearance before returned to civilian use, items of UXO are sometimes discovered and can present a potential risk to construction projects.

This section of the report discusses the generic types of Allied ordnance typically encountered on areas associated with former military activity.

12.2. Land Service Ammunition

The risk from Land Service Ammunition is being considered due to evidence that the local area was used for training and the storage of ordnance by the Home Guard during WWII, see Section 13.2.

The term LSA covers items of ordnance that are propelled, placed, or thrown during land warfare. These items may be filled or charged with explosives, smoke, incendiary, or pyrotechnics and can be divided into five main groups:

Land Service Ammunition	
Item	**Description**
Mortar Rounds	A mortar round is normally nosed-fused and fitted with its own propelling charge. Its flight is stabilised by the use of a fin. They are usually tear-drop shaped (though older variants are parallel sided), with a finned 'spigot tube' screwed or welded to the rear end of the body which houses the propellant charge. Mortars are either High Explosive or Carrier (i.e. smoke, incendiary, or pyrotechnic).
Grenades	A grenade is a short range weapon designed to kill or injure people. It can be hand thrown or fired from a rifle or a grenade launcher. Grenades either contain high explosive or smoke producing pyrotechnic compounds. The common variants have a classic 'pineapple' shape.
Projectiles	A projectile (or shell) is propelled by force, normally from a gun, and continues in motion using its kinetic energy. The gun a projectile is fired from usually determines its size. A projectile contains a fuzing mechanism and a filling. Projectiles can be high explosive, carrier or Shot (a solid projectile).
Rockets	Rockets were commonly designed to destroy heavily armoured military vehicles (anti-tank weapon). The device contains an explosive head (warhead) that can be accelerated using internal propellants to an intended target. Anti-aircraft rocket batteries were also utilised as part of air defence measures.
Landmines	A landmine is designed to be laid on or just below the ground to be exploded by the proximity or contact of a person or vehicle. Landmines were often placed in defensive areas of the UK to obstruct potential invading adversaries.

In the UK unexploded or partially exploded mortars and grenades are the most common items of LSA encountered, as they could be transported and utilised anywhere. They are mostly encountered in areas used for military training and are often found discarded on or near historical military bases. Images of the most commonly found items of LSA are presented in **Appendices x – xii**.

12.3. Small Arms Ammunition

The most common type of ordnance encountered on land used by the military are items of Small Arms Ammunition (SAA). SAA refers to the complete round or cartridge designed to be discharged from varying sized hand-held weapons such as rifles, machine guns and pistols. SAA can include bullets, cartridge cases and primers/caps. Example images of the most SAA are presented in **Appendix xiii**.

12.4. 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
• Anti-aircraft gun emplacements to engage enemy aircraft. • Fighter aircraft to act as interceptors. • Rockets and missiles were used later during WWII.	• Blackouts and camouflaging to hinder the identification of Luftwaffe targets. • Decoy sites were located away from targets and used dummy buildings and lighting to replicate urban, military, or industrial areas. • Barrage balloons forced enemy aircraft to greater altitudes. • Searchlights were often used to track and divert adversary bomber crews during night raids.

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

12.4.1. 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 LAA Ammunition	**Gun type**	**Calibre**	**Shell Weight**	**Shell Dimensions**
	3.0 Inch	76mm	7.3kg	76mm x 356mm
	3.7 Inch	94mm	12.7kg	94mm x 438mm
	4.5 Inch	114mm	24.7kg	114mm x 578mm
	40mm	40mm	0.9kg	40mm x 311mm
Z-AA	The three inch unrotated rocket/projectile known as the UP-3 had initially been developed for the Royal Navy. The UP-3 was also used in ground-based single and 128-round launchers known as ''Z'' batteries. The rocket, containing a high explosive warhead was often propelled by cordite.			

The conditions in which anti-aircraft projectiles may have fallen unnoticed within a site area are analogous to those regarding air 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 Air Delivered Ordnance section of this report.

Illustrations of Anti-Aircraft artillery, projectiles and rockets are presented at **Appendix xiv**.

13. The Likelihood of Contamination from Allied Ordnance

13.1. Introduction

When undertaking construction work within or immediately adjacent to a site with previous and/or current military use, it is often considered likely to contain an elevated risk of contamination from Allied UXO. This assumption of risk is based on the following reasoning:

- The clearance of ordnance from military camps, depots, storage facilities, ranges and training areas were not always effectively managed, or undertaken to equivalent degrees of certainty. In addition, search and detection equipment used over seventy years ago following WWII has proved ineffective both for certain types of UXO and at depths beyond capability.
- In the vast majority of cases, explosive ordnance would have been stored and available for use at military installations. Ordnance ranged from small arms and land service ammunition to weapons components and larger, air delivered items. During periods of heightened activity, ordnance was also frequently lost in transit, particularly between stores and assigned training locations.
- The military generally did not anticipate that their land would be later sold for civilian development, and consequently appropriate ordnance disposal procedure was not always adhered to. It was not uncommon for excess or unwanted ordnance to be buried or burnt within the perimeters of a military establishment as a means of disposal. Records of such practice were rarely kept.

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. Auxiliary Unit Operational Bases

Several auxiliary unit (AU) operational bases were recorded in the local area. These bases were constructed by the Royal Engineers after the Dunkirk evacuation in 1940 as fears of a potential German invasion of Britain mounted. They were intended to be used by small bands of local volunteers tasked with conducting guerrilla activities behind German lines and as such were often stored with items of LSA and SAA. Due to the clandestine nature of AU bases – only a handful of local people would have been aware of a base's existence – and the fact that no official records of them were kept, the exact location and usage of these installations is often difficult to discern.

13.2.1. Auxiliary Units in the site vicinity

The *British Resistance Archive*, an online history of auxiliary units, provided information regarding a local Auxillary Unit, the Swineshead Patrol, which is understood to have had a base on site. The Swineshead Patrol was made of seven volunteers and its first base was stated to have been 'in the area of Royalty Farm [*in the north of Site B*] near Swineshead Bridge'. This unit formed part of the Lincolnshire Group 5, which had further AUs stationed in Kirton, Helpringham and Donington.

Heritage England also recorded an Auxiliary Unit base adjacent to the west of Site B, 'on land to the west of Swineshead Bridge'.[7] Another base was recorded approximately 2km east at Swineshead, one was recorded 5km east at New Hammond Beck/Kirton and one was recorded 5km west at Swaton/Helpringham.[8]

A former member of the Swineshead Patrol recalled:

> 'We trained using real explosives, brought down trees and that sort of thing. No one from the surrounding area took much notice of a few extra explosions going off. We used to go out at night 'attacking' different villages. There would be a target in the village we had to aim for and put a plastic explosive on. The Army would be there and would know we were coming and they had to try and stop us. […] We were issued with an amazing set of supplies – revolvers and Sten guns, hand grenades, knives and plastic explosives.'[9]

In addition, an online history of the South Holland area states that:

> 'Auxiliary units were made up of men who knew their own territory. […] They were trained to use firearms, explosives, silent killing, and sabotage. A pistol was issued to each man […] and AUs were given priority access to all sorts of ordnance. Some patrols had daggers, grenades, sniper rifles, gelignite, plastic explosives, detonators, fuse pressure switches, trip switches and anti-tank sticky bombs. […] Patrols near Boston were at Swineshead and Kirton.'[10]

It is unknown if the operational base at Royalty Farm/Swineshead Bridge was cleared after WWII.

13.3. Local Home Guard Training

Evidence was found to suggest that local Home Guard units trained in the local area. According to an account from an individual who lived in Swineshead during WWII:

> 'I used to watch the Home Guard and other civil defence units [potentially AUs] having exercises on Sunday mornings. […] There used to be a pillbox built of sandbags and old railway sleepers at a road junction, near to where I lived. Us kids used it as a den but had to vacate it on Sunday mornings when the Home Guard were on exercises.'[11]

The local village of Heckington is also understood to have had its own local Home Guard, although whether they trained in the area near to the site is unknown.[12]

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[7] https://heritage-explorer.lincolnshire.gov.uk/Monument/MLI125216.
[8] https://heritage-explorer.lincolnshire.gov.uk/Monument/MLI125217; https://heritage-explorer.lincolnshire.gov.uk/Monument/MLI13430; https://heritage-explorer.lincolnshire.gov.uk/Monument/MLI125207.
[9] British Resistance Archive.
[10] [redacted]
[11] BBC, WW2 People's War.
[12] Ibid.

13.4. Swineshead Prisoner of War Camp

An online study of WWII-era structures in the United Kingdom, specifically Prisoner of War Camps, indicates the presence of such a camp at Swineshead, located east of the site boundary.[13] An anecdotal account states 'Prisoners of war helped on the farm and lived in a barn close to the farm' in East Heckington, part of which occupies Site A.[14]

13.5. Aircraft Crashes

Several aircraft crashes were recorded in the local area. An online record of aircraft crashes in Lincolnshire from 1914-2018 was consulted and WWI/WWII-era logs have been transcribed below:

Aircraft Crashes[15]			
Date	**Location**	**Type of aircraft**	**Comments**
17th March 1918	Bicker Fen [*on Site B*]	Royal Aircraft Factory RE8	Stalled on approach
26th January 1943	Swineshead	Vickers Wellington	Broke up in the air during fighter affiliation, crashed
23rd February 1944	500km west of Swineshead	Miles Master	RAF Canada

13.6. 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 *Military camps present an elevated risk from ordnance simply due to the large military presence and likelihood of associated live ordnance training.*	1st Line Defence could find no evidence of a military camp within the site. An online study of WWII-era structures in Britain suggests that a POW camp was located in Swineshead during and after the war.[16] An account from the BBC's *WW2 People's War* also states that several POWs were housed on a farm in East Heckington.[17] However, the presence of POWs is not thought to have significantly affected the risk of UXO contamination within the site boundary.
Anti-Aircraft Defences *Anti-Aircraft defences were employed across the country. Proximity to anti-aircraft defences increases the chance of encountering AA projectiles.*	An anti-aircraft searchlight is understood to have been located adjacent to the central eastern border of Site B. It is unknown if this searchlight was armed with weaponry/items of SAA. Several more AA searchlights were recorded within approximately 2-3km of the site. The conditions in which HAA or LAA projectiles may have fallen unnoticed within a site footprint are generally analogous to those regarding German air delivered ordnance.

[13] [redacted]
[14] BBC, WW2 People's War.
[15] T.N. Hancock, Aircraft Crashes in the Traditional County of Lincolnshire, 1914-2018.
[redacted]
[17] BBC, WW2 People's War.

Home Guard Activity *The Home Guard regularly undertook training and ordnance practice in open areas, as well as burying ordnance as part of anti-invasion defences.*	The local area in and around Swineshead is understood to have been used by a local Home Guard unit for training, who also manned a pillbox in the area during exercises. Evidence of Home Guard activity is often difficult to locate, owing to the ad-hoc nature of Home Guard activity within each local area. Such training was often conducted on a small scale at the discretion of individual commanders and as such was seldom recorded officially.
Defensive Positions *Defensive positions suggest the presence of military activity, which is often indicative of ordnance storage, usage or disposal.*	Beyond the reference to the pillbox used by a local Home Guard unit, there is no evidence to suggest that the site was occupied by defensive features.
Training or firing ranges *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.*	The local area was used for training by both a local Home Guard unit and the Swineshead Auxiliary Unit, the latter of which is also understood to have engaged in mock attacks on nearby villages using practice explosives.
Defensive Minefields *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.*	There is no evidence of defensive minefields affecting the site.
Ordnance Stores *Ordnance stores often contained large quantities of munitions. Adjacent areas may also have been used to bury or dispose of excess ordnance.*	An Auxiliary Unit Operational Base was recorded at Royalty Farm/Swineshead Bridge, on/adjacent to Site B. These small-scale bases were typically stored with items of LSA and SAA, real and plastic explosives, and fuses and detonators, and were intended to be used by specialist members of the local Home Guard in the event of a potential German invasion of Britain. Three more Auxiliary Unit bases were recorded between 2km and 5km of the site boundary, suggesting that the local area was used for training by several units.
Ordnance Manufacture *Ordnance manufacture indicates an increased chance that items of ordnance were stored, or disposed of, within a location.*	No information of ordnance being stored, produced, or disposed of within the proposed site could be found.
Military Related Airfields *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.*	The site was not situated within the perimeters or vicinity of a military airfield. However, several aircraft crashes were recorded in the local area, including one approximately 500m west of Swineshead in 1944.

14. The Likelihood of UXO Contamination Summary

The following table assesses the likelihood that the site was contaminated by items of German air 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	The research has evaluated pre- and post-WWII Ordnance Survey maps, written records, historical literature, anecdotal evidence and in-house datasets for the site. The record set is of generally poor quality. There was little information regarding bombing/bomb damage in the local area and WWII-era aerial photography was not available to consult. Records of military installations on/near to the site were also vague at times with regards to their location. However, there was some information available regarding local Home Guard and auxiliary units.
German Air Delivered Ordnance	• During WWII, the site was located within the Rural District of East Kesteven and the Rural District of Boston. The Rural District of Spalding was also located adjacent to the south of the site boundary. According to official Home Office bombing statistics, these districts each sustained an overall very low density of bombing, with an average of less than 3 bombs per 1,000 acres recorded in each. This is mainly due to the rural environment of the local area and the lack of significant Luftwaffe targets nearby. Nevertheless, the towns of Boston and Sleaford are known to have suffered sporadic bombing raids during the war. • The site area was primarily occupied by open land/fields. East Heckington was located in northern section of the site (the southern section of Site A) and the *GNR* railway and *South Forty Foot Drain* ran through/adjacent to the centre of the site (the northern section of Site B). • Several anecdotal accounts recorded isolated bomb incidents in the local area, including at a field near to East Heckington, the *GNR* railway and Swineshead (located approximately 750m east of Site B). Incidents were also recorded in the civil parishes of Heckington, Great Hale, Little Hale, South Kyme and Helprignham, all of which bordered the site boundary to the west. • The ground cover across almost the entire site would not have been particularly conducive to the detection of signs of UXO. For example, the entry hole of an unexploded bomb could have been as little as 20cm in diameter and therefore overlooked in certain ground conditions, especially large areas of open land. Similarly, the level of access across most of the site is not thought to have been frequent, with the exception being sections of the site occupied by railway lines or features associated with East Heckington. Both of these factors are however considered to be less of a concern on this occasion due to the limited level of bombing in the region. • When taking the overall very-low density of bombing recorded in the region and the lack of any significant urban, industrial or military targets in the locality (the surrounding area was largely agricultural land) the risk of UXO contamination is not considered to be elevated above the 'background level' of risk for this section of the UK. • Subsequently, although a number of incidents are recorded in the locality, the quantity of these is not considered unusual considering the large size of the site area and as a result, these incidents are not considered to significantly elevate the risk of UXO on site. • While the possibility of UXO falling unnoticed and remaining today within the site area cannot be entirely dismissed, due to the site's size and open nature, no definitive evidence could be identified to suggest that the site area in particular is at an increased risk of encounter of UXO. For this reason, the site has been

	deemed to be at a **Low Risk** from items of unexploded German air-delivered ordnance. • *It should be noted however that the while risk from UXO is not considered significant enough to warrant active UXO risk mitigation measures, within any section of the site area, it is certainly recommended that ground personnel are given UXO safety and awareness briefings to make them aware of the history of the site, what to look out for, and what to do in the event that a suspect item is encountered.*
Allied Ordnance	• An Auxiliary Unit (AU) operational base was recorded at Royalty Farm/Swineshead Bridge, near to the *GNR* railway and the *South Forty Foot Drain*, the former location understood to be situated within the northern section of Site B. AUs were small bands of local volunteers tasked with conducting guerrilla activities behind German lines in the event of a potential German invasion of Britain. As such, these small scale bases were typically stored with items of Land Service Ammunition (LSA) and Small Arms Ammunition (SAA), explosives, rifles, fuses, detonators and sticky bombs. Indeed, one member of the local Swineshead AU stated: 'we were issued with an amazing set of supplies – revolvers and Sten guns, hand grenades, knives and plastic explosives'. It is unknown if this base has been cleared post-WWII. • The Swineshead Auxiliary Unit is understood to have trained in the local area and conducted mock attacks on nearby villages with plastic explosives. The British Army is also understood to have taken part in these exercises. A member of the local Swineshead Patrol further stated: 'We trained using real explosives, brought down trees and that sort of thing. No one from the surrounding area took much notice of a few extra explosions going off'. Three more Auxiliary Unit bases were recorded between 2km and 5km of the site boundary, suggesting that the local area was used for training by several such units. • The local area in and around Swineshead is also understood to have been used for training by a local Home Guard unit, who also manned a pillbox in the area during exercises. • An anti-aircraft searchlight is understood to have been located adjacent to the central eastern border of Site B, although it is unknown if this searchlight was defended with weaponry. • In summary, an Auxiliary Unit operational base was recorded on/adjacent to the northern section of Site B. These bases were typically stored with items of LSA, SAA and explosives. The local Swineshead Auxiliary Unit is also understood to have trained in the local area and took part in mock attacks on nearby villages with the British Army. It is also unknown if this base was cleared after WWII. Considering the presence of this unit and the operational base, this part of the northern section of Site B has been assessed to be at **Medium Risk** of military ordnance. See risk mapping of the site on **Annex G.** • While much of the site area was not located near to the Auxiliary Base, it cannot be completely discounted that the open land/fields around the base were used for associated training or the storage/disposal of ordnance by the Home Guard. Thus, whilst there is no positive evidence that there was a military presence within the rest of the site area and the risk is assessed to be low, awareness briefings or a site specific safety package should be considered as a minimum precaution for these areas.

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

Former military sites (or at least certain areas within their footprint) are often subject to clearance before they are returned to civilian use by the MoD. If a site is retained by the military, it is possible that no clearance operations have ever been undertaken. However, UXO is sometimes still discovered even on sites where clearance operations are known to have been undertaken. The detail and level of survey and targeted investigation undertaken by the military will depend on the former use of the site and purpose of the clearance (i.e. disposal, redevelopment, return to agriculture, etc.).[18] The level of clearance will also depend on the available technology, resources and practices of the day.

It therefore cannot be assumed that the risk of UXO remaining has been completely mitigated, even though EOC tasks have been undertaken at a former military site.

15.3. Post-War Development

There has been little significant post-WWII development across the site, as it is still almost entirely occupied by open land/fields. Two substations and a wind farm comprising 13 turbines have been built in the south of Site B.

The risk of UXO remaining is considered to be mitigated at the location of and down to the depth of any post-war redevelopment on site. For example, the risk from deep buried UXO will only have been mitigated within the volumes of any post-war pile foundations or deep excavations for basement levels. The risk will however remain within virgin geology below and amongst these post-war works, down to the maximum bomb penetration depth.

[18] CIRIA C681.

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 works 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.

Generally speaking, the risk of encountering any type of UXO will be minimal for any works planned within the footprint and down to the depth of post-war foundations and excavations.

16.2. Encountering Air Delivered Ordnance

Since an air 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.

16.3. Land Service/Small Arms Ammunition Encounter

Items of LSA and SAA are mostly encountered in areas previously used for military training. Such items could have been lost, burnt, buried or discarded during being in use by the military. Due to this, LSA are most likely to be encountered at relatively shallow depths – generally in the top 1m below ground level. Therefore, such items are most likely to be encountered during open excavation works. In some cases, there is the potential that LSA or SAA may be present on the surface of the ground – especially in areas with active military use or were recently in use by the MoD.

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 Air 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. 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 circumstance. 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.

17.3. Land Service /Small Arms Ammunition Initiation

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

If left alone, an item of LSA will pose little/no risk of initiation. Therefore, if it is not planned to undertake construction/intrusive works at the site, the risk of initiation of any LSA that may be present would be negligible. Similarly, those accessing a contaminated area would be at minimal risk if they do not interfere with any UXO present on the ground. Clearly for many end uses, however, the presence of UXO anywhere on a site would not be acceptable as it could not be guaranteed that the items will not be handled, struck or otherwise affected, increasing the likelihood of initiation.
Items of SAA are much less likely to detonate than LSA or UXBs, but can be accidentally initiated by striking the casing, coming into contact with fire, or being tampered with/dismantled. It is likely that the detonation of an item of SAA would result in a small explosion, as the pressure would not be contained within a barrel. Detonation would only result in local overpressure and very minor fragmentation from the cartridge case.

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 German and anti-aircraft unexploded ordnance at the site of proposed works. The risk from Allied unexploded ordnance is not considered to be homogenous. The central section of the site has been elevated to **Medium Risk**, due to the presence of a WWII-era Home Guard Auxiliary base in this approximate location. The remainder of the site is considered to be of **Low Risk**, although it cannot be completely discounted that Home Guard activity also affected this area.

Northern Section of Site B (Medium Risk Area)

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

Remainder of the Site

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

Please note – although the risk from unexploded ordnance across the majority of the site has been assessed as 'Low', this does not mean there is 'no' risk of encountering UXO. This report has been undertaken with due diligence, and all reasonable care has been taken to access and analyse relevant historical information. By necessity, when dealing historical evidence, and when making assessments of UXO risk, various assumptions have to be made which we have discussed and justified throughout this report. Our reports take a common-sense and practical approach to the assessment of risk, and we strive to be reasonable and pragmatic in our conclusions.

It should however be stressed that if any suspect items are encountered during the proposed works, 1st Line Defence should be contacted for advice/assistance, and to re-assess the risk where necessary. The mitigation measures outlined in the next section are recommended as a minimum precaution to alert ground personnel to the history of the site, what to look out for, and what measures to take in the event that a suspect item is encountered. It should also be noted that the conclusions of this report are based on the scope of works outlined in the 'Proposed Works' section of this report. Should the scope of works change or additional works be proposed, 1st Line Defence should be contacted to re-evaluate the risk.

20. Proposed Risk Mitigation Methodology

20.1. General

A combination of the following risk mitigation measures are recommended to support the proposed works at Heckington Fen:

Type of Work	Recommended Mitigation Measure
All Works	• **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. • **Site Specific Safety Package (SSSP)** As part of the site safety induction all personnel involved in intrusive ground works should attend a UXO Awareness Briefing before starting work. In the first instance the briefings should be delivered by a fully qualified Unexploded Ordnance (UXO) Specialist however for longer term projects, where it may not be a requirement for an UXO Specialist to be present on site all times, the UXO SSSP's can be commissioned to allow a contractors representative to deliver the briefings.
Shallow Intrusive Works/Open Excavations in Medium Risk Area	• **A Non-Intrusive UXO Magnetometer Survey** A Non-Intrusive survey is undertaken using a man-portable magnetometer. Data is recorded and then interpreted to map magnetic fields and model discrete magnetic anomalies which may show the characteristics of UXO. The anomalies can then be investigated by a target investigation team. Where this type of survey is not practical (due to for example terrain or ground conditions), on-site UXO specialist support is recommended. • **Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works** When on site the role of the UXO Specialist would include: • Monitoring works using visual recognition and instrumentation, including immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site. • Providing UXO awareness briefings to any uninformed staff and advise staff of the need to modify working practices to take account of the ordnance risk. • To aid incident management which would involve liaison with the local authorities and police should ordnance be identified and present an explosive hazard.

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 **09/09/22**

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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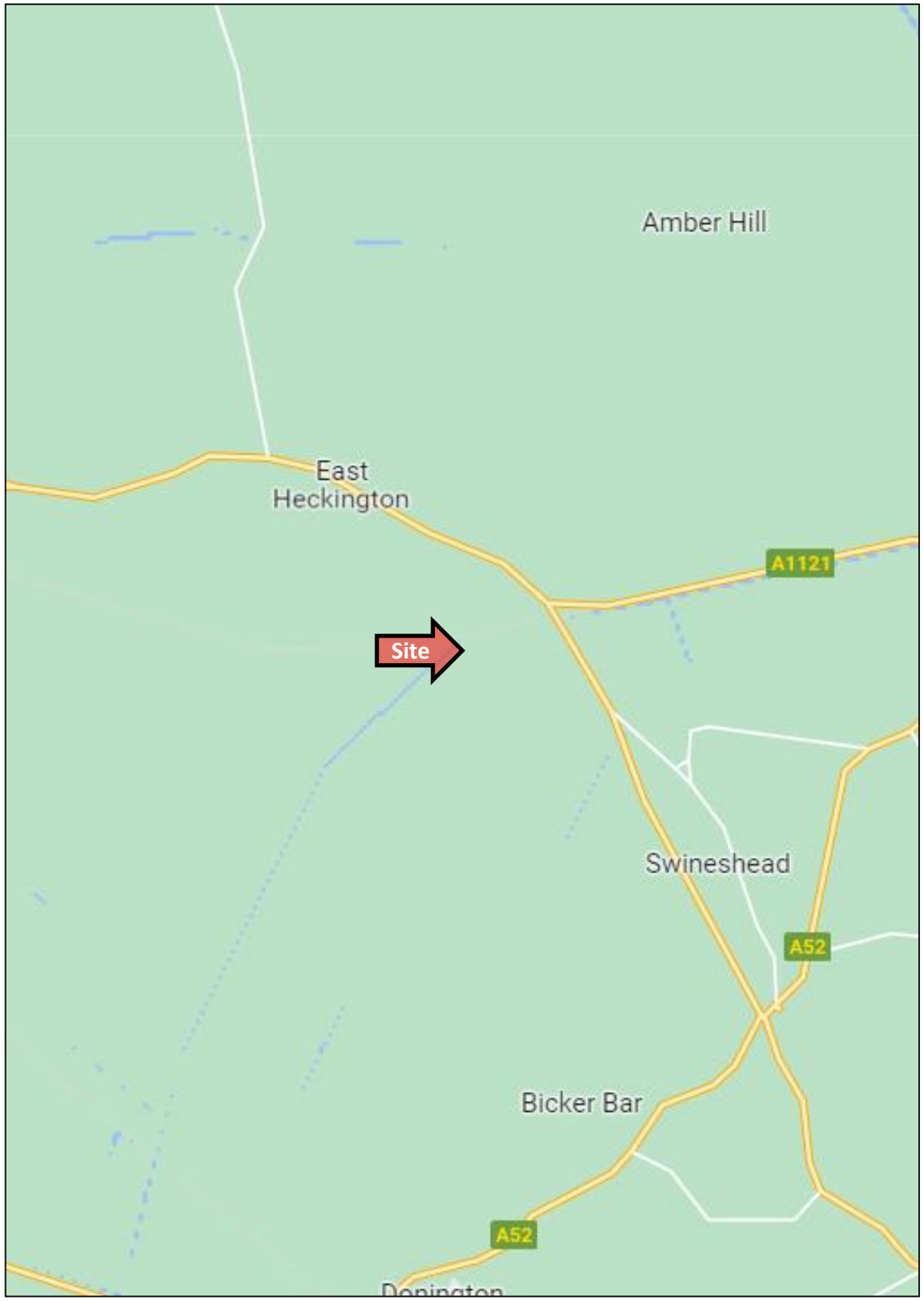
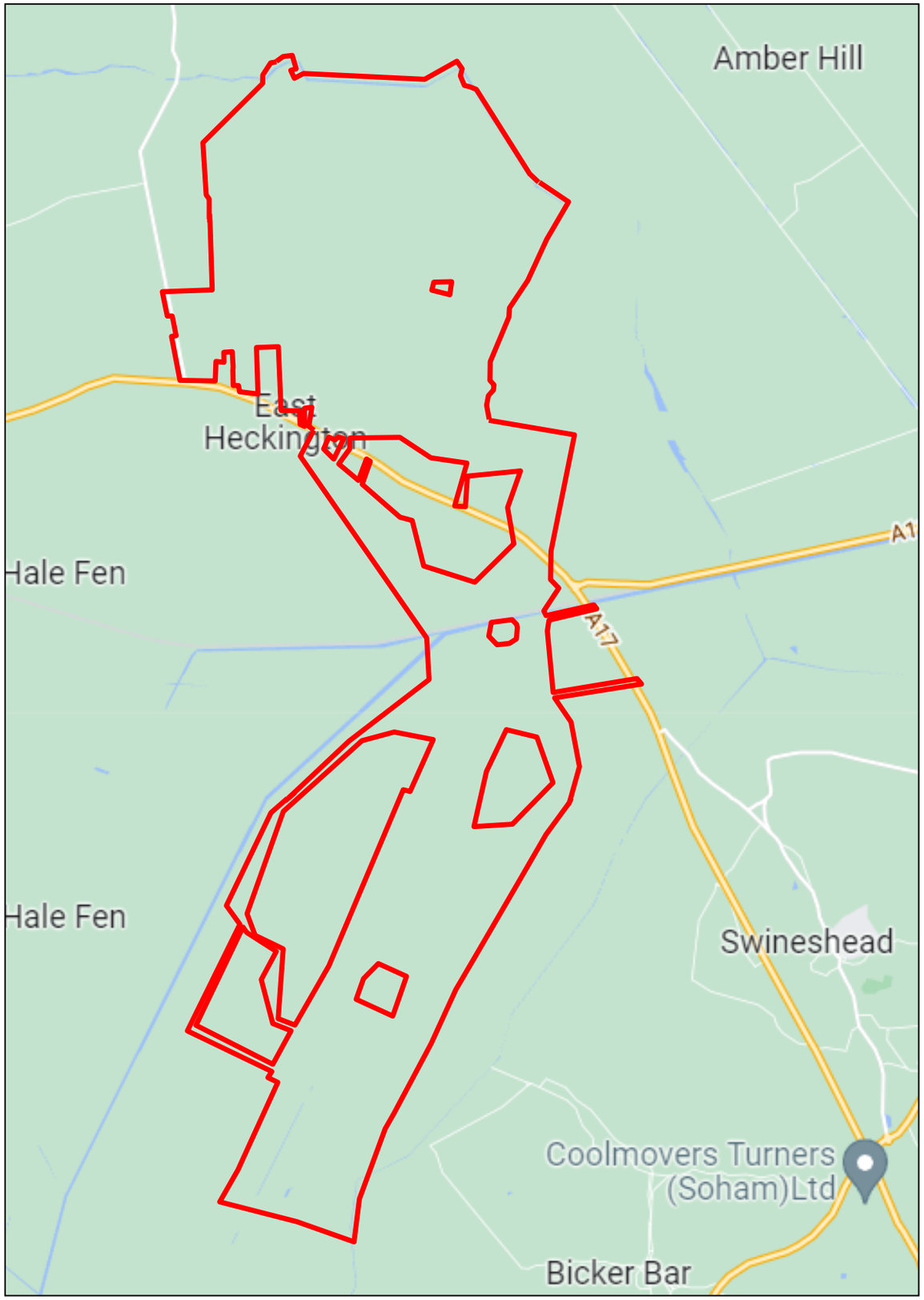
This report has been prepared by 1st Line Defence Limited with all reasonable care and skill. The report contains historical data and information from third party sources. 1st Line Defence Limited has sought to verify the accuracy and comprehensiveness of this information where possible but cannot be held accountable for any inherent errors. Furthermore, whilst every reasonable effort has been made to locate and access all relevant historical information, 1st Line Defence cannot be held responsible for any changes to risk level or mitigation recommendations resulting from documentation or other information which may come to light at a later date.

Site Location Maps

Annex: **A**





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Client:	**Ecotricity (Heck Fen Solar) Ltd**
Project:	**Heckington Fen, Lincolnshire**
Ref:	**DA16024-01**

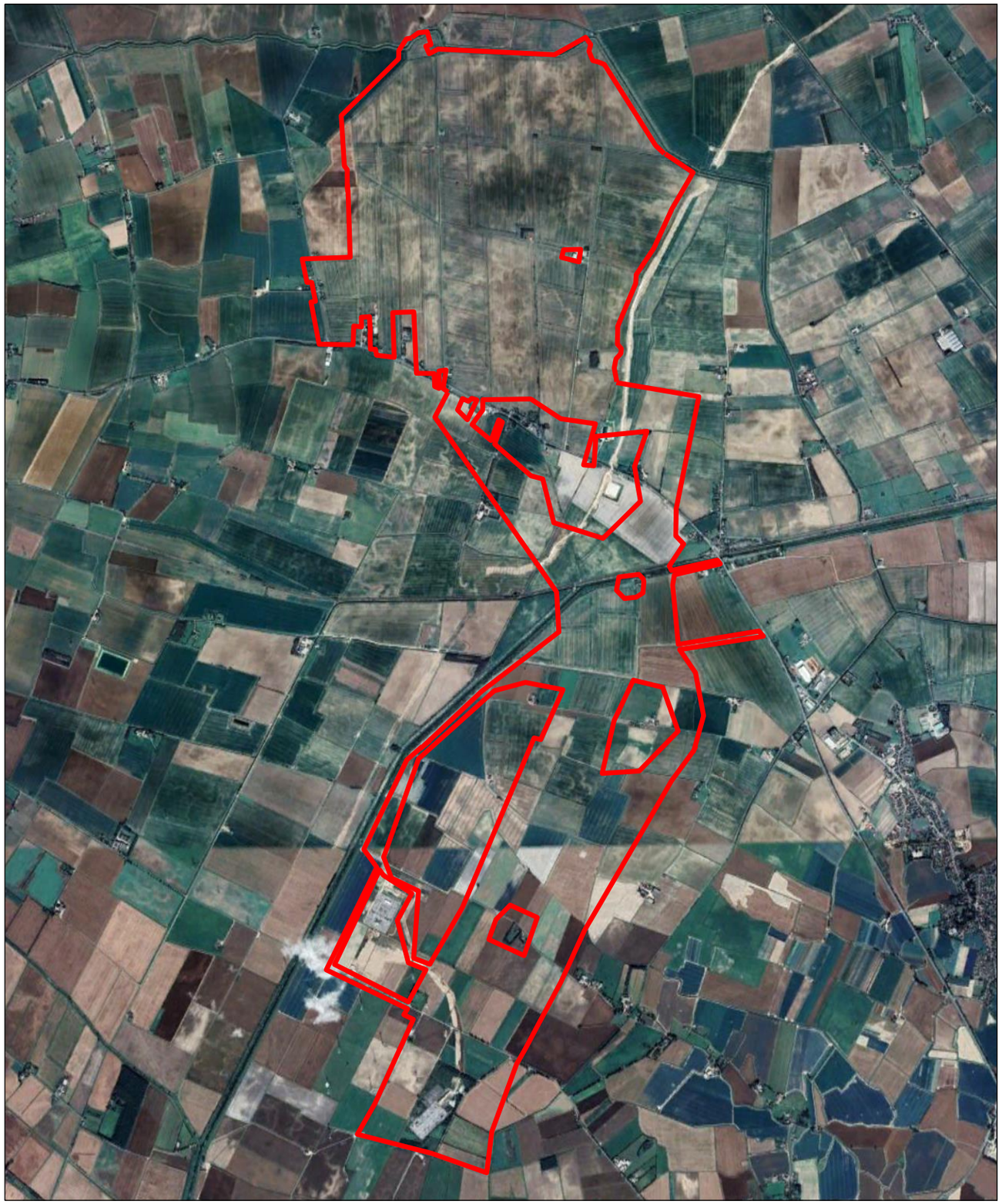
Approximate site boundary

N

Source: Google Maps

Recent Aerial Photography

Annex: **B**



Approximate site boundary

N

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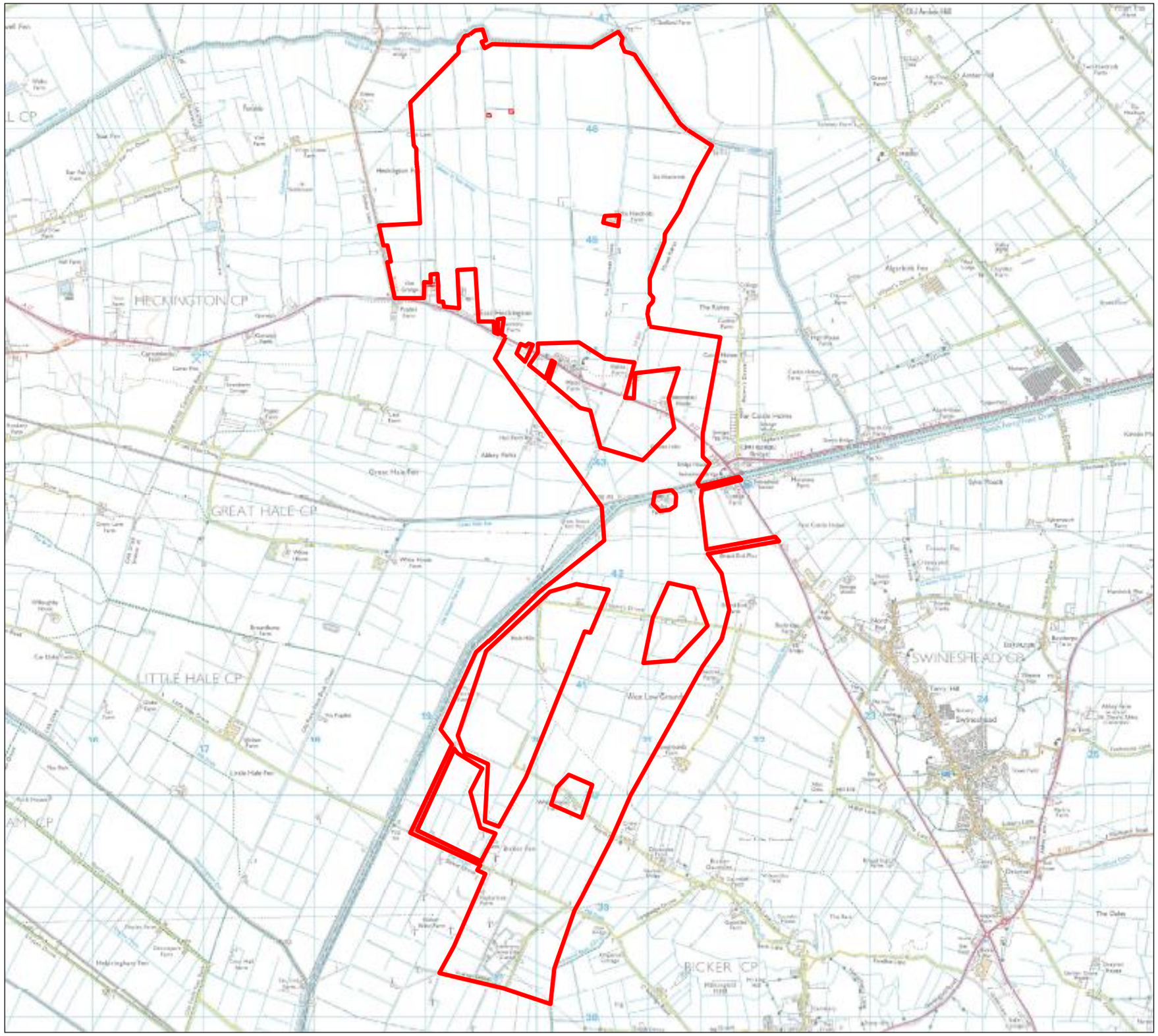
Project: **Heckington Fen, Lincolnshire**

Ref: **DA16024-01**

Source: Google Earth

Client Approved Site Plans

Annex: **C1**



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Ref:	**DA16024-01**

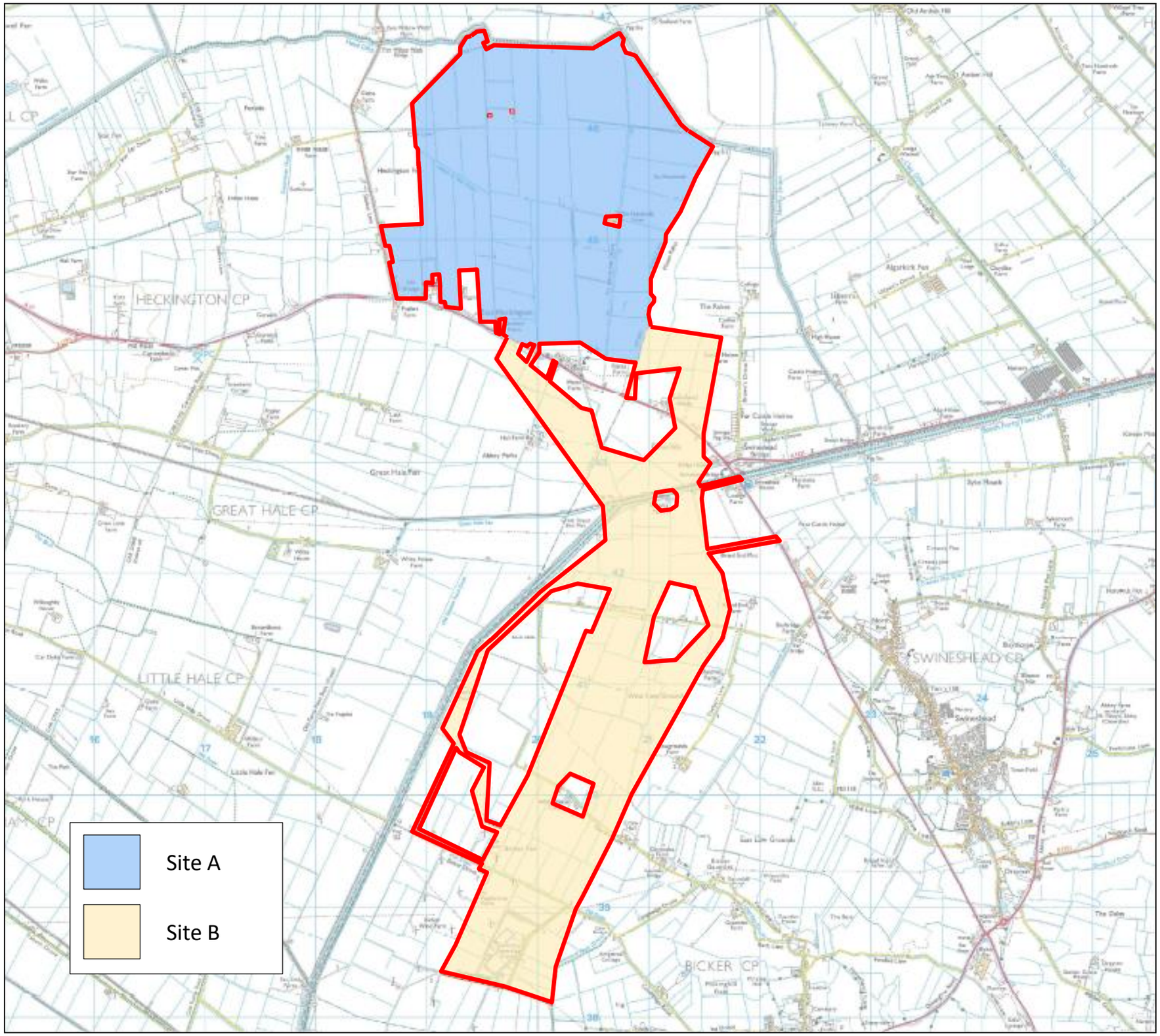
Approximate site boundary

N

Source: Ecotricity (Heck Fen Solar) Ltd

Client Approved Site Plans

Annex: **C2**



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Project: **Heckington Fen, Lincolnshire**

Ref: **DA16024-01**

Approximate site boundary

N

Source: Ecotricity (Heck Fen Solar) Ltd

1903-06 Historical Mapping

Annex: **D1**

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Project: **Heckington Fen, Lincolnshire**

Ref: **DA16024-01**

Source: NLS Mapping

1946-51 Historical Mapping

Annex: D2

Client:	Ecotricity (Heck Fen Solar) Ltd
Project:	Heckington Fen, Lincolnshire
Ref:	DA16024-01

Approximate site boundary

N

Source: NLS Mapping

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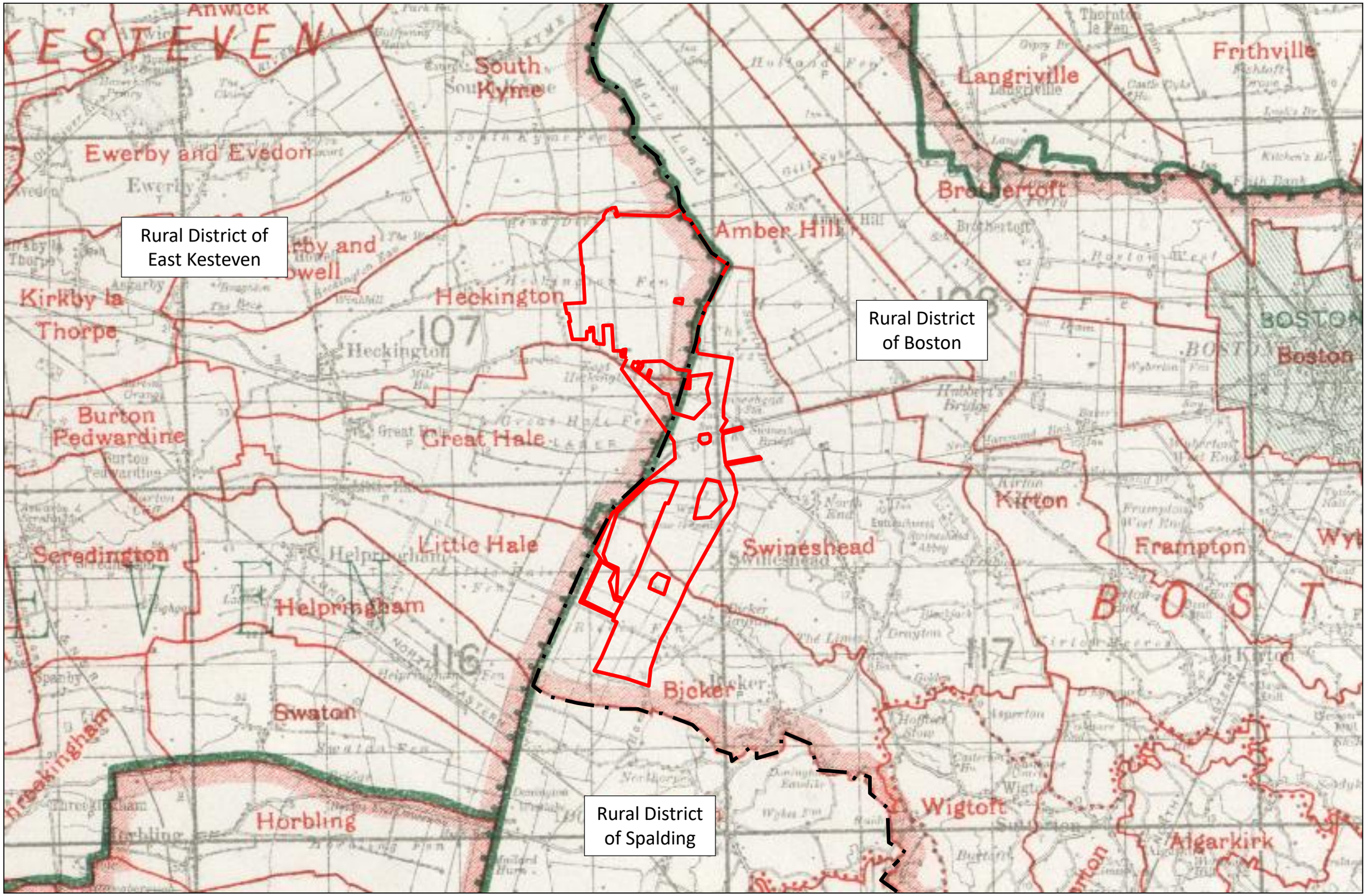

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Client: **Ecotricity (Heck Fen Solar) Ltd**

Project: **Heckington Fen, Lincolnshire**

Ref: **DA16024-01**

Approximate site boundary

N

Source: Vision of Britain

depth of over 1".

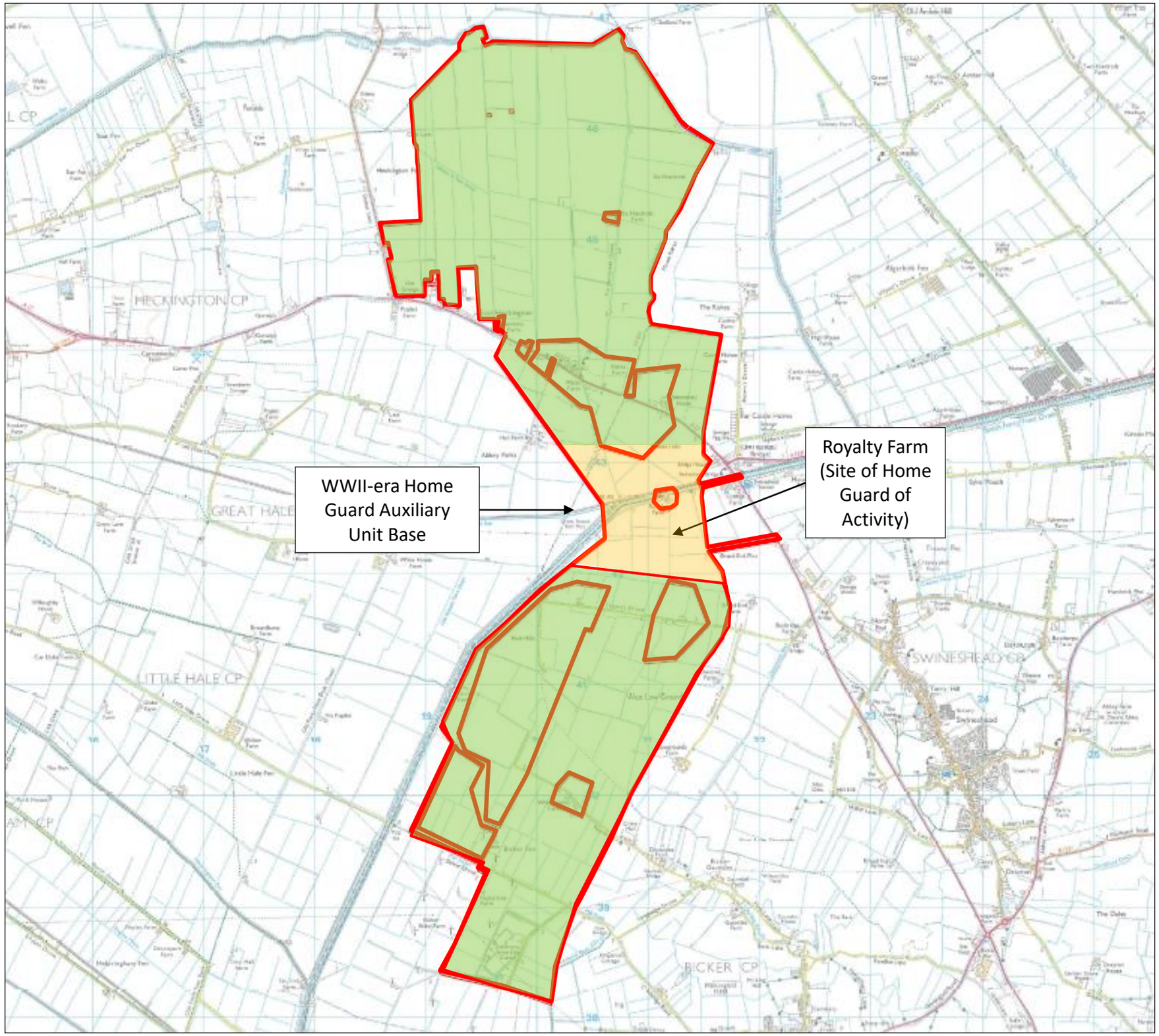
Bombs No. 5-8 fell in fields on the South side of the River Witham and outside the built up area. Nos. 7 and 8 are U.X.B's and Nos. 5 and 6, 250 kg. quick fusing. No. 6 cut the overhead cable of the Mid-Lincs. Electric Light Company, resulting in the cutting off of electric supply over a wide area, including Boston and several R.A.F. Stations. This damage was repaired by 18.00 hours on the 23rd.

Bombs Nos. 9-12, all U.X.B's, fell in a long stick in open fields to the South West of the town. Nos. 9 and 10 straddled the Boston-Grantham railway.

Boston, situated as it is on flat low lying ground, ...

Allied UXO Risk Map

Annex: **G**



Low Risk

Medium Risk

Low and Medium Risk Areas:

- Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works
- Risk Management Plan

Medium Risk Area:

- Non-Intrusive UXO Magnetometer Survey and Target Investigation (where conditions are practical).
- Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works.

For indicative purposes – not to scale

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Ref: **DA16024-01**

Approximate site boundary

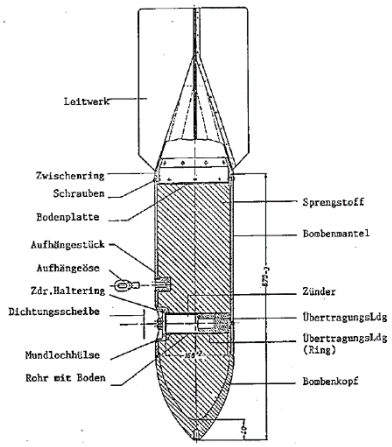
N

Source: 1sr Line Defence

Examples of German Bombs - HE

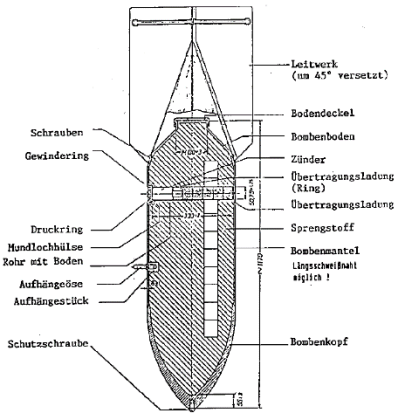
SC 50kg

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.



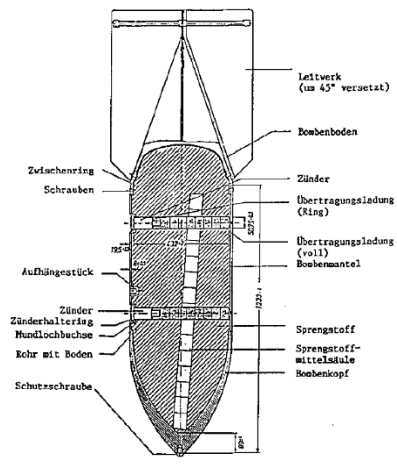
SC 250kg

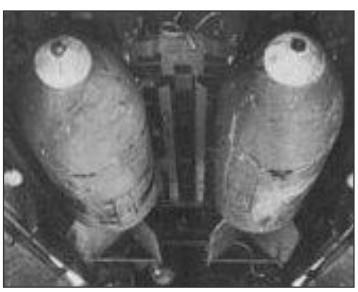
Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground 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).



SC 500kg

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





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Project: **Heckington Fen**

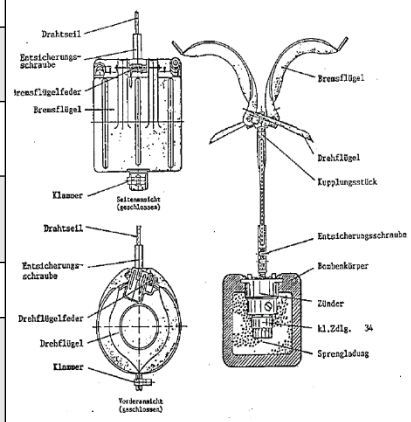
Ref: **DA16024-01**

Source: Various sources

Examples of German Bombs - HE, AP and Parachute Mines

SD2 Butterfly Bomb

Bomb Weight	2kg (4.41lb)
Explosive Weight	7.5oz (212.6 grams) of TNT surrounded by a layer of bituminous composition.
Fuze Type	41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuze (anti-handling device)
Bomb Dimensions	Length 240 mm Width 140 mm Height 310 mm
Body Diameter	3in (7.62 cm) diameter, 3.1in (7.874) long
Use	It was designed as an anti-personnel/fragmentation weapon. They were delivered by air, being dropped in containers that opened at a predetermined height, thus scattering the bombs.
Remarks	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.

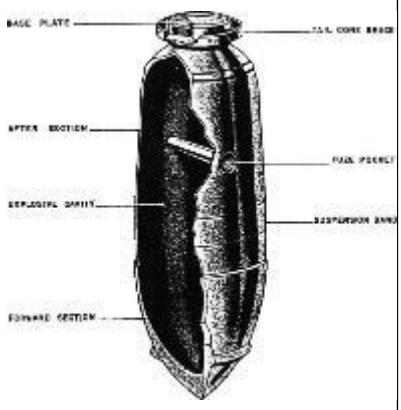


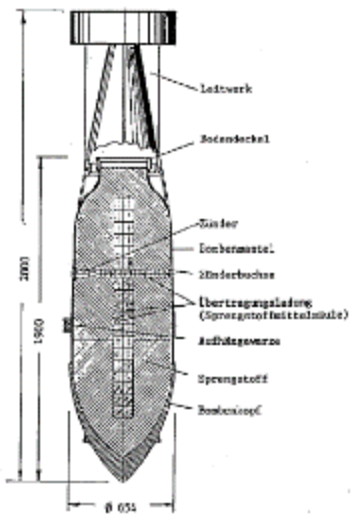
Parachute Mine (Luftmine B / LMB)

Bomb Weight	987.017kg (2176lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Impact/ Time delay / hydrostatic pressure fuze
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against civilian, military and industrial targets. Designed to detonate above ground level to maximise damage to a wider area.
Remarks	Parachute Mines were normally carried by HE 115 (Naval operations), HE 111 and JU 88 aircraft types. Deployed a parachute when dropped in order to control its descent.

SC 1000kg

Bomb Weight	996-1061kg (1,058-1,146lb)
Explosive Weight	530-620kg (551-573lb)
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 (77 x 25.2in)
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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Project: **Heckington Fen**

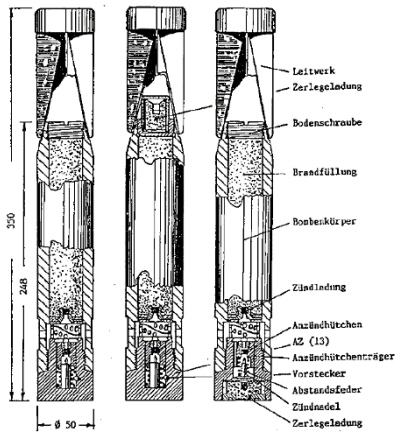
Ref: **DA16024-01**

Source: Various sources

Examples of German Bombs - Incendiary

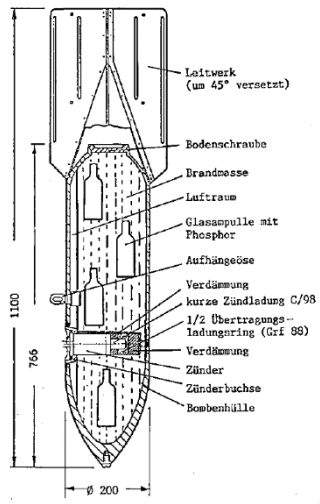
1kg Incendiary Bomb

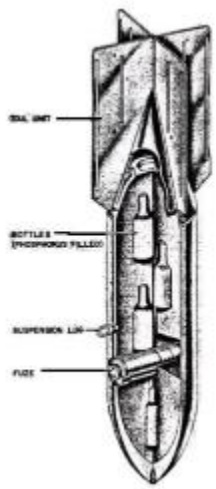
Bomb Weight	1.0 and 1.3kg (2.2 and 2.87lb)
Explosive Weight	680gm (1.3lb) Thermite
Fuze Type	Impact fuze
Bomb Dimensions	350 x 50mm (13.8 x 1.97in)
Body Diameter	50mm (1.97in)
Use	As incendiary – dropped in clusters against towns and industrial complexes
Remarks	Magnesium alloy case. Sometimes fitted with high explosive charge. The body is a cylindrical alloy casting threaded internally at the nose to receive the fuze holder and fuze.



C50 A Incendiary Bomb

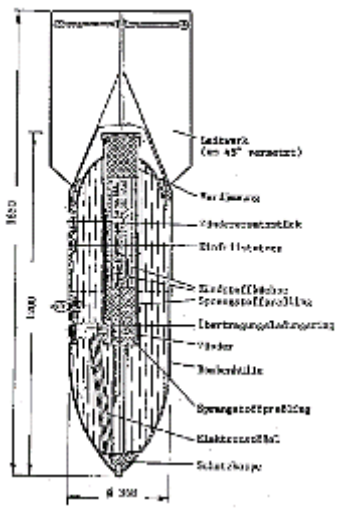
Bomb Weight	c41kg (90.4lb)
Explosive Weight	0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against all targets where an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





Flam C-250 Oil Bomb

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



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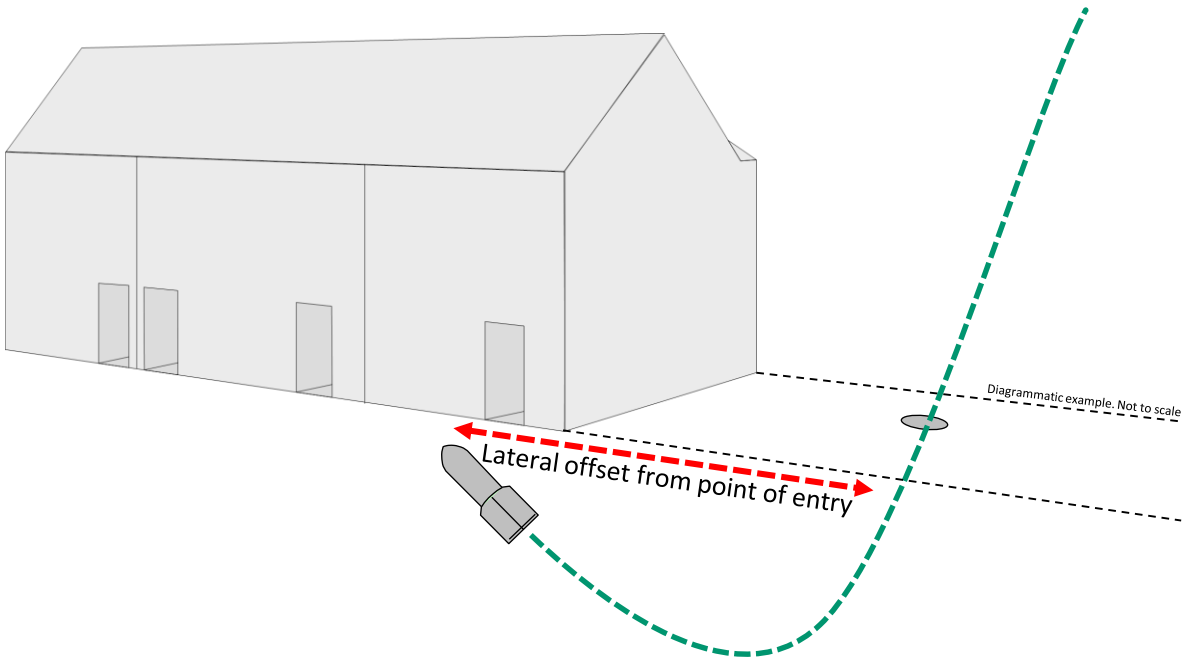
Project: **Heckington Fen**

Ref: **DA16024-01**

Source: Various sources

Example of UXO Entry Hole / The 'J-curve' Effect Principle



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**).

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Source: Various sources

BBC NEWS

Bermondsey bomb: World War Two device safely removed

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

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

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

Examples of Unexpected Detonation of WWII Bombs

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

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

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

19th September 2013

BBC NEWS

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

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Source: Various news sources

Examples of Land Service Ammunition finds in the UK

Unexploded Second World War bomb discovered under Somerset footpath

By Western Daily Press | Posted: January 21, 2014

The unexploded bomb was found in Somerset

Comments (0)

An unexploded bomb dropped in Britain during the Second World War has finally been discovered – underneath a popular footpath in Somerset.

23 August 2014 Last updated at 15:01

Unexploded WW2 bomb found at Kenfig Pool, Bridgend

Dean Smith believes the shell was made in Germany

Bomb experts have been called to a south Wales nature reserve after an unexploded World War Two shell was discovered by a walker in Bridgend.

Dean Smith, 38, of Pyle, was walking near Kenfig Pool on Saturday when he saw a fin sticking out of the sand.

He reached down to pick it up, but ending up falling and landed with the 2ft-long (0.6m) bomb on top of him.

The site has been cordoned off by police and the Royal Logistics Corps will carry out a controlled explosion.

Related Stories

'Panic' as dog nearly thrown grenade

WW2 bomb found at wind farm exploded

WWII bomb found in kitchen cupboard

Mortar thought to be from WWII found on Oshawa's Camp-X grounds

August 24, 2016 | 5:42 am

What is believed to be a World War II mortar has been discovered in south Oshawa. A man out in Intrepid Park, the site of the Camp-X Second World War training grounds, discovered the round with his metal detector on Tuesday evening. Durham police are held the scene overnight awaiting military officials from Trenton to come and properly detonate the mortar.

Unexploded bomb found in farmer's field

17 May 2010

A live Second World War mortar shell was blown up by Army experts after a farmer found it in his field.

The discovery was made in the field alongside the A20 between Folkestone and Dover.

The mortar shell, which was around a foot long and 3in in diameter, was around 50ft from the main road.

The farmer alerted police and PC Trevor Moody and PCSO Michelle Brady went to the field.

PC Moody contacted the Army who sent in a bomb disposal unit.

An Army officer confirmed the live shell was from the Second World War and was packed with high explosives.

They moved it a safe distance away from the A20 and carried out a controlled explosion.

PC Moody said: "Given that we live in an area that saw much action during the Second World War, it is not uncommon for us to be alerted about unexploded bombs."

The incident was on Thursday.

Click here for more news from Kent.

Royal Navy bomb disposal experts remove a World War Two shell discovered in a nature reserve

- A World War Two bomb was discovered in a Plymouth nature reserve
- Amateur metal detector found the shell and partially dug it up
- Royal Navy experts carried the explosive away before disposing of it

By VALERIE EDWARDS FOR MAILONLINE
PUBLISHED: 01:29, 13 January 2016 | **UPDATED:** 09:51, 13 January 2016

Share 338 shares 10 View comments

A World War Two bomb was reportedly found at Efford Nature Reserve in Plymouth after a member of the public was metal detecting and partially dug it up.

The Royal Navy Bomb Disposal team was called in to remove the bomb and police have closed off Military Lane, with the possibility of Military Road also being closed.

Police were called at around 1.30pm yesterday after what appeared to be a shell was discovered and partially dug up near Military Lane, Efford.

Holiday beach cordoned off after landslip sends more than a THOUSAND Second World War bombs and rockets tumbling onto the sands

- Bad weather led to ground movement which exposed the huge arsenal at Mappleton, East Riding
- A dog walker stumbled across the deadly find on Saturday and 15 controlled explosions were carried out
- Rockets, mortar bombs and 25-pounder bombs were recovered after they were fired into the cliffs by RAF aircraft during the war
- Most of the devices were dummy rounds used for bombing practice but contain enough explosives to cause terrible injuries

© Jonathan Pow

Bomb Beach Alley: Rockets were found after a landslide on Mappleton beach in 2012

Army bomb disposal team called to Blacksole Bridge in Herne Bay

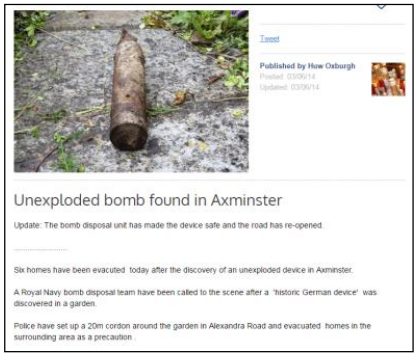
by Aidan Barlow abarlow@thekmgroup.co.uk 08 July 2015

It was like a scene from Dad's Army when Army bomb disposal experts found wartime explosives made by the Home Guard in makeshift bottles.

A team was called to the Blacksole Bridge in Herne Bay after the wartime bombs were found.

The team from the Royal Logistics Corps set up a 30 metre exclusion zone for pedestrians around the railway embankment after the suspected homemade phosphorous bombs were found.

The scene at Blacksole Bridge after wartime explosives were found in the railway cutting



Tweet

Published by Huw Oxburgh

Posted: 03/06/14

Updated: 03/06/14

Unexploded bomb found in Axminster

Update: The bomb disposal unit has made the device safe and the road has re-opened.

Six homes have been evacuated today after the discovery of an unexploded device in Axminster.

A Royal Navy bomb disposal team have been called to the scene after a 'historic German device' was discovered in a garden.

Police have set up a 20m cordon around the garden in Alexandra Road and evacuated homes in the surrounding area as a precaution.

Storms and floods unearth unexploded wartime bombs

By Claire Marshall
BBC environment correspondent

There has been a dramatic increase in the number of wartime bombs unearthed because of the winter storms and flooding.

Bomb disposal teams in the South West have dealt with double the number of unexploded ordnance than in the same period last year.

Since mid December, the Royal Navy's Southern Dive Unit has recovered or disposed of 244 items of ordnance.

During the same period last year, they dealt with just 108 items.

The storms have uncovered a lethal past

Almost 70 years after the end of WWII, one legacy of that conflict continues to turn up on beaches and harbours around Britain.

Unexploded shells, bombs and mines continue to be discovered every year, and the Royal Navy's Southern Dive Unit is tasked with making these devices safe.

Its area of responsibility stretches for some 2,250km (1,400 miles). It begins from the highwater mark in Hull and proceeds seaward to the territorial limit, and then runs clockwise around the British Isles - including the Isle of Wight, Channel Islands, and Isles of Scilly - to finish in Liverpool.

Related Stories

Ancient trees revealed by storms

Land Service Ammunition (LSA) resulting from historic military activity is commonly encountered across the UK by the public and construction industry alike. Such finds are much more common in rural areas than in urban environments, and can often be anticipated in areas such as former RAF stations or ranges. However, many such items are encountered entirely by surprise where the landowner or developer has no knowledge of any previous military use of the land.

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Project: **Heckington Fen**

Ref: **DA16024-01**

Source: Various news sources

8th October 2010

BBC

WWII bomb found at Bicker building site

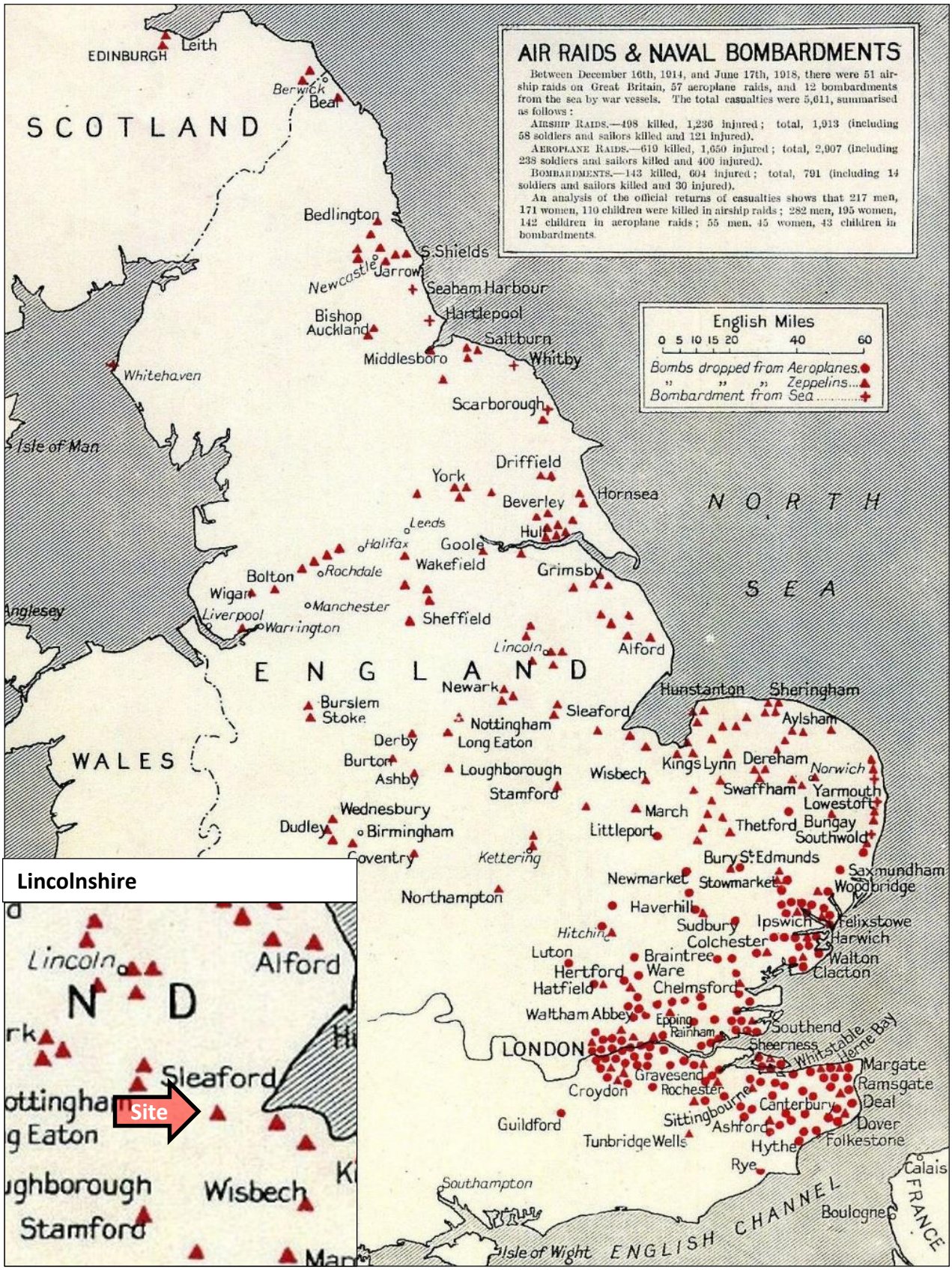
A bomb squad has safely disposed of an unexploded WWII shell which was found at a building site in Lincolnshire.

The device - believed to be the nose cone of a plane-mounted bomb - was uncovered at the former GW Gedney site in Bicker.

Police called a team of experts from RAF Wittering near Stamford, who removed it on Wednesday evening.

The bomb had retained its detonation pin and mounting bracket, said the Lincolnshire force.

WWI Map of Air Raids and Naval Bombardments



Lincolnshire

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Project: **Heckington Fen**

Ref: **DA16024-01**

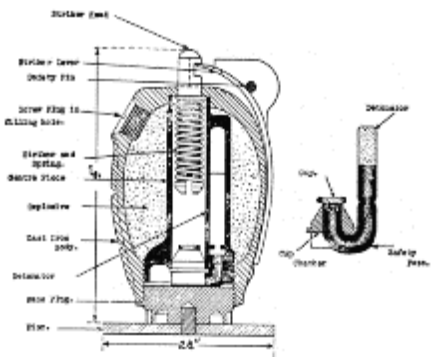
Source: J. Morris, *German Air Raids on Britain*

Examples of LSA - Grenades

Appendix: x

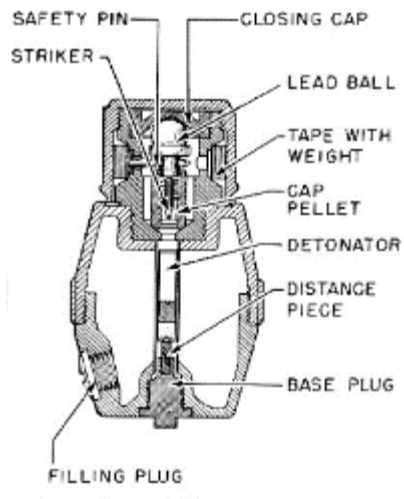
No. 36 'Mills' Grenade

Weight	760g filled (1ib 6oz)
Explosive Weight	71g (2.5 oz) Baratol filling.
Fuze Type	4 second delay hand-throwing fuze
Dimensions	95 x 61mm (3.7 x 2.4in)
Use	Fragmentation explosive at approx. 30m range 100m range of damage.
Remarks	First introduced in 1915 its classic grooved 'pineapple' design was designed to provide uniform fragmentation. Approx. over 70million were produced.



No. 69 Grenade

Weight	383g (0.81b)
Explosive Weight	93g (3.25 oz) of either Amatol, Baratol or Lyddite
Fuze Type	'All-ways' Fuze. Compromised of a safety cap, a weighted streamer attached to a steel ball bearing and a safety bolt designed to detonate from any point of impact.
Dimensions	114 x 60mm (4.5 x 2 .4 in)
Use	A blast grenade for use as an offensive weapon.
Remarks	Introduced December 1940 and made from the plastic Bakelite as opposed to conventional metals. Detection is difficult due to this low metal content.



L2 Grenade

Weight	454g (16 oz)
Explosive Weight	164g. (16 oz)
Fuze Type	Time Friction Fuze
Dimensions	Approx. 99 x 57 mm (3.9 x 2.2 in)
Use	A widely used anti-personnel grenade, a version of the American M26. Variants still see use in the present day.
Remarks	The L2 series also came as a Practice (L3) grenade and a Drill (L4) Grenade. The Drill variant, with a non-functional fuze and no filing, is visible on the far right.

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Project: **Heckington Fen**

Ref: **DA16024-01**

Source: Various sources

Examples of LSA - Mortars

Typical 2 Inch High Explosive Mortar

Weight	1.02kg (2.25lb)
Maximum Range	460m (500yards)
Filling	200g RDX/TNT
Dimensions	51 x 290mm (2in x 11.4 in)
Fuze Type	An impact fuze which detonates the fuze booster charge and in turn the high explosive charge.
Use	A small, portable mortar introduced into the British army in 1938. It had greater range and firepower over hand and rifle grenades, and was used to attack targets behind cover with high explosive rounds.
Remarks	Detonation causes the mortars bomb body to shatter producing optimum fragmentation and blast effect at the target.

Typical 3 inch Smoke Mortar

Weight	4.5kg (9lb 14oz)
Maximum Range	2515m (2,750 yards)
Filling	White phosphorus & smoke fill (also came in Explosive & Illuminating models)
Bomb Dimensions	490 x 76mm (19.3in x 3in)
Fuze Type	An impact fuze which initiates a bursting charge. This ruptures the mortar bomb 's body and disperses the phosphorus filler
Use	As a screening devices for unit movement or to impair enemy field of vision.
Remarks	This mortars long cylindrical body and tail sometimes causes it to be misrecognised as a German incendiary bomb.

ML 4.2 inch Mortar

Weight	9kg (19lb 13oz)
Maximum Range	3,750m (4,100 yards)
Filling	High explosive, smoke (white phosphorous or Titanium Tetrachloride) or chemical
Bomb Dimensions	500 x 105 mm (19 in x 4 in)
Fuze Type	Sensitive fuze with HE bursting charge.
Use	A widely used heavy motor which first saw use in 1942 and saw usage throughout the post-war period.
Remarks	Different markings denoted different filings. See image to the right.

L to R: HE, Smoke, Chemical, Smoke BE.

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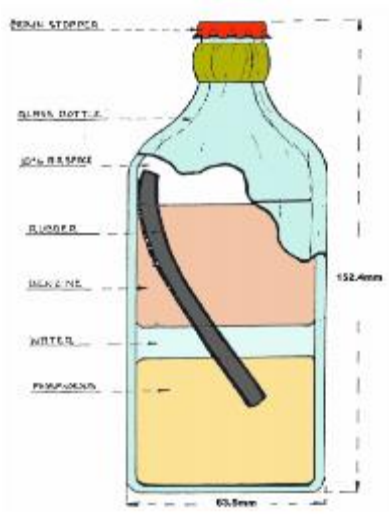
Examples of LSA - Home Guard Ordnance

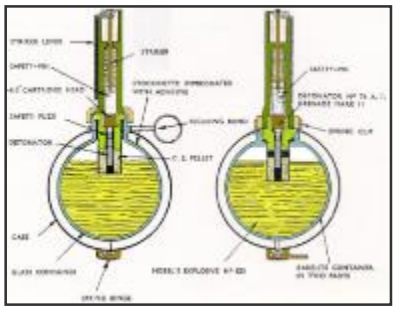
Self Igniting Phosphorous (SIP) Grenades

Weight	Various
Filling	White Phosphorous and Benzene
Design	The filling was contained in a pint sized glass bottle with water and a strip of rubber. Over time the rubber dissolved to create a sticky which would self ignite when the bottle broke.
Use	Originally intended as an anti-tank incendiary weapon deployed by hand. Designed to be produced cheaply without consuming materials needed to produce armaments on the front line.
Remarks	The Home Guard hid caches of these grenades during the war for use in the event of an invasion. Not all locations were officially recorded and some caches were lost. Occasionally discovered today. In all cases, the grenades are still found to be dangerous.



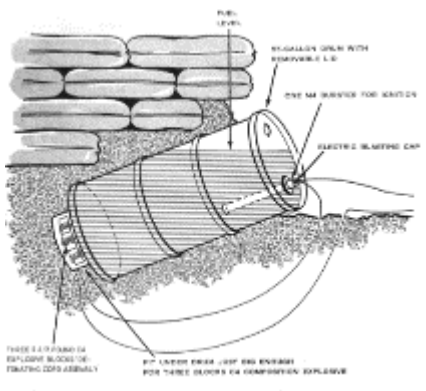
No. 74 Grenade (Sticky Bomb)

Weight	Approx. 1.1kg (2ib 4oz)
Filling	Approx. 600g Nobel's No.283 (Nitro-glycerine)
Design	A glass ball on the end of a Bakelite (plastic) handle. The inside of the ball would contain the explosive filling and the outside a very sticky adhesive coating.
Use	An anti-tank grenade primarily issued to the home guard. It required the user to come in very close proximity with the target and smash the glass explosive container against it.
Remarks	One of a number of weapons developed for use as an *ad hoc* solution to the lack of sufficient anti-tank guns in the aftermath of the Dunkirk evacuation amid fear of German invasion.



Flame Fougasse Bomb

Weight	Various
Filling	Initially a mixture of 40% petrol and 60% gas. Ammonal provided the propellant charge.
Design	Usually constructed from a 40-galleon drum dug into a roadside and camouflaged.
Use	As an improvised anti-tank bomb. When triggered the Fougasse could project a beam of burning sticky fuel in a fixed direction from up to 3m (10ft) wide and 27m (30yards) long.
Remarks	A highly unorthodox weapon designed by the Petroleum warfare department to address a critical lack of weapons in 1940. 50,000 are estimated to have been distributed around the UK.



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Source: Various sources

Examples of Small Arms Ammunition

Cannon Ammunition

Rifle Ammunition

Buried and Decayed Ammunition

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Examples of Anti-Aircraft Projectiles

QF 3.7 Inch WWII 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	High Explosive Anti-Aircraft projectile. 4.5in projectiles were also used in this role.
Ceiling	30,000ft to 59,000ft

40mm Bofors Projectile

Projectile Weight	1.96lb (0.86kg)
Explosive Weight	300g (0.6lb)
Fuze Type	Proximity and Mechanical Time Fuze
Rate of Fire	120 rounds per minute
Projectile Dimensions	40mm x 310mm (1.6in x 12.2in)
Ceiling	23,000ft (7000m)

Unrotated Projectile (UP) – Z Battery

Projectile Weight	84lb (24.5kg)
Warhead Weight	4.28lb (1.94kg)
Warhead	Aerial Mine with a No. 700 / 720 fuze
Filling	High Explosive
Dimensions	1930mm x 82.6mm (76 x 3.25in)
Use	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.

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