Campsfield IRC Expansion

AtkinsRéalis

Detailed Unexploded Ordnance (UXO) Threat and Risk Assessment with Risk Mitigation Strategy

Meeting the requirements of the United Kingdom's
Construction Industry Research and Information Association's
Unexploded Ordnance Risk Management Framework:
"Unexploded Ordnance (UXO) – A Guide for the Construction Industry" (C681)
and in compliance with the Construction (Design and Management) Regulations 2015

6 Alpha Associates Ltd

Project No.: 10029

8th December 2025

V1.0

Using This Report

This Detailed UXO Threat and Risk Assessment with Risk Mitigation Strategy is designed to inform the reader whether military related Unexploded Ordnance (UXO) is likely to pose a hazard at the Study Site and if so, to calculate the level of risk generated by proposed or likely ground intrusive operations at the Site. The assessment is intended to meet with the requirement of Stages 2 and 3 of the *Health and Safety Executive* endorsed *CIRIA C681 UXO Risk Management Framework* – for which *6 Alpha* were the lead technical author.

There are two prospective outcomes of this report; either the risk level requires a Risk Mitigation Strategy (Stage 3 of the *CIRIA C681* framework) aimed at reducing UXO risks As Low As Reasonably Practicable (ALARP) in accordance with the Project's minimum legal responsibility; or that no further action is required. In the former instance *6 Alpha* will provide a Risk Mitigation Strategy consisting of proactive and/or reactive risk mitigation measures aimed at reducing the identified risks to ALARP.

Document Control

Version	Author(s)	Reviewed By	Recipient
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Executive Summary

Document Scope

6 Alpha Associates Limited (6 Alpha) has been commissioned by *AtkinsRéalis* to provide an Unexploded Ordnance (UXO) Threat and Risk Assessment with Risk Mitigation Strategy, for the Site described as "Campsfield IRC Expansion". The Study Site is centred on *British National Grid Reference* 447426, 214575.

UXO Threat Assessment Summary

The output of *6 Alpha*'s UXO Threat Assessment is summarised at Table I:

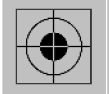
UXO Threat Assessment Summary			
Threat Source		**Result**	**Comments**
	Was the Site or its vicinity considered a primary bombing target during WWII?	✓	*Luftwaffe* aerial photography identified *Oxford-Kidlington Airfield* (on-site) as a primary bombing target.
	Was the Site or its vicinity bombed during WWII?	✓	*RAF Kidlington,* located in the immediate vicinity of the Study Site, was subjected to numerous bomb strikes during WWII which caused damage to structures within the airfield and to structures on-site.
	Was the Site or its vicinity damaged by bombing during WWII?	✓	
	Has any *British* military activity been identified in the area?	✓	*RAF Kidlington* was located immediately to the north and was an active military facility throughout WWII. After the war, the airfield was also used as a disposal site for captured *German* ordnance. As a result, it is possible live and/or inert munitions were stored on-site or nearby, as demonstrated by the previous UXO finds potentially on-site.
	Has ordnance been manufactured and/or stored at the Site or its vicinity?	✓	
	Does UXO contamination pose a potential hazard at the Study Site?	✓	Given the bombing and military activity recorded on-site and nearby, it is considered possible that UXO might be encountered.

Table I: UXO Threat Assessment Summary

UXO Threat Items

Given the evidence presented at Table I, *6 Alpha* consider it reasonably foreseeable that a UXO encounter could occur at this Site. The most probable UXO threat items are *German* aerially delivered ordnance and *British* AXO/LSA/SAA. *British* AXO/LSA/SAA pose a residual threat.

Potential UXO Burial Depth

Given the likely ground conditions at the Study Site, the average WWII bomb penetration depth has been calculated as 6m below WWII ground level at this Study Site. Although larger unexploded bombs could be present below this depth (potentially up to 13m), they were deployed infrequently during WWII and are highly unlikely to be encountered.

British AXO/LSA/SAA also poses a potential UXO threat at this Site but is much more likely to be shallow buried, up to 2m below the WWII ground level.

UXO Risk Pathways

The Study Site has undergone significant post-WWII development in certain areas, specifically concerning the development of multiple structures in the northern sector by 1974, along with the demolition of these structures and construction of new buildings in the south-eastern sector by 2004. Moreover, the Client has informed *6 Alpha* that the current *IRC* on-site has been refurbished and reopened. Consequently, it is considered unlikely for a UXO risk pathway to be generated by proposed works within ground that has been disturbed since WWII.

Nonetheless, given the depths of the proposed intrusive works below ground level, a potential UXO risk pathway could be generated by intrusive works within any remaining area(s) of ground that has not been disturbed **since the time it might have been contaminated with UXO**.

UXO Risk Assessment

A Semi-Quantitative UXO Risk Assessment has been undertaken and the UXO risk rating is assessed to be:

HIGH

Such risks may pose harm to human health and damage any equipment involved in intrusive activities; the former is intolerable. Therefore, such risks will require mitigating in accordance with the As Low As Reasonably Practicable (ALARP) principle, through the implementation of a risk mitigation strategy (see below, and Part III of the report).

Risk Mitigation Strategy

6 Alpha recommends that the UXO risk to the proposed intrusive works is reduced ALARP, through the implementation of both proactive and reactive UXO risk mitigation measures.

Recommended UXO Risk Mitigation Measures

There following risk mitigation measures summarised at Table II, are recommended as a minimum in order to reduce risks ALARP during intrusive works in **all previously undisturbed ground**.

UXO Risk Mitigation Measures Overview							
Proposed Intrusive Works		**Emergency Response Plan**	**Safety and Awareness Briefings**	**On-Call EOD Engineer**	**UXO Watching Brief**	**Non-Intrusive UXO Survey**	**Intrusive UXO Survey**
Open Works	Trial Pits	✓	✓	✗	✓	✓	✗
	Excavations	✓	✓	✗	✓	✓	✗
	Trenching	✓	✓	✗	✓	✓	✗
Blind Works	Boreholes	✓	✓	✗	✗	✗	✓
	Piling	✓	✓	✗	✗	✗	✓
Residual UXO Risk Rating		**ALARP**					

Table II: UXO Risk Mitigation Measures Overview

Recommended Next Steps

6 Alpha recommend that the Client's next steps are focused upon phase four of the UXO Risk Management Framework namely, the detailed design and implementation of the recommended UXO risk mitigation measures outlined above.

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Acronyms and Abbreviations

AAA	Anti-Aircraft Artillery	**m^2**	Square Metres
ALARP	As Low As Reasonably Practicable	**NEQ**	Net Explosive Quantity
ARP	Air Raid Precaution	**NGR**	National Grid Reference
AXO	Abandoned Explosive Ordnance	**OS**	Ordnance Survey
BGS	British Geological Survey	**RAF**	Royal Air Force
BPD	Bomb Penetration Depth	**SAA**	Small Arms Ammunition
CIRIA	Construction Industry Research and Information Association	**SQRA**	Semi-Quantitative Risk Assessment
CS	County Series	**TNT**	Trinitrotoluene
EOD	Explosive Ordnance Disposal	**UK**	United Kingdom
HE	High Explosive	**UXB**	Unexploded Bomb
HDD	Horizontal Directional Drilling	**UXO**	Unexploded Ordnance
IB	Incendiary Bomb	**V Weapons**	*Vergeltungswaffen* – Vengeance Weapons
kg	Kilogram	**WWI**	World War One
km	Kilometre	**WWII**	World War Two
LSA	Land Service Ammunition		
m	Metre		

Part I: Introduction

1 Document Overview

1.1 Scope of Work

6 Alpha Associates Limited (6 Alpha) has been commissioned by *AtkinsRéalis* to provide an Unexploded Ordnance (UXO) Threat and Risk Assessment with Risk Mitigation Strategy, for the Site described as "Campsfield IRC Expansion".

1.2 Study Site Location

The Study Site is situated within the village of *Kidlington* and totals an area of 4.29ha. The Study Site is centred on [redacted] and consists of multiple structures, hardstanding, and areas of undeveloped ground.

The Site's Location and Site Boundary is depicted at Appendices 1 and 2, with aerial photography of the Study Site presented at Appendix 3 and 4.

1.3 Aims and Objectives

This document has the following aims and objectives:

1.3.1 Aims

The document aims to assess and evidence the nature and scope of the UXO risks to people, plant, equipment and/or the environment at this Study Site. In the event that an intolerable UXO risk is identified, a recommended UXO risk mitigation strategy will also be articulated.

1.3.2 Objectives

The document has the following objectives:

- To assess the nature and scope of potential UXO contamination at the Study Site;
- To assess whether any UXO contamination generated at the Site is likely to remain extant;
- To consider whether the proposed intrusive works will generate a viable UXO risk pathway;
- To identify those sensitive receptors likely to be impacted by an inadvertent UXO encounter during the proposed intrusive works;
- To assess the UXO risk to those sensitive risk receptors during intrusive works;
- To outline proportional risk mitigation measures that are consistent with a coherent overarching risk mitigation strategy, in order to effectively manage the UXO risk in accordance with the As Low As Reasonably Practicable (ALARP) principle.

2 Introduction to UXO Risk Management

2.1 Definition of UXO

For the purposes of this risk assessment, *6 Alpha* have adopted the definition of UXO outlined in the undermentioned *Construction Industry Research and Information Association* (CIRIA) *C681* guide, as follows:

"Explosive ordnance that has been primed, fuzed, armed, or otherwise prepared for use and used in an armed conflict. It may have been fired, dropped, launched or projected and should have exploded but failed to do so…UXO also refers to explosive ordnance that has not been used during an armed conflict, that has been left behind or dumped by a party to an armed conflict, and which is no longer under control of the party that left it behind or dumped it..."

2.2 Generic UXO Threats

There are multiple factors which may have contributed to the UXO contamination of a construction site in the *UK* but generally, UXO contamination is likely to result from the warfighting activity associated with WWI and WWII, the military occupation and use of land such as airfields, camps and training areas, and/or the manufacture of munitions to support the armed forces.

For example, *WWII Bomb Census* data compiled by the *Ministry of Home Security* calculated that approximately 10% of bombs dropped on *Britain* during WWII failed to function as designed. If the bomb did not detonate when it was dropped, the force of impact enabled the Unexploded Bomb (UXB) to penetrate the ground. Whilst efforts were made to locate and render safe those UXBs that were observed entering the ground (or left behind clear evidence of having done so) during WWII, evidence of such UXBs was readily obscured by bomb damage debris, vegetation and a lack of footfall in some settings – thus, ensuring that an unquantifiable number of UXBs were left *in situ* below the surface of the ground.

Additionally, it has been estimated that at least 20% of the *UK's* land surface area has been used for military training activities or has otherwise been requisitioned for military use historically. Therefore, *British* Abandoned Explosive Ordnance (AXO), Land Service Ammunition (LSA), Small Arms Ammunition (SAA) and aerially delivered ordnance is also commonly encountered in areas that were formerly occupied by military forces (such as *Royal Air Force* (RAF) airfields, military camps and/or military training areas). Conventional and chemical munitions dumping was also prevalent in these periods with little consideration given to future safety implications. There was also widespread unrecorded dumping of LSA and SAA below the ground that was rarely recorded because the activity was often perceived to be inconsequential.

2.3 Generic UXO Risks

The explosive or chemical fill within UXO rarely becomes inert or loses its effectiveness with age, but the explosive fill may change or crystallise over time – increasing the high explosive's sensitivity to a physical shock or an impact. Trigger mechanisms and fuses, which may have failed, may corrode and deteriorate over time, becoming more sensitive to detonation. It is therefore possible that a significant impact on the UXO case, and the resultant effect upon the fuse, may cause its inadvertent detonation.

2.4 UXO Industry Best Practice

In the absence of specific legislation concerning the management of UXO risks during construction projects, the *UK*'s *CIRIA* has published a best practice guide for the assessment and management of UXO risk in the construction industry (*CIRIA* document reference C681). The *CIRIA C681* guide has been judged and recognised by the *Health and Safety Executive* as a minimum standard of good practice, that satisfies the law when applied in an appropriate manner.

6 Alpha were *CIRIA's* lead technical author for their *C681* publication and as such, are in a unique position to ensure that Clients manage UXO risk in a safe, cost-effective and time-efficient manner.

2.5 UXO Risk Management Strategic Framework

At Section 5 of *CIRIA's* C681 guide, a framework for the management of UXO risk is articulated and consists of four key stages. These correspond with the framework employed by *6 Alpha*, as presented at Table 1.

6 Alpha Risk Management Framework	UXO Risk Management Phase	CIRIA C681 Risk Management Framework	Delivered within Report? (✓/✗)
UXO Threat Assessment	**STAGE ONE**	Preliminary Risk Assessment	✓
UXO Risk Assessment	**STAGE TWO**	Detailed Risk Assessment	✓
Risk Mitigation Strategy	**STAGE THREE**	Risk Mitigation	✓
Implementation	**STAGE FOUR**	Implementation	✗

Table 1: 6 Alpha and CIRIA UXO Risk Management Frameworks

3 UXO Threat and Risk Assessment Methodology

3.1 Source – Pathway – Receptor Risk Model

The source-pathway-receptor model is a conceptual risk model employed by *6 Alpha* across all projects and it informs how UXO risks are assessed. The model also helps to explain the link between the separate sections of this report and the UXO risk assessment at Section 7. The components of the model are as follows:

3.1.1 UXO Sources

The nature and scope of the UXO threat is summarised in the UXO threat assessment (at Section 4) and it forms the source element of the source-pathway-receptor model.

3.1.2 UXO Pathways

The UXO pathways are the routes by which the sources can reach the receptors. UXO pathways are likely to be either by contact and/or through soil energy transfer, through which the resulting shock wave (generated by a UXO source, or sources) may reach potential receptors. Nonetheless, surface events may also generate a through-air risk pathway in which blast and fragmentation from the UXO sources may also reach the receptors.

UXO risk pathways may be generated by a variety of operations that interact with the ground. Therefore, likely operations have been assessed and summarised (at Section 6), to demonstrate the potential risk pathway elements of the model.

3.1.3 UXO Receptors

Receptors are defined as anything which might be adversely affected by the consequences of an inadvertent detonation of any UXO source through an identified pathway. The proximity, robustness, and sensitivity of such receptors is essential in determining their capacity to withstand such high explosive effects and defining what degree of UXO risk might be tolerated (if any).

3.2 Semi-Quantitative Risk Assessment Methodology

The assessment of UXO risk is a semi-quantitative measure of the probability of UXO encounter and initiation and the consequence of an inadvertent UXO initiation; the former being a function of the identified hazard and proposed development methodology and the latter being a function of the type of hazard and the proximity of personnel (and/or other sensitive receptors) to the hazard.

UXO risk is calculated using the following formula:

Risk **(R)** = Probability **(P)** x Consequence **(C)**

3.3 Information Sources

Significant archive research associated with the Study Site has been undertaken to corroborate and to highlight, relevant potential sources of UXO contamination as well as to assess their likelihood of encounter. For the production of this report, *6 Alpha* have reviewed information from the following sources:

- Information gathered from the *National Archives* at *Kew*, including but not limited to:
  - *Ministry of Home Security WWII Bomb Census* statistics;
  - *Air Raid Precaution* (ARP) written records and associated bomb strike mapping;
  - *Ministry of Home Security Daily Intelligence Reports*;
  - Official WWII bomb damage mapping;
- *Ministry of Defence* (MoD) *Abandoned Bomb Register*;
- *Former 33 Engineer Regiment* (Explosive Ordnance Disposal – EOD) records at *Carver Barracks, Wimbish*;
- Post-WWII *RAF* aerial photography;
- *County Series* (CS) and *Ordnance Survey* (OS) mapping.

3.3.1 Azimuth© UXO Threat Database

The above list is not exhaustive, and *6 Alpha's Azimuth*© database has also been heavily drawn upon to deliver the UXO threat assessment element of this report. The *Azimuth*© database contains digitised historic charts, aerial photographs and other extensive analogue records from an exhaustive range of additional national, regional and global archives and/or data sets that have been digitised.

3.4 Constraints

This UXO threat and risk assessment is constrained and limited by that information which is reasonably available to *6 Alpha* at the time of writing, as well as that UXO information that is reasonably accessible in a variety of archives, which *6 Alpha* have digitised and georeferenced or have otherwise summarised in written form.

This document may require updates and changes, especially wherever and whenever the circumstances and factors associated with assessing UXO risk change. For example, if UXO threats are subsequently discovered and they are different from those that have been anticipated, and/or if the proposed intrusive operations are significantly changed.

In such circumstances, risks may require re-evaluation, and any such changes are to be made by *6 Alpha*, to ensure the continued technical veracity and risk management efficacy of this document.

Part II: UXO Threat & Risk Assessment

4 UXO Threat Assessment

4.1 WWII Aerial Bombing

During WWII, the county of *Oxfordshire* was home to numerous targets that were of interest to the *Luftwaffe* – predominantly military in nature. The county subsequently played a major role in training and supply during WWII, such as the development of numerous military airfields throughout the county, new hospitals, additional farming, military and prisoner of war camps and the establishment of the *Central Ordnance Depot* at *Bicester*. Numerous areas around *Oxfordshire* were hit, with most of the bombing occurring to areas within the *Rural Districts* of *Ploughley* and *Bullingdon & Thame* with approximately 4,100 bombs impacting across the county in total during WWII.

4.1.1 WWII HE Bomb Density

The Study Site was located within *Ploughley Rural District,* as presented at Appendix 5. This region recorded one HE bomb strike per 100 hectares, a "very low" level of bombing. However, further site-specific data has been considered regarding the potential bombing of the Site during WWII.

4.1.2 WWII Luftwaffe Bombing Targets

Luftwaffe aerial reconnaissance photography identified the Study Site as a primary bombing target as part of *Oxford-Kidlington Airfield*.

The locations of *Luftwaffe* bombing targets, in relation to the Study Site, are presented at Appendix 6.

4.1.3 WWII Bomb Strikes

During WWII, *ARP* wardens and other local officials compiled detailed logs of bomb strikes across their respective districts that were then often consolidated and mapped at the end of WWII. These records were not available for the Study Site, likely due to its location adjacent to a military airfield. Nonetheless, further research of historical records noted that *RAF Kidlington* (located immediately to the north at its closest point) was subjected to numerous air raids – with as many as 25 HE bomb strikes dropped on the airfield in total during WWII; at least two being UXBs. Whilst the exact location of each individual bomb strike was not recorded, during the first raid in November 1940 confirmed hits were noted near *Armoury Huts, No.4 Hanger* and the landing ground (approximately 330m to the north-north-east of the Site). However, during two latter raids in May and August 1941, collectively 20 HE bomb strikes were recorded as impacting on the airfield. It should however be noted that the *Air Training Oxford Ltd Factory* (located on-site) was damaged during the raid in November 1940, indicating that bomb strikes may have impacted significantly closer to the Study Site than otherwise indicated.

Furthermore, whilst IBs may have fallen within the Study Site, they were dropped in large clusters and accurate record keeping was often either non-existent or perfunctory.

In addition to IBs and HE bomb strikes, during the latter stage of WWII, when more conventional aerial bombardment of the *UK* had significantly declined, the main threat came from *V* type weapons. *V1* and *V2* rockets were thin-skinned, unmanned and inaccurate weapons and generally exploded upon impact and thus, are less likely to pose a UXO threat. There is also no evidence to suggest that the Study Site (or its immediate vicinity) was subjected to rockets strikes during WWII.

4.1.4 WWII Bomb Damage

Official bomb damage mapping associated with the Study Site was not available. Nonetheless, whilst neither an analysis of post-war mapping nor 1945 aerial photography identified any potential bomb damage on-site or nearby, further research of historical records noted that in addition to the damage sustained at the *Air Training Oxford Ltd Factory*, damage was also noted to the *Armoury Huts* and *No.4 Hanger* sustained during the raid in November 1940. Other areas of the airfield and/or its immediate vicinity were also almost certainly damaged as a result of the aforementioned air raids, in May and August 1941.

4.1.5 UXB Entry Holes

The CS mapping prior to WWII (1936) and aerial photography (1945) shows that the Study Site was located within a densely developed urban area during WWII, with the Study Site itself consisting of *Campsfield House* and undeveloped ground. Given the undermentioned use of *Campsfield House* as a servicing and repair facility during WWII, it is likely that the Study Site would have been accessed frequently during WWII and would have been with inspected for UXB entry holes following any air raids, which would have been noted and dealt with at the time. Given that sections of the Study Site were undeveloped, however, and it is unknown how comprehensive these inspections would have been. Moreover, as bomb damage was recorded on-site, it is possible that bomb damage debris may have concealed a UXB entry hole causing it to have gone unnoticed.

4.2 *British* Military Activity

There is evidence to suggest that military activity has occurred at the Study Site and/or its immediate area previously, as detailed below:

4.2.1 Historic Military Activity

RAF Kidlington was identified in the immediate vicinity of the Study Site during WWII (immediately to the north at its closest point, on the far side of *Langford Lane*). *Kidlington Aerodrome* was initially opened from the late-1930s as a civilian flying school to train reserve *RAF* pilots. However, after the outbreak of WWII, the aerodrome was requisitioned as *RAF Kidlington* as a Relief Landing Ground for

RAF Abington as well as briefly serving as an operational *Bomber Command* facility. Nonetheless, the main function of the airfield was primarily as a training and maintenance installation – a role it would hold throughout WWII. Notably, glider training commenced from 1942 onwards, with *No.101 (Glider) Operational Training Unit* formed at *Kidlington* – the first of its kind in the *RAF*.

The Study Site itself was located outside of the main airfield site, although it was linked to the airfield via a track to allow for aircraft testing. *Air Training Oxford Ltd,* originally based on the main site, was relocated to *Campsfield House* (located on-site), which was utilised as a repair and maintenance facility for various aircraft including *Hawker Hurricanes* and *North American P-51 Mustangs*

An analysis of official *RAF Kidlington* site plans also identified various munitions/weapons storage facilities including a *Rifle Store* 70m to the north and an *Armoury* approximately 330m to the north-north-east of the Site.

The airfield was also defended by numerous anti-aircraft artillery gun batteries, which were active in repelling a *German* aircraft in February 1941 and would almost certainly have been fired in defence of the area during the aforementioned air raids. In addition, other WWII-era defensive features were identified in the wider area including three pillboxes, the closest located 585m to the north-east and one battle headquarters 590m to the north-east. Finally, "pipe mines", which were small pipe-shaped explosives, were also often buried underneath military facilities (including airfields) and were to be detonated in the event of invasion to deny use of the area to the enemy. Nonetheless, there is no evidence of any pipe mines being deployed at *RAF Kidlington.*

Therefore, it is considered likely that live and/or inert munitions were stored, located and/or fired from this Study Site during WWII. It was common for surplus munitions to be buried at former military facilities, and these were often abandoned at the end of the war, the remnants of which are known as AXO [redacted]

The location of the wartime airfield boundary, in relation to the Study Site, is presented at Appendix 7.

4.2.2 Post-WWII Military Activity

After the war *Kidlington* was used by *No.42 (Maintenance*) *Group, RAF* as a disposal area for surplus *German* ordnance. By 1951, the last active *RAF* unit at *Kidlington* was *No.96 Maintenance Unit*. The airfield was soon returned to civil use and has since been repurposed as *London Oxford Airport*.

The likely storage and transport of munitions and other military equipment and personnel through the Study Site since WWII also has the potential to generate a UXO hazard at the Site. However, there is generally a lower likelihood of encountering modern munitions due to the more stringent record-

keeping associate with munitions storage and transport (meaning that munitions are unlikely to have become deliberately buried at the Site) and the greater administration of munitions disposal when compared with historical activities.

4.3 Previous UXO Encounters

An analysis of historic records noted several UXO encounters within the vicinity of the Study Site, as follows:

4.3.1 Abandoned Bombs

The Abandoned Bomb register was compiled from wartime records and was published in the form of a written answer to the *House of Commons* in 1996. The list initially only covered abandoned bombs in *London* but has since been released for the rest of the UK.

An examination of the *MoD*'s official abandoned bomb records has not identified any abandoned bombs on-site or within 1,000m of the Study Site boundary.

4.3.2 WWII UXO Disposal Tasks

An examination of pertinent historical records associated with the Study Site has identified the following UXO disposal tasks within 1,000m of the Study Site:

- An analysis of high-level bomb strike mapping noted at least two UXBs impacting on *RAF Kidlington* during WWII – although the exact location of these UXBs was not recorded.

4.3.3 Post-WWII UXO Encounters

[redacted]

- [redacted]
- One WWII-era live mortar shell was encountered, and later destroyed, at a house in a residential area of *Kidlington* on the 7th June 2014 – although the exact location was not recorded.

4.4 UXO Threat Summary

Given the evidence presented above, *6 Alpha* consider it reasonably foreseeable that a UXO encounter could occur at this Site. The most probable UXO threat items are *German* aerially delivered ordnance and *British* AXO/LSA/SAA associated with the military activity in the immediate vicinity. *British* AAA projectiles may pose a residual threat as they likely fired in defence of the local area during air raids.

5 UXO Burial Depths

5.1 Overview

It is important to establish the likely burial depth for threat spectrum UXO at the Study Site. The potential penetration depth of an UXB was dependent on a number of factors including but not restricted to: those prior to striking the ground (e.g. velocity and orientation of the UXB, the release altitude from the aircraft and encounters with infrastructure during its fall); those encountered at the point of impact (i.e. was the impact on concrete, grass, water etc.); and the below ground level conditions (e.g. infrastructure/services, basements, foundations, and geology).

Accordingly, the ground conditions at the Study Site must be understood in order to determine the average and maximum *German* UXB penetration depths, as well as the potential for other types of munitions to be buried. The provenance of made ground must also be considered in order to accurately determine the ground levels at the time when UXO contamination may have occurred (so as to accurately determine the average/maximum Bomb Penetration Depth (BPD)) and subsequently to inform any further recommendations.

5.2 Ground Conditions

BGS borehole log "*SP41SE502 – County Dairies (Oxford) Limited 1*" (located 470m to the east-south-east), recorded the following strata:

Depth bgl (m)	Strata
0.00m to 1.00m	**Clay**
1.00m to 5.50m	**Gravel**
5.50m to 11.30m	**Clay**

Table 2: Ground Conditions Summary

In addition, an analysis of *BGS* mapping associated with the Study Site suggests that the Site is likely to be underlain by a bedrock of "*Cornbrash Formation - Limestone*".

5.3 UXB Burial Depths

Based on the ground conditions described above, the average BPD for a 250kg *German* HE bomb is assessed to be approximately 6m below WWII ground level, with the maximum BPD considered to be approximately 14m below WWII ground level.

Although it is possible that the *Luftwaffe* deployed larger bombs in the area, an analysis of WWII bomb census data clearly evidences that their deployment was infrequent. Therefore, to use such larger bombs for BPD calculations **is not justifiable under the ALARP principle and thus, *CIRIA* C681 guidance**.

WWII *German* bombs have a greater penetration depth when compared to IBs and AAA projectiles, which are unlikely to be encountered at depths greater than 1m below WWII ground level.

5.3.1 The J-Curve Effect

As a UXB penetrated the ground, it's velocity naturally slowed where it either came to an abrupt stop (e.g., against foundations) or would continue along a route of least resistance – which often resulted in a curving of the trajectory back towards the surface. This is known as the "J Curve" effect and often resulted in a considerable horizontal off-set from the point of entry. This explains why UXBs have been discovered against or under the foundations of buildings which were present during WWII, or many meters from their entry holes. A diagrammatical representation of the "J Curve" effect is presented at Figure 1.

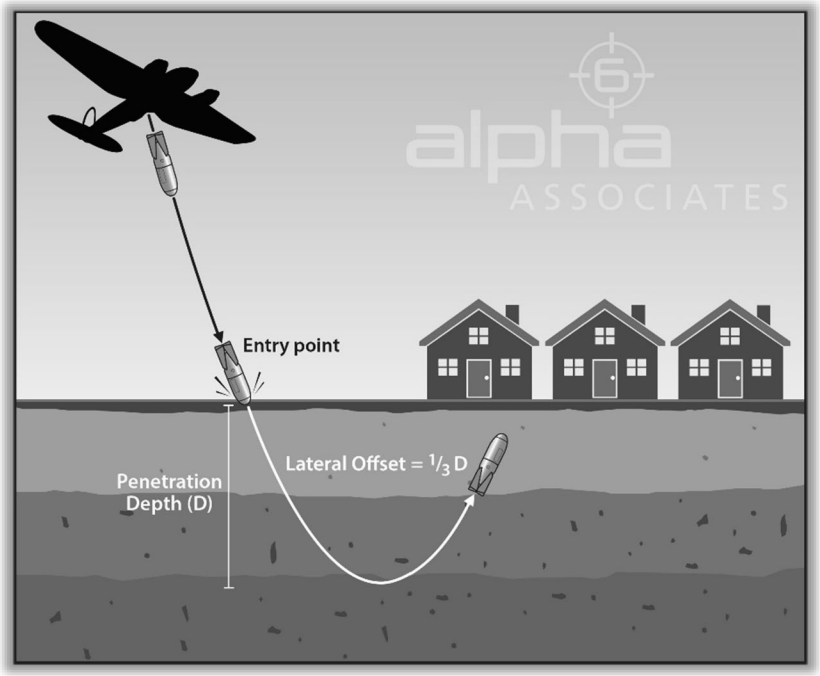


Figure 1: The J-Curve Effect

5.4 AXO/LSA/SAA Burial Depths

If present, *British* AXO/LSA/SAA are likely to be encountered in previously undisturbed ground to depths of circa 2.0m.

6 UXO Risk Pathways

6.1 Overview

In order to assess whether a viable UXO risk pathway might exist at the Study Site, potential UXO contamination sources must be assessed (and have been at Section 4 of the report) and the likely depth of UXO contamination ought to be established (as per Section 5 of the report). Additionally, the Site's construction history ought to be considered to assess whether any previous intrusive works will have encountered and removed any UXO contamination previously generated at the Site.

6.2 Study Site Construction History

From an analysis of *CS* and *OS* mapping, together with aerial photography, the following site history can be deduced:

Year	Development History
1936 CS Map	The Study Site was situated in an undeveloped rural area and comprised undeveloped ground.
1945 Aerial Photography	Structures were visible in the south-eastern sector.
1967 OS Map	Changes were not recorded at the Study Site.
1974 OS Map	Multiple structures had been developed in the northern sector, and structures in the south-eastern sector had been demolished.
1991 OS Map	Structures in the northern sector had been demolished.
2004 Aerial Photography	Additional structures and hardstanding were visible in the south-eastern sector.
2016 OS Map	A structure in the south-eastern sector had been extended.
2025 OS Map	Changes were not recorded at the Study Site.

Table 3: Study Site Development History

As per Table 3, it is apparent that the Study Site has undergone significant post-WWII development in certain areas, specifically concerning the development of multiple structures in the northern sector by 1974, along with the demolition of these structures and construction of new buildings in the south-

eastern sector by 2004. Moreover, the Client has informed *6 Alpha* that the current *IRC* on-site has been refurbished and reopened. Consequently, it is considered likely that any UXO contamination within ground that has been disturbed since WWII would likely have been discovered and removed. Nonetheless, it is apparent that the previous intrusive works are unlikely to have mitigated the UXO risk in all areas of the Study Site down to the likely average UXO burial depth of 6m below ground level.

6.3 Proposed Works

An outline of the proposed intrusive works is also presented in order to evidence the potential UXO risk pathways that may be generated, should such work encounter those threat spectrum UXO that have been identified in Section 4.

The Client has not informed has not informed *6 Alpha* of the specific works to be undertaken at this Study Site, although the current *IRC* has been previously refurbished and reopened. Consequently, a number of ground investigation and construction methodologies will be assumed to be undertaken.

As a result, it is apparent that potential proposed intrusive works might generate a UXO risk pathway in ground that has not been previously disturbed (including any ground below post-WWII intrusive work) to a depth of 6m below WWII ground level

If the planned methods are changed or different from those assumed by *6 Alpha* at Section 7 of this report, then the risk assessment is to be reviewed and, if necessary, updated by *6 Alpha*.

7 UXO Risk Assessment

7.1 Threat Items

The most probable sources of UXO risk at this Study Site are *German* aerially delivered ordnance and *British* AXO/LSA/SAA associated with the military activity in the immediate vicinity. *British* AAA projectiles may pose a residual threat as they likely fired in defence of the local area during air raids.

7.2 Risk Pathways

Given the nature and scope of the prospective UXO hazard at the Study Site, all types of aggressive intrusive activities (i.e., investigative groundworks and construction methodologies) into previously undisturbed ground (including ground below any post-WWII redevelopment) to a depth of 6m below WWII ground level may generate a significant risk pathway.

7.3 Risk Receptors

The likely risk receptors include:

- Site personnel;
- Plant and equipment;
- Third-party infrastructure (utilities/services) and buildings;
- The natural environment.

The consequences of a UXO initiation may include:

- Injuries and/or fatalities to personnel;
- Damage to plant and equipment, nearby buildings and/or infrastructure;
- Rupture and damage underground utilities/services and the natural environment.

The consequences of an unexpected and unplanned UXO discovery might include:

- Incurring delays and additional costs through the expenditure of additional risk mitigation resources and EOD clearance;
- Disruption to local community;
- Negative publicity.

7.4 Semi-Quantitative Risk Assessment

A Semi-Quantitative Risk Assessment (SQRA) has been undertaken and the results of the SQRA are presented at Table 4.

Activity	UXO Threat Item	Probability (SH+EM=P)	Consequence (D+PSR=C)	Risk (PxC=R)
Trial Pits	Aerial Bombs	2+2=4	3+3=6	**4x6=24**
	AXO/LSA/SAA	2+2=4	3+2=5	**4x5=20**
	AAA Projectiles	1+2=3	3+1=4	**3x4=12**
Boreholes	Aerial Bombs	2+3=5	3+2=5	**5x5=25**
	AXO/LSA/SAA	2+3=5	3+2=5	**4x5=25**
	AAA Projectiles	1+3=4	3+1=4	**4x4=16**
Excavations	Aerial Bombs	2+2=4	3+3=6	**4x6=24**
	AXO/LSA/SAA	2+2=4	3+2=5	**4x5=20**
	AAA Projectiles	1+2=3	3+1=4	**3x4=12**
Trenching	Aerial Bombs	2+2=4	3+3=6	**4x6=24**
	AXO/LSA/SAA	2+2=4	3+2=5	**4x5=20**
	AAA Projectiles	1+2=3	3+1=4	**3x4=12**
Piling	Aerial Bombs	2+3=5	3+2=5	**5x5=25**
	AXO/LSA/SAA	2+3=5	3+2=5	**4x5=25**
	AAA Projectiles	1+3=4	3+1=4	**4x4=16**

Table 4: UXO SQRA Results

7.4.1 SQRA Conclusions

The SQRA has determined that the proposed intrusive works may generate, as a reasonable worst-case scenario, a ***HIGH*** level of risk at the Study Site. Such risks may pose harm to human health and damage any equipment involved in intrusive activities; the former are intolerable. Therefore, such risks will require mitigating in accordance with the ALARP principle, as per Part III of this report.

Part III: UXO Risk Mitigation Strategy

8 UXO Risk Mitigation Strategy

8.1 Strategic Overview

As per *CIRIA* C681 guidance, *6 Alpha* recommended that the identified UXO risks are reduced ALARP. Crucially, the ALARP principle states that if the cost of reducing a risk significantly outweighs the benefit, then the risk may be considered tolerable. This does not mean that there is never a requirement for UXO risk mitigation, but that any mitigation must demonstrate that it is beneficial. Any additional mitigation that delivers diminishing benefits and that consumes disproportionate time, money and effort are considered *de minimis* and thus unnecessary. Because of this principle, UXO risks will rarely be reduced to zero (nor need they be).

Consequently, the following proactive and reactive UXO risk mitigation measures ought to be implemented ahead of proposed intrusive operations at the Study Site in order to reduce the identified UXO risks to ALARP.

8.2 Proactive UXO Risk Mitigation Measures

The following proactive risk mitigation measures should be undertaken prior to the commencement of intrusive works:

8.2.1 Non-Intrusive UXO Survey and/or EOD Engineer in the Watching Brief Role

Where “open” intrusive works into previously undisturbed ground are proposed and where the extent is likely to be within the effective capabilities of survey equipment, a non-intrusive geophysical UXO survey should be trialed.

If the trial proves successful, a non-intrusive geophysical UXO survey should be employed either site-wide, or in specific areas where intrusive works are proposed, to identify for signs of sub-surface anomalies which may model as the threat spectrum UXO in advance of said works.

If the survey proves partially or wholly ineffective, an EOD Engineer should be present in the UXO Watching Brief role to monitor ongoing “open” intrusive works to identify any suspicious items that may be UXO related.

8.2.2 Intrusive Magnetometer Survey

Where “blind” intrusive works into previously undisturbed ground are proposed, an intrusive UXO survey (employing down-hole magnetometer or *MagCone* techniques) is strongly recommended in advance of the works, to identify for signs of sub-surface anomalies which may model as threat spectrum UXO. Such a survey should extend to the **assessed average bomb penetration depth of 6m**

bgl or to the maximum depth of the works, whichever is encountered first, or until geology is encountered through which it is assessed a UXB would not penetrate.

8.2.3 Geophysical UXO Survey Efficacy

Certain ground conditions may constrain geophysical UXO surveys, as magnetometer surveys are adversely affected by mineralised and made ground. Nonetheless, *6 Alpha* can advise the likely efficacy of such survey work in advance of their trial and implementation as and when required.

8.3 Reactive UXO Risk Mitigation Measures

The following reactive risk mitigation measures should also be undertaken for all activities in all areas:

8.3.1 Operational UXO Emergency Response Plan

A UXO-specific Emergency Response Plan should be held on-site to guide and plan for the actions which should be undertaken in the event of a suspected or real UXO discovery (this plan can be supplied by *6 Alpha*).

8.3.2 UXO Safety and Awareness Briefings

A UXO Safety and Awareness Briefing is recommended and is essential when there is a possibility of an explosive ordnance encounter; these briefings are a vital part of the general safety requirement. All personnel working on the Site should receive a briefing on the following:

- The identification of threat spectrum UXO;
- What actions they should take to keep people and equipment away from such a hazard and to alert site management.

Information concerning the nature of the UXO threat should also be held in the site office and displayed for general information on noticeboards - both for reference and as a reminder for ground workers.

The safety awareness briefing is an essential part of the *Health & Safety Plan* for the site and helps to evidence conformity with the appropriate health and safety standards and legislation.

8.4 ALARP Safety Sign Off Certification

ALARP safety sign-off certification provides an independent source of evidence that a Client has followed industry best practice and has successfully managed and reduced UXO risks to ALARP. Following the execution of *6 Alpha's* UXO risk mitigation measures, we can deliver ALARP safety sign-off certification, in advance of the proposed operations.

In such circumstances the project will be able to certify for the benefit of all of its stakeholders, that all reasonably practicable measures have been taken to protect contractors from UXO hazards and

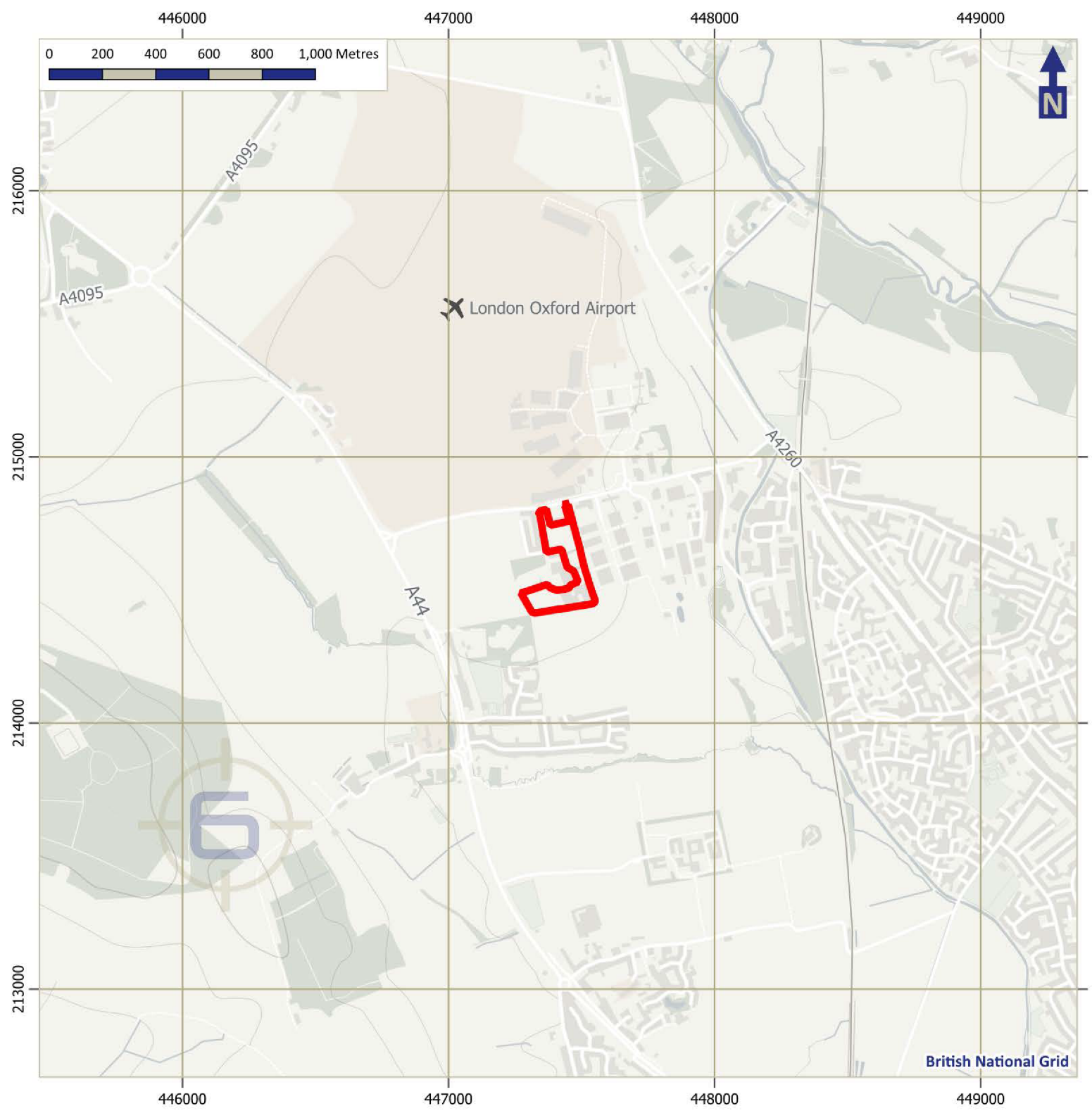
that the commissioning Client will have acted in compliance with industry best practice as well as the national safety legislation.

8.5 Recommended Next Steps

We recommend that the Client's next steps are focused upon phase four of the UXO Risk Management Framework namely, the detailed designs of the recommended proactive UXO risk mitigation measures as outlined above.

Appendices

Appendix 1 – Site Location



Site Location

BOMB SEARCH

LEGEND

Site Boundary

British National Grid

Address

Campsfield IRC Expansion

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
10029	1	DB	LG	03/12/2025

alpha ASSOCIATES
special risks consultancy

W W W . 6 A L P H A . C O M
E: ENQUIRY@6ALPHA.COM | T: +44 (0)203 371 3900

Appendix 2 – Site Boundary

Site Boundary

BOMB SEARCH

LEGEND

Site Boundary

British National Grid

Address

Campsfield IRC Expansion

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
10029	2	DB	LG	03/12/2025

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special risks consultancy

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Modern Aerial Photography

BOMB SEARCH

LEGEND

Site Boundary

British National Grid

Address

Campsfield IRC Expansion

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
10029	3	DB	LG	03/12/2025

alpha ASSOCIATES
special risks consultancy

Map data: ©2025 Google

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1945 Aerial Photography

BOMB SEARCH

LEGEND

Site Boundary

British National Grid

Address

Campsfield IRC Expansion

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
10029	4	DB	LG	03/12/2025

alpha ASSOCIATES
special risks consultancy

Map data: Google, The GeoInformation Group, Infoterra Ltd, Bluesky, Getmapping plc

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Appendix 5 – WWII High Explosive Bomb Density

WWII High Explosive Bomb Density

BOMB SEARCH

LEGEND

Site Boundary

High Explosive Bomb Density

- Less than 15 bombs per 100 hectares
- 16-25 bombs per 100 hectares
- 26-35 bombs per 100 hectares
- 36-45 bombs per 100 hectares
- Over 46 bombs per 100 hectares

British National Grid

Address

Campsfield IRC Expansion

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
10029	5	DB	LG	03/12/2025

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special risks consultancy

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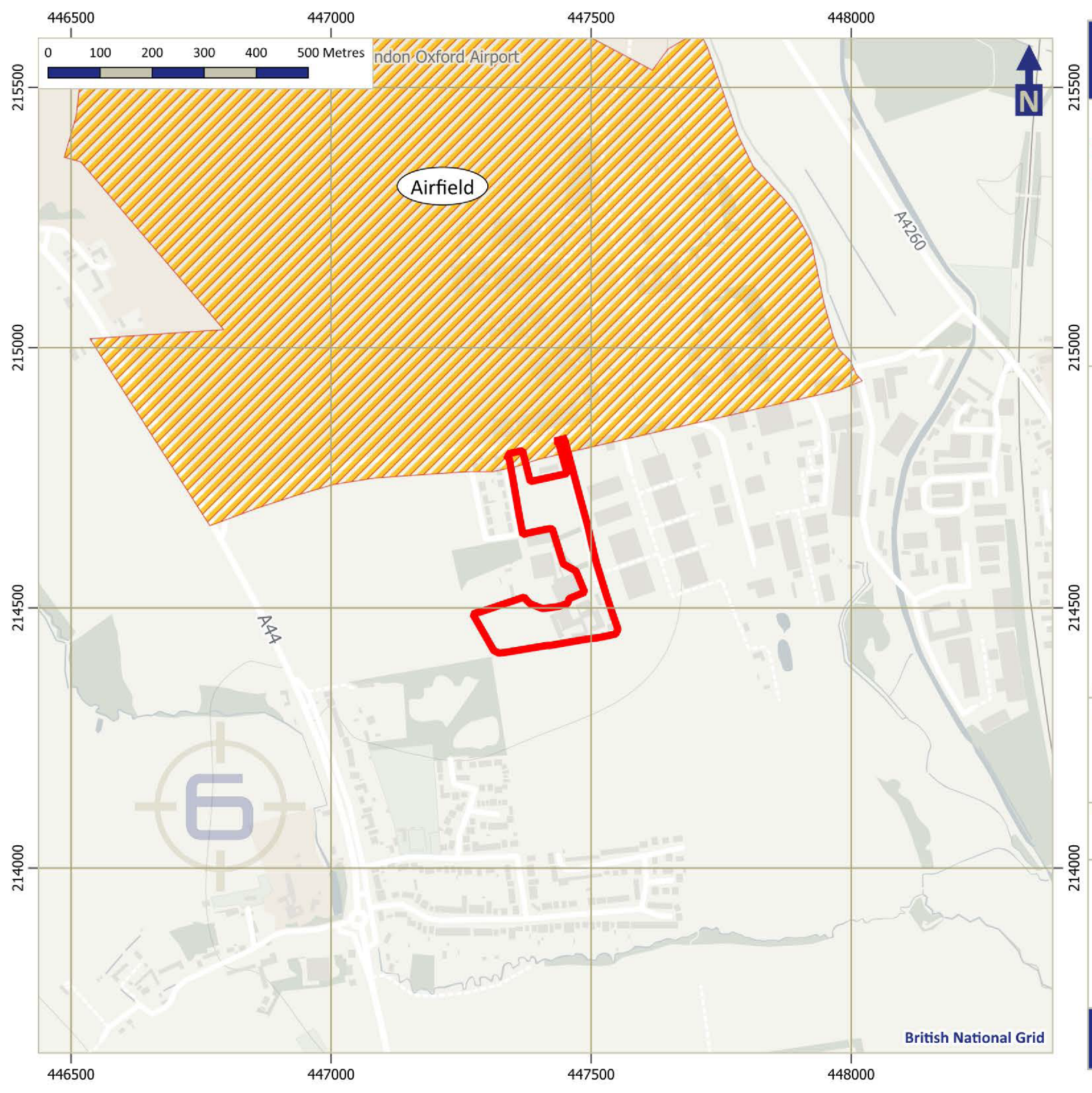

WWII Luftwaffe Bombing Targets

BOMB SEARCH

LEGEND

- Site Boundary
- Luftwaffe Target

British National Grid

Address

Campsfield IRC Expansion

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
10029	6	DB	LG	03/12/2025

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Historical Military Activity

BOMB SEARCH

LEGEND

- Site Boundary
- Military Airfield Boundary

British National Grid

Address

Campsfield IRC Expansion

PROJECT NO.	FIGURE	DRAWN	CHECKED	DATE
10029	7	DB	LG	03/12/2025

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