APPENDIX 6 – UXO ASSESSMENT

JOMAS ENGINEERING ENVIRONMENTAL

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Geotechnical Engineering and Environmental Services across the UK.

DETAILED UNEXPLODED ORDNANCE (UXO) RISK ASSESSMENT

FOR THE SITE AT

Elleray Hall & North Lane Depot, Teddington TW11
And
East Car Park, Teddington TW11

This report has been produced by Primely on behalf of JOMAS

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EXECUTIVE SUMMARY

Site location and general description

Primely Ltd has been commissioned by *JOMAS ASSOCIATES Ltd* to carry out a detailed Unexploded Ordnance (UXO) Risk Assessment for the development projects at North lane depot East car park, Teddington TW11 0HG and Elleray Hall, Elleray Road, Teddington TW11 0HG. The sites are centred approximately on National Grid Reference TQ 15689 70909.

The site is bounded on all sides by private homes, with North Lane on its West and Middle Lane centred between the two plots as seen in figure 2.1.

The site is currently occupied by commercial buildings in part and associated with hard-standing tarmacked ground.

TW11 0HG is currently in Coronavirus (Covid-19) England Tier 5 (Stay at home)
Data from NHSX, correct as of 16th January 2021

Scope of proposed works

It is understood that a series of site investigation works are planned across the site area.

Risk assessment

Primely Ltd has assessed that there is a **LOW** risk of items of unexploded German aerial delivered. Other types of munitions also constitute a **LOW** risk**.**

- The site is located within the London Borough of Richmond upon Thames, historic county of Middlesex, which sustained a low-density bombing campaign during the Blitz.
- Official records show that 59 high explosive (HE) bombs were dropped in Teddington throughout the war.
- November 1940 saw the borough sustain its highest casualties. 74 people were killed.
- On the night of November 29,130 bombs and between 3,000 and 5,000 incendiary devices rained down on Twickenham and Teddington, destroying 150 houses and damaging more than 6,000 others.

- The National Physical Laboratory had been designated a special target by the Luftwaffe, as it was here the engineer and aeronautical designer Barnes Wallis was developing the 'Bouncing Bomb', later to be used by the RAF in the famous Dambusters raid of May 1943. The raid destroyed Germany's Mohne and Eder dams.
- There was an American army base in Bushy Park (600m south west of the site).
- Teddington Film Studios, one of the few British studios (2km southeast), received a direct hit from a V1 on the evening of July 5, 1944.
- By the end of the war, 143 civilians had been killed in air raids, 500 houses had been destroyed, and another 32,000 residences had sustained damage.

Recommended risk mitigation measures

To support the proposed works, Primely Ltd suggests the following risk mitigation measures:

- No further action. However, re-active measures should be employed such as a UXO “Toolbox” brief, a UXO ‘Emergency Management Plan’ and/or an “on-call” service.

Primely Ltd can supply the above services.

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Acronyms and abbreviations

AAA	Anti-Aircraft Artillery
AP	Armour Piercing
AP	Anti-Personnel
ARP	Air Raid Precaution (Wardens)
BD	Bombing Density
BGL	Below Ground Level
BGS	British Geological Survey (UK)
BH	Borehole
BPD	Bomb Penetration Depth
CDM	Construction (Design and Management) Regulations 2015 (UK)
CIRIA	Construction Industry Research and Information Association
CPT	Cone Penetrometer Test
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
ERP	Emergency Response Plan
ERW	Explosive Remnants of War
FFE	Free From Explosives
GI	Ground Investigation
GPS	Global Positioning System
HE	High Explosive
HSE	Health and Safety Executive
HSWA	Health and Safety at Work Act 1974
IB	Incendiary Bomb
JSEODOC	Joint Services Explosive Ordnance Disposal Operations Centre (UK)
LE	Low Explosive
LM	Luftmine (Germany)
HSWA	Health and Safety at Work Act 1974
IB	Incendiary Bomb
JSEODOC	Joint Services Explosive Ordnance Disposal Operations Centre (UK)
LE	Low Explosive
LM	Luftmine (Germany)
LSA	Land Service Ammunition MOD Ministry of Defence (UK)
NEQ	Net Explosive Quantity
RAF	Royal Air Force
RN	Royal Navy
ROF	Royal Ordnance Factory
SAA	Small Arms Ammunition
SAP	Semi-Armour-Piercing
RAF	Royal Air Force
SI	Site Investigation
SIP	Self-Igniting Phosphorous
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V1	Vengeance Weapon 1 - Flying bombs
V2	Vengeance Weapon 2 - Flying bombs
WAAF	Women Auxiliary Air Force
ROF	Small Arms Ammunition
SI	Site Investigation

INTRODUCTION

Primely Ltd has been commissioned by *JOMAS ASSOCIATES* to carry out a detailed Unexploded Ordnance (UXO) Risk Assessment for the development projects at North Lane Depot East car par and Elleray Hall, Elleray Road, Teddington TW11 0HG*, United Kingdom*. The desk study provides a detailed assessment of the location with regards to the risks of encountering items of unexploded ordnance and the consequences of that encounter.

This report documents the findings of the study carried out for the assessment of the potential risk from deep buried unexploded High Explosive (HE) bombs and munitions constituents at the site, and make suitable recommendations to mitigate the risk to a level that is as low as reasonable and practicable (ALARP).

Reasonable efforts have been exerted to ensure that significant and sufficient available historical information has been accessed and checked. The evidence assessed has been, where possible, included in the report to enable *JOMAS* and its representatives to understand the basis of the risk assessment.

Primely Ltd cannot be held responsible for inaccuracies, gaps in the available historical information, or for any changes to the assessed level of risk or risk mitigation measures based on documentation or other information that may have become available or discovered later than the date of this study.

The exact location of ordnances, their nature, as well as their quantities is ambiguous to say the least with absolute exactitude because wartime records are difficult to verify. However, our study leans on the accumulation and careful analysis of a multitude of accessible evidence.

There are several sources of information through which investigations for UXO hazards can be collected; these include the national archives, MoD archives, local historical sources, historical mapping, as well as available aerial photography. Information was considered only if it reasonably correlated with the site.

1. METHODOLOGY

1.1 Method objectives

This report follows the guidelines outlined in CIRIA Report C681, '*Unexploded Ordnance (UXO): A Guide for the Construction Industry'* which represents best practice and has been endorsed by the HSE. The report recommends 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 (ALARP).

The ALARP principle is a key factor in efficiency and effectiveness in reducing UXO risks. Any additional mitigation that delivers low benefits but consumes disproportionate time, money, and effort, is dimmed unnecessary. It is important to note that the principle is not trying to reduce the risk to zero, but to find the balance of reducing the cost of a risk significantly without compromising safety. The assessment of UXO risk is a measure of probability of encountering a deep buried unexploded ordnance and the consequence of that encounter. If risks of an UXO were identified, the methods of mitigation recommended in this report are considered reasonably and sufficiently robust to reduce them to ALARP.

Primely Ltd has been supporting the UK construction industry with UXO Risk Management measures and can support JOMAS ASSOCIATES through the whole risk management process. We offer the complete UXO risk management process from the preliminary and detailed desk study through to on-site support.

1.2 Sources of Information

Reasonable effort has been made to ensure that relevant evidence was consulted and presented to produce a thorough and comprehensible report. To achieve this, the following records and archives material, held in the public domain, have been accessed:

- Primely Ltd in-house data base.
- The National Archives, Kew.
- Historical mapping datasets.
- British Geological Survey
- Historic England National Monuments Record.
- Available material from 33 Engineer Regiment (EOD) Archive.
- Open sources such as published books and verified online resources.

2. SITE DETAILS AND DESCRIPTION

2.1 Site location and Description

The investigation is for the sites located at North lane depot East car park and Elleray Hall, Elleray Road, Teddington TW11 0HG, United Kingdom. The site is centred approximately on National Grid Reference TQ 15689 70909.

The site is bounded on all sides by private homes, with North Lane on its West and Middle Lane centred between the two plots as seen in figure 2.1 below.

The site is currently occupied by commercial buildings in part and associated with hard-standing tarmacked ground.

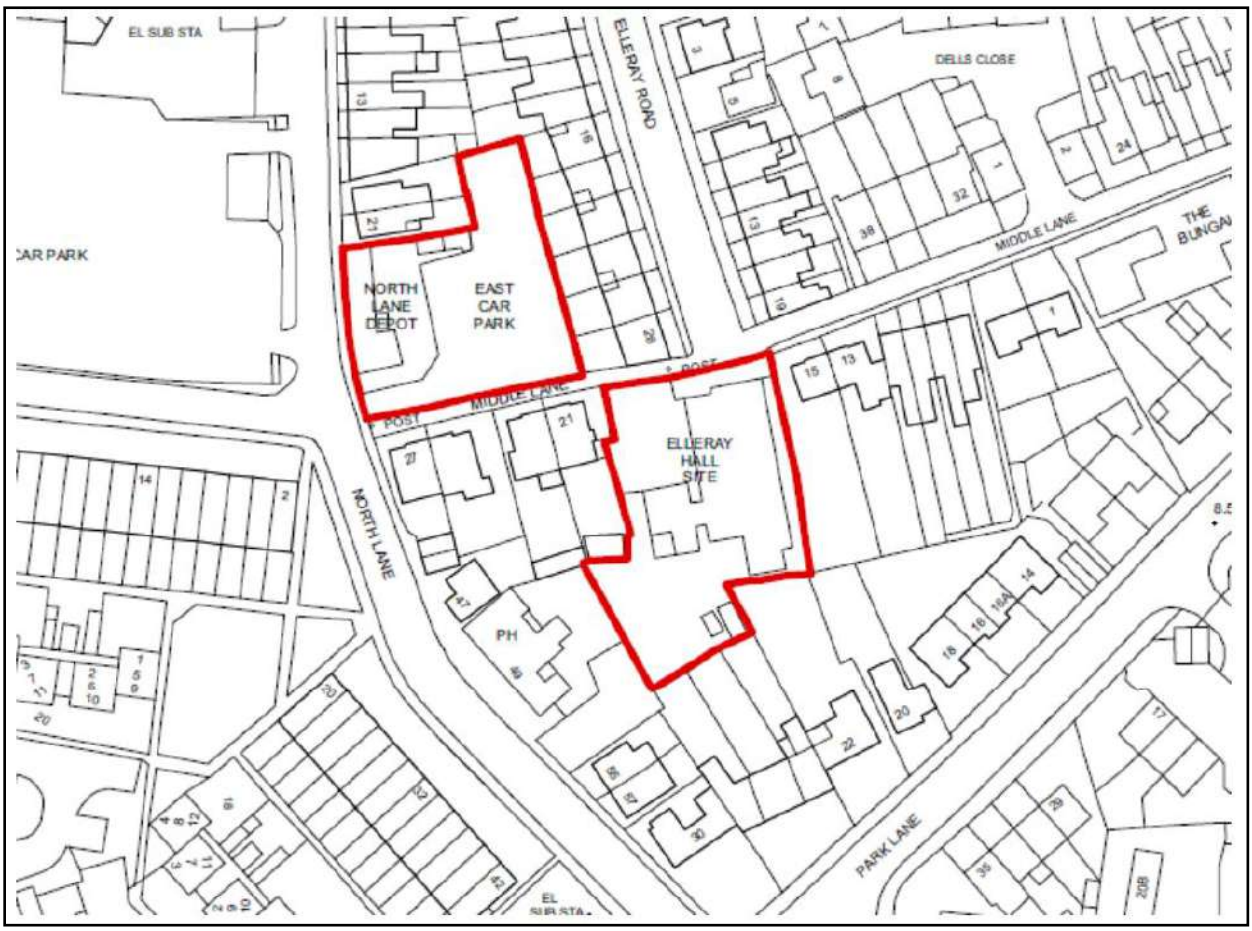


Figure 2.1: Description of the site location

2.2 Proposed Scheme of work

It is understood that a series of site investigation works are planned across the site area.

2.3 Ground Conditions - Geology

It should be noted that the maximum depth that a bomb could reach may vary across a site and will be largely dependent on the specific underlying geological strata and its density.

2.4 Historical Ground Investigation Data

The British Geological Survey Geology of Britain web map services provides access to the geographic locations and logs of historical borehole investigations and well installations located nearby, to the north and east of the site (See figure 2.4 below).

Figure 2.4: Historical borehole records (Source: BGS Web Service)

Table 2.4.1 below displays the strata succession encountered in the boreholes (See appendix for full log). No boreholes were found closer to the site.

Table 2.4.1: LITTLE QUEENS ROAD TWICKENHAM

Name: LITTLE QUEENS ROAD TWICKENHAM **Reference:** TQ17SE19 **Length (m):** 9.600000 **Easting**: 515500 **Northing:** 170800		
Geological section	**Thickness**	**Depth**
Topsoil	0.2m	0.6
Made ground	5.9m	6.1m
Gravel	0.3m	6.4m
Brown clay	0.3m	6.7m
Blue clay	3m	9.77m

Table 2.4.2: GOVERNMENT CHEMIST LAB NPPL 11

Name: GOVERNMENT CHEMIST LAB NPPL 11 **Reference:** TQ17SE64/K **Length (m):** 10.000000 **Easting:** 515470 **Northing:** 170750		
Geological section	**Thickness**	**Depth**
Made ground	5.9m	1.0m
Gravel	0.3m	1.8m
Weathered London clay	0.3m	7.8m
London clay	3m	8m

3. HISTORICAL DATASETS

3.1 General

The following section presents information identified relating to the site of military value of various types. The focus of this report concerns German aerial delivered weapons dropped during WWI and WWII.

The Great War started in Belgium and France along the Western Front in 1914 but by the beginning of 1915 it had moved closer to home. During the first great war, London was targeted and bombed by Zeppelin Airships. An estimated 250 tons of ordnance were dropped upon the city, most of which fell on the City of London. The first Zeppelin raid over London came on the 31st May 1915 and the increasing threat of attack saw the establishment of a ring of defensive airfields around the city.

The country received a much-needed respite from bombing in June 1941, when Luftwaffe squadrons were ordered to concentrate on the war against Russia. The resumption of Hitler's bombing of England, a period known as The Little Blitz, did not occur until the spring of 1944, when raids were launched from Luftwaffe bases in occupied France.

WWI bombs were generally smaller in sizes and were dropped from a lower altitude which resulted in a limited penetration in depth of these ordnances. This report has placed a greater emphasis on WWII bombs as they can be found significantly deeper than the WWI ordnances.

3.2 Site History

The sites are situated in Teddington, in the London Borough of Richmond upon Thames. It is also in the historic county of Middlesex.

In 1800 the population of Teddington was under 700, in 100 houses. The number of houses had probably doubled by the 1860s, but the population was still only just over 1000. In 1861 the Manor of Teddington, which consisted of nearly half the parish, was sold for the development of desirable villas. To assist this development the railway arrived in 1863.

There were no buildings in Broad Street in 1800 although there were houses in Middle Lane backing on to Broad Street and in Park Lane, including the alms houses, built in 1739 and demolished in about 1950. Elleray Villa was built by 1820 on the corner of North Lane with an entrance in Broad Street. The house was demolished in about 1890 and the site crossed by Elleray Road. There was a house round the corner in Stanley Road in 1800. It is thought that this was the house called Maud Cottage, later called The Hollies or the Old Hollies. The house was demolished in 1965 to make way for the redevelopment of the land between Somerset Road and Walpole Road.

Built in 1911, Elleray Hall's initial purpose was to act as a parish hall. It wasn't until 1950's Teddington's Old Peoples' Welfare Committee (T.O.P.W.C.) began utilising the hall for distributing off-ration sweets to its local elderly community. T.O.P.W.C. had been formed in 1946 with the aim of aiding the elderly with fuel and food. Seventy-two years on, T.O.P.W.C. has become Elleray Community Association but its objective of combating isolation in the neighbourhood continues.

At the end of October 1940, concerns ran high when a bomb landed on the apron of Teddington Weir. The breach caused by the bomb's detonation created a reduction in the depth of water at Teddington Reach (1.6 km east of the site) by six feet, making navigation impossible except at high tides. Those dwelling on Trowlock Island were marooned temporarily. Full navigation of the Reach would not be restored for seven weeks.

In the months that followed, the aerial bombardment grew heavier. November 1940 saw the borough sustain its highest casualties. 74 people were killed, the majority in a devastating attack which took place on the night of November 29. 130 bombs and between 3,000 and 5,000 incendiary devices rained down on Twickenham and Teddington, destroying 150 houses and damaging more than 6,000 others. The worst damage was sustained just 130m north of the depot, at Church Road.
Mrs Lilian Dring, a Teddington resident, wrote: *"Most of Teddington became a raging inferno. Duty rotas were abandoned and every available warden was on duty most of the night. The Baltic Timber Yard, Stanley Road* (which is just over 300m north west of the site) *and the Baptist Church went up in mountains of flame which almost met over our heads as we patrolled Walpole Road."*

Another tragedy occurred the same night. Bombs intended to pulverize the National Physical Laboratory at Teddington exploded over a public air raid shelter in the laboratory's grounds, killing eight residents of Walpole Crescent. The NPL (circa 500m Northwest of the sites of interest) had been designated a special target by the Luftwaffe, as it was here the engineer and aeronautical designer Barnes Wallis was developing the 'Bouncing Bomb', later to be used by the RAF in the famous Dambusters raid of May 1943. The raid destroyed Germany's Mohne and Eder dams.

During the 'Little Blitz', as far as residents of the borough were concerned, the worst of these raids occurred on February 25, 1944, when 45 bombs were dropped in an effort to destroy both the National Physical Laboratory and an American army base in Bushy Park (600m south west of the site). The Luftwaffe missed their targets. Three bombs fell in Fulwell Golf Course (1.2km north) and 28 landed in Hampton and Hampton Hill (1.6km northwest).

Teddington Film Studios, one of the few British studios (2km southeast) to remain in operation during World War II, received a direct hit from a V1 on the evening of July 5, 1944. The bomb completely gutted the main studio and took the life of 'Doc' Salomon, the studio's American production manager. This effectively put an end to Teddington Studio's valiant efforts to produce morale-boosting films throughout the war. Understandably, the psychological impact these missiles had on the local population was devastating. An even greater threat was posed by the sophisticated, longer-range V2 rockets. Unlike the V1, which could be seen and heard from a distance, the V2 was silent and there was no warning

of its arrival: it simply dropped to the ground and exploded violently on impact. The only V2 to land in the area, at the rear of Fairfax Road, 1.3km southeast, left a crater 40 feet wide and 8 feet deep. Fear of this new menace from the skies led to the evacuation of 7,000 women and children from the borough in July 1944.

By the end of the war, 143 civilians had been killed in air raids, 500 houses had been destroyed, and another 32,000 residences had sustained damage.

3.2.1 Second World War Bombing Statistics

The following table summarises the quantity of German bombs (excluding 1kg incendiaries and antipersonnel bombs) falling on the borough of Richmond upon Thames between 1940 and 1945.

Table 3.2.1 Ordnance Statistic within the borough[1]

Record of German Ordnance Dropped on Teddington		
Area Acreage		**N/A**
Weapons	High Explosive Bombs (all types)	59
	Parachute Mines	-
	Oil Bombs	-
	Phosphorus Bombs	-
	Fire Pot	-
	Pilotless Aircraft (V-1) incidents	-
	Long Range Rockets (V-2) incidents	-
Total		
Items per 1000 acres		N/A

[1] **Source**: Home Office Statistics

This table does not include UXO found during or after WWII.

1kg incendiary and anti-personnel bombs were frequently considered too numerous to be recorded and their locations to be registered. They were, consequently, considered to have been dropped ubiquitously across the area. Although the risk relating to Incendiary bombs is lesser than that relating to larger HE bombs, they are still lethal as they were designed to inflict damage and injury. The risk of harm should not be dismissed.

3.3 Ordnance Survey Historical Maps

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

Table 3.3 – Ordnance Survey Historical Maps Description

Pre WW1		
Date	**Scale**	**Description**
1896	1:2,500	The site is bounded by Broad street to the north, Park Lane to the south, North Lane to the west and Elleray road to the east. It is set in rural Teddington and contains two buildings that are not clearly defined.
1915	1:2,500	During WW1, there were developments adjacent to the site with the emergence of a row of terraced houses facing Elleray road and a Hall at the bottom of the site. The area itself illustrates a progress in development.

Pre WW2		
Date	**Scale**	**Description**
1920	1:2,500	After WW1, there has been minimal changes to the area.
1934	1:10,560	In the period before WW2, very little or no changes have taken place from the previous map edition. Memorial Hospital has been built west of the area, on a site that previously used to be a Nursery.

Post WW2		
Date	**Scale**	**Description**
1959	1:2,500	The site is unchanged with only the Hall being converted into Works building. The area itself is more urbanised with more building's, particularly in the open spaces south and east of the site.
1963-1979	1:2,500	No changes on the site. Nursery and allotment areas towards the south-west have been developed with more housing.
1991	1:2,500	Changes have taken place on the site with a car park built on the north and a Day Centre at the south. Buildings west of the site, adjacent to North Lane have also been replaced by a big car park.
1975	1:10,000	No discernable changes have taken place.
1987	1:10,000	No discernable changes have taken place.

3.4 Aerial Bombing

The focus of research is centered on German air-delivered ordnance dropped during WW1. However, other forms of explosive contamination will be considered. It is assessed that the risk of encountering WW1 bombs is low as they were dropped from a lower altitude and were generally smaller in sizes, resulting in a much lower penetration depth.

As for the site of interest in **figure 3.4.1** below show the concentric red lines that portray a high bombing density on and around the site area. This indicates that there has been a significant tonnage of bombs dropped in the area. This may be due to the high number of military target present in the area.

3.5 Sources of Potential Unexploded Ordnance

During WWI and WWII, many towns and cities across the UK were subjected to bombing which often resulted in extensive damage to town centres, docks, railways, industrial areas, and other infrastructures. Part of the destruction could be associated with the poor accuracy of the technology and the nature of bombing techniques.

The bombing records were gathered by the police, Air Raid Precaution (ARP) wardens, and military personnel. The records were maintained locally and/or by regions, in the form of written records, maps (depicting strikes' locations and damage to structures). Records were detailed and typically made through direct observations, or by post-raid surveys. As the immediate priority was to assist casualties and minimise damage, loss or incompletion of some records were inevitable.

UXO found at diverse sites in the UK originates from three principal sources;

1. During escape of Luftwaffe aircrafts from an aerial attack, they would drop some or all their load resulting in bombs being found in unexpected locations. This is commonly referred to as tip and run. The CIRIA publication C681 suggests that approximately 10 per cent of all munitions deployed failed to function as designed. Thus, many remained buried and can present a potential risk especially to workers undertaking construction and civil engineering groundwork.
2. During transportation of aggregate containing munitions from a contaminated area to an area that was previously free of UXO.
3. 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 constructed to deliberately cause incorrect targeting, often built in remote and uninhabited areas.

3.5.1 Allied as source of UXO

As the pressure mounted during WWII, the government requisitioned considerable areas of land for defence, where the armed forces would carry out training, construction of airfields and facilities for munitions production and storage. It has been estimated that at least 20 per cent of the UK's land has been used for military training at some point.

Thousands of tons of the munitions used during the war were used for the Allied Forces weapon testing, and military training. Therefore, allied UXO contamination derived from legacy munitions from military training, deliberate or accidental dumping (AXO), and ordnance that directly resulted from war fighting activities are known as Explosive Remnants of War.

There is no supporting evidence that the site had been used for military purpose or even to store resources. The closest legitimate target was the training ground at Mill green.

3.5.2 German as source of UXO

Where a bomb fails to detonate upon penetration of the ground, it leaves behind an entry hole that is not always apparent, and some were unreported, leaving the buried bomb being unrecorded. Aerial bombing of London witnessed a wide range of German bombs.

3.6 WWII German aerial Ordnance Type Description High Explosive (HE) Bombs

3.6.1 German SC50 and SC250

The SC series of High Explosive Bombs were thin cased bombs used for general demolition. In this series, most bombs were between 50kg to 500kg, with larger bombs of up to 1,800kg **(see Annex A)**. Their fill of high explosive made up half their weight. The SC50 was made of a 'one piece drawn steel body'. The SD series were bombs made with a thicker case and a lower charge weight and were generally used against hardened targets (See table 3.6.1 below).

Table 3.6.1: Range of German bomb series

Weight in Kg	Weight in lb	Series
50kg	112lb	S.C. or S.D.
250kg	550lb	S.C. or S.D.
500kg	1,000lb	S.C. or S.D.
1000kg	2,400 lb	S.C. (Herman)
1,000kg	2,400 lb	S.D. (Esau)
1,400kg	3,200 lb	S.D. (Fritz)
1,800kg	4,000 lb	S.C. (Satan)

3.6.2 1Kg Incendiary Bomb SD2 'Butterfly' Bomb (Armed status)

The 1 kg B1E incendiary bomb **(see annex B)** consisted of a cylinder of magnesium alloy, with an incendiary filling of thermite with three steel fins. These bombs were ignited by a small percussion charge, fired upon impact. Explosive heads were later incorporated into the IB. Whilst Incendiary Bombs may have fallen within the Study Site, they were considered ubiquitous and record keeping of those were sometimes discarded if they were under 1kg.

3.6.3 The Butterfly Bomb (or Sprengbombe Dickwandig 2 kg or SD2)

These were a German 2-kilogram antipersonnel sub munition used by the Luftwaffe, made of a thin cylindrical metal outer shell which hinged open when the bomblets were deployed **(see annex B).** The design was very distinctive and easy to recognise as it had the appearance of a large butterfly. SD2 bomblets were dropped in large numbers from containers holding between 6 and 108 sub munitions. These broke open in air and scattered the sub-munitions.

3.6.4 V1s and V2s

The final phase of bombing began at the end of 1944 when the first V2 rocket exploded in addition to IBs and HE bomb strikes. The fear of the V1 flying bombs and V2 rockets was tangible. These unmanned bombs were caused when London targets were overshot. The V type rockets were thin-skinned, unmanned, and less accurate weapons **(see annex C)**. There was no advance warning for a rocket which travelled faster than the speed of sound, reaching its target four minutes after launch. Enormously destructive, they caused huge craters and flattened whole rows of houses. Across London thousands of homeless people needed rehousing.

3.7 Consequences of interaction

A friction impact from intrusive machineries could provoke a shock-sensitive fuse explosive. The effects of chemical breakdown of the explosive fill and the 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 around the fuse pocket which could detonate the main charge.

Upon detonation, factors that may be affected may vary depending on the site-specific conditions but can be summarised as:

- 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.

The depth that an unexploded bomb will penetrate depends on several factors including:

- Size and shape of bomb
- Height of release
- Velocity and angle of bomb
- Nature of the ground cover
- The Geology.

Unexploded ordnance does not spontaneously explode as military HE. It is generally reasonably stable and requires significant energy for detonation to occur. In the case of a German UXB, discovered within the construction site, there are other potential initiation mechanisms such as a significant impact e.g. from piling machinery or large and violent mechanical excavation, onto the main body of the weapon (unless the fuse is struck).

Most German bomb and mine fuses were electric and were highly engineered compared to their British equivalents. A small proportion of German WWII bombs employed clockwork fuses. It is probable that clockwork or mechanical fuse mechanisms would have corroded since WWII and this will generally prevent them from functioning.

4. REQUIREMENT FOR UXO RISK ASSESSMENT

4.1 Background

There is currently no formal obligation for construction or development projects to undertake a UXO risk assessment in the UK and there is no specific legislation enforcing this on the management for the mitigation of UXO risk. However, the CDM legislation outlined below makes noticeably clear that those responsible for intrusive works should undertake a comprehensive and robust assessment of the potential risks to employees and implement mitigation measures to address any hazards identified.

4.2 CDM Regulations 2015

The Construction (Design and Management) Regulations 2015 defines 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 coordinators, 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. The CDM 2015 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 or obtain an appropriate assessment of potential UXO risks at the site.
- Emplace appropriate risk mitigation measures if necessary.
- Supply all parties with relevant risk information.
- Prepare a suitably robust emergency response plan.

4.3 Other legislations

The 1974 Health and Safety at Work Act dictates that all employers have a responsibility under this Act 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. In the event of a casualty resulting from the failure of an employer or client to address the risks relating to UXO, the organisation may be criminally liable under the Corporate Manslaughter and Corporate Homicide Act 2007.

5. DATA ANALYSIS

The sites are situated in Teddington, in the London Borough of Richmond upon Thames. It is also in the historic county of Middlesex. The borough received a low bombing campaign during the war.

There were no buildings in Broad Street (150m northeast of the site) in 1800 although there were houses in Middle Lane backing on to Broad Street and in Park Lane, including the alms houses, built in 1739 and demolished in about 1950. Elleray Villa was built by 1820. The house was demolished in about 1890 and the site crossed by Elleray Road.
Built in 1911, Elleray Hall's initial purpose was to act as a parish hall.
At the end of October 1940, a bomb landed on the apron of Teddington Weir. The breach caused by the bomb's detonation created a reduction in the depth of water at Teddington Reach (1.6 km east of the site) by six feet, making navigation impossible.
November 1940 saw the borough sustain its highest casualties. 74 people were killed, the majority in a devastating attack which took place on the night of November 29. 130 bombs and between 3,000 and 5,000 incendiary devices rained down on Twickenham and Teddington, destroying 150 houses and damaging more than 6,000 others. The worst damage was sustained just 130m north of the depot, at Church Road.

Another tragedy occurred the same night. Bombs intended to pulverize the National Physical Laboratory at Teddington exploded over a public air raid shelter in the laboratory's grounds, killing eight residents of Walpole Crescent. The NPL (circa 500m Northwest of the sites of interest) had been designated a special target by the Luftwaffe, as it was here the engineer and aeronautical designer Barnes Wallis was developing the 'Bouncing Bomb', later to be used by the RAF in the famous Dambusters raid of May 1943. The raid destroyed Germany's Mohne and Eder dams.

There was an American army base in Bushy Park (600m south west of the site), which was hit by 45 bombs On February 25, 1944.

The National Physical Laboratory was an official Luftwaffe target, which it missed their targets. Three bombs fell in Fulwell Golf Course (1.2km north) and 28 landed in Hampton and Hampton Hill (1.6km northwest).

Teddington Film Studios, one of the few British studios (2km southeast) to remain in operation during World War II, received a direct hit from a V1 on the evening of July 5, 1944. By the end of the war, 143 civilians had been killed in air raids, 500 houses had been destroyed, and another 32,000 residences had sustained damage.

6. RISK ASSESSMENT

There is a **low** risk of encountering German air delivered HE bombs. British AAA projectiles and Incendiary bombs pose a **low** threat.

6.1 Maximum Bomb Penetration Depth

A key consideration when assessing the likelihood of finding a high explosive bomb is the depth at which they may be found. The penetration is dependent upon the:

- **Nature** of the ground;
- **Weight** of the ordnance;
- **Type** of ordnance.

6.1.1 The J-Curve Effect

When an air-delivered bomb penetrates the ground after it is dropped from height, it is slowed by its passage through underlying soils, its trajectory curves towards the surface with a final 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. This underground trajectory is known as a **J curve (See Annex E)** and is the reason why bombs can be found under basements that were constructed before WW2.

Research during WW2 suggested that a 1000kg bomb dropped in clay could theoretically penetrate a vertical depth of 25m and 8m horizontally. It should be noted that the maximum **actual** depth of penetration observed in the research for a 1000kg bomb was 12.5m. Contemporary bomb disposal guidance indicated that only 1% of bombs (of 50kg or heavier) penetrated more than 9m.

6.1.2 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.

6.1.3 Site Specific Bomb Penetration Considerations

Although it is possible that the Luftwaffe deployed bombs in the area, their deployment was infrequent, and to use such larger (or the largest) bombs for BPD calculations were 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. Given the development of the Site after WWII, the presence of Unexploded Ordnance is significantly reduced, unless a cross contamination has taken place.

6.2 Risk Pathway

Given the types of UXO that might be present on Site, all types of aggressive intrusive engineering activities (i.e. excavations 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.

6.4 Risk Rating Calculation

This Semi-Quantitative Risk Assessment assesses and rates the risks posed by the most probable threat items when conducting many different activities on the site. Risk Rating is determined by calculating the probability of encountering UXO and the consequences of initiating it.

Table 6.4.1 – UXO Risk Calculation

UXO RISK CALCULATIONS TABLE – ALL AREAS				
Activities	**Threat item**	**Probability (SH X EM=P)**	**Consequence (DXPSR=C)**	**Risk rating (PXC=RR)**
Trial Pits (Within existing foundations)	HE Bombs	1x1=1	2x3=6	1x6=6
	AAA projectiles	1x1=1	3x2=6	1x6=6
	IBs	1x1=1	2x3=6	1x6=6
Boreholes (Within existing foundations)	HE Bombs	1x2=2	2x2=4	2x4=8
	AAA projectiles	1x1=1	2x2=4	1x4=4
	IBs	1x1=1	2x2=4	1x4=4
Piling (Within existing foundations)	HE Bombs	1x3=3	3x1=3	3x3=4
	AAA Projectiles	1x1=1	3x2=6	1x6=6
	IBs	1x1=1	2x2=4	1x4=12

SH: Site History
EM: Engineering Methodology
P: Probability
D: Depth
C: Consequence
PSR: Proximity to Sensitive Receptors
RR: Risk Rating

Key

Low	Medium	High	Very High

Probability Calculation

The potential that an item of UXO would detonate, if encountered, relies on a number of variable factors. There are no empirical means of accurately and reasonably calculating the probability of an UXO detonation during intrusive site activities. During the semi quantitative risk assessment process, SH and IM are scored from 1 to 3 with 1 = Low, 2 = Medium and 3 = High. Probability is therefore scored 1 to 9.

Table 6.4.2 – Risk Rating - Probability and Consequence

		Probability					
		1	2	3	4	6	9
Consequence	1	1	2	3	4	6	9
	2	2	4	6	8	12	18
	3	3	6	9	12	18	27
	4	4	8	12	16	24	36
	6	6	12	18	24	36	54
	9	9	18	27	36	54	81

Table 6.4.3 – Risk Scoring Categories

Risk Rating (P x C)	Risk Rating (P x C)	Risk Tolerability	Action Required
1-9	Low	Partly Tolerable	Re-active measures should be employed such as a UXO “Toolbox” brief, a UXO ‘Emergency Management Plan’ and/or an “on-call” service.
12-18	Low-Medium	Less Tolerable	
24-27	Medium-High	intolerable	Pro-active measures should be employed such as EOD Engineer Site Supervision and Magnetometer Surveys.
36-81	High	Highly Intolerable	

In utilising table 6.4.3 above, Primely Ltd can assess the risk tolerability and devise a suitable level of risk mitigation to meet the ALARP principle.

7 RECOMMENDED RISK MITIGATION MEASURES

For the works carried out at North Lane depot East car park, Teddington TW11 0HG and Elleray Hall, Elleray Road, Teddington TW11 0HG, United Kingdom, Primely Ltd estimates that there is a LOW risk of deep buried UXO and recommends:

No further action. However, re-active measures should be employed such as a UXO "Toolbox" brief, a UXO 'Emergency Management Plan' and/or an "on-call" service. A Site Management documentation detailing the actions to undertake in the event of a suspected or real UXO discovery should be held on-site to guide, which can be supplied by Primely Ltd.

This desktop assessment is based upon analysis of historical evidence along with other data readily available. Every reasonable effort has been made to locate and present significant and pertinent information.

Primely Ltd cannot be held accountable for any changes to the assessed risk level or risk mitigation measures, based on documentation or other data that may come to light later than the date of this study or which was not available to Primely Ltd during the production of this report.

The accuracy of WWII era records sometimes proves difficult to verify. Therefore, conclusions as to the exact location and nature of a UXO risk can rarely be quantified and are to a degree subjective. To counter this, a range of sources have been consulted and analysed. Wartime records show that the quality and nature of record keeping varied between boroughs; while some local authorities maintained records with a methodical approach, others considered a more vague, dispersed, and narrow in scope. Many other records were damaged or destroyed in subsequent bombing raids. Furthermore, records of attacks on military or strategic targets were often maintained separately from the general records and those have not always survived.

BIBLIOGRAPHY

1. https://osmaps.ordnancesurvey.co.uk
2. http://bombsight.org
3. http://mapapps2.bgs.ac.uk/geoindex/home.html?layer=BGSBoreholes
4. https://www.ordnancesurvey.co.uk/shop/mapsheetfinder.html#mapsheet-viewer
5. https://www.telegraph.co.uk/news/2016/05/10/did-a-nazi-bomb-land-near-your-house-during-the-blitz/
6. THE BOMBING OF BRITAIN 1940-1945 EXHIBITION, university of Exeter,
7. https://humanities.exeter.ac.uk/media/universityofexeter/collegeofhumanities/history/researchcentres/centreforthestudyofwarstateandsociety/bombing/THE_BOMBING_OF_BRITAIN.pdf
8. https://books.google.co.uk/books?id=42fFwAEACAAJ&dq=This+Semi-Quantitative+Risk+Assessment+assesses+and+rates+the+risks+posed+by+the+most+probable+threat+items+when+conducting+many+different+activities+on+the+Site.+Risk+Rating+is+determined+by+calculating+the+probability+of+encountering+UXO+and+the+consequences+of+initiating+it.&hl=en&sa=X&ved=0ahUKEwjY6pKdhKrjAhUBSRUIHdL8BU8Q6AEIMzAB
9. https://www.legislation.gov.uk/ukpga/1974/37
10. https://books.google.co.uk/books?id=sib_sgEACAAJ&dq=The+1974+Health+and+Safety+at+Work+Act+dictates+that+all+employers+have+a+responsibility+under+this+Act+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.&hl=en&sa=X&ved=0ahUKEwj3peiziqrjAhXjmFwKHe4ND2MQ6AEILjAB
11. https://www.cps.gov.uk/legal-guidance/corporate-manslaughter
12. https://books.google.co.uk/books?id=M-6wAAAACAAJ&dq=In+the+event+of+a+casualty+resulting+from+the+failure+of+an+employer+or+client+to+address+the+risks+relating+to+UXO,+the+organisation+may+be+criminally+liable+under+the+Corporate+Manslaughter+and+Corporate+Homicide+Act+2007.&hl=en&sa=X&ved=0ahUKEwjezNixjKrjAhWIgVwKHYE7AKc4ChDoAQhVMAg

13. http://www.hse.gov.uk/corpmanslaughter/
14. http://www.hse.gov.uk/foi/internalops/ocs/100-199/165_10.htm
15. http://www.hse.gov.uk/pubns/wrdp1.pdf
16. https://www.fieldfisher.com/publications/2014/10/corporate-manslaughter-cases-in-2014
17. https://www.shponline.co.uk/corporate-manslaughter/
18. https://www.kingsleynapley.co.uk/insights/blogs/criminal-law-blog/corporate-manslaughter-and-health-and-safety
19. http://www.hse.gov.uk/pUbns/priced/l153.pdf
20. http://www.hse.gov.uk/construction/cdm/2015/responsibilities.htm
21. https://books.google.co.uk/books?id=DU08XwAACAAJ&dq=The+Construction+(Design+and+Management)+Regulations+2015+defines+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+coordinators,+designers,+and+contractors+to+those+working+on,+or+affected+by,+a+project.&hl=en&sa=X&ved=0ahUKEwikwPL-j6rjAhVhnVwKHXEFDqIQ6AEIVTAH
22. https://books.google.co.uk/books?id=_wUpQwAACAAJ&dq=In+addition+to+IBs+and+HE+bomb+strikes,+two+%E2%80%98V%E2%80%99+type+weapons+strikes+have+been+recorded+near+the+site.&hl=en&sa=X&ved=0ahUKEwisg-KPkarjAhWQgVwKHVAFD64Q6AEIQTAE
23. https://books.google.co.uk/books?id=_wUpQwAACAAJ&dq=In+addition+to+IBs+and+HE+bomb+strikes,+two+%E2%80%98V%E2%80%99+type+weapons+strikes+have+been+recorded+near+the+site.&hl=en&sa=X&ved=0ahUKEwisg-KPkarjAhWQgVwKHVAFD64Q6AEIQTAE
24. https://www.flightjournal.com/germanys-v-2-rocket/
25. http://www.twickenham-museum.org.uk/detail.php?aid=390&ctid=4&cid=40
26. https://www.google.com/search?biw=993&bih=544&tbm=isch&sa=1&ei=DL4lXZqlAtyBjLsPoOO50Ag&q=german+v2+rockets&oq=german+v2+rockets&gs_l=img.3..0i24.6067.7320..8185...0.0..0.281.421.0j1j1.....0....1..gws-wiz-img.GmqoYvV-0fU
27. https://www.awm.gov.au/collection/C148379
28. https://www.iwm.org.uk/collections/item/object/30020459

29. https://media.iwm.org.uk/ciim5/260/717/000000.jpg?_ga=2.35370849.117168925.1562755539-503030435.1562172104
30. https://www.lbhf.gov.uk/community/ve-day/how-second-world-war-changed-hf-forever
31. https://www.lbhf.gov.uk/sites/default/files/section_attachments/suds_design_and_evaluation_guide.pdf
32. https://www.britannica.com/event/the-Blitz#ref345824

REFERENCES

1. Unexploded Ordnance: A Critical Review of Risk Assessment Methods, Issue 1674, *MR (Rand Corporation)*
2. *Unexploded Ordnance: A Critical Review of Risk Assessment Methods*, Jacqueline MacDonald
3. German Air-dropped Weapons to 1945, Wolfgang Fleischer, Midland, 2004, ISBN: 1857801741, 9781857801743
4. Acceptable risk, Baruch Fischhoff, Sarah Lichtenstein, Steven L. Derby - 1983

   The Baby Killers: German Air Raids on Britain in the First World War, Thomas Fegan - 2013

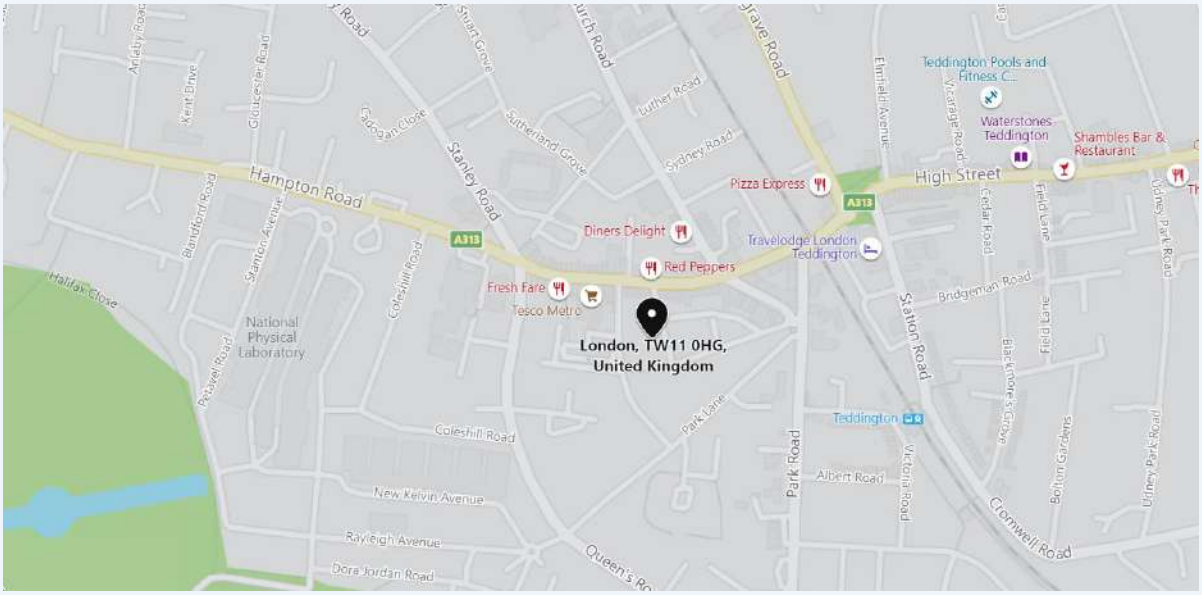
   The Blitz Then and Now, Volume 3, Winston G. Ramsey - 1990
5. https://www.legislation.gov.uk/ukpga/1974/37
6. Managing Health and Safety in Construction: Construction (Design and Management) Regulations 2015: Guidance on Regulations
7. Health and Safety at Work Etc. Act 1974,*Part 37 of Public General Acts - Elizabeth II*, H.M. Stationery Office, 1974, ISBN: 0105437743, 9780105437741
8. Identifying and Managing Risk, Will Baker, Howard Reid, Pearson Education Australia, 2004
9. http://www.hse.gov.uk/corpmanslaughter/
10. http://www.hse.gov.uk/foi/internalops/ocs/100-199/165_10.htm
11. http://www.hse.gov.uk/pubns/wrdp1.pdf
12. Managing health and safety in construction (Design and Management) Regulations 2015
13. http://www.hse.gov.uk/construction/cdm/2015/responsibilities.htm
14. http://www.legislation.gov.uk/uksi/2015/51/contents/made
15. Managing Health and Safety in Construction: Construction (Design and Management) Regulations 2015: Guidance on Regulations
16. Temporary Works: Principles of Design and Construction, Murray Grant, Peter F. Pallett, ICE Publishing, 2012 - Technology & Engineering
17. Unexploded Ordnance (UXO): A Guide for the Construction Industry, Kevin Stone, CIRIA,

2009 https://media.iwm.org.uk/ciim5/260/717/000000.jpg?_ga=2.35370849.1171689925.1562755539-503030435.1562172104

18. http://www.hertsgeolsoc.ology.org.uk/IntroToHertsGeology.htm
19. historicengland.org.uk/listing/the-list/list-entry/1188970
20. https://www.hertsmere.gov.uk/Documents/09-Planning--Building-Control/Planning-Policy/Local-Plan/SADMS-EB01-LCA-001Introduction.pdf
21. https://www.layersoflondon.org/map/51.49986695847889,-0.19481597551930466
22. https://www.britannica.com/event/the-Blitz#ref345824

APPENDICES

Appendix A Site Location



Appendix B Historical Borehole scans

SITE INVESTIGATION REPORT No.41413

LOCATION

PROPOSED DEVELOPMENT.
THE CAUSEWAY.
TEDDINGTON.
MIDDLESEX

TQ17SE 181

FOR

PETTITT & MOORE.
CONSULTING ENGINEERS
84, COLDHARBOUR LANE,
HAYES,
MIDDLESEX.

JANUARY 1979

TQ17SE 181
1583 7049

MAY GURNEY (TECHNICAL SERVICES) Ltd., NORWICH

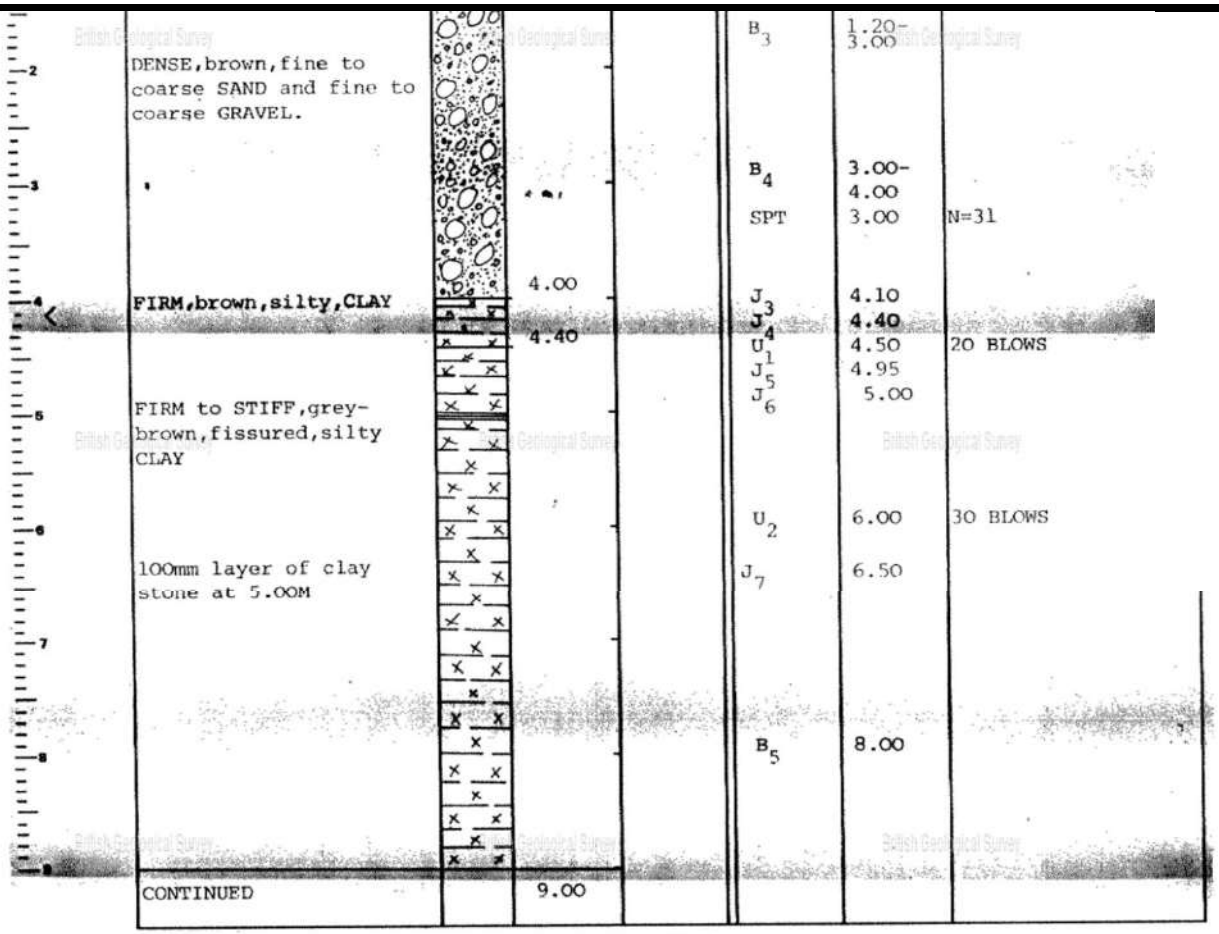
LOCATION: The Causeway, Teddington, Middlesex.

JOB No. 41413 **BORE HOLE No.** 1 Sheet 1

COMMENCED: 16.12.78 **COMPLETED:** 16.12.78 **DIAMETER:** 150mm

GROUND WATER struck at.....m. below ground level. Standing at. 3.20 m. below ground level

DESCRIPTION	LEGEND	DEPTH METRES	O.D. LEVEL	SAMPLE/ TEST	DEPTH METRES	REMARKS
GROUND LEVEL		0.00		J_1	0.20	
Dark grey-brown, clay, sand, gravel, glass etc – FILL.		0.60		B_1	0.20-0.60	
VERY DENSE, brown, clayey, fine to coarse SAND and GRAVEL.		1.20		J_2	0.70	
				B_2	0.70-1.20	
				SPT	1.00	N=67
				SPT	1.50	65 BLOWS FOR 225mm



DESCRIPTION	LEGEND	DEPTH METRES	O.D. LEVEL	SAMPLE/ TEST	DEPTH METRES	REMARKS
				B_3	1.20-3.00	
DENSE, brown, fine to coarse SAND and fine to coarse GRAVEL.				B_4	3.00-4.00	
				SPT	3.00	N=31
		4.00		J_3	4.10	
FIRM, brown, silty, CLAY				J_4	4.40	
		4.40		U_1	4.50	20 BLOWS
				J_1	4.95	
				J_5	5.00	
FIRM to STIFF, grey-brown, fissured, silty CLAY				J_6		
				U_2	6.00	30 BLOWS
100mm layer of clay stone at 5.00M				J_7	6.50	
				B_5	8.00	
CONTINUED		9.00				

WATER ADDED TO ASSIST BORING

KEY: B = Bulk sample; J = Jar sample; U = 100mm undisturbed sample.
W = Water sample; S.P.T. = Standard Penetration Test.
N = Number of blows per 300mm penetration in S.P.T.
H.V. = Hand Vane Test; C = Undrained shear strength.

MAY GURNEY (TECHNICAL SERVICES) Ltd., NORWICH

LOCATION: The Causeway, Teddington, Middlesex.

JOB No. 41413 **BORE HOLE No.** 1 Sheet 2

COMMENCED: 16.12.78 **COMPLETED:** 16.12.78 **DIAMETER:** 150mm

GROUND WATER struck at.....m. below ground level. Standing at 3.20m. below ground level

DESCRIPTION	LEGEND	DEPTH METRES	O.D. LEVEL	SAMPLE/ TEST	DEPTH METRES	REMARKS
CONTINUED		9.00				
FIRM to STIFF, grey-brown fissured, silty CLAY				U_3	9.50	38 BLOWS
				J_8	10.00	
END OF BOREHOLE		10.00				

WATER ADDED TO ASSIST BORING

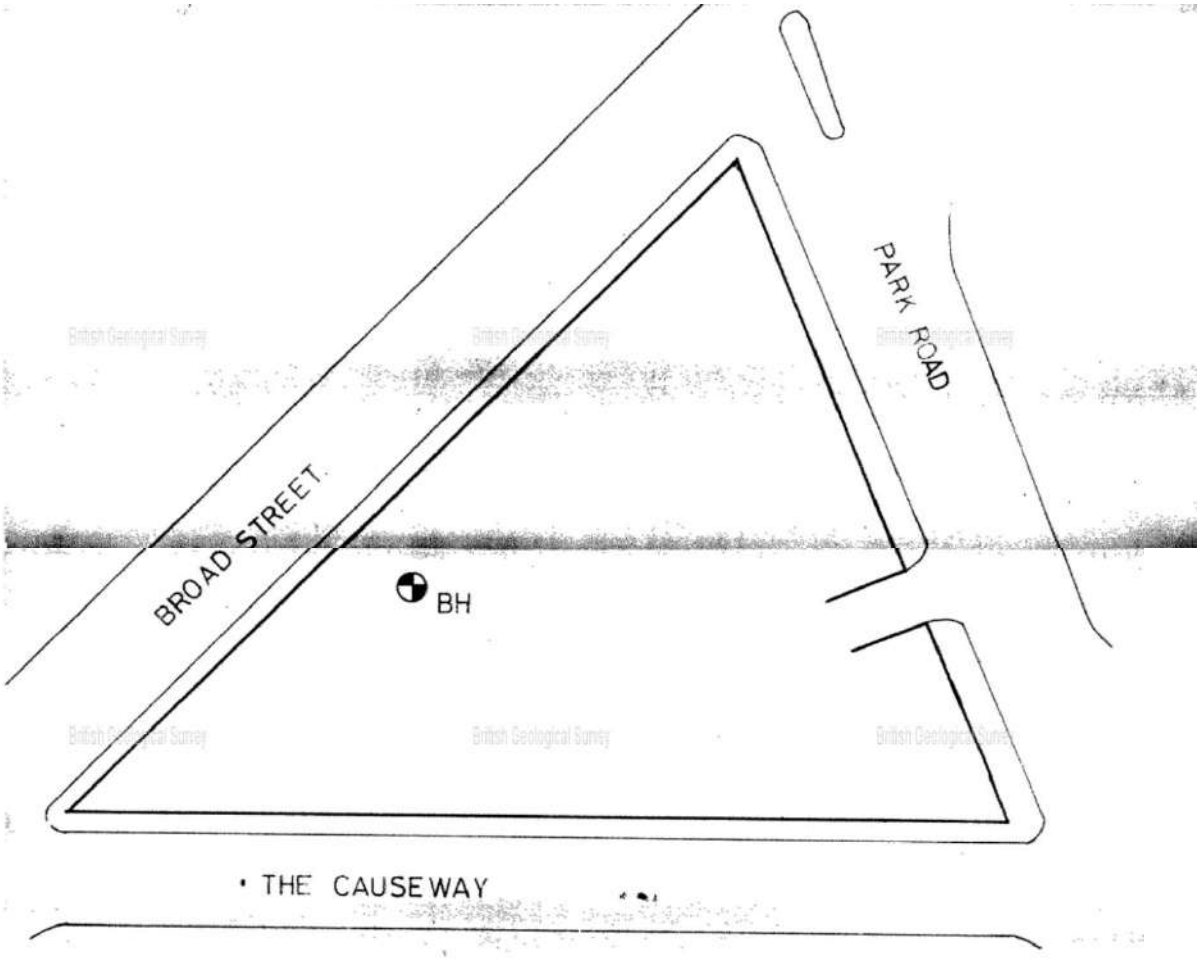
KEY: B = Bulk sample; J = Jar sample; U = 100mm undisturbed sample.
W = Water sample; S.P.T. = Standard Penetration Test.
N = Number of blows per 300mm penetration in S.P.T.
H.V.= Hand Vane Test; C = Undrained shear strength.

TQ17SE 181

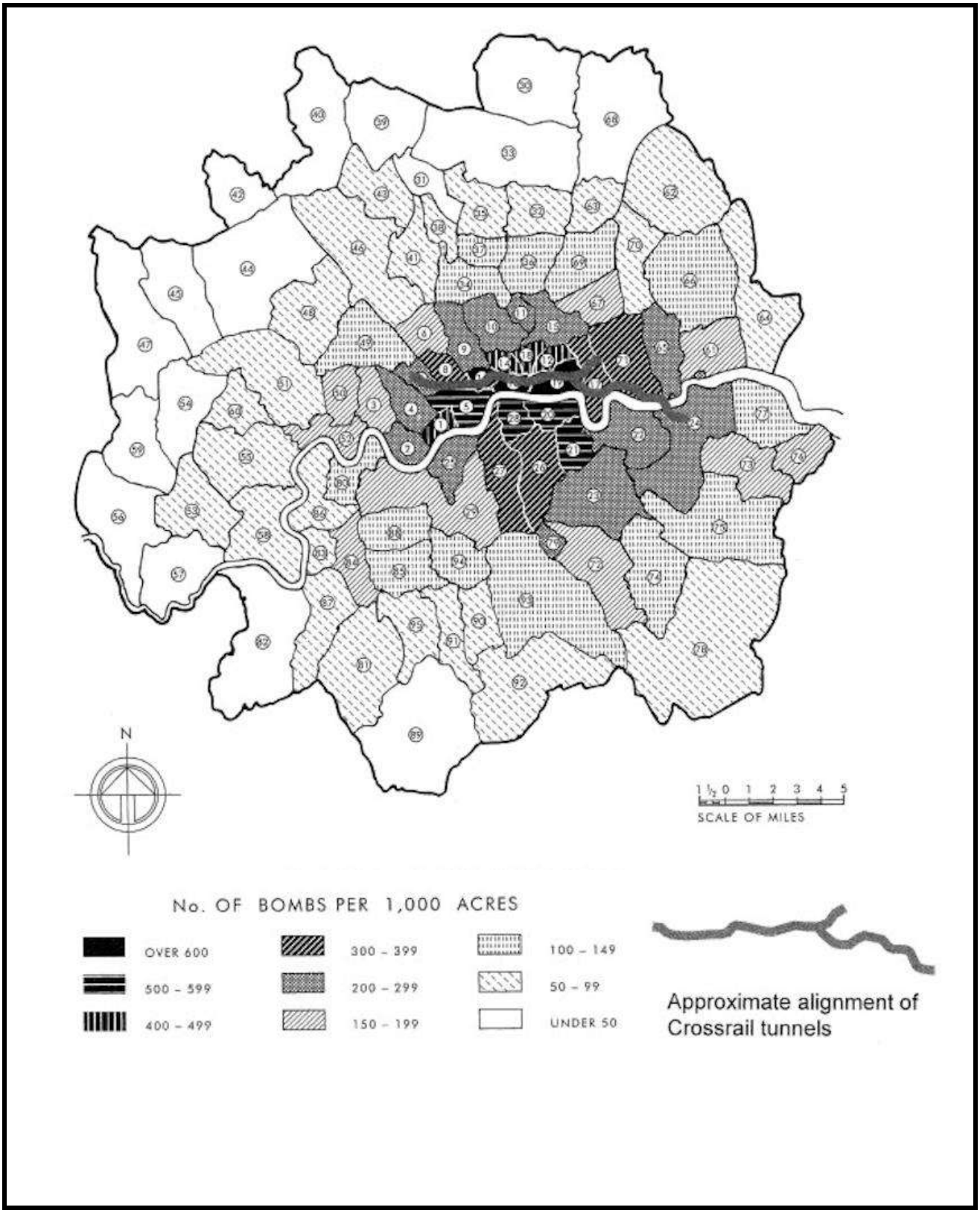
MAY, GURNEY (TECHNICAL SERVICES) LTD.

Site plan showing borehole position.

scale 1:500 ref: 41413/SP1



Appendix C London bombing census Map



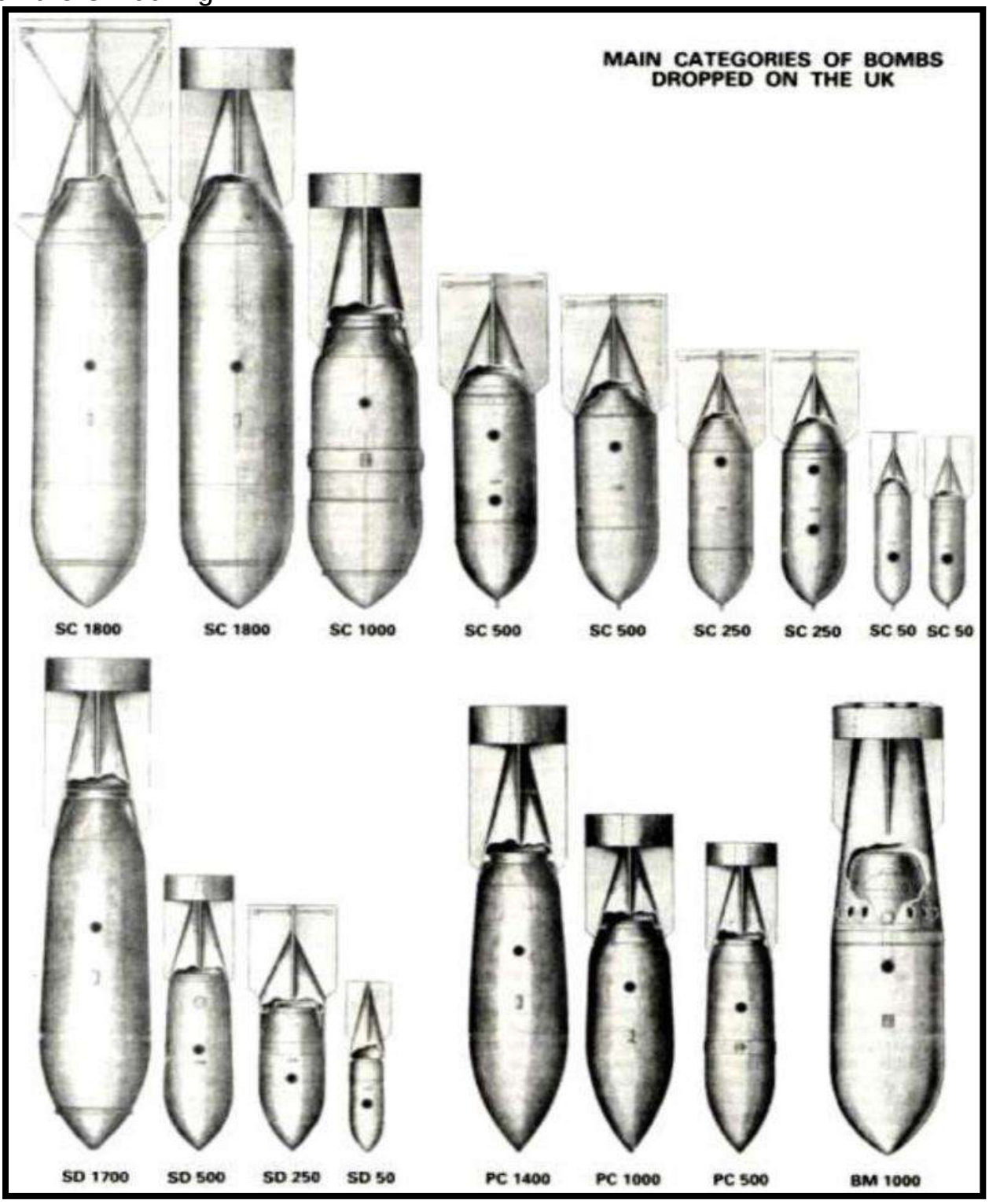
Appendix D Bomb Damage Maps

Bombsight free public resource - bomb location map
No map available

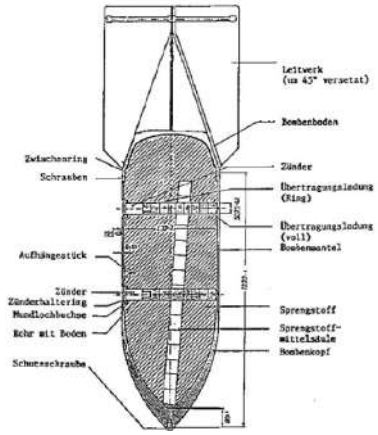
LCC Bomb Damage Maps
No map available.

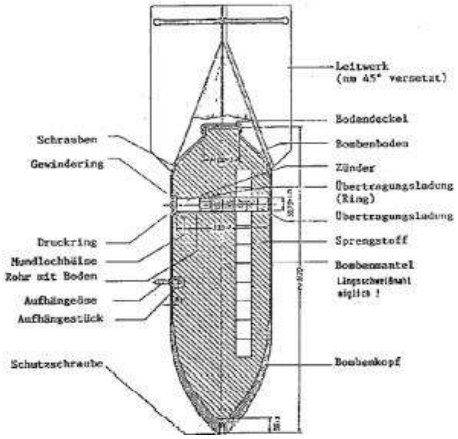
ANNEXES

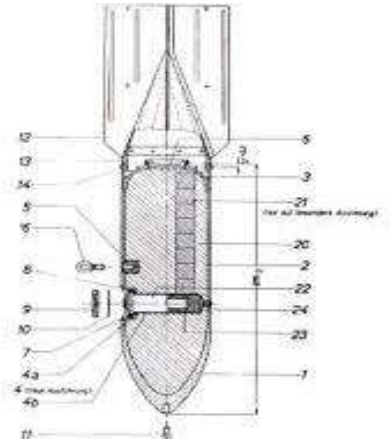
ANNEX A – German Bombs Series and Main categories of bombs dropped on the UK during WWII



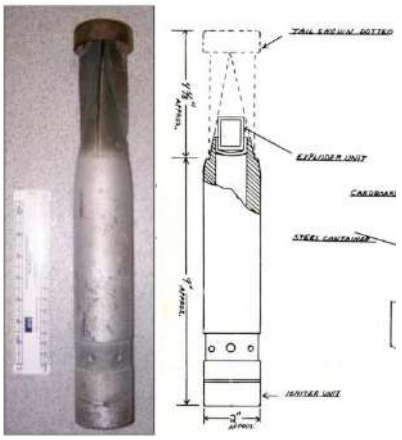
ANNEX B Most used Bombs

SC500 HE Bomb		
	**Variants**	K, L2, J
	Mass	500 kg (1,100 lb)
	Length	2.03 m (6 ft 8 in)
	Diameter	457 mm (18 in)
	Fill	Amatol; TNT; Trialent
	Fill weight	220 kg (490 lb)

SC250 HE Bomb		
	**Weight**	250 kg (550 lb)
	Length	164 cm (65 in) (overall) 120 cm (47 in) (body)
	Diameter	37 cm (15 in)
	Filling	Amatol (60%) / TNT (40%) or TNT with a variety of additives including wax, woodmeal, aluminum powder, naphthalene and ammonium nitrate
	Filling weight	250 kg (550 lb)
	Length	164 cm (65 in) (overall) 120 cm (47 in) (body)

SC50 HE Bomb		
	**Overall Length**	46.1 inches (1,171 mm)
	Body Length	30.0 inches (762 mm)
	Body Diameter	7.9 inches (201 mm)
	Tail Width	16.1 inches (409 mm)
	Filling Weight	24.4 kilograms (54 lb)
	Total Weight	55 kilograms (121 lb)
	Charge/Weight Ratio	45.75%
	Explosive Filling	Cast TNT, Amatol or Trialen
	Bomb Type	High Explosive

Incendiary Bomb



Bomb weight	1kg
Construction	Electron case with steel nose cap
Length	350mm
Body diameter	30mm
Fill	650g (1.7 lb) Thermite
Fuse	impact
used extensively in WW II and often in a conjunction with HE bombs.	

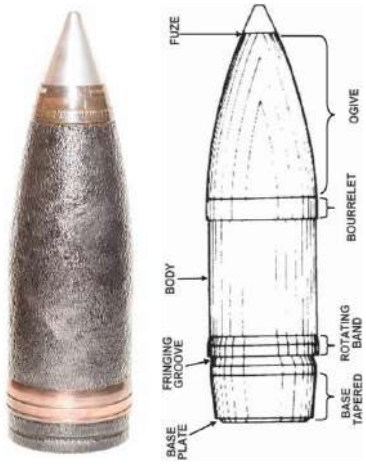
SD-2 Butterfly bomb

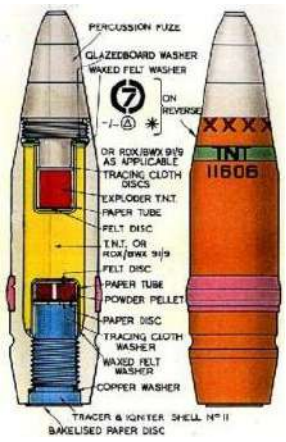
Weight	2Kg
Length	200mm
Body diameter	80mm
explosive	Fp 60/40
NEQ	0.225Kg (0.496lb)
Fuse	Mechanical Clockwork/ Mechanical time or B1/B2 Harassment
German 2 kg anti-personnel submunition used by the Luftwaffe during ww2. They were packed into containers holding between 6 and 108 submunitions.	

Parachute Mine (Luftmine B / LMB)

Bomb Weight	987.017kg (2176lb)
ExplosiveWeight	125-130kg (276-287lb)
Fuze Type	Impact/ Time delay / hydrostatic pressure fuze
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Remarks	Parachute Mines were normally carried by HE115 (Naval operations), HE 111 and JU 88 aircraft types. Deployed a parachute when dropped in order to control its descent.

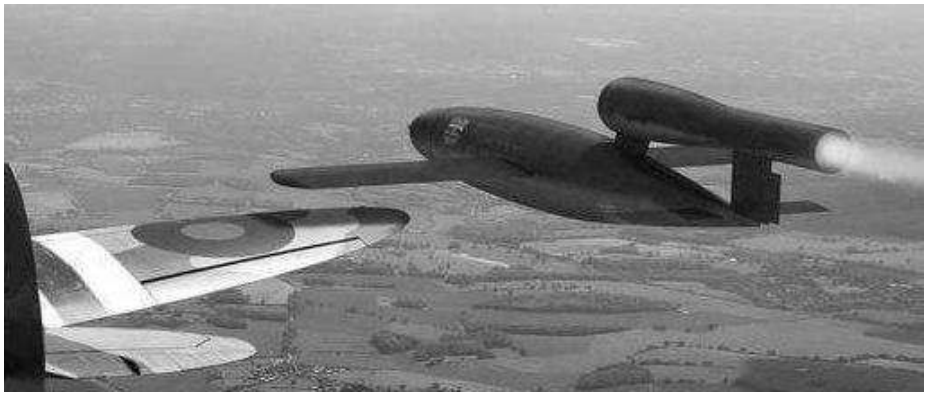
ANNEX C British Anti Aircrafts Ammuntions

3.7” British Anti Aircraft Artillery Projectile (AAA)		
	**Body**	forward centring bands and a wider driving band. Square-based Brass cartridge shell with tapered nose
	Dimensions	94mm x 360mm (3.7 x 14.7”)
	Weight	12.7kg (28lb)
	Fuze	Mechanical time fuze
	Composition	Cast steel
	Explosive	Amatol, TNT or RDX/TNT. MK6 had

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

ANNEX D – Vengeance weapons

Annex D1 The V1 Flying Bomb



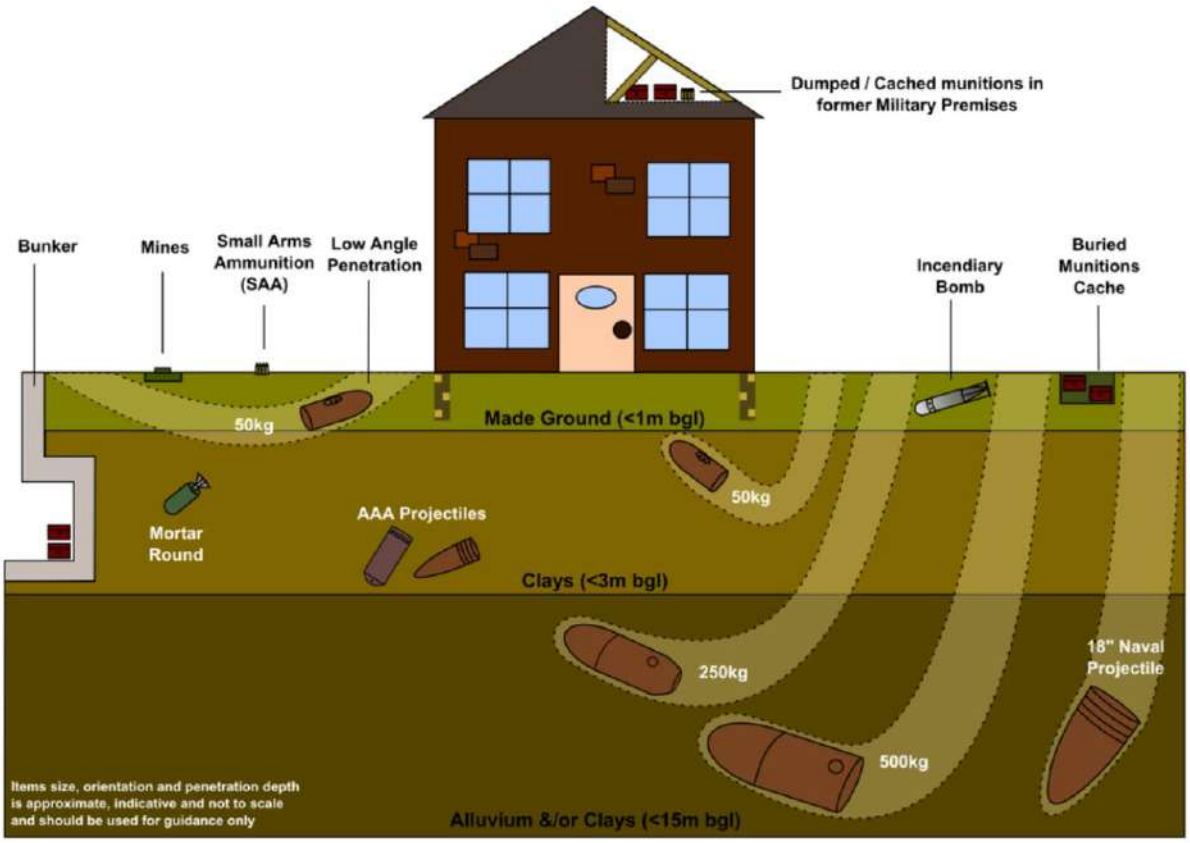
The V1 Flying bomb was the world's first cruise missile, they were also known as Doodle bugs or Vengeance weapon. The V1 was an unmanned plane that delivered a ton of high explosive. Between June 1944 and March 1945, 2419 of them exploded in London. The V1 was capable of inflicting huge damage to buildings, homes, and personnel. In the inner London suburbs where terrace houses were packed together, sometimes up to 20 houses would totally collapse, just at one hit. The blast area of a V1 extended across a radius of 400 -600 yards in each direction. https://youtu.be/ro4ApX7EhJw

Annex D2 The V2 Rocket

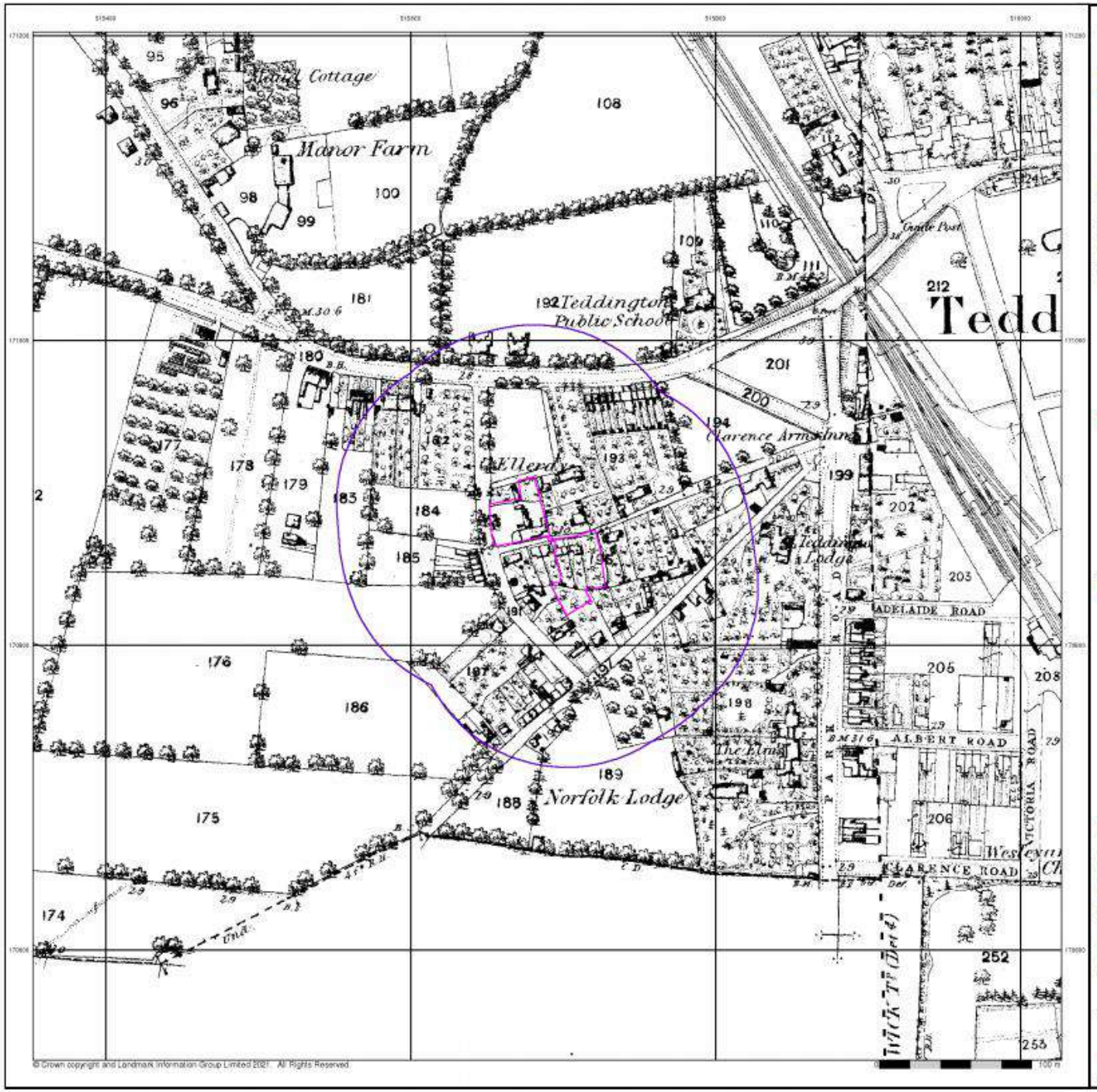
https://rarehistoricalphotos.com/v2-rocket-in-pictures/

In addition to type and weight designations, HE bombs sometimes carried a suffix to indicate the type of fuse or zünder employed, i.e, mV = *"mit Verzögerung"* (with short delay action) and LZZ = *"LangZeitZünder"* (long time delay). Thus, for example, the designation SC250 LZZ identified a general purpose, high explosive bomb, weighing 250kg and fitted with a long delay fuse. The thin-cased general purpose was called the "*sprengbombe cylindrich*" (SC. Used for blast effect, they had a relatively high charge ratio of 55%. Used primarily for general demolition, something like 80% of German high explosive bombs dropped on the UK were of the SC type.

ANNEX E The J – Curve



ANNEX F: Historical Maps



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Published 1865 - 1874

Source map scale - 1:2,500

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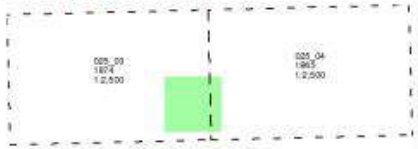
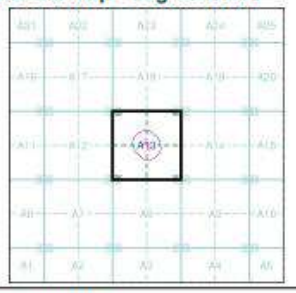
Map Name(s) and Date(s)



Historical Map - Segment A13



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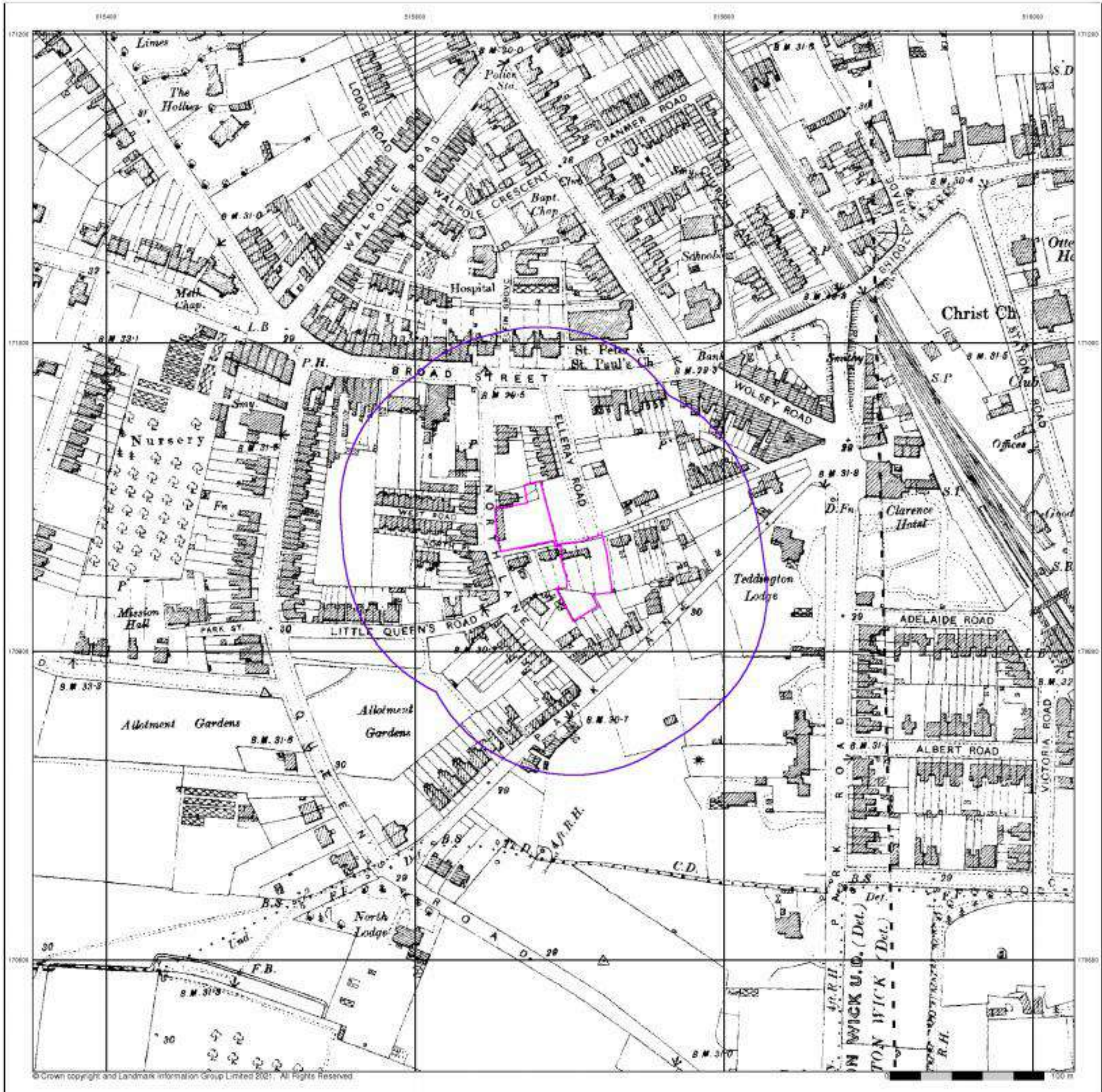
Search Buffer (m):	100

Site Details

Elleray Hall Social Club, Elleray Road, TEDDINGTON, TW11 0HG



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London

Published 1896

Source map scale - 1:2,500

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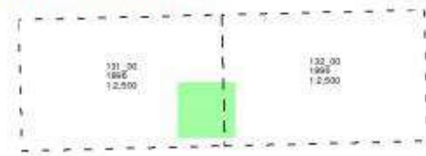

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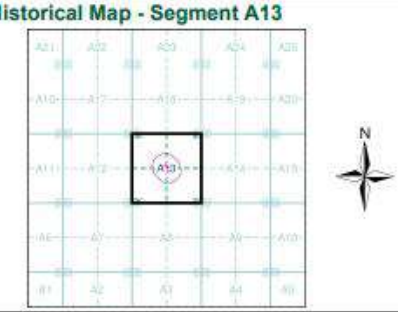

Order Details

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Search Buffer (m): 100

Site Details

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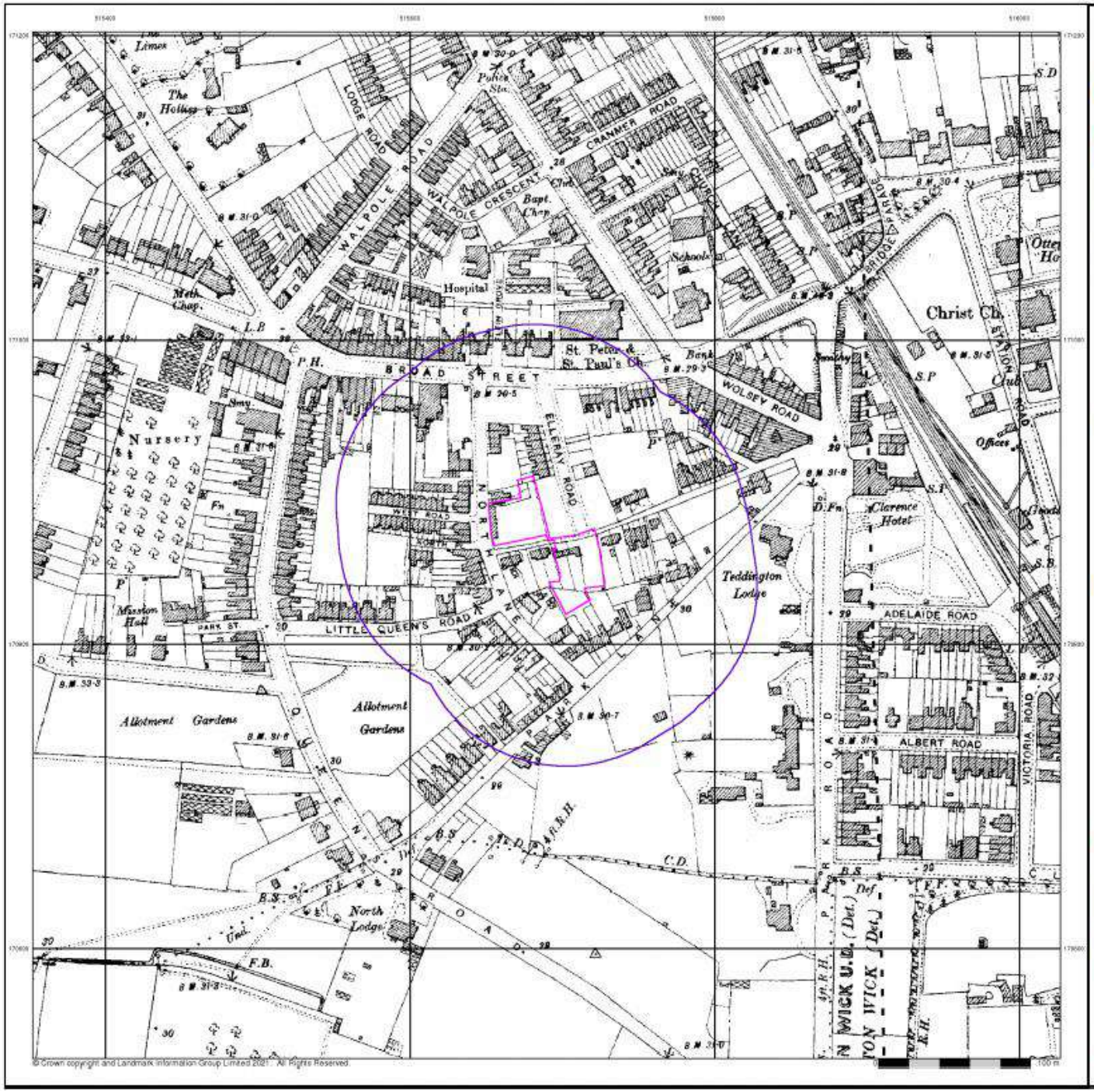

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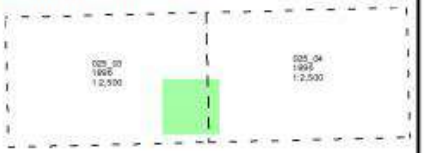
Middlesex

Published 1896

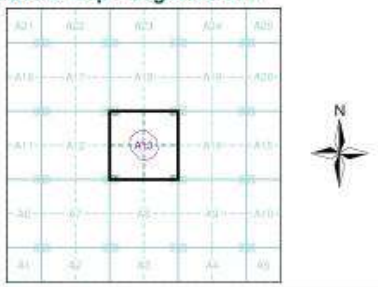
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840's. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



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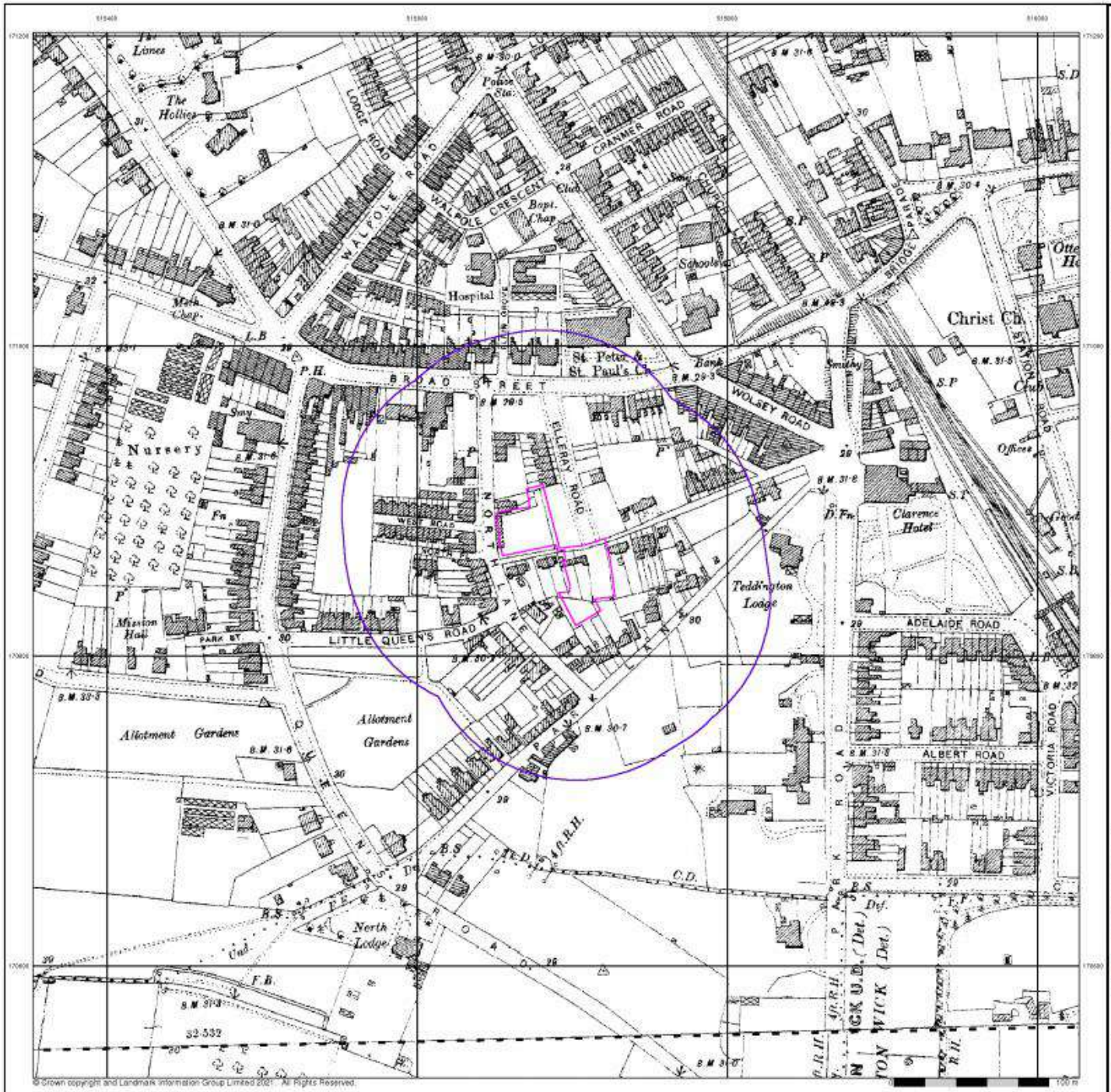

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Source map scale - 1:2,500

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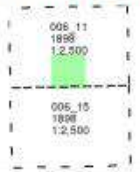
Map Name(s) and Date(s)



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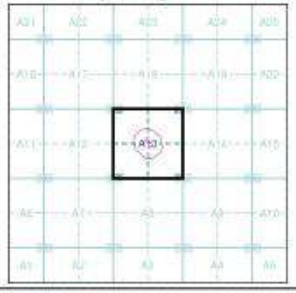

Order Details

Order Number:	271376665_1_1
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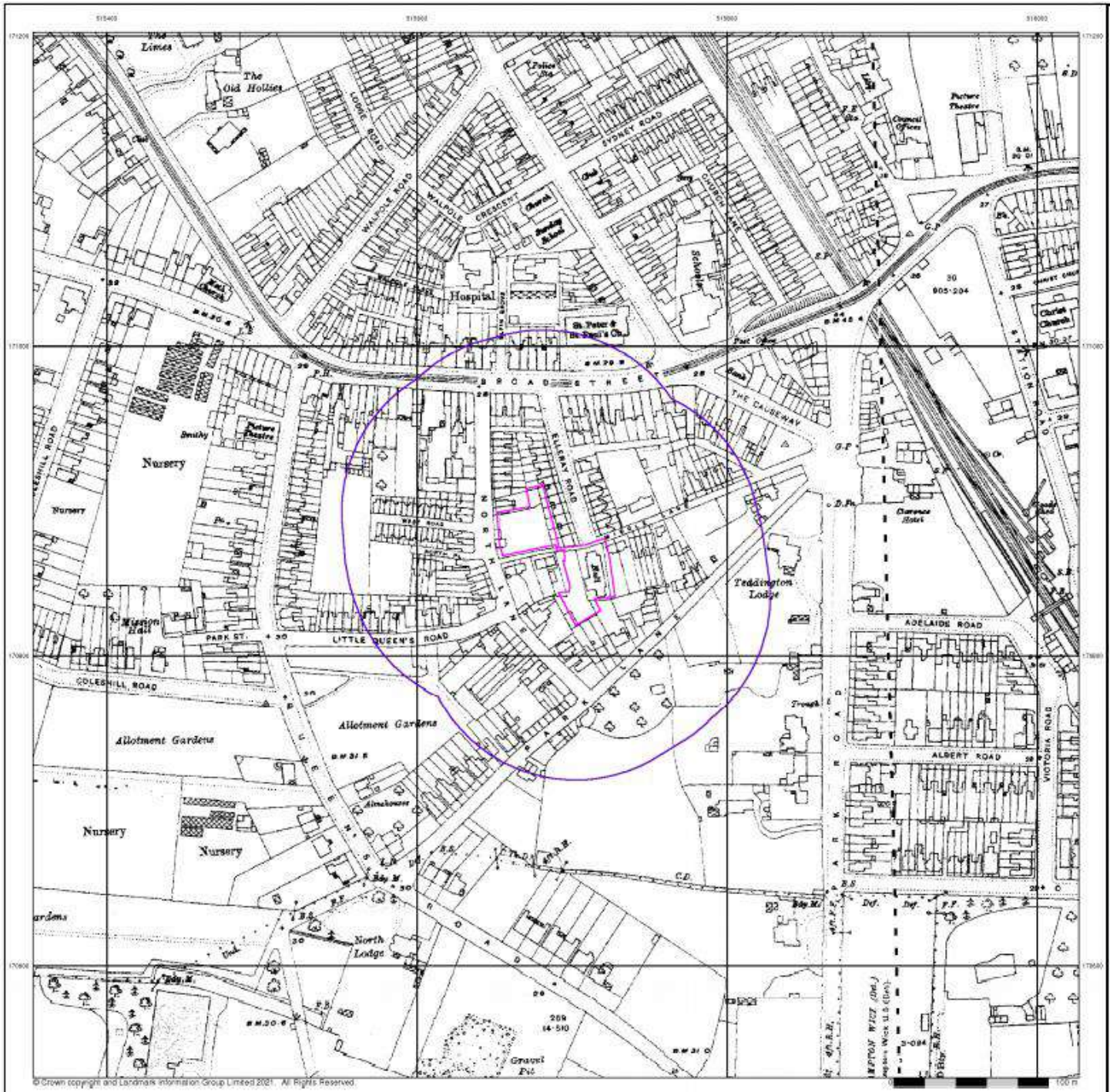

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Middlesex

Published 1915

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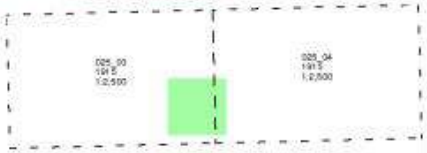

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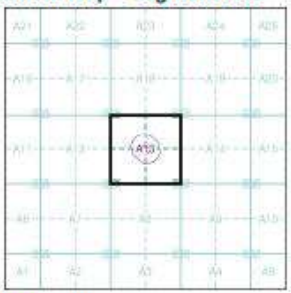

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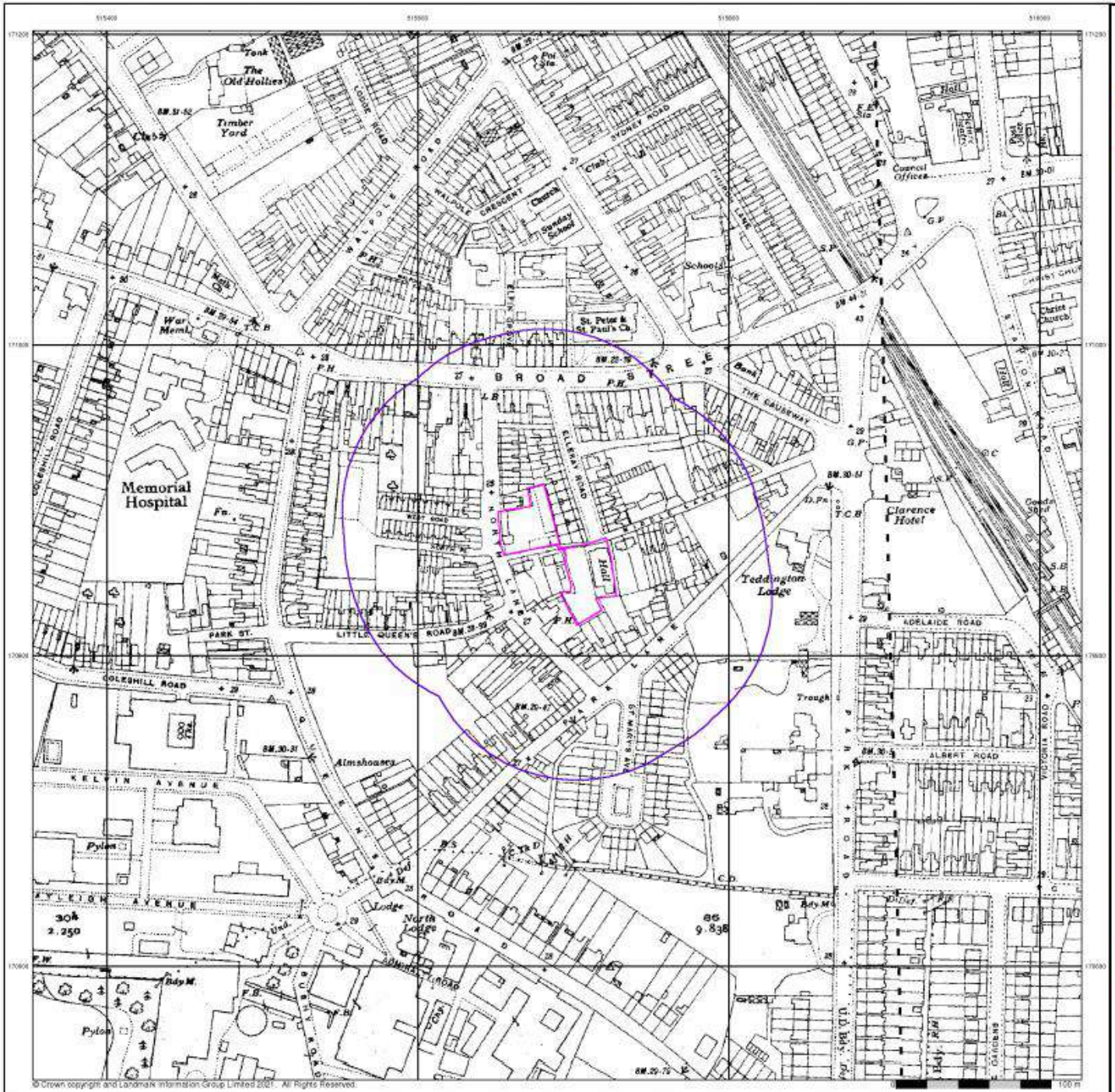

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Middlesex

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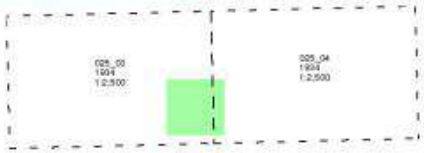

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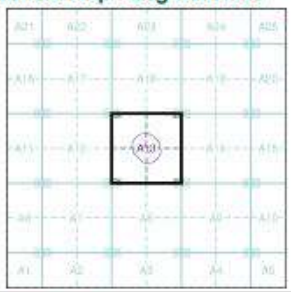

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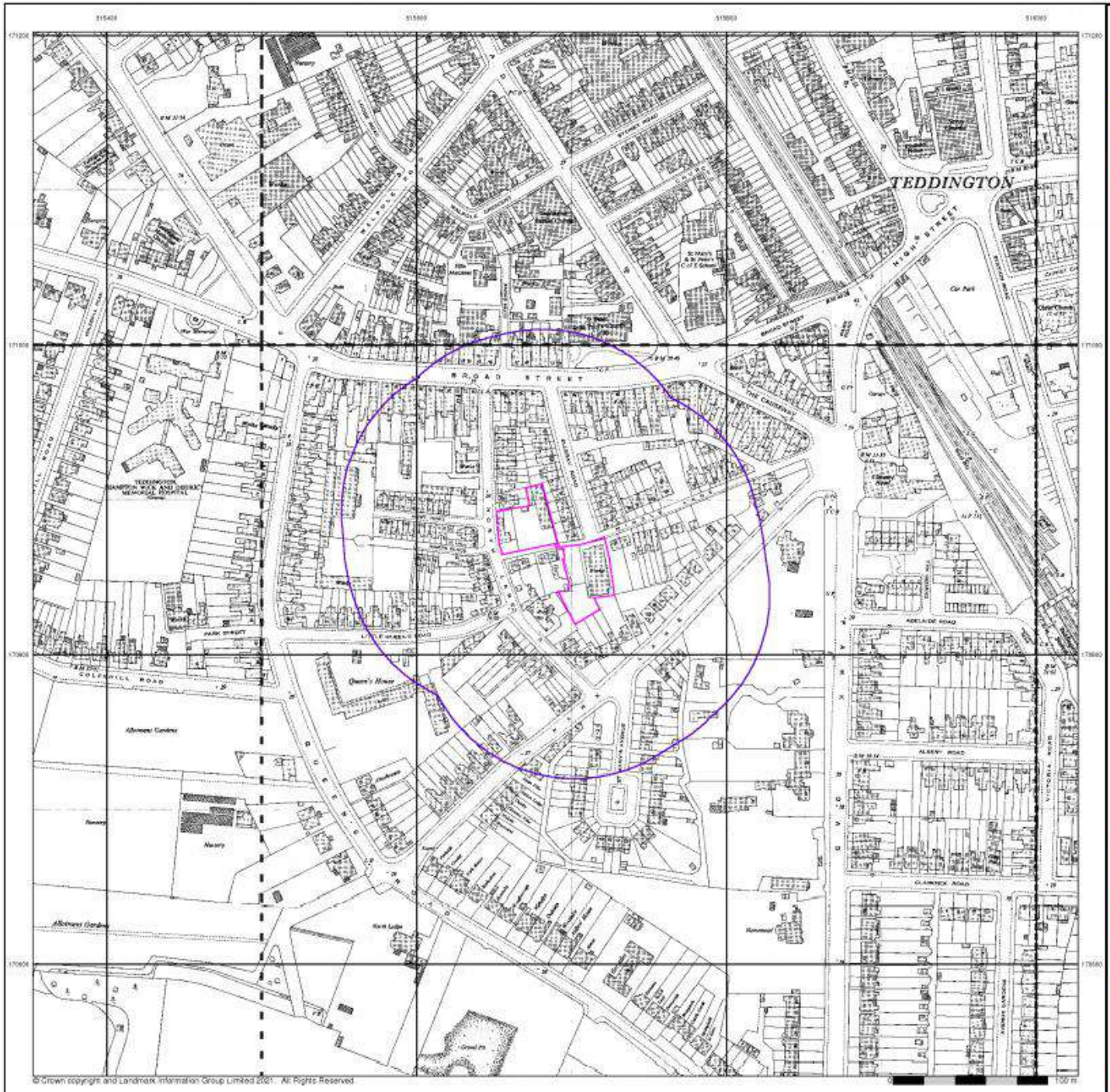

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Ordnance Survey Plan

Published 1959

Source map scale - 1:1,250

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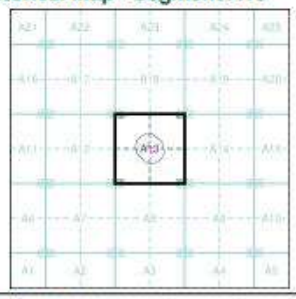
Map Name(s) and Date(s)

Historical Map - Segment A13



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Slice:	A
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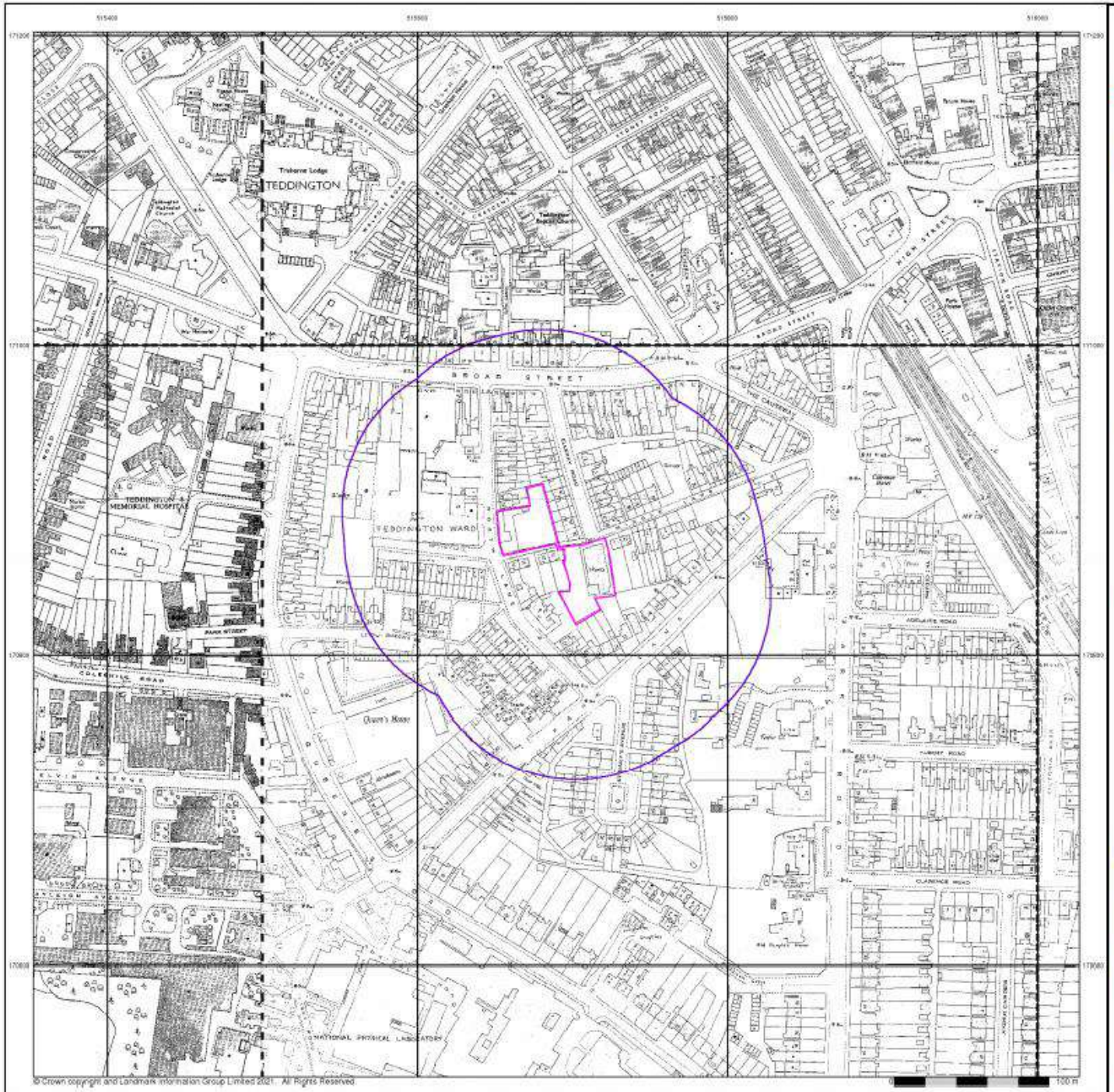

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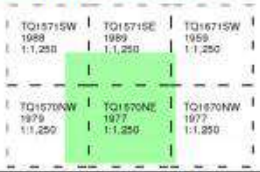
Additional SIMs

Published 1959 - 1989

Source map scale - 1:1,250

The SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



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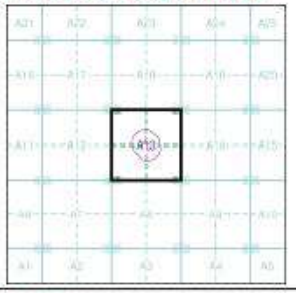

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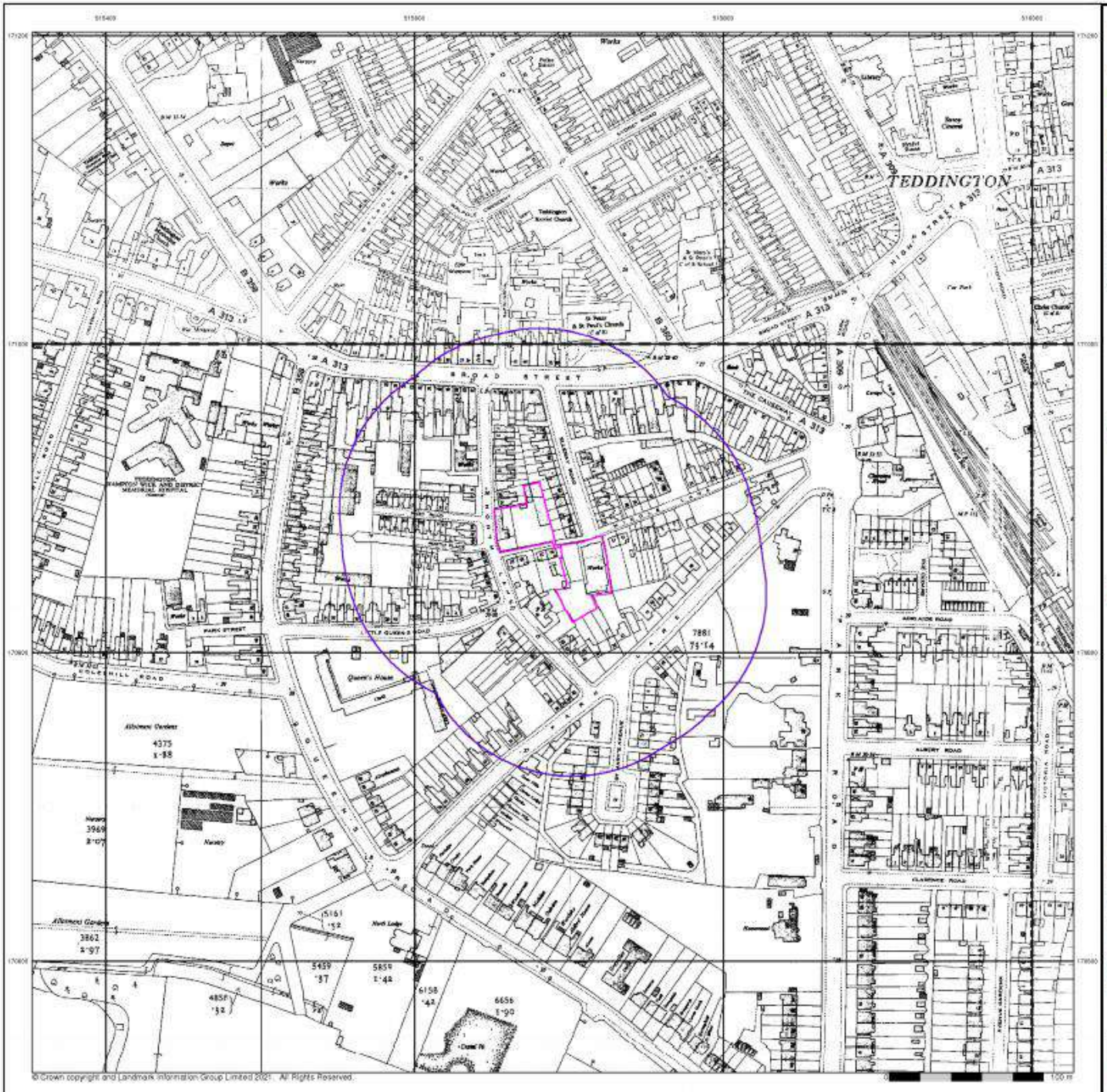
Elleray Hall Social Club, Elleray Road, TEDDINGTON, TW11 0HG



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Published 1960 - 1962

Source map scale - 1:2,500

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Map Name(s) and Date(s)

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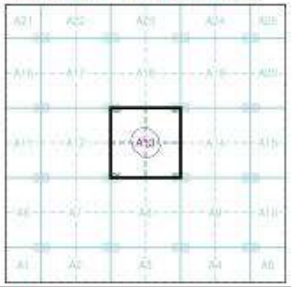

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Site Details

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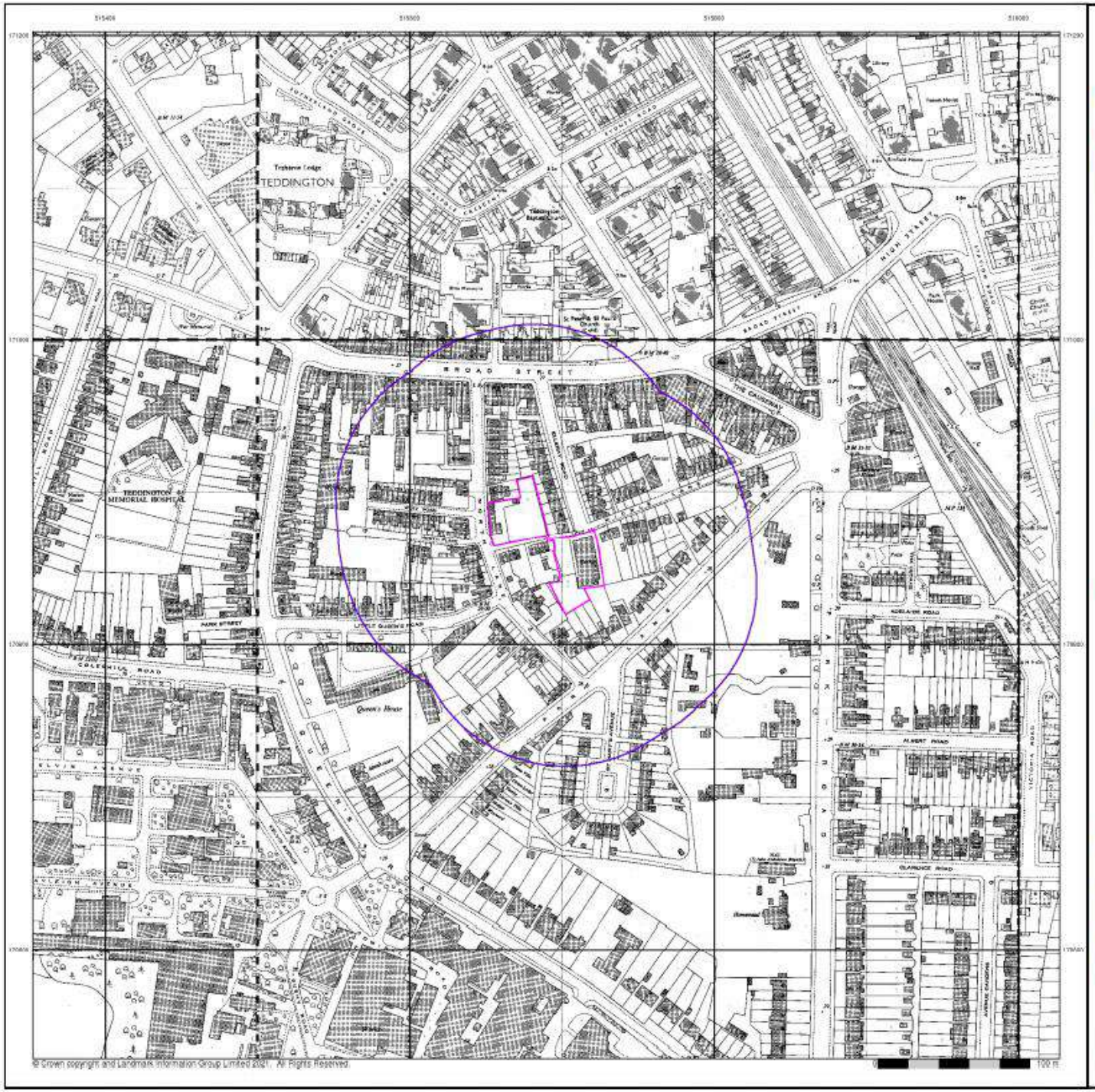

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Published 1963 - 1979

Source map scale - 1:1,250

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Map Name(s) and Date(s)

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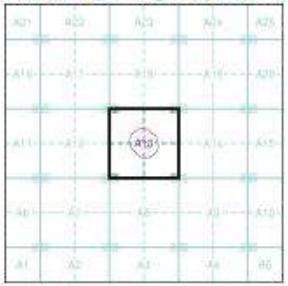

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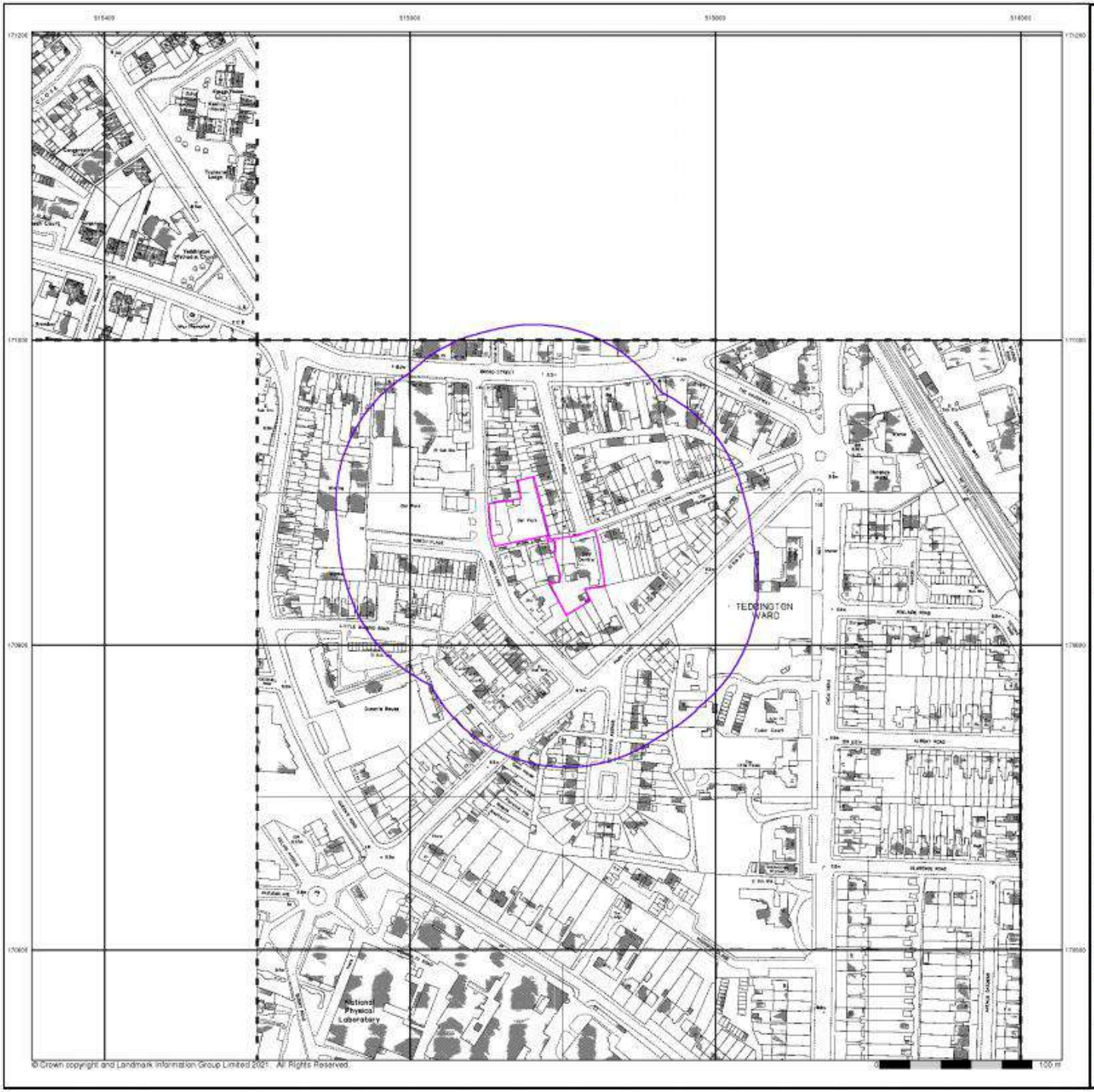

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Ordnance Survey Plan

Published 1973 - 1987

Source map scale - 1:1,250

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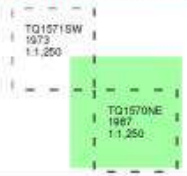
Map Name(s) and Date(s)



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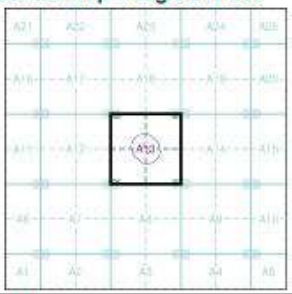

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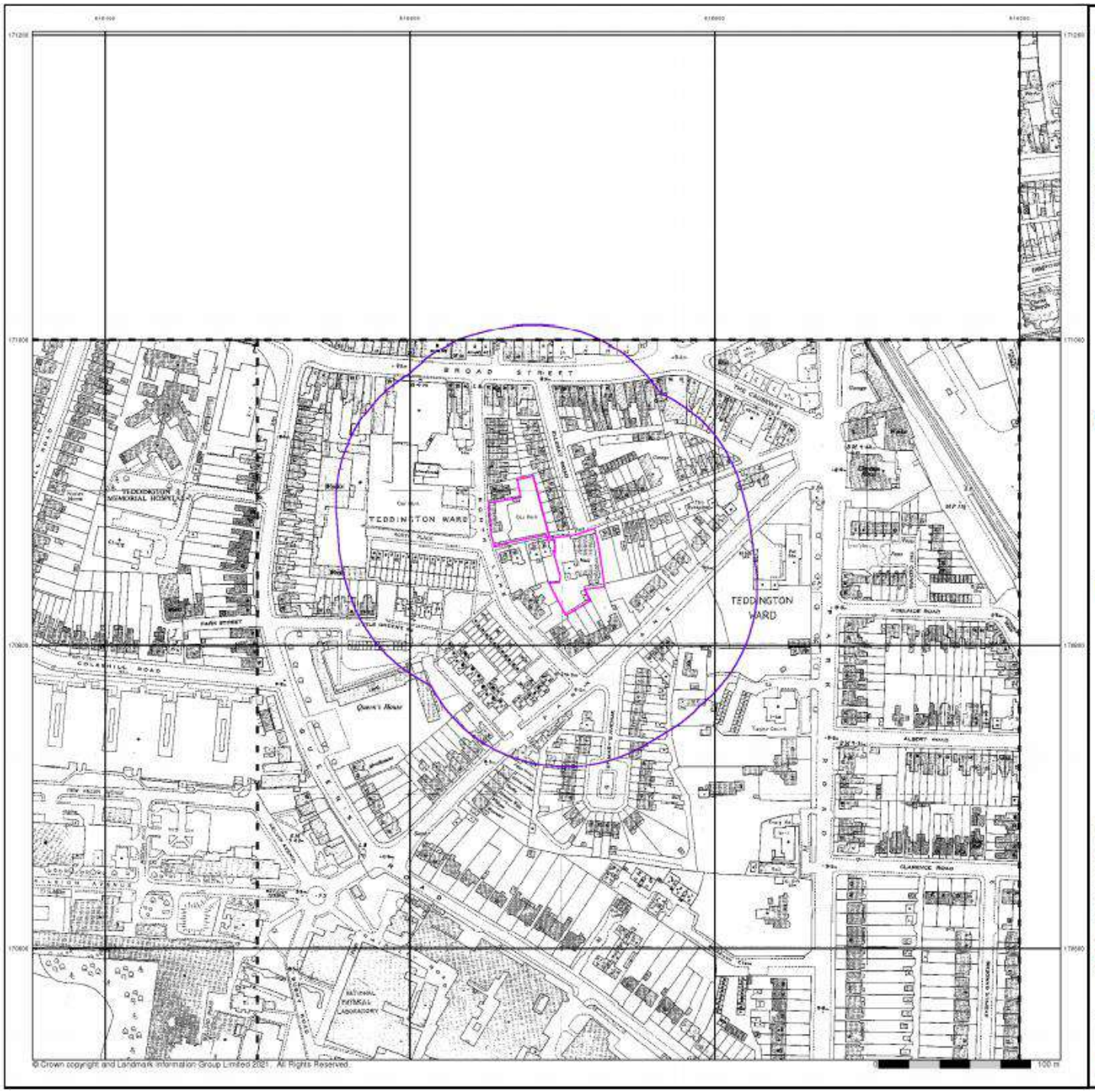

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Additional SIMs

Published 1983 - 1990

Source map scale - 1:1,250

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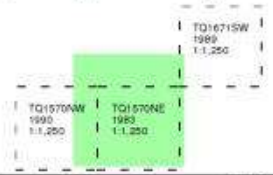
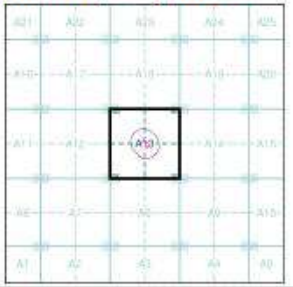
Map Name(s) and Date(s)



Historical Map - Segment A13



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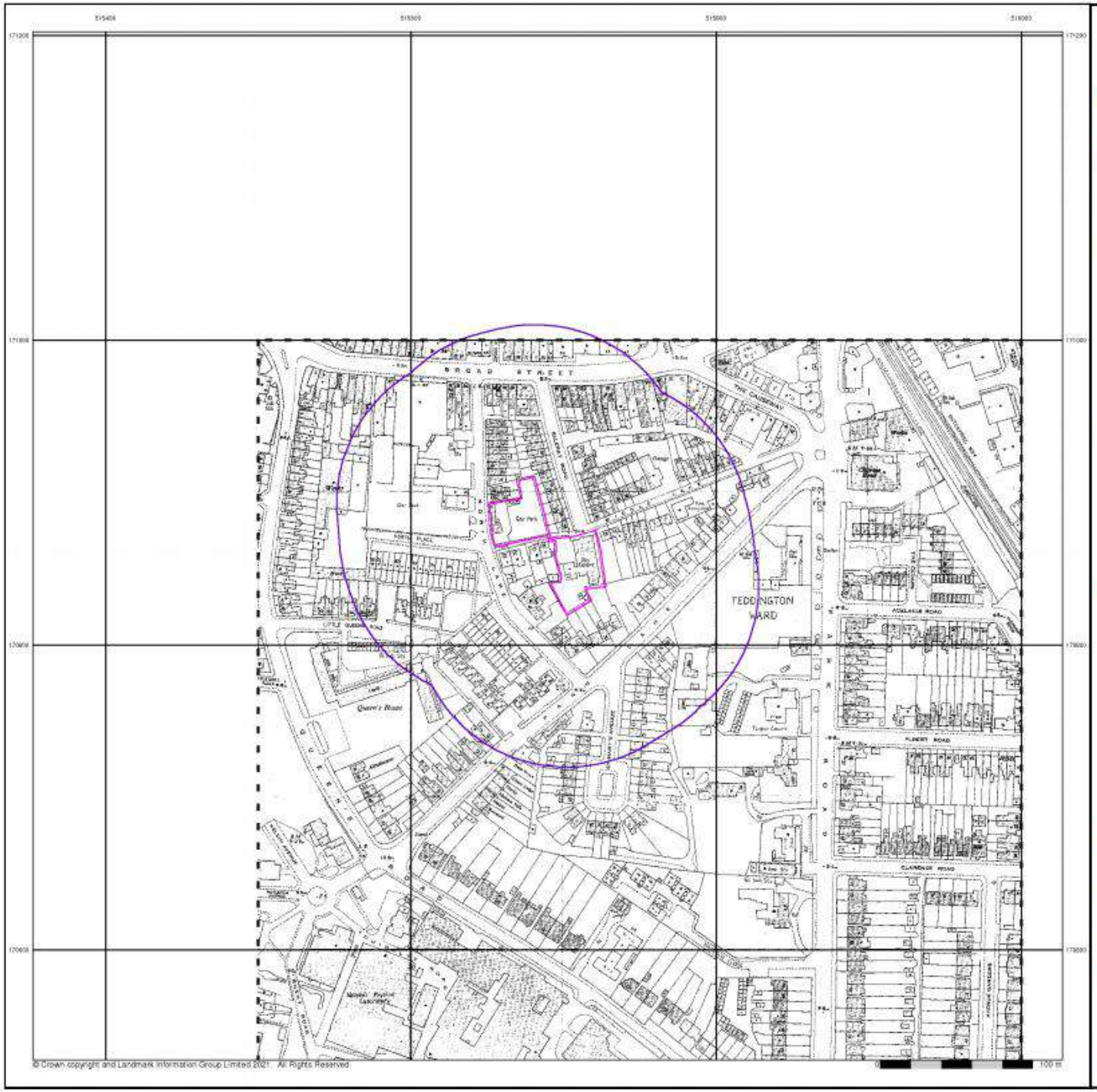
Site Details

Elleray Hall Social Club, Elleray Road, TEDDINGTON, TW11 0HG



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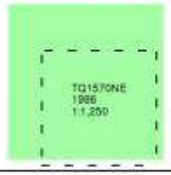
Additional SIMs

Published 1986

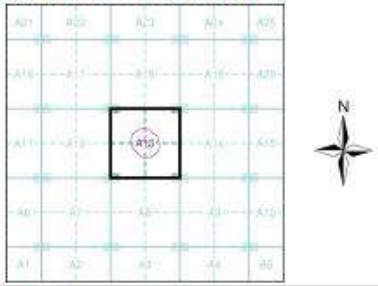
Source map scale - 1:1,250

The SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	271376665_1_1
Customer Ref:	TW11
National Grid Reference:	515690, 170870
Slice:	A
Site Area (Ha):	0.25
Search Buffer (m):	100

Site Details

Elleray Hall Social Club, Elleray Road, TEDDINGTON, TW11 0HG

Landmark INFORMATION GROUP
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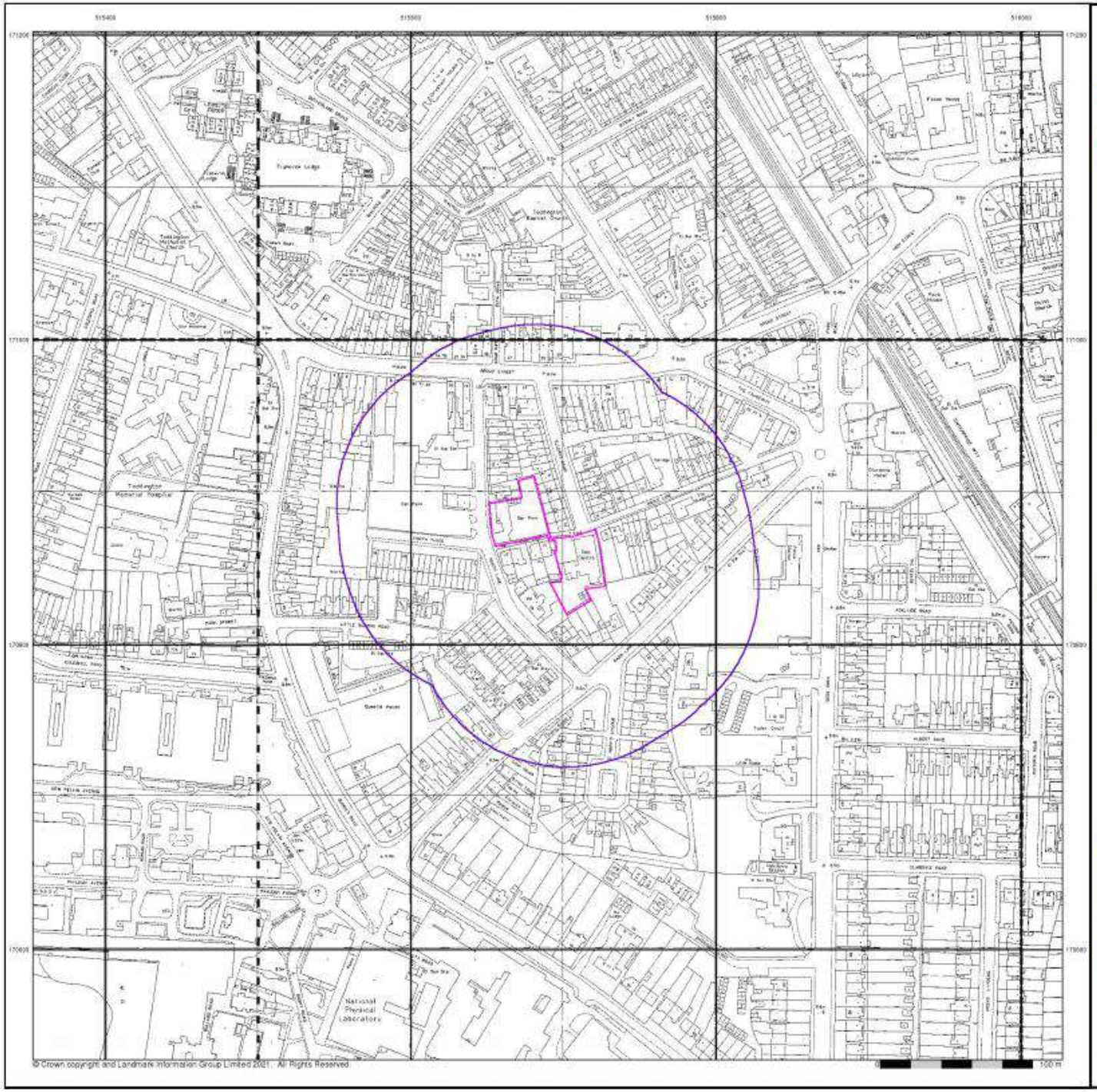
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



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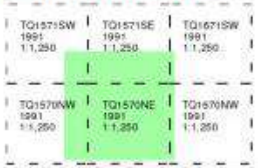
Large-Scale National Grid Data

Published 1991

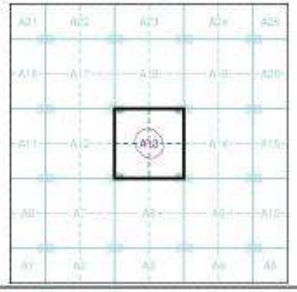
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13

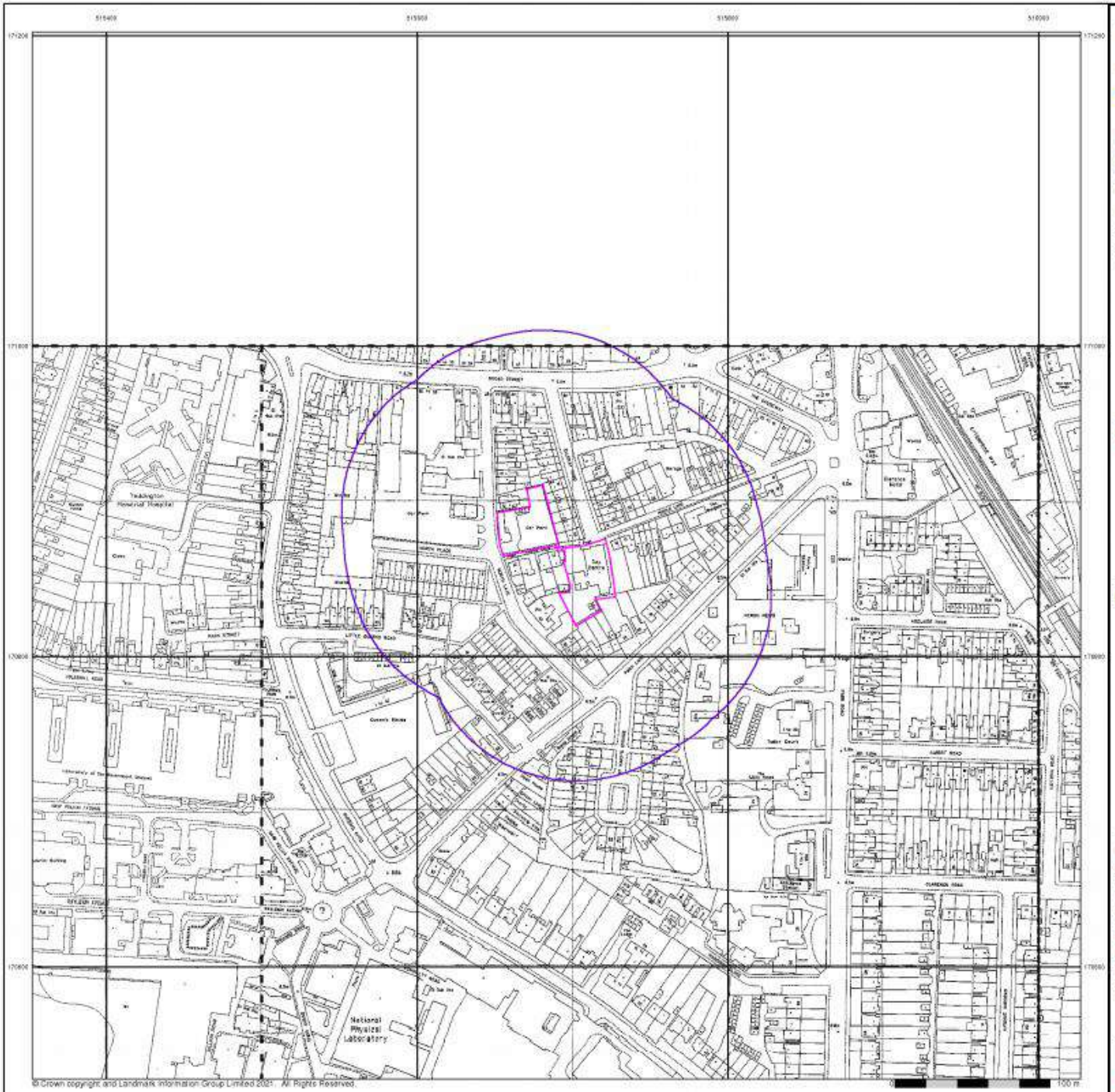


Order Details

Order Number:	271376665_1_1
Customer Ref:	TW11
National Grid Reference:	515690, 170870
Slice:	A
Site Area (Ha):	0.25
Search Buffer (m):	100

Site Details

Elleray Hall Social Club, Elleray Road, TEDDINGTON, TW11 0HG



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LANDMARK INFORMATION GROUP®

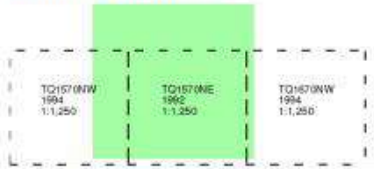
Large-Scale National Grid Data

Published 1992 - 1994

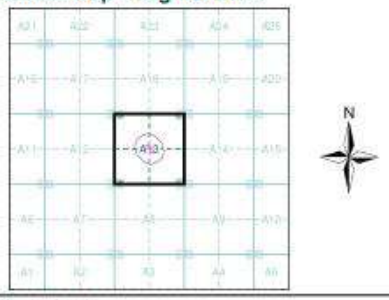
Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	271376665_1_1
Customer Ref:	TW11
National Grid Reference:	516600, 170870
Slice:	A
Site Area (Ha):	0.25
Search Buffer (m):	100

Site Details

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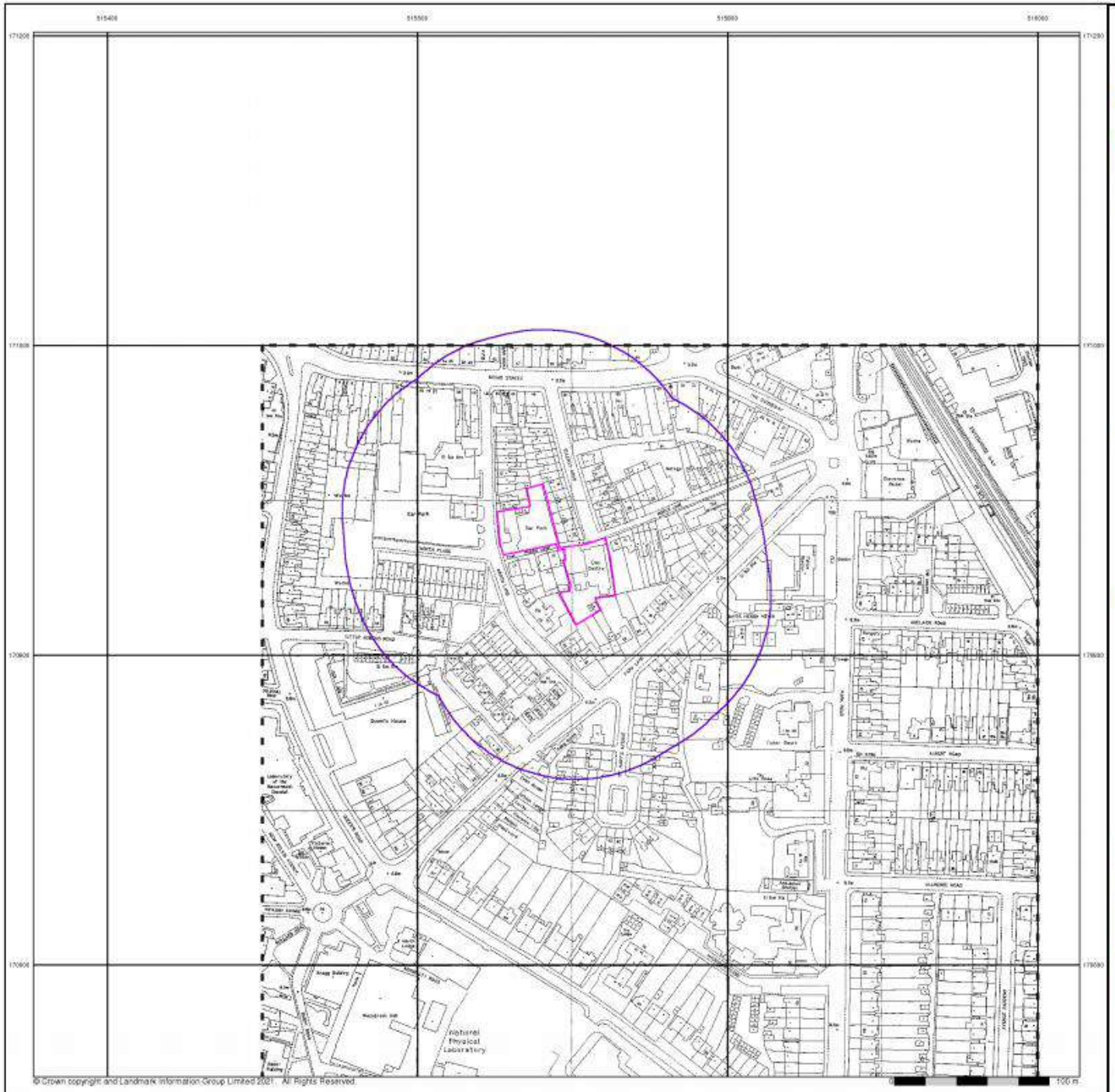

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LANDMARK INFORMATION GROUP®

Large-Scale National Grid Data

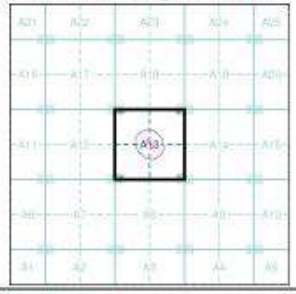
Published 1994

Source map scale - 1:1,250

'Large Scale National Grid Data' superseded SIM cards (Ordnance Survey's 'Survey of Information on Microfilm') in 1992, and continued to be produced until 1999. These maps were the fore-runners of digital mapping and so provide detailed information on houses and roads, but tend to show less topographic features such as vegetation. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)

Historical Map - Segment A13



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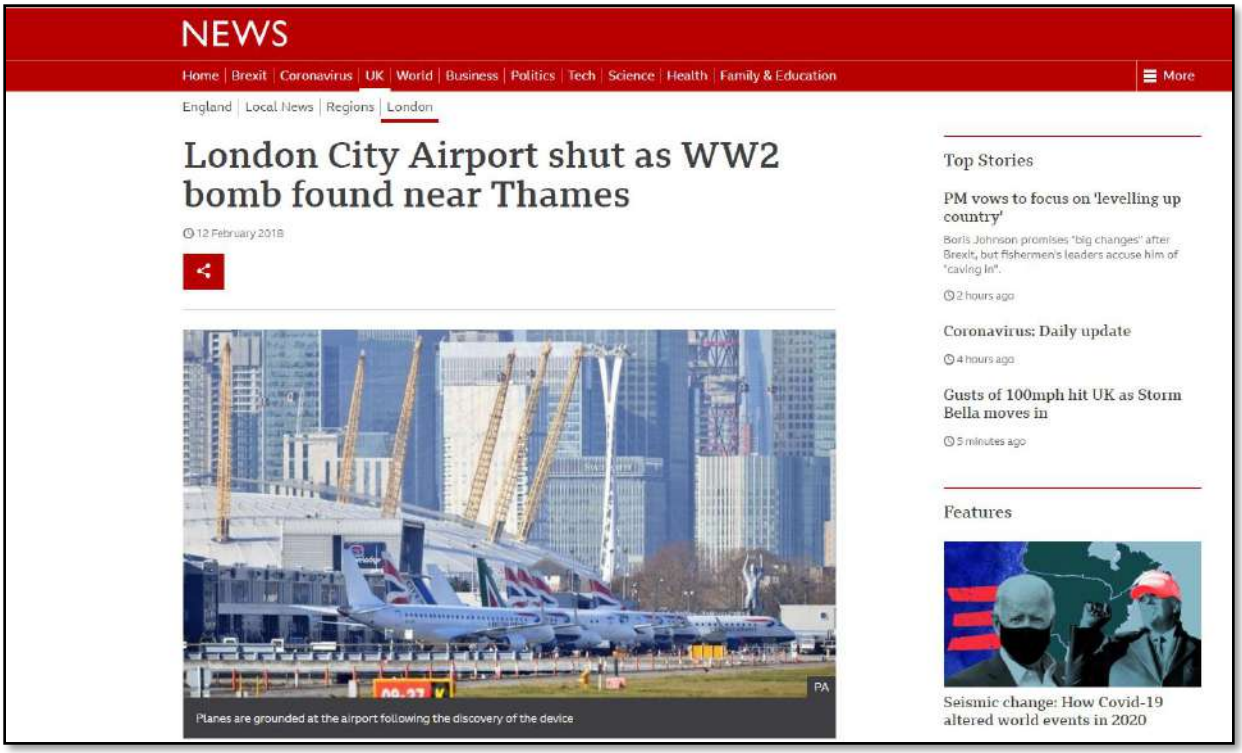
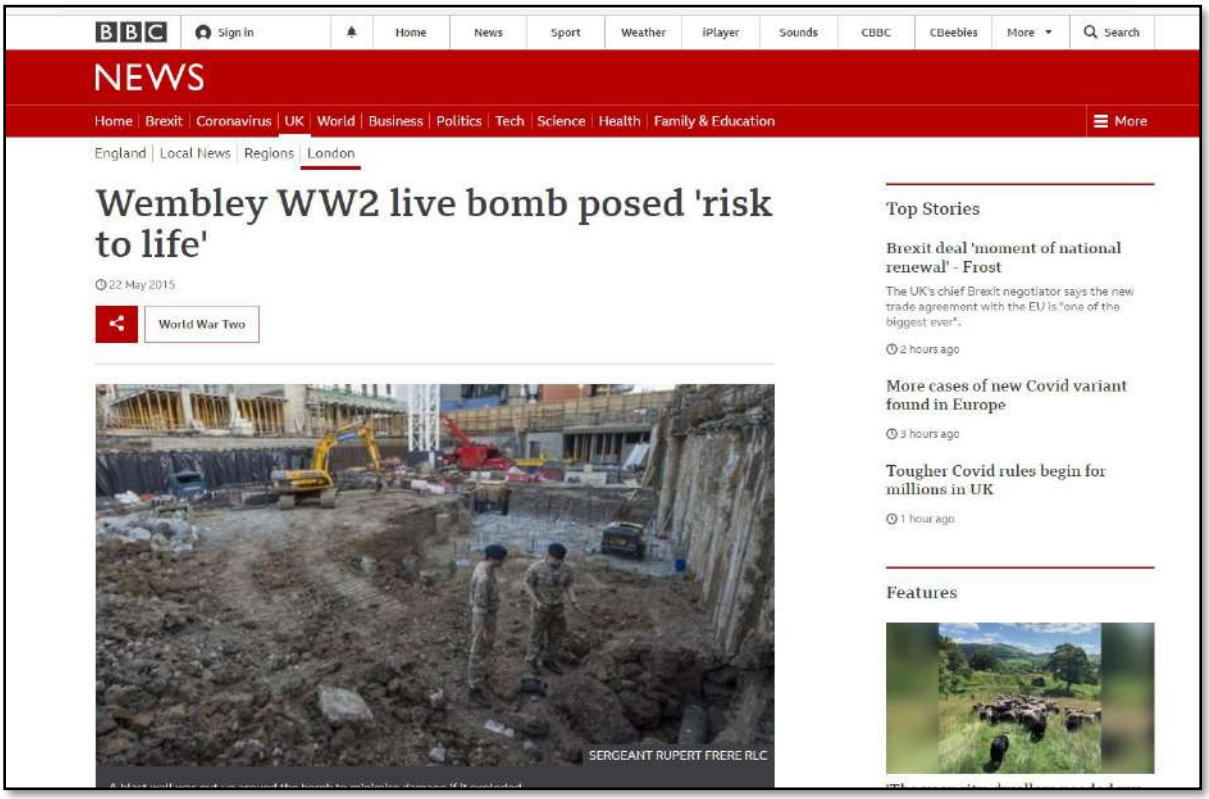
SOME BOMB INCIDENTS IN THE UK IN RECENT YEARS

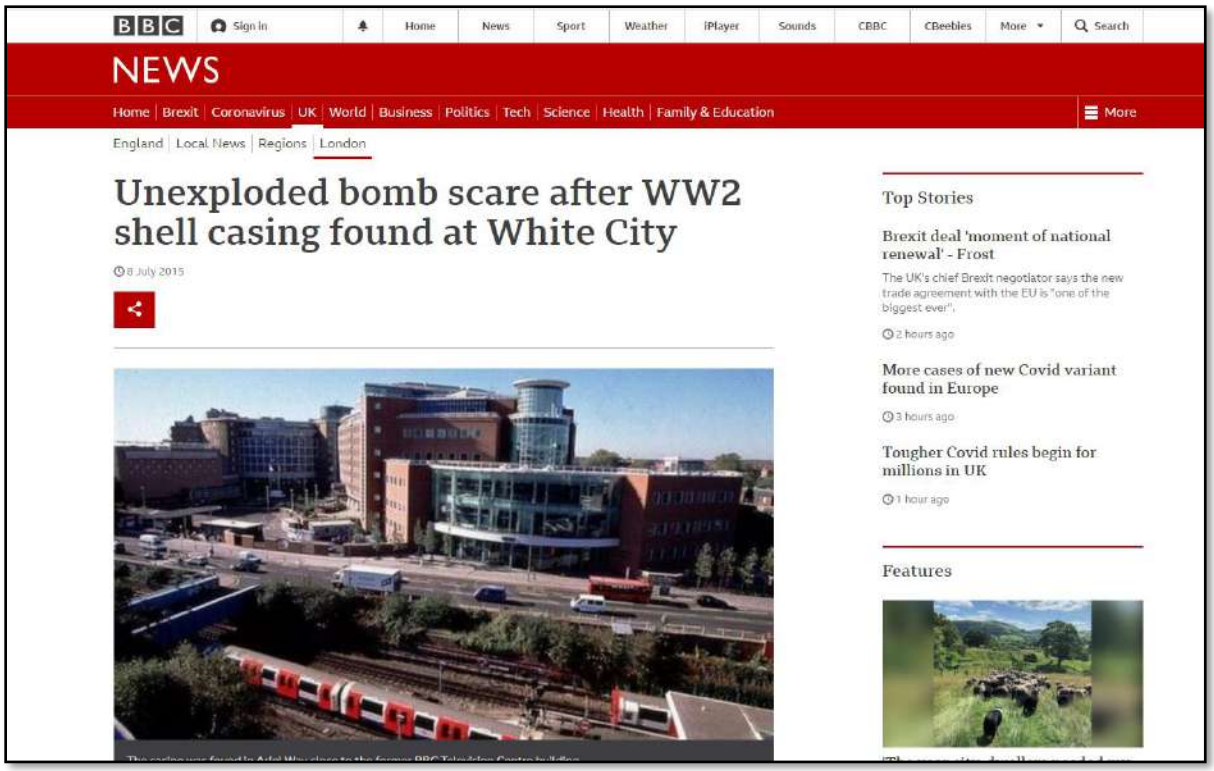
Kingston (2019)



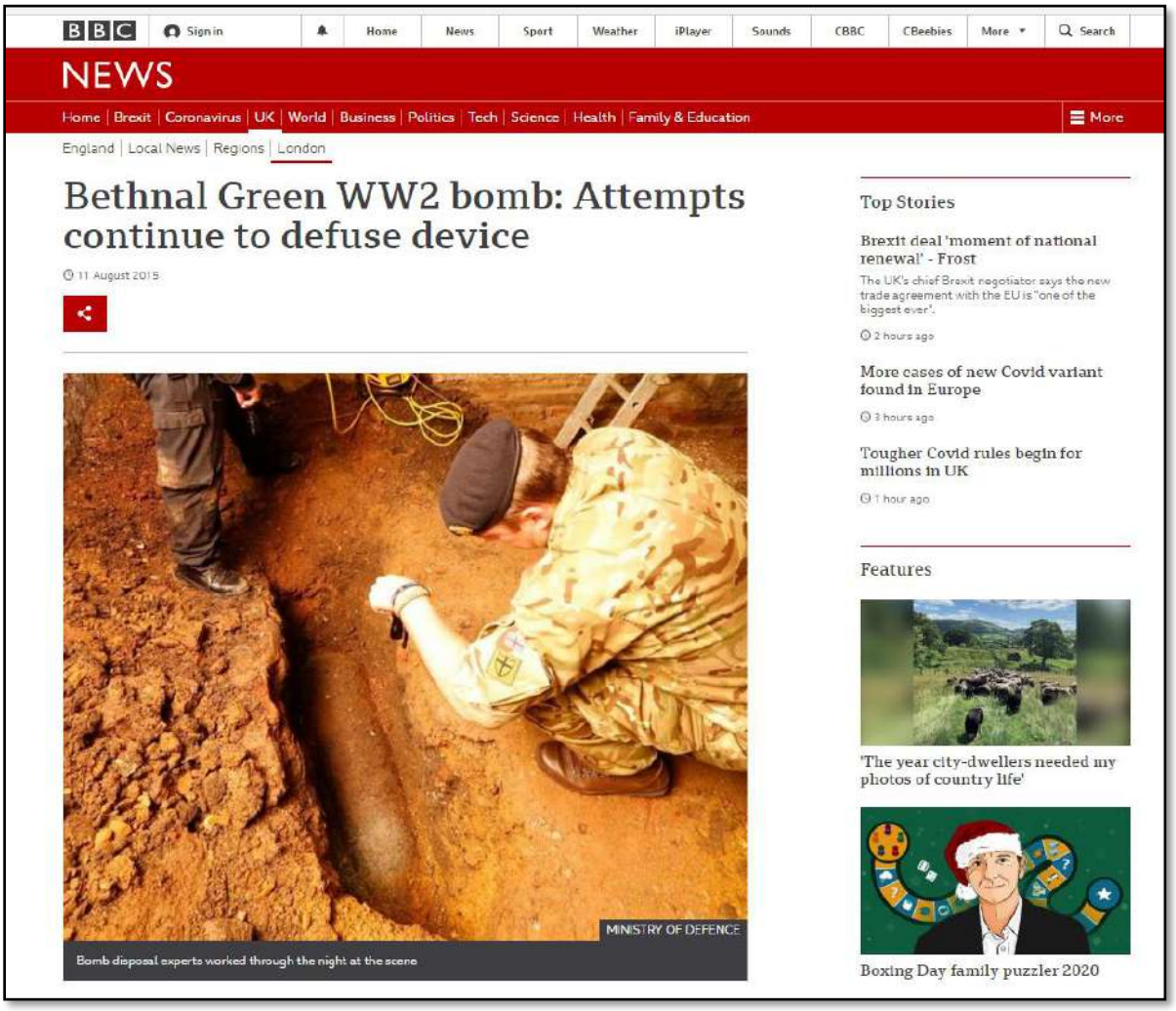
City Airport (2018)



Wembley (May 2015)



White City (July 2015)



Bethnal Green (April 2015)