

PLANNING ACT 2008
INFRASTRUCTURE PLANNING
(APPLICATIONS: PRESCRIBED FORMS AND PROCEDURE) REGULATIONS 2009
REGULATION 5 (2) (a)

PROPOSED PORT TERMINAL AT FORMER TILBURY POWER STATION

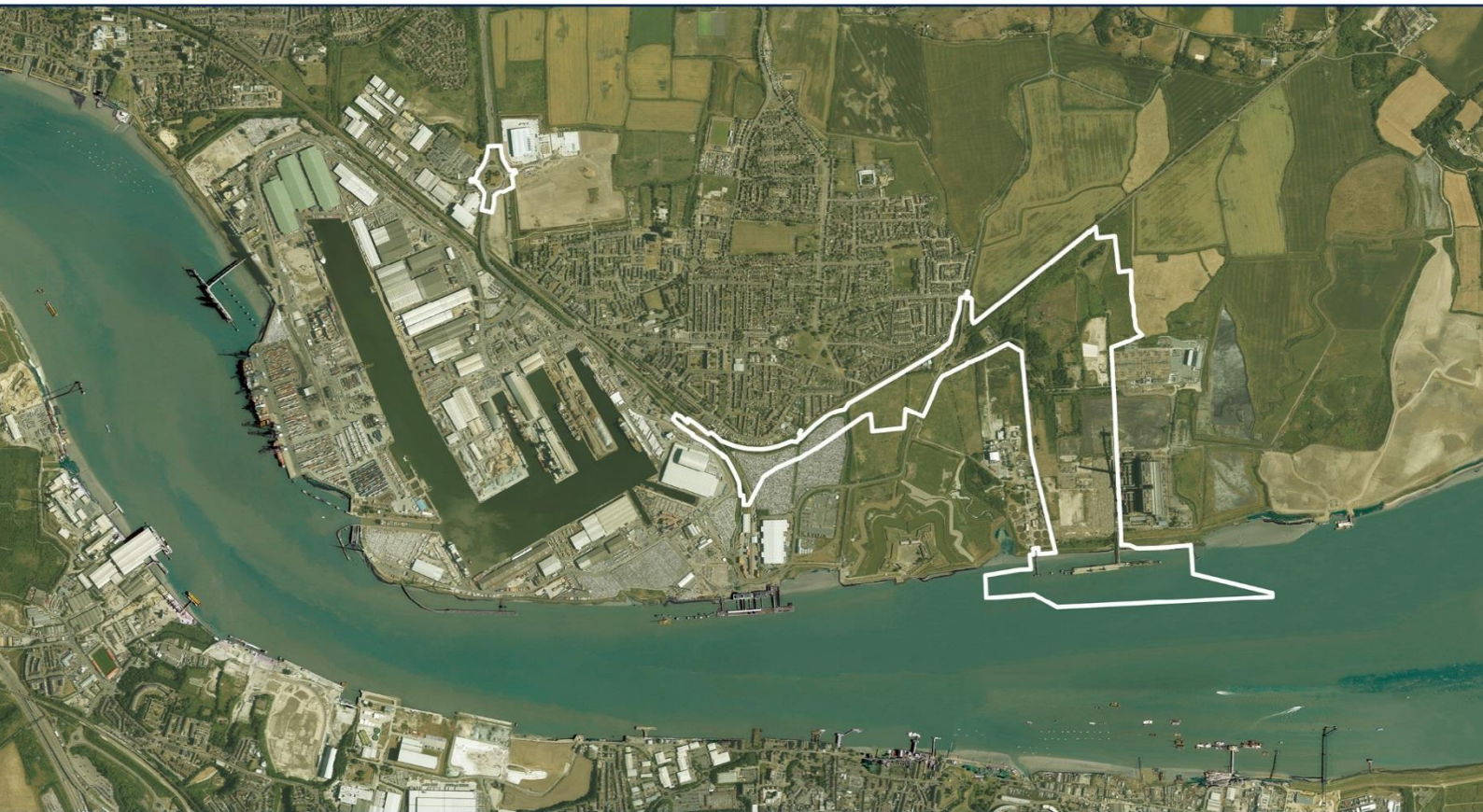
TILBURY2

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VOLUME 6 PART B

ES APPENDIX 15.E: DETAILED UXO RISK ASSESSMENT

DOCUMENT REF: 6.2 15.E



1ST LINE DEFENCE



UXO SOLUTIONS



Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	Port of Tilbury		
Client	Port of Tilbury London Limited		
Site Address	Tilbury, Essex		
Report Reference	DA3222-01	Revision	00
Date	4 th May 2016		
Originator	SM		




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Executive Summary

Site Location

The site is situated in the town of Tilbury within the borough of Thurrock, Essex, Eastern England.

The northern border of the site is lined with a railway line, which separates it from the residential parts of Tilbury, present to the north-west. Areas to the north-east largely consist of open fields, while Tilbury Power Station and associated infrastructure is located immediately east of the site. The River Thames runs to the south of the site, while further industrial infrastructure as well as Tilbury Fort and a large commercial area is present on the landmass outside of site boundaries to the south-west. The premises of Tilbury Docks is located to the west of the site.

The site is situated on the approximate OS grid references: **TQ 6592976795** (at its north-eastern point), **TQ 6625675230** (at its south-eastern point), and **TQ 6404175923** (at its western point).

Proposed Works

It is understood that proposed work on the site involves port-related developments. The exact scope of intrusive works is not known.

Geology and Bomb Penetration Depth

The British Geological Survey (BGS) map shows the site to be underlain by the Seaford Chalk Formation and Newhaven Chalk Formation – Chalk, of the Cretaceous Period. Borehole information has been recorded in various locations across the site down to a range of depths. Maximum bomb penetration capabilities vary across the site due to its site, but are assessed to reach down to 12m in depth. An assessment can be made by a UXO Specialist on site for individual locations if necessary.

UXO Risk Assessment

After considering the following facts, 1st Line Defence considers there to be a **Medium Risk** that items of unexploded German air-delivered ordnance could have fallen unnoticed and unrecorded within the site boundary, and a **Low-Medium Risk** of the site being contaminated with Allied ordnance.

German UXB Risk:

- During WWII the Urban District of Thurrock was subject to a Moderate density bombing campaign, with 46 items falling per 1,000 acres. The majority of the site was located on West Tilbury Marshes, in close proximity to Tilbury Docks (part of the site was situated on this complex) and Tilbury Fort. Both of these premises were targeted by the Luftwaffe during the war. As well as this, its location on the Thames placed it on route for German aircraft travelling to London.
- Available bomb census maps and ARP incident records plot a high localised bombing density in the Docks area, as well as in the neighbouring town. As the site was to the east of this on open ground, no bomb census mapping is available and records are less specific, due to the relative lack of importance/consequence of this area being bombed. Several references were found to incidents occurring on the open marshland (the accuracy of the high-level bombing employed during WWII generally meant that many bombs did not fall on their intended targets), but based on the available record sets, it has not been possible to determine exactly how many or where these strikes occurred.
- Large sections of this area were dug with anti-glider defences, and access and checks are likely to have been minimal, possibly for the most part non-existent. The soft, scrubby nature of the groundcover would also not have been conducive to the observation of UXO entry holes even if the area had been subject to checks. The entry hole of a 50kg UXB could be as little as 20cm in diameter (and even smaller for anti-aircraft artillery projectiles) and could even close up in marshy conditions. For these reasons, no one section of the marsh can be considered a 'low' risk from having been contaminated with unexploded ordnance. It should be noted that of significant concern is the open stretch of water at the southern end of the site. Had bombs fallen within this area, there is effectively negligible chance of them being either observed or recovered.
- Some sections of the site to the west run closer to habitation and infrastructure, particularly in the western section of the site. Generally, this would improve the likelihood that evidence of UXO would be noted and reported. However, imagery has shown both similar poor ground conditions and evidence of damage to structures the closer to the Docks the site runs. There is the potential in damaged areas that due to resulting rubble/debris on the ground, subsequent strikes in the same location can go undetected, and therefore not dealt with.



UXO Risk Assessment

Allied Ordnance:

- The report has also considered the potential for encountering unexploded ordnance relating to Allied military use of the area. It is known that D-Day preparations were conducted across Tilbury, and the Home Guard were in operation at Tilbury Fort. Several defensive positions were also present in the surrounding area.
- No evidence has been found of military activity directly on site which would indicate a 'high' risk of encountering UXO – although given the factors outlined in this report, the possibility certainly cannot be discounted.

Post-War Redevelopment

- Some sections of the site have been subject to significant post-war development. In the south-eastern section of the site, Tilbury Power Station was constructed including a number of industrial structures, patches of hard-standing and roadways. Infrastructure of this nature is also sparsely spread across the remainder of the eastern and central sections of the site. In the western section of the site, a car-parking area has been developed as well as a new roadway and general ground development in Tilbury Docks.
- Development of structures, roadways, and patches of hard-standing ground will have required minimal excavation work. Where this development has taken place the risk of encountering shallow buried UXO, especially 1kg incendiaries and anti-aircraft projectiles will have been partly mitigated.
- It is not known whether any development will have required deeper foundations. The risk from deep-buried unexploded bombs is only considered mitigated at locations where post war piling or deep foundations have taken place.

Recommended Risk Mitigation Measures

The following risk mitigation measures are recommended to support the proposed works at the Port of Tilbury site:

All works

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

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

- Non-Intrusive UXO Survey

Where this type of survey is not practical (due to for example terrain or ground conditions), the following is recommended to support shallow intrusive works:

- Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works

The nature of the ground stabilisation process means that a UXO Specialist Presence is not practical. Where this is being undertaken; and a Non-Intrusive UXO Survey is not practical; and the risk has not been mitigated by post-war redevelopment, the following is recommended:

- Intrusive Magnetometer Survey down to a maximum bomb penetration depth

Deep intrusive works (boreholes and piles)

- Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth (on land)
- Marine Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth (in water)

Dredging in water

- Non-Intrusive UXO Survey
- Unexploded Ordnance (UXO) Marine Specialist Presence on Site to support shallow intrusive works

Further detail on this range of support options is given in [Section 17](#). It is recommended that further discussions are held regarding the most appropriate and cost-effective mitigation measures, based on the exact nature and scope of works planned.

In making this assessment and recommending the above risk mitigation measures, 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.

**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
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

Executive Summary	II
Glossary	IV
Contents	V
Annexes	VII
1. Introduction	1
1.1. Background.....	1
2. UK Regulatory Environment	2
2.1. General	2
2.2. CDM Regulations 2015	2
2.3. The 1974 Health and Safety at Work Act	2
2.4. Additional Legislation	2
3. Role of Commercial UXO Contractors and The Authorities	3
3.1. Commercial UXO Contractors.....	3
3.2. The Authorities	3
4. The Report	4
4.1. Report Objectives.....	4
4.2. Risk Assessment Process.....	4
4.3. Sources of Information	4
5. Reporting Conditions	5
5.1. General Considerations	5
5.2. Background to Bombing Records.....	5
6. The Site	6
6.1. Site Location	6
6.2. Site Description.....	6
7. Scope of the Proposed Works	6
7.1. General	6
8. Ground Conditions	6
8.1. General Geology	6
8.2. Site Specific Geology.....	6
9. Site History	7
9.1. Ordnance Survey Historical Maps.....	7
9.2. Oblique Photographs of the Site.....	7
10. Aerial Bombing Introduction	8
10.1. General	8
10.2. Generic Types of WWII German Air-delivered Ordnance.....	8
10.3. Failure Rate of German Air-Delivered Ordnance	10
10.4. V-Weapons	10
11. UXB Ground Penetration	11
11.1. General	11
11.2. The J Curve Effect.....	11
11.3. WWII UXB Penetration Studies.....	11
11.4. Site Specific Bomb Penetration Considerations	11



12. Initiation of Unexploded Ordnance12

 12.1. General 12

 12.2. UXB Initiation Mechanisms..... 12

 12.3. Effects of Detonation 12

13. The Risk from German UXBs.....13

 13.1. World War I 13

 13.2. World War II Bombing of Tilbury and Thurrock 13

 13.3. Second World War Bombing Statistics 14

 13.5. Thurrock Goes to War..... 16

 13.6. Tilbury Record of War Damaged Properties 17

 13.7. Tilbury Docks Air Raid Precautions Bomb Census Map..... 18

 13.8. WWII-Era Aerial Photographs 18

 13.10. Bombing Decoy Sites 19

 13.11. Abandoned Bombs..... 20

 13.12. Bomb Disposal Tasks 20

 13.13. Evaluation of Bombing Records..... 20

14. The Risk from Allied Military Ordnance22

 14.1. General 22

 14.2. Tilbury Fort 22

 14.3. D-Day Preparations in Tilbury..... 22

 14.4. Allied Defensive Positions 23

 14.5. Land Service Ammunition 24

 14.6. Small Arms Ammunition 24

 14.7. Defending Thurrock from Aerial Attack 24

 14.8. Anti-Aircraft Artillery (AAA) and Projectiles..... 25

 14.9. Evaluation of Allied Military Ordnance Risk 26

15. Ordnance Clearance and Post-WWII Ground Works27

 15.1. General 27

 15.2. UXO Clearance..... 27

 15.3. Post war Redevelopment..... 27

16. 1st Line Defence Risk Assessment28

 16.1. Risk Assessment Stages 28

 16.2. Assessed Risk Level 30

17. Proposed Risk Mitigation Methodology30

 17.1. General 30

Bibliography33

Annexes

List of Report Annexes	
Annex A	Site Location Maps
Annex B	Recent Aerial Photography
Annex C	Example of Borehole Data
Annex D	Pre and Post-WWII Historical Maps
Annex E	Oblique Photographs of the Site
Annex F	Examples of German Air Delivered Ordnance
Annex G	Example of 50kg Bomb Entry Hole
Annex H	Examples of UXO Incidents
Annex I	Example of WWI Gotha Aircraft Raid on Thames Estuary
Annex J	Luftwaffe Target/Reconnaissance Imagery
Annex K	Photographs of Bomb Damage in Tilbury
Annex L	Photograph of Bombs Dropped on Tilbury
Annex M	Damage to Railway Cottages, 18 th September 1940
Annex N	Tilbury Docks Consolidated Bomb Map
Annex O	WWII-Era RAF Aerial Photography of the Site
Annex P	Visual Representation of Bomb Damage
Annex Q	D-Day Marshalling Areas Map
Annex R	Military/Civil Facilities in Tilbury
Annex S	Information on Anti-Glider Obstacles
Annex T	Examples of LSA
Annex U	Examples of SAA
Annex V	Examples of Anti-Aircraft Projectiles
Annex W	UXO Find in Tilbury, 1992

1st Line Defence Limited

Detailed Unexploded Ordnance (UXO)

Risk Assessment

Site: Port of Tilbury
Client: Port of Tilbury London Limited

1. Introduction

1.1. Background

1st Line Defence has been commissioned by Port of Tilbury London Limited to produce a Detailed Unexploded Ordnance (UXO) Risk Assessment for the proposed works at the Port of Tilbury site.

UXO in the UK can originate from three principal sources:

1. Munitions deposited as a result of military training procedures 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, defensive activities or area denial.

In certain parts of the UK buried UXO can present a significant risk to construction works and development projects. Whilst UXO may certainly present a safety risk even the simple discovery of a suspected device during on-going works can cause considerable disruption to production and cause unwanted delays and expense.

This report will examine in detail all the factors that could potentially contribute to a risk from UXO at the site in question. For the majority of sites in the UK the likelihood of encountering UXO of any sort is minimal and generally no further action will be required beyond an initial desktop risk assessment. However, if a potential risk is identified, the report will make recommendations for the most appropriate and work-specific measures available in order to reduce the risk to as low as reasonably practicable. Full analysis and evidence will be provided to allow to client to fully understand the basis for the assessed risk level and any recommendations.

The report directly follows the guidelines set out in the document CIRIA C681 'Unexploded Ordnance (UXO) A Guide for the Construction Industry'.

2. UK Regulatory Environment

2.1. General

There is no formal requirement for undertaking an assessment of UXO risk for construction projects in the UK, nor any specific legislation covering 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.) do undertake a comprehensive and robust assessment of potential risks to employees and that mitigation measures are put in place to address any identified hazards.

2.2. CDM Regulations 2015

This legislation defines the responsibilities of all parties (primarily the Client, the CDM Co-ordinator, the Designer and the Principal Contractor) involved with works. Under CDM2015, the client has the 'legal responsibility for the way that a construction project is managed and run and they are accountable for the health and safety of those working on or affected by the project'.

Although UXO is not specifically addressed, the regulations effectively place obligations on all these 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.

2.3. The 1974 Health and Safety at Work Act

All employers have a responsibility under the Health and Safety at Work Act of 1974 (and the Management of Health and Safety at Work Regulations of 1999) to ensure, so far as is reasonably practicable, the health and safety of their employees and that of other persons who are affected by their work activity (including the general public).

2.4. Additional Legislation

Other relevant legislation includes the Safety at Work Regulations 1999 and The Corporate Manslaughter and Corporate Homicide Act 2007.

3. Role of Commercial UXO Contractors and The Authorities

3.1. Commercial UXO Contractors

The role of an experienced UXO specialist such as 1st Line Defence is to provide expert knowledge and guidance to the client on the most appropriate and cost effective approach to UXO risk management on a site.

The undertaking of Preliminary and Detailed UXO Risk Assessments is the first step in this risk management process. The extensive amount of specialist experience, weapons knowledge, datasets and historical information available to 1st Line Defence in particular, allows a robust, detailed and realistic assessment of the potential risk, and the recommendation of suitable mitigation measures if deemed necessary.

In addition to undertaking specialist Risk Assessments, a commercial UXO contractor will be able to provide pre-construction site survey and clearance/avoidance, as well as a reactive response to any suspect finds.

The presence on site of a qualified UXO Specialist with ordnance recognition skills will avoid unnecessary call-outs to the authorities and allow for arrangement to be made for the removal and disposal of low risk items. If high risk ordnance is discovered, actions will be co-ordinated with the authorities with the objective of causing the minimum possible disruption to site operations whilst putting immediate, safe and appropriate measures in place.

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

3.2. The Authorities

The Police have the responsibility for co-ordinating the emergency services in the case of an ordnance-related incident on a construction site. They will make an initial assessment and if they judge necessary, impose a safety cordon and/or evacuation and call the military authorities Joint Services Explosive Ordnance Disposal (JSEOD) to arrange for investigation and/or disposal. In the absence of an UXO Specialist on site many Police Officers will use the precautionary principle, impose cordon/evacuation and await advice from the JSEOD. The discovery of UXO will invariably cause work to cease on the site and may require the evacuation of the site and neighbouring properties.

The priority JSEOD will give to the police request will depend on their judgement of the nature of the UXO risk, the location, people and assets at risk and the availability of resources. They may respond immediately or as resources are freed up. 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 site or destroyed by controlled explosion. In the latter case additional cordons and/or evacuations may be necessary and the process will take longer.

It should be noted that following the discovery of an item of UXO, the military authorities will only carry out further investigations or clearances in very high profile or 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 i.e. the appointment of a commercial contractor to manage the situation.

4. The Report

4.1. Report Objectives

The aim of this report is to undertake a fair, proportionate and comprehensive assessment of the potential risk from UXO at the Port of Tilbury site. Every reasonable effort will be made to ensure that all available and pertinent historical information and records are accessed and checked. Full analysis and evidence will be provided where possible to allow the Client to fully understand the basis for the risk assessment.

Site specific risk mitigation measures will be recommended if deemed necessary, to reduce the risk from explosive ordnance during the envisaged works to as low as reasonably practicable.

4.2. Risk Assessment Process

1st Line Defence undertakes a five-step process for assessing the risk posed by UXO:

1. The risk that the site was contaminated with UXO.
2. The risk 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 considered in detail, site specific and non-site specific factors including:

- Evidence of German bombing, delivery of UXBs, records of abandoned bombs and maximum bomb penetration depth assessment.
- Site history, occupancy and conditions during WWII.
- The potential legacy of Allied military activity.
- Details of the specific UXO threat and any known UXO clearance work.
- The extent of any post-war redevelopment.
- The extent and nature of any proposed works.

4.3. Sources of Information

In order to produce a robust and thorough assessment of UXO risk, detailed historical research has been carried out by specialist researchers. Military records and archive material held in the public domain have been accessed. Information from the following sources has been consulted for this report:

- The National Archives, Kew; Essex Record Office; and Thurrock Museum.
- Landmark Maps.
- Historic England National Monuments Record.
- Relevant information supplied by Port of Tilbury London Limited.
- 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 book and internet resources.

Research involved a visit to the Essex Record Office, Thurrock Museum, and the National Archives, Kew.

5. Reporting Conditions

5.1. General Considerations

It is important to note that this desktop assessment is based largely upon research of historical evidence. Although every effort has been made to locate all significant and pertinent information, 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 – see 'Background to Bombing Records'. As a consequence, conclusions as to the exact location, quantity and nature a UXO risk can rarely be definitive. To counter this, it is essential that as many different sources and types of information as possible are consulted and analysed before a conclusion is reached. 1st Line Defence cannot be held responsible for inaccuracies or gaps in the available historical information.

5.2. Background to Bombing Records

In September 1940, the Government started to collect and collate information relating to damage sustained during bombing raids. The data became known as the 'Bomb Census'. Initially, only information relating to London, Birmingham and Liverpool was collated, but quickly the bomb census was extended to cover the rest of the UK.

Its purpose was to provide the Government with a complete picture of raid patterns, types of weapon used and damage caused – in particular to strategic services and installations such as railways, factories and public utilities.

Information was gathered locally by police, Air Raid Wardens and military personnel. They noted when, where and what types of bombs had fallen during an air raid, and passed this on to the Ministry of Home Security. Records of strikes were made either through direct observation or by post-raid surveys. However, the immediate priority was to deal with casualties and minimise damage. As a result, it is only to be expected that the records kept were often incomplete and contradictory.

Prior to the official 'Bomb Census', record keeping in the early months of the war was not comprehensive. The quality, detail and nature of record keeping could vary considerably from borough to borough and town to town. Many records were even damaged or destroyed in subsequent attacks. Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are 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.



6. The Site

6.1. Site Location

The site is situated in the town of Tilbury within the borough of Thurrock, Essex, Eastern England.

The northern border of the site is lined with a railway line, which separates it from the residential parts of Tilbury, present to the north-west. Areas to the north-east largely consist of open fields, while Tilbury Power Station and associated infrastructure is located immediately east of the site. The River Thames runs to the south of the site, while further industrial infrastructure as well as Tilbury Fort and a large commercial area is present on the landmass outside of site boundaries to the south-west. The premises of Tilbury Docks is located to the west of the site.

The site is situated on the approximate OS grid references: **TQ 6592976795** (at its north-eastern point), **TQ 6625675230** (at its south-eastern point), and **TQ 6404175923** (at its western point).

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

6.2. Site Description

The site is an irregular-shaped parcel of land. This predominantly consists of undeveloped marshland, particularly in the central section of the site. Small parts of this are intercepted by roadways, a railway line or patches of hard-standing ground/small structures. The most south-eastern section consists of Tilbury Power Station infrastructure, including structures, hard-standings, coal tips, jetties and other infrastructure which extends onto the River Thames. The most western section of the site consists of a hard-standing car parking, patches of vegetation and roadways leading into Tilbury Docks.

A recent aerial photograph and site boundary is presented in **Annex B**.

7. Scope of the Proposed Works

7.1. General

It is understood that proposed work on the site involves port-related developments. The exact scope of intrusive works is not known.

8. Ground Conditions

8.1. General Geology

The British Geological Survey (BGS) map shows the site to be underlain by the Seaford Chalk Formation and Newhaven Chalk Formation – Chalk, of the Cretaceous Period.

8.2. Site Specific Geology

Borehole data has been collected previously at a number of locations around the site and has been taken into account for this report. An example of one of these borehole logs, taken in the central section of the site, is presented in **Annex C**.

9. Site History

9.1. Ordnance Survey Historical Maps

Pre and post-WWII historical maps for the site were obtained by 1st Line Defence from Old-Maps.co.uk and Landmark Maps. These are presented in **Annex D**.

Pre-WWII Period		
Date	Scale	Description
1938	1:10,560	This map shows the site to consist almost entirely of the 'West Tilbury Marshes'. The London, Tilbury & Southend Railway runs to the north of the site, and intercepts site boundaries briefly in the central section of the site. The 'Old Counter Wall' also passes through the south-eastern section of the site. The western section of the site consists of part of the 'Tilbury East (Railway) Junction' – located within this is railway sidings, an engine shed, and residential properties (referred to as Railway Cottages). Also included in this section is part of the premises of Tilbury Docks, including more residential properties (Orient Road and Peninsula Road), 'Workmen's Dwellings', and a Hall.
1940	1:2,500	This map shows is exclusively the western section of the site in higher detail. This displays indicated marshland to the east. Within the 'Tilbury East Junction' the site is occupied by railway sidings/track, an engine shed and 'Railway Cottages' properties. Further along to the west, the site consists of a roadway, and properties on Peninsula Road, Orient Road, and 'Workmen's Dwellings'.

Post-WWII Period		
Date	Scale	Description
1961-1962	1:10,560	This map shows development on the 'West Tilbury Marshes', including the development of several large structures labelled as 'Works' and a 'Jetty' on the Thames in the south-eastern section of the site. This area of industry extends out of site boundaries to the west. The remainder of the marshland is predominantly undeveloped, aside from small roadways in the central section. The western section of the site is largely similar to the previous edition, though the Railway Cottages on site are no longer evident. Residential properties on Orient Road and Peninsula Road remain, however the 'Workmen's Dwellings' and Hall are removed.
1982-1994	1:10,000	This map shows significant further development in the south-eastern section in the site, resulting in the construction of the 'Tilbury Power Station' which takes over much of its premises. Scattered industrial units are shown to have been constructed in the eastern and central section of the site, as well as a number of supplementary roadways. Properties in the western section (including housing and port facilities) are no longer present.

9.2. Oblique Photographs of the Site

Oblique photographs of the site were obtained from *Britain From Above*, and are presented in **Annex E**. The first of these, dated 17th July 1938, shows the eastern and central sections of the site located on Tilbury Marshes and part of the River Thames. The entirety of the site is shown to consist of this river and marshland and is unoccupied, aside from a railway and roadway in the northern area. The second image, dated earlier in May 1934, shows the western section of the site. This consists of the East Tilbury Junction and sidings, and the residential properties in the Railway Cottages and on Orient Road and Peninsula Road. The most western point of the site consists of what is annotated as the

'Workingman's Dwellings' in the 1938 OS historical map, though the nature of the structures/ground in this area is not clear.

10. Aerial Bombing Introduction

10.1. General

During WWI and WWII, many towns and cities throughout 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 techniques often resulted in all areas around a specific target 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 and while extensive efforts were made to locate and deal with these UXBs at the time, many still remain buried and can present a potential risk to construction projects.

The main focus of this report with regards to bombing will be weapons dropped during WWII, although WWI bombing will also be considered.

10.2. Generic Types of WWII German Air-delivered Ordnance

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 below. Examples of German air delivered ordnance are presented at **Annex F**.

Generic Types of WWII German Air Delivered Ordnance	
High Explosive (HE) Bombs	
Frequency	In terms of weight of ordnance dropped, HE bombs were the most frequent weapon deployed by the Luftwaffe during WWII.
Size/Weight	Most bombs were 50kg, 250kg or 500kg (overall weight, about half of which was high explosive) though larger bombs of up to 2000kg were also used.
Description	High explosive bombs are thick-skinned and typically have sufficient mass and velocity and a suitably streamlined shape to enable them to penetrate the ground if they failed to explode on the surface.
Likelihood of detecting Unexploded	Although efforts were made to identify the presence of unexploded ordnance following a raid, often the damage and destruction caused by bombs which did detonate often made observation of UXB entry holes impossible. The entry hole of an unexploded bomb can be as little as 20cm in diameter and easily overlooked in certain ground conditions (See Annex G). Furthermore, ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. UXB's therefore present the greatest risk to present-day intrusive works.
Aerial or Parachute Mines	
Frequency	These were much less frequently deployed than HE and incendiary bombs due to their size, cost and their difficulty technically to deploy.
Size/Weight	Their weight was either 500kg or 1000kg (overall weight, of which about 2/3 was explosive) depending on the type of mine. Their length ranged from 1.73-2.64m.



Description	The Luftmines (LMA-500kg and LMB-1000kg) were magnetic sea mines which were thin walled, cylindrical in shape with a hemispherical nose and were deployed under a green artificial silk parachute about 8m in diameter. They were fitted with magnetic and later with acoustic or magnetic/acoustic firing. When the mine hit the water and sank to more than 8ft, hydrostatic pressure and the dissolution of a soluble plug actuated the magnetic device and the mine became operational against shipping. The mine was also armed with a clockwork bomb fuze which caused the bomb to explode when used against land targets, and this was started by the impact of hitting the ground. The Bombenmine (BM 1000, Monika, or G Mine) was also used. This was fitted with a tail made from Bakelite which broke up on impact. It had a photoelectric cell beneath a cover which detonated the bomb if exposed to light to counteract the work of bomb disposal units.
Likelihood of detecting Unexploded	The aerial mines were either 500kg or 1000kg (overall weight, of which about 2/3 was explosive) depending on the type of mine. Their length ranged from 1.73-2.64m. They were much less frequently deployed than H.E. and Incendiary bombs due to their size, cost and the fact that they could not be delivered to point targets. If functioning correctly, parachute mines would generally have had a slow rate of descent (falling at about 40 mph) 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. When operating as designed they caused considerable damage due to the high weight of explosive and their detonation at or near the surface. However 1st Line Defence does not consider there to be a significant risk from unexploded aerial mines on land.
1kg Incendiary Bombs	
Frequency	In terms of number of weapons dropped these small Incendiaries were the most numerous. Millions of these weapons were dropped throughout WWII.
Size/Weight	1kg
Description	These thermite filled devices were jettisoned from air-dropped containers. Some variants had explosive heads and these present a risk of detonation during intrusive works.
Likelihood of detecting Unexploded	They had very limited penetration capability and in urban areas especially would usually 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 easily have gone unnoticed.
Large Incendiary Bombs	
Frequency	These items of ordnance were not as common as the 1kg Incendiaries however they were still more frequently deployed than the Parachute Mines and Anti-Personnel Bomblets.
Size/Weight	These could weigh up to 350kg.
Description	They 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 generally did not penetrate the surface.
Likelihood of detecting Unexploded	If they 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	
Frequency	They were not commonly used and generally considered to pose a low risk to most works in the UK.
Size/Weight	The size and weight ranged depending on the type used. The most common was the "Butterfly Bomb" (SD2) which weighed 2kg and contained 225 grams of TNT.
Description	The 'Butterfly Bomb' had an 8cm long, thin, cylindrical, cast iron outer shell which hinged open when the bomblet deployed gave it the superficial appearance of a large butterfly. A steel cable 15 cm long was attached via a spindle to an aluminium fuze. The wings at the end were canted



	at an angle to the airflow, which turned the spindle anti-clockwise as the bomblet fell. After the spindle had revolved approximately 10 times (partially unscrewing itself from the bomb) it released a spring-loaded pin inside the fuze, which fully armed the SD2 bomb. They were generally lethal to anyone within a radius of 10 metres (33 ft) and could inflict serious shrapnel injuries. There were a number of variants, the most common being the SD2 which weighed 2kg and contained 225 grams of TNT. They were not commonly used and generally considered to pose a low risk to most works in the UK.
Likelihood of detecting Unexploded	SD2 bomblets were not dropped individually, but were packed into containers holding between 6 and 108 submunitions however, AP bombs had little ground penetration ability and should have been located by the post-raid survey unless they fell into water, dense vegetation or bomb rubble.

10.3. Failure Rate of German Air-Delivered Ordnance

It has been estimated that 10% of the German HE bombs dropped during WWII failed to explode as designed. This estimate is based on the statistics of wartime recovered UXBs and therefore will not have taken account of the unknown numbers of UXBs that were not recorded at the time. It is therefore quite likely that the average failure rate would have been higher than this.

There are a number of reasons why an air-delivered weapon might fail to function as designed:

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

War Office Statistics document that a daily average of 84 bombs which failed to function were dropped on civilian targets in Great Britain between 21st September 1940 and 5th July 1941. 1 in 12 of these probably mostly fitted with time delay fuzes exploded sometime after they fell, the remainder were unintentional failures.

From 1940 to 1945 bomb disposal teams dealt with a total of 50,000 explosive items of 50 kg and over i.e. German bombs, 7,000 AAA shells and 300,000 beach mines. These operations resulted in the deaths of 394 officers and men. However, unexploded ordnance is still regularly encountered across the UK, especially in London; see press articles in **Annex H**.

10.4. V-Weapons

From mid-1944, Hitler's 'V-weapon' campaign began. It used newly developed unmanned cruise missiles and rockets. The V1 known as the *Flying Bomb* or *Doodlebug* and the V2, a Long Range Rocket, were launched from bases in Germany and occupied Europe. A total of 2,419 V1s and 517 V2s were recorded in the London Civil Defence region alone.

Although these weapons caused considerable damage their relatively low numbers allowed accurate records of strikes to be maintained. These records have mostly survived. It should be stressed that there is a negligible risk from unexploded V-weapons on land today since even if the 1000kg warhead failed to explode, the weapons are so large that they would have been observed and the threat dealt with at the time. Therefore V-weapons are referenced in this report not as a viable risk factor, but primarily in order to help account for evidence of damage and clearance reported.



11. UXB Ground Penetration

11.1. 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 groundcover
- Underlying geology

Geology is perhaps the most important variable. If the ground is soft, there is more potential for deeper penetration – peat and alluvium are easier to penetrate than gravel and sand for example and the bomb is likely to come to rest at deeper depths. Layers of hard strata will significantly retard and may stop the trajectory of a UXB.

11.2. 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.

11.3. 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, mostly in the London area. They then came to conclusions as to the likely average and maximum depths of penetration of different sized bombs in different geological strata.

They concluded that the largest common German bomb, 500kg, had a likely 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.

11.4. Site Specific Bomb Penetration Considerations

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

- WWII Geology – Seaford Chalk Formation and Newhaven Chalk Formation
- Impact Angle and Velocity – 10-15° from Vertical and 270 metres per second.
- Bomb Mass and Configuration – The 500kg SC (General Purpose) HE bomb, without retarder units or armour piercing nose. This was the largest of the common bombs used against Britain.

Borehole information has been recorded in various locations across the site down to a range of depths. Maximum bomb penetration capabilities vary across the site due to its site, but are assessed to reach down to 12m in depth. An assessment can be made by a UXO Specialist on site for individual locations if necessary.

12. Initiation of Unexploded Ordnance

12.1. General

Unexploded ordnance does not spontaneously explode. All high explosive 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.

12.2. UXB Initiation Mechanisms

There are a number of ways in which UXB can be initiated. These are detailed in the table below.

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	This is the most likely scenario resulting in the weapon detonating; 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 H2 details UXB incidents where intrusive works have caused UXBs to detonate, resulting in death or injury and damage to plant.

12.3. 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 weakening of support structures
- Environment – introduction of potentially contaminating materials



13. The Risk from German UXBs

13.1. World War I

During WWI Essex was within the range of Zeppelin Airships and Gotha and Giant fixed-wing aircraft and was often used as a route to targets in London or the midlands from occupied Europe. As a result Essex did suffer a degree of material damage at the hands of German aerial bombing in WWI. A Zeppelin raid was specifically reported on Tilbury on the 2nd September 1916, though the exact location and ordnance dropped is unknown. It is claimed that during the war anti-aircraft guns at Tilbury Fort helped shoot down a Zeppelin airship (type L15). Gotha aircraft also often travelled up to the Thames in the latter stages in the war, and dropped ordnance on coastal towns such as Gravesend (approximately 1km to the south) – the route of one of these raids is shown in **Annex I**.

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.

13.2. World War II Bombing of Tilbury and Thurrock

The Luftwaffe's initial objective for the attacks on Great Britain was to paralyse the country's industrial capability by bombing the docks, warehouses, wharves, railway lines, factories and power stations. As the war progressed this strategy gradually changed to the indiscriminate bombing of civilian areas in an attempt to disrupt everyday life and hurt morale.

The area of Thurrock in southern Essex was located near the Thames Estuary, on route for Luftwaffe aircraft heading towards and returning from raids on London. As a result, between 1940 and 1945 it sustained a series of sporadic air raids, with a moderate amount of ordnance dropped by the Luftwaffe on the region through carpet bombing and 'tip-and-run' raids. These attacks were mostly focused on coastal areas due to recognition of the river's curve. Railway lines were similarly identifiable for the air, and targeted for their importance to the nation's infrastructure – it is likely that the site area would have sustained residual bombing due to the presence of the London, Tilbury and Southend Railway (LTSR) running alongside the northern border of the site.

As well as this, Tilbury was specifically targeted due to the historical military and commercial nature of the area. This is confirmed by Luftwaffe target reconnaissance photography, presented in **Annex J**. **Annex J1** places particular emphasis on Tilbury Fort, located within 200m of the site. The fort, used for defence against foreign invasion at irregular intervals stretching from the 16th up to the 20th centuries, was loaded with HAA emplacements prior to WWI. These remained in use during WWII to ward off Luftwaffe aircraft travelling along the Thames. Military activity was rife across the area, particularly in the early part of the war, at which point concern about a land invasion of Britain was high. Coalhouse Fort (located approximately 3km to the east of the site) was equipped with coastal defence guns manned by units of the Royal Artillery. Over the course of the war both Allied and United States troops were situated in the area – more discussion of this military presence can be found in **Section 14**. Shown in **Annex J2** is Tilbury Docks, of which the most western part of the site was situated within. The docks were at the time of the war one of Britain's major container ports, and were targeted accordingly. Later in the war, it was involved in the preparation for the Allied invasion of Normandy in 1944, through production of the Mulberry Harbour (used to facilitate rapid offloading of cargo) and PLUTO (oil pipelines beneath the English Channel).

While Thurrock did not suffer as severely as other areas in the south-east, the consequences were still significant. The first major raids occurred in August 1940, and continued over the following months.

The worst raid on Tilbury occurred on the 19th September 1940, in which countless houses were seriously damaged as well as the *Basin Tavern* and the Tilbury laundry. Images of this destruction can be seen in **Annex K**. A supposed image of the Luftwaffe dropping bombs on the Port of Tilbury on the 4th October 1940 is also presented in **Annex L**, though the reliability of this is not known. The main period of bombing ended in May 1941, and Thurrock sustained very few raids for the remainder of the war. The area also received relatively few V1 and V2 weapons, and sustained little residual damage. Final official figures for the years 1939/1945 in Thurrock were 88 civilians killed by enemy action with a further 40 missing.

Records of bombing incidents in the civilian areas of Tilbury were collected by the Air Raid Precautions wardens and collated by the Civil Defence Office. Some other organisations, such as the London Port Authority and railways, 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 capital 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 the Urban District of Thurrock are presented in the following sections.

13.3. Second World War Bombing Statistics

The following tables summarise the quantity of German bombs (excluding 1kg incendiaries and anti-personnel bombs) falling on the Urban District of Thurrock between 1940 and 1945.

Record of German Ordnance Dropped on the Urban District of Thurrock		
Area Acreage		40,552
Weapons	High Explosive Bombs (all types)	1,614
	Parachute Mines	44
	Oil Bombs	21
	Phosphorus Bombs	88
	Fire Pot	32
	Pilotless Aircraft (V1)	36
	Long Range Rockets (V2)	33
Total		1,868
Number of Items per 1000 acres		46.1

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 incendiaries are not particularly significant in the threat they pose, they nevertheless are items of ordnance that were designed to cause damage and inflict injury and should not be overlooked in assessing the general risk to personnel and equipment. The anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous.

13.4. Thurrock Air Raid Precautions Bomb Incident Records

Written incident records were obtained from the Essex Record Office. A transcript of the associated written records for bombs which fell in the area is presented in the table below. Records are often vague in description, and do not tend to give specific property numbers on the roads given. Only those

recorded incidents on or in close proximity to the site have been transcribed, with those in close proximity highlighted in bold.

Date Range	Comments
16 th August 1940	HE bombs dropped in Tilbury Docks and the town of Tilbury, exact locations not given.
18 th August 1940	HE bombs recorded north of the railway line in Tilbury, including in the field at the rear end of London Road, within 150m of the site.
28 th August 1940	Incendiary bombs in Tilbury. Two of these were reported on an open field by Bryanston Road, in immediate proximity to the site. Two more were also reported on Tennyson Walk, within 250m.
1 st September 1940	HE bombs dropped on Tilbury, including on Quebec Road, Sydney Road, Calcutta Road, Toronto Road, and Dock Road. One also fell opposite No. 8 Railway Cottages, within 70m of the site.
2 nd September 1940	A HE bomb was dropped in a field in front of the Gatehouse by Tilbury Fort, approximately 450m from the site. Unexploded bombs were also recorded on Ferry Road (passes through the site), 27 Kelvin Road (approximately 280m from the site), and Montreal Road (within 300m of the site).
4 th September 1940	HE bombs were dropped on Tilbury Docks, included an unexploded bomb on No 15 Shed, approximately 440m from the site.
5 th September 1940	HE and incendiary bombs dropped on Tilbury Docks and town. This included a HE bomb and UXB's reported near the Railway Cottages, possibly within the site boundary. A HE bomb was also recorded by the Steam Laundry (approximately 190m from the site), and two unexploded HE bombs in a ditch north of the World's End Public House (approximately 400m from the site).
10 th September 1940	Incendiary bombs dropped on 15 Fielding Avenue, Tilbury, approximately 450m from the site.
18 th September 1940	HE bombs fell on Tilbury. Several are recorded on the Railway Cottages, possibly within the site boundary. Further bombs fell on Tilbury Docks, all on open ground. 1 unexploded HE was reported on the Labour Exchange Building on Calcutta Road (approximately 350m from the site), while a number of bombs fell on roads including Montreal Road and Sydney Road, the closest being approximately 200m from the site.
19 th September 1940	Several HE bombs hit the premises of Tilbury Fort, within 200m of the site. A HE bomb was also recorded on 2 Hume Avenue, also approximately 200m from the site.
20 th September 1940	A HE bomb reported to have exploded on open ground near Fort Road, possibly within the site boundary.
3 rd November 1940	Two HE bombs fell on Tilbury Docks.
4 th December 1940	A HE bomb fell on Dock Road, exact location unknown. Its closest potential location to the site is 70m.
8 th December 1940	Over 100 incendiary bombs on Tilbury Docks, some of which fell on railway track. A UXB was also found on Bermuda Road, approximately 200m from the site.
9 th December 1940	Unexploded incendiary bombs recorded on 26 Fielding Avenue, within 500m of the site.
9 th January 1941	1 UXB was reported in field 50 yards north of Bryanston Road, Tilbury, approximately 100m from the site. This is stated to have been dealt with.
12 th January 1941	Several HE's recorded in Tilbury Docks area – one unexploded HE was reported in allotments near St. Andrews Road, within 30m of the site. This is stated to have been dealt with. A HE was also recorded south of St. Andrews Road, though the exact location is unknown. Another, possibly unexploded, was recorded south of Dock Road, which runs alongside to the north of part of the site, so may place the strike within a distance of roughly 80m.

	Incendiary bombs were also recorded on Tilbury Marshes, the area of the majority of the site.
5 th February 1941	Incendiary bombs dropped on Tilbury Docks.
5 th March 1941	Two HE's reported on Fort Road, the exact location unknown – this road runs through the centre of the site, so may place the strike in close proximity.
15 th March 1941	Incendiary bombs recorded on Calcutta Road, approximately 340m from the site, and two HE's on Lansdowne Road Tilbury, approximately 430m from the site.
19 th April 1941	Incendiary bombs dropped between Laundry and Board of Trade Offices on Ferry Road, Tilbury Docks, at a distance from approximately 200m away from the site.
4 th February 1944	1 HE bomb reported falling on Fort Road, and incendiary bombs on Ferry Road – both of these runs through the site and therefore may place the strikes in close proximity.
28 th February 1944 (believed)	1 unexploded AA shell was reported in a field in marshes approximately 280m from the site.
26 th June 1944	AA shell fell in Civic Square, Tilbury, approximately 460m from the site.
4 th December 1944	A V2 Long-Range Rocket fell by railway sidings, approximately 350m from the site.

Reference was also found to several HE bombs and a UXB falling on the Tilbury Marshes in September and October 1940, which much of the site is situated on. The exact location of these strikes, and their status, is not known. It is possible that additional incidents on Tilbury Marshes were not recorded in these incident records, due to lack of relative importance/consequence.

13.5. Thurrock Goes to War

The book *Thurrock Goes to War* by Roger Reynolds and Jonathan Catton gives a summarised account of incidents in the Tilbury area during WWII referenced in the bibliography. This is transcribed below – those in the immediate vicinity have been highlighted in bold.

Date Range	Comments
3 rd August 1940	HE bombs fell at Condovers Farm, West Tilbury.
10 th August 1940	HE bombs fell at Handels Crescent, Tilbury.
16 th August 1940	Extensive raids occurred over the south of England, including on Tilbury. Five bombs were recorded in the residential area of Tilbury, and destroyed a house at 204 Feenan Highway, approximately 1.2km from the site. Damage elsewhere, including on Stephenson Avenue and Spencer Walk, both approximately 500m from the site. Nine bombs fell in the docks area – two of these on the quayside by number 9 shed approximately 500m from the site, and four on a ship (the S.S. Clan Forbes).
28 th August 1940	Unspecified number of bombs fell on Tilbury, location unspecified.
30 th August 1940	Unspecified number of bombs fell on Tilbury, location unspecified.
1 st September 1940	Bombers crossed the coast heading to London, but were turned back by heavy A.A. fire, so dropped their load on a secondary target, the Tilbury Docks. Most missed their target, with 30 to 40 fell on the town, wrecking the Railwaymen's Club (approximately 400m from the site), demolishing a wing at Tilbury laundry, and damaging over 155 houses in total. One bomb fell in rear garden of 5 Kelvin Avenue, approximately 350m from the site, directly hitting an Anderson shelter.
5 th September 1940	An enemy bomber jettisoned its load over Tilbury. In Tilbury Docks, the Orient Line offices approximately 750m from site, Shipping Federation offices and

	Bibby Line offices were gutted, and two ships set alight. Four UXB's remained after this.
18 th September 1940	Incendiary bomb attack, which set light to several properties including the Workingmens Club. HE Bombs later fell, with the majority among the council houses in The Circle, Feenan Highway, Spencer Walk and Arkwright Road, the latter the nearest approximately 550m from the site.
19 th September 1940	The worst recorded raid on Tilbury so far. The Basin Tavern which stood in the dock close to the new dry dock, approximately 250m from the site, was destroyed. The even numbered properties on 38-62 Montreal Road, properties 13/21 Railway Cottages (located within 50m of the site) , and 77-79 Toronto Road, St. Johns Church (within 100m of the site) and the Vicarage were damaged. Several properties were also certified as 'unsafe, for demolition only' – these were numbers 22-30 and 40-50 Ottawa Road, 92 Dock Road, 26/28 Feenan Highway, 17/19 Parker Road, 57/87 and 24/36 Kipling Avenue, 64/72 Fielding Avenue, 57/61 Quebec Road, 47/57 Calcutta Road, and 28/42 Church Road. Some people were evacuated from their homes because of UXBs – it was noted that a 'small area near the dock had been devastated'.
16 th October 1940	Bomber dropped load on Tilbury area. Also a UXB detonated on waste ground near Tilbury Fort, bomb moved from Horndon-on-the-Hill.
26 th October 1940	Two HE bombs fell on Tilbury.
2 nd November 1940	A magnetic mine exploded beneath two Port of London Authority tugs, Lea and Deanbrook. The lock side, quay and pumping equipment all sustained serious damage.
16 th December 1940	A British Hurricane fighter (attached to 85 Squadron) crashed and exploded in the docks.
17 th May 1942	Bombs dropped on West Tilbury village, approximately 1.2km from the site, causing blast damage to the post office and several houses nearby.
4 th February 1944	Incendiary bomb attack destroyed the Tilbury Hotel, approximately 500m from the site.
23 rd February 1944	HE bomb fell in Cowper Road, Tilbury, approximately 500m from the site.
11 th June 1944	Parts of a British Mosquito night fighter found strewn across the marshes of Tilbury, Grays and West Thurrock.
16 th June 1944	V1 landed in Tilbury, causing minor damage to 135 houses and shops.
13 th January 1945	V2 Rocket fell at West Tilbury near the village, and the blast caused damage to the Kings Arm public house and to the Rectory. Both of these were located approximately 1.2km from the site.

13.6. Tilbury Record of War Damaged Properties

A record of properties in Tilbury that sustained bomb damage during WWII was obtained from Thurrock Museum. This provides the date that damage was reported, and in some cases the ordnance involved. A list of those properties located within 100m of the site is presented below, with those on the boundary of the site highlighted in bold.

Date Range	Properties Damaged	Distance from Site
1 st September 1940	No.'s 2-9, 25 and 27 Railway Cottages	Within 50m
18th September 1940	No.'s 1-32 Railway Cottages (caused by HE blast)	No.'s 13-20 on site

	No.'s 1-4, 7, 9, and 11-13 Orient Road	No.'s 11-13 on border of site
	No.'s 15-16, and 18-30 Peninsula Road	No.'s 18-30 on border of site
16 th October 1940	No.'s 1-6, 10-12, and 22-32 Railway Cottages	Within 50m

The register of damage sustained by two Railway Cottages properties (no.'s 14 and 16) on the 18th September 1940 is presented in full detail in **Annex M**.

13.7. Tilbury Docks Air Raid Precautions Bomb Census Map

A bomb census map showing HE bomb strikes, magnetic sea mine incidents, V1 Pilotless Aircraft strikes and V2 Long-Range Rocket strikes on the Tilbury Docks area was supplied by the client. It is believed that this was compiled by the Port of London Authority at the end of the war. The area covered by this map only includes the most western section of the site. This is presented in **Annex N** and discussed below.

Tilbury Docks Consolidated Bomb Map – Annex N	
Date Range	Comments
Consolidated bomb plot map: 1940 - 1945	<p>This map records a high number of HE incidents on Tilbury Docks. No bombs are recorded on site, though it is unclear whether this is due to it falling out of the remit of these particular record set – the site is shown to consist of railway track and housing in this map, and not port facilities. This is likely to be the case, given that other sources record damage to the Railway Cottages, which is not recorded on this map.</p> <p>The nearest recorded strike to the site is plotted on allotment gardens, approximately 100m to the west of the site boundary.</p>

13.8. WWII-Era Aerial Photographs

High resolution scans of WWII-era aerial photography for the site area were obtained from the National Monuments Record (Historic England) to cover the site area. Imagery dated from 1944 – 1946 is presented in **Annex O**.

18th April 1944 – This image presented in **Annex O1** primarily shows the central and western sections of the site. The majority of the site is shown to consist predominantly of open, undeveloped marshland, with no indication of active use. Anti-glider obstacles are shown to be installed on these marshes (and are discussed in further detail in [Section 14.4](#)) which would suggest that the area was not regularly accessed by civilian personnel. Due to the soft nature of this ground cover as well as the quality of the imagery, it is not possible to make a reliable visual assessment on the presence of bomb damage in this area. Several small structures are located on these marshes which are shown to be intact, and are likely to be in agricultural use on the extremities of the open land. The south-eastern section is shown to border an industrial works, which also appear to be intact. A railway line and roadway (Fort Road) is shown to run through the centre of the site.

The western section shows the part of the site containing the West Tilbury (Railway) Junction, as well as part of Ferry Road. Within the junction, various engine sheds, storage units and track are shown to be present. The ground appears to be vegetated in nature. Also in this area is a cleared patch of land which 1938 OS mapping (see **Annex D2**) suggests previously housed a row of 'Railway Cottages'. Similarly, along Ferry Road, the site contains another segment of cleared ground which is shown in the same map edition to have previously housed a row of 'Workingmen's Dwellings'. Cleared ground is often indicative of serious bomb damage, to the extent that the structures were deemed necessary to

demolish. The remainder of the site in this section appears to be hard-standing, aside from a small area in the north-western corner.

Also shown in the image is a number of military camps and installations in the general Tilbury area – these are discussed in further detail in [Section 14](#).

11th October 1946 – This image presented in **Annex O2** shows the central and eastern sections of the site at a later date than the previous image. Again the majority of the site consists of marshland, aside from the area in its most south-eastern point which stretches over a segment of the River Thames. There is no suggestion that the marshland in the south-eastern section of the site received any access from the neighbouring industrial works. As with the previous image, it is not possible to identify signs of bomb damage on the ground. Military activity in the area is shown to be totally removed by this date, including the removal of the anti-glider obstructions on site.

13.9. Visual Representation of Bomb Damage

The clearance and bomb damaged areas evident on the RAF aerial photography dated 18th April 1944 is highlighted in **Annex P**. Due to the vague nature of references to bombing incidents in records, it is not possible to create an accurate map of bombing incident locations. However, a visual representation of bomb damage in the area has been produced based on clear visual indications of bomb damage in Tilbury town, as well as the properties listed as damaged in [Section 13.6](#) (obtained from Thurrock Museum). This shows that bomb damage was spread through much of the town. It should be noted that while these properties are listed as damaged, this is believed to include properties that received slight cosmetic damage as RAF aerial photography shows many ‘damaged’ properties to be intact, and standing.

13.10. 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. Each of these 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 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 a Naval Coast MQL, approximately 1.6km to the east of the site. This Naval Decoy was installed to protect shipping concentrations on the Thames near Tilbury and Gravesend.

13.11. 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 were 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 on the site of proposed works. The nearest is recorded in the River Thames, opposite Gravesend Rowing Club, approximately 800m south-west of the site.

13.12. 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 Port of Tilbury London Limited will be advised.

13.13. Evaluation of Bombing Records

Item	Conclusion
<p>Density of Bombing</p> <p><i>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.</i></p>	<p>The Urban District of Thurrock was subject to a Moderate density of bombing with 46 items recorded per 1,000 acres. Tilbury was specifically targeted by the Luftwaffe due to the presence of Tilbury Fort (a coastline defensive fortification) and Tilbury Docks, which held significant commercial value for the country. Thurrock ARP incident records indicate a large number of bombing incidents in the surrounding area of the site, though due to the often vague nature of records the locations of these cannot be confirmed. It is likely that at least one incident occurred on/in close proximity to the site in the location of the WWII-era 'Railway Cottages'.</p>



<p>Ground Cover</p> <p><i>The type & amount of ground cover existing during WWII would have a substantial influence on any visual indication that may indicate UXO being present.</i></p>	<p>The ground cover on site was mixed in composition during WWII. Much of the eastern and central sections of the site consisted of marshland. There is the potential that such ground cover can provide UXO a means to go unnoticed. A small area in the south-eastern corner of the site was also located on the River Thames – in this area it is likely that dropped UXO would not have been visible. The western section of the site was located on the West Tilbury (Railway Junction), and Tilbury Docks. This section contained parts of several properties (the ‘Railway Cottages’ and on ‘Orient Road’), as well as railway infrastructure. It is anticipated that strikes in this area would have caused major visible disturbance. However, RAF aerial photography from 1944 shows these properties to be cleared by the end of the war, possibly as a result of bomb damage. Had this been the case and resulting rubble/debris been present on site, it is possible that UXO may have fallen undetected.</p>
<p>Access Frequency</p> <p><i>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 are also likely to have been subject to post-raid checks for evidence of UXO.</i></p>	<p>It is not believed that the majority of the site, located on marshland, was accessed frequently during the war. WWII-era imagery shows that anti-glider obstructions were located on this marshland, which would indicate that the land was primarily used for defence against land invasion, and therefore left undeveloped. Parts of the land located closer to the railway line, roadways and structures may have received some degree of access, albeit marginal. The western section of the site located near Tilbury Docks it is anticipated to have received a regular degree of access due to its importance to transport and the functioning of the docks, however direct access may have significantly decreased to bomb damaged areas.</p>
<p>Damage</p> <p><i>If buildings or structures on a site suffered 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</i></p>	<p>Thurrock ARP incident records, and the Tilbury War Damage Register indicate that the ‘Railway Cottages’ properties located in the western section of the site sustained bomb damage during WWII, and were subsequently cleared. There is also what appears to be a sizeable clearance area further to the west in this same section. Pre-war OS mapping from 1940 shows ‘Workingmen’s Dwellings’ in this location. It is possible that further strikes on damaged areas, prior to clearance, may have been overlooked and not recorded. Potential bomb damage in the remainder of the site is not clear due to the soft nature of much of the ground/presence of water, and the quality of available aerial wartime imagery.</p>
<p>Bomb Failure Rate</p>	<p>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.</p>
<p>Abandoned Bombs</p>	<p>1st Line Defence holds no records of abandoned bombs within the site vicinity. The nearest is recorded in the River Thames, approximately 800m south-west of the site.</p>
<p>Bombing Decoy sites</p>	<p>1st Line Defence could find no evidence of bombing decoy sites in the immediate vicinity of the site. The nearest was located approximately 1.7km to the east of the site.</p>
<p>Bomb Disposal Tasks</p>	<p>1st Line Defence could find no evidence of Bomb Disposal Tasks within the site boundary and immediate area.</p>

14. The Risk from Allied Military Ordnance

14.1. General

In addition to the risk from aerial delivered UXO, this report also assesses the potential risk from Allied military ordnance. Contamination from items of Land Service (LSA) and Small Arms Ammunition (SAA) may result, for example, from historic occupation of an area or its use for military training. Proximity to HAA batteries can also put the site at risk from buried unexploded Anti-Aircraft projectiles fired during WWII.

Tilbury held a role in coastal defence dating back for several centuries and during WWII had a significant Allied presence. The town was heavily involved in the Normandy Landings of 6th June 1944. The general area surrounding the site also contains a large number of 'anti-invasion' defensive sites.

14.2. Tilbury Fort

The construction of the first fortifications at Tilbury came as a result of Henry VIII's review of coastal defences in the mid-sixteenth century. While they did not see any action, the fort was still held up as a key strategic point in the defence of the capital. In 1588, a camp for troops was created close to the fort in response to the threat of the Spanish Armada. The fort was re-strengthened in the seventeenth century following Dutch attacks on the Thames. Barracks were added in the early eighteenth century, as part of attempts to turn Essex into a county-wide armed camp ready to combat the danger of invasion. The Crimean War of the mid-nineteenth century however saw the relegation of Tilbury to Britain's second defensive line, as the main defensive line moved closer to the sea.

During WWI, for the fort was armed with anti-aircraft guns, which were claimed to have shot down a German Navy Zeppelin airship, L15. The fort was garrisoned until the 1920s, but fell into disuse until the Second World War when the Home Guard took over control of the fort. In the earlier part of the war the 'gun operations room' which controlled AA guns on the Thames and Medway was based in the fort's chapel, before moving to Vange in Basildon in 1940. The waste ground around the fort was also used in this period to detonate UXBs that were often brought from other areas. The fort was extensively damaged during the Second World War by German bombers, including the destruction of a barrack block. Tilbury Fort was never involved in any of the direct conflict for which it was designed, and the only casualty occurring at the fort was in 1776 following a heated cricket match between Essex and Kent.

Records state that the fort stored AA shells as well as other ammunition during WWI, and was occupied by the Home Guard in WWII.

14.3. D-Day Preparations in Tilbury

The preparation for the invasion of continental Europe, 'Operation Overlord', was complex and far reaching. Tilbury, as with many of the coastal towns in southern England, was heavily involved. In the build-up to D-Day, important places in the country were designated as 'Marshalling Areas', which held men and vehicles prior to embarkation. The construction of these involved the erection of temporary hutments, as well as quickly laid tarmac road systems. The Tilbury area was located in 'Marshalling Area S'. Within this, the residential part of Tilbury was located in 'Sub-Area S2', and the Tilbury Docks in 'Embarkation Area E5'. A map showing this 'Marshalling Area' and its relation to the site is shown in **Annex Q** (a key is presented in **Annex Q2**).

A number of installations were located across the area. Embarkation HQ was situated at St. Chads School, which had direct lines to all other control sites; the Royal Army Service Corps (RASC) held stores at Sheds 12, 32 and 33 in the dock; the Quartermaster held stores at the Salvation Army hut in the town; the Maritime Royal Artillery Headquarters were situated at 3 Lawrence Cottages; and a Gas

Decontamination Centre was located on Quebec Road. As well as this, three embarkation hards were located in Tilbury Docks, and various other temporary camps and security posts in the town.

RAF aerial photography dated 18th April 1944 shows many of these installations/military camps in the surrounding area of the site. Visible in the image are several tented army camps and requisitioned army buildings. These are highlighted in **Annex R1**, and shown in more detail in **Annex R2**. Aerial photography dated 11th October 1946 shows the military presence to be largely removed by this point, though it reveals a pillbox outside the eastern part of the site (the limitations of the previous image do not show this). The location of this is annotated in **Annex R3**.

The Docks were also involved in two vital projects relating to ‘Operation Overlord’. The first of these was the construction of the ‘Mulberry Harbours’, which acted as floating breakwaters (made of concrete units) to be sunk off the coast of Normandy during D-Day. The second important device was the PLUTO (Pipe-Lines Under The Ocean), which consisted of underground oil pipelines under the English Channel. These were constructed in two newly-made factories on Port of London Authority land in Tilbury, both located approximately 2km to the north-west of the site. It was the duty of the P.L.A. police to maintain a high level of security and keep the area in ‘blackout’ – a permit was required to enter the docks area.

The first 200 wounded soldiers from the Normandy landings arrived in Tilbury on 10th June 1944, and injured servicemen continued to arrive through Tilbury for the rest of the war.

14.4. Allied Defensive Positions

The area surrounding the proposed site contained a number of defensive military installations during WWII, mostly due to its vulnerability as an invasion site and formed an extension of the Thames coast defensive line. Towards the latter stages of WWII several additional positions were constructed in conjunction with a number of army billets/camps surrounding the main residential area of Tilbury. The remains of many of these features are still visible today. The locations of allied defensive positions in the immediate vicinity of the site (as well as notable Allied positions in the wider surrounding area) have been checked and are summarised below.

Allied Defensive Positions	
Position	Comments
Pillboxes	A non-hexagonal type pillbox was in operation in close proximity to the south-eastern corner of the site on the Thames coastline, at a distance of approximately 50m from the site. Another pillbox was situated on Tilbury Fort, approximately 400m from the site.
Mortar Emplacements	Several Spigot type Mortar emplacements were located on Tilbury Fort, from approximately 450m away from the site. Spigot Mortars were specifically used as an anti-tank weapon against land invasion, but could also be used as an anti-aircraft defence.
Pipe Mines	Two pipe mines are recorded in the surrounding area of the site, approximately 800m and 1km to the north of the site. These items typically comprised a horizontally bored pipe packed with explosives, used to instantly create an anti-tank obstacle or to ruin a road or runway thereby denying its use by an enemy.
Anti-Glider Obstructions	Anti-glider obstructions were present over much of the site during WWII, on the West Tilbury Marshes. These features commonly consisted of lines of linear trenches and were constructed across coastal areas to prevent landing of enemy aircraft in open areas. An aerial image of these on site, and generic images of these installations in general, are presented in Annex S .

Minefields	An electrically fired mine field was located on the river's edge near Coalhouse Fort, approximately 3km east of the site.
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14.5. Land Service Ammunition

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

Mortars	A bomb, normally nosed-fused and fitted with its own propelling charge. Its flight is stabilised by the use of a fin. They are usually tear-dropped shape (though older variants are parallel sided) with a finned 'spigot tube' screwed or welded to the rear end of the body which houses the propellant charge. They are either High Explosive or Carrier (i.e. smoke, incendiary or pyrotechnic).
Grenades	A short range weapon (explosive range 15-20m) which can be thrown by hand or alternatively fired from the end of a rifle or a purposely designed grenade launcher. They can either be High Explosive or Carrier (usually smoke) and common variants have a classic 'pineapple' shape.
Projectiles	A projectile (or shell) is defined as an object which can be propelled by force, normally from a gun, and continues in motion by virtue of its kinetic energy. It contains a fuzing mechanism and a filling. Projectiles can be High Explosive, Carrier or Shot (a solid projectile).
Rockets	A rocket is defined as a missile that obtains thrust from a rocket engine. Military rockets are used to propel warheads to an intended target. This warhead will contain an explosive charge normally initiated on contact or at a predetermined height / proximity from target.
Landmines	A landmine is a munition designed to be placed under, on, or near the ground or other surface and to be exploded by the presence, proximity or contact of a person or vehicle.

Unexploded or partially unexploded Mortars and Grenades are among the most common items of LSA encountered in the UK as they could be transported and utilised anywhere. They are commonly encountered in areas used by the military for training and are often found discarded on or near historic military bases.

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

Images of the most commonly found items of LSA are presented in **Annex T**.

14.6. Small Arms Ammunition

The most common type of ordnance encountered on land utilised by the military are items of Small Arms Ammunition (SAA). SAA can be accidentally initiated by striking the rear part of the casing or if thrown into a fire. However, even if an item functioned the explosion would not be contained within a barrel and detonation would only result in local overpressure and very minor fragmentation from the cartridge case. Images of SAA are presented in **Annex U**.

14.7. Defending Thurrock from Aerial Attack

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

Passive Defences	Active Defences
These included defence tactics such as: <ul style="list-style-type: none"> 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 targets 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: <ul style="list-style-type: none"> Fighter aircraft to act as interceptors. Anti-aircraft gun batteries. The use of rockets and missiles (later during WWII).

14.8. Anti-Aircraft Artillery (AAA) and Projectiles

At the start 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 and 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 and 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 and, from 1942, large 5.25 inch weapons began to be 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 1800m.

The HAA projectiles were high explosive shells, usually fitted with a time delay or barometric pressure fuze to make them explode at a pre-determined height. If they failed to explode or strike an aircraft, they would eventually fall 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 the ground they did not have great penetration ability and are therefore likely to be found close to WWII ground level. These shells are frequently mistakenly identified as small German air-delivered bombs, but are differentiated by the copper driving band found in front of the base. With a high explosive fill and fragmentation hazard these items of UXO present a significant risk if encountered. The smaller 40mm projectiles are similar in appearance and effect to small arms ammunition and, although still dangerous, present a lower hazard because of a lower 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.

Several HAA batteries were located in the surrounding area of Tilbury, the nearest approximately 1.2km to the south of the site in Gravesend. Another was located approximately 1.8km to the east near East Tilbury.

An LAA (32) battery was also situated at Tilbury, and housed 20 light guns. The exact location of this is unknown. As well as this, the Mortar emplacements situated at Tilbury Fort, from approximately 450m away from the site, could also be used to fire at aircraft.

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

14.9. Evaluation of Allied Military Ordnance Risk

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

Item	Conclusion
Military Camps	Tilbury was involved in the D-Day preparations, and was situated in Marshalling Sub-Area 'S2'. As a result, a number of military camps and facilities were located in the surrounding area of the site, the closest activity being a tented camp approximately 35m from the site boundary.
Anti-Aircraft Defences	The nearest HAA battery to the site was situated approximately 1.2km to the south. An LAA battery was also situated in Tilbury, and Spigot Mortar emplacements at Tilbury Fort which were at times used as makeshift anti-aircraft defences.
Home Guard Activity	Evidence suggests that the Home Guard were stationed at Tilbury Fort and the Tilbury Docks during WWII. Groups in the Essex battalions intended to defend the Thames from any land invasion of the county.
Defensive Positions	Anti-glider obstructions were located over much of the eastern and central parts of the site, on Tilbury Marshes. Pillboxes/coastal batteries and mortar emplacements were also located in the surrounding area of the site, including on Tilbury Fort. It is possible that ordnance was burnt, buried or improperly disposed of on-site/in its surrounding area between these installations.
Training or firing ranges	No evidence of these in close proximity to the site could be found.
Defensive Minefields	No evidence could be found of defensive minefields in close proximity to the site. The nearest recorded was a minefield across the River Thames off Coalhouse Fort, approximately 3km to the east.

Ordnance Manufacture	No evidence of ordnance manufacture could be found.
Military Related Airfields	The site was not situated in the immediate vicinity of a military airfield. The nearest was RAF Gravesend, located approximately 4km to the south-east of the site.
Explosive Ordnance Clearance Tasks	1 st Line Defence has evidence of an ordnance clearance operation in Tilbury – see Section 15.2 . We have not received confirmation whether any official ordnance clearance operations have taken place on site.

15. Ordnance Clearance and Post-WWII Ground Works

15.1. General

The extent to which any ordnance clearance activities have taken place on site or extensive ground works have occurred is relevant since on the one hand they may indicate previous ordnance contamination but also may have reduced the risk that ordnance remains undiscovered.

15.2. UXO Clearance

1st Line Defence has evidence of an ordnance clearance operation conducted by 33 EOD Regiment in Tilbury, though the exact location is unknown. This resulted in a find of a German-dropped 250kg HE, which is pictured in **Annex W**. We have not received confirmation whether this, or any other official ordnance clearance operations have taken place on site.

15.3. Post war Redevelopment

There has been a significant amount of re-development on the site post-WWII. The extent of the developments and depth of foundations can partly mitigate the UXO risk as any present items of UXO may have been uncovered during the works.

Tilbury Power Station was constructed post-war in the south-eastern section of the site, including a number of industrial structures and large patches of hard-standing ground. Several other industrial units, patches of hard-standing ground and roadways have also been constructed and are sparsely spread in the remainder of the eastern and central sections of the site. In the western section of the site, a car-parking area has been developed as well a new roadway (St. Andrews Road) and general ground development in Tilbury Docks.

Development of structures, roadways, and patches of hard-standing ground will have required minimal excavation work. Where this development has taken place the risk of encountering shallow buried UXO, especially 1kg incendiaries and anti-aircraft projectiles will have been partly mitigated.

It is not known whether any development will have required deeper foundations. The risk from deep-buried unexploded bombs is only considered mitigated at locations where post war piling or deep foundations have taken place.

16. 1st Line Defence Risk Assessment

16.1. Risk Assessment Stages

Taking into account the quality of the historical evidence, the assessment of the overall risk to the proposed works 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, Thurrock ARP incident records, Tilbury War Damage Register, Tilbury Docks bomb census map, local sources and in-house data and post-WWII era aerial photographs for the site. The record is of reasonable quality, with much detail given to the nature of military activities in the area. While a number of records relating to bombing incidents was obtained, these are often vague in relation to the location of strikes and it is also anticipated that incidents may have not have been specifically recorded on the marshland which covers much of the site.
The Risk that the Site was Contaminated with UXO	<p>After considering the following facts, 1st Line Defence considers there to be a Medium Risk that items of unexploded German air-delivered ordnance could have fallen unnoticed and unrecorded within the site boundary, and a Low-Medium Risk of the site being contaminated with Allied ordnance.</p> <p>German UXB Risk</p> <ul style="list-style-type: none"> • During WWII the Urban District of Thurrock was subject to a Moderate density bombing campaign, with 46 items falling per 1,000 acres. The majority of the site was located on West Tilbury Marshes, in close proximity to Tilbury Docks (part of the site was situated on this complex) and Tilbury Fort. Both of these premises were targeted by the Luftwaffe during the war. As well as this, its location on the Thames placed it on route for German aircraft travelling to London. • Available bomb census maps and ARP incident records plot a high localised bombing density in the Docks area, as well as in the neighbouring town. As the site was to the east of this on open ground, no bomb census mapping is available and records are less specific, due to the relative lack of importance/consequence of this area being bombed. Several references were found to incidents occurring on the open marshland (the accuracy of the high-level bombing employed during WWII generally meant that many bombs did not fall on their intended targets), but based on the available record sets, it has not been possible to determine exactly how many or where these strikes occurred. • Large sections of this area were dug with anti-glider defences, and access and checks are likely to have been minimal, possibly for the most part non-existent. The soft, scrubby nature of the groundcover would also not have been conducive to the observation of UXO entry holes even if the area had been subject to checks. The entry hole of a 50kg UXB could be as little as 20cm in diameter (and even smaller for anti-aircraft artillery projectiles) and could even close up in marshy conditions. For these reasons, no one section of the marsh can be considered a 'low' risk from having been contaminated with unexploded ordnance. It should be noted that of significant concern is the open stretch of water at the southern end



	<p>of the site. Had bombs fallen within this area, there is effectively negligible chance of them being either observed or recovered.</p> <ul style="list-style-type: none"> Some sections of the site to the west run closer to habitation and infrastructure, particularly in the western section of the site. Generally, this would improve the likelihood that evidence of UXO would be noted and reported. However, imagery has shown both similar poor ground conditions and evidence of damage to structures the closer to the Docks the site runs. There is the potential in damaged areas that due to resulting rubble/debris on the ground, subsequent strikes in the same location can go undetected, and therefore not dealt with. <p>Allied Ordnance</p> <ul style="list-style-type: none"> The report has also considered the potential for encountering unexploded ordnance relating to Allied military use of the area. It is known that D-Day preparations were conducted across Tilbury, and the Home Guard were in operation at Tilbury Fort. Several defensive positions were also present in the surrounding area. No evidence has been found of military activity directly on site which would indicate a 'high' risk of encountering UXO – although given the factors outlined in this report, the possibility certainly cannot be discounted.
<p>The Risk that UXO Remains on Site</p>	<p>Some sections of the site have been subject to significant post-war development. In the south-eastern section of the site, Tilbury Power Station was constructed including a number of industrial structures, patches of hard-standing and roadways. Infrastructure of this nature is also sparsely spread across the remainder of the eastern and central sections of the site. In the western section of the site, a car-parking area has been developed as well a new roadway and general ground development in Tilbury Docks.</p> <p>Development of structures, roadways, and patches of hard-standing ground will have required minimal excavation work. Where this development has taken place the risk of encountering shallow buried UXO, especially 1kg incendiaries and anti-aircraft projectiles will have been partly mitigated.</p> <p>It is not known whether any development will have required deeper foundations. The risk from deep-buried unexploded bombs is only considered mitigated at locations where post war piling or deep foundations have taken place.</p>
<p>The Risk that UXO may be Encountered during the Works</p>	<p>The most likely scenarios under which items of UXO could be encountered during construction works is during piling, drilling operations or bulk excavations for basement levels. The overall risk will depend on the extent of the works, such as the numbers of boreholes/piles (if required) and the volume of the excavations.</p> <p>Since an air-dropped bomb may come to rest at any depth between just below ground level and its maximum penetration depth, 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.</p>
<p>The Risk that UXO may be Initiated</p>	<p>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 than, say, machine excavation where the force of impact is generally lower and the item more likely to be observed.</p> <p>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.</p> <p>For piling works planned at the Port of Tilbury 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.</p>

The Consequences of Encountering or Initiating Ordnance	<p>The repercussions of the inadvertent detonation of UXO during intrusive ground works are potentially profound, both in terms of human and financial cost. A serious risk to life and limb, damage to plant and total site shutdown during follow-up investigations are potential outcomes.</p> <p>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 for anything from a few hours to a week with potentially significant cost in lost time.</p> <p>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.</p>
--	--

16.2. Assessed Risk Level

Taking into consideration the findings of this study, 1st Line Defence considers there to be a **Medium Risk** from unexploded ordnance on the site of proposed works.

Medium Risk

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

17. Proposed Risk Mitigation Methodology

17.1. General

A potential risk of encountering unexploded ordnance has been assessed at the Port of Tilbury site. The risk is deemed to be mainly from unexploded air-delivered bombs, though there remains also a risk from items of LSA and SAA related to military activity and defensive positions in the area.

Some sections of the site have been subject to significant post-war development, notably towards the southern end. At the locations of and down to the depth of post-war foundations and excavations, there is not considered to be a significant risk of encountering UXO or of UXO remaining. For works being undertaken within these areas and down to these depths, proactive UXO support is not deemed necessary beyond an awareness briefing.

It is recommended that any proposed boreholes and piled foundations are subject to an intrusive UXO magnetometer survey to ensure that they are clear from deep-buried ferrous anomalies. Similarly, it

is recommended that any open intrusive works in at-risk areas be either cleared where possible by a non-intrusive magnetometer survey and Target Investigation phase, or where this is not viable due to ground conditions, supported by a UXO specialist ‘Watch and Brief’.

It is understood that some areas of the site will be subject to soil stabilisation, for which ‘Watch and Brief’ will not be possible – as a result where ground conditions do not allow a non-intrusive magnetometer survey and Target Investigation phase to be carried out, an intrusive UXO magnetometer may be necessary.

For works being undertaken within the Thames in the most south-eastern section of the site, 1st Line Defence can provide various support measures from marine intrusive magnetometer survey from a fixed platform for piling to provision of UXO marine specialist to support/monitor dredging works and non-intrusive marine UXO survey.

It is recommended that further discussions are held regarding the most appropriate and cost-effective mitigation measures, based on the exact nature and scope of works planned.

The range of support options are presented below:

Type of Work	Recommended Mitigation Measure
All Works	<ul style="list-style-type: none"> • Site Specific Unexploded Ordnance Awareness Briefings to all personnel conducting intrusive works. <p>A specialised briefing is always advisable when there is a possibility of explosive ordnance contamination. It is an essential component of the Health & Safety Plan for the site and conforms to requirements of CDM Regulations 2015. All personnel working on the site should be instructed on the identification of UXO, actions to be taken to alert site management and to keep people and equipment away from the hazard. Posters and information of a general nature on the UXO risk should be held in the site office for reference and as a reminder.</p>
Shallow Intrusive Works/Open Excavations on Land	<ul style="list-style-type: none"> • A Non-Intrusive UXO Magnetometer Survey. <p>A Non-Intrusive survey is proactively carried out using a man-portable magnetometer. Data is recorded and then interpreted using advanced software in order to map magnetic fields and model discrete magnetic anomalies which show characteristics of UXO. The targets can then be relocated and investigated by a target investigation team. Where this type of survey is not practical (due to for example terrain or ground conditions), on-site UXO specialist support is recommended.</p> <ul style="list-style-type: none"> • Unexploded Ordnance (UXO) Specialist Presence on Site to support shallow intrusive works. <p>When on site the role of the UXO Specialist would include; monitoring works using visual recognition and instrumentation and 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 received them earlier and advise staff of the need to modify working practices to take account of the ordnance risk, and finally to aid Incident Management which would involve liaison with the local authorities and Police should ordnance be identified and present an explosive hazard.</p>
Borehole/Piles on Land	<ul style="list-style-type: none"> • Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth. <p>1st Line Defence can deploy a range of intrusive magnetometer techniques to clear ahead of all the pile locations. The appropriate technique is governed by a number of factors, but most importantly the site’s ground conditions. The</p>



	appropriate survey methodology would be confirmed once the enabling works have been completed.
Borehole/Piles in Water	<ul style="list-style-type: none"> • Marine Intrusive Magnetometer Survey of all Borehole and pile locations down to a maximum bomb penetration depth. <p>1st Line Defence can deploy a range of intrusive magnetometer techniques to clear ahead of all the pile locations, and conduct this from a raised platform. The appropriate survey methodology would be confirmed once the enabling works have been completed.</p>
Dredging in Water	<ul style="list-style-type: none"> • A Non-Intrusive Marine UXO Magnetometer Survey. <p>A Non-Intrusive survey is proactively carried out using a man-portable magnetometer. Data is recorded and then interpreted using advanced software in order to map magnetic fields and model discrete magnetic anomalies which show characteristics of UXO. The targets can then be relocated and investigated by a target investigation team. Where this type of survey is not practical (due to for example terrain or ground conditions), UXO specialist support is recommended:</p> <ul style="list-style-type: none"> • Unexploded Ordnance (UXO) Marine Specialist Presence on Site to support shallow intrusive works. <p>When on site the role of the UXO Marine Specialist would include; monitoring works using visual recognition and instrumentation and 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 received them earlier and advise staff of the need to modify working practices to take account of the ordnance risk, and finally to aid Incident Management which would involve liaison with the local authorities and Police should ordnance be identified and present an explosive hazard.</p>

In making this assessment and recommending these risk mitigation measures, 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

4th May 2016

This Report has been produced in compliance with the Construction Industry Research and Information Association (CIRIA) C681 guidelines for the writing of Detailed Risk Assessments in regard to the UXO risk.

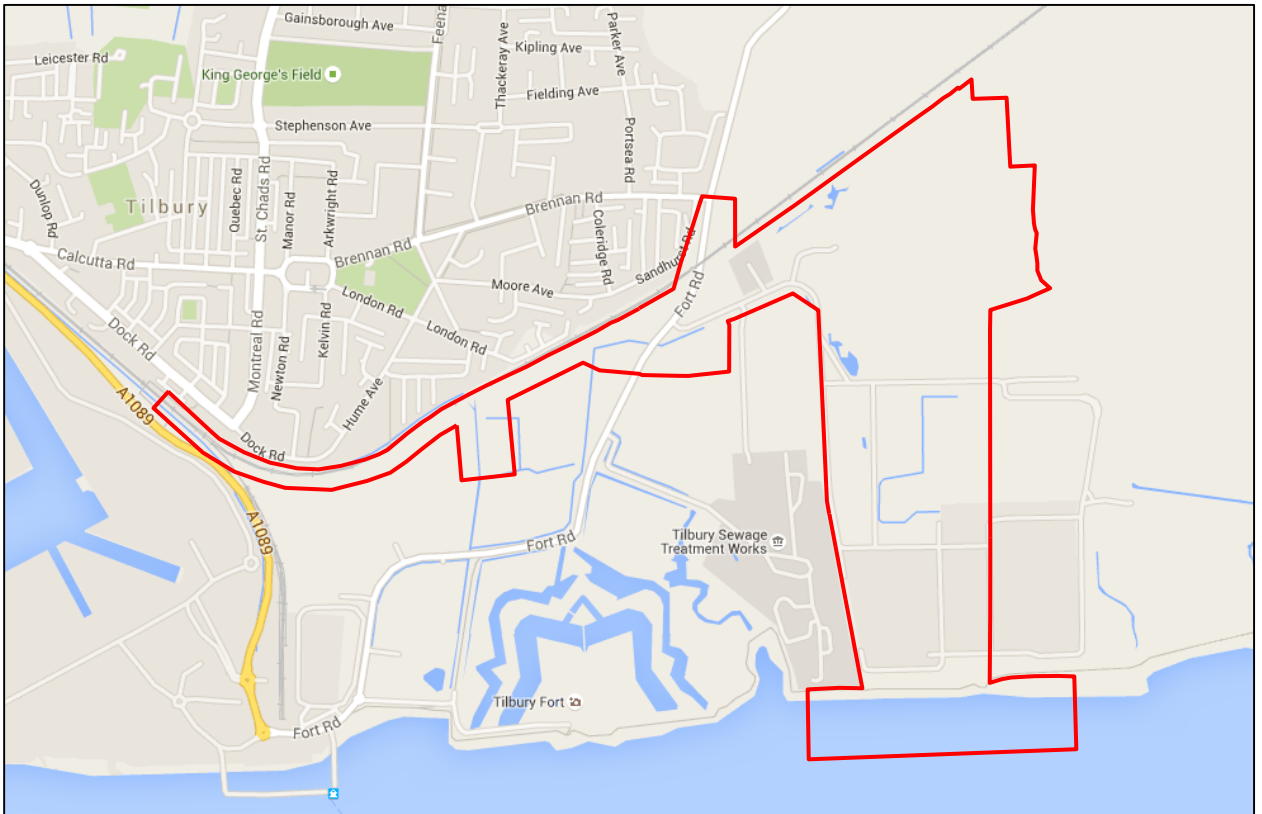
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This report has been prepared by 1st Line Defence Limited with all reasonable care and skill. The report contains historical data and information from third party sources. 1st Line Defence Limited has sought to verify the accuracy and completeness 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



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

Client: **Port of Tilbury London Limited**

Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: Google Maps

Approximate site boundary





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Project: **Port of Tilbury**

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Source: Google Earth™ Mapping Services

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RPS®		BOREHOLE LOG						Borehole No. BH-Z19-01			
Project Name: Tilbury Power Station		Co-ordinates:		Date(s): 19/05/2015 - 22/05/2015			Sheet 1 of 2				
Project No: JER6376-TB		Easting: 565557		Drilling Method: Pipe Diameter: 50mm		Hole Type: CP					
Location: Tilbury		Northing: 176389		Cable Percussion Rig.		Casing Diameter (mm) Casing Depth (m)					
Client: RWE Generation		Ground Level (mAOD): 2.43		Logged By: MV		Scale: 1:50					
Well	Water Table	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale	
		Depth (m)	Type	Results							
		0.15	ES		0.00	(0.15)	2.42		Firm brown slightly gravelly sandy SILT with roots and rootlets. Gravels are fine to coarse and subangular to subrounded flint. (MADE GROUND)		
		0.30	ES		0.15	(0.15)	2.28				
		0.50	B		0.30	(0.20)	2.12				
		0.70	ES		0.55	(0.15)	1.88				
		1.00	D		0.70		1.72				
		1.00	B								
		1.00	SPT(S)	N=13 (2,3/4,5,2,2)							
						(0.00)					Stiff dark grey slightly gravelly sandy SILT. Gravels are subangular to subrounded fine to coarse of flint and clinker. (MADE GROUND)
		2.00	D								
		2.00	UT								
		2.50	ES								
		2.70	ES		2.70	(0.30)	-0.28				Firm dark greyish green clayey sandy SILT. Sand is fine. Reworked Alluvium (MADE GROUND)
		3.00	D		3.00		-0.57				Very soft dark greenish black very organic silty CLAY. Strong organic odour noted. (ALLUVIUM)
		3.00	SPT(S)	N=0 (0,0/0,0,0,0)		(1.00)					
		4.00	D								
		4.00	UT								
		4.45	D								
		4.60			4.60		-2.17				Very soft bluish grey slightly sandy silty very organic CLAY. (ALLUVIUM)
	5.00	SPT(S)	N=3 (1 for 75mm/1,0,1,1)		(0.00)						
	6.00	D									
	6.50	UT									
	6.95	D			(0.70)						
	7.30			7.30		-4.18	Soft plastic dark brown clayey fibrous PEAT. (PEAT)				
	8.00	D									
	8.00	SPT(S)	N=0 (0,0/0,0,0,0)			-4.88	Very soft bluish grey slightly organic silty CLAY. (ALLUVIUM)				
	9.00	D									
	9.50	SPT(S)	N=0 (0,0/0,0,0,0)								
	10.00	D									
Continued on next sheet											
Remarks Hand pit excavated to 1.2 m. Unable to undertake SPT at 19m due to blowing sands.				Groundwater			Chiselling				
				Strike Depth (m)	Casing Depth (m)	Level After 20 Min (m)	Duration (Min)	Top Depth (m)	Base Depth (m)		
				1.50	1.30	1.45					
				13.40	13.00	13.40					
				14.00	13.00	2.40					



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Project: Port of Tilbury		
Ref: DA3222-01	Source: Port of Tilbury London Limited	
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Example of Borehole Data

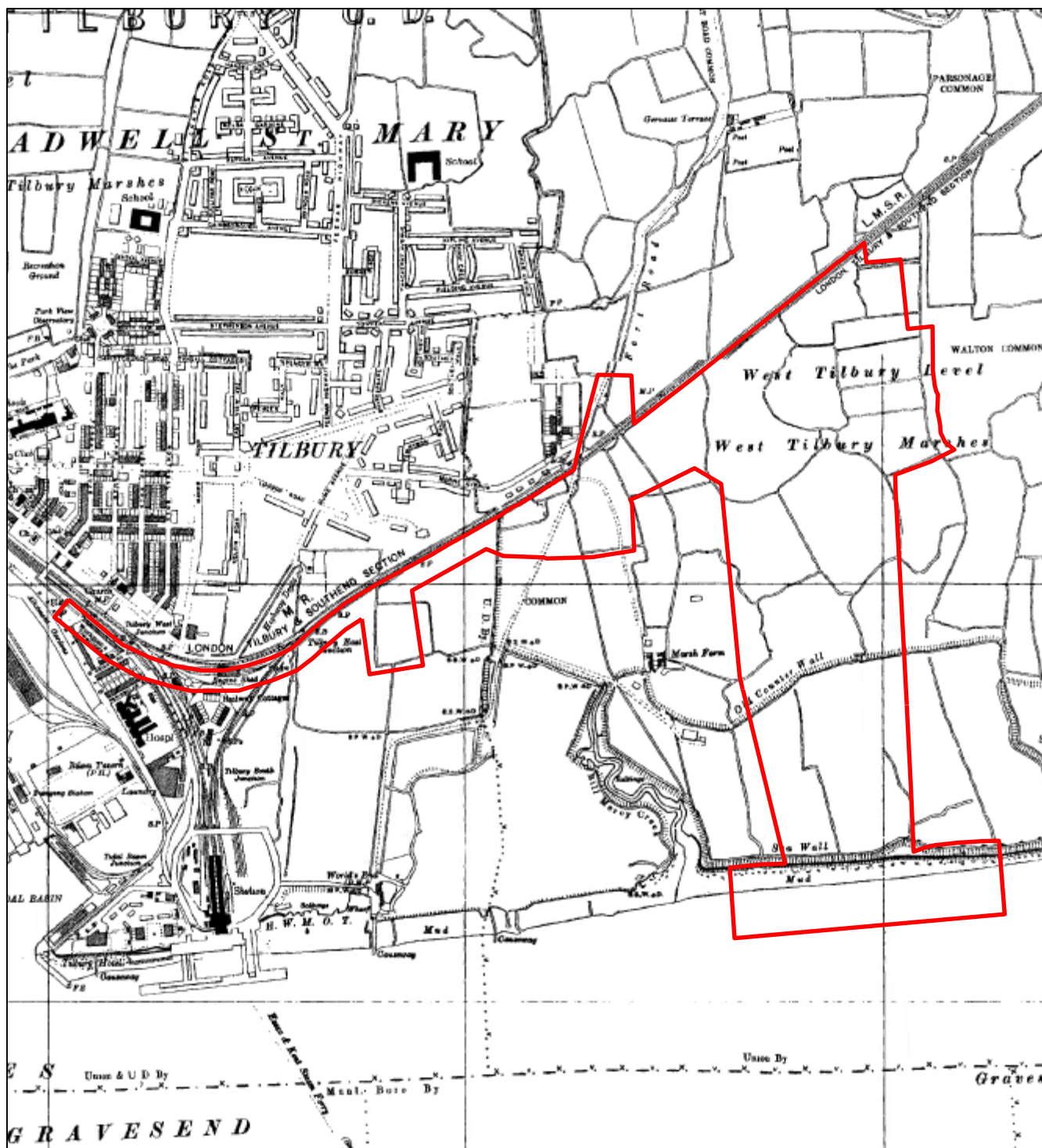
RPS®		BOREHOLE LOG					Borehole No. BH-Z19-01				
Project Name: Tilbury Power Station		Co-ordinates:		Date(s): 19/05/2015 - 22/05/2015			Sheet 2 of 2				
Project No: JER6376-TB		Easting: 565557		Drilling Method: Pipe Diameter: 50mm		Hole Type: CP					
Location: Tilbury		Northing: 176389		Cable Percussion Rig.		Scale: 1:50					
Client: RWE Generation		Ground Level (mAOD): 2.43		Logged By: MV		Casing Diameter (mm) 150 200					
						Casing Depth (m) 20.00 3.00					
Well	Water Status	Samples & In Situ Testing			Depth (mbGL)	Thickness (m)	Level (mAOD)	Legend	Stratum Description	Scale	
		Depth (m)	Type	Results							
		11.00	D							11	
		11.00	SPT(S)	N=0 (0,0/0,0,0,0)							
		11.65	D			(6.70)				12	
		12.50	D								
		12.50	UT								
		13.00	D							13	
		14.00	B		14.00		-11.58		Dense becoming very dense dark grey silty gravelly SAND. Sand is fine. Gravels are subangular to subrounded and fine to coarse of flint. (KEMPTON PARK GRAVEL MEMBER)		14
		14.00	SPT(C)	N=44 (7,7/44 for 270mm)							
		15.00	D							15	
		15.50	SPT(C)	N=50 (3,6/50 for 275mm)		(0.00)					
	16.00	D							16		
	17.00	B		17.00		-14.58		Dark grey silty sandy GRAVEL with occasional cobbles. Sand is fine to coarse. Gravels are subangular to rounded, fine to coarse of flints. Cobbles are fine. (KEMPTON PARK GRAVEL MEMBER)		17	
	18.00	D							18		
	19.00	D							19		
	20.00	D						End of Borehole at 20.00m	20		
Remarks Hand pit excavated to 1.2 m. Unable to undertake SPT at 15m due to blowing sands.				Groundwater			Chiselling				
				Strike Depth (m)	Casing Depth (m)	Level After 20 Mins (m)	Duration (Mins)	Top Depth (m)	Base Depth (m)		
				1.50	1.20	1.25					
				13.40	13.00	13.40					
				14.00	13.00	2.40					



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Source: Port of Tilbury London Limited



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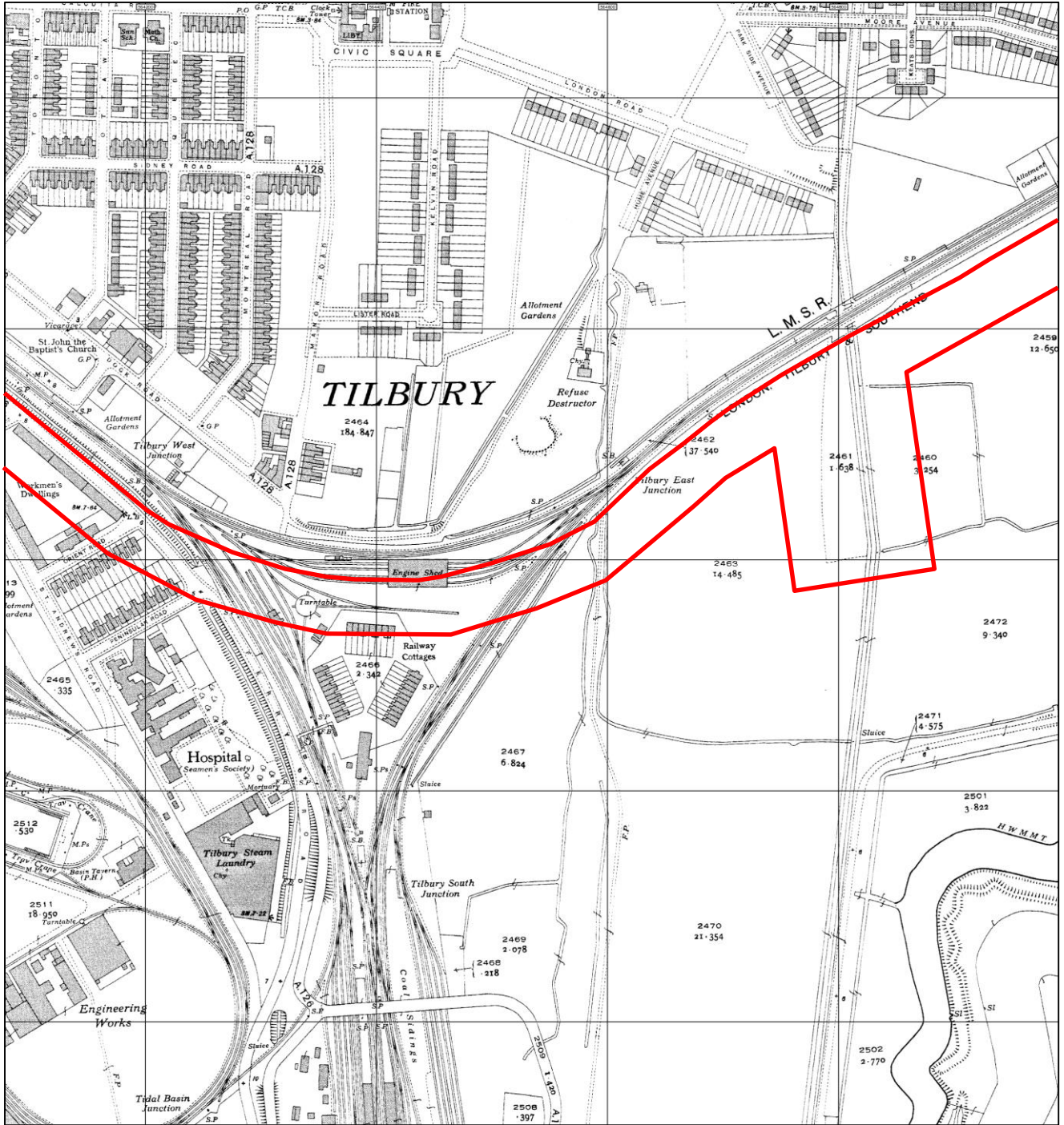
Approximate site boundary

Project: **Port of Tilbury**



Ref: **DA3222-01**

Source: Old-Maps.co.uk



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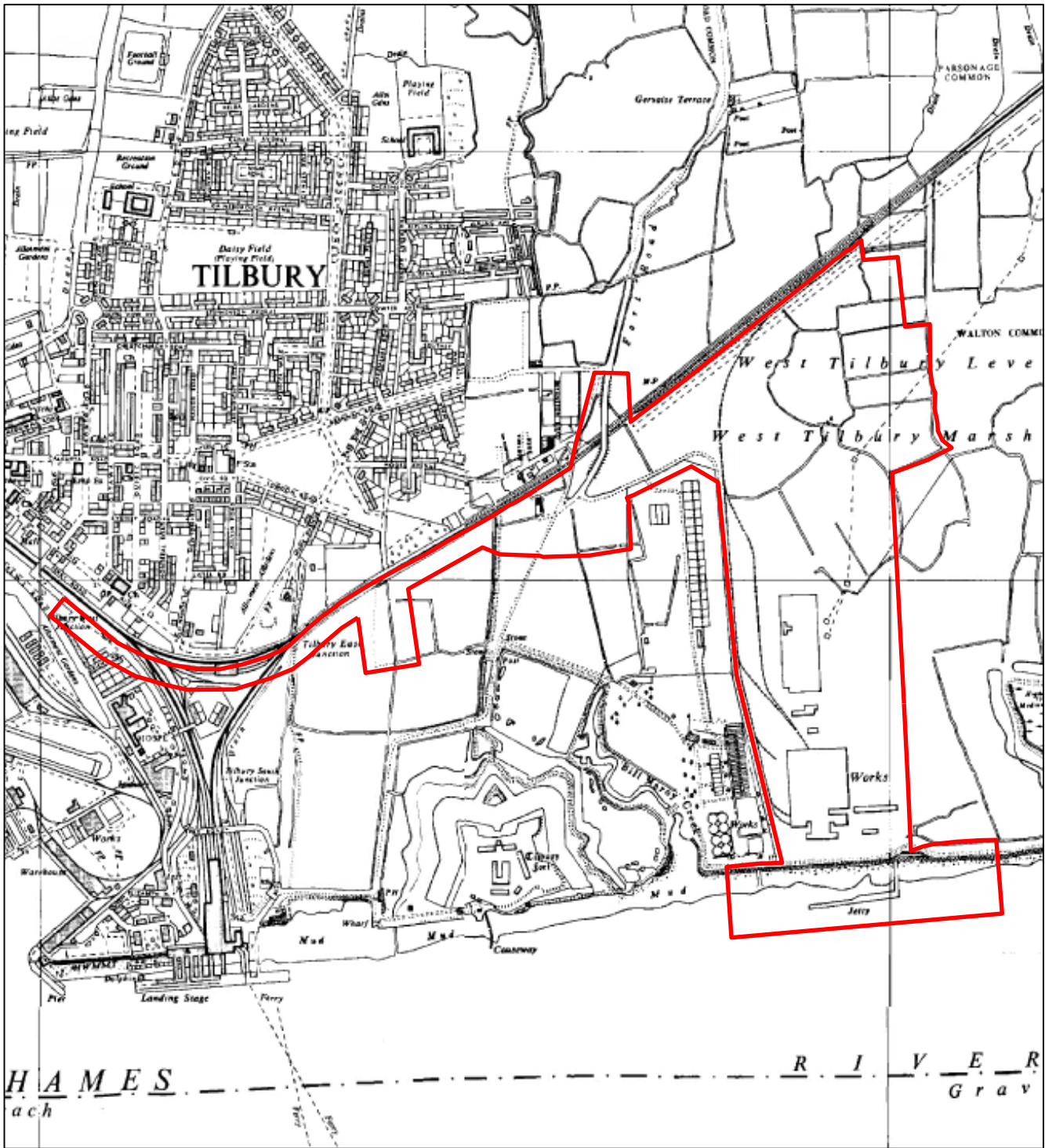
Approximate site boundary

Project: **Port of Tilbury**



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Source: Landmark Maps



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 **Approximate site boundary**

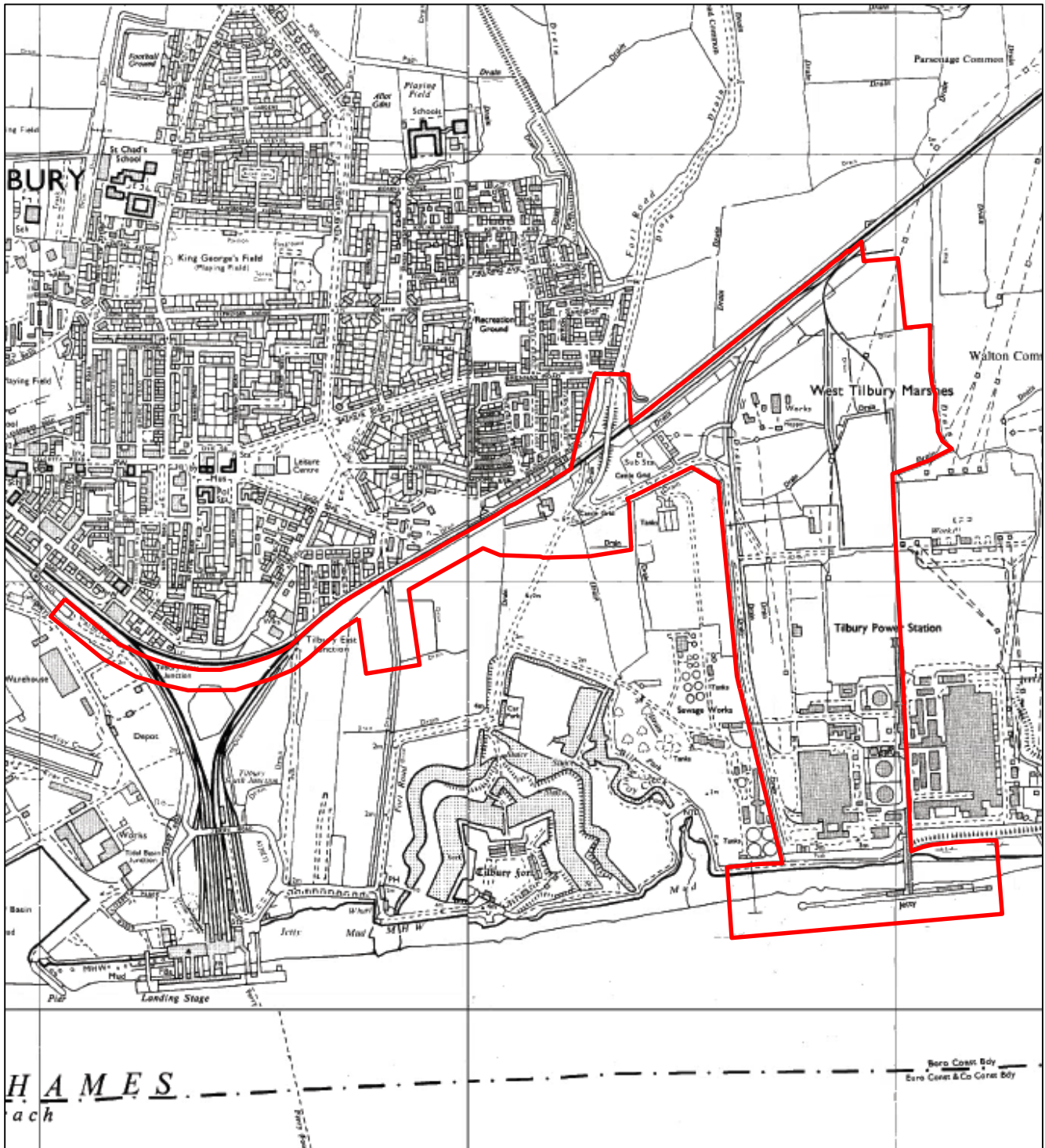


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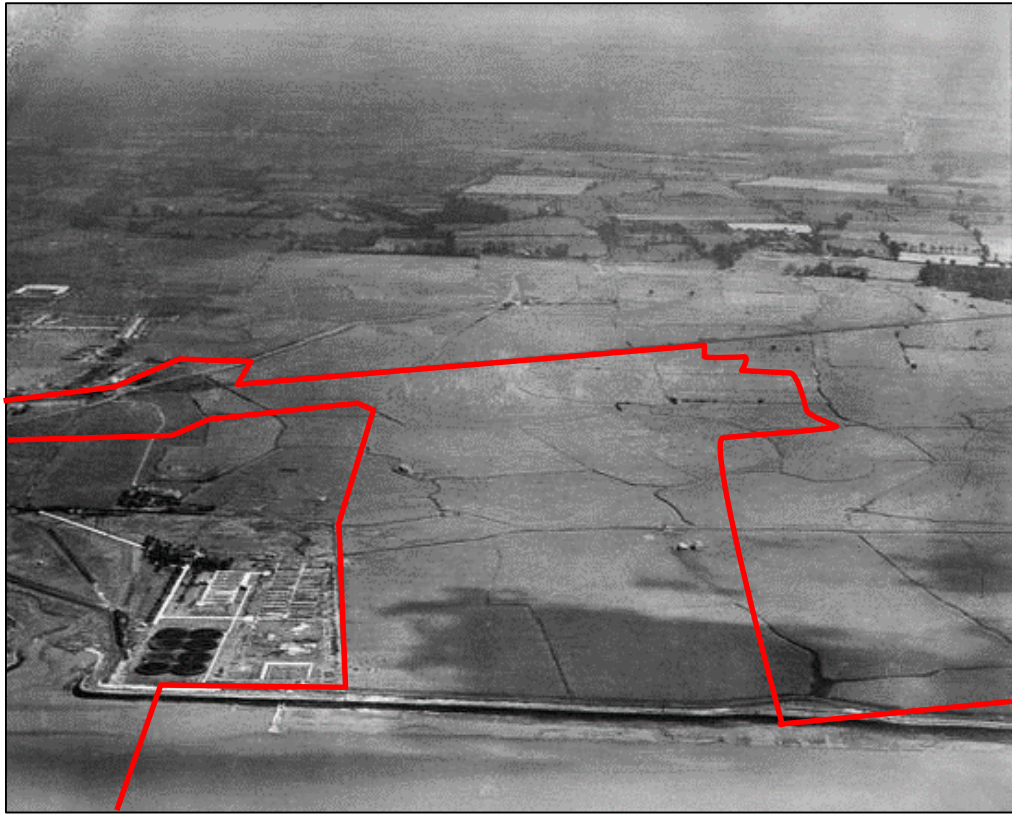
Project: **Port of Tilbury**

Ref: **DA3222-01**

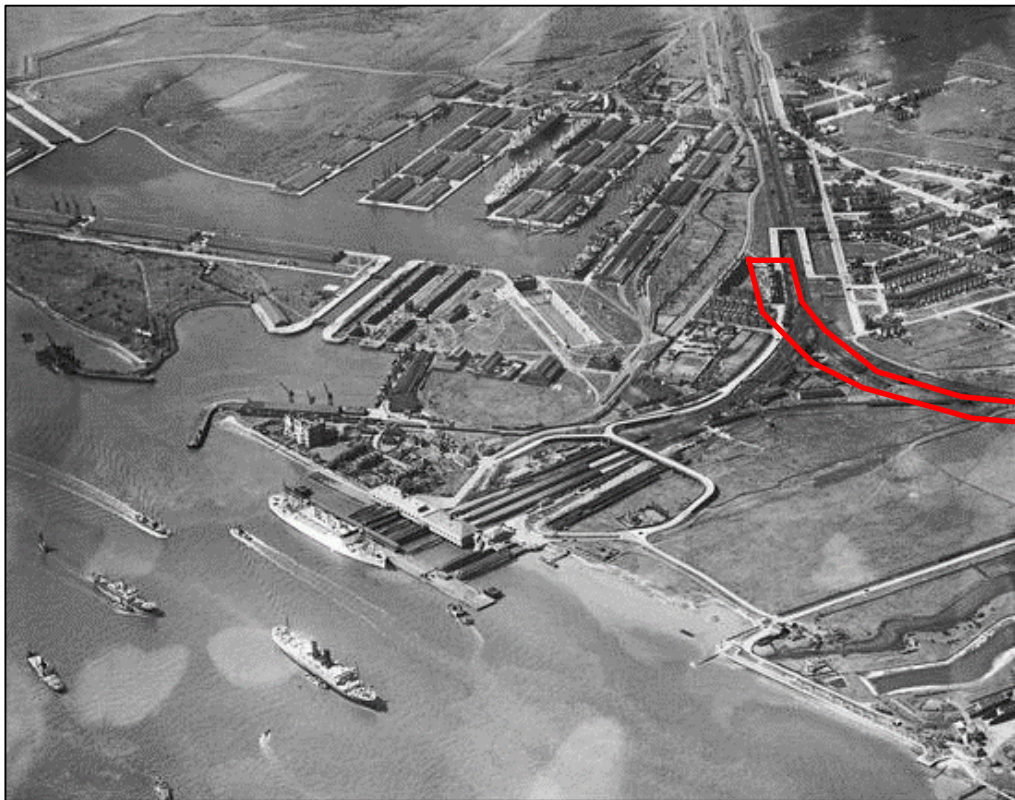
Source: Old-Maps.co.uk

 **Approximate site boundary**





Sewage works and Tilbury Marshes, Tilbury, from the south, 1938



Tilbury Docks, Tilbury, 1934



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Client: **Port of Tilbury London Limited**

 **Approximate site boundary**

Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: *Britain From Above*

SC 50kg	
Bomb Weight	40-54kg (110-119lb)
Explosive Weight	c25kg (55lb)
Fuze Type	Impact fuze/electro-mechanical time delay fuze
Bomb Dimensions	1,090 x 280mm (42.9 x 11.0in)
Body Diameter	200mm (7.87in)
Use	Against lightly damageable materials, hangars, railway rolling stock, ammunition depots, light bridges and buildings up to three stories.
Remarks	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.

SC 250kg	
Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground installations.
Remarks	It could be carried by almost all German bomber aircraft, and was used to notable effect by the Junkers Ju-87 Stuka (Sturzkampfflugzeug or dive-bomber).

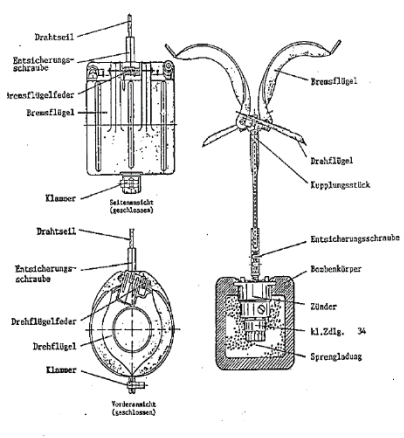

SC 500kg	
Bomb Weight	480-520kg (1,058-1,146lb)
Explosive Weight	250-260kg (551-573lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1957 x 640mm (77 x 25.2in)
Body Diameter	470mm (18.5in)
Use	Against fixed airfield installations, hangars, assembly halls, flyovers, underpasses, high-rise buildings and below-ground installations.
Remarks	40/60 or 50/50 Amatol TNT, trialene. Bombs recovered with Trialene filling have cylindrical paper wrapped pellets 1-15/16 in. in length and diameter forming

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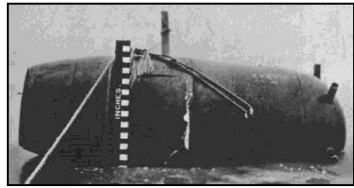

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Client: Port of Tilbury London Limited		
Project: Port of Tilbury		
Ref: DA3222-01	Source: Various sources	

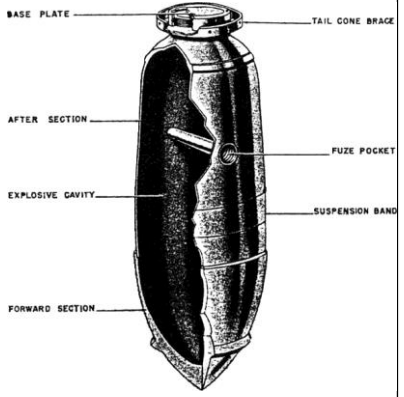
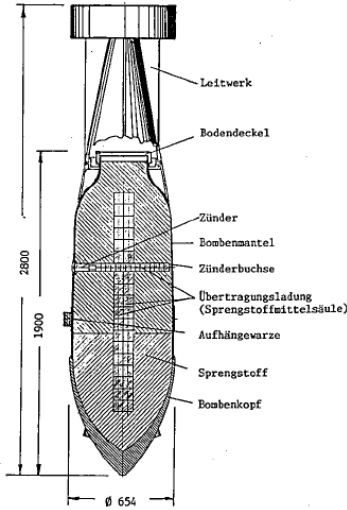
SD2 Butterfly Bomb	
Bomb Weight	2kg (4.41lb)
Explosive Weight	7.5oz (225 grams) of TNT surrounded by a layer of bituminous composition.
Fuze Type	41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuze (anti-handling device)
Bomb Dimensions	Length 240 mm Width 140 mm Height 310 mm
Body Diameter	3in (7.62 cm) diameter, 3.1in (7.874) long
Use	It was designed as an anti-personnel/fragmentation weapon. They were delivered by air, being dropped in containers that opened at a predetermined height, thus scattering the bombs.
Remarks	The smallest and most common conventional German bomb. Nearly 70% of bombs dropped on the UK were 50kg.

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

SC 1000kg	
Bomb Weight	996-1061kg (1,058-1,146lb)
Explosive Weight	530-620kg (551-573lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Filling	Mixture of 40% amatol and 60% TNT, but when used as an anti-shipping bomb it was filled with Trialen 105, a mixture of 15% RDX, 70% TNT and 15% aluminium powder.
Bomb Dimensions	2800 x 654mm (77 x 25.2in)
Body Diameter	654mm (18.5in)
Use	SC type bombs are General Purpose Bombs used primarily for general demolition work. Constructed of parallel walls with comparatively heavy noses. They are usually of three piece welded construction



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Project: **Port of Tilbury**

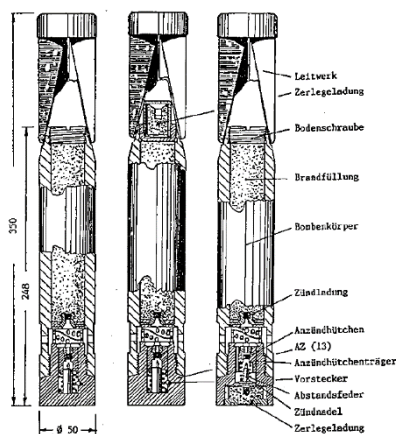
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German Incendiary Bombs

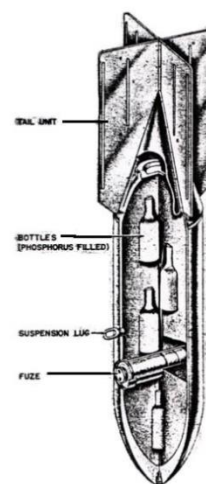
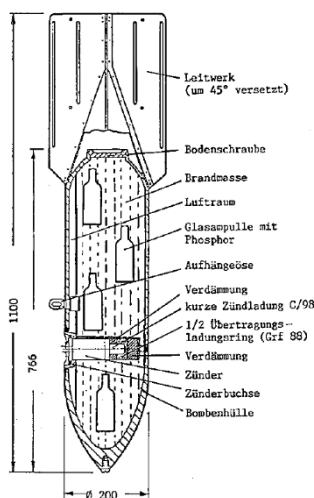
1kg Incendiary Bomb

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



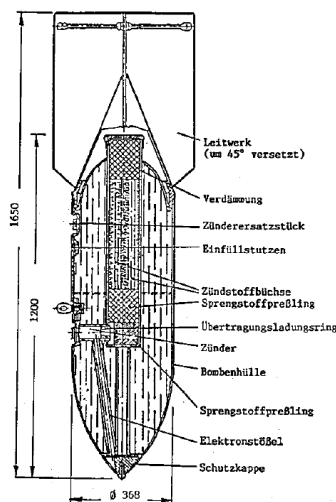
C50 A Incendiary Bomb

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



Flam C-250 Oil Bomb

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



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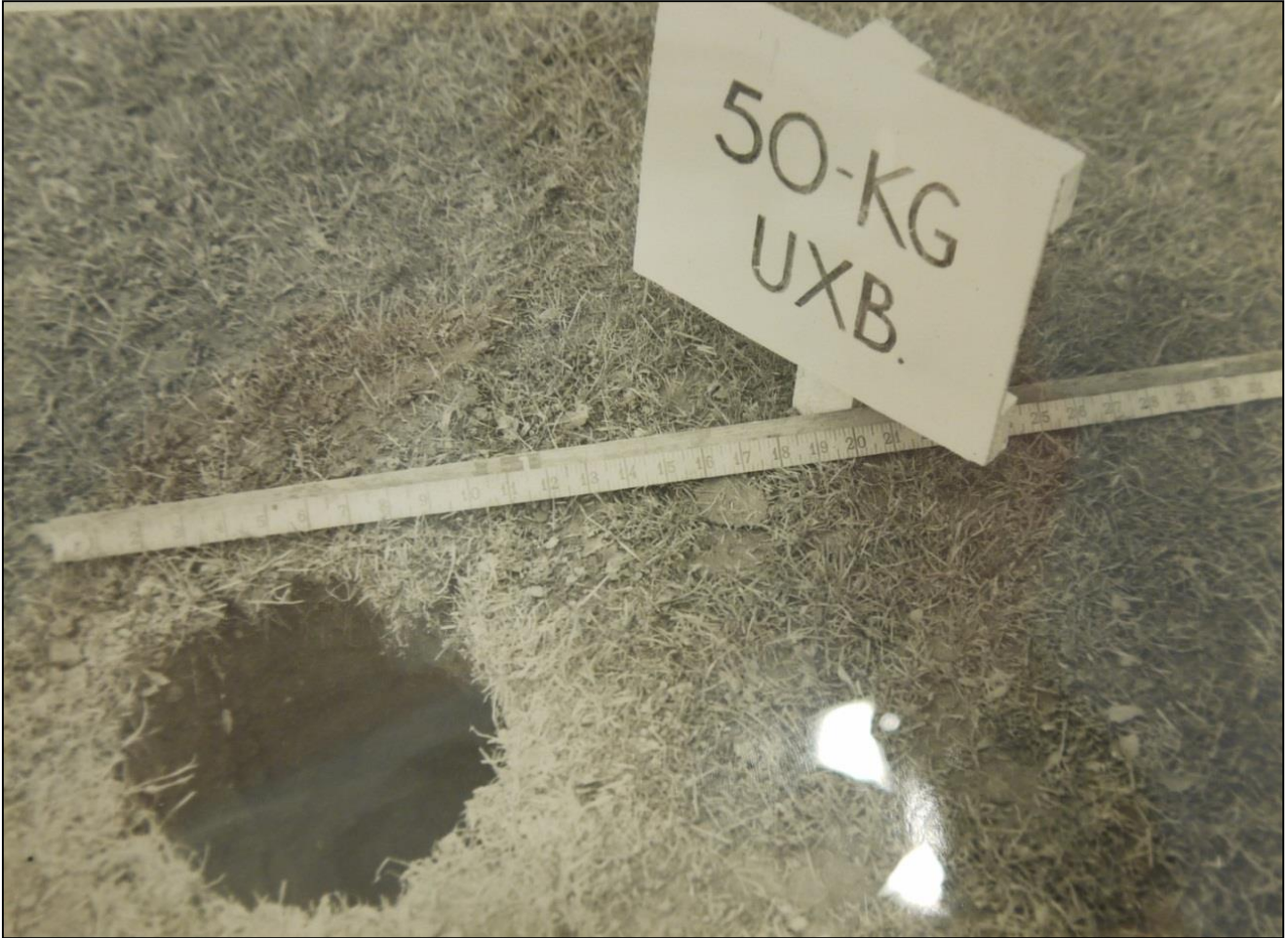
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German 50kg HE Bomb Entry Hole



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Examples of UXO incidents in the UK

LIVE BBC NEWS CHANNEL

Page last updated at 14:45 GMT, Friday, 22 May 2009 15:45 UK

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Building site WWII bomb exploded

A controlled explosion has been carried out on a World War II bomb found on a building site in East Sussex.

The 110lb (50kg) SC50 bomb, thought to have been dropped from a German aircraft in 1940 or 1941, was found at the Hollenden House site in Bexhill.

Children at St Peter and St Paul Primary School next door in Buckhurst Road were sent home early after the discovery on Thursday.

Police said a 160ft (50m) cordon was put round the site during the blast.



Breaking News: UXB in Beckton - controlled explosion ends the drama

Colin Grainger, Editor

Sunday, December 19, 2010

9:32 AM

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Bomb disposal experts carried out a controlled explosion last night on a 250kg World War II shell discovered at Britain's largest sewage works.

Bomb disposal experts carried out a controlled explosion last night on a 250kg World War II shell discovered at Britain's largest sewage works.

The bomb was found at Beckton sewage works off Jenkins Lane after surveyors preparing the site for a £200m expansion detected an unusual magnetic force underground on Saturday morning.

The Thames Water workers immediately alerted police and army ordnance experts, who attended the site and confirmed it was an unexploded German warhead.

A 400-metre exclusion zone was set up before the bomb was destroyed at the works under controlled conditions at 9pm on Saturday.



The World War Two bomb that was found on the 2012 Olympic site in Stratford back in 2009. Picture: Steve Poston

Second World War bomb which caused commuter chaos has been diffused

By DAILY MAIL REPORTER

Last updated at 4:42 PM on 08th June 2008

Comments (0) Share +1 0 Tweet 0 Like 3

An unexploded Second World War bomb which forced the closure of a number of transport routes in the capital was defused today.

Army experts worked to disarm the 2,000lb UXB faced delays after discovering metal used to make the Second World War device was thicker than expected.

This morning, however, military engineers managed to cut through the casing of the bomb, which measures 5ft by 2ft, enabling them to begin 'steaming' the explosive inside to make it safe.



Effort: Army experts' machines and the unexploded bomb in East London

Commuters faced the prospect of more Tube chaos, however, as lines near the danger area were closed.

The bomb, which is lying on a gas main just 50 yards from the main sewage pump for east London, was unearthed by a mechanical digger on Monday in the banks of the Lea in Bromley-by-Bow near the Olympic site.

Construction workers made the discovery while widening the bank to take barges for the 2012 Games village construction.

It had lain dormant there for more than 60 years.

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

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

By EMILY ALLEN and MARK BRANAGAN

PUBLISHED: 08:11, 23 July 2012 | UPDATED: 02:42, 24 July 2012

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Examples of Unexpected Detonation of WWII Bombs

BASF has confirmed that an explosive device, most likely a World War II-era bomb, caused the blast that left one person injured Tuesday at a plant construction site in Germany.

The explosion was reported at BASF's Ludwigshafen toluene diisocyanate (TDI) plant, which recently broke ground for a 300,000 metric tons per year TDI production plant and other construction to expand its facilities.



BASF is expanding their its Ludwigshafen location by expanding several plants and building a TDI plant, which was the site of an explosion on Tuesday (Feb. 26). One person was injured in the blast, which BASF believes was caused when excavation work detonated a bomb.

Early reports had speculated that excavation work had detonated a bomb from World War II. While the age of the bomb has not been confirmed, BASF has said that an explosive device was detonated.

BASF Provides Some Details

Responding to a request from *PaintSquare News* for more information on Wednesday (Feb. 27), BASF's manager of media relations and corporate communications Europe, Ursula von Stetten, wrote in an email, "So here [are] the facts: The detonation took place at 10:00 a.m. One person was injured; the injury is not serious. He will be kept in the hospital for some days.

"Cause of the detonation was an explosive device, presumably a bomb deriving from the Second World War. The device detonated when grounding work was done. No details on [a] delay [are] available. At the moment, the exact circumstances of the incident are [being] evaluated."

World War II Bomb Explodes on German Motorway

A highway construction worker in Germany accidentally struck an unexploded World War II bomb, causing an explosion which killed him and wrecked several passing cars.

Tweet 0 Recommend 1



A cutting machine lies wrecked by the side of the A3 motorway next to a small crater left by the explosion.

A World War II bomb has exploded during construction work on a German highway, killing one worker and injuring several motorists who were driving past, police said.

The worker had been cutting through the road surface near the south-western town of Aschaffenburg when his machine struck the bomb and triggered it. Police said they weren't sure yet what type of bomb it was. "The explosion seems to have been too small for it to have been an aircraft bomb," a police spokesman said.

The A3 Autobahn linking the cities of Frankfurt and Würzburg has been blocked in both directions.

More than 60 years since the end of World War II, construction workers still frequently unearth unexploded bombs and it is not uncommon for whole city districts to be cordoned off and even evacuated while bomb disposal experts defuse them.

Indeed, just last week, some 22,000 people were evacuated from their homes in Hanover when three World War II bombs were discovered.

Allied pilots rained nearly 2 million tons of explosives on Germany during the war. Landmines, hand grenades, mortar bombs and anti-tank devices from the fighting on German soil at the end of the war are also found, and authorities say it will take decades before the country is cleared of duds.

Between 400 and 600 bombs are discovered a year in the state of North Rhine-Westphalia alone, where the heavily industrialized Ruhr region was a major target for Allied bombers.



WWII bomb injures 17 at Hattingen construction site

Published: 19 Sep 08 16:53 CET

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Seventeen people were injured on Friday when a construction crew unwittingly detonated a buried World War II-era bomb in Hattingen.

- [Liberals grit teeth ahead of May state election](#) (17 Mar 12)
- [Nazi death camp guard Demjanjuk dies](#) (17 Mar 12)
- [Stupid stunt causes bomb scare chaos](#) (18 Mar 12)

An excavator apparently drove over a 250-kilogramme (550 pound) American bomb, damaging surrounding buildings. Most of the injured suffered auditory trauma from the blast, and the excavator operator suffered injuries to his hands, police in the German state of **North Rhine-Westphalia** said.

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

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2 June 2010 Last updated at 15:37

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World War II bomb kills three in Germany

Three people have been killed and six injured trying to defuse a World War II bomb in central Germany.

Workers building a sports stadium had earlier unearthed the bomb in the town of Goettingen.

It was not immediately clear why the bomb, reportedly weighing 500kg (1,100lb), had detonated.

Unexploded WWII bombs dropped by Allied planes are frequently found in Germany, though it is unusual for them to explode unexpectedly.

A special commission is investigating the causes of the explosion, while prosecutors are considering whether the team leader should face charges of manslaughter through culpable negligence, the BBC's Oana Lungescu reports from Berlin.

The blast happened an hour before the defusing operation was due to start.

Officials said the three men who died were experienced sappers, or combat engineers, who over 20 years had defused up to 700 bombs.

More than 7,000 people were immediately evacuated when the 500kg bomb was found. Several schools, a kindergarten and local companies remain closed.



All the victims were involved in an operation to defuse the bomb



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Bermondsey bomb: World War Two device safely removed

24 March 2015 | London



RUPERT FRERE

An unexploded World War Two bomb found in south London has been driven away safely under police and Army escort. The 500lb (250kg) device was found on a building site in Grange Walk, Bermondsey on Monday. Two primary schools were closed and hundreds of homes were evacuated as a precaution.

A cordon and 656ft (200m) exclusion zone was lifted at about 18.15 GMT as the bomb was removed to a quarry in Kent to be detonated, police said.

The Metropolitan Police force said the device was a "SA" 250kg WWII German air-dropped bomb, known to the Army's Royal Logistic Corps bomb disposal experts.

London Fire Brigade said that between 2009 and 2014 it was called to seven unexploded Second World War bombs and five unexploded hand grenades.



RUPERT FRERE



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Wembley WW2 live bomb poses 'risk to life'

An unexploded World War Two bomb uncovered by builders near Wembley Stadium poses "a genuine risk to life", the Army says.

Homes and businesses have been evacuated and the Army has built a blast wall around the bomb in case it goes off accidentally.

The 50kg (110lb) device, thought to date from the early 1940s German air raids on London, was found on Thursday.



Empire Way is partially closed and a 400m cordon has been erected.

The evacuated businesses are believed to include the TV studio where Britain's Got Talent is filmed.

An Army spokesman said: "This bomb is a live munition in a potentially dangerous condition so it's important that people listen to the police and evacuate their homes if asked.


"We will do all we can to minimise the disruption, but ask the public to bear with us.

"Any bomb, even under a controlled explosion, could cause significant damage to property and there is a genuine risk to life".

London's Victoria Street tube station evacuated over unexploded bomb

PUBLISHED 05/02/2016 | 10:57



Police established a cordon around Victoria Station

Victoria Station has been evacuated during this morning's rush hour after an alert was raised over an "unexploded bomb".

Thousands of people were ordered to leave both the Tube and rail station.

The Met Police say officers are attending a building site following the discovery of what is believed ordnance from World War II.

Images on social media show a heavy police presence and cordon as commuters left the station.

The Tube, mainline rail and bus stations were reopened around 10.15am as the incident was stood down.

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England Regions London

Unexploded bomb scare after WW2 shell casing found at White City

8 July 2015 | London



The casing was found in Ariel Way close to the former BBC Television Centre building

An unexploded bomb alert in west London caused major disruption - but cordons were lifted when it was found to be just a shell casing, posing no danger.

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England Regions London

Bethnal Green WW2 bomb: Attempts continue to defuse device

11 August 2015 | London



Bomb disposal experts worked through the night at the scene

Experts are continuing their work to try to defuse an unexploded World War Two bomb which prompted the evacuation of 150 people in east London.



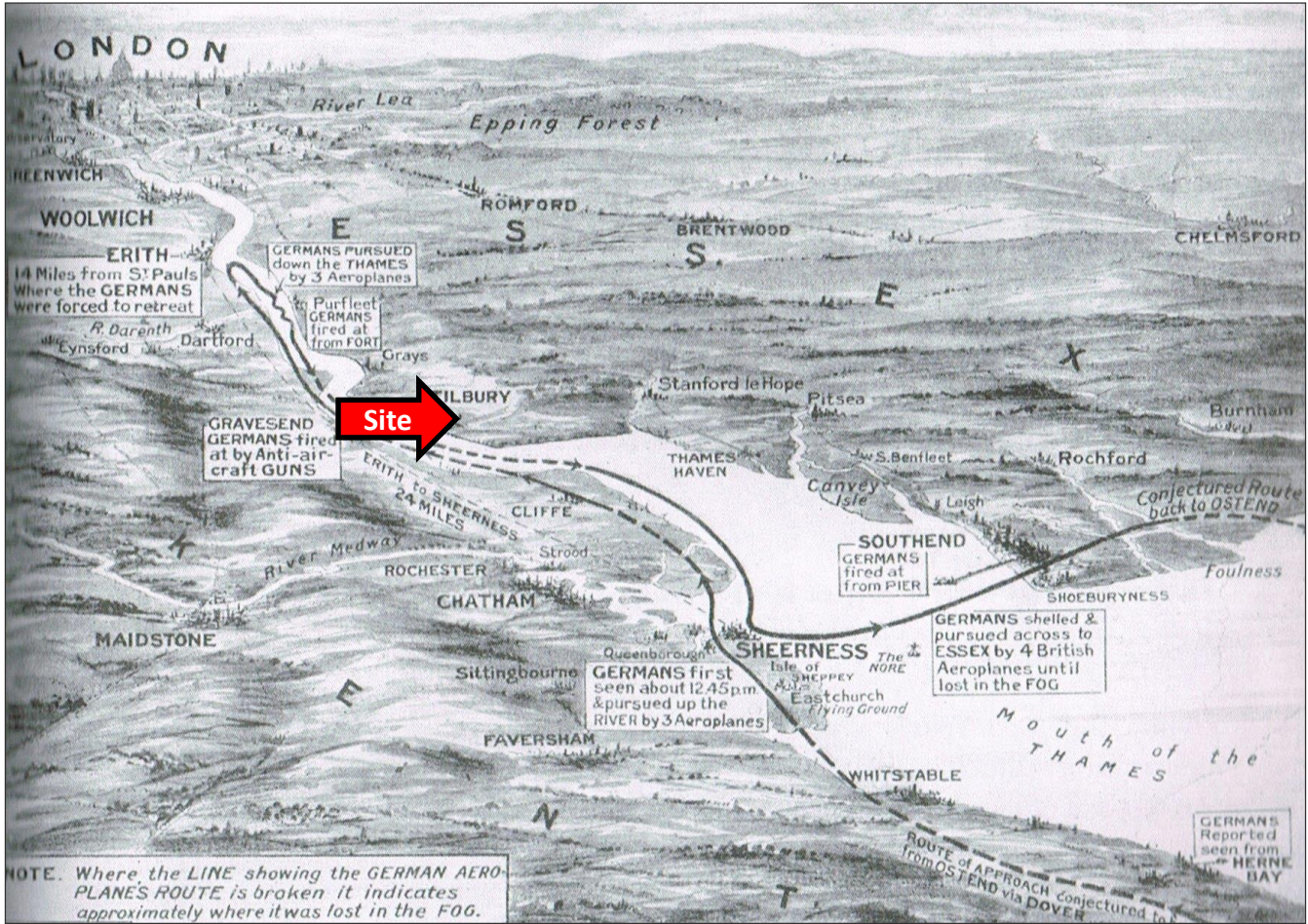
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The route of an early air raid by a German Gotha aircraft. German planes would often use the River Thames as a guide to targets in London.



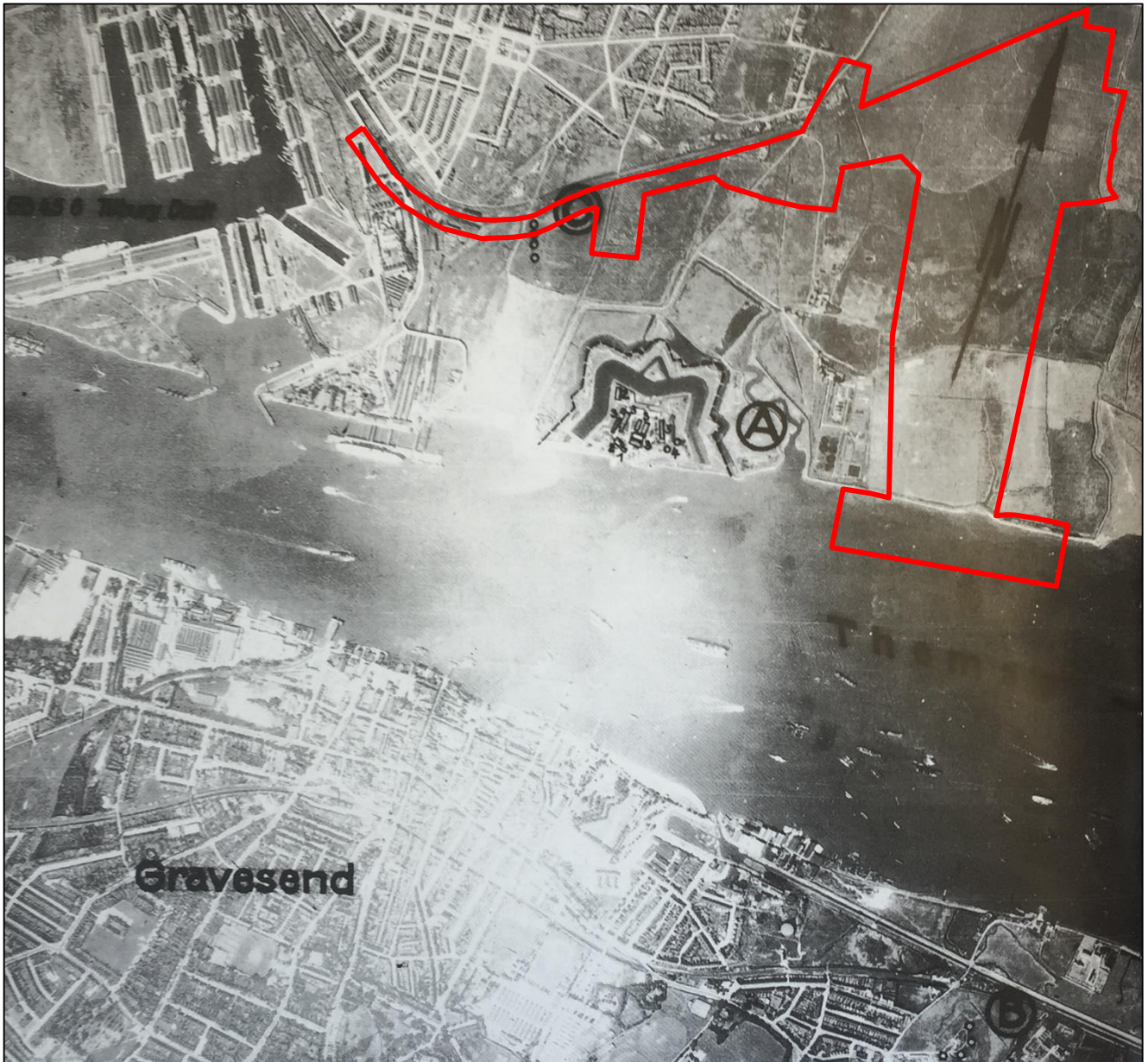
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Project: **Port of Tilbury**

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Source: *More Front-Line Essex, Foley*



- A. Fort Tilbury
- B. 'Heavy Anti-Aircraft Fire'
- C. 'Slight Anti-Aircraft Fire'



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Approximate site boundary



Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: Nigel J. Clarke, "Adolf Hitler's Home Counties Holiday Snaps"



A. Power Plant



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 **Approximate site boundary**



Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: Nigel J. Clarke, "Adolf Hitler's Home Counties Holiday Snaps"



Houses in Dickens Avenue, Tilbury, after the air raids on 19th September 1940



4 Railway Cottages, Tilbury, after the air raids on 19th September 1940



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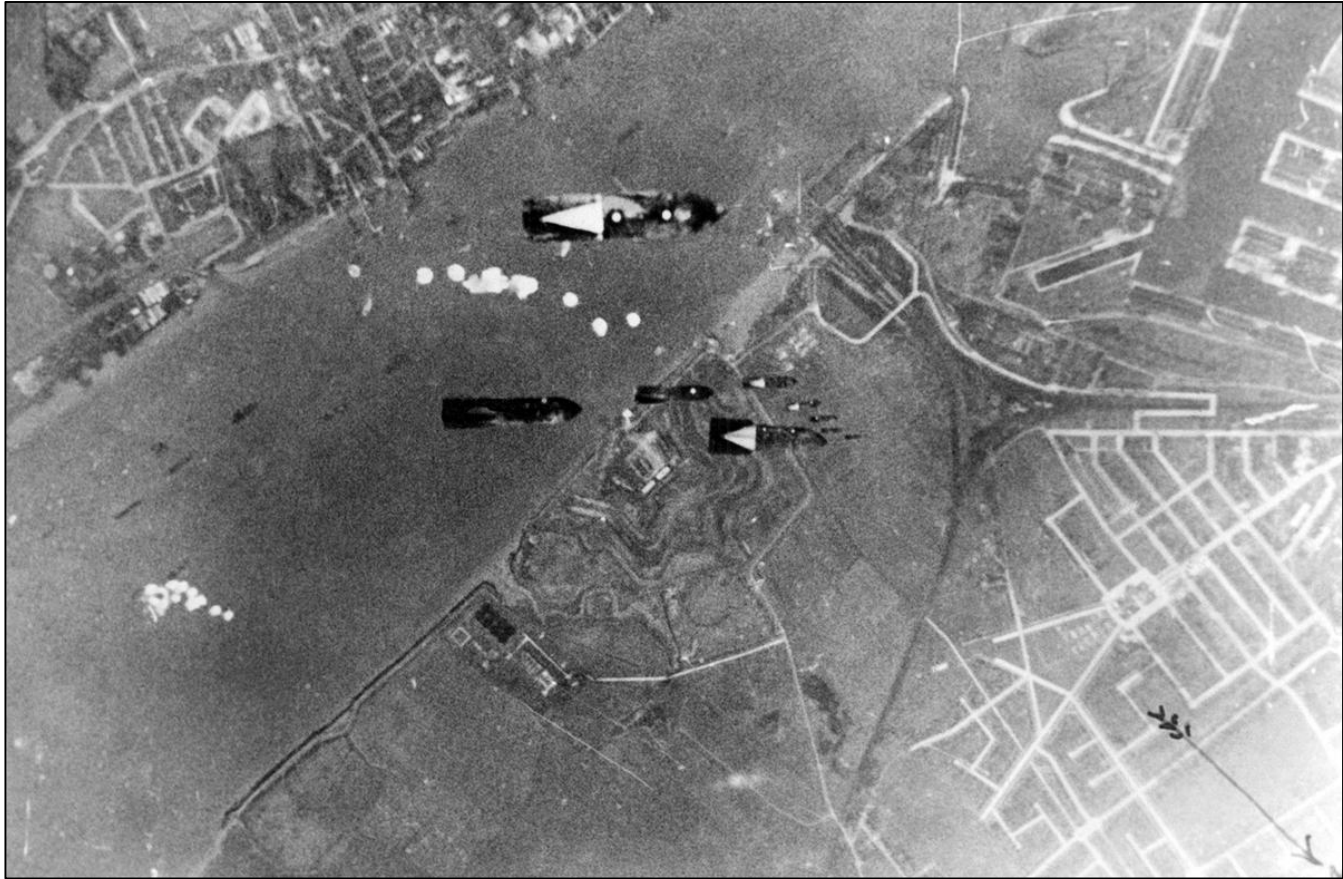
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Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: *Thurrock Goes to War*, Reynolds and Catton

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Bombs dropping on the Port of Tilbury on October 4th 1940.
It is claimed that the first group of bombs hit ships lying on the Thames, and the second on Tilbury Docks.



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Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: *Thurrock Goes to War*, Reynolds and Catton

LOCAL AUTHORITY: THURROCK URBAN DISTRICT COUNCIL. SHEET No. 851

RECORD OF WAR DAMAGED BUILDINGS. DISTRICT

OCCUPIER: Mr. Billins OWNER: L.M.S. Railway Co., ADDRESS OF PROPERTY: 14 Railway Cottages, Tilbury.

SURVEYED BY: L.W. Wood DATE: 18.9.40 DAMAGED: 24.9.40 INSPECTED: 10.10.40 DESCRIPTION OF PROPERTY: Dwelling House RATEABLE VALUE: £ 10 RATE BOOK REF.

CONDITION: 1A-Totally Destroyed. 1B-Demolition Necessary. 1C-Seriously Damaged. (1) Still Usable. (2) Evacuated or to be Evacuated. 1D-Slightly Damaged.

GENERAL REMARKS

DAMAGE: AIR ATTACK. H.E. Bomb blast

VALUE OF DAMAGE SEE DISTRICT VALUER

W.D.P. FORMS SENT MINISTRY OF HEALTH DISTRICT VALUER 5.11.40.

W.D.P. CLAIM FORMS SENT OWNER OCCUPIER 3.9.40. 30.9.40.

OWNER: Now Residing At. No. of Persons to be Re-Housed Elsewhere: M. F.

DEMOLITION AUTHORIZED BY: DEMOLITION INSTRUCTIONS GIVEN TO: ORDER REF. 19

DEMOLITION COMMENCED: 19 DEMOLITION COMPLETED: 19

NOTICE OF INTENTION TO CARRY OUT WORKS OF REPAIR: 19 REPAIR AUTHORIZED BY: REF. TO REPAIR SPECIFICATION OR INSTRUCTIONS

REPAIR INSTRUCTIONS GIVEN TO: DATE REPAIRS COMMENCED: 19 DATE REPAIRS COMPLETED: 19

DETAILS OF DAMAGE INCLUDED ON FORM W.D.P.1.	PART I SHEET No.	PART II SHEET No.	PART III SHEET No.	DAMAGE CATEGORY			
				A	B	C	D
						1	2

14 Railway Cottages, Tilbury

LOCAL AUTHORITY: THURROCK URBAN DISTRICT COUNCIL. SHEET No. 853

RECORD OF WAR DAMAGED BUILDINGS. DISTRICT

OCCUPIER: Mr Smith OWNER: L.M.S. Railway Co., ADDRESS OF PROPERTY: 16 Railway Cottages, Tilbury.

SURVEYED BY: S. Wood DATE: 18.9.40 DAMAGED: 24.9.40 INSPECTED: 10.10.40 DESCRIPTION OF PROPERTY: Dwelling House RATEABLE VALUE: £ 10 RATE BOOK REF.

CONDITION: 1A-Totally Destroyed. 1B-Demolition Necessary. 1C-Seriously Damaged. (1) Still Usable. (2) Evacuated or to be Evacuated. 1D-Slightly Damaged.

GENERAL REMARKS

DAMAGE: AIR ATTACK - H.E. Bomb

VALUE OF DAMAGE SEE DISTRICT VALUER

W.D.P. FORMS SENT MINISTRY OF HEALTH DISTRICT VALUER 5.11.40.

W.D.P. CLAIM FORMS SENT OWNER OCCUPIER 3.9.40. 25.9.40.

OWNER: Now Residing At. No. of Persons to be Re-Housed Elsewhere: M. F.

124, Lorrington Rd. Stansted-le-Hope.

DEMOLITION AUTHORIZED BY: DEMOLITION INSTRUCTIONS GIVEN TO: ORDER REF. 19

DEMOLITION COMMENCED: 19 DEMOLITION COMPLETED: 19

NOTICE OF INTENTION TO CARRY OUT WORKS OF REPAIR: 19 REPAIR AUTHORIZED BY: REF. TO REPAIR SPECIFICATION OR INSTRUCTIONS

REPAIR INSTRUCTIONS GIVEN TO: DATE REPAIRS COMMENCED: 19 DATE REPAIRS COMPLETED: 19

DETAILS OF DAMAGE INCLUDED ON FORM W.D.P.1.	PART I SHEET No.	PART II SHEET No.	PART III SHEET No.	DAMAGE CATEGORY			
				A	B	C	D
				A			

16 Railway Cottages, Tilbury



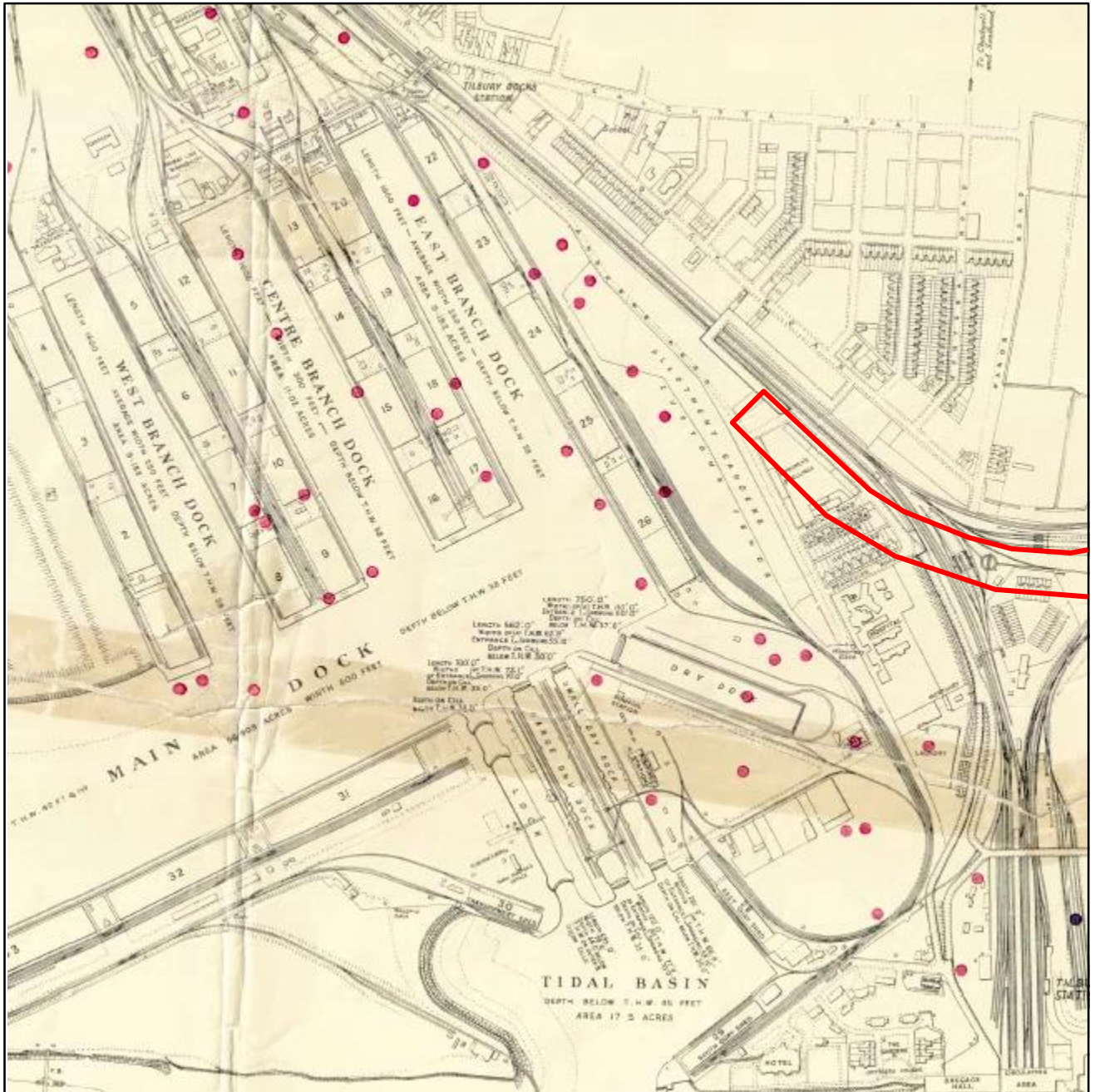
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Source: **Thurrock Museum**



KEY

- Red. H. E.
- Green. Magnetic Sea Mines.
- Blue. V. I.
- Purple. V. 2.



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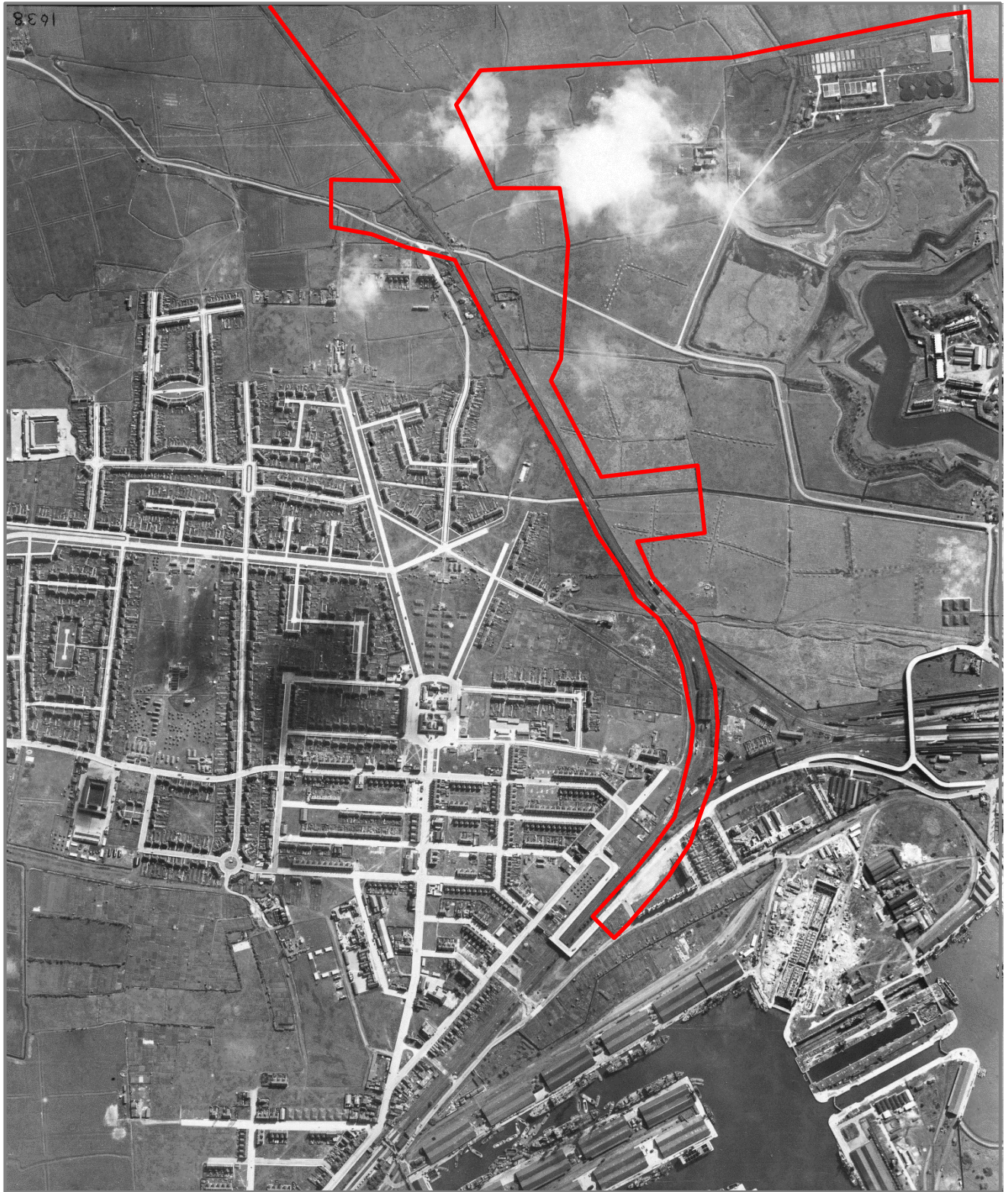
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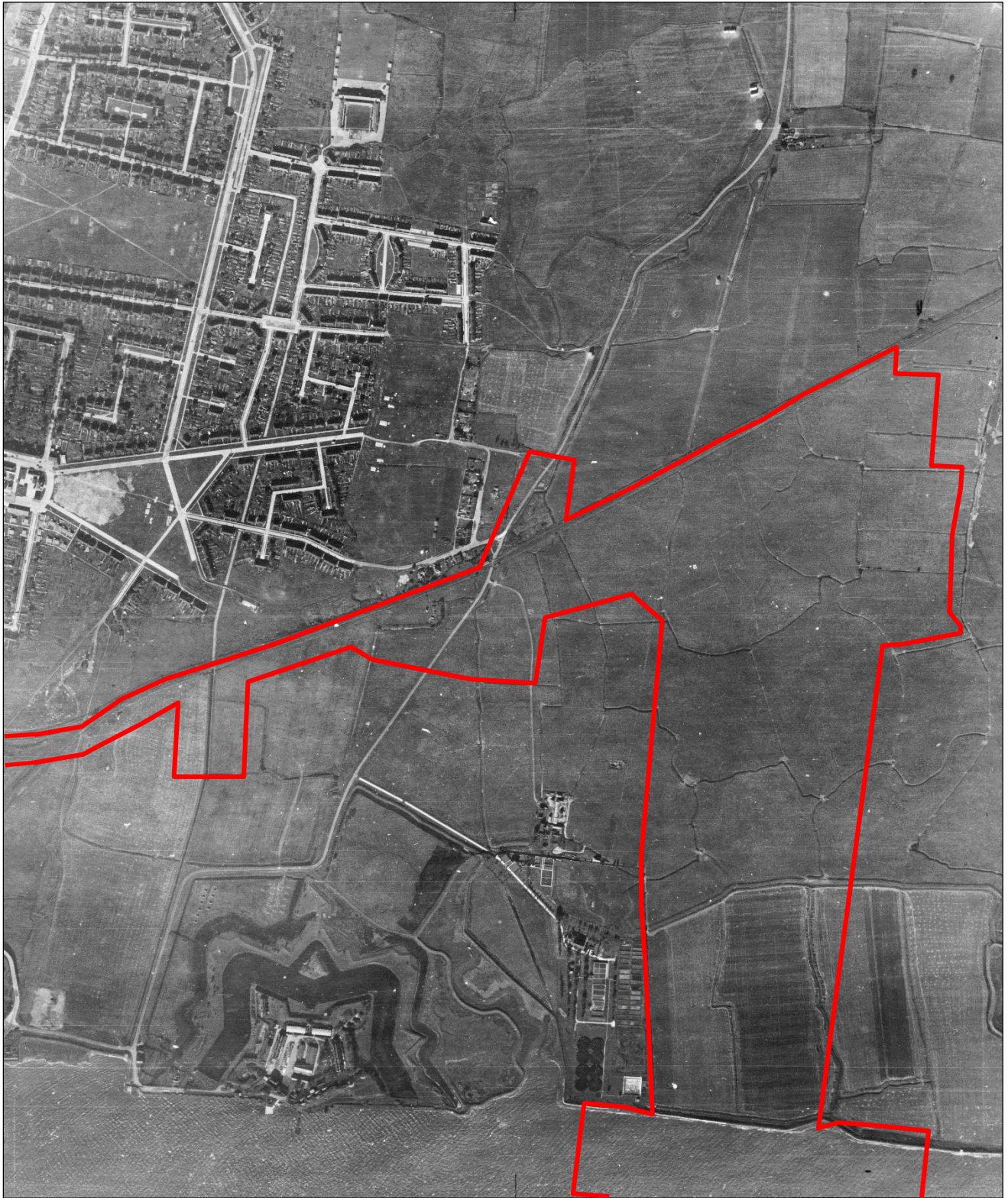


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 **Approximate site boundary**

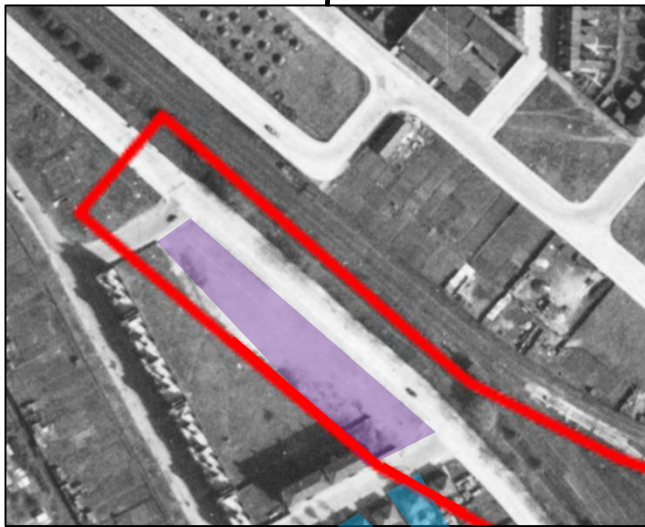
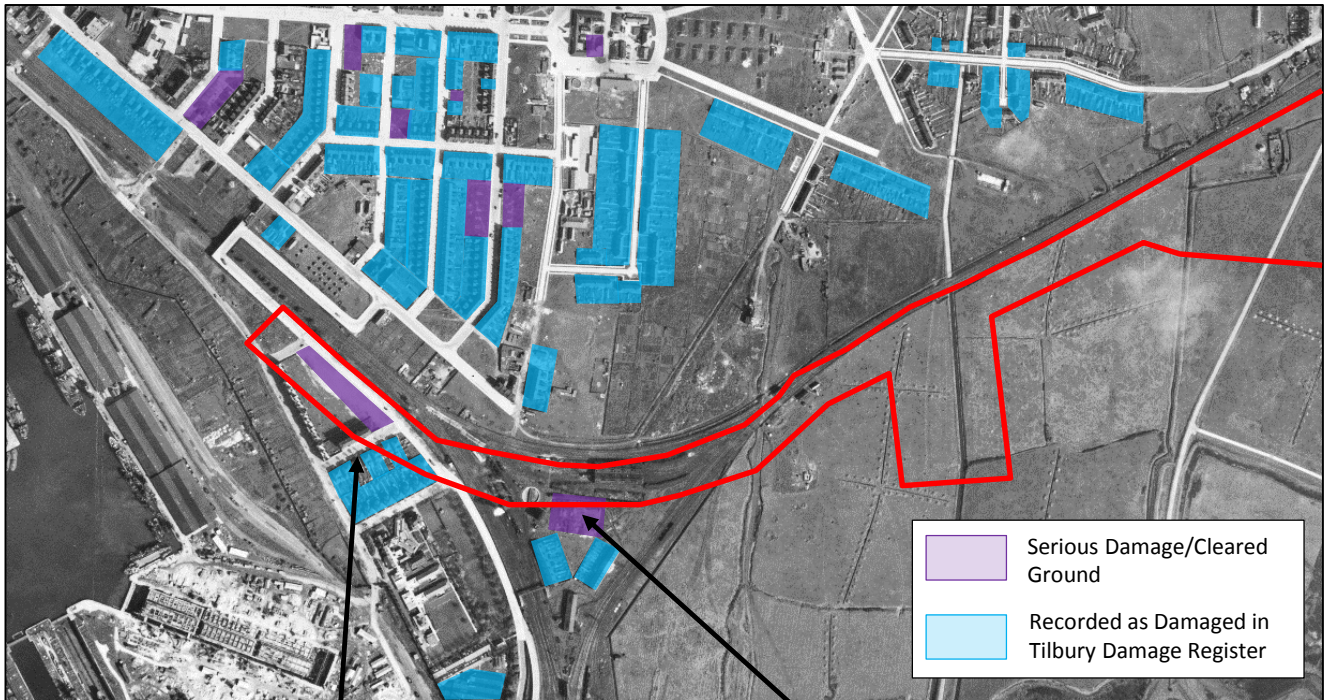


Project: **Port of Tilbury**

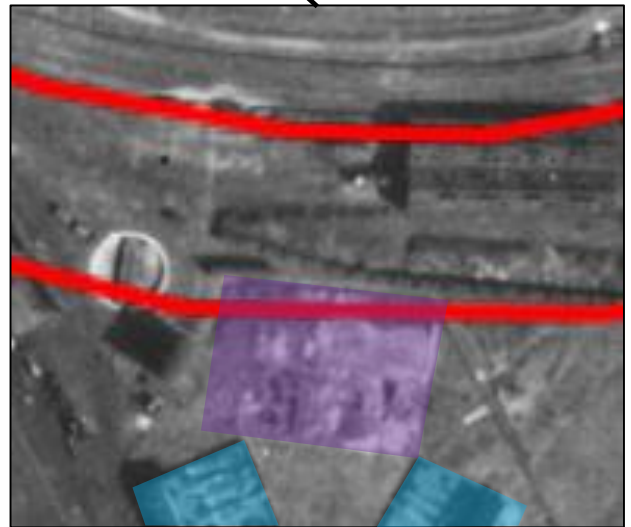
Ref: **DA3222-01**

Source: National Monuments Record Office (Historic England)

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Damage to Railway Cottages



Possible Clearance Area at Workingmen's Dwellings



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Approximate site boundary

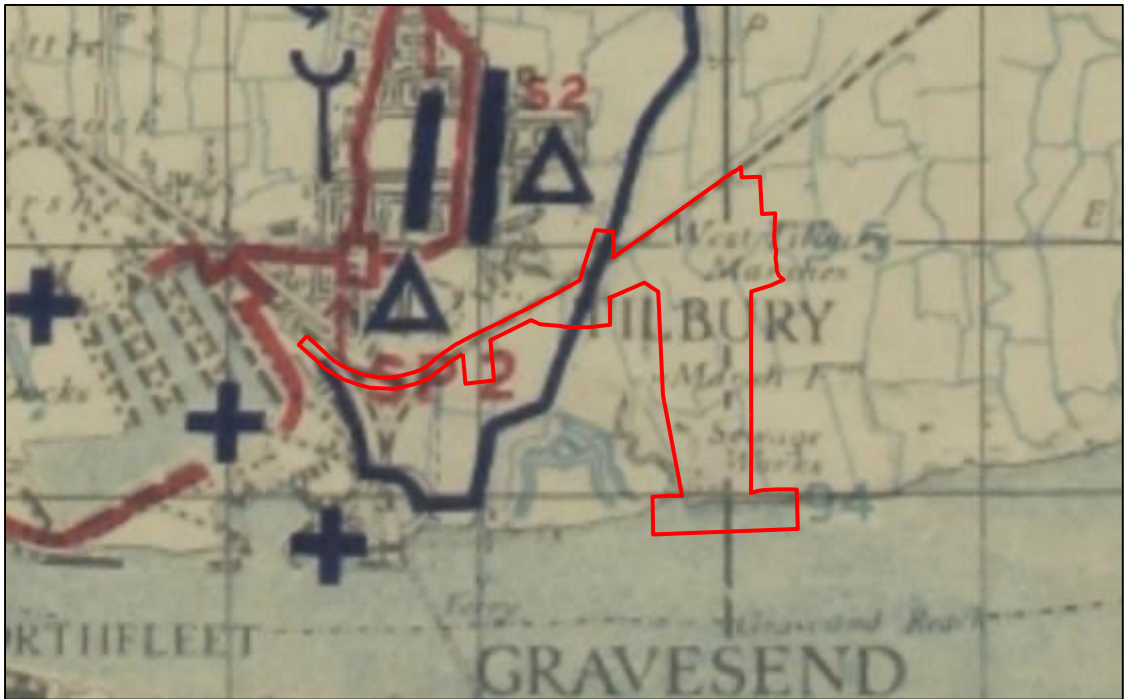


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Enlarged view of site area



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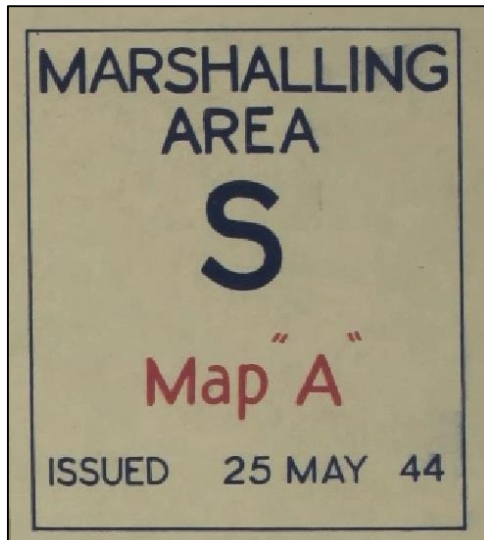


Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: Essex Record Office

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OP & ADM ROUTES (TWO WAY)		EMBARKATION AREA HQ	
ADM ROUTES (TWO WAY)		ADM INSTALLATIONS (NAMED)	
ONE WAY ROUTES	 	REC POST (REME)	
VEH PARKS		CRS	
NUMBERED STANDINGS		RCRP (NUMBERED)	
MARSHALLING AREA HQ		TP (NUMBERED)	
SUB AREA HQ		SP (NUMBERED)	
SUB AREAS (SERIALLY NUMBERED)		PORTS OR HARDS	
CAMPS		REGULATED AREA BDY	
		LONDON DIST BDY	



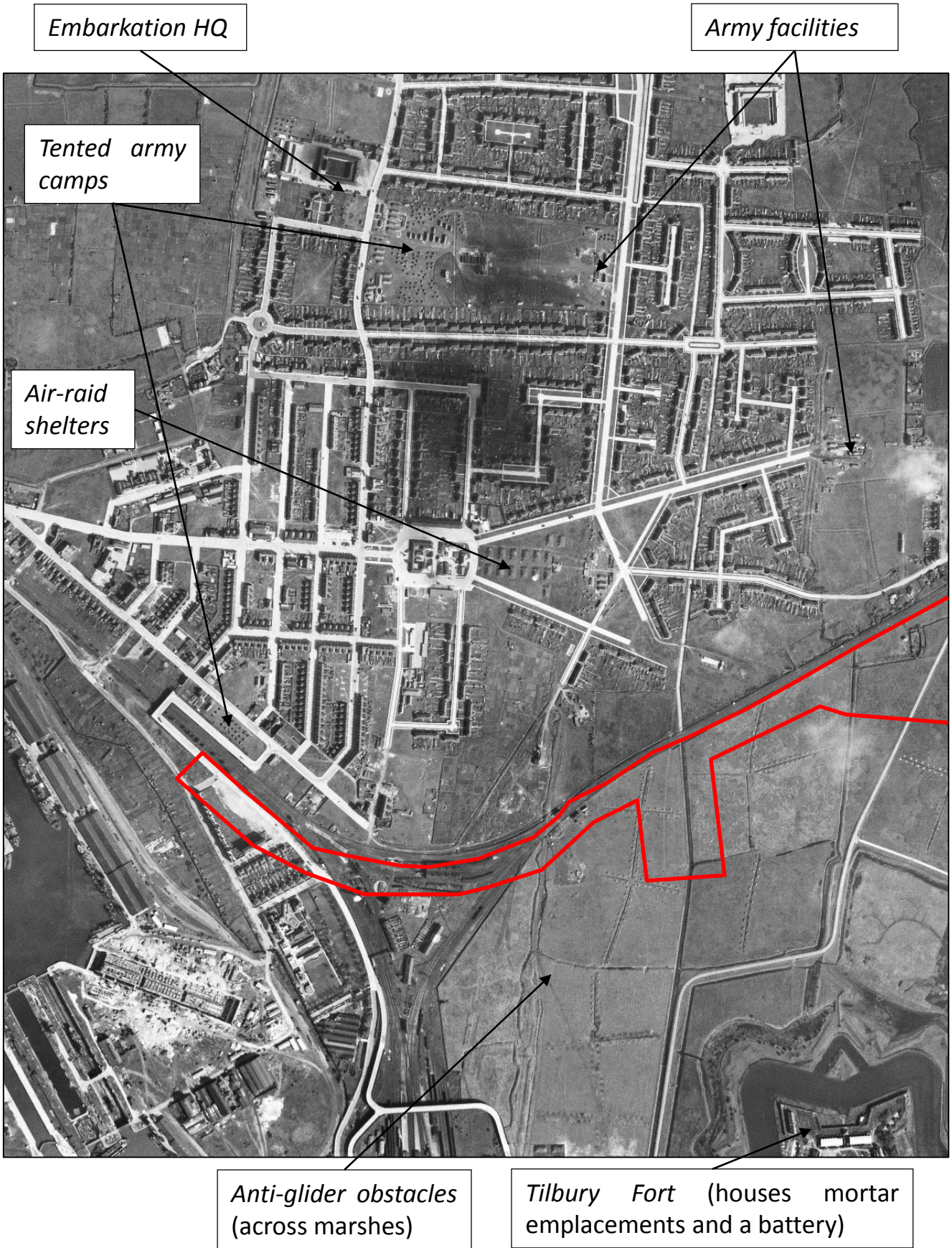
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Tel: +44 (0)1992 245 020

Client: **Port of Tilbury London Limited**

Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: Essex Record Office



Anti-glider obstacles (across marshes)

Tilbury Fort (houses mortar emplacements and a battery)



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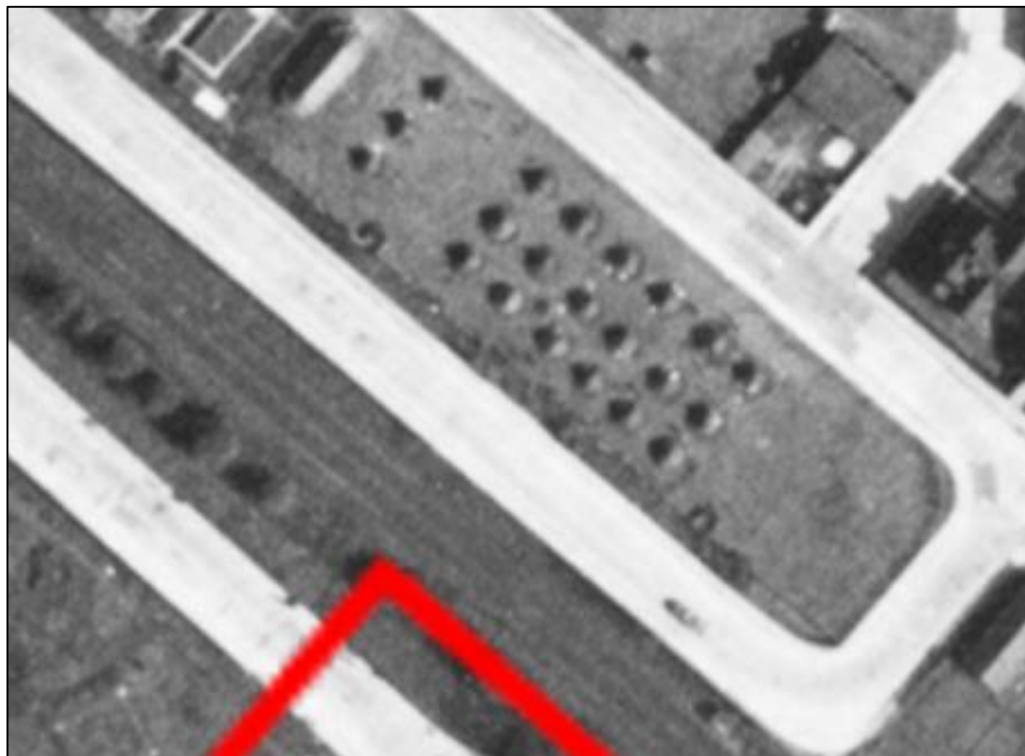
 **Approximate site boundary**



Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: 1st Line Defence



Tented army camp. Approximately 35m from site boundary to the north on other side of railway line (boundary shown above)



Tented army camps and additional facilities. Approximately 800m from the site to the north.



Requisitioned St. Chad's School building, location of Embarkation HQ. Approximately 950m from the site to the north.



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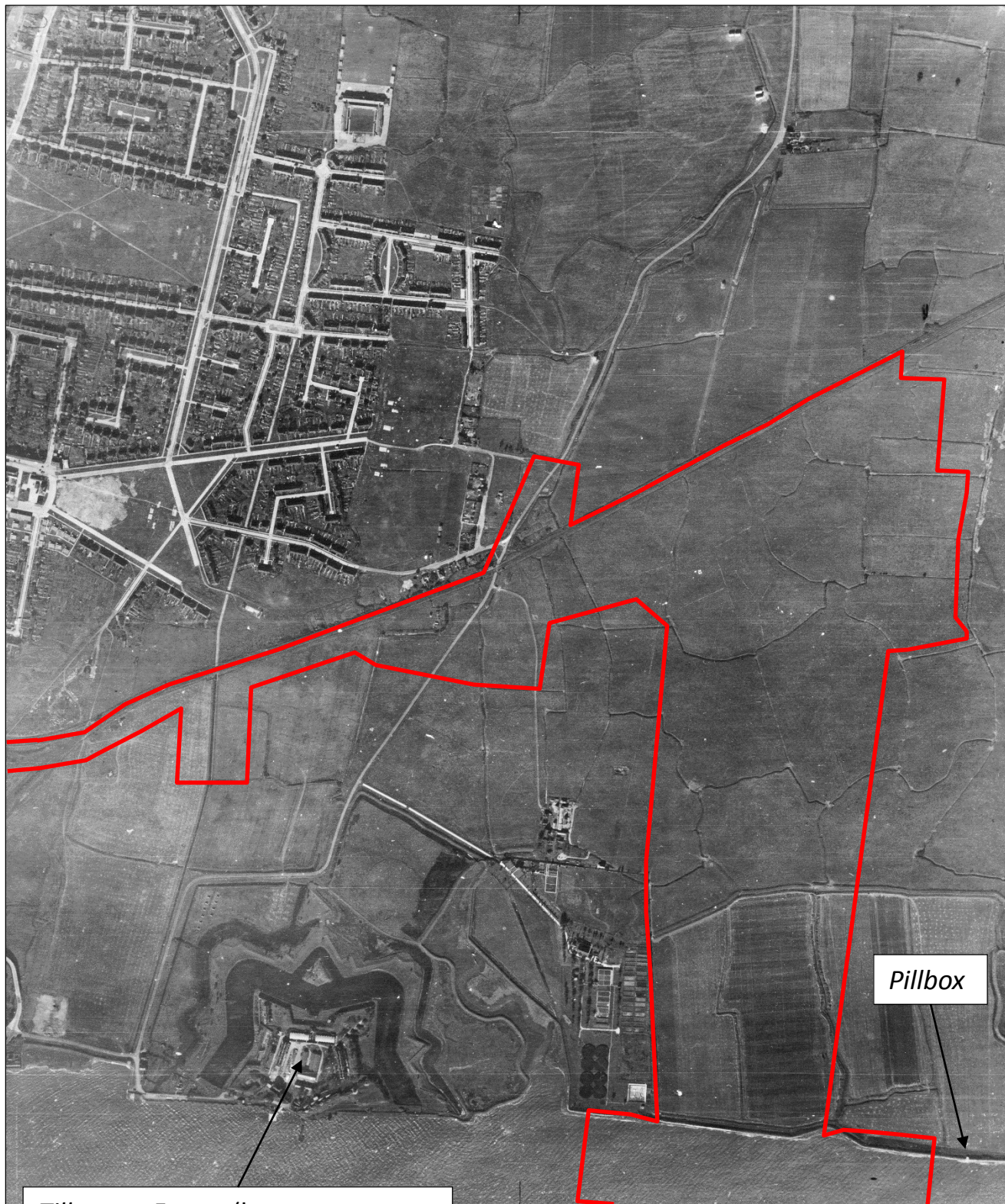


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Ref: **DA3222-01**

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Tilbury Fort (houses mortar emplacements and a battery)

Pillbox



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— Approximate site boundary

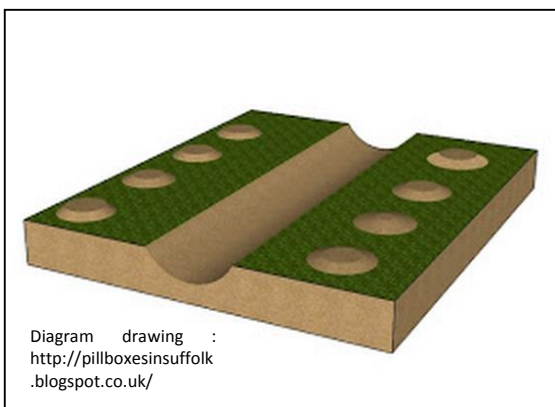


Project: **Port of Tilbury**

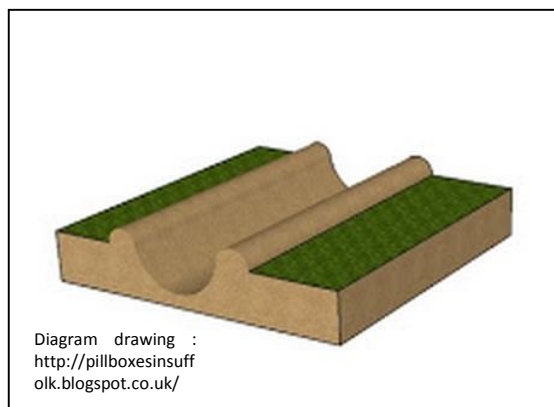
Ref: **DA3222-01**

Source: 1st Line Defence

Layouts of Anti-Glider Obstacles/Ditches



Layout 1: spoil piles would be formed into mounds at a slight distance away from the trench line.



Layout 2: spoil piles would be formed into a 'lip' by the trench line.



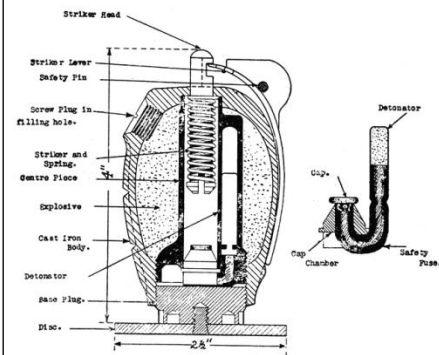
Image of anti-glider ditch on the ground



Anti-glider obstacles in central section of site

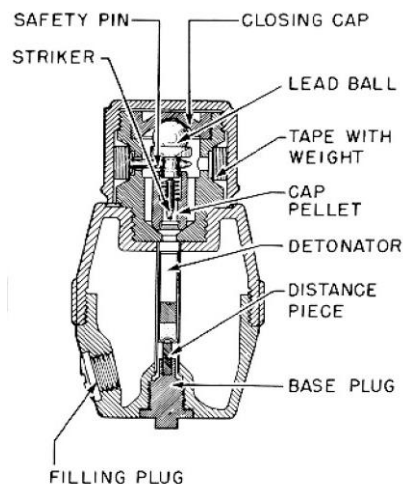
No. 36 'Mills' Grenade

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



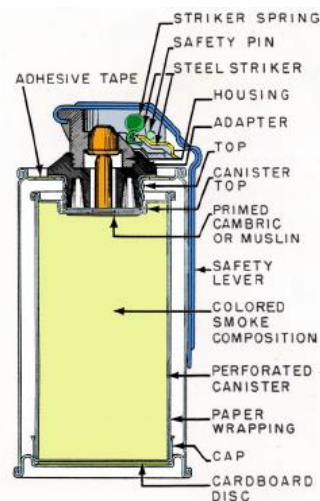
No. 69 Grenade

Weight	383g (0.81lb)
Explosive Weight	93g (3.25 oz) of either Amatol, Baratol or Lyddite
Fuze Type	'All-ways' Fuze. Compromised of a safety cap, a weighted streamer attached to a steel ball bearing and a safety bolt designed to detonate from any point of impact.
Dimensions	114 x 60mm (4.5 x 2.4 in)
Use	A blast grenade for use as an offensive weapon.
Remarks	Introduced December 1940 and made from the plastic Bakelite as opposed to conventional metals. Detection is difficult due to this low metal content.



No. 83 Smoke Grenade

Weight	Approx. 680g (1.5lb)
Explosive Weight	Approx. 170-200g. (6-7 oz)
Fuze Type	Originally used a friction system using a match head composition. Later developed to a striker lever ignition system.
Dimensions	Approx. 65 x 115mm (2.5 x 4.4 in)
Use	Use as a target or landing zone marking device and as a screening method for troop / unit movement.
Remarks	This basic design stayed relatively unchanged up to the 1980's. The letters CCC were often etched into the body of the grenade in the colour of the smoke.



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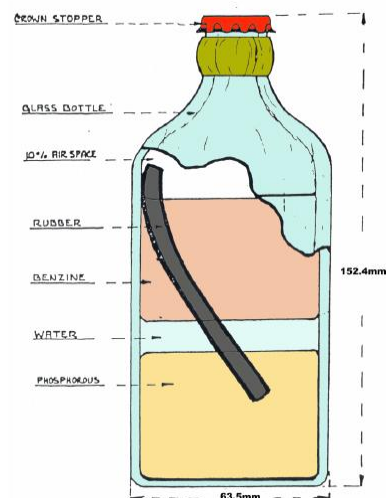
Project: **Port of Tilbury**

Ref: **DA3222-01**

Source: Various sources

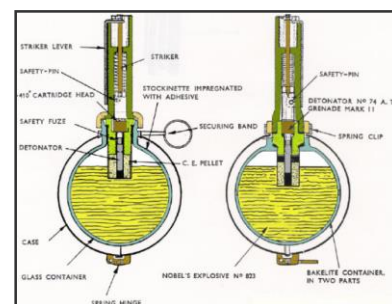
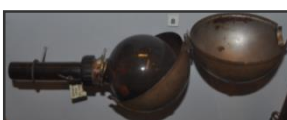
Self Igniting Phosphorous (SIP) Grenades

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



No. 74 Grenade (Sticky Bomb)

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



Flame Fougasse Bomb

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

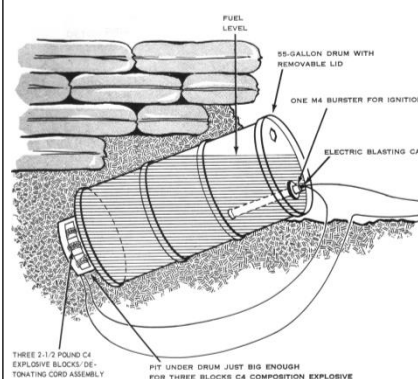


Figure 21. Flame fougasse (55-gallon drum).



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Source: Various sources

Mortars

Typical 2 Inch High Explosive Mortar

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



Typical 2/3 inch Smoke Mortar

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



Typical 2 inch Illuminating Mortar

Weight	0.45kg (1lb)
Maximum Range	460m (500yards)
Filling	Magnesium Powder – Potassium Nitrate
Bomb Dimensions	51 x 290mm
Fuze Type	An expulsion charge ignites and ejects the candle assembly. A spring ejects the parachute which slows the descent of the ejected burning candle.
Use	Provided adequate illumination to support infantry combat, aerial photography and army movement.
Remarks	The 2inch mortar was issued to every platoon in the British Army.



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Cannon Ammunition



Rifle Ammunition



Buried and Decayed Ammunition



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Anti-Aircraft Projectiles

QF 3.7 Inch WWII Anti-Aircraft Projectile

Projectile Weight	28lb (12.6 kg)
Explosive Weight	2.52lbs
Fuze Type	Mechanical Time Fuze
Dimensions	3.7in x 14.7in (94mm x 360mm)
Rate of Fire	10 to 20 rounds per minute
Use	High Explosive Anti-Aircraft projectile. 4.5in projectiles were also used in this role.
Ceiling	30,000ft to 59,000ft



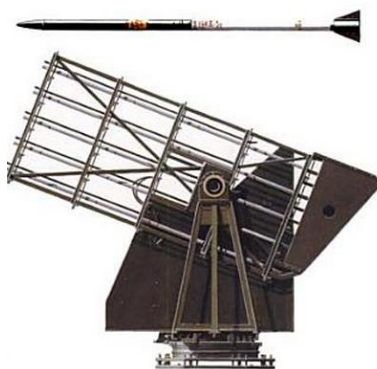
40mm Bofors Projectile

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



Unrotated Projectile (UP) – Z Battery

Projectile Weight	84lb (24.5kg)
Warhead Weight	4.28lb (1.94kg)
Warhead	Aerial Mine with a No. 700 / 720 fuze
Filling	High Explosive
Dimensions	1930mm x 82.6mm (76 x 3.25in)
Use	As a short range rocket-firing anti-aircraft weapon developed for the Royal Navy. It was used extensively by British ships during the early days of World War II. The UP was also used in ground-based single and 128-round launchers known as Z Batteries.



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250kg HE bomb found in Tilbury, 1991



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