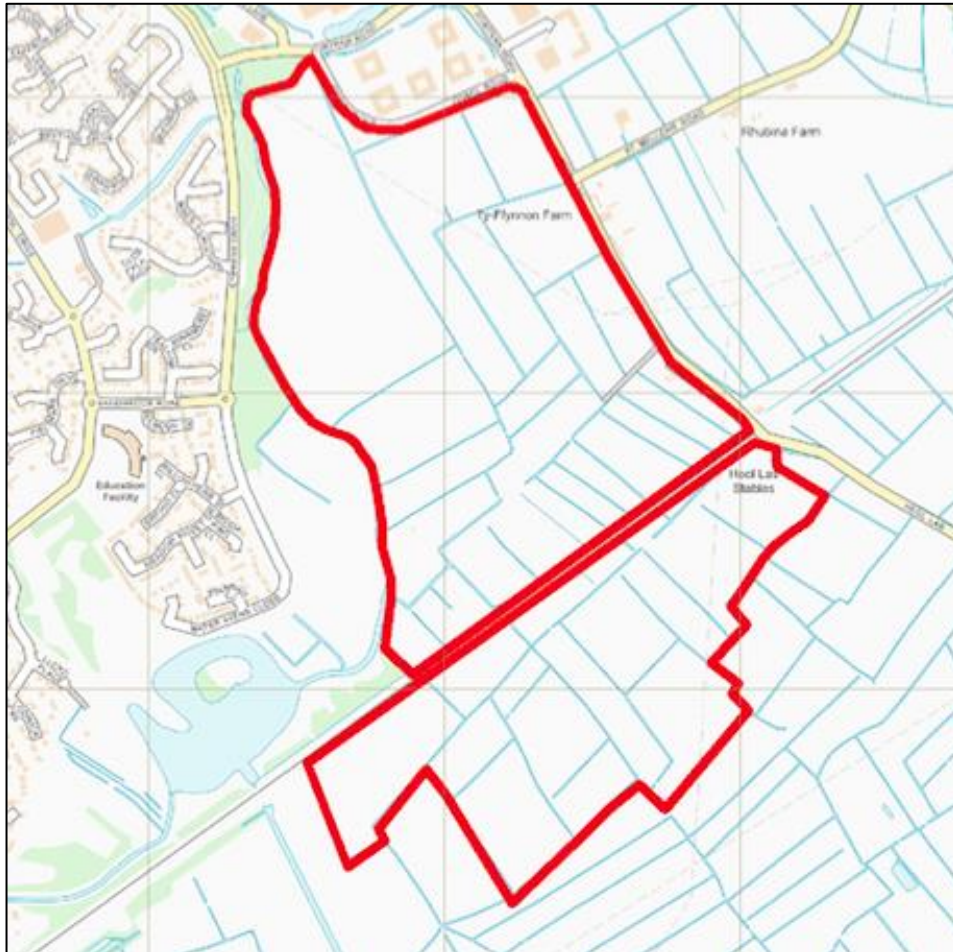


Detailed Unexploded Ordnance (UXO) Threat & Risk Assessment

Meeting the requirements of *CIRIA* C681 'Unexploded Ordnance (UXO)
A guide for the Construction Industry' Risk Management Framework



PROJECT NUMBER	P6665	ORIGINATOR	L. Gregory
VERSION NUMBER	1.0	REVIEWED BY	B. Wilkinson (7 th June 2018)
CLIENT	Arup	RELEASED BY	S. Barratt (11 th June 2018)
SITE	St Mellons, Cardiff		
RATING	LOW - This Site requires limited further action to reduce risk to ALARP during intrusive activities.		

Contents

Contents.....	1
Acronyms and Abbreviations.....	2
EXECUTIVE SUMMARY.....	3
ASSESSMENT METHODOLOGY	5
STAGE ONE – SITE LOCATION AND DESCRIPTION	6
Proposed Works.....	6
Ground Conditions	6
STAGE TWO – REVIEW OF HISTORICAL DATASETS.....	7
STAGE THREE – DATA ANALYSIS.....	11
STAGE FOUR – RISK ASSESSMENT	12
Threat Items	12
Bomb Penetration Depth	12
UXO Risk Calculation Table	13
STAGE FIVE – RECOMMENDED RISK MITIGATION MEASURES	14
Report Figures.....	15

FIGURES

- Figure One - Site Location
- Figure Two - Site Boundary
- Figure Three - Aerial Photography (Current)
- Figure Four – Aerial Photography (1945)
- Figure Five - WWII High Explosive Bomb Density

Acronyms and Abbreviations

AA	Anti-Aircraft	NEQ	Net Explosive Quantity
AAA	Anti-Aircraft Ammunition	NFF	National Filling Factory
ALARP	As Low As Reasonably Practicable	NGR	National Grid Reference
AOD	Above Ordnance Datum	OD	Ordnance Datum
ARP	Air Raid Precaution	OS	Ordnance Survey
AXO	Abandoned Explosive Ordnance	PM	Parachute Mine
BD	Bomb Disposal	PoW	Prisoner of War
BDO	Bomb Disposal Officer	RADAR	Radio Detection And Ranging
bgl	Below Ground Level	RAF	Royal Air Force
BGS	British Geological Survey	RN	Royal Navy
BH	Borehole	RNAS	Royal Naval Air Service
BPD	Bomb Penetration Depth	ROF	Royal Ordnance Factory
CDP	Cast Driven Piles	SAA	Small Arms Ammunition
CFA	Continuous Flight Auger	TA	Territorial Army
CIRIA	Construction Industry Research and Information Association	TNT	Trinitrotoluene
CPT	Cone Penetration Testing	UK	United Kingdom
CS	County Series	UN	United Nations
EO	Explosive Ordnance	USAAF	United States Army Air Force
EOC	Explosive Ordnance Clearance	UXB	Unexploded Bomb
EOD	Explosive Ordnance Disposal	UXO	Unexploded Ordnance
GI	Ground Investigation	V Weapons	<i>Vergeltungswaffe</i> – Vengeance Weapons
GIS	Geographic Information Systems	WD	War Department
GL	Ground Level	WWI	World War One
GP	General Purpose	WWII	World War Two
GPS	Global Positioning Systems		
HAA	Heavy Anti-Aircraft		
HE	High Explosive		
HO	Home Office		
HSE	Health and Safety Executive		
IB	Incendiary Bomb		
kg	Kilograms		
km	Kilometres		
LAA	Light Anti-Aircraft		
LCC	London County Council		
LE	Low Explosive		
LSA	Land Service Ammunition		
m	Metres		
MoD	Ministry of Defence		
mm	Millimetres		

EXECUTIVE SUMMARY

Study Site

The Client has defined the Study Site as “St Mellons, Cardiff”. The Site is located at NGR 325107, 180862.

Risk Level

LOW

Potential Threat Sources

The most probable UXO threat is posed by WWII *German* HE bombs, whilst IBs and *British* AAA projectiles (which were used to defend against *German* bombing raids) pose a residual threat.

Risk Pathway

Whilst there is a residual UXO risk within this Site, 6 Alpha do not believe there is a significant risk pathway to warrant on-site pro-active UXO risk mitigation measures.

Key Findings

During WWII, the Study Site was situated within the *Magor & St Mellons Rural District*, which recorded two HE bomb strikes per 100 hectares, a very low level of bombing.

Luftwaffe aerial reconnaissance photography associated with the Site did not identify any primary bombing targets on-site or within 1,000m of it. Nonetheless, a railway line and railway depot located in the vicinity may have been considered secondary bombing targets.

ARP records did not cover the Study Site. However, further research of historical records identified that the *Starfish* decoy sites located, 200m south-west and 940m south-south-east was successful in drawing *Luftwaffe* bombing raids away from *Cardiff* and therefore would have been subjected to bomb strikes.

Official bomb damage mapping associated with the Site was not available. Given that the Study Site was undeveloped during WWII, post-WWII mapping would not ordinarily be expected to display any bomb damage within the Site boundary. However, an analysis of post-war mapping and further research of historical records did not identify any potential bomb damage on-site or in close proximity to it.

Aerial photography (1945) associated with the Site shows that it was located within an undeveloped rural area during WWII. Structures did not occupy the Site, however a railway line was developed between the two sectors of the Site. As a result, whilst railway authorities may have inspected the railway line for UXB entry holes following any raids, it is highly unlikely that UXB entry holes across the entire Site would have been recorded and reported.

Whilst the village of *St Mellons* has developed post-1945 along the north and western borders of the Site, the lack of post-war development on-site means that the potential for deep buried UXO to be present within the Site is assessed to be extant. Given that there is no evidence to suggest the Site was subjected to bombing nor did it sustain bomb damage directly, the following risk mitigation measures are recommended as a minimum, in order to reduce risks ALARP, during all intrusive works.

EXECUTIVE SUMMARY (...continued)

Recommended Risk Mitigation

All Groundworks in All Areas:

1. Operational UXO Emergency Response Plan; appropriate Site Management documentation should be held on Site to guide and plan for the actions which should be undertaken in the event of a suspected or confirmed UXO discovery (this plan can be supplied by *6 Alpha*);

2. UXO Safety & Awareness Briefings; the briefings are essential when there is a possibility of an-UXO / UXB encounter and are a vital part of the general safety requirement. All personnel working on the Site should receive a briefing on the identification of an UXO / UXB, 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 / UXB threat should be held in the Site office and displayed for general information on notice boards, 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 principles laid down in the *CDM* regulations 2015 (this briefing can be delivered directly, or in some cases remotely, by *6 Alpha*).

For further information, please contact *6 Alpha Associates*:

Website: <http://www.6alpha.com>

Telephone: +44 (0)2033 713 900

Email: enquiry@6alpha.com

ASSESSMENT METHODOLOGY

Approach

6 Alpha Associates is an independent, specialist risk management consultancy practice, which has assessed the risk of encountering UXO (as well as buried bulk high explosives) at this Site, by employing a process advocated for this purpose by CIRIA. The CIRIA guide for managing UXO risks in the construction industry (C681) not only represents best practice but has also been endorsed by the HSE. Any risk mitigation solution is recommended *only* because it delivers the Client a risk reduced to ALARP at best value.

UXO hazards can be identified through the investigation of local and national archives associated with the Site, MoD archives, local historical sources, historical mapping as well as contemporaneous aerial photography (if it is available). Hazards will have only been recorded if there is specific information that could reasonably place them within the boundaries of the Site. The amalgamation of information is then assessed to enable the researcher to provide relevant and accurate risk mitigation practices.

The assessment of UXO risk is a measure of *probability of encounter* and *consequence of encounter*; the former being a function of the identified hazard and proposed development methodology; the latter being a function of the type of hazard and the proximity of personnel (and/or other 'sensitive receptors', such as equipment) to the hazard, at the moment of encounter.

If UXO risks are identified, the methods of mitigation we have recommended are considered reasonably and sufficiently robust to reduce them to ALARP. We advocate the adoption of the legal ALARP principle because it is a key factor in efficiently and effectively ameliorating UXO risks. It also provides a ready means for assessing the Client's tolerability of UXO risk. In essence, the 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 consume disproportionate time, money and effort are considered *de minimis* and thus unnecessary. Because of this principle, UXB and UXO risks will rarely be reduced to zero (nor need they be).

Important Notes

Key source material is referenced within this document, whilst secondary/anecdotal information may be available upon request.

Although this report is up to date and accurate at the time of writing, our databases are continually being populated as and when additional information becomes available. Nonetheless, 6 Alpha have exercised all reasonable care, skill and due diligence in providing this service and producing this report.

The assessment levels are based upon our professional opinion and have been supported by our interpretation of historical records and third party data sources. Wherever possible, 6 Alpha has sought to corroborate and to verify the accuracy of all data we have employed, but we are not accountable for any inherent errors that may be contained in third party data sets (e.g. *National Archive* or other library sources), and over which 6 Alpha cannot exercise control.

STAGE ONE – SITE LOCATION AND DESCRIPTION

Study Site

The Client has defined the Study Site as “St Mellons, Cardiff”. The Site is located at NGR 325107, 180862. The Site location and Site boundary are presented at *Figures 1* and *2* respectively.

Location Description

The Study Site is situated within the *Magor & St Mellons Rural District* and covers an area of approximately 74.26 hectares (ha).

Furthermore, the Site is bounded by:

- North: *St Mellons Business Park*;
- East: Undeveloped fields;
- South: Undeveloped fields;
- West: *Cyrpress Drive* & residential housing.

Aerial Photography (Current) (*Figure 3*)

Current aerial photography corroborates the information above and shows that the Site is situated within a developing rural area.

Proposed Works

The Client has described the following: “*Works at the site are anticipated to include the construction of 2-3 storey buildings. The buildings are anticipated to be piled into the underlying bedrock and the ground investigation is likely to consist of many CPTs into the underlying bedrock. During construction, it is anticipated that band drains will be installed through the tidal flat deposits across the site*”.

Ground Conditions

It is important to establish the specific ground conditions in order to determine the maximum *German* UXB penetration depth as well as the potential for other types of munitions to be buried.

If the Site investigations and/or construction methodologies change, and/or if a specific methodology is to be employed, and/or if the scope of work is focused upon a specific part of the Site, then *6 Alpha* are to be informed so that the prospective UXO risks and the associated risk mitigation methodology might be re-assessed. Certain ground conditions may also constrain certain types of UXO risk mitigative works e.g. magnetometer survey is adversely affected in mineralised and made ground.

Ground Conditions

The client provided *6 Alpha* with the document “*Representative BH log.pdf*” which recorded the following strata:

Depth bgl (m)	Strata	Description
0.00m to 7.00m	Clay	Tidal flat deposits - soft to firm clay/silt with peat bands. The tidal flat deposits will vary in thickness from <0.5m to approx. 7m.
7.00m to 10.00m	Sand	Glacial till – gravelly silt/sand with cobbles and boulders.
10.00m to 13.00m	Mudstone	Weathered bedrock (mudstone).
13.00m to 14.00m	Mudstone	Intact bedrock (mudstone).

STAGE TWO – REVIEW OF HISTORICAL DATASETS

Sources of Information Consulted

The following primary information sources have been used in order to establish the background UXO threat:

1. *6 Alpha's Azimuth Database*;
2. *Home Office WWII Bomb Census Maps*;
3. WWII and post-WWII aerial photography;
4. Official Abandoned Bomb Register;
5. Information gathered from the *National Archives at Kew*;
6. Historic UXO information provided by *33 Engineer Regiment (Explosive Ordnance Disposal)* at *Carver Barracks, Wimbish*.

Potential Sources of UXO Contamination

In general, there are several activities that might contaminate a site with UXO but the three most common ways are: legacy munitions from military training/exercises; deliberate or accidental dumping (AXO) and ordnance resulting from war fighting activities (also known as the Explosive Remnants of War (ERW)).

During WWII, the *Luftwaffe* undertook bombing campaigns all over the *UK*. The most common type of UXO discovered today is the aerially delivered high explosive (HE) bomb, which are comparatively thick-skinned and dropped from enemy aircraft. If the bomb did not detonate when it was dropped, the force of impact enabled the UXO to penetrate the ground, often leaving behind it a UXB entry hole. These entry holes were not always apparent and some went unreported, leaving the bomb buried and unrecorded. More rarely, additional forms of *German* UXO are occasionally discovered including *inter alia* V1 and V2 rockets, Incendiary Bombs (IBs), and Anti-personnel (AP) bomblets.

Although the *Luftwaffe* had designated primary bombing targets across the *UK*, their high-altitude night bombing was not accurate. As a result, thousands of buildings were damaged and civilian fatalities were common. Bombs were also jettisoned over opportunistic targets and residential areas were sometimes struck.

As the threat of invasion lingered over *Britain* during WWII, defensive actions were undertaken. The *British* and *Allied Forces* requisitioned large areas of land for military training and bomb storage (including HE bombs, naval shells, artillery and tank projectiles, explosives, LSA and SAA). Thousands of tonnes of these munitions were used for the *Allied Forces* weapon testing and military training alone. It has been estimated that at least 20 per cent of the *UK's* land has been used for military training at some point.

The best practice guide for dealing with your UXO risks on land (CIRIA publication C681) suggests that approximately 10 per cent of all munitions deployed failed to function as designed. ERW are therefore, still commonly encountered, especially whilst undertaking construction and civil engineering groundwork.

Furthermore, in exceptional circumstances, UXO is discovered unexpectedly and without apparent rational explanation. There are several ways this might occur:

- When *Luftwaffe* aircraft wished to swiftly escape e.g. from an aerial attack, they would jettison some or all of their bombs and flee. This is commonly referred to as *tip and run* and it has resulted in bombs being found in unexpected locations;
- Transportation of aggregate containing munitions to an area that was previously free of UXO, usually related to construction activities employing material dredged from a contaminated offshore borrow site;
- Poor precision during targeting (due to high altitude night bombing and/or poor visibility) resulted in bombs landing off target, but within the surrounding area.
- *British* decoy sites were also constructed to deliberately cause incorrect targeting. For obvious reasons, such sites were often built in remote and uninhabited areas.

Site History

From an analysis of the CS and OS historical mapping associated with the Site, the following Site history can be deduced:

Year	On-Site	Vicinity
1898-1902 CS Map	The Study Site did not consist of any structures.	The Site was situated within a rural area with a line of the <i>Great Western Railway</i> running between the northern and southern sector.
1916 CS Map	Changes were not recorded at the Study Site.	Changes were not recorded in the vicinity.
1947-1948 CS Map	Changes were not recorded at the Study Site.	Changes were not recorded in the vicinity.
1963-1964 OS Map	Changes were not recorded at the Study Site.	Railway depot constructed south-west of the Site.
1970-1973 OS Map	An electricity pylon route was developed partially on-site.	Residential properties were developed to the west of the Site.
1987-1992 OS Map	Changes were not recorded at the Study Site.	Continued urban expansion to the west of the Site. Construction of the business park and a factory immediately north of Site.
2002 OS Map	Changes were not recorded at the Study Site.	Changes were not recorded in the vicinity.
2010 OS Map	Changes were not recorded at the Study Site.	Changes were not recorded in the vicinity.
2014 OS Map	Changes were not recorded at the Study Site.	Changes were not recorded in the vicinity.

Aerial Photography (1945) (Figure 4)

The aerial photography (1945) associated with the Site shows that the Site was located within a largely rural area with a railway line situated between the northern and southern sectors of the Site.

WWII Bombing of Wales

Cardiff and *Swansea* were subject to the most sustained attacks in *Wales* during WWII. In *Cardiff*, over the course of the war, 33,000 houses sustained damage, over 500 were demolished and 355 civilians were killed. *Swansea* suffered the most intense single attack when a raid that lasted three nights in February 1941 destroyed half the buildings located within the town centre. Approximately 30,000 bombs were dropped; 575 business premises burnt out; 282 houses demolished and 11,084 damaged. 227 people were killed.

The docks and industrial works of *Cardiff* and *Swansea* made them obvious targets but there were attacks elsewhere too. Ordnance factories, oil installations, mining towns and even rural communities were bombed by orchestrated attacks, lost planes or those just eager to lose their payload before returning home.

The first *Luftwaffe* bombing attack sustained by *Swansea* occurred on the 27th June 1940. This was the first of 44 such bombing raids endured by *Swansea* throughout the course of WWII.

WWII Luftwaffe Bombing Targets

Prior to WWII, the *Luftwaffe* conducted numerous aerial photographic reconnaissance missions over *Britain*, recording key military, industrial and commercial facilities for attack, in the event of war. In addition, logistics infrastructure and public services, such as railways, canals, power stations, reservoirs, water and gas works were also considered viable bombing targets.

Luftwaffe aerial reconnaissance photography associated with the Site did not identify any primary bombing targets on-site or within 1,000m of it. Nonetheless, a railway line (located between the north and south sectors of the Site) and a railway depot (located 885m west-south-west) may have been considered secondary bombing targets.

WWII HE Bomb Strikes

During WWII, ARP wardens compiled detailed logs of bomb strikes across their respective districts. ARP records did not cover the Study Site. However, further research of historical records identified that the *Starfish* decoy site located 940m south-south-east was successful in drawing *Luftwaffe* bombing raids away from *Cardiff* and therefore would have been subjected to bomb-strikes. Furthermore, whilst IBs may have fallen within the Study Site, they fell in such large numbers that accurate record keeping was either non-existent or perfunctory therefore, their prospective presence cannot be either corroborated or discounted.

In addition to IBs and HE bomb strikes, during the latter part of the war when aerial bombing had significantly declined, the main threat came from V type weapons. V1 and V2 rockets were thin-skinned, unmanned and inaccurate weapons. Despite this, there is no evidence to suggest that the Site (or its immediate vicinity) was subjected to rockets strikes during WWII.

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 which in turn will be influenced on factors such as 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 finally, the below ground level conditions which were encountered such as infrastructure e.g. services, basements, foundations, and geology e.g. made ground, clay, sand, etc. Further, as the UXB penetrated the ground, it's velocity naturally slowed where, it either came to an abrupt stop e.g. against foundations or would continue for 10's of feet 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 is often the reason why UXBs have been discovered against or under the foundations of buildings, which were present during WWII, or many meters from the point of impact.

WWII Bomb Damage

Official bomb damage mapping associated with the Site was not available. However, given that the Study Site and wider area were undeveloped during WWII, post-WWII mapping would not ordinarily be expected to display any bomb damage within the Site boundary. Furthermore, an analysis of post-war mapping and further research of historical records did not identify any potential bomb damage on-site or in close proximity to the Site.

WWII HE Bomb Density (Figure 5)

The Study Site was located within the *Magor & St Mellons Rural District*, which recorded two HE bombs per 100 hectares, a very low level of bombing.

Abandoned Bombs

An examination of the official abandoned bomb records did not identify any tasks within 1,000m of the Site.

Records of WWII UXB Disposal Tasks

Civil defense records did not identify any UXB disposal tasks within *Magor & St Mellons Rural District* from 1940-45. However, it is known that these records are incomplete, some having been destroyed by enemy action during WWII.

Records of Post-WWII UXB Disposal Tasks

An examination of the post-WWII BDO tasks associated with the area has not identified any BDO operations within 1,000m of the Site.

WWII Site Use

The CS mapping prior to WWII (1922), shows that the Study Site was located in a rural area. The Site itself did not consist of any structures, however a railway line was situated between the northern and southern sectors of the Site. As a result, whilst railway authorities may have inspected the railway line for UXB entry holes following any raids, it is highly unlikely that UXB entry holes across the entire Site would have been recorded and reported.

Sources of UXO Contamination

The most likely source of UXO contamination is from *German* aerially delivered ordnance, which ranges from small IBs through to large HE bombs (the latter forms the principal threat). Additional residual contamination may be present from *British* AAA projectiles (which were used to defend the UK against *German* bombing raids).

STAGE THREE – DATA ANALYSIS

Variable	Result	Comment
Was the area considered to be a primary bombing target?	✗	No primary targets were identified within 1,000m.
Was the Site or the immediate area bombed during WWII?	✓	Further research identified that the <i>Starfish</i> decoy sites located in the vicinity were successful in drawing <i>Luftwaffe</i> bombing raids away from Cardiff, and therefore, would have been subject to bomb strikes.
Did the Site or the immediate area experience bomb damage?	✗	There is no evidence of bomb damage on-site or in the vicinity.
Was the ground undeveloped during WWII?	✓	The Site did not consist of any structures during WWII.
Would the footfall have been high in the area?	✗	Given the undeveloped nature of the Site and its surrounding area, footfall in the area is likely to have been low.
Would a UXB entry hole have been observed during WWII?	✗	Given the undeveloped nature of the Site and its surrounding area, UXO entry holes may have gone unnoticed.
Have military personnel ever occupied the Site?	✗	No military facilities were identified on-site. However, a PoW camp was located 605m north near <i>Castleton</i> .
Would munitions have been manufactured, stored and/or fired from the Site?	✗	There is no evidence to suggest munitions were located or fired from this Site.
Would previous intrusive works have removed the potential for UXO to be present?	✗	The Site has not been subjected to any significant post-war development. Therefore, there is the potential for UXO to be present.
Are proposed intrusive works likely to extend into previously undisturbed ground?	✓	Large areas of the Site have remained undeveloped since WWII and therefore all proposed works will extend into previously undisturbed ground.
Is there potential for an unplanned encounter with UXO to occur during proposed intrusive works?	✓	Given the lack of post-war development of the Site, it is considered possible for an unplanned encounter with UXO to occur.
Does the probability of UXO vary across the Site?	✗	The probability of UXO discovery is considered homogenous across the entire Site.

STAGE FOUR – RISK ASSESSMENT

Threat Items

The most probable UXO threat items are *German* HE bombs, whilst IBs and *British* AAA projectiles pose a residual threat. The consequences of initiating *German* HE bombs are more severe than initiating IBs or AAA projectiles, and thus they pose the greatest prospective risk to intrusive works.

Bomb Penetration Depth

Considering the ground conditions (highlighted in Stage 1), the average BPD for a 250kg *German* HE bomb within clay and sand is assessed to be approximately 7m bgl, with the maximum BPD considered to be approximately 16m bgl. Although it is possible that the *Luftwaffe* deployed larger bombs in the area, their deployment was infrequent, and to use such larger (or the largest) bombs for BPD calculations are not justifiable on either technical or risk management grounds.

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 bgl. However, due to the “J Curve” and the potential for structures to impede the penetration into the ground, HE bombs have been discovered at much shallower depths than the average.

Risk Pathway

Given the types of UXO that might be present on-site, all types of aggressive intrusive engineering activities (i.e. CPT and piling) may generate a significant risk pathway. Whilst not all UXO encountered aggressively will initiate upon contact, such a discovery could lead to serious impact on the project especially in terms of critical injury to personnel, damage to equipment and project delay.

Prospective Consequences

Consequences of UXO initiation include:

1. Fatally injure personnel;
2. Severe damage to plant and equipment;
3. Deliver blast and fragmentation damage to nearby buildings;
4. Rupture and damage underground utilities/services.

Consequences of UXO discovery include:

1. Delay to the project and blight;
2. Disruption to local community/infrastructure;
3. The expenditure of additional risk mitigation resources and EOD clearance;
4. Incurring additional time and cost.

UXO RISK CALCULATION

Site Activities

Although there is some variation in the probability of encountering and initiating items of UXO when conducting different types of intrusive activities, CPT and piling have been described for analysis at this Site. The consequences of initiating UXO vary greatly, depending upon, *inter alia* the mass of HE in the UXO and how aggressively it might be encountered. For this reason, *6 Alpha* has conducted separate risk rating calculations for CPT and piling.

Risk Rating Calculation

6 Alpha's Semi-Quantitative Risk Assessment assesses and rates the risks posed by the most probable threat items when conducting a number of different activities on the Site. Risk Rating is determined by calculating the probability of encountering UXO and the consequences of initiating it.

UXO Risk Calculation Table – All Areas

Activity	Threat Item	Probability (SH+EM=P)	Consequence (D+PSR=C)	Risk Rating (PXC=RR)
Cone Penetration Test (CPT)	HE Bombs	0+3=3	3+2=5	3x5=15
	AAA Projectiles	0+3=3	3+1=4	3x4=12
	IBs	0+3=3	3+1=4	3x4=12
Piling	HE Bombs	0+3=3	3+2=5	3x5=15
	AAA Projectiles	0+3=3	3+1=4	3x4=12
	IBs	0+3=3	3+1=4	3x4=12

Abbreviations – Site History (SH), Engineering Methodology (EM), Probability (P), Depth (D), Consequence (C), Proximity to Sensitive Receptors (PSR) and Risk Rating (RR).

STAGE FIVE – RECOMMENDED RISK MITIGATION MEASURES

Do the ground conditions support a geophysical UXO survey?

Intrusive Methods of Mitigation – Intrusive magnetometry may be effective on this Site, prior to CPT and piling especially. However, any ferrous metal/red brick contamination in made ground/old foundations may affect the detection capability of the UXB survey equipment, as it passes through the contaminated layer especially. Nonetheless, beyond the contaminated strata such a survey should prove effective.

Mitigation Measures to Reduce Risk to 'ALARP'

Activity	Risk Mitigation Measures	Final Risk Rating
All Activities in All Areas	<p>1. Operational UXO Emergency Response Plan; appropriate Site Management documentation 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 <i>6 Alpha</i>);</p> <p>2. UXO Safety & Awareness Briefings; the briefings are essential when there is a possibility of explosive ordnance encounter and are a vital part of the general safety requirement. All personnel working on the Site should receive a briefing on the identification of a UXB, 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 UXB threat should be held in the Site office and displayed for general information on notice boards, both for reference and as a reminder for ground workers. The safety awareness briefing is an essential part of the <i>Health & Safety Plan</i> for the Site and helps to evidence conformity with the principles laid down in the <i>CDM regulations 2015</i> (this brief can be delivered directly, or in some cases remotely, by <i>6 Alpha</i>).</p>	ALARP

This assessment has been conducted based on the information provided by the Client, should the proposed works change then *6 Alpha* should be re-engaged to refine this risk assessment

Report Figures

Figure One - Site Location

PROJECT NO. P6665	FIGURE 1	DRAWN RG	CHECKED SB	DATE 05 June 2018	Contains Ordnance Survey data © Crown copyright and database right 2017	Produced by and Copyright to 6 Alpha Associates Ltd. Users noting any errors please notify 6 Alpha.	
-----------------------------	--------------------	--------------------	----------------------	-----------------------------	--	--	---

Figure Two - Site Boundary

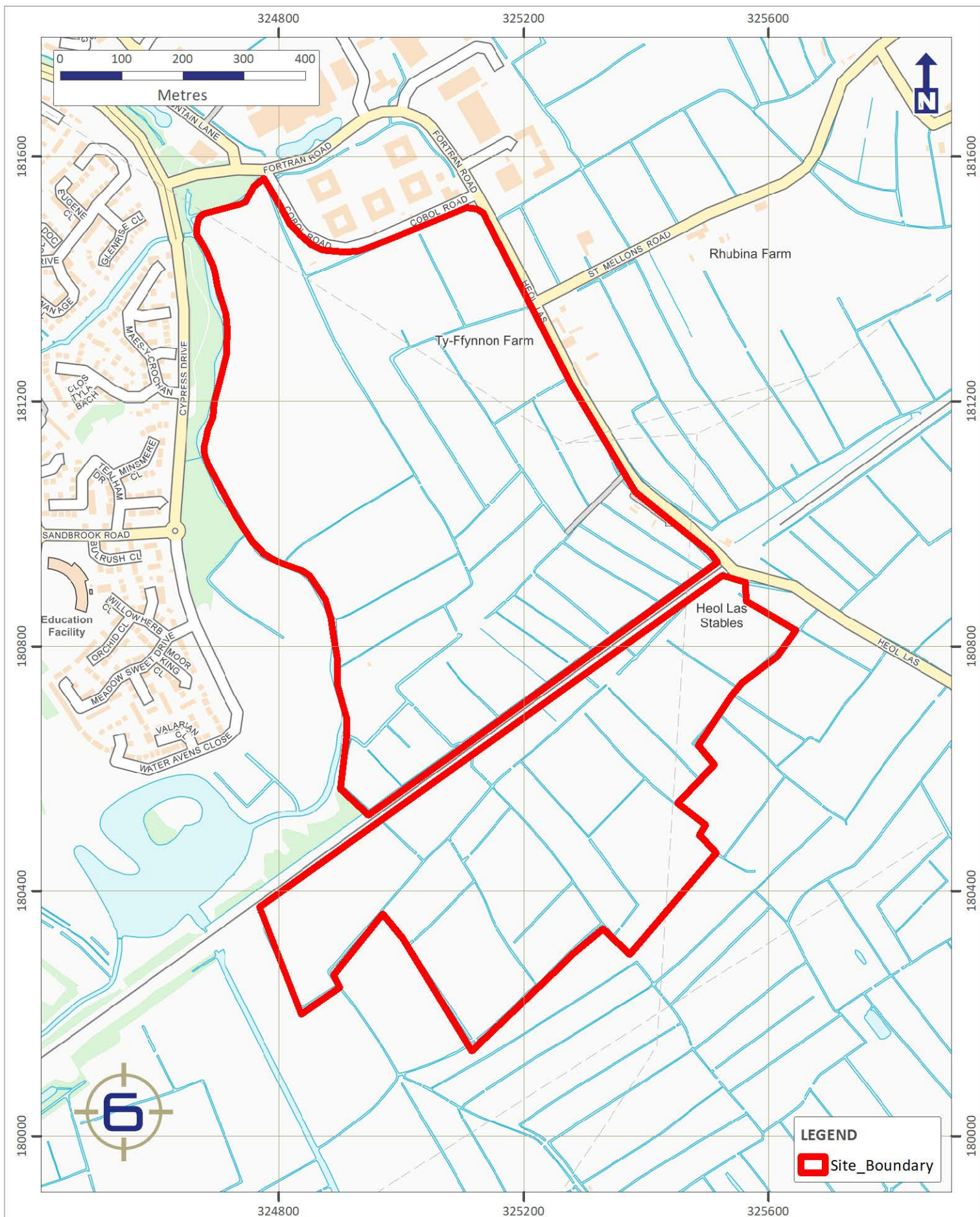


Figure Three - Aerial Photography (Current)

ST MELLONS, CARDIFF

Aerial Photography (Current)

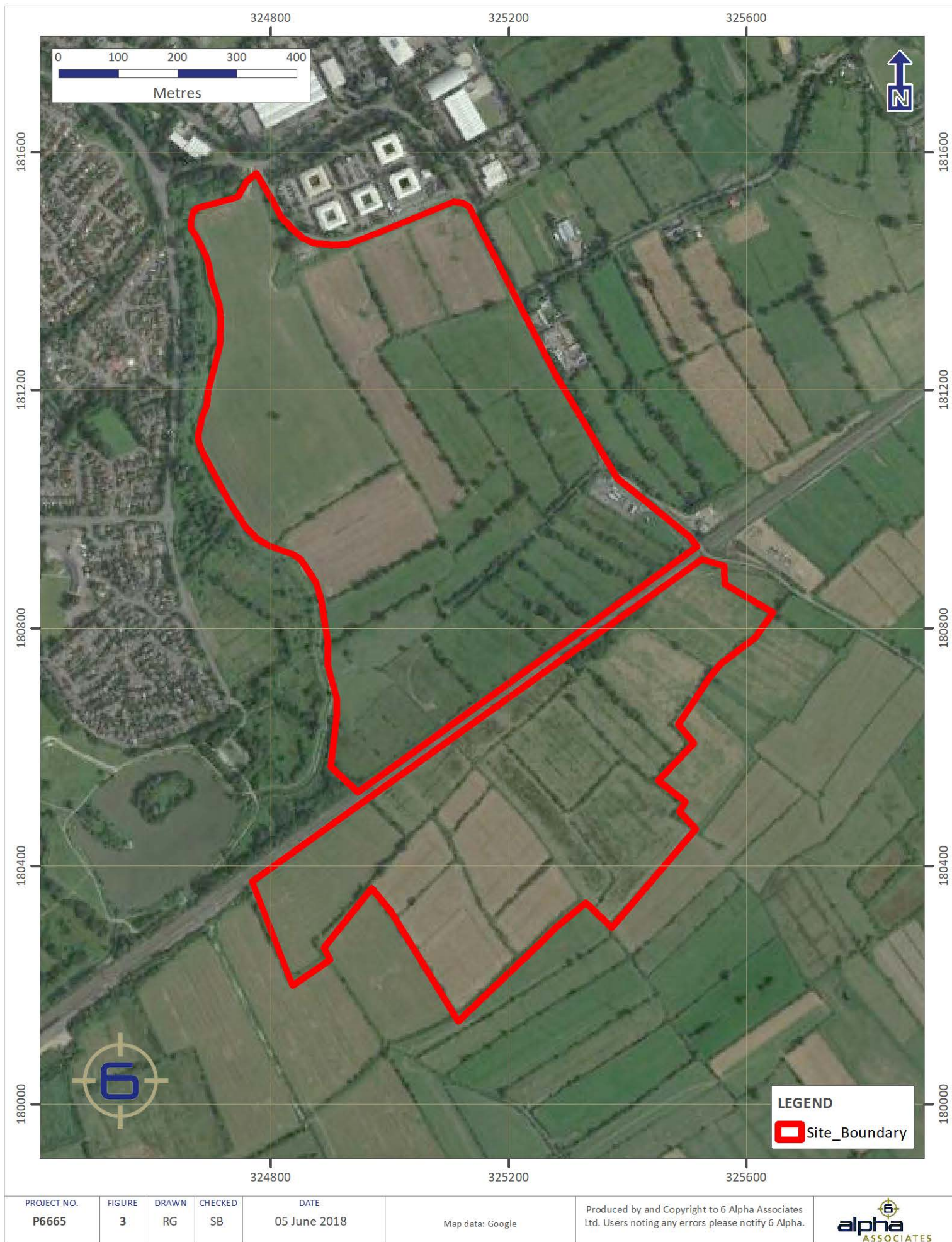
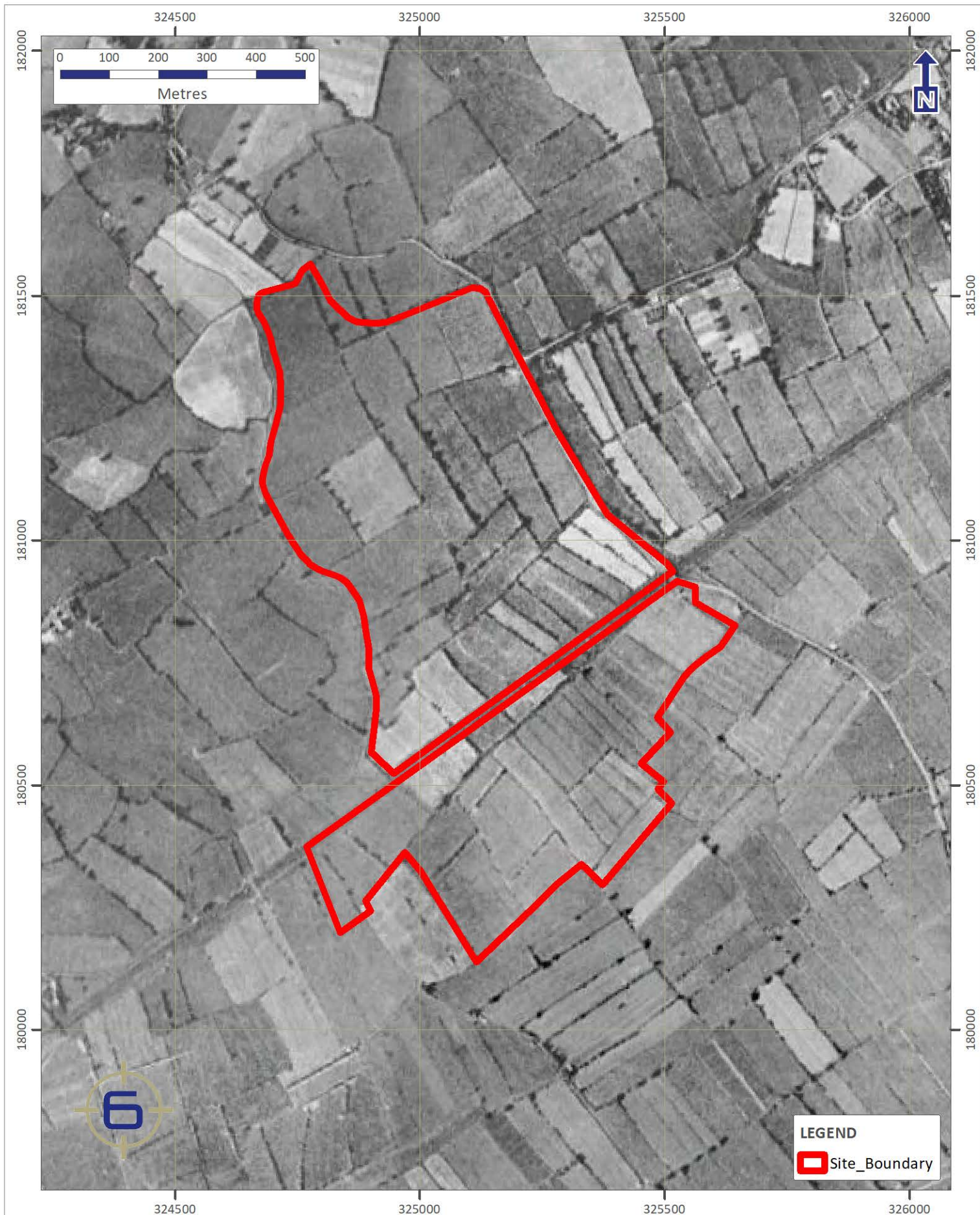


Figure Four – Aerial Photography (1945)

ST MELLONS, CARDIFF

Aerial Photography (1945)



PROJECT NO. P6665	FIGURE 4	DRAWN RG	CHECKED SB	DATE 05 June 2018	Map data: Google, The GeoInformation Group	Produced by and Copyright to 6 Alpha Associates Ltd. Users noting any errors please notify 6 Alpha.	 <p>6 alpha ASSOCIATES</p>
----------------------	-------------	-------------	---------------	----------------------	---	--	---

Figure Five - WWII High Explosive Bomb Density

