ROTARY OPEN HOLE RECORD SHEET

STRATA SURVEYS LIMITED

Job No.: 8327

Location: Grinfield Street Liverpool SJ 3956

Client: Joseph Finney PLC

Project Ref.:

Borehole No. R5

Sheet 1 of 1.

357

Equipment and methods: Rotary open hole - air flush

Casing Diameter (mm): 120

Casing Depth (m): 13.50

3640 9042

Drilled by: GD

Ground level: m AOD

Co-ordinates:

Date: 18/08/95

Casing Depth (m)	Water Depth (m)	Field Records	Depth (m) from	Depth (m) to	Description	Depth & Thickness (m)	Reduced Level (m AOD)	Strata Legend
		D 1	0.00	0.50	MADE GROUND (Brown sandy ashy brick rubble)	(2.50)		
					MADE GROUND (Brickwork)	2.50 (0.20) 2.70		
					VOID	(2.10)		
					MADE GROUND (Brickwork and sandstone blocks)	4.80 (0.75) 5.55		
					VOID	(2.55)		
		D 2	8.10	13.40	MADE GROUND (Brick rubble very loose below 11.40m)	8.10		
					(Continued.....)			

Remarks

1) Voids encountered at 2.70-4.80m and 5.55-8.10m
2) Drill string penetrating without flush or rotation from 11.40-13.40m
3) Water standing at 15.40m on completion

Logged by: Driller

Date:

Checked by:

Approved by:

FIG No.

Scale 1:100

STRATA SURVEYS LIMITED

ROTARY OPEN HOLE RECORD SHEET

Location Grinfield Street Liverpool SJ3935

Client: Joseph Finney PLC Project Ref.:

Borehole No. R5

Sheet 2 of 1.

357

Job No.: 8327

Equipment and methods Rotary open hole - air flush

Casing Diameter (mm) 120

Casing Depth (m) 13.50

Drilled by GD

Ground level m AOD

Co-ordinates

Date 18/08/95

CASING DEPTH (m)	WATER DEPTH (m)	Field Records	Depth (m) from	Depth (m) to	Description	Depth & Thickness (m)	Reduced Level (m AOD)	Strata Legend
					(....cont.)	(5.30)		
		D3	13.40	15.80	Red brown fine to medium grained SANDSTONE	13.40		
		W1	15.40			(2.40)		
		-(18/08)-			borehole complete	15.80		

Remarks

Logged by | Date

Checked by

Approved by

Scale 1:100

FIG No.

STRATA SURVEYS LIMITED

ROTARY OPEN HOLE RECORD SHEET

Location Grinfield Street Liverpool
Client: Joseph Finney PLC
Project Ref.:

Borehole No. R5
Sheet 2 of 1.

Job No.: 8327

Equipment and methods Rotary open hole - air flush
Casing Diameter (mm) 120
Casing Depth (m) 13.50

Drilled by GD
Ground level m AOD
Co-ordinates
Date 18/08/95

CASING DEPTH (m)	WATER DEPTH (m)	Field Records	Depth (m) from	Depth (m) to	Description	Depth & Thickness (m)	Reduced Level (m AOD)	Strata Legend
					(....cont.)	(5.30)		
		D 3	13.40	15.80	Red brown fine to medium grained SANDSTONE	13.40		
		W1	15.40			(2.40)		
		-(18/08)-			borehole complete	15.80		

Remarks

Logged by | Date
Checked by
Approved by

Scale 1:100

FIG No.

5339 SE/35A

REPORT NO. 8327

GRINFIELD STREET / SMITHDOWN LANE

LIVERPOOL

for

JOSEPH FINNEY PLC
Grange Yard
Grange Lane
Winsford
Cheshire
CW7 2BP

Engineers

HOWARD AND McNAMARA
Suite 1B
The Shakespeare Centre
Shakespeare Road
Southport
PR8 5AB

compiled by

A.W. WALKER BSc
M.S. WATTON B.Eng

STRATA SURVEYS LIMITED
Strata House
Holmes Chapel Road
Middlewich
Cheshire
CW10 OJB

Tel:01606-834637
Fax:01606-836657

26th September 1995

STRATA SURVEYS LIMITED

ROTARY OPEN HOLE RECORD SHEET

Location Grinfield Street Liverpool 353956
Client: Joseph Finney PLC Project Ref.:

Borehole No. R10
Sheet 1 of 1 . 361

Job No.: 8327

Equipment and methods Rotary open hole - air flush
Casing Diameter (mm) nil
Casing Depth (m) nil

3637 9090

Drilled by GD
Ground level m AOD
Co-ordinates
Date 17/08/95

CASING DEPTH (m)	WATER DEPTH (m)	Field Records	Depth (m) from	Depth (m) to	Description	Depth & Thickness (m)	Reduced Level (m AOD)	Strata Legend
					MADE GROUND (Brown clayey sandy concrete brick and ash)	(1.75)		
		-(17/08)-			Red brown fine to medium grained SANDSTONE	1.75 (0.25) 2.00		
					borehole complete			

Remarks
1) No voids encountered

Logged by Driller
Date
Checked by
Approved by
FIG No.

Scale 1:100

STRATA SURVEYS LIMITED

Job No.: 8327

ROTARY OPEN HOLE RECORD SHEET

Location Grinfield Street Liverpool SJ395L

Client: Joseph Finney PLC

Project Ref.:

Borehole No. R10A

Sheet 1 of 2.361

Equipment and methods Rotary open hole - air flush

Casing Diameter (mm) 120

Casing Depth (m) 3.00

Drilled by GD

Ground level m AOD

Co-ordinates

Date 17/08/95

CASING DEPTH (m)	WATER DEPTH (m)	Field Records	Depth (m) from	Depth (m) to	Description	Depth & Thickness (m)	Reduced Level (m AOD)	Strata Legend
		D 1	0.00	1.20	MADE GROUND (Brown clayey sandy concrete rubble)	(1.20)		
		D 2	1.20	2.00	MADE GROUND (Black ash)	1.20 (0.80)		
		D 3	2.00	3.80	Red brown fine to medium grained SANDSTONE (Continued.....)	2.00		
		D 4	3.80	6.80				
		D 5	6.80	9.80		(13.8)		
		D 6	9.80	12.80				

Remarks
1) No voids encountered
2) Water standing at 6.20m 18/08am

Logged by Driller | Date

Checked by

Approved by

FIG No.

Scale 1:100

STRATA SURVEYS LIMITED

ROTARY OPEN HOLE RECORD SHEET

Location Grinfield Street Liverpool SJ 3956

Client: Joseph Finney PLC

Project Ref.:

Borehole No. R10A

Sheet 2 of 2. 361

Job No.: 8327

Equipment and methods Rotary open hole - air flush

Casing Diameter (mm) 120

Casing Depth (m) 3.00

Drilled by GD

Ground level m AOD

Co-ordinates

Date 17/08/95

CASING DEPTH (m)	WATER DEPTH (m)	Field Records	Depth (m) from	Depth (m) to	Description	Depth & Thickness (m)	Reduced Level (m AOD)	Strata Legend
					(....cont.)			
		D 7	12.80	15.80				
		~(17/08)~						
					borehole complete	15.80		

Remarks

Logged by Date

Checked by

Approved by

Scale 1:100

FIG No.

APPENDIX 4

Zetica UXO Data

REGIONAL UNEXPLODED BOMB RISK

MERSEYSIDE

DENSITY OF BOMBS PER BOROUGH

Borough	High explosive	Anti-personnel	Incendiary
Bebington	354	0	373
Birkenhead	556	0	5
Crosby	277	0	10
Liverpool	2332	0	117
St Helens	116	0	6

On average, 10% of high explosive and 50% of incendiary bombs failed to explode.

BOMB RISK MAP

OTHER WWII TARGETS
- military
- transport
- utilities
- industry
- docks
- other

BOMB TONNAGE
- >1000
- >500
- >100
- >0
- unverified

BOMB RISK
- high
- moderate
- low

The information in this regional UXB risk map is derived from a number of sources and should be read in conjunction with the "Users' Guide" (printed overleaf). Zetica cannot guarantee the accuracy or completeness of the information or data.

This map covers regions of coast with beaches, estuaries and alike. Further consideration of the bomb risk is required in these areas. The often inaccessible nature and changing ground conditions (e.g. movement of silt that may contain ordnance) means that historical bombing records for these areas are often poor or inaccurate and further assessment of the bomb risk may be required as part of a site specific study.

BOMB MAP USERS' GUIDE

Sources of information and explanation of bomb risk

Why?

Unexploded bombs (UXB) still present a risk to construction projects long after the end of the Second World War (WWII). UXBs often entered the ground unnoticed at high velocity and penetrated to a depth of several metres. Here they remain – vulnerable to disturbances from construction work. Beyond the depth of shallow excavation work, the greatest risk is to piling, drilling and probing crews. A piling rig could repeatedly hit a UXBs with considerable force before the crew realises an obstruction has been impacted. It could then be up to 72 hours before the detonator activates.

Who?

The responsibility for avoiding UXB risk usually lies with construction companies or house builders particularly those who are redeveloping urban sites. In addition, project engineering or environmental consultants are expected to advise their clients of a site's history. Other interested parties include those organisations whose employees are physically at most risk from intrusive works, normally piling companies, drillers or probing operators.

How?

UXB risk should be assessed for every site, but especially those in known heavily bombed areas or those situated near war-time strategic installations that were priority targets for enemy aircraft, for example, airfields. Zetica's regional bomb risk map is therefore a first point of reference from which the relative, potential abundance of UXBs can be judged. Consultants then advise their clients that an ordnance-risk desk study is required, which they may obtain from external sources. Construction companies or house builders who assess their own risk could choose to come direct to Zetica.

When?

Do not wait for the piling or drilling company to be on site before thinking about UXB risk – it will inevitably cause delays and higher costs. Request the regional bomb risk map from Zetica as soon as a site is being considered, and then use it to help you or your clients to decide if an ordnance-risk desk study is required.

Where?

Maps can be obtained for any county in England, Scotland, Wales or Northern Ireland – or for any London borough. They can help determine the areas that were most heavily bombed – but no part of the country should be considered 100% safe from UXB risk. Even remote rural areas can have a high risk if, for example, they were locations for decoy airfields or beacons that were lit to fool enemy pilots into thinking they had located a burning city that had been successfully hit by others in the raid.

How to use this regional map

This map is designed to give you an indication of the potential risk from UXBs in your area. If you are conducting work that involves excavation, piling or other disturbance of the ground, then you should use the map to identify the category of risk for your site.

The risk boundaries are a guide, compiled from data based on the political areas for which records are held; being just outside a high-risk area does not mean there is no UXB risk. You should use the map to assist in your decision of whether to investigate the UXB risk further.

Information on the regional risk remaining from UXBs in the UK

Zetica has built the largest UXB database of its kind in the UK. It includes a unique digital library of bomb census data, and maps showing key strategic points and bombing densities from the First and Second World Wars. The main sources of information include records from central government (Public Records Office), the Ministry of Defence, and the German Luftwaffe.

Using information from this database, Zetica has published maps of UXB risk on a regional, county and borough scale. The maps indicate relative degrees of UXB risk based on available records for bombing densities and known targeted areas for regions within the UK. The risk is broken down into individual boroughs, towns or cities. The data are based on the historical boroughs and are then overlaid onto the modern map. It is important to note that more-detailed research may be required for individual sites, particularly where proximity to a potential WWII target means the local risk may be higher.

High risk

Areas designated as high risk are those that show a high density of bombing hits (50+ bombs per 1000 acres) and abundant potential WWII targets. In high-risk regions, further action to mitigate UXB risk is considered essential.

Moderate risk

Moderate-risk regions are those that show a bomb density of between 11 and 50 bombs per 1000 acres and that may contain potential WWII targets. Action to mitigate the risk is considered essential, albeit more likely that a reduced scope of work is required compared with that needed for high-risk regions.

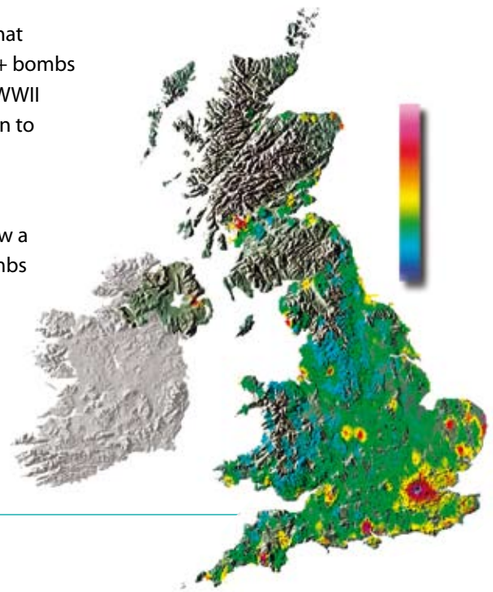
Low risk

Low-risk regions are those with a bombing density of up to 10 bombs per 1000 acres. These areas are considered to have a significant but low UXB risk. In general, further action to mitigate the risk is considered prudent, although not essential. Care is required when assessing the risk for specific sites where the risk may be higher because of local wartime activity.

Other WWII targets

Other regions with the risk of UXBs are key strategic points as defined by the government during WWII as representing potential enemy targets. Where these exist outside areas mapped as high, moderate or low risk, a site-specific assessment of the UXB risk may be required.

Relative UXB risk across UK



What to do if…

…you have a site that has a potential UXB risk

In the absence of current legislation requiring you to address the risk from UXBs, your responsibilities under health and safety legislation and regulations such as construction design and management require that you address all identified risks. The first stage is to request further advice from a professional adviser such as Zetica, or to gain more site-specific information by commissioning an ordnance-risk desk study. Then a strategy to deal with the risk can be established that is tailored to your proposed work.

…you find a suspect item or require advice

If during site works you find a suspect (ordnance-related) item, it is very important that you do not touch or move it (even if it has already been moved by an excavator). If it is clearly ordnance related, then dial 999 and ask for the police. Ensure that the area around the item is kept as clear as possible without placing yourself at risk. If you are unsure and do not wish to cause undue alarm, or you just require some advice, then you can call Zetica. We have experienced qualified UXB specialists on hand who can offer support and advice during any site works.

More-detailed procedures should be established in advance if you are in an area where the risk of finding a UXB is shown to be significant (moderate to high).

Site-specific desktop studies

Zetica is able to provide high-quality, site-specific UXB risk information for any residential, industrial or commercial property in the UK. These desktop studies provide details of the bombing density within an area and for the site itself, in order to indicate the risks of UXBs still being present. A risk assessment is provided to facilitate informed decision making on whether any further risk mitigation measures are required.

APPENDIX 5

UXO Desk Study

1ST LINE DEFENCE
UXO SOLUTIONS

Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	Kaplan
Client	Curtins
Site Address	Smithdown Lane, Liverpool, L7 3ED
Report Reference	DA4024-01
Date	23rd March 2017
Originator	SM

1ST LINE DEFENCE
UXO SOLUTIONS

Find us on Twitter and Facebook

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www.1stlinedefence.co.uk

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Unit 3, Maple Park, Essex Road, Hoddesdon, Herts. EN11 0EX
Tel: +44 (0)1992 245 020 info@1stlinedefence.co.uk

Executive Summary

Site Location and Description

The site is situated in the city of Liverpool, north-west England, approximately 2.1km east of the city centre.

The site constitutes a large area of land, much of which forms the former premises of Archbishop Blanch School. Mount Vernon Road runs along the northern border of the site. Irvine Street and Mason Street are situated to the east; a railway tunnel to the south; and Smithdown Lane and Minshull Street to the west.

The site is approximately centred on the OS grid reference: **SJ 3630490351**

Proposed Works

The Kaplan project is believed to involve the construction of numerous multi-storey structures on site. The exact scope of intrusive works at this stage has not been disclosed for the purpose of the report.

Geology and Bomb Penetration Depth

The British Geological Survey (BGS) map shows the site to be underlain by the Chester Pebble Beds Formation – Sandstone and Pebbly (gravelly), formed in the Triassic Period.

It has not been possible to determine maximum bomb penetration capabilities at this stage due to the limit of available site specific geotechnical information. An assessment can be made once such 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 site and will be largely dependent on the specific underlying geological strata and its density.

UXO Risk Assessment

1st Line Defence has assessed that to be a risk ranging from **Low** to **Medium** on the site of proposed works, dependent on location. A risk-map has been produced, see **Annex P**.

- During WWII the County Borough of Liverpool was subjected to a high density bombing campaign, with an average 91.5 items falling per 1,000 acres according to Home Office statistics. Bombing was largely concentrated on the city centre and docks, although the residential area to the east of the city in which the site was situated did not escape German raids. Bombing can be attributed to the presence of these targets, and the indiscriminate bombing of civilian areas.
- Historical OS mapping indicates that the site consisted predominantly of residential properties in wartime as well as intersecting roadways. A storage yard and church were also located in the southern area of the site. Post-war mapping and RAF aerial photography from April 1946 suggest that several areas across the site (as well as in its immediate vicinity) were cleared/ruined following bomb damage.
- Limited information regarding the bombing of the city of Liverpool has survived to date. No detailed bomb plot or damage maps, or complete set of written incident records, appear to have survived the war. A limited amount of written records were obtained from the Liverpool Record Office and the Liverpool Echo, and were checked for the site area. These sources record three HE bombing incidents within the site area, and an additional two incidents within 100m of its boundary.
- It is anticipated that a substantial amount of rubble and debris would have been present in the areas of damage/clearance within and adjacent to the site. Evidence of UXO could easily be overlooked within such areas – UXBs falling into bomb rubble was one of the most common scenarios whereby they would go unobserved and unreported (note that the entry hole of a 50kg bomb could be as little as 20cm in diameter). Direct access to these areas is also likely to have significantly decreased following damage, reducing post raid checks for signs of UXO. A 'buffer' zone has been placed around these cleared areas to account for the possibility of 'J-curve', whereby a bomb can end up laterally offset from its point of entry (see Section 12.2).
- The remainder of properties, yards and roadways on site appear in 1947 imagery to have survived the war intact, with only minor cosmetic damage inflicted. This type of ground cover should have been conducive to UXO detection, and access to unaffected housing is expected to have been regular. Consequently, the risk of contamination in these areas, and outside of the buffer zones, is considered to be low.
- There is no evidence that the site formerly had any military occupation or usage that could have led to contamination with other items of ordnance.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the Kaplan, Smithdown Lane site:

Low Risk Areas

All Works

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

Medium Risk Areas

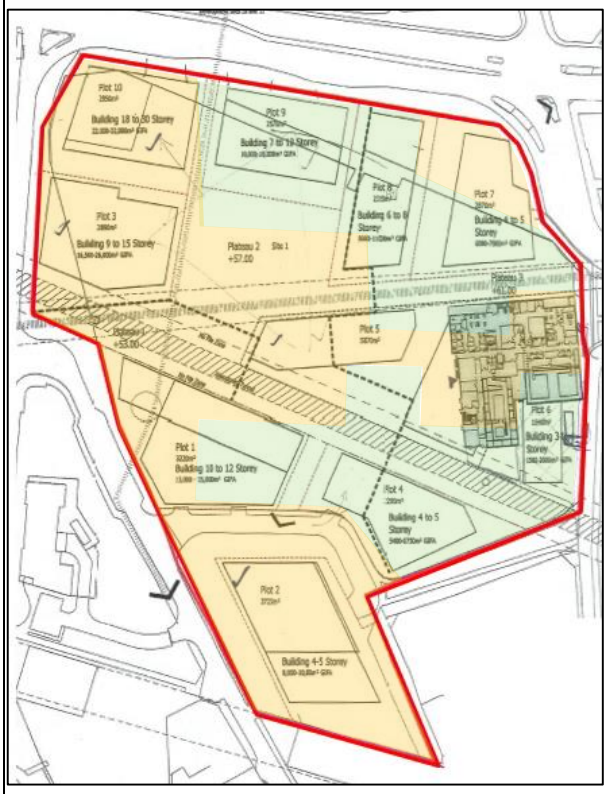
Open intrusive works (trial pits, service pits, open excavations, shallow foundations etc.)

- UXO Specialist On-site Support and Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works

Boreholes and Piled Foundations

- Intrusive Magnetometer Survey of all borehole and pile locations/clusters down to maximum bomb penetration depth

Risk Map



Low Risk Areas:

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

Medium Risk Areas:

- Unexploded Ordnance (UXO) Specialist presence on site to support open intrusive works
- Intrusive Magnetometer Survey of any borehole or pile locations/clusters down to an assessed maximum bomb penetration depth

Medium Risk

Low Risk

For indicative purposes – not to scale

Glossary

Abbreviation	Definition
AA	Anti-Aircraft
AAA	Anti-Aircraft Ammunition
AFS	Auxiliary Fire Service
AP	Anti-Personnel
ARP	Air Raid Precautions
AWAS	Air Warfare Analysis Section
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
FP	Fire Pot
GM	G Mine (Parachute mine)
HAA	Heavy Anti Air
HE	High Explosive
IB	Incendiary Bomb
LAA	Light Anti Air
LCC	London County Council
LRRB	Long Range Rocket Bomb (V2)
LSA	Land Service Ammunition
MOL	Molotov (Incendiary Bomb)
OB	Oil Bomb
PAC	Pilotless Aircraft (V1)
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
SD1000	1000kg high explosive bomb
SD2	2kg incendiary
SIP	Self-Igniting Phosphorous
U/C	Unclassified bomb
UP	Unrotated Projectile (rocket)
USAAF	United States Army Air Force
UX	Unexploded
UXAA	Unexploded Anti Air
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V1	Vengeance Weapon 1
V2	Vengeance Weapon 2
WAAF	Women's Auxiliary Air Force
X	Exploded

Contents

Annexes

List of Report Annexes	
Annex A	Site Location Maps
Annex B	Recent Aerial Photography
Annex C	Site Plan
Annex D	Pre and Post-WWII Historical Maps
Annex E	Examples of German Air Delivered Ordnance
Annex F	Examples of Unexploded Bomb Entry Holes
Annex G	Examples of UXO Incidents
Annex H	Illustration of the J-Curve Effect
Annex I	WWI Air Raids & Naval Bombardments in the UK
Annex J	Luftwaffe Target Mapping for Liverpool
Annex K	Bomb Damage in Liverpool
Annex L	Liverpool Bomb Map
Annex M	'Liverpool Echo' Bomb Layers
Annex N	1946 RAF Aerial Photography
Annex O	Examples of Anti-Aircraft Projectiles
Annex P	Risk Maps of the Site Area

1st Line Defence Limited
Detailed Unexploded Ordnance (UXO) Risk Assessment

Site: Kaplan Site, Smithdown Lane, Liverpool
Client: Curtins

1. Introduction

1.1. Background

1st Line Defence has been commissioned by Curtins to produce a Detailed Unexploded Ordnance (UXO) Risk Assessment for the proposed works at the Kaplan site.

Buried UXO can present a significant risk to construction works and development projects. The discovery of a suspected 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 deposited as a result of military training and exercises.
2. Munitions lost, burnt, buried or otherwise discarded either deliberately, accidentally, or ineffectively.
3. Munitions resulting from wartime activities including German bombing in WWI and WWII, long range shelling, and defensive activities.

This report will assess the collective factors that may contribute to the risk of UXO contamination. If a potential risk is identified, 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 enable the client to understand the basis for the assessed risk level and any recommendations.

This report follows 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 the Kaplan site. Every reasonable effort has been made to ensure that all available historical information has been accessed and checked. Where possible, evidence has been included in the report to enable the client to understand the basis of the risk assessment.

The report will 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 risk that the site was contaminated with UXO.
2. The risk that UXO remains on the site.
3. The risk that UXO may be encountered during the proposed works.
4. The risk 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 and 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

To produce a thorough assessment of UXO risk, military records and archive material held in the public domain have been accessed. The following sources have been consulted for this report:

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

Research involved a visit to The National Archives.

2.4. General Considerations of Historical Research

This desktop assessment is based largely upon analysis of historical evidence. Every reasonable effort has been made to locate significant and pertinent information, and the sources consulted have been presented in this report. 1st Line Defence cannot be held accountable for any changes to the assessed level of risk 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 at the time of the report's production.

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 many sources and types of information have been consulted, analysed and presented. The same methodology is applied to each report during the risk assessment process. 1st Line Defence cannot be held responsible for inaccuracies or gaps in the available historical information.

3. Background to Bombing Records

During WWII bombing records were gathered by the police, Air Raid Precaution (ARP) wardens and military personnel. Records were maintained in the form of local and regional written records, maps depicting the locations of individual strikes, and maps indicating the levels of damage sustained by structures. Records typically noted when, where and what types of bombs had fallen during an air raid. Records of bomb strikes were made either through direct observation or by post-raid surveys. The immediate priority was frequently focussed on assisting casualties and minimising damage. As a result some records were incomplete and contradictory.

The quality, detail and nature of record keeping could vary considerably between boroughs and towns. No two areas were collated or recorded data in the same way. Some areas maintained bomb and damage mapping, some provided grid references of strikes, and some are too vague in detail to be able to ascertain exactly where bombs fell. Many records were even damaged or destroyed in subsequent bombing 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. Furthermore, records of attacks on military or strategic targets were often maintained separately from the general records and have not always survived.

4. Background to Allied Records

During WWII considerable areas of land were requisitioned by the army for the purpose of defence, training, and the construction of airfields and facilities for munitions production. Records relating to military features vary and some areas may remain censored. Within urban environments datasets will be consulted detailing the location of munitions works and air and land defences. In rural locations it may be possible to obtain plans of airfields and military establishments, as well as training logs, personal memoirs, and operational plans.

5. UK Regulatory Environment

5.1. 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.

5.2. CDM Regulations 2015

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

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

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

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

5.3. 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.

5.4. 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.

6. Role of Commercial UXO Contractors and The Authorities

6.1. Commercial UXO Contractors

In the event that a risk of UXO contamination is detected at the proposed site, the support of a UXO specialist may be recommended. A UXO specialist may be able to avoid unnecessary call-outs to the authorities through the disposal or removal of low risk items. In addition a specialist will assist in the swift recognition of high risk items, and will thereafter co-ordinate with the local authority with the objective of causing minimal levels of disruption to site operations, whilst putting in place safe and appropriate measures.

For more information on the role of commercial UXO specialists, see *CIRIA C681*.

6.2. The Authorities

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

The priority given to the police request will depend on JSEOD's judgement of the nature of the UXO risk, the location, people and assets at risk, as well as the availability of resources. They may respond immediately or it can take 1-2 days and often longer for the authorities to respond and deal with a UXB.

Depending on the on-site risk assessment the item of ordnance may be removed from the site and/or destroyed by a controlled explosion. The latter process is lengthy and may necessitate the establishment of addition cordons and evacuations.

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

7. The Site

7.1. Site Location

The site is situated in the city of Liverpool, north-west England, approximately 2.1km east of the city centre.

The site constitutes a large area of land, much of which forms the former premises of Archbishop Blanch School. Mount Vernon Road runs along the northern border of the site. Irvine Street and Mason Street are situated to the east; a railway tunnel to the south; and Smithdown Lane and Minshull Street to the west.

The site is approximately centred on the OS grid reference: **SJ 3630490351**

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

7.2. Site Description

The proposed site is a large irregular-shaped parcel of land. It currently consists predominantly of hard-standing, with patches of vegetation interspersed across its premises. Several multi-storey residential structures are situated within the southernmost area.

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

8. Scope of the Proposed Works

8.1. General

The Kaplan project is believed to involve the construction of numerous multi-storey structures on site. The exact scope of intrusive works at this stage has not been disclosed for the purpose of the report.

9. Ground Conditions

9.1. General Geology

The British Geological Survey (BGS) map shows the site to be underlain by the Chester Pebble Beds Formation – Sandstone and Pebbly (gravelly), formed in the Triassic Period.

9.2. Site Specific Geology

Site specific geotechnical data was not available at the time of the production of this report.

10. Site History

10.1. Ordnance Survey Historical Maps

Historical maps were obtained for this report and are presented in **Annex D**. These maps provide an indication of the composition of the site pre and post- WWII. See below for a summary of the site on various mapping editions.

Pre-WWI		
Date	**Scale**	**Description**
1927	1:2,500	This map shows the site to consist of a dense residential area. This comprises a large number of residential properties situated on intersecting roadways which pass through the site – these include Hatfield Street, Parron Street, Cranbourne Street, Paddington, Edge Mount, Alice Street, Albert Street, and Garden Street. A *School* is also located in a southern area of the site, alongside several unlabelled structures. A *Drill Hall* is situated to the immediate south-east of the site area.

Post-WWII		
Date	**Scale**	**Description**
1954	1:1,250	This map displays significant changes within the site boundary. Numerous pre-war structures on site are no longer evident in this edition, with cleared ground evident in their place. *Ruins* are also annotated in several locations. In a north-western area and southern area of the site, pre-war structures are replaced by what appears to be new prefabricated structures. The previously existing drill hall to the south west is now labelled as a *T.A Centre*.
1978-1984	1:1,250	This map indicates major redevelopment across the site. This has resulted in the construction of a school across much of the site area, labelled as *Paddington Comprehensive School*. Prefabricated structures remain in a southern area of the site alongside several newly constructed residential structures.

1st Line Defence have inquired about obtaining pre and post-WWII fire insurance plans for the site. Unfortunately no relevant records could be found during the production of this report.

11. Aerial Bombing Introduction

11.1. General

During WWI and WWII, many towns and cities across the UK were 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 bombing techniques often resulted in neighbouring areas to specific targets being bombed.

In addition to raids which concentrated on specific targets, indiscriminate bombing of large areas also took place – notably the London 'Blitz', but also affecting 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.

With regards to bombing, the main focus of research for this report will be weapons dropped during WWII, although WWI bombing will also be considered.

11.2. Generic Types of WWII German Air-delivered Ordnance

An understanding of the type and characteristics of the ordnance used by the Luftwaffe during WWII allows an informed assessment of the hazards posed by any unexploded items that may remain in situ on a site. A brief summary of these characteristics is given in the table below. Examples of German air delivered ordnance are presented in **Annex E**.

Generic Types of WWII German Air Delivered Ordnance				
Type	Description	Size/Weight	Frequency	Likelihood of detecting Unexploded
High Explosive (HE) Bombs	A HE bomb typically has a strong metal casing, which provides a 'thick skin' that is designed to fragment on detonation. HE bombs possess a sufficient mass and velocity to enable penetration of the ground if they failed to explode. In addition the shape and fins are aerodynamic to keep the tip end of the bomb facing downward.	Most bombs were 50kg, 250kg or 500kg, although larger bombs of up to 1,800kg were also used. About half the weight of HE bombs comprised of explosive TNT or Amatol.	In terms of weight of ordnance dropped, HE bombs were the most frequent weapon deployed by the Luftwaffe during WWII.	Although efforts were made to identify the presence of unexploded ordnance following a raid, often the damage and destruction caused by detonated bombs made observation of UXB entry holes impossible. The entry hole of an unexploded bomb can be as little as 20cm in diameter and was easily overlooked in certain ground conditions (see **Annex F**). Furthermore, ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. UXBs therefore present the greatest risk to present–day intrusive works.
Aerial or Parachute Mines (PM)	Luftmines (LMA-500kg and LMB-1000kg) were magnetic sea mines which were thin walled, cylindrical in shape with a hemispherical nose, deployed by parachute. For use on land, the mines were armed with a clockwork bomb fuze which caused the bomb to explode after impact. When operating as designed they caused considerable damage due to the high weight of explosive and their detonation at or near the surface.	PMs either weighed 500kg or 1000kg (approximately 2/3 of the overall weight was explosives) depending on the type of mine. Their length ranged from 1.73-2.64m.	PMs were deployed less frequently than HE and Incendiary bombs due to their size, cost and the difficulty of their deployment.	If functioning correctly, PMs generally would have had a slow rate of descent and were very unlikely to have penetrated the ground. Where the parachute failed, mines would have simply shattered on impact if the main charge failed to explode. There have been extreme cases when these items have been found unexploded. However, in these scenarios, the ground was either extremely soft or the munition fell into water.
1kg Incendiary Bombs (IB)	1kg IB devices had a magnesium shell and were filled with thermite; both components were designed to burn after igniting on impact. They were jettisoned from air-dropped containers.	1kg in weight and approximately 14 inches long.	In terms of the number of weapons dropped, small IBs were the most numerous. Millions of these weapons	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 bomb rubble, they could have gone unnoticed.

	Some variants had explosive heads presenting an increased risk if encountered during works.		were dropped throughout the war.	
Large Incendiary Bombs (IB)	Large IBs had various flammable fill materials (including oil and white phosphorus), and a small explosive charge. They were designed to explode and burn close to the surface. Although they were often the same shape as HE bombs, they were thin-skinned and did not generally penetrate the surface.	Large IBs Weighed up to 350kg.	Large IBs were not as common as the 1kg IBs, although they were more frequently deployed than the Parachute Mines and Anti-Personnel 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.
Anti-personnel (AP) Bomblets	The SD2 'Butterfly Bomb' had an 8cm long, thin, cylindrical shaped, cast iron outer shell which hinged open when the bomblet deployed. A 15cm long steel cable was attached via a spindle to an aluminium fuze. They were generally lethal to anyone within a radius of 10 metres (33 ft) and could inflict serious shrapnel injuries.	The size and weight ranged depending on the type used. The SD2 weighed 2kg and contained 225 grams of TNT.	AP Bomblets 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.

11.3. Failure Rate of German Air-Delivered Ordnance

It has been estimated that 10% of the German HE bombs dropped during WWII failed to explode as designed. There are a number of reasons why an air-delivered weapon might fail to function as designed:

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

From 1940 to 1945 bomb disposal teams 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, especially in London; see press articles in **Annex G**.

11.4. V-Weapons

From mid-1944, Hitler's 'V-weapon' campaign began. 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 Liverpool were generally too far to be considered for V-weapon strikes by the Luftwaffe.

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

12. UXB Ground Penetration

12.1. General

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.

12.2. The J-Curve Effect

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 up to 15m. An illustration of the J-curve effect can be seen in **Annex H**.

12.3. WWII UXB 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. Conclusions were made as to the likely average and maximum depths of penetration of different sized bombs in different geological strata.

For example, the largest common German bomb (500kg) had a likely concluded penetration depth of 6m in sand or gravel but 11m in clay. The maximum observed depth for a 500kg bomb was 11.4m and for a 1000kg bomb 12.8m. Theoretical calculations suggested that significantly greater penetration depths were probable.

12.4. Site Specific Bomb Penetration Considerations

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

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

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

13. Initiation of Unexploded Ordnance

13.1. General

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

13.2. UXB Initiation Mechanisms

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.

Annex G2 details UXB incidents where intrusive works have caused UXBs to detonate, resulting in death or injury and damage to plant.

13.3. Effects 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.

14. The Risk from German Air Delivered UXBs

14.1. World War I

During WWI Great Britain was targeted and bombed by Zeppelin Airships and by Gotha and Giant fixed-wing aircraft. The first raid of 1916 was carried out by the German navy. Liverpool does not appear to have been successfully bombed during WWI. Nine Zeppelins were sent to Liverpool on the night of 31st January/1st February, but a combination of poor weather, difficult navigation and mechanical problems scattered the aircraft across the English Midlands and a number of towns were bombed subsequently. See **Annex I** for a WWI bomb plot map of the UK.

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

14.2. World War II Bombing of Liverpool

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. A**s** the war progressed the Luftwaffe bombing campaign expanded to include the indiscriminate bombing of civilian areas in an attempt to subvert public morale.

The outbreak of WWII placed Liverpool in a position of immense strategic importance. After London, it was the UK's largest port, as well as being the major port facing westwards, towards the Atlantic Ocean. It was a busy centre for coastal traffic and handled a third of the UK's imports and exports. During the war, this proportion rose dramatically, due to the vulnerability of London and ports on the east coast to air raids and naval forces. In addition to food, fuel, raw materials, weapons and troops entered the country through the Liverpool Docks. Because of the huge dock system within Liverpool & its surrounding towns of Bootle, Wallasey and Birkenhead, Liverpool's docks represented the number one target for enemy bombers outside London. Fatalities in the city were twice as high as any other British port.

Luftwaffe target mapping of areas in the east of Liverpool, near the site area, is presented in **Annex J**. The nearest recorded target to the site is Kensington Reservoir (belonging to Liverpool Corporation Water Works) approximately 600m to the north-east. Other targets annotated include Edge Hill railway sidings from 700m to the south-east, and a Tobacco Factory approximately 1.2km to the north.

The first major raid in Liverpool took place on the 28th August, then occurred regularly until the rest of the year. The single biggest loss of life in Liverpool (and according to Winston Churchill the worst of any civilian incident in the war) occurred on the 29th November, when a parachute mine hit the air raid shelter below Ernest Brown Junior Instructional Centre on Durning Road approximately 750m east of the site. Images of this incident can be seen in **Annex K**. The intensity of raids did not ease, and subsequently between the dates of 1st and 8th May 1941 Liverpool suffered the 'May Blitz'. German planes dropped 870 tonnes of high explosive bombs and over 112,000 incendiary bombs over this period, resulting in the death of 1,453 civilians.

Records of bombing incidents in the civilian areas of the region were collected by the Air Raid Precautions wardens and collated by the Civil Defence Office. Some other organisations, such as the port and railway authorities, maintained separate records. Records would be in the form of typed or hand written incident notes, maps and statistics. Bombing data was carefully analysed, not only due

to the requirement to identify those parts of the country most needing assistance, but also in an attempt to find patterns in the Germans' bombing strategy in order to predict where future raids might take place.

Records of bombing incidents for Liverpool are presented in the following sections.

14.3. Second World War Bombing Statistics

The following table summarises the quantity of German bombs (excluding 1kg incendiaries and anti-personnel bombs) falling on the County Borough of Liverpool between 1940 and 1945.

Record of German Ordnance Dropped on the County Borough of Liverpool		
Area Acreage		**27,321**
Weapons	High Explosive Bombs (all types)	2,332
	Parachute Mines	117
	Oil Bombs	50
	Phosphorus Bombs	0
	Fire Pot	0
	Pilotless Aircraft (V1)	0
	Long Range Rockets (V2)	0
Total		**2,499**
Number of Items per 1000 acres		**91.5**

Source: Home Office Statistics
This table does not include UXO found during or after WWII.

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

14.4. Liverpool Bomb Plot Map

A bomb plot map was obtained from the Liverpool Record Office. It is believed to be an enlarged photograph of a pin-board map from the period. The map covers the entire county borough of Liverpool, and it is thus hard to exactly pinpoint bomb strikes when magnified. The section showing the area of the site is presented in **Annex L**.

Liverpool Bomb Plot Map – Annex L	
Date Range	**Comments**
Consolidated bomb plot map: presumed 1940 - 1945	The site has been placed as accurately as is possible on this map, although the small scale of the map means the exact site boundary is difficult to place. It suggests three locations on site sustained serious HE bomb damage, with further damage plotted within 100m to the east and south.

14.5. 'Liverpool Echo' Bomb Layers

These layers come from the website of the 'Liverpool Echo'. It is believed that this source is based on a record held by the Liverpool Record Office referred to as a 'Brief Survey of Incidents'. As such, the

record is only expected to reference isolated incidents across the entirety of the war, and therefore is not consolidated. Particular focus is given to the 'May Blitz' period of 1941. These layers were downloaded and overlaid onto Google Earth. The site and surrounding bombing are shown in **Annex M**.

Liverpool Echo Bomb Layers – Annex M	
Date Range	**Comments**
Mostly unspecified, though dates are given for the 'May Blitz' of 1st-8th May 1941	These data-sets do not record any incidents on the site or its immediate vicinity. The nearest bombing incident recorded appears to have caused damage to 112 and 114 Saxony Road, approximately 150m to the north-east of the site. Specific detail is given to a bombing incident occurring on the 6th/7th May 1941, in which St. Catharine's Church, Abercromby Square was destroyed by a fire. This took place approximately 350m to the south-west of the site.

14.6. Liverpool Bomb Damage Tracings

Several tracings of bomb damage were obtained from the National Archives for the city of Liverpool. These tracings show buildings that were hit by bombing, and were likely traced from historical OS maps of the time. As they were traced, they do not show buildings that were not damaged. The tracings were looked through, and no tracings concerning the site area were found.

14.7. WWII-Era Aerial Photographs

A high resolution scan of WWII-era aerial photography for the site area was obtained from the National Monuments Record Office (Historic England). This photograph is dated 1st April 1946 and provides a record of the potential composition of the site during the war, as well as its condition immediately following the war (**see Annex N**).

Imagery shows several large areas of cleared ground across parts of the site. These locations are consistent with the 1954 edition of OS mapping seen in **Annex D3**, though prefabricated structures do not appear to have been constructed on site at this point. Several structures on site display minor cosmetic damage in the form of disturbed roofing, though most remaining structures appear to be intact. The exception to this is the southern area of the site in which several structures appear to have sustained serious structural damage.

An annotation of the photograph can be seen in **Annex N2**. This highlights bomb damaged areas evident in the image. Also annotated is the locations of *Ruins* noted in the 1953 edition of mapping – most of these appear to be intact, suggesting that damage was relatively minor or that repair work was carried out.

14.8. Bombing Decoy Sites

The decoy principal – drawing German bombers away from their designated targets onto dummy sites five or six miles away – began in WWI to protect RAF stations. In 1939 a new department was set up to investigate and coordinate the concept of defence by deception. A whole range of decoy sites were developed – some of them became very elaborate and covered large areas.

Common WWII Decoy Site Variants	
Decoy Type	**Description**
K-site	Daytime dummy airfield. Dummy aircraft and infrastructure.

Q-site	Night time dummy airfield. Intended to represent the working lights of an airfield after dark.
QL	Night time dummy infrastructure. Replicating the lights and workings of marshalling yards, naval installations, armament factories etc.
QF	Fire based decoy. Initially for aircraft factories, RAF maintenance units and ordnance works to simulate them on fire following bombing.
Oil QF	Simulation of burning oil tanks.
Starfish	Replicating a city under incendiary attack.

By June 1944, decoy sites had been attacked on 730 occasions. Attacks ranged from a single night-time bomber dropping its load onto a "Q" site, to the mass attacks on Starfish sites. In diverting the high explosives and incendiaries from the intended targets they were undoubtedly responsible for saving the lives of thousands of people.

Works planned in the vicinity of WWII decoy sites can be at an elevated risk from UXBs as the facilities were specifically designed to be bombed. It was not uncommon for evidence of UXBs at a decoy site to be overlooked following a raid. Given that the sites were on open ground, sometimes agricultural fields, UXB entry holes were not always evident.

Records indicate that bombing decoy sites were present for the region of the site during WWII. The nearest was situated approximately 7.6km to the north-east of the site, and acted as a Civil QL and QF for the city of Liverpool.

14.9. Abandoned Bombs

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

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

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

14.10. Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment (EOD) is currently facing considerable delay. It has therefore not been possible to include any 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 Curtins will be advised.

14.11. Evaluation of Bombing Records

Item	Conclusion
Density of Bombing *It is important to consider the bombing density when assessing the possibility that UXBs remain in an area. High levels of bombing density could allow for error in record keeping due to extreme damage caused to the area.*	The County Borough of Liverpool was subject to a high bombing density of 91.5 items per 1,000 acres during WWII. While the site was located in a residential area of the city, it was situated within 1km of Kensington Reservoir, and Edge Hill railway sidings, both annotated in Luftwaffe target mapping. A bomb census map obtained from Liverpool Record Office records three HE bombing incidents within the site area, with two additional incidents recorded in the immediate vicinity of the site. The record set for Liverpool is known to be incomplete, and no full set of incident records or bomb census mapping was available from either local or national archives.
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.*	Historical OS mapping indicates that in the initial stages of WWII the site was comprised almost entirely of residential properties and intersecting roadways. Intact structures and small garden areas are likely to have been conducive to UXO detection, due to the resulting structural/ground disturbance an incident would cause. In areas of the site where structures sustained serious damage, resulting rubble or debris may have obscured such visual indicators of UXO entry.
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.*	As the site was situated in a dense urban location, it is anticipated at least in the war's initial stages, it received a regular degree of access and that checks for UXO were carried out on its premises. Direct access to damaged areas is likely to have significantly decreased following bombing incidents, as such additional incidents in the same location may have gone unrecorded.
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*	RAF aerial photography from 1st April 1946 displays numerous areas of clearance on site and in its surroundings. Clearance areas tend to indicate serious bomb damage. It is anticipated therefore that for a period prior to clearance, significant rubble or debris would have been present in these locations. The majority of remaining pre-war structures on site appear to be largely intact, with only minor cosmetic damage evident – the exceptions to this are several structures in the southern area of the site, which appears to have sustained serious structural damage.
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	1st Line Defence holds no records of abandoned bombs at or within the site vicinity.
Bombing Decoy sites	1st Line Defence could find no evidence of bombing decoy sites within the site vicinity.
Bomb Disposal Tasks	1st Line Defence could find no evidence of Bomb Disposal Tasks within the site boundary and immediate area.

15. The Risk from Allied Ordnance

15.1. General

The potential risk of encountering allied ordnance on construction sites is particularly elevated in areas previously associated with military activity. This includes munitions deposited by military training exercises, dumped as a result of poor working practices, or deliberately placed to prevent adversary occupation and from other home defence activities. For example, contamination from items of Land Service (LSA) and Small Arms Ammunition (SAA) may result from historic occupation of an area or its use for military training.

Urbans areas, such as that within which the site falls, can be at risk from buried unexploded Anti-Aircraft projectiles fired during WWII – see below.

15.2. Defending Liverpool from Aerial Attack

Both passive and active defences were deployed against enemy bombers attacking targets in the Liverpool region.

Passive Defences	Active Defences
These included defence tactics: • To hinder the identification of targets, by using lighting blackouts at night and camouflaging strategic installations. • To mislead bomber pilots into attacking decoy sites located away from the city with the use of dummy buildings or lighting to replicate that of the city under attack. • To force attacking aircraft to higher altitudes with the use of barrage balloons.	These relied on a coordinated combination of a number of installations in order to actively engage and oppose attacking aircraft. Some of these installations were: • Fighter aircraft to act as interceptors. • Anti-aircraft gun batteries. • The use of rockets and missiles (later during WWII).

15.3. Anti-Aircraft Artillery (AAA) and Projectiles

At the onset of WWII two types of Anti-Aircraft Artillery (AAA) guns were deployed:

- Heavy Anti-Aircraft Artillery (HAA), using large calibre weapons, such as the 3.7" QF (Quick Firing) gun
- Light Anti-Aircraft Artillery (LAA) using smaller calibre weapons, such as 40mm Bofors gun.

During the early war period there was a severe shortage of AAA available. Older WWI 3" and modified naval 4.5" guns were deployed alongside those available 3.7" weapons.

The maximum ceiling height of fire at that time was around 11,000m for the 3.7" gun and less for other weapons. As the war progressed improved variants of the 3.7" gun were introduced. From 1942, large 5.25'' weapons were brought into service. These had significantly improved ceiling heights of fire reaching over 18,000m.

The LAA batteries were intended to engage fast, low flying aircraft and were typically deployed around airfields or strategic installations. These batteries were mobile and could be moved to new positions with relative ease when required. The most numerous of these were the 40mm Bofors gun, which could fire up to 120 x 40mm HE shells per minute to over 1,800m.

The HAA projectiles were high explosive shells, usually fitted with a time delay or a barometric pressure fuze to make them explode at a pre-determined height. If they failed to explode or strike an aircraft they would eventually descend back to earth. Details of the most commonly deployed WWII AAA projectiles are shown below:

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

Although the larger unexploded projectiles could enter beneath the ground surface, they did not have a great penetration ability and are therefore likely to be found close to WWII ground level. Frequently, these shells are sometimes mistakenly identified as small German air-delivered bombs but are differentiated by the copper driving band found in front of the base. If encountered, the high explosive fill and fragmentation hazard of these items of UXO would present a significant risk.
The smaller 40mm projectiles are similar in appearance and effect to SAA and, although still dangerous, present a lower hazard due to its decreased explosive content. They are still dangerous because they were fitted with an impact initiated fuze, which was also a spin-decay self-destruct mechanism.

Numerous unexploded AAA shells were recovered during and following WWII and are still occasionally encountered on sites today.

The closest recorded HAA battery to the site was situated approximately 1.2km to the east of the site on Wavertree Botanic Gardens. It should be noted that the positions of mobile LAA gun batteries were generally not well recorded, if at all.

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

15.4. Evaluation of Allied Ordnance Risk

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

Item	Conclusion
Military Camps	1st Line Defence could find no evidence of a Military Camp within the site. A *Drill Hall* and *TA Centre* are situated to the immediate south-east of the site area on historical mapping but are not anticipated to have been used for the storage or deployment of items of explosive ordnance.
Anti-Aircraft Defences	1st Line Defence could find no evidence of Anti-Aircraft Defences in the site proximity. The nearest was a HAA battery situated approximately 1.2km to the east of site.
Home Guard Activity	Evidence of Home Guard training areas and activities is difficult to obtain. 1st Line Defence has no evidence of any Home Guard activities on the site.

Defensive Positions	There is no evidence of any defensive structures in the vicinity of the site.
Training or firing ranges	No evidence of these could be found.
Defensive Minefields	No evidence of these could be found.
Ordnance Manufacture	No evidence of ordnance manufacture could be found.
Military Related Airfields	The site was not situated within the vicinity of a military airfield.
Explosive Ordnance Clearance Tasks	1st Line Defence holds no records of EOC operations on the site.

16. Ordnance Clearance and Post-WWII Ground Works

16.1. General

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.

16.2. UXO Clearance

1st Line Defence has no evidence that any official ordnance clearance operations have taken place on site. Note however that we have not received confirmation of this fact from 33 EOD Regiment.

16.3. Post war Redevelopment

Major redevelopment took place on the site post-war. All pre-war structures present on site were demolished and a school complex constructed by the 1970's. This comprised adjoining multi-storey structures, areas of hard standing and vegetation. Several multi-storey residential structures were also constructed in the southern area of the site. The buildings associated with the school were later demolished.

It is expected that shallow excavations have taken place across the site, and as such the risk of encountering shallow-buried UXO, especially 1kg incendiaries and anti-aircraft projectiles, will have been partially mitigated.

It is known whether deeper excavations have taken place on site. The risk of encountering deeper-buried UXO is considered mitigated down to the depths and in the locations of post-war piling or foundations.

17. 1st Line Defence Risk Assessment

17.1. 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.

UXO Risk Assessment	
Quality of the Historical Record	The research has located and evaluated pre- and post-WWII Ordnance Survey maps, bomb plot mapping/data-sets for the city of Liverpool, in-house data and post-WWII era aerial photographs for the site. The record set for Liverpool is known to be incomplete, and it is believed that most WWII ARP records were lost in the bombing period. As such, no complete set of incident records or bomb census mapping is known to be available from either local or national archives.
The Risk that the Site was Contaminated with UXO	After considering the following facts, 1st Line Defence has assessed there to be a risk ranging from **Low** to **Medium** on the site of proposed works, dependent on location. A risk-map has been produced, see **Annex P**. • During WWII the County Borough of Liverpool was subjected to a high density bombing campaign, with an average 91.5 items falling per 1,000 acres according to Home Office statistics. Bombing was largely concentrated on the city centre and docks, although the residential area to the east of the city in which the site was situated did not escape German raids. Bombing can be attributed to the presence of these targets, and the indiscriminate bombing of civilian areas. • Historical OS mapping indicates that the site consisted predominantly of residential properties in wartime as well as intersecting roadways. A storage yard and church were also located in the southern area of the site. Post-war mapping and RAF aerial photography from April 1946 suggest that several areas across the site (as well as in its immediate vicinity) were cleared/ruined following bomb damage. • Limited information regarding the bombing of the city of Liverpool has survived to date. No detailed bomb plot or damage maps, or complete set of written incident records, appear to have survived the war. A limited amount of written records were obtained from the Liverpool Record Office and the Liverpool Echo, and were checked for the site area. These sources record three HE bombing incidents within the site area, and an additional two incidents within 100m of its boundary. • It is anticipated that a substantial amount of rubble and debris would have been present in the areas of damage/clearance within and adjacent to the site. Evidence of UXO could easily be overlooked within such areas – UXBs falling into bomb rubble was one of the most common scenarios whereby they would go unobserved and unreported (note that the entry hole of a 50kg bomb could be as little as 20cm in diameter). Direct access to these areas is also likely to have significantly decreased following damage, reducing post raid checks for signs of UXO. A 'buffer' zone has been placed around these cleared areas to account for

	the possibility of 'J-curve', whereby a bomb can end up laterally offset from its point of entry (see Section 12.2). • The remainder of properties, yards and roadways on site appear in 1947 imagery to have survived the war intact, with only minor cosmetic damage inflicted. This type of ground cover should have been conducive to UXO detection, and access to unaffected housing is expected to have been regular. Consequently, the risk of contamination in these areas, and outside of the buffer zones, is considered to be low. • There is no evidence that the site formerly had any military occupation or usage that could have led to contamination with other items of ordnance.
The Risk that UXO Remains on Site	Major redevelopment took place on the site post-war. All structures present on site were demolished, the area cleared, and a school complex constructed. This comprised adjoined structures, areas of hard standing and vegetation. Several multi-storey residential structures were also constructed in the southern area of the site. The buildings associated with the school were later demolished. It is expected that shallow excavations have taken place across the site, and as such the risk of encountering shallow-buried UXO, especially 1kg incendiaries and anti-aircraft projectiles, will have been partially mitigated. It is known whether deeper excavations have taken place on site. The risk of encountering deeper-buried UXO is considered mitigated down to the depths and in specific locations of post-war piling or foundations.
The Risk that UXO may be Encountered during the Works	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 risk of encountering will depend on the extent of the works, such as the numbers of boreholes/piles (if required) and the volume of the excavations. An air-dropped bomb may come to rest at any depth between just below ground level and its maximum penetration depth. Consequently there is also a chance that such an item could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level.
The Risk that UXO may be Initiated	The risk that UXO could be initiated if encountered will depend on its condition, how it is found, and the energy with which it is struck. Certain construction activities such as piling and percussive drilling pose a greater risk of initiating UXO in comparison to machine excavation, where the force of impact is generally lower and the item more likely to be observed. If a UXB is struck by piling or percussive drilling equipment, the force of the impact can be sufficient to detonate the main high explosive charge irrespective of the condition of the fuze or other components. Violent vibration might also impart enough energy to a chemical detonator for it to function, and there is a potential risk that clockwork fuzes could restart. If piling works are planned at the Kaplan site, there is a potential risk that a UXB, if present, could be initiated. The risk of initiation is assessed to be lower for any shallow intrusive works planned.
The Consequences of Encountering or Initiating Ordnance	The repercussions of the inadvertent detonation of UXO during intrusive ground works are potentially severe, 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. If appropriate risk mitigation measures are put in place, the chances of initiating an item of UXO during ground works is comparatively low. The primary consequence of encounter of UXO will therefore be economic. This would be particularly notable in the case of a high-profile site and sites where it is necessary to evacuate the public from the

	surrounding area. A site may be closed 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 loss of production. Generally, the first action of the police in most cases will be to isolate the locale whilst awaiting military assistance, even if this turns out to have been unnecessary.

17.2. Assessed Risk Level

Taking into consideration the findings of this study, 1st Line Defence considers there to be a risk ranging from **Low** to **Medium** from unexploded ordnance on the site of proposed works. A risk-map has been produced, see **Annex P**.

Medium Risk – Areas of the site in which WWII-era structures were seriously damaged, or consist of ground less conducive to UXO detection. This has been extended to account for the risk from the J-curve effect.

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German UXB's			✓	
Allied AAA			✓	
German Incendiaries and AP bomblets			✓	
Other Allied Military Ordnance	✓			

Low Risk – Areas of the site in which WWII-era structures/roadways survived intact, and fall outside the buffer zone accounting for the potential J-curve effect.

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
German UXB's		✓		
Allied AAA		✓		
German Incendiaries and AP bomblets		✓		
Other Allied Military Ordnance	✓			

18. Proposed Risk Mitigation Methodology

18.1. General

The following risk mitigation measures are recommended to support the proposed works at the Kaplan, Smithdown Lane site:

Type of Work	Recommended Mitigation Measure
All Works	• **Site Specific Unexploded Ordnance 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 that a suspect item is encountered. 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.
Shallow Intrusive Works/Open Excavations (*in Medium Risk areas*)	• **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 staff that have not already received them 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. UXO Safety and Awareness briefings will be provided to all ground personnel by the UXO Specialist once on site.
Borehole/Piles (*in Medium Risk areas*)	• **Intrusive Magnetometer Survey of all borehole and pile locations down to a maximum bomb penetration depth:** 1st Line Defence can deploy a range of intrusive magnetometer techniques to clear pile locations. The appropriate technique is influenced by a number of factors, but most importantly the site's ground conditions. The appropriate survey methodology would be confirmed once the enabling works have been completed.

In making this assessment and recommending these risk mitigation measures, if known, the proposed 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 **23rd March 2017**

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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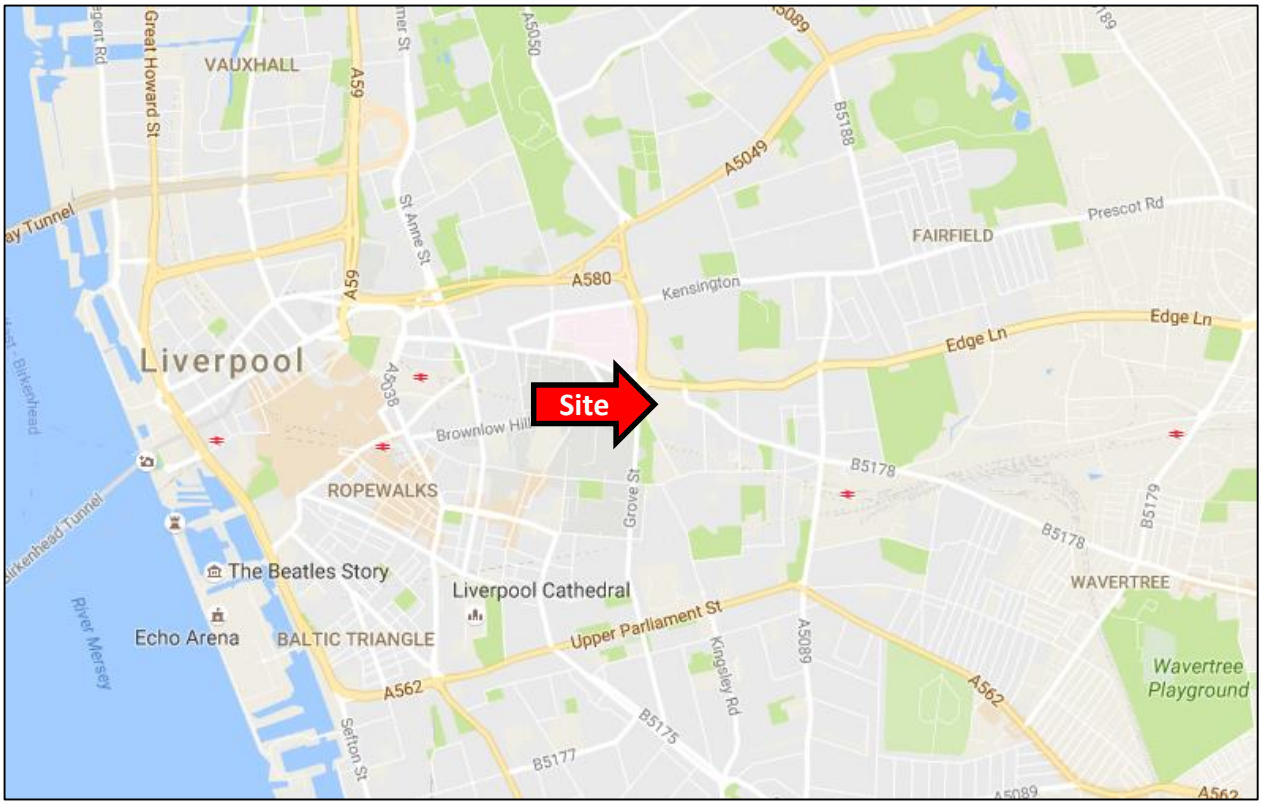
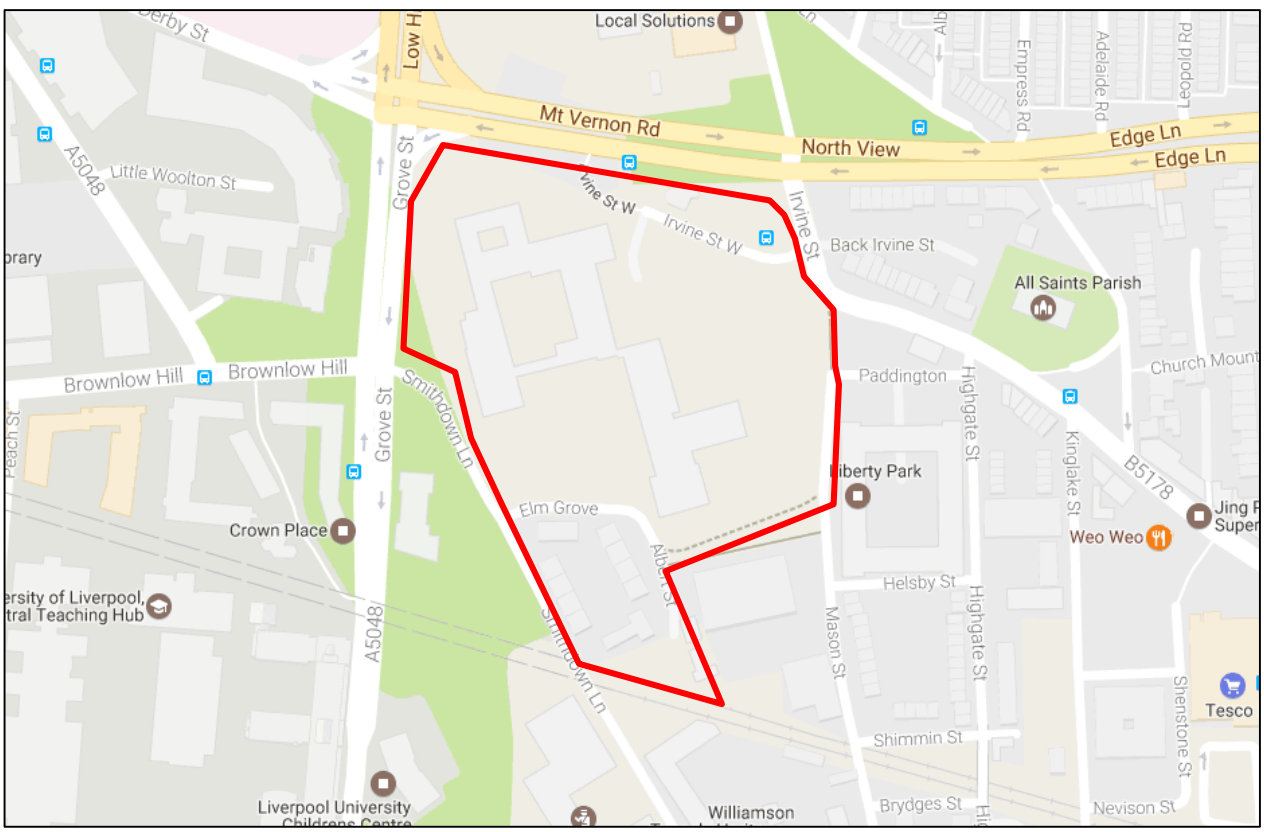
This report has been prepared by 1st Line Defence Limited with all reasonable care and skill. The report contains historical data and information from third party sources. 1st Line Defence Limited has sought to verify the accuracy and comprehensiveness of this information where possible but cannot be 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:	**Curtins**	Approximate site boundary	N
Project:	**Kaplin, Smithdown Lane, Liverpool**		
Ref:	**DA4024-01**	Source: Google Maps	

Recent Aerial Photography

Annex: **B**

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Approximate site boundary

Project: **Kaplin, Smithdown Lane, Liverpool**

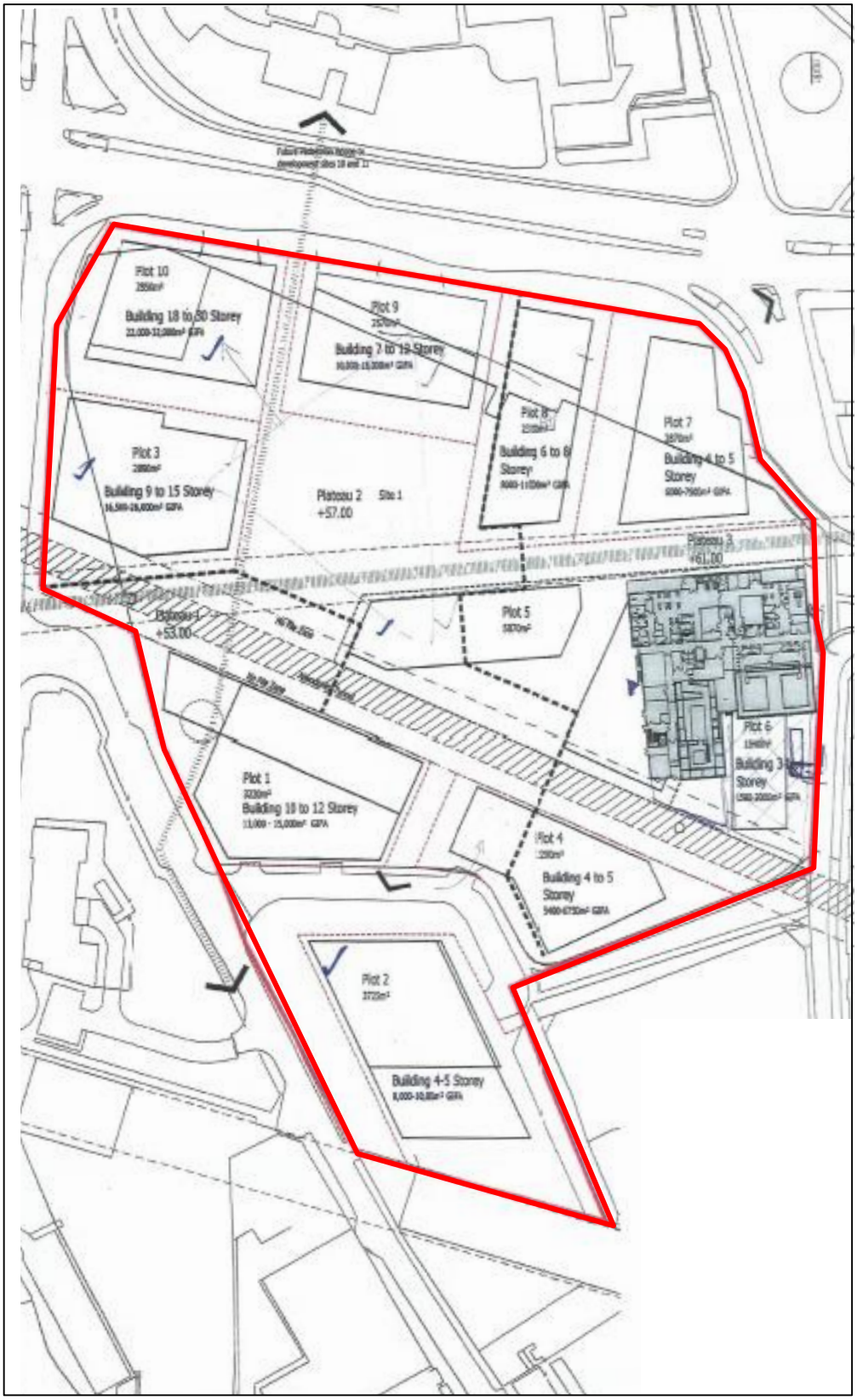
N

Ref: **DA4024-01**

Source: Google Earth ™ Mapping Services

Client Provided Site Plan

Annex: C



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Approximate site boundary

N

Project: **Kaplin, Smithdown Lane, Liverpool**

Ref: **DA4024-01**

Source: Curtins

1927 Historical Map

Annex: D1

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Project: **Kaplin, Smithdown Lane, Liverpool**

Ref: **DA4024-01**

Source: Landmark Maps

Approximate site boundary

N