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BIJLAGE 9 DETAILED UXO MARINE RISK ASSESSMENT

NEU-ACM-CAB-NL-AP-PN-0012

ASITE DOCUMENT NUMBER

Revision Tracking

Revision No.	Revision Date	Author	Checked By	Approver	Revision Notes
P01	19/04/2021	AECOM		Neuconnect	

Originator's Reference:	ITT Reference Number:
N/A	

Bijlage 9: Detailed UXO Risk Assessment, 1st line defence, 10 augustus 2018

Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany
Client	Intertek
Site Address	Kent, England to Lower Saxony, Germany
Report Reference	DA6316-01
Date	10th August 2018
Originator	MN

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Executive Summary

Description and Location of Study Area

The proposed HVDC (high voltage direct current) Electricity Transmission Interconnector is understood to be a new subsea cable between existing substations and electricity grids in the UK and continental Europe.

The HVDC project is designed to provide the first direct energy link between the UK and Germany, with the aim of delivering an increased security of supply, fuel diversity and greater competition to both nation's networks. It will allow a capacity of up to 1.4GW of electricity to flow in both directions, connecting two of Europe's largest energy markets and allowing the integration of renewable energy sources.

The study area is approximately 700km in length and spans the southern section of the North Sea. It stretches through the UK's TW (territorial waters) and EEZ (exclusive economic zone), the Netherlands' EEZ and Germanys' TW and EEZ; including small areas of initial landfall identified at the Isle of Grain, UK and Hooksiel, Germany.

The study area comprises one singular route between the approximate latitudes and longitudes: **51°27'48.31"N 0°42'43.77"E** (at its western endpoint) and **53°38'12.20"N 8° 5'14.08"E** (at its eastern endpoint). It does not connect between these points in a straight course.

The western end of the study area, situated on the UK mainland, comprises a small area of coastline and surrounding rural land on the Isle of Grain. The eastern end of the study, situated on the German mainland, occupies a small area of open land surrounding the Am Tiefen Fahrwasser roadway and the coastline of Hooksiel.

The remainder of the study area occupies a large expanse of open water within the Thames Estuary and the North Sea.

Proposed Works

At the time of the production of this report, it is understood that a geotechnical survey is already underway, with geotechnical sampling planned at every 1km across the study area between the UK and Germany. Limited information was provided by the client regarding the exact scope of this survey, which is anticipated to include vibrocore and cone penetrometer tests (CPT) within areas of open water and investigatory boreholes and trial pits within areas of landfall.

It is understood that the project is currently going through a period of further project development ahead of a full submission being made to the UK and German regulators in 2019. Final approval for the scheme is expected in 2020, allowing construction to start shortly afterwards. The current target date for project completion is 2023.

As a result, limited information is available concerning the final methodology of the proposed cable installation. However, typical intrusive activities within the marine environment for this type of project could include the use of anchors, cable trenching equipment, pre-lay grapnel runs, boulder removal ploughs, mass flow excavators, dredging and the placement of material mattresses on the seabed.

It should be noted that such activities might exceed the boundary of the proposed study area provided. A 1km buffer zone has therefore been considered on either side of the centre line of the proposed cable area for the purpose of this report.

Seabed Geology

The British Geological Survey (BGS) map, the German Federal Institute for Geosciences and Natural Resources (BGR) Geoviewer and the European Marine Observation and Data Network (EMODnet) were consulted for the purpose of this report. These sources show the bedrock geology of the western endpoint of the study area, within the UK landfall on the Isle of Grain, to be underlain by the London Clay Formation – clay and silt, with superficial deposits of Alluvium – clay, silt, sand, peat and gravel. The bedrock geology of the eastern endpoint of the study area, within the German landfall, is shown to consist of sedimentary material overlain by clay, silt and sand.

The offshore bedrock geology varies considerably over the length of the proposed route and includes areas underlain by:

- Mudstone and sandstone (undifferentiated) and tuff.
- Rock, siliciclastic, argillaceous with sandstone (undifferentiated).
- Brielle Ground Formation - sand.
- Pliocene sedimentary material.

UXO Risk Assessment

1st Line Defence has assessed a potential risk within the location of the study area from UXO contamination, based on the following potential sources:

Coastal Armament Training Areas

- The firing areas of three historic armament training ranges are situated directly across the section of the study area within the Thames Estuary on WWII-era armament training and 'danger area' mapping. These comprise the former Sheerness and Grain, Yantlet and Shoeburyness Artillery Ranges, the latter of which still plays an extensive role in the testing and development of ordnance on behalf of the MoD today. Two smaller historic ranges are also denoted within the Thames Estuary, to the south-east of this section of the study area. Barton Point, a heavy and light anti-aircraft range, was situated at a distance of approximately 2-5km and 22 Leysdown, an RAF live bombing range, was situated at a distance of approximately 5-6km.
- Based on the available historical documentation, it is anticipated that both live and practice ammunition would been deployed during these ranges operation, with both categories of ordnance still employed at Shoeburyness today. The presence of these armament ranges therefore significantly increases the likelihood that items of Allied ordnance could have been expended through training exercises or firing practices within the westernmost of the study area, from the Isle of Grain to the approaches to the Thames Estuary. This is further demonstrated by the large number of UXO discoveries within the region in the post war period. Selective imagery, taken from hundreds of items found during UXO clearance dredging operations in the Princess Channel in the 2000s, is presented in **Annex O**.
- The majority of items or ordnance used in the coastal armament training areas within the Thames Estuary will have consisted of LSA and SAA. Though larger, aerial delivered bombs will have been deployed at the site of the 22 Leysdon RAF range. The smallest type of LSA typically used by British forces during the WWII-era were three pounder projectiles, though smaller sizes of projectiles may have been utilised. Items of ordnance fired within the estuary's danger areas are not anticipated to have always detonated on impact with the water and have the potential to remain live and settle within the estuary's bed.

Munitions Dumpsites

- A concentration of historic munitions dumpsites has been identified within the eastern section of the study area, off the coastline of North Germany. These dumpsites are believed to have formed part of a wider programme of ammunition dumping across the German North Sea Coast at the end of WWII, resulting in an estimated 750,000 to 1.5 million tons of munitions dumped from both German and Allied sources. This included an estimated 250,000 tons of ammunition shipped from the Port of Wilhelmshaven alone. Although the closest three dumpsites are situated at an approximate distance of 1-2km from the study area, this is still of concern, as it is possible that dumped munitions may have either been deposited outside their designated areas or have else migrated within the region over time.
- Extensive munition recovery is known to have been undertaken in the region between 1952-1958 to recover various UXO related metals. However this type of clearance work is rarely comprehensive and subsequent experimental recovery operations undertaken by the German government in the 1990's are known to have still resulted in the discovery of large volumes of items, including the recovery of 3,000kg of munitions in 1991 and 4,669kg of munitions in 1999. It is therefore anticipated that large amounts of ammunition are still present on and around these former dumping areas, with some sources suggesting that an estimated 10,000-50,000 tons of munitions may still be present in Lower Saxonian waters.

Aerial Bombing

- The risk of contamination from items of air delivered UXO is considered most significant within the eastern endpoint of the study area, at the approach to the Jade Bight. This is due to the number of Allied air raids carried out on Wilhelmshaven during WWII. An estimated 5,327.5 tons of bombs are believed to have been dropped by 2,141 bombers of the USAAF on targets on and around the city, which is anticipated to have led to a significant increase in the density of bombing in the surrounding area. It should be noted however that the eastern endpoint section of the study area has undergone significant land reclamation since the 1970's and that such activity will have significantly mitigated the potential for larger items of UXO remain, provided that the fill material used was not from a contaminated source.
- The western endpoint of the study area was situated within a district of Kent that sustained a low-moderate density of German aerial bombing throughout the war. However its location within the Isle of Grain, at the confluence of the River Medway and Thames, is anticipated to elevate bombing due to its position on Luftwaffe flights paths and the presence of several significant nearby Luftwaffe targets, such as the former Grain oil refinery, the Allhallows bombing decoy sites and Sheerness Docks.
- The density of aerial bombing is anticipated to have been considerably lower across the offshore areas that occupy the vast majority of the proposed study area. However, potential sources of contamination identified in this

UXO Risk Assessment

environment include the dumping of ordnance during plane to plane engagements and attacks on military and merchant shipping. The possibility that such items may be present within any offshore area subsequently cannot be completely discounted. Furthermore, the risk of contamination from aerial delivered bomb is considered to increase within the Thames Estuary and within areas close to the German coastline, due to the increased volume of Luftwaffe and Allied bomber activity documented in these regions.

Wartime Coastal Defences

- Due to its strategic location, the Isle of Grain was occupied by an extensive network of coastal military defences, including fortified structures, coastal artillery batteries and other gun emplacements throughout the 19th and early 20th centuries. The majority of these defences were deemed redundant after WWI with only Grain Fort, Dummy Battery and Grain Tower Battery armed and operational at the start of WWII. However, a number of anti-aircraft emplacements, emergency coastal artillery batteries and static defensive potions, such as anti-tank blocks, were later established across combat the increased potential threat of a Nazi invasion, as well as to combat Luftwaffe raids.
- It is anticipated that these defensive positions on and surrounding the western endpoint of the study area would have been manned by the relevant members of the Armed Forces for a significant period before, during and after both world wars. This suggests that SAA and LSA would have been stored in these areas and highlights the potential for contamination to have resulted at key points, especially when the threat of invasion rescinded mid-way through WWII and surplus weaponry would have needed disposal. Defensive positions such as anti-aircraft batteries, coastal batteries and other gun emplacements could also have resulted in contamination across the wider area of this section of the study area, across the Thames Estuary.

Sea Mines

- Sizeable mine laying campaigns were undertaken by both Britain and Germany across the North Sea in WWI and WWII. The majority of the study area appears to have been situated across several of the more prominent of the WWII-era minefields, including significant defensive areas off the east coast of Britain and the north coast of Germany. Evidence has also been found to indicate that air deployed mines were regularly dropped within the Thames Estuary by the Luftwaffe between 1940-1941.
- A precise assessment of the current risk from mines across the length of the study area is difficult to ascertain. Efforts were made by both Germany and Britain post-war to remove or make safe the areas mined during the war. However such clearance tasks do not guarantee the complete removal of all mines within a danger area, especially as such items have the potential to migrate or became covered due to sediment and tidal action over a long period of time. It is therefore not possible to discount the possibility of encountering aerial, surface or submarine laid sea mines across any offshore section of the proposed study area.

Wreck Sites

- A number of listed historic wrecks have been identified on and around the study area. The majority of these wrecks are situated within shallower waters, at the approach to the Thames Estuary and off the coastlines of Germany. These wrecks often demonstrate the presence of both sea mines and aerial bombing during WWI and WWII.
- The majority of wrecks identified are commercial vessels, though several WWII-era British military wrecks are also recorded in the western and central sections of the study area, including the submarine HMS Truculent, three destroyers and several minesweeper trawlers. The eastern section of the study area, off the German coastline, contains several German military wrecks. These consist of the WWI-era cruiser SMS Yorck, the WWII-era DW 07 Patrol Boat (Trinchen Behrens) and two WWII-era minesweepers. Such vessels are anticipated to have carried items of ordnance at the time of their loss and, if not recovered, could have contaminated their immediate surroundings.

Torpedoes/Anti-Submarine Weapons

- It is well documented that both torpedoes and anti-submarine weapons were employed as part of aerial and naval warfare across the North Sea during WWI and WWII, although their numbers were relatively low when compared with other types of munitions. However, historical records indicate that submarine activity within the region was limited by the presence of defensive minefields and the British blockades of German ports and as a result, the U-boat campaigns of both world wars were predominantly focused on more viable shipping targets in the Atlantic Ocean. This is correlated by the available data concerning wreck sites, which indicates that only one WWI-era torpedo related wreck is situated in the vicinity of the study area and none related to anti-submarine weaponry, despite its length and position. Nevertheless it not possible to completely discount the presence of such items at the location of the study area to their usage in the wider area.

UXO Risk Mitigation

This report has concluded that there is a risk from unexploded ordnance along the proposed HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom and Wilhelmshaven, Germany. The risk has been broadly split into five different zones, which each contain varying levels of assessed risk from different potential sources:

- UK Mainland – Risk from German air delivered ordnance and historic Allied ordnance.
- Thames Estuary – Significant risk from smaller items of LSA/SAA originating from historic and contemporary ranges within the estuary.
- Main Offshore Area (North Sea) – Primary risk from larger items, originating from historic sea minefields.
- German Approaches –Significant risk from both larger and smaller items of UXO, originating from a number of historic munitions dumps.
- German Mainland – Primary risk from Allied air delivered ordnance.

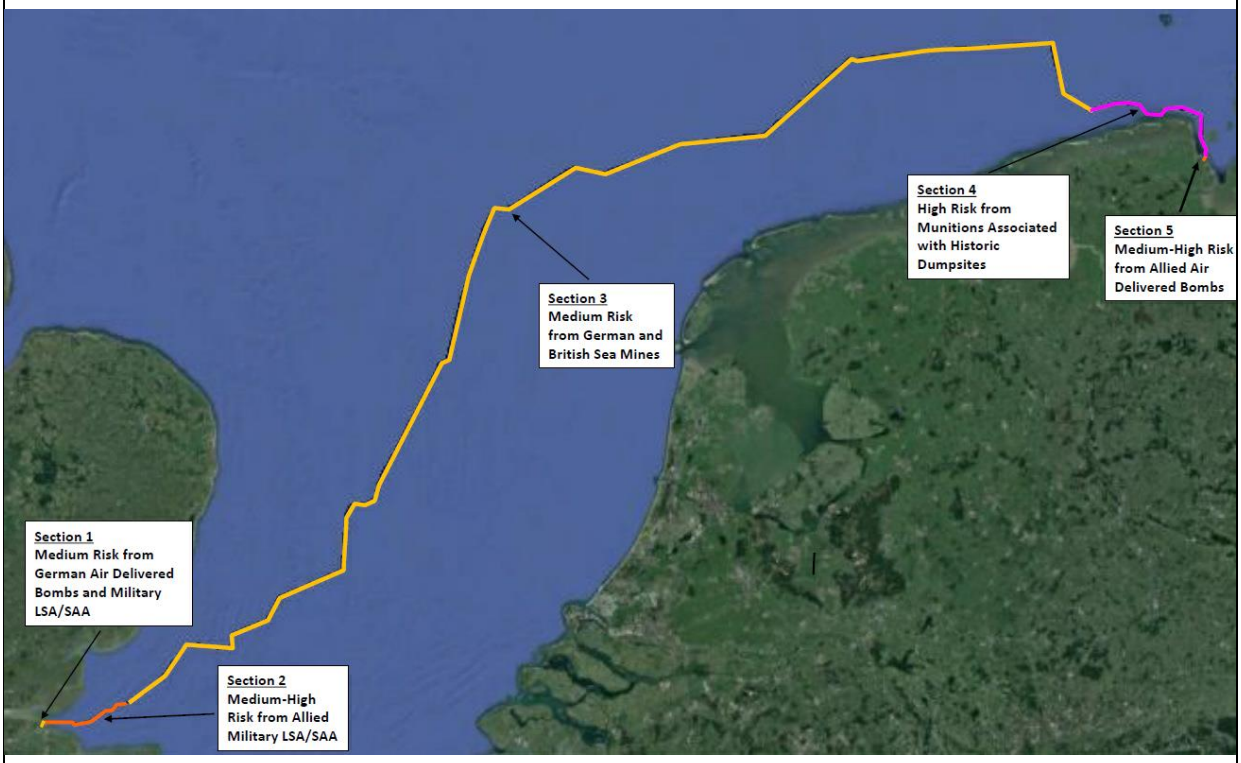
Offshore UXO Risk Mitigation

Due to the level of risk identified, it is recommended that 1st Line Defence Risk are contacted to discuss the creation of risk mitigation plan for each specific phase of works within the study area. The methodology of any measures should be tailored to take into account the nature and size of UXO items assessed most likely to be encountered in each section of the study area.

Onshore/Nearshore UXO Risk Mitigation

For onshore/foreshore works at both the western and eastern end points of the route, it is also recommended that proactive support is provided by a UXO specialist. This would include UXO Safety and Awareness Briefings for all operatives conducting intrusive works, UXO support for trial pits and the clearance of all proposed boreholes by magnetometer survey. Depending on the ground conditions present it may also be viable to undertake a non-intrusive magnetometer survey and target investigation on beach and inland areas.

Risk Map



For indicative purposes – not to scale.

Low Risk | Medium Risk | Medium-High Risk | High Risk

Glossary

Abbreviation	Definition
AA	Anti-Aircraft
AAA	Anti-Aircraft Ammunition
AFS	Auxiliary Fire Service
AP	Anti-Personnel
ARP	Air Raid Precautions
AXO	Abandoned Explosive Ordnance
DA	Delay-action
EOC	Explosive Ordnance Clearance
EOD	Explosive Ordnance Disposal
FP	Fire Pot
GM	G Mine (Parachute mine)
HAA	Heavy Anti-Aircraft
HE	High Explosive
IB	Incendiary Bomb
LAA	Light Anti-Aircraft
LRRB	Long Range Rocket Bomb (V-2)
LSA	Land Service Ammunition
MOL	Molotov (Incendiary Bomb)
OB	Oil Bomb
PAC	Pilotless Aircraft (V-1)
PB	Phosphorous Bomb
PM	Parachute Mine
POW	Prisoner Of War
RAF	Royal Air Force
RFC	Royal Flying Corps
RNAS	Royal Naval Air Service
SAA	Small Arms Ammunition
SD1000	1,000kg high explosive bomb
SD2	Anti-personnel “Butterfly Bomb”
SIP	Self-Igniting Phosphorous
U/C	Unclassified bomb
UP	Unrotated Projectile (rocket)
USAAF	United States Army Air Force
UX	Unexploded
UXAA	Unexploded Anti-Aircraft
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	Flying Bomb (Doodlebug)
V-2	Long Range Rocket
WAAF	Women’s Auxiliary Air Force
X	Exploded

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

Site: HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom and Wilhelmshaven, Germany.
Client: Intertek

1. Introduction

1.1. Background

1st Line Defence has been commissioned by Intertek to conduct an Offshore Detailed Unexploded Ordnance (UXO) Risk Assessment for the planned works at HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom, and Wilhelmshaven, Germany. (Note - for the purposes of this report the name of the project will also be referred to as 'the study area' or will else be shortened to 'the HVDC Electricity Transmission Interconnector'.)

UXO in offshore areas of the UK can originate from three principal sources:

1. Munitions resulting from wartime activities including ship-to-ship engagements, aerial bombing, long range shelling and defensive activities in both WWI and WWII.
2. Munitions deposited as a result of military training and exercises.
3. Munitions lost, burnt, buried or otherwise discarded either deliberately, accidentally, or ineffectively.

During WWI and WWII, significant quantities of explosive ordnance was either dropped from the air or placed on and around the beaches of the UK, including both bombs and mines. There is also a legacy of military activity which has led to contamination off the UK coast – including offshore munitions dumping, firing ranges, training exercises, military related wrecks, torpedoes and depth charges. UXO which was deployed during such military activities, but failed to initiate, or else has been dumped at sea can present a significant risk to construction works and development projects. The discovery of a suspect device during works can cause considerable disruption to operations as well as cause unwanted delays and expense.

This report will assess the potential factors that may contribute to the risk of UXO contamination, by examining the history of the area, and the activities and deployment of various types of weaponry that may have led to contamination. The risk of ordnance remaining, of ordnance being encountered and the consequences of any encounter will also be examined. If an elevated risk is identified at the site, this report will suggest appropriate mitigation measures, in order to reduce the risk to as low as is reasonably practicable.

This report complies with the guidelines outlined in *CIRIA C754*, 'Assessment and Management of Unexploded Ordnance (UXO) Risk in the Marine Environment'.

2. Method Statement

2.1. Report Objectives

The aim of this report is to conduct a comprehensive assessment of the potential risk from UXO during and prior to the installation of the HVDC Electricity Transmission Interconnector. The report will also suggest appropriate site and work-specific risk mitigation measures to reduce the risk from explosive ordnance during the envisaged works to a level that is as low as reasonably practicable.

2.2. Risk Assessment Process

1st Line Defence has undertaken a five-step process for assessing the risk of UXO contamination:

1. The risk that the study area was contaminated with UXO.
2. The risk that UXO remains within the study area.
3. The risk that UXO may be encountered during the proposed works.
4. The risk that UXO may be initiated.
5. The consequences of initiating or encountering UXO.

In order to address the above 1st Line Defence has taken into consideration site specific and non-site specific factors including:

- The military history of the area.
- Offensive and defensive mine laying.
- Firing ranges.
- Naval exercise areas.
- Official and unofficial munitions dumping sites.
- Use of torpedoes and depth charges.
- Military-related wrecks.
- Records of aerial bombing.

2.3. Sources of Information

Every reasonable effort has been made to ensure that relevant evidence has been consulted and presented in order to produce a thorough and comprehensible report for the client. To achieve this the following, which includes military records and archive material held in the public domain, have been accessed:

- The National Archives (Kew, England), the German Federal Archives (Koblenz, Germany), he Archive of the City of Wilhelmshaven, the Netherlands National Archives, The Hague Record Office and Kent Record Office.
- The UK Hydrographic Office, the OSPAR Commission and wrecksite.eu.
- Relevant information supplied by Intertek.
- Available material from 33 Engineer Regiment (EOD) Archive.
- 1st Line Defence's extensive historical archives, library and UXO geo-datasets.
- Open sources such as published books and internet resources.

Research involved a visit to The National Archives and the UK Hydrographic Office.

2.4. General Considerations of Historical Research

This desktop assessment is based largely upon analysis of historical evidence. Every reasonable effort has been made to locate and present significant and pertinent information. 1st Line Defence cannot be held accountable for any changes to the assessed risk level or risk mitigation measures, based on documentation or other data that may come to light at a later date, or which was not available to 1st Line Defence during the production of this report.

It is often problematic and sometimes impossible to verify the completeness and accuracy of WWII-era records. This is compounded offshore by the limitations of record keeping over water, where the observation and positional accuracy of incidents was difficult to maintain. As a consequence, conclusions as to the exact location and nature of a UXO risk can rarely be quantified and are to a degree subjective. To counter this, a range of sources have been consulted and analysed. The same methodology is applied to each report during the risk assessment process. 1st Line Defence cannot be held responsible for any inaccuracies or the incompleteness in available historical information.

3. UK Legislative and Regulatory Environment

3.1. General

There is no formal obligation requiring a UXO risk assessment to be undertaken for construction projects in the UK, nor is there any specific legislation stipulating the management or mitigation of UXO risk. However, it is implicit in the legislation outlined below that those responsible for intrusive works (archaeology, site investigation, drilling, piling, excavation etc.) should undertake a comprehensive and robust assessment of the potential risks to employees and that mitigation measures are implemented to address any identified hazards. Outside of the UK, other EU member states have very similar legislation to ensure high standard of health, safety and welfare during construction projects. Outside of the EU, local requirements may not correspond to the standard of EU requirements.

3.2. CDM Regulations 2015

The Construction (Design and Management) Regulations 2015 (CDM 2015) define the responsibilities of parties involved in the design and construction of temporary or permanent structures in the UK and associated territorial waters. As well as the construction of any renewable energy structures in the renewable energy zone, defined as any area outside of UK territorial waters designated for the utilisation of energy from water or winds.

For construction projects located beyond UK territorial waters but within the UK continental shelf there is no specific health and safety legislation, but current practice is to adopt a proactive approach on construction projects by applying the principles of existing CDM legislation. The UK continental shelf is defined by the greater of the natural prolongation of land territory to the continental margin's outer edge or 200 nautical miles from the coastal state's baseline.

The CDM 2015 establishes a duty of care extending from clients, principle co-ordinators, designers, and contractors to those working on, or affected by, a project. Those responsible for construction projects may therefore be accountable for the personal or proprietary loss of third parties, if correct health and safety procedure has not been applied. Although the CDM does not specifically reference UXO, the risk presented by such items is both within the scope and purpose of the legislation. It is therefore implied that there is an obligation on parties to:

- Provide an appropriate assessment of potential UXO risks at the site (or ensure such an assessment is completed by others).

- Put in place appropriate risk mitigation measures if necessary.
- Supply all parties with information relevant to the risks presented by the project.
- Ensure the preparation of a suitably robust emergency response plan.

3.3. The 1974 Health and Safety at Work etc. Act

All employers have a responsibility under the Health and Safety at Work etc. Act 1974 and the Management of Health and Safety at Work Regulations 1999, to ensure the health and safety of their employees and third parties, so far as is reasonably practicable and conduct suitable and sufficient risk assessments.

3.4. Additional Legislation

In the event of a casualty resulting from the failure of an employer/client to address the risks relating to UXO, the organisation may be criminally liable under the Corporate Manslaughter and Corporate Homicide Act 2007.

4. Role of Commercial UXO Contractors and The Authorities

4.1. Commercial UXO Specialists

The role of UXO Specialist such as 1st Line Defence (often referred to also as UXO Consultant or UXO Contractor) is to provide expert knowledge and guidance to the client on the most appropriate and cost-effective approach to UXO risk management at a site.

The principal role of a UXO Specialist is to provide the client with an appropriate assessment of the risk posed by UXO for a specific project, and identify suitable methodology for the mitigation of any identified risks to reduce them to an acceptable level. If required the UXO consultant may also provide additional support, such as the sign-off of documentation, post appointment.

The requirement for a UXO Specialist should ideally be identified in the initial stages of a project, and it is recommended that this occur prior to the start of any detailed design. This will enable the client to budget for expenditure that may be required to address the risks from UXO, and may enable the project team to identify appropriate techniques to eliminate or reduce potential risks through considered design, without the need for UXO specific mitigation measures.

1st Line Defence also have the capability to provide whatever UXO risk mitigation services are required in order to reduce a risk to as low as reasonably practicable. In the marine environment, this can involve the provision of appropriate survey and clearance methodology, as well as what to do should a suspect anomaly or item of ordnance be encountered either on the seabed or on board a vessel.

For more information on the role of commercial UXO specialists, see *CIRIA C754 and C681*.

4.2. The Authorities

In the UK the police are responsible for coordinating the emergency services in the event of encountering a high-risk item of UXO above the high water mark (HWM) and HM Coastguard below. This will include establishing a cordon and evacuating people from the area. In specific circumstances operations above the high water mark will be undertaken by the Royal Logistical Corps or the Corps of Royal Engineers and operations below the HWM undertaken by the Royal Navy. Note however that the Corps of Royal Engineers remain responsible for land mines encountered below the HWM and that the RAF is responsible for Allied air delivered weaponry on RAF technical ranges, regardless of their position in relation to the HWM.

The police have a responsibility to co-ordinate the emergency services in the event of an ordnance-related incident at a construction site on land (such as works on or beyond the beach). Upon inspection they may impose a safety cordon, order an evacuation, and call the military authorities Joint Services Explosive Ordnance Disposal (JSEOD) to arrange for investigation and/or disposal. The JSEOD are responsible for tasking appropriate MoD assets to provide military EOD support where there is a perceived threat to life or unacceptable economic damage. In the absence of a UXO specialist, police officers will usually employ such precautionary safety measures, thereby causing works to cease, and possibly requiring the evacuation of neighbouring businesses and properties.

The priority given to the police request will depend on JSEOD's judgement of the nature of the UXO risk, the location, people and assets at risk, as well as the availability of resources. The speed of response varies; authorities may respond immediately or in some cases it may take several days for the item of ordnance to be dealt with. Where there is a realistic expectation of encountering munitions during works and a threat to life does not exist the JSEOD may not treat each occurrence as an emergency and will recommend the construction company puts in place alternative procedures, such as the appointment of a commercial UXO contractor to manage the situation.

Depending on the on-site risk assessment the item of ordnance may be removed from the site and/or destroyed by a controlled explosion. The latter process is lengthy and may necessitate the establishment of additional cordons and evacuations. Following the removal of an item of UXO, the military authorities will only undertake further investigations or clearance operations in high risk situations.

5. The Study Area

5.1. Background

The proposed HVDC (high voltage direct current) Electricity Transmission Interconnector is understood to be a new subsea cable between existing substations and electricity grids in the UK and continental Europe.

The project is designed to provide the first direct energy link between the UK and Germany, with the aim of delivering an increased security of supply, fuel diversity and greater competition to both nation's networks. It will allow a capacity of up to 1.4GW of electricity to flow in both directions, connecting two of Europe's largest energy markets and allowing the integration of renewable energy sources.

5.2. Location of the Study Area

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Location maps are presented in **Annex A**.

5.3. Description of the Study Area

The western end of the study area, situated on the UK mainland, comprises a small area of coastline and surrounding rural land on the Isle of Grain. The eastern end of the study, situated on the German mainland, occupies a small area of open land surrounding the Am Tiefen Fahrwasser roadway and the coastline of Hooksiel.

The remainder of the study area occupies a large expanse of open water within the Thames Estuary and the North Sea. According to information provided by the client, the maximum water depth encountered in this area is 62 metres.

Recent aerial imagery of the study area is presented in **Annex B**.

5.4. Ordnance Survey Historical Maps

Historical ordnance survey maps were obtained for this report and are presented in **Annex C**. See below for a summary of the site history shown on acquired mapping.

The Isle of Grain / Thames Estuary	
Date	**Description**
1896	This map edition is of both small scale and limited quality. However, it is possible to discern that that the western endpoint of the study area, on UK landfall, is predominantly occupied by open marshland within the Isle of Grain. White Hall Farm is identifiable to the west, the village of Grain to the south and Grain Tower to the south-east. The remaining visible section of the study area is occupied by open water within the Thames Estuary. Southend and Shoeburyness are identifiable across this body of water to the far north and north-east of this section of the study area.

1937- 1958	This map is of larger scale and subsequently shows the western endpoint of the study area in more detail. This area has remained occupied by open ground, though it is labelled 'saltings' and shown to be intersected by a footpath. Of note is the presence of an artillery range and Yantlet Battery to the west, within Grain Marsh. Grain Fort and Wing Battery are outlined to the south-east.

Wilhelmshaven/ North Germany	
Date	**Description**
1901	This map edition depicts the eastern endpoint of the study area, situated between the North Sea and the Jade Blight. The endpoint of the route itself is situated some distance from the German coastline during this period, indicating that significant land reclamation has taken place in this area in later years. The wider surrounding area of land appears relatively rural in nature, aside from the position of Wilhelmshaven to the south.

6. Scope of the Proposed Works

6.1. General

The proposed works are believed to comprise a series of pre-construction surveys, followed by the subsequent subsea cable installation.

6.1.1. The Survey Campaign

At the time of the production of this report, it is understood that a geotechnical survey is already underway, with geotechnical sampling planned at every 1km across the study area between the UK and Germany. Limited information was provided by the client regarding the exact scope of this survey, which is anticipated to include vibrocore and cone penetrometer tests (CPT) within areas of open water and investigatory boreholes and trial pits within areas of landfall.

It is also anticipated that additional survey methodology will be employed for future survey work, including the use of swath bathymetry, sidescan sonar, sub bottom profiling, magnetometry, and ROV grabs, to acquire data for the confirmation of the location of the offshore route; as well as to determine the appropriate installation and protection methods to be adopted.

6.1.2. The Cable Installation

It is understood that the project is currently going through a period of further project development ahead of a full submission being made to the UK and German regulators in 2019. Final approval for the scheme is expected in 2020, allowing construction to start shortly afterwards. The current target date for project completion is 2023.

As a result, limited information is available concerning the final methodology of the proposed cable installation. However, typical intrusive activities within the marine environment for this type of project could include the use of anchors, cable trenching equipment, pre-lay grapnel runs, boulder removal ploughs, mass flow excavators, dredging and the placement of material mattresses on the seabed.

It should be noted that such activities might exceed the boundary of the proposed study area provided. A 1km buffer zone has therefore been considered on either side of the centre line of the proposed cable area for the purpose of this report.

7. Ground Conditions

7.1. General Geology

The British Geological Survey (BGS) map, the German Federal Institute for Geosciences and Natural Resources (BGR) Geoviewer and the European Marine Observation and Data Network (EMODnet) were consulted for the purpose of this report. These sources show the bedrock geology of the western endpoint of the study area, within the UK landfall on the Isle of Grain, to be underlain by the London Clay Formation – clay and silt, with superficial deposits of Alluvium – clay, silt, sand, peat and gravel. The bedrock geology of the eastern endpoint of the study area, within the German landfall, is shown to consist of sedimentary material overlain by clay, silt and sand.

The offshore bedrock geology varies considerably over the length of the proposed route and includes areas underlain by:

- Mudstone and sandstone (undifferentiated) and tuff.
- Rock, siliciclastic, argillaceous with sandstone (undifferentiated).
- Brielle Ground Formation - sand.
- Pliocene sedimentary material.

7.2. Site Specific Geology

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

8. Introduction to UXO and The Marine Environment

8.1. General

Many different types of UXO can be found in marine environments, primarily as a result of historic military activity. 'Poor housekeeping' by armed forces has also led to the loss or deliberate dumping of items of UXO within shores and waters. The United Nations distinguishes these activities into the following categories: defensive military activity, offensive military activity and AXO (Abandoned Explosive Ordnance). Further background to these categories in relation to the site location is provided in Section 9 of this report.

The following sections will provide an introduction to the types of ordnance that might be discovered on marine sites, their failure rates and their potential for initiation; as well as an introduction to the interaction between UXO and the marine environment.

8.2. Generic Types of Ordnance found in the Marine Environment

An understanding of the principal types of ordnance encountered in marine environments allows a more informed assessment of the hazards posed by any unexploded items that may remain in situ on a site. Items of ordnance most commonly found on maritime sites include:

- Sea mines
- Depth charges
- Torpedoes
- Air delivered iron bombs
- Artillery projectiles

- LSA (Land Service Ammunition)
- SAA (Small Arms Ammunition)

Images and brief summaries of the characteristics of the above listed types of ordnance are presented in **Annex D**. Please note that their descriptions are not exhaustive and it is possible that other forms of UXO will be present in the marine environment.

8.3. Failure Rate of Ordnance

It has been estimated that 10% of conventional ordnance failed to function as designed and remained unexploded. Reasons for why such weapons might have failed to function as designed include:

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

From 1940 to 1945 bomb disposal teams on land dealt with a total of 50,000 explosive items of 50kg, over, 7,000 anti-aircraft projectiles and 300,000 beach mines. Unexploded ordnance is still regularly encountered across both the UK and mainland Europe; see press articles in **Annex E**.

8.4. Initiation of Unexploded Ordnance

Unexploded ordnance does not spontaneously explode. All high explosive filling requires significant energy to create the conditions for detonation to occur. In the case of unexploded ordnance discovered within the marine environment, there are a number of potential initiation mechanisms (see table below)

UXO Initiation Mechanisms	
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.
Friction Impact	The most likely scenario resulting in the detonation of a UXO is friction impact initiating the shock-sensitive fuze explosive. The combined effects of the marine environment 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.
Sympathetic Detonation	The positioning of several items of UXO in close proximity may result in the sympathetic detonation of multiple items, following the initial detonation of just one item. This can occur within features such as munitions dumps and minefield, where large number of UXO are closely grouped together.
Natural Events	Seismological events, such as earthquakes and tsunamis, can generate sufficient kinetic energy to detonate UXO.

8.5. The Physical Marine Environment

The physical conditions that exist within the marine environment and their behaviour over time can have a significant impact on the position and condition of items of UXO. The following physical aspects

are described in the table below, alongside an overview of how these physical conditions and changes can interact with UXO

Physical Conditions	Description	Effect on UXO
Geology and Sediments	Much of the marine environment comprises underlying rock overlain by less consolidated sediments, such as silts, clays, sands and gravels. The extent of overlying sediment cover can vary significantly between areas of little or no sediment cover, such as areas of exposed rock, and areas of the seabed with a sediment thickness greater than hundreds of metres.	The composition of the sediment cover present and the underlying geology will determine the depth to which some items of UXO initially penetrate the seabed or shore. As well as to what extent such items may subsequently become buried by natural processes.
Bedforms	Bedforms may form depressions, such as channels, and extrusions across large areas of the seabed and typically include mobile sediments, such as mega ripples and sand waves. Subsequently many areas of the seabed are not uniformly flat. More substantial features, such as sand ridges, sand ribbons and sand or gravel banks may also be present in some cases. Bedform features are often indicative of the relationship between the physical processes and sediments present. The asymmetry of bedforms can demonstrate active processes of sediment erosion, transport and deposition.	The presence of a bedform can be used to determine the net direction of active sediment transport. Highly mobile seabed and shore areas are more likely to result in notable changes to bed levels over time and can be monitored to infer more information regarding the potential burial or exposure of items of UXO present.
Coastal Processes	The energy generated from physical processes, such as winds, water and tides have their greatest effect on the surface of a water body and reduce with the depth of a water column. These forces may be affected by the modification of both wave and tidal processes in areas near to the shore, which can cause larger forces to be exerted on items or sediments present on the sea bed.	The force of these coastal process is affected by the relationship between water depth and wave length. Information about these factors can be used to determine the depth of a wave influence and whether the wave will have a significant interaction with items of UXO present on the seabed.
Sediment Transport and Morphological Change	Physical forces exerted onto the seabed or shore may also cause sediment transport, depending on the size of the sediment grains and the level of force. This movement can take the form of bedload transport, where sediment moves directly across the seabed or suspended load transport, where sediment is instead transported across the water column.	Sediment transport can take the form of a gradual, progressive trend or can occur rapidly as a result of storm or surge events. Significant sediment movement is therefore difficult to determine. The influence of this sediment transport and any resulting morphological change can affect the exposure and movement of UXO present.

8.6. Interaction between UXO and the Marine Environment

These physical marine conditions can interact with items of UXO present in the marine environment in the following three principal ways:

8.6.1. Exposure or Penetration into the Seabed or Shore

Some types of UXO will be initially deployed directly on the seabed or the shore, such as sea and land mines. Whilst other types of UXO, including artillery projectiles, depth charges, air delivered bombs, LSA and SAA may only reach these surfaces after travelling through air and water. The initial resting place and penetration of UXO depends on a large number of factors, including the geology of the seabed or shore, the presence and thickness of any overlying sediment layers, the residual kinetic energy of the item of UXO and its angle of entry.

The initial position of an item of UXO within the seabed or shore surface can be classified as unburied, partially buried or fully buried. In addition, it should be noted that some items, such as buoyant sea mines, are not initially deployed directly on the seabed but will sink over time and come to rest of the seabed's surface.

8.6.2. The Subsequent Burial or Uncovering of UXO

After its initial position within the marine environment an item of UXO may experience burial, due to the vertical deposition of sediments or uncovering due to the vertical erosion of sediments. Consequently, some items will experience cycles of burial, uncovering and re-burial due to regular trends of erosion deposition. These sediment movements can be the result of both near-field and far-field process and can be formed by gradual ongoing erosion trends or cycles of change dominated by temporal effects, such as seasonal cycles.

8.6.3. Migration of UXO

UXO in the marine environment has the potential to migrate if subject to sufficient force from metocean processes. Due to the weight and density of most large types of UXO, migration distances are likely to be small for such items, but can be greater during storm events or surges, or within areas where the seabed slopes significantly. Smaller types of UXO, such as LSA and SAA, are much more likely to migrate within the marine environment.

An exception to this description of migration are buoyant sea mines. These items should be considered separately because they have the potential for much greater distances of migration, driven by tidal currents, if they become loose from their moorings. Theoretically migration distances in this scenario could be as far as the distance of the tidal excursion each day and could extend up to several kilometres. However, such items will lose buoyancy over time and will come to rest upon the seabed, following which the normal rules of migration will apply.

Studies of UXO migration in the marine environment are still relatively limited today and require detailed information about the type of UXO and the metocean conditions present, as well as data regarding the composition of seabed sediments, bedforms and the underlying geology. It is therefore rarely possible to determine the initial location of an item of UXO in the marine environment or its potential migration distance with a great deal of accuracy.

9. The Risk from UXO

The presence of UXO in the marine environment can broadly be classified as the legacy of three activities: defensive military activity, offensive military activity and AXO (abandoned explosive ordnance). These categories are however not definitive, as some UXO items may be multi-category.

9.1. Defensive Military Activity

Defensive military activity incorporates defensive munitions employed not only during periods of major conflict, such as WWI and WWII, but also the intervening years. Defensive munitions are most likely to be found within areas used to guard maritime zones, such as designated sea minefields and coastal armament areas, as well as areas associated with military training, such as ranges and camps. Consequently, defensive munitions can include sea mines, land mines, artillery projectiles and LSA.

Defensive naval activity played a significant role in Europe during both WWI and WWII, as each side attempted to defend their territories from invasion and reinforce certain key points and areas overseas. Such activities also played a significant part in the economic survival of each nation during these periods, with a large number of both munitions and vessels regularly deployed to defend merchant shipping from attack.

9.2. Offensive Military Activity

UXO associated with offensive military activity is more likely to originate from periods of major conflict, particularly during WWI and WWII in Europe. Offensive munitions may consist of any item used to attack or engage a target in combat and can result from such activities as aerial bombing, sea mining and vessel to vessel engagements. Offensive munitions therefore cover a broad variety of items and can include aerial bombs, sea mines, land mines, torpedoes, artillery projectiles, LSA and depth charges.

Offensive naval military activity in Western Europe during WWI and WWII included the blockade of ports, attacks on merchant shipping, the transport of military forces and large scale naval conflicts, such as the Battle of Jutland.

9.3. Abandoned Explosive Ordnance (AXO)

Items of AXO are more likely to be found on or near areas where the deliberate dumping of munitions is recorded to have taken place, or else in close proximity to the wrecks of munition carrying aircraft and naval vessels. One well-documented case close to the study area is the wreck of the SS Richard Montgomery, an American liberty ship, which ran aground on a sandbank in the Medway in August 1944. This vessel is recorded to have been carrying 6,127 tons of munitions and is still designated as dangerous under the Protection of Wrecks Act today.

Large numbers of AXO present today result from the practice of sea dumping, which was the internationally accepted method of disposal of surplus munitions at the end of WWII. For example, the British Army designated over 1.2 million tons of ordnance to be disposed of during this period, with Beaufort's Dyke, situated off Stranraer, designated as the principal offshore disposal point. Beauforts Dyke remains Europe's biggest underwater dump for surplus ammunition today, with more than one millions ton of ordnance, including bombs, projectiles and explosive material deposited between 1920 and 1976.

10. Wrecks

10.1. General

Many military and civilian vessels were sunk in European waters during WWI and WWII, predominantly due to U-boat activity as well as the presence of offensive and defensive mining. Often, research into the location of wrecks and the reason for their loss can indicate the types of weapons that were deployed in an area – whether they were bombed, torpedoed or mined for example – and therefore the nature of any items that might remain.

Some wrecks can pose a threat today due to their particular cargo, especially those in use by the military or responsible for the transportation of weapons and explosives. However, seabed contamination from military-related wrecks tends to be fairly localised since the munitions are generally enclosed within the hull of the vessel, or will often collect in scours around the wreck. Furthermore, weapons in transit were typically unfuzed so pose less of a direct threat than weaponry that has fired but failed to detonate.

10.2. Shipwrecks

Records of shipwrecks between the Isle of Grain and Wilhelmshaven were obtained from wrecksite.eu and the UKHO. An overlay showing the locations of recorded wrecks on aerial imagery is presented in **Annexes F1-F7**. Shipwrecks recorded within the study area and its immediate surroundings have been included and are detailed in the accompanying tables presented in **Annexes F9-F10.**

This data shows the majority of shipwrecks to be concentrated within the western section of the proposed study area, across the approach to the Thames Estuary. Most of the wrecks within this region were the result of mines (potentially British or German in origin), with 13 vessels recorded as sunk by this method. A smaller number of vessels are recorded to have been sunk by German WWII-era raids, as well as by circumstances unrelated to explosive ordnance.

Significantly fewer wrecks are recorded across the more central sections of the study area, across what is now the British and Dutch EEZ's. The majority of wrecks within this region are recorded to be the result of mines originating from German submarines, though one German torpedo incident and three circumstances unrelated to explosive ordnance are also noted.

The concentration of wrecks slightly increases within the eastern section of the study area, within what is now the German EEZ. The majority of these wrecks are recorded to have been the result of Allied WWII-era air raids, with the exceptions of one unspecified wreck and another that was the result of a German defensive mine in WWI.

10.2.1. Military Related Shipwrecks

The majority of wrecks recorded within the western and central section of the study area concerned either Neutral or Allied cargo ships, though several British military wrecks are also recorded within the area during WWII. These included the submarine HMS Truculent, the destroyers HMS Coquette, HMS Vimiera and HMS Ivanhoe and several minesweeper trawlers. One U-boat wreck (U-31) is also recorded in this region in 1915.

The eastern section of the study area, off the German coastline, contains several German military wrecks. These consist of the WWI-era cruiser SMS Yorck, the WWII-era DW 07 Patrol Boat (Trinchen Behrens) and two WWII-era minesweepers.

A number of these military vessels are recorded to have contained specific armaments, such as QF 12 pounder guns, QF 6 pounders guns, A.A emplacements, Lewis Guns and torpedoes (see **Annex F9** for

further details). However even unspecified military related vessels have the potential to have been carrying items of unexploded ordnance at the time of their loss.

10.3. Aircraft Crashes

During WWII, many hundreds of aircraft were shot down and lost over Western Europe. The English Channel and the North Sea were the focus of a significant proportion of air activity during this period, with many hundreds of aircraft being abandoned or crash-landed due to combat damage or technical failures. Losses by the Luftwaffe and by RAF Fighter Command were most significant during the four months of the Battle of Britain (Jul 1940 - Oct 1940), during which 234 RAF aircraft are documented to have crashed within British waters.

Given the relatively low speed of impact, aircraft that crashed at sea were often largely intact as they came to rest on the sea floor and may have remained so. Although subsequent damage by shipping, corrosion and movements in the physical marine environment, such as storm surges, can have a significant impact on a crash site. The risk of encountering UXO at aircraft crash sites is determined through considerations of the aircraft's specification, its potential bomb load, the nature of the crash and the extent of any recovery operations.

One aircraft crash site has been identified approximately 370m from the western section of the study area, at the mouth of the Thames Estuary. The name and category of this aircraft is not specified, though it is likely to be a WWII-era bomber because of the size of its fuselage (recorded at 40ft across). The cause and date of this crash is not known, with the wreck site discovered in 1991.

No evidence could be found to suggest the presence of any other wartime era aircraft wrecks in the study area in wrecksite.eu or the available UKHO records. However, it is conceivable that additional unrecorded aircraft wrecks may be present in the region. This is because a large section of the study area is anticipated to have been regularly patrolled by both Luftwaffe and RAF aircraft during WWII, when undertaking operations such as reconnaissance tasks, bombing sorties or the escort of merchant and naval shipping. Furthermore, the exact locations of wartime era crash sites over water were often difficult to accurately record and locate.

10.4. Deductions

The position and concentration of wrecks across the approach to the Thames Estuary suggest the presence of a sizeable minefield within this section of the proposed study area. This is likely to have been present during the earlier period of WWII, with all mine-related wrecks in this area dated between 1940-1942. Two wrecks also indicate that German air raids on shipping occurred in this region in 1940.

The positioning of wrecks within the more central areas of the study area are fewer and further between. Nevertheless, the nature of these wrecks indicates that areas of minefields were present between UK and German waters during both WWI and WWII, with a small number of mine related wrecks recorded from both periods; mainly situated off the east coast of England. A single torpedo related wreck dating from 1939 and a U-boat wreck in 1915, suggests that U-boat activity was relatively limited across the majority of the study area during both wartime periods.

In contrast, the nature of most of the wrecks within the eastern section of the study area, off the German coastline, indicates Allied aerial bombing on shipping in the region. These consist of five vessels sunk by Allied torpedo bombers and aerial deployed mines in 1944. One wreck, the SMS Yorck, also indicates the presence of a German defensive minefield in the vicinity in WWI.

11. Sea Mines

11.1. General

Sea mines are self-contained explosive devices placed in water to destroy ships, submarines and other watercraft. These weapons are laid and left until they are triggered by the approach, or contact with a vessel. Naval mines can be used offensively, to hamper enemy shipping and restrict it to a harbour, or defensively, to protect friendly shipping and create "safe zones".

During WWI, it is estimated that up to around 128,000 mines were laid in the sea around the coast of the UK, both offensively by the German Navy and defensively by the British Navy. This included minefields actively laid by German aircraft, destroyers and minelayers off British harbours. Both navies continued to deploy defensive and offensive defensive fields during WWII, with approximately 100,000 mines laid in the North Sea and Thames Estuary alone. Although attempts were made to remove or make safe sea mines deployed during WWII around the coastlines of Europe, it is estimated by some sources that up to 70% of sea mines were not recovered.

Mines are most frequently classified by their position in the water, delivery method and method of activation. A mine's position in the water can include bottom mines which rest on the ground, moored mines used for deeper-water areas and drifting mines, which float freely. Delivery methods include aircraft-laid mines, surface-laid mines and submarine-laid mines. The method of activation can be divided into two categories. Contact mines are designed to explode on contact with the hull of a ship and influence mines are triggered by the vicinity of a ship or submarine, rather than by direct physical contact.

Further details of these classifications, alongside examples of common types, are presented in **Annexes D1-D3**.

11.2. Historical Accounts

Historical accounts of minelaying operations across the study area were found in both online and written texts, most notably including *The War at Sea 1939-1945* by S W Roskill, *The Battle of the East Coast (1939-1945)* by J.P. Foynes and at Naval-History.net. The most relevant information found has been divided into several regions, presented in the sections below:

11.2.1. The East Coast

Several detailed references have been found to the development of one of the largest WWII-era British minefields, known as the 'East Coast Mine Barrier' between Scotland and the Dover Straits. This mine area, declared on the 24th December 1939, was initially constructed over an eight-month period in 1940, following the laying of over 17,000 contact and influence mines. It is indicated to have had an average mine density of 10-11 items per square mile, across an area that was over 500 miles long and more than 15 miles in width in certain sections, with five gap areas (Gaps A-E) present to allow the safe transit of Allied and neutral vessels.

This defensive minefield was initially predominantly designed to protect merchant shipping conveys travelling off the East Coast of England from German U-Boat attacks, but was later expanded and readapted as an anti-invasion measure in 1941 and 1942. An approximate sketch of this minefield, taken from The *War at Sea 1939-1945*, is presented in **Annex G1**. This source indicates that the East Coast Barrier intercepted a section of the study area, off the coast of East Anglia.

11.2.2. The North Sea

These secondary sources also specify the development of additional German and British minefields within the North Sea in WWII. It is indicated that a German Declared Mine area was announced on the

3rd September 1939 over a large rectangular area, 180 miles in length and 60 miles in width, stretching north from Dutch waters. This feature is shown to have been overlapped to the east by a British Declared Mine Area, announced on the 4th September 1939, which was presumably designed to counteract the aforementioned German minefield's position. Their positions are also approximately depicted in **Annex G1** and are shown to occupy a significant section of the east of the study area.

Both of these North Sea mine areas are believed to have remained in place for the remainder of the war, with the British Declared Area subsequently reinforced during the military offensives on Europe in 1944-1945. No further details could be found regarding the type or number of mines in each mine area, nor their exact locations.

11.2.3. The Thames Estuary

Due to the presence of the Thames Estuary Boom and surrounding coastal defences, there was little viable opportunity for German naval forces to lay mines directly within the Thames Estuary during both world wars. However, a number of written accounts have been found to suggest that German air minelaying did regularly take place within the estuary in WWII, mostly in an attempt to disrupt commercial shipping travelling to and from the docklands of London. These air raids predominantly took place between 1940-1941 and reached their peak during the 8-15th December 1940, when approximately 350 IX Loftkorps aircraft, armed with two mines apiece, sunk 16 ships in the region. These raids included the use of delayed action mines, causing shipping losses to occur into the New Year.

A map depicting the main area targeted during this period and the locations of ships sunk is presented in **Annex G1**. This source confirms that aerially deployed mines were dropped within the westernmost section of the study area, within and across the approach to the Thames Estuary.

11.3. Mine Charts

During the outbreak of WWII an index chart, showing Allied and Axis mining activities in home waters was produced by the British Admiralty Office. This source, which was updated every fortnight consisted of an outline chart showing command limits, overprinted in red for details of mines and searched channels. During the latter years of the war, it was re-schemed and extended to include the eastern shores of the North Sea. This chart, labelled 'No. Z 27' and several other special charts in this series, giving details of shallow and deep minefields, were obtained from the National Archives and the UKHO. The relevant excerpts are presented in **Annexes G2-G6** and are described in the accompanying table below.

Mine Charts– Annexes G2-G6	
Name and Date Range	**Comments**
British Islands: Approximate Position of Minefields – January 1915	This mine map was contained within an operations logbook compiled by the British Admiralty during WWI. It depicts several German minefields off the east coast of Britain, including one area labelled as the 'Southwould Area' at the western section of the study area. A British minefield is shown to the south of the study area on the approach to the Channel and is surrounded by an area of 'drifting British mines'. Some of these drifting mines also appear to intercept a small section of the study area.
No. Z 28 British Islands and North Sea: Deep Minefields – November 1940	This map does not show any deep minefields on or near the study area. Several small lines of deep mines are however show in the wider surrounding area, off the east coast of Britain. Note - the 'East Coast Mine Barrier' is also depicted within this map edition and shows that a part of the study area was situated within 'Gap E'.

No. Z 36 The North Sea: Positions of British and German Sea Mines – 1941	The central section of the study area is shown to pass through two separate German minefields, one of which also contains a small circular British minefield. The far eastern section of the study area intercepts the edge of another German minefield before passing through several British minefields off the coast of Northern Germany.
No. Z 27 British Islands and Adjacent Waters Minefields – July 1945	This map is believed to provide a consolidated record of major WWII-era minefields in the region. It shows a large British declared mine area (believed to be the East Coast Mine Barrier discussed in section 11.2.1) off the east coast of Britain, intercepting the western section of the study area. The central and eastern sections of the study area are positioned across several significant German and British Minefields situated across the North Sea.

It should be noted that the positions of minefields depicted within these record sets are based on navigational practices and equipment dating to WWI/WWII. Furthermore, all of these map editions are off relatively small scale. They are therefore used to provide an approximate guide of the locations of historical mine areas, whose true positions may have differed.

11.4. Deductions

It is rarely possible to compile a completely accurate picture of the location and composition of historic minefields in the marine environment. Nevertheless, both the primary and secondary historical sources discussed above indicate that sizeable mine laying campaigns were undertaken by both Britain and Germany across the North Sea in WWI and WWII. The majority of the study area appears to have been situated across several of these WWII-era minefields, including significant defensive areas off the east coast of Britain and the North German coastline. Evidence has also been found to indicate that air deployed mines were regularly dropped within the Thames Estuary by the Luftwaffe between 1940-1941.

Efforts were made by both Germany and Britain post-war to remove or make safe the areas mined during the war. However such clearance tasks do not guarantee the complete removal of all mines within a danger area, especially as such items have the potential to migrate or became covered due to sediment and tidal action over a long period of time. It was common practice to cut the mooring cables of buoyant mines using minesweeper vessels, and then to shoot and sink any mines which came to the surface. Inevitably, some cables will not have been cut and many mines will not have been detonated by the shooting. These would end up sinking but still being 'viable' weapons. Furthermore, some WWII-era mines were fitted with scuttling circuits which caused them to sink after a specified period of time, on occasion prior to the period of post-war clearance. It is therefore not possible to discount the possibility of encountering surface or submarine laid sea mines across the proposed study area.

12. Torpedoes

12.1. General

A torpedo is a self-propelled weapon with an explosive warhead, launched above or below the water surface, propelled underwater towards a target, and designed to detonate either on contact with its target or in proximity to it.

Torpedo design changed little from 1870 until the 1940s. During WWI torpedoes were widely used in to disrupt shipping and to sink submarines. Germany disrupted supply lines to Britain largely through use of submarine torpedoes, while Britain targeted U-boats with the weapon (sinking a total of 20 in this way over the course of the war). In WWII both Allied and Axis forces used torpedoes primarily against enemy warships. During this period, torpedoes were aimed to explode underneath a ship, to counter the heavy armour of these vessels and instead damage its keel, or the other structural members in the hull.

Failed torpedoes can sink to the seabed with their warheads intact when they run out of fuel. They are sometimes encountered off the UK coastline, mainly by fishermen – for example, one was recovered by trawlermen off the coast of Eastbourne in March 2013. Typically, the warheads contain around 200-300kg of explosives.

Examples of WWII-era torpedoes are presented in **Annex D4**.

12.2. Torpedoes in the Study Area

Information regarding the usage of torpedoes by any vessel is generally difficult to ascertain, as historic naval records rarely clarify the exact location and numbers of torpedoes deployed during wartime. Some information regarding the potential presence of torpedoes at a site location can however be inferred by the nature of recorded shipwrecks in the region.

The wreck data obtained from Wrecksite.eu and the UKHO only records one vessel, the SS Kaunas, to have been sunk by a torpedo attack in the vicinity of the study area. This cargo ship was sunk by the German U-boat U-57 on the 17th November 1939. No other WWII-era torpedo related shipwrecks were recorded in this region.

The wrecks of the U-boat U-31 and the German torpedo ship S-22, though not torpedo related, do indicate that vessels capable of deploying torpedoes were operational in the study area during WWII. Likewise, an overlay of U-boat losses presented in **Annex H** suggests that these types of vessels were also present in the North Sea in WWII. This source also shows that the Port of Wihelmshaven, near the easternmost point of the study area, was the home of the 2nd U-boat flotilla from Sep 1936 to May 1941.

12.3. Deductions

It is well documented that torpedoes were employed as part of both aerial and naval warfare across the North Sea during WWI and WWII, although their numbers were relatively low when compared with other types of munitions. Historical records indicate that a number of vessels within the region were subject to torpedo attacks as part of a policy of 'unrestricted submarine warfare' during both world wars, but that submarine activity within the region was limited by the presence of defensive minefields and the British blockades of German ports. As a result, the U-boat campaigns of both world wars were predominantly focused on more viable shipping targets in the Atlantic Ocean, in an attempt to disrupt transport and supply between the US and the UK.

This limitation of torpedo attacks in the region is correlated by the available data concerning wreck sites, which indicates that only one WWI-era torpedo related wreck is situated in the vicinity of the

study area, despite its length and position. However, it is not possible to completely discount the possibility of unrecorded torpedo activity, due to the known deployment of such items across the wider region.

13. Anti-Submarine Weapons

13.1. General

The most common anti-submarine weapon was a depth charge. The weapon is dropped into water (either by a ship or aircraft) near a target, detonates, and consequently subjects it to a powerful and destructive hydraulic shock. Most depth charges use high explosive charges and a fuze set to detonate the charge, typically at a specific depth.

Depth charges were developed during WWI by Britain for use against German U-boats and were subsequently utilised in both war periods. While deployed far less than torpedoes, the weapon acted as the principal anti-submarine weapon for surface ships. The first models were steel canisters filled with TNT explosives and detonated at a depth pre-set by a hydrostatic valve. The first recorded sinking of a German U-boat as a result of a depth charge occurred on 22nd March 1916, off the coast of Ireland.

Anti-submarine spigot mortars were also deployed by the Royal Navy from 1942. The most common was the Hedgehog mortar which had contact fuzing and was fired in batches of 24 (16kg charge weight). The larger Squid mortar was fired in salvoes of three and had a charge weight of 45kg. These devices accounted for more U-boat losses than depth charges and their ratio of successes to attacks was much better. However up to the middle of 1944 depth charges remained the principal anti-submarine weapon for surface ships

Examples of anti-submarine weapons are presented in **Annex D5**.

13.2. Anti-Submarine Weapons in the Study Area

As with torpedoes, the exact locations and number of anti-submarine weapons deployed during wartime is often difficult to determine – generally even more so than for torpedoes. Information from Wrecksite.eu and the UKHO does not indicate that any wrecks related to anti-submarine weaponry occurred directly within the study area but does suggest that these types of incidents occurred across other parts of the North Sea. An overlay of WWII-era U-boat losses presented in **Annex H,** records seven U-boat losses in the general surrounding area. However only one vessel, situated approximately 13 miles off the coastline of East Anglia, is labelled to have been sunk by depth charges.

13.3. Deductions

Anti-submarine weapons were deployed by most major military powers in the waters of Europe during WWI and WWII. Such items were not generally deployed in high numbers but were concentrated within regions subject to high volumes of German submarine activity, off the south and east coasts of the English mainland and across the North Atlantic.

Historical records indicate that depth charges were most commonly deployed to combat German U-boats in the North Sea, with other anti-submarine weapons, such as the Hedgehog and Squid spigot mortars put into operation from 1942. However little evidence could be found to support the presence of any anti-submarine activity in the immediate vicinity of the study area, as no wrecks related to these types of munitions are documented in the vicinity. Nevertheless it not possible to completely discount the presence of such items at the location of the study area to their usage in the wider area.

14. Offshore Munitions Dumps

14.1. General

Large quantities of munitions were dumped at designated sites or randomly jettisoned into the sea following WWI and WWII. These included conventional munitions such as bombs, grenades, torpedoes and mines, as well as incendiary devices and chemical munitions.

The presence of munitions in the sea can pose a risk to fishermen, coastal users and the offshore construction industry. As recently as 2005, three fishermen were killed in the southern North Sea when a WWII bomb believed to originate from a dump site exploded on their fishing vessel after having been caught in their nets.

Information on the amounts and locations of dumped munitions is recognised to be incomplete, but the existence of dumped munitions should always be a consideration for offshore construction projects. In 2004, OSPAR began a programme to establish the extent of munitions dumping and to monitor the frequency of encounters. This has revealed that munitions were dumped at 148 sites and that 1,879 encounters with munitions have occurred since 2004. Around 58% of reported munitions were encountered by fishermen and 29% found on the shore. Following discovery, 76%, of these items were removed from the sea or neutralised; 11% were returned to the sea for safety reasons.

14.2. Munitions Dumps in the Study Area

The overlay provided in **Annex I** shows the approximate location of historic munitions dumpsites recorded by OSPAR in the region of the study area. Two conventional munitions dumpsites are recorded in the vicinity of the western section of the study area, off the coastline of Essex and off the coastline of East Anglia. Seven munition dumpsites are clustered around the easternmost section of the study area, around the islands of Spiekeroog and Wangerooge and to the north of the Jade Blight.

Information was obtained from an assessment of Sea Ammunition Pollution by the German Federal Government concerning two of the dumpsites near the eastern section of the study area. One of these sites, located approximately 3.5 miles north of the eastern-tip of Spiekeroog is described as containing 'an unknown amount of mustard gas and other chemical warfare agents from both world wars[1].' Whilst the dumpsite situated just off the Jade Blight, near the eastern endpoint of the study area, is described to have been subject to the dumping of between 716,000 and 1.32 million tons of munitions in the immediate post war period. Salvage operations in the 1950s later discovered 'numerous shells, bombs, and other munitions containing mustard gas and other chemical warfare agents[2]'.

14.3. Deductions

The two dumpsites recorded within the western section of the site, off the coastline of the UK are not considered to be of close enough proximity to pose a direct risk to the study area, with the nearest plotted approximately 4km west of the study area's centre line.

Of more significant concern is the proximity of a cluster of munitions dumpsites surrounding the eastern section of the site, off the coastline of North Germany. These dumpsites are believed to have formed part of a wider programme of ammunition dumping across the German North Sea Coast at the end of WWII, resulting in an estimated 750,000 to 1.5 million tons of munitions dumped from both

[1] *."Munitionsbelastung der deutschen Meeresgewässer – Bestandsaufnahme und Empfehlungen (Stand 2011)" Meeresumwelt: Bundes-Länder Messprogramm., 2011 P. 48*

[2] *"Munitionsbelastung der deutschen Meeresgewässer – Bestandsaufnahme und Empfehlungen (Stand 2011)" Meeresumwelt: Bundes-Länder Messprogramm., 2011 P. 42*

German and Allied sources. This included an estimated 250,000 tons of ammunition shipped from the Port of Wilhelmshaven alone.

Extensive munition recovery was subsequently undertaken by the German authorities between 1952-1958, as part of the recovery of valuable metals (see **Annex J)**. This was predominantly based at a plant in Wilhelmshaven, which is known to have recovered over 50,000 tons of munitions at its peak between 1952-1954. However this type of clearance work is rarely comprehensive and subsequent experimental recovery operations undertaken by the German government in the 1990's are known to have still resulted in the discovery of large volumes of items, including the recovery of 3000kg of ammunition (including over 1000 individual shells) in 1991 and 4,669kg of munitions in 1999. It is therefore anticipated that large amounts of ammunition are still present on and around these former dumping areas, with some sources suggesting that an estimated 10,000-50,000 tons of munitions may still be present in Lower Saxonian waters[3].

15. Coastal Armament Training Areas

15.1. General

There are a number of historic and contemporary armament firing ranges recorded located across the Thames Estuary. Such ranges will have left a legacy of UXO contamination along the coast, which may pose a threat to offshore intrusive works and dredging.

15.2. Armament Training Area Mapping

A set of mapping was acquired from The National Archives showing the location of WWII-era armament training areas in the UK in relation to the study area. A relent section of this record, presented in **Annexes K,** shows the westernmost section of the study area to directly intercept the following three armament training areas.

- A81 Shoeburyness Artillery Range.
- A83 Yantlet Zone Coastal Artillery Range.
- A85 Sheerness and Grain Coastal Artillery Range.

These ranges have a designated 'danger area' of up to 20,000ft, 13,000ft and 6,000ft respectively and appear to cover a significant portion of the Thames Estuary from each side. Two smaller ranges are also denoted to the south-east of this section of the route. N25 Barton Point, a Heavy and Light anti-aircraft range, is situated at a distance of approximately 2-5km and 22 Leysdown, an RAF live bombing range, is situated at a distance of approximately 5-6km. These ranges have a designated 'danger area' up to 20,000ft and 25,000ft respectively.

15.3. Shoeburyness Ranges

MoD Shoeburyness is the only significant military installation still active within the Thames Estuary today. Situated approximately 6km north of the study area, this range was originally formed around the time of the Crimean War, by the Board of Ordnance in 1849, and was commissioned as an artillery testing and practice range. Over the years it became the site of the Royal Artillery School of Gunnery and was significantly expanded to include Foulness, New England and Havengore Islands. During both world wars the site remained predominantly in use as a coastal artillery school, before transitioning into more of a weapons development and testing role in the post-war period. A plan of Shoeburyness Ranges, based on WWII-era Bye-Laws, is presented in **Annex L**.

[3] *Dumping and re-occurrence of ammunition on the German North Sea coast, from Chemical munition dump sites in coastal environments Gerd Liebezeit.*

Today some of the former range area has closed or since been subject to redevelopment, but the remainder remains managed by Qinetiq, on behalf of the Ministry of Defence for 'defence testing and evaluation'. This includes testing weapons systems at various stages of their development, the disposal of expired ammunition and live-ammunition training in Explosive Ordnance Disposal techniques.

15.4. Yantlet Range (Grain Island Firing Point)

In 1917 the Admiralty requisitioned marshland to the east of Yantlet Creek, approximately 1.5km west of the western endpoint of the study area. Weapons testing commenced in 1919 and in the 1920s the War Office formerly purchased this area for the purpose of a building a firing point for the testing of artillery and other large weapons. This was known as both Grain Island Firing Point and Yantlet Battery and essentially functioned as an 'out' battery for the experimental establishment at Shoeburyness, on the opposite side of the Thames Estuary (discussed in section 15.3). Between the 1920s and the 1940s this establishment was predominantly used for the observation of the trajectory and landing of long range shells fired towards Maplin Sands in Shoeburyness, along the 'Grange Range Line' depicted in **Annex L2**. Infrastructure is known to have included a gun emplacement, a railway gun emplacement, domestic quarters, administrative offices, an internal railway linked to the national network and a wharf for the transport of munitions, guns and mountings. Some of these features are visible within the WWII-era imagery of the facility presented in **Annex M1**.

Post war the facility at Yantlet Creek was largely dismantled following a decrease in the testing of heavy artillery projectiles. The War Office's use of the area shifted to the establishment of a demolition range at a nearby location, on the coastline of the Isle of Grain. This feature is depicted in the 1960's Bye-Law plan in **Annex M2**, which shows the boundary of the associated danger area to be situated just outside of the western point of the study area. Live firing ceased in the Isle of Grain in the 1950's but this demolition area is believed to still be occasionally used for munitions disposal.

15.5. Sheerness and Grain Range

The Sheerness and Grain Artillery Range was comprised of three different firing points, based at Grain Battery, approximately 800m east of the study area, Sheerness Battery, opposite the River Medway and Fletcher Battery, on the Isle of Sheppey. Historical Bye-Law records indicate that the range was predominantly used to practice the firing of heavy artillery projectiles and was operational from the pre-war period through to the 1950s. A sample firing programme from 1932 shows the Grain and Sheerness batteries to have conduced live firing practice for 52 days and 20 nights in a calendar year, with Fletcher Battery used for 6 days during the same period.

Grain Battery is of particular interest, due to its close proximity to the westernmost point of the study area. This feature was constructed between 1900-1901 as a concrete emplacement with earth embankments. It operated in association with Grain Fort to the north (more detail of which is provided in section 16.2.2) and was originally armed with four 6 inch breech loading guns. In 1915 one of these guns was replaced with an M.I.R gun but the battery largely retained the same layout and composition until its decommission in the post-war period.

15.6. Deductions

The majority of items of ordnance used at the coastal armament training areas within the Thames Estuary will have consisted of LSA and SAA. Though larger aerially delivered bombs will have been deployed at the site of the 22 Leysdon RAF range. The smallest type of LSA typically used by British forces during the WWII-era were three pounder projectiles (such as the Hotchkiss, Vickers and Nordenfelt 47mm varieties), which were generally used by naval guns, coastal defence guns and anti-aircraft guns. Smaller sizes of projectiles may have been utilised at the ranges, but the most common small projectile is likely to have been the aforementioned three pounder HE. Items of ordnance fired

within the estuary's danger areas are not anticipated to have always detonated on impact with the water and have the potential to remain live and settle within the estuary's bed.

Based on the available historical documentation it is anticipated that both live and practice ammunition would been employed during these range's operation, with both categories of ordnance still employed at Shoeburyness today. The presence of these armament ranges therefore significantly increases the likelihood that items of Allied ordnance could have been expended within the westernmost of the study area, from the Isle of Grain to the approaches to the Thames Estuary. This is demonstrated by the number of UXO discoveries within the region in the post war period. Example imagery of items found during UXO clearance dredging operations in the Princes Channel in the 2000s is presented in **Annex O**.

16. Wartime Coastal Defences

16.1. General

Prior to and during the early stages of WWII, defensive positions were established along the British coastline in order to delay or prevent the threat of invasion. This network was known as the 'coastal crust' and comprised a vast network of hundreds of pillboxes, constructed across vulnerable points, as well as a mixture of defensive features including coastal batteries, pipe mines, machine gun turrets, anti-tank guns and barbed wire. The 'coastal crust' was devised in conjunction with the General Headquarters Line (GHQ Line) defensive line and was then subdivided into a network of Command Lines and Corps Lines, designed to protect specific geographical areas or directional approaches. Similar defensive networks were established along the coastline of Great Britain during both WWI and the pre-war era.

In comparison, very little information is available concerning the wartime defence of the German North Sea coastline. Due to the geographical position and the presence of extensive sea minefields in the surround the region of the site location was not identified as a viable location for invasion during and is not anticipated to have been defended to the extent of the coastlines of France and the Netherlands. Nevertheless some positions are believed to have been present as part of the defence of the port of Wilhelmshaven, including anti-aircraft positions.

16.2. The Defence of the Isle of Grain

The Defence of Britain Project database was accessed during the production of this report; this database records the '20th century militarised landscape of the United Kingdom' and is based on field and documentary work undertaken in the late 20th century. This records numerous defensive positions within and surrounding the western endpoint of the study area on the Isle of Grain.

In general, defensive positions can be split into two categories – anti-invasion and anti-aircraft. These will be discussed in turn in the following subsections, alongside a summary of the relevant positions recorded on site. The locations of these positions are annotated on WWII-era RAF aerial photography, see **Annex N**.

16.2.1. Anti-Invasion Defences

Due to its strategic location, covering the confluence of the River Thames and the River Medway, the Isle of Grain is recorded to have contained numerous anti-invasion defences dating back to as early as the 1500's. A brief description of each of the WWI and WWII-era defences in the region, separated by installation type, is presented in the table below. The majority of these positions are highlighted in the WWII-era imagery presented in **Annex N**.

Anti-Invasion Defences	
Type of Installation	**Summary**
Coastal Batteries	Wing Battery and Grain Battery were both situated near Grain Fort, approximately 1km south of the study area and were operational during WWI. The former comprising two 4.7" QF guns and two 11" RMLS and the latter comprising four 6" BL guns. The original Grain Battery (later renamed Dummy Battery) was situated 1km further south of these batteries, off Port Victoria Road. This position was operational throughout both world wars but was considered obsolete as an artillery battery by WWI and was instead armed with two 3" anti-aircraft guns, manned by the Kent RGA Territorials. Additional WWII-era coastal artillery batteries were also referenced across the Isle of Grain in the surrounding area of the western endpoint of the study area. However not further details regarding the exact locations of these emergency batteries could be found.
Gun Emplacements (Grain Tower)	The most significant gun emplacement within the Isle of Grain was Grain Tower (otherwise known as 'The Three Gun Tower'), which was positioned on a tidal mudflat off the Medway Channel, approximately 2km south of the western endpoint of the study area. This former 19th century Martello Tower was adapted over time for different armament and was used up to and during the Second World War. During the First World War it contained two mounted 4.7-inch breech-loading guns and was used as the anchor point for a defensive boom across to Sheerness. In the Second World War it contained a twin 6-pounder quick-firing gun installation and functioned as both an anti-motor torpedo boat site and a searchlight. The tower was reduced to care and maintenance in 1944 and decommissioned in 1956. Several additional gun emplacements are referenced within the Isle of Grain, the exact locations of which cannot be confirmed.
Anti-Tank Blocks	A length of anti-tank obstacles (referred to as 'dragon's teeth') were constructed along the north shore of the Isle of Grain in the early period of WWII. These obstacles extend to the north-west of the isle and are shown to directly intercept the western endpoint of the study area in 1946 imagery, see **Annex N**. Most of these features are still present today.
Machine Gun Emplacements	Several machine gun emplacements were present in the Isle of Grain during WWII. Imagery of these emplacements in front of Grain Fort and on the foreshore of the isle are also presented in **Annex N**.
Pillbox	The nearest pillbox is recorded approximately 1km south of the western endpoint of the study area, near Grain Fort. A series of pillboxes are recorded at a further distance from the study area, along the Isle of Grain coastline.
Spigot Mortar Emplacement	A spigot mortar emplacement is recorded within the southern side of Grain Fort during WWII, approximately 1km south of the western endpoint of the study area,
Coastal Artillery Searchlights	Two WWII-era coastal artillery searchlights are recorded approximately 900m east of the western endpoint of the study area, in front of Grain Fort. Several additional installations of this type were situated further along the coastline of the Isle of Grain.

16.2.2. Grain Fort

Grain Fort is of particular interest due to its close proximity to the western endpoint of the study area. This feature was initially constructed during the 1860s as an anti-invasion measure against Napoleonic France and was designed as a self-defensible keep which, in the event of invasion could co-operate with Slough Fort in Allhallows to defend the time Isle of Grain. It was subsequently modified and improved during both world wars, including the addition of two 4.7-inch breech loading guns shortly before WWI and the installation of a twin 6 pounder, 10 cwt. QF (quick firing) coastal artillery gun installation in WWII. The fort was decommissioned in 1956 and subsequently demolished, with only the fort's earthworks and a brick revetment still visible today.

16.2.3. Isle of Grain Seaplane Station

This station, situated approximately 2.5km south of the western endpoint of the study area, off Port Victoria Road, was developed in 1912 by the Royal Naval Air Service. It was initially designed to house aircraft and up to 800 accompanying airmen to intercept Zeppelin's raids over the Thames. Towards the end of WWI the station was taken over by the newly formed RAF and took on more of an experimental role, including use for seaplane testing. This continued until 1922 when the facility was taken over by the Royal Navy as an armament depot. Its buildings later formed a residential area known as Bungalow Town, until its demolition in the 1950s.

16.3. Anti-Aircraft Artillery (AAA)

Anti-aircraft guns were installed on the coastline to deter enemy aircraft from carrying out bombing raids inland on valuable targets. During WWII three main types of gun sites existed: heavy anti-aircraft (HAA), light anti-aircraft (LAA) and 'Z' batteries (ZAA). If the projectiles and rockets fired from these guns failed to explode or strike an aircraft, they would descend back to land.

Anti-Aircraft Artillery	
Type of Installation	**Summary**
HAA	These large calibre guns such as the 3.7" QF (Quick Firing) were used to engage high flying enemy bombers. They often fired large HE projectiles, usually initiated by integral fuzes which triggered by impact, area, time delay or a combination of aforementioned mechanisms. A WWII-era HAA gun battery and an accompanying 40mm LAA Bofors gun emplacements were situated in the immediate vicinity of the western endpoint of the study area, at White Hall Farm These positions are visible in the WWII-era imagery presented in **Annex N**, alongside an accompanying military camp. This position is also recorded to have contained two 6" BL guns as a temporary wartime emergency battery in 1915. Other HAA installations in the region include an additional HAA battery 2km to the south near the Medway Channel and a 1930's era 4.5" gun at Grain Fort.
LAA	These mobile guns were intended to engage fast, low flying aircraft. They were typically rotated between locations on the perimeters of towns and strategically important industrial works. As they could be moved to new positions with relative ease when required, records of their locations are limited. A number of LAA positions comprising both 40mm Bofors guns and 20mm Oerlikon guns are recorded across the Isle of Grain, mostly along the isle's north and eastern coastlines.
Machine gun posts	These posts were established at some significant military and industrial positions. Machine guns rounds were a largely ineffective form of AAA (Anti-Aircraft Ammunition). Machine guns usually fired the .303 round.

	Several machine gun emplacements were situated within the Isle of Grain during WWI, however these positions are not believed to have been employed as anti-aircraft guns.

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

16.4. The Defence of Hooksiel/Wilhelmshaven

Detailed information concerning German WWI and WWII-era military defences is difficult to access in the public domain, with significant quantities of records held by the German military authorities believed to have been lost or destroyed during the process of both world wars. It has been possible however to establish that a ring of defences, mainly comprising anti-aircraft emplacements, were situated around the port of Wilhelmshaven during WWI and WWII.

The closest of these defences to the eastern endpoint of the study area is believed to be a battery position at Hooksiel, situated approximately 4km to the west. This battery was equipped with four 15cm Howitzers guns during WWI and secured with a water-filled ditch, barbed wire fencing and trenches. After the war, the building was closed as part of German disarmament but was subsequently reoccupied on the outbreak of WWII in 1939. During this period, three 8.8 cm Flak 18 anti-aircraft guns were manned within this facility sheltered by a fortified casemate. The entire military complex was expanded during the later years of the war to house additional military personnel and was protected by a series of static defensive positions, including grenade launchers and machine guns.

16.5. Deductions

Due to its strategic location, the Isle of Grain was occupied by a concentration of coastal military defences, including fortified structures, coastal artillery batteries and other gun emplacements throughout the 19th and early 20th centuries. The majority of these defences were deemed redundant after WWI with only Grain Fort, Dummy Battery and Grain Tower Battery armed and operational at the start of WWII. A number of anti-aircraft emplacements, emergency coastal artillery batteries and static defensive potions, such as anti-tank blocks, were however later established across the isle to combat the increased potential threat of a German invasion and German air raids.

It is anticipated that these defensive positions on and surrounding the western endpoint of the study area, on the Isle of Grain, would have been manned by the relevant members of the Armed Forces for a significant period before during and after both world wars. This suggests that SAA and LSA would have been stored in these areas and highlights the potential for contamination to have resulted at key points, especially when the threat of invasion rescinded mid-way through WWII and surplus weaponry would have needed disposal. Defensive positions such as anti-aircraft batteries, coastal batteries and other gun emplacements could also have resulted in contamination across the wider area of this section of the study area, across the Thames Estuary.

No evidence could be found to suggest that any defensive positions were established on or surrounding the immediate area of the eastern end point of the study area during WWI or WWII. This is largely due to its occupation by open water during both periods, which was not reclaimed until the 1970's. A ring of positions was however situated in the wider area, as part of the defence of Wilhelmshaven.

17. Aerial Delivered Iron Bombs

17.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships as well as Gotha and Giant fixed-wing aircraft. A WWI map of air raids and naval bombardments across England is presented in **Annex**

S. Though records indicate that Sheerness experienced air raids during WWII, there is no evidence to suggest that the Isle of Grain was ever directly subjected to WWI-era bombing.

The Royal Naval Air Service (RNAS) undertook a number of bombing missions on strategic military and industrial targets on Germany during WWI, predominantly focused on Zeppelin airbases. Though relatively few in number it is estimated that through the process of these raids Britain dropped 660 tons of bombs on Germany, approximately double that dropped by Germany on Britain. No information could be found to suggest that the area surrounding Wilhelmshaven was bombed during WWI. Very little information was compiled about WWI-era bombing in offshore areas.

WWI bombs were generally smaller than those used in WWII and were dropped from a lower altitude. This resulted 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, especially in an 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.

17.2. World War II

17.2.1. Britain

The Luftwaffe's main objective for the attacks on Britain was to inhibit the country's economic and military capability. To achieve this they targeted airfields, depots, docks, warehouses, wharves, railway lines, factories, and power stations. As the war progressed the Luftwaffe bombing campaign expanded to include the indiscriminate bombing of civilian areas in an attempt to subvert public morale.

During WWII the western endpoint of the study area was situated within the Strood Rural District, which sustained an overall low-moderate density of bombing. However, available accounts indicate that bombing in the Isle of Grain was more severe when compared to other parts of the district. This is anticipated to have been partially due to its location between the Thames and Medway estuaries, which Luftwaffe bomber pilots would use as a navigational aid to reach targets in London. Bombing in the region can also be accounted for by the presence of several significant visible targets including a N series naval decoy for Chatham Docks near Allhallows, an oil terminal bombing decoy at Hook's Fleet, Sheerness Dockyard and Naval Base, Grain Fort and the various oil depots in the south of the Isle of Grain, in Wallend. A number of these targets are highlighted within Luftwaffe aerial reconnaissance mapping and imagery presented in **Annex T**.

17.2.2. Germany

The Allied Forces conducted extensive bombing raids over Germany during WWII, from the outbreak of war through to the eve of VE Day. RAF raids were generally initially focused on prominent military and industrial targets across the country, which took place during a series of daylight operations between 1939-1942. As the war progressed these raids gradually shifted to incorporate a wider range of targets and following the issue of the 'Area Bombing Directive' on the 14th February 1942, also became officially focused on damaging the morale of the German population. Following the entry of the US in the war and USAAF bombing sorties across Europe, RAF bombing operations on Germany in 1944-1945 were largely shifted to night raids. Operations also supported the Allied armies in the build up to D-Day and the subsequent invasion of Europe.

The city of Wilhelmshaven was identified early on by the Allied forces as a major objective for aerial bombing raids, due to its importance to German Naval production and relatively accessible position across the North Sea. It was subject to the first RAF Bomber Command raid of WWII on the 4th September 1939 and subsequently sustained a number of significant RAF raids between 1939-1943, mostly focused on the city's harbour and naval infrastructure. From 1943 to 1945 the city was also

subject to heavy raids from USAAF bombers. Combined these air raids reportedly resulted in the demolition of two thirds of the city's port buildings and infrastructure.

17.2.3. Offshore

In contrast, records concerning aerial bombing over European offshore areas are much more limited. This is because of restrictions in observation and the fact that very few permanent industrial or military targets of significance were situated offshore; though it was not uncommon for pilots to target both merchant and naval shipping with aerial bombardment through both planned and opportunistic raids. It is also possible that bombs could have been aerially deployed within European waters because of aerial engagements between Axis and Allied pilots, as well as the deliberate dumping of munitions by pilots attempting to return home.

17.3. WWII Bombing of Isle of Grain

17.3.1. Home Office Bombing Statistics

The following table summarises the quantity of German aerial delivered bombs (excluding 1kg incendiaries and anti-personnel bombs) dropped on the Strood Rural District between 1940 and 1945. Note this record is not believed to cover any offshore areas.

Record of German Ordnance Dropped on the Strood Rural District		
Area Acreage		**48,811**
Weapons	High Explosive bombs (all types)	1,804
	Parachute mines	24
	Oil bombs	55
	Phosphorus bombs	117
	Fire pots	14
	Pilotless aircraft (V-1)	37
	Long range rocket bombs (V-2)	9
Total		**2,060**
Number of Items per 1,000 acres		**42.2**

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

Detailed records of the quantity and locations of the 1kg incendiary and anti-personnel bombs were not routinely maintained by the authorities as they were frequently too numerous to record. Although the risk relating to incendiary bombs (IB's) is lesser than that relating to larger high explosive bombs (HE's), they were similarly designed to inflict damage and injury. Anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous. Although Home Office statistics were not recorded, both types of item should not be overlooked when assessing the general risk to personnel and equipment.

Examples of German Air-Delivered Ordnance are presented in **Annex R**.

17.3.2. Kent ARP Daily Bomb Maps

A collection of wartime map sheets of the county of Kent, showing the locations of dropped HE bombs, parachute mines, incendiary bombs, cross channel shelling and aircraft crash incidents, were obtained from the Kent Library and History Centre. Incidents were recorded daily throughout the early stages of the war, although map editions from 1942 onwards record strikes over multiple days.

Due to the information being recorded on small scale mapping depicting the whole county, it has not been possible to determine the exact locations of individual strikes, beyond establishing the approximate locality of the incident. Moreover, it is typical that single plotted strikes may represent numerous incidents of bombing. This is especially likely in cases of incendiary bombing, as incendiary bombs were frequently deployed in high numbers.

The maps that show bomb strikes on and in the vicinity of the site are presented in **Annex U**.

Kent ARP Daily Bomb Maps – Annex U	
Date Range	**Comments**
11th July 1940	Incendiary and HE bombing is recorded in the general area.
10th August 1940	Incendiary and HE bombing is recorded in the general area.
30th August 1940	Two German planes downed offshore in the general vicinity.
11th September 1940	HE bombing is recorded to the south.
7th October 1940	HE bombing is recorded to the south
17th October 1940	HE bombing is recorded to the south.
18th October 1940	HE bombing is recorded to the east.
17th November 1940	Incendiary bombing is recorded to the south
27th November 1940	HE bombing is recorded to the immediate south-east
13th December 1940	Three parachute mines are recorded to the east, in the Thames Estuary.
19th April 1941	HE bombing is recorded to the south and east.
1st June 1941	HE bombing is recorded to the south-east.

17.3.3. Written Bomb Incident Records

Written incident records were obtained from the Kent History and Library Centre. Records for Strood Rural District do not appear to be comprehensive, with only a single day in 1940 and 1941 covered and the main body of the records only appearing to begin in 1942. As Kent ARP bomb maps indicate, raids in the vicinity of the site occurred across multiple dates during 1940 and 1941, so if any incidents did occur directly within the site area, these would not likely be covered by the date range of these records. Furthermore, it is considered unlikely that any detailed records would have been maintained concerning bombing incidents within areas of open water.

17.3.4. WWII-Era Aerial Photographs

High resolution scans of WWII-era aerial photography for the western endpoint of the study area were obtained from the National Monuments Record Office (Historic England). This photography is dated 28th August 1942 and 1st May 1946 and provides a record of the potential composition of the site during the war, as well as its condition immediately following the war (see **Annex V**).

Imagery indicates that the western endpoint of the study area was occupied by a small area of coastline and adjacent open grassland during WWII, much as it is today. It is intercepted by a row of anti-tank blocks, situated surrounding the coastline and is located in close proximity to a HAA battery, which comprises several individual gunpoints. An associated camp, connected to this HAA battery by a roadway, comprises rows of nissen huts and other similar structures, which may have been used for storage or the billeting of troops. This could have included relevant anti-aircraft divisions or members of the Home Guard.

No obvious indicators of bomb damage, such as structural damage, cratering or other such ground disturbances could be identified within the immediate area of this section of the study area. Such features can however be difficult to discern within open ground and may have been obscured by the date of this image, taken several years after the main period of bombing in the region.

17.3.5. Bombing Decoy Sites

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

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

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

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

In-house data sets indicate that several WWII-era bombing decoy sites were present in the general proximity of the western endpoint of the study area on the Isle of Grain. An Oil QF is recorded approximately 3km to the west near Allhallows to decoy a series of significant gas installations situated at Wallend. An N-Series Naval Decoy was also recorded adjacent to the aforementioned decoy, at Binney Farm, and was designed to divert bombing from Chatham Docks. The decoy site mapping, presented in **Annex W**, confirms the presence of QF Decoy sites within the Isle of Grain, although their positon and number does vary between map editions.

17.4. Inland Abandoned Bombs

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

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

1st Line Defence holds no records of officially registered abandoned bombs at or near the western endpoint of the study area, in the Isle of Grain.

17.5. Inland Bomb Disposal Tasks

1st Line Defence has no evidence that any official ordnance clearance operations have taken place on or near the western endpoint of the study area, in the Isle of Grain. Note however that we have not received confirmation of this fact from 33 EOD Regiment.

17.6. WWII Bombing of Friesland

17.6.1. Bomb/Damage Statistics

No official statistics regarding the number and types of bombs dropped by Allied forces are believed to have been compiled for the eastern endpoint of the study area, in North Germany. Largely due to the relatively rural composition of the local area and its occupation in part by open water during WWII.

Detailed records of the quantity and locations of bomb strikes on the nearby city of Wilhelmshaven, situated approximately 13km to the south, are however anticipated to have been compiled by the relevant German authorities. Information provided from both the German Federal Archives, Koblenz, and the Archive of the City of Wilhelmshaven, indicates that the majority of such records were lost or destroyed during the process of the war, but the following statistics have been correlated across several online and published secondary sources.

Record of Buildings Destroyed in Wilhelmshaven	
	City and Shipyard
Commercial	406
Industrial	11
Civil and Local Government	15
Residential	5,600
Total	**6,079**

Record of Allied Ordnance Dropped on Wilhelmshaven		
	City	**Shipyard**
High Explosive Bomb	11,045	863
Aerial Mines	35	8
Incendiary Bombs	73,295	16,577
Total	**84,375**	**17,448**

17.6.2. Written Records

A total of 102 air strikes are believed to have taken place on Wilhelmshaven between the 4th September 1939 and the 30th March 1945, 17 of which were classified as ' major attacks'. Written information about each of these major attacks raid has been obtained from a number of secondary historical texts, including *Daylight Bombing Operations 1939-1942* by W Martin*, The Mighty Eighth War Diary* by Roger Freeman and a transcript of the Campaign Diary for RAF Bomber Command, which

was compiled for the organisation's 60th Anniversary. Details of each raid are presented in the tables below, which are divided into RAF and USAAF air raids.

RAF Air Raids 1939-1943	
Date Range	**Comments**
4th September 1939	Ten Bristol Blenheims of No. 110 and No. 107 Squadrons attacked units of the German fleet at low altitude, losing half their number without achieving any significant damage.
18th December 1939	Battle of the Heligoland Bight. RAF bombers approaching the German Bight en route to targets within Wilhelmshaven were engaged by German fighters, inflicting heavy casualties and destroying 12 of the 22 Vickers Wellingtons.
8th July 1941	Three bombers of No. 90 Squadron RAF, carrying two tons of bombs each, bombed from an altitude too high for German interceptors to reach but only one was able to drop ordnance on their target.
28-29th December 1941	217 sorties by RAF Bomber Command; Wilhelmshaven, Hüls, and Emden were the main targets.
11-12th February 1943	220 sorties were flown by 177 aircraft, comprising 129 Lancasters, 40 Halifaxes and eight Stirlings from RAF Bomber Command, targeting the major Kriegsmarine bases around Wilhelmshaven. The naval arsenal, including ammunition, mine and torpedo stores at Mariensel exploded, destroying approximately 50 hectares of structures. Three aircraft were lost.

USAAF Air Raids 1943-1945	
Date Range	**Comments**
27th January 1943	55 bombers of the Eighth Bomber Command dropped 137 tons of bombs on warehouses and industrial plants, losing three aircraft.
22nd March 1943	Attack by six groups of B-17s and B-24 Liberators on a U-boat yard.
21st May 1943	German fighter reaction against a raid by 77 B-17s on Wilhelmshaven resulted in the loss of ten per cent of the bomber force.
11th June 1943	252 B-17's are dispatched against a U-boat yard at Wilhelmshaven and the Cuxhaven port area.
26th July 1943	Wilhelmshaven bombed as a target of opportunity by the 94th Bomb Group.
3rd November 1943	21 groups totalling 539 aircraft attacked the port area of Wilhelmshaven.
3rd February 1944	Major attack by 609 B-17s on the port area of Wilhelmshaven.
3rd March 1944	91 B-17s of the 1st Bomb Division bombed Wilhelmshaven as a target of opportunity when bad weather forced the rest of the 760-bomber mission force to turn back from the first attack on Berlin
27th August 1944	Wilhelmshaven again bombed as a target of opportunity, by 34 B-17s originally sent to Berlin
27-28th February 1945	Night mission by 8AF and RAF Pathfinder Force on Wilhelmshaven's oil storage facilities
30th March 1945	358 B-24s of the Eighth Air Force undertake the final major air raid on the city.

17.6.3. Bomb Damage Mapping

Bomb damage mapping of the Wilhelmshaven area of the site was obtained from the Archive of the City of Wilhelmshaven and is presented in **Annex Y**. This source is indicated to have been compiled by British intelligence, based on damage visible in aerial imagery dated October 1944. It demonstrates

the severity and extent of bomb damage across the city during this period, which appears to have been concentrated around the industrial and naval dockyards in the south and east of the city.

This level of damage displayed approximately correlated with sources that suggest Wilhelmshaven was one of the most destroyed cities in Lower Saxony. 60 percent of the residential buildings were destroyed.

17.7. Deductions

The western endpoint of the study area was situated within a district of Kent that sustained an overall low-moderate density of bombing during the war. Despite this, the volume of bombing within the immediate locality, within the Isle of Grain, is anticipated to be elevated in comparison to the surrounding area. This is due to the presence of several significant Luftwaffe targets, such as the Port of the Admiralty Oil Refinery to the south at Wallend, naval and oil decoy sites to the west near Allhallows and Sheerness Docks to the east. In addition, its position at the confluence of the River Medway and Thameswould have increased the potential for opportunistic 'tip and run' bombing by Luftwaffe pilots travelling to and from targets in London and the Medway towns. Subsequently, despite the presence of nearby military infrastructure, it is not possible to discount the possibility of an item of UXO falling unnoticed within the section of the study area; especially considering the open, rural nature of the groundcover present.

Less detailed information is available concerning the deployment of aerial delivered ordnance within the offshore areas that occupy the vast majority of the proposed study area. However, potential sources of contamination identified include the dumping of ordnance during plane-to-plane engagements and attacks on military and merchant shipping, both of which are recorded in number across the North Sea for the main duration of WWII. Any bombs falling during such circumstances are not likely to have been observed or investigated and thus the possibility that aerially delivered UXO may be present within any offshore areas also cannot be completely discounted, though the likelihood of contamination from such items across the majority of the study area is not considered to be high.

The risk of encountering German aerial delivered bombs is however considered to be elevated within the Thames Estuary, on account of the documented number of Luftwaffe bombers that used this feature as a navigational aid to reach targets within London and within the estuary, which is referenced to have been specifically targeted on several occasions in its own right. Likewise, the risk of encountering Allied aerial delivered is considered to increase within offshore areas situated closer to the German coastline, where a greater number of Allied attacks on shipping is known to have taken place.

The risk of contamination from items of air delivered UXO is considered most significant within the eastern endpoint of the study area, at the approach to the Jade Bight. This is due to the number of air raids conducted on the area of Wilhelmshaven during WWII, with an estimated 5,327.5 tons of bombs dropped by 2,141 bombers of the USAAF alone – with is anticipated to have had a significant effect on the density of bombs dropped in the surrounding area. It should be noted however that the eastern endpoint section of the study area has undergone significant land reclamation since the 1970ss and that such activity will have significantly mitigated the potential for larger item of UXO remain, provided that the fill material used was not from a contaminated source, such as bomb rubble.

18. Munitions Encounters in the Study Area

18.1. OSPAR Commission Data

The OSPAR Commission has been collecting data on offshore encounters with munitions since 1999 and has compiled an extensive database of such incidents off the UK coast and in the North Sea. A total of 1,879 encounters were reported by Belgium, France, Germany, Ireland, the Netherlands,

Spain, Sweden and the UK. Of the 1,879 munitions encounters reported, 1,595 (85%) were described as conventional, 30 (2%) as chemical and 254 (14%) were of unknown type. In this report, phosphorus devices are taken to be conventional munitions. The devices encountered on 786 occasions (42%) were reported to be in various stages of corrosion, from partly to completely corroded, 14 (1%) were described as being live or in good condition and the state of the remainder were unknown or not reported.

An overlay depicting the approximate locations of offshore munition encounters reported in close vicinity to the study area, as recorded by OSPAR since 2004, is presented in **Annexes Z1-Z6**. This covers the OSPAR maritime area, which includes both the North Sea and the remaining offshore areas of the proposed study area. However due to the nature of its compilation, this record should not be considered to be comprehensive.

Three offshore munition encounters are indicated near the western section of the study area, at the approach to the Thames Estuary. 11 munition encounters are clustered in the central section of the site between UK and Dutch waters, with three more encounters identified in the eastern section of the site, on the approach to the Jade Bight. The munitions found are all of the conventional type, with the exception of one 'unknown' item. Data related to these encounters is transcribed in the table presented in **Annexes Z7-Z8**.

18.2. UXO Clearance / EOC Tasks

1st Line Defence holds a database of historic EOC (Explosive Ordnance Clearance) tasks carried across Great Britain by 33 EOD Regiment. Though this source is understood to not be comprehensive, no clearance tasks are recorded within the immediate area of the western endpoint of the study area, in the Isle of Grain.

18.3. Deductions

The documented munition encounters within the Thames Estuary are most likely attributable to the presence of several historic and contemporary armament ranges in the region. Munition encounters across the remainder of the region could be the result of a wider range of potential sources, such as historic minefields, ship-to-ship engagements, munitions dumps and aerial bombing. These encounters demonstrate the potential for other such items to be present within the region.

19. 1st Line Defence Risk Assessment

19.1. Risk Assessment Stages

Taking into account the quality of the historical evidence, the assessment of the overall risk from unexploded ordnance is based on the following five considerations:

1. That the study area was contaminated with unexploded ordnance.
2. That unexploded ordnance remains within the study area.
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.

19.2. The Risk that the Site was contaminated with UXO

After considering the following facts, 1st Line Defence believes that there is a risk of UXO contamination from the following sources across the study area:

Coastal Armament Training Areas

- The firing areas of three historic armament training ranges are situated directly across the section of the study area within the Thames Estuary on WWII-era armament training and 'danger area' mapping. These comprise the former Sheerness and Grain, Yantlet and Shoeburyness Artillery Ranges, the latter of which still plays an extensive role in the testing and development of ordnance on behalf of the MoD today. Two smaller historic ranges are also denoted within the Thames Estuary, to the south-east of this section of the study area. Barton Point, a heavy and light anti-aircraft range, was situated at a distance of approximately 2-5km and 22 Leysdown, an RAF live bombing range, was situated at a distance of approximately 5-6km.

- Based on the available historical documentation, it is anticipated that both live and practice ammunition would been deployed during these ranges operation, with both categories of ordnance still employed at Shoeburyness today. The presence of these armament ranges therefore significantly increases the likelihood that items of Allied ordnance could have been expended through training exercises or firing practices within the westernmost of the study area, from the Isle of Grain to the approaches to the Thames Estuary. This is further demonstrated by the large number of UXO discoveries within the region in the post war period. Selective imagery, taken from hundreds of items found during UXO clearance dredging operations in the Princess Channel in the 2000s, is presented in **Annex O**.

- The majority of items or ordnance used in the coastal armament training areas within the Thames Estuary will have consisted of LSA and SAA. Though larger, aerial delivered bombs will have been deployed at the site of the 22 Leysdon RAF range. The smallest type of LSA typically used by British forces during the WWII-era were three pounder projectiles, though smaller sizes of projectiles may have been utilised. Items of ordnance fired within the estuary's danger areas are not anticipated to have always detonated on impact with the water and have the potential to remain live and settle within the estuary's bed.

Munitions Dumpsites

- A concentration of historic munitions dumpsites has been identified within the eastern section of the study area, off the coastline of North Germany. These dumpsites are believed to have formed part of a wider programme of ammunition dumping across the German North Sea Coast at the end of WWII, resulting in an estimated 750,000 to 1.5 million tons of munitions dumped from both German and Allied sources. This included an estimated 250,000 tons of ammunition shipped from the Port of Wilhelmshaven alone. Although the closest three dumpsites are situated at an approximate distance of 1-2km from the study area, this is still of concern, as it is possible that dumped munitions may have either been deposited outside their designated areas or have else migrated within the region over time.

- Extensive munition recovery is known to have been undertaken in the region between 1952-1958 to recover various UXO related metals. However this type of clearance work is rarely comprehensive and subsequent experimental recovery operations undertaken by the German government in the 1990's are known to have still resulted in the discovery of large volumes of items, including the recovery of 3,000kg of munitions in 1991 and 4,669kg of munitions in 1999. It is therefore anticipated that large amounts of ammunition are still present on and around these former dumping areas, with some sources suggesting that an estimated 10,000-50,000 tons of munitions may still be present in Lower Saxonian waters.

Aerial Bombing

- The risk of contamination from items of air delivered UXO is considered most significant within the eastern endpoint of the study area, at the approach to the Jade Bight. This is due to the number of Allied air raids carried out on Wilhelmshaven during WWII. An estimated 5,327.5 tons of bombs are believed to have been dropped by 2,141 bombers of the USAAF on targets on and around the city, which is anticipated to have led to a significant increase in

the density of bombing in the surrounding area. It should be noted however that the eastern endpoint section of the study area has undergone significant land reclamation since the 1970's and that such activity will have significantly mitigated the potential for larger items of UXO remain, provided that the fill material used was not from a contaminated source.

- The western endpoint of the study area was situated within a district of Kent that sustained a low-moderate density of German aerial bombing throughout the war. However its location within the Isle of Grain, at the confluence of the River Medway and Thames, is anticipated to elevate bombing due to its position on Luftwaffe flights paths and the presence of several significant nearby Luftwaffe targets, such as the former Grain oil refinery, the Allhallows bombing decoy sites and Sheerness Docks.
- The density of aerial bombing is anticipated to have been considerably lower across the offshore areas that occupy the vast majority of the proposed study area. However, potential sources of contamination identified in this environment include the dumping of ordnance during plane to plane engagements and attacks on military and merchant shipping. The possibility that such items may be present within any offshore area subsequently cannot be completely discounted. Furthermore, the risk of contamination from aerial delivered bomb is considered to increase within the Thames Estuary and within areas close to the German coastline, due to the increased volume of Luftwaffe and Allied bomber activity documented in these regions.

Wartime Coastal Defences

- Due to its strategic location, the Isle of Grain was occupied by an extensive network of coastal military defences, including fortified structures, coastal artillery batteries and other gun emplacements throughout the 19th and early 20th centuries. The majority of these defences were deemed redundant after WWI with only Grain Fort, Dummy Battery and Grain Tower Battery armed and operational at the start of WWII. However, a number of anti-aircraft emplacements, emergency coastal artillery batteries and static defensive potions, such as anti-tank blocks, were later established to combat the increased potential threat of a Nazi invasion, as well as to combat Luftwaffe raids.
- It is anticipated that these defensive positions on and surrounding the western endpoint of the study area would have been manned by the relevant members of the Armed Forces for a significant period before, during and after both world wars. This suggests that SAA and LSA would have been stored in these areas and highlights the potential for contamination to have resulted at key points, especially when the threat of invasion rescinded mid-way through WWII and surplus weaponry would have needed disposal. Defensive positions such as anti-aircraft batteries, coastal batteries and other gun emplacements could also have resulted in contamination across the wider area of this section of the study area, across the Thames Estuary.

Sea Mines

- Sizeable mine laying campaigns were undertaken by both Britain and Germany across the North Sea in WWI and WWII. The majority of the study area appears to have been situated across several of the more prominent of the WWII-era minefields, including significant defensive areas off the east coast of Britain and the north coast of Germany. Evidence has also been found to indicate that air deployed mines were regularly dropped within the Thames Estuary by the Luftwaffe between 1940-1941.
- A precise assessment of the current risk from mines across the length of the study area is difficult to ascertain. Efforts were made by both Germany and Britain post-war to remove or make safe the areas mined during the war. However, such clearance tasks do not guarantee the complete removal of all mines within a danger area, especially as such items have the potential to migrate or became covered due to sediment and tidal action over a long period of time. It is therefore not possible to discount the possibility of encountering aerial, surface or submarine laid sea mines across any offshore section of the proposed study area.

Wreck Sites

- A number of listed historic wrecks have been identified on and around the study area. The majority of these wrecks are situated within shallower waters, at the approach to the Thames Estuary and off the coastlines of Germany. These wrecks often demonstrate the presence of both sea mines and aerial bombing during WWI and WWII.
- The majority of wrecks identified are commercial vessels, though several WWII-era British military wrecks are also recorded in the western and central sections of the study area, including the submarine HMS Truculent, three destroyers and several minesweeper trawlers. The eastern section of the study area, off the German coastline, contains several German military wrecks. These consist of the WWI-era cruiser SMS Yorck, the WWII-era DW 07 Patrol Boat (Trinchen Behrens) and two WWII-era minesweepers. Such vessels are anticipated to have carried items of ordnance at the time of their loss and, if not recovered, could have contaminated their immediate surroundings.

Torpedoes/Anti-Submarine Weapons

- It is well documented that both torpedoes and anti-submarine weapons were employed as part of aerial and naval warfare across the North Sea during WWI and WWII, although their numbers were relatively low when compared with other types of munitions. However, historical records indicate that submarine activity within the region was limited by the presence of defensive minefields and the British blockades of German ports. As a result, the U-boat campaigns of both world wars were predominantly focused on more viable shipping targets in the Atlantic Ocean. This is correlated by the available data concerning wreck sites, which indicates that only one WWI-era torpedo related wreck is situated in the vicinity of the study area and none related to anti-submarine weaponry, despite its length and position. Nevertheless it not possible to completely discount the presence of such items at the location of the study area due to their usage in the wider area.

19.3. The Risk that UXO Remains

One of the main activities which can reduce the risk of encountering UXO in the marine environment is dredging. For instance, regular dredging can lower the risk of encountering smaller items of ordnance, such as projectiles. This type of activity is anticipated to have taken place during land reclamation on and around the eastern endpoint of the study area in the 1970's, off Hooksiel. It is considered significantly less likely for larger items of wartime era UXO to remain within new areas of post-war land fill, provided that such land was not drawn from a contaminated source.

Generally, UXO in the marine environment will not have a great penetration capability into the seabed. However, heavier items such as iron bombs can settle into soft sediment or mud and on occasions become completely buried and thus remain in situ. (This penetration depth will vary based on the depth of water and geotechnical properties present.) The composition of offshore geology is understood to vary considerably across the study area and will likely include superficial deposits of a soft nature. At such locations there is a potential risk that UXO could be buried on or partially beneath the seabed which would require further investigation/consideration.

As well as the risk from ordnance remaining in-situ there is also a possibility that ordnance may have migrated within the study area. As physical processes, such as currents and tidal action can result in UXO being moved significant distances from their point of origin.

19.4. The Risk that UXO may be Encountered during the Works

The probability of encountering items of UXO is based both on the composition of the site, i.e. its history and physical environment and the type of project works undertaken. These factors are addressed in turn below:

19.4.1. Historical Context

1st Line Defence has identified several potential historical sources of UXO contamination within the proposed HVDC Electricity Transmission Interconnector route. There is a residual risk from torpedoes, anti-submarine weapons, mines, air-delivered bombs and from munitions associated with military related wrecks / dump sites within the offshore environment. Significant risk from Allied Land Service Ammunition (LSA) of various age and calibre has been identified in the area surrounding the Thames estuary and from munitions dumpsites. This site history will also affect the prospective distribution and positions of items of UXO, as well as its initiation failure rates.

19.4.2. Physical Environment

Physical environmental factors affecting UXO encounter will include the bathymetry and depth of water present, the seabed geology and the impact of physical processes, such as storm surges and tidal currents, which may cause UXO uncovering, burial and migration.

19.4.3. Type of Project Works

Given the nature of the proposed works, there is a risk that UXO may be encountered during intrusive activities during both the initial geotechnical survey campaign and the subsequent cable installation. Intrusive works within the marine survey includes geotechnical sampling planned at every 1km across the study area between the UK and Germany. This is anticipated to include vibrocore and cone penetrometer tests (CPT) within areas of open water and investigatory boreholes and trial pits within areas of landfall.

Limited information is available concerning the final methodology of the proposed cable installation. However, intrusive activities may include the usage of pre-lay grapnel runs and removal ploughs; as well as the use of cable trenching equipment to install cabling into the seabed. During such operations, the risk to the vessel and to operatives will depend on factors such as the distance behind the vessel that the equipment and cabling will be towed. There is also a small potential for smaller items of UXO to be caught up on equipment which comes into contact with the seabed and brought on board the vessel.

19.5. The Risk that UXO may be Initiated

The risk that UXO could be initiated if encountered will depend on its condition, how it is found and the energy with which it is struck. Most unexploded munitions do not become less dangerous with age and could still function as designed if disturbed. Furthermore, it is possible that seawater may have degraded certain types of munition over time leaving them in a more sensitive state.

Unexploded munitions do not spontaneously explode. All high explosive requires significant energy to create the conditions for detonation to occur. In the case of unexploded munitions discovered within the marine environment, there are a number of potential initiation mechanisms:

- Direct impact onto the main body of the weapon

  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, to initiate an item of ordnance such as an iron bomb. Such violent action can cause the bomb to detonate.

- Re-starting the clock timer in the fuze

  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 60

years that would prevent clockwork mechanisms from functioning, but the possibility cannot be discounted.

- Friction impact initiating the shock-sensitive fuze explosive

  This is the most likely scenario resulting in the weapon detonating. 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.

- It is considered unlikely that magnetic or acoustic sea WWI and WWII-era mines would function as originally designed, due to failures in their power supply, however there have been reports of such mines brought up in fishing nets detonating in recent history – possibly as a result of mishandling. In principle, WWI and WWII contact mines could still be initiated through impact with chemical horns. If the firing circuit was intact the release of electrolyte could theoretically activate the battery and detonate the mine.

- In cases where multiple items of UXO are situated in close proximity, there is also the potential for the initiation of one item to initiate others through a process known as sympathetic detonation.

In summary the risk of initiation is dependent on what part of the UXO is contacted and with what type and degree of force, as well as the sensitivity of the component in question. In any case an item of UXO encountered that has not been initiated should always be treated as live.

19.5.1. Initiation and the Type of Project Works

Generally more aggressive activities increase the risk of initiating items of UXO. To illustrate this effect some examples of common offshore project works are displayed in the table below.

Probability	Factors	Example
Very Low	Benign Activities	Non-intrusive geophysical surveys, eg side scan sonar and magnetometry.
Low	Relatively Benign Activities	Vibrocore Sampling
Medium	Relatively Aggressive Activities	Jack up barge installation, including the application of loads to each leg.
High	Aggressive Activities	Cable ploughing under load
Very High	Very Aggressive Activities	Pile driving from a jack up barge.

19.6. The Consequences of Encountering or Initiating UXO

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 UXO detonating offshore might include but are not limited to the following summarised below:

- People – death or injury of vessel operatives, divers, nearby public etc.
- Equipment – damage to vessels, ploughs, anchors etc.
- Natural Environment – death or injury to marine fauna (fish/marine mammals) and habitats.
- Historic Environment – damage or destruction of listed buildings, wrecks and landscapes.

The initiation of a small item of ordnance such as a small calibre projectile at depth during intrusive works may result in damage to plant and potentially injury of personnel. However, the initiation of a larger weapon such as a high explosive bomb or sea mine during works could have severe consequences in terms of both damage and loss of life and limb.

If an item of ordnance is accidentally brought on board without it being noticed, even a small projectile or item of Land Service Ammunition can pose a significant risk to vessel operatives.

19.7. Assessed Risk Level

Taking into consideration the findings of this study, 1st Line Defence does not consider the risk from UXO to be homogenous across the study area. Different sections have been assessed as at varying levels of risk, originating from different ordnance types. An assessment of the risk posed by UXO across the proposed HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom and Wilhelmshaven, Germany has therefore been divided into the following four areas, which are outlined in **Appendix i**.

Section 1: The UK Mainland

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
Air Delivered Bombs			✓	
Anti-Aircraft Artillery Projectiles			✓	
Allied Military Land Service Ammunition (Grenades, Mortars etc.)			✓	

Section 2: Thames Estuary

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
Air Delivered Bombs			✓	
British Sea Mines		✓		
German Sea Mines			✓	
Allied Military Land Service Ammunition (Grenades, Mortars etc.)			✓	
Torpedoes		✓		
Anti- Submarine Weapons		✓		
Munitions Dumpsites		✓		

Section 3: Main Offshore Area (North Sea)

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
Air Delivered Bombs		✓		
British Sea Mines			✓	
German Sea Mines			✓	
Allied Military Land Service Ammunition (Grenades, Mortars etc.)	✓			
Torpedoes		✓		
Anti- Submarine Weapons		✓		
Munitions Associated with Dumpsites[4]		✓		

Section 4: German Approaches

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
Air Delivered Bombs			✓	
British Sea Mines			✓	
German Sea Mines		✓		
Allied Military Land Service Ammunition (Grenades, Mortars etc.)		✓		
Torpedoes		✓		
Anti- Submarine Weapons		✓		
Munitions Associated with Dumpsites[5]				✓

Section 5: The German Mainland

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High

[4] This assessed risk level is based on the current location of the study area, as depicted in the annexes of this report. If the location of the study area was to change significantly in relation to the location of recorded munition dumpsites 1st Line Defence should be contacted and this risk level reassessed.

[5] This assessed risk level is based on the current location of the study area, as depicted in the annexes of this report. If the location of the study area was to change significantly in relation to the location of recorded munition dumpsites 1st Line Defence should be contacted and this risk level reassessed.

Air Delivered Bombs			✓	
Anti-Aircraft Artillery Projectiles		✓		
Allied Military Land Service Ammunition (Grenades, Mortars etc.)		✓		

Note - The risk from UXO originating from wrecks/crashed aircraft is considered to be low across the study area as a whole, as such features have been identified as few and far between. The localised risk will however be increased within the area of any military related wrecks present directly on route.

20. UXO Risk Mitigation

20.1. General

This report has concluded that there is a risk from unexploded ordnance along the proposed HVDC Electricity Transmission Interconnector between the Isle of Grain, United Kingdom and Wilhelmshaven, Germany. The risk has been broadly split into five different zones, which each contain varying levels of assessed risk from different potential sources:

- UK Mainland – Risk from German air delivered ordnance and historic Allied ordnance.
- Thames Estuary – Significant risk from smaller items of LSA/SAA originating from historic and contemporary ranges within the estuary.
- Main Offshore Area (North Sea) – Primary risk from larger items, originating from historic sea minefields.
- German Approaches –Significant risk from both larger and smaller items of UXO, originating from a number of historic munitions dumps.
- German Mainland – Primary risk from Allied air delivered ordnance.

20.2. Offshore UXO Risk Mitigation

Due to the level of risk identified, it is recommended that 1st Line Defence Risk are contacted to discuss the creation of risk mitigation plan for each specific phase of works within the study area. The methodology of any measures should be tailored to take into account the nature and size of UXO items assessed most likely to be encountered in each section of the study area.

20.3. Onshore/Nearshore UXO Risk Mitigation

For onshore/foreshore works at both the western and eastern end points of the route, it is also recommended that proactive support is provided by a UXO specialist. This would include UXO Safety and Awareness Briefings for all operatives conducting intrusive works, UXO support for trial pits and the clearance of all proposed boreholes by magnetometer survey. Depending on the ground conditions present it may also be viable to undertake a non-intrusive magnetometer survey and target investigation on beach and inland areas.

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 **10th August 2018**

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

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This report has been prepared by 1st Line Defence Limited with all reasonable care and skill. The report contains historical data and information from third party sources. 1st Line Defence Limited has sought to verify the accuracy and comprehensiveness of this information where possible but cannot be held accountable for any inherent errors. Furthermore, whilst every reasonable effort has been made to locate and access all relevant historical information, 1st Line Defence cannot be held responsible for any changes to risk level or mitigation recommendations resulting from documentation or other information which may come to light at a later date.

Study Area Location Maps

Annex: **A**

1ST LINE DEFENCE

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

Client:	**Intertek**	**Approximate study area**	N
Project:	**HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**		
Ref:	**DA2985-01**	Source: Google Maps	

Present-day Aerial Photography

Annex: **B**

1ST LINE DEFENCE

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Client: **Intertek**

Approximate study area

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

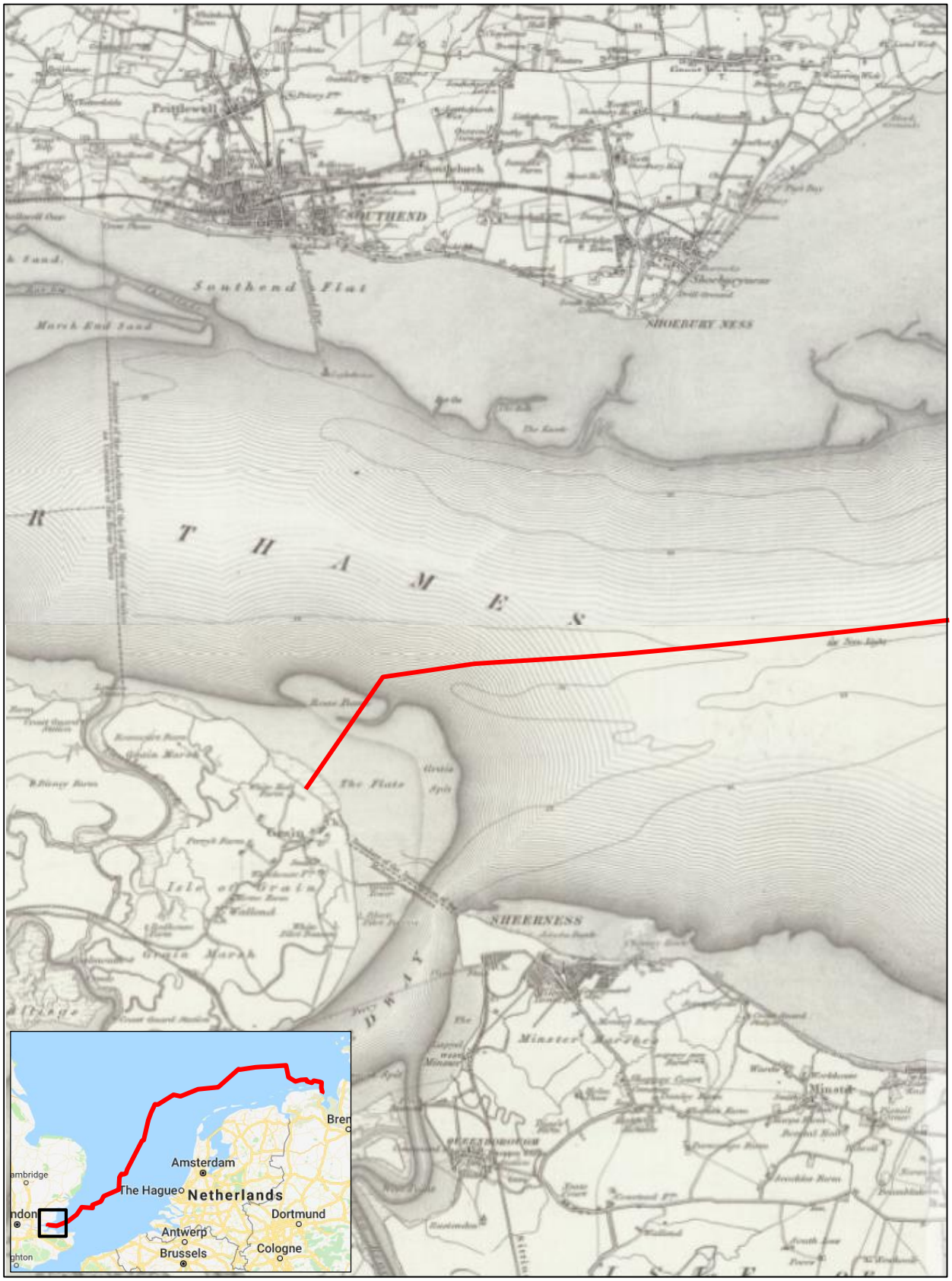
N

Ref: **DA2985-01**

Source: Google Earth ™ Mapping Services

1896 Historical Map – Thames Estuary

Annex: C1



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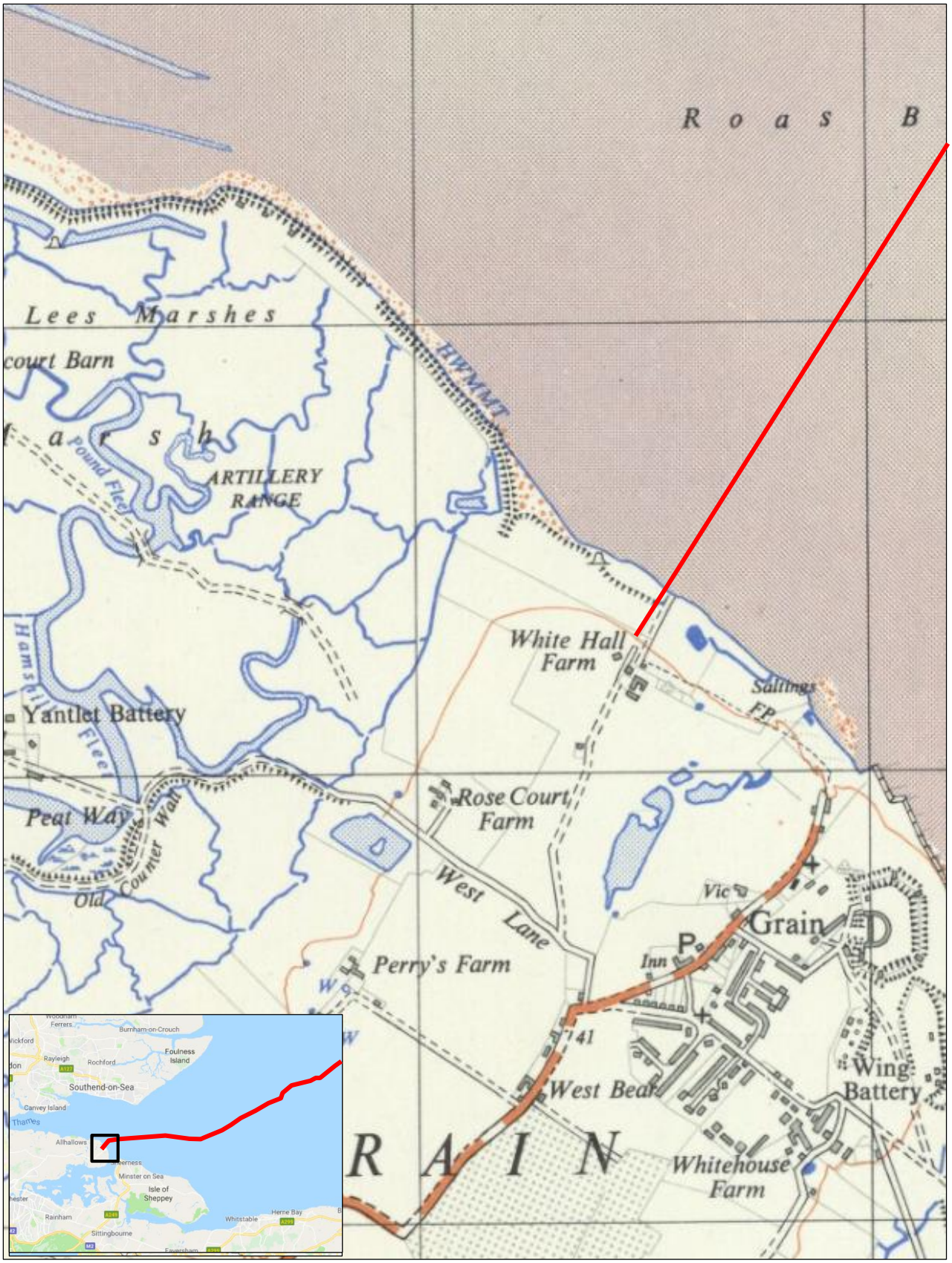
Ref:	**DA2985-01**	Source: NLS Mapping	

1937-1958 Historical Map – Isle of Grain

Annex: C2



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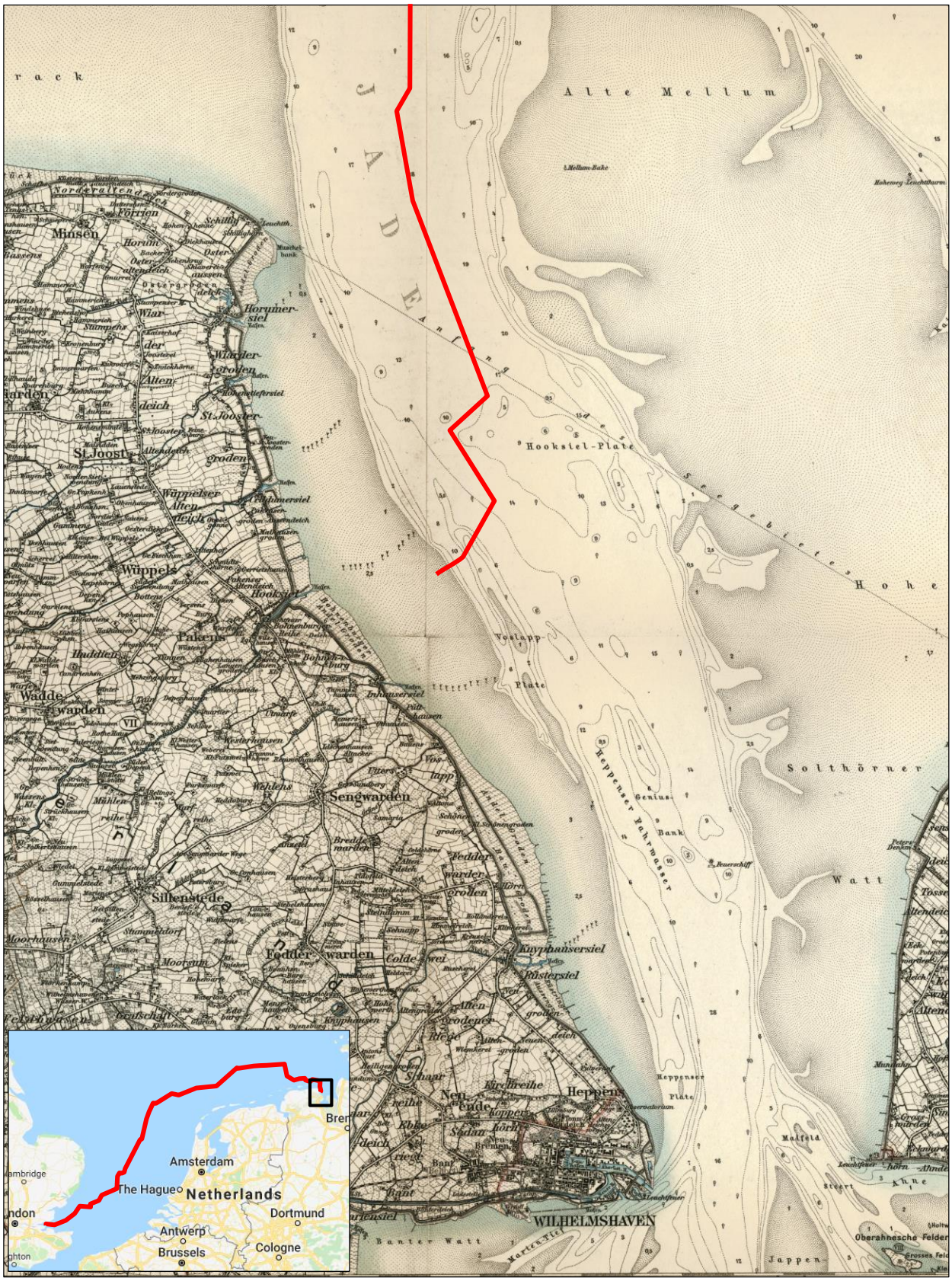
Ref:	**DA2985-01**	Source: NLS Mapping	

1901 Historical Map – Wilhelmshaven

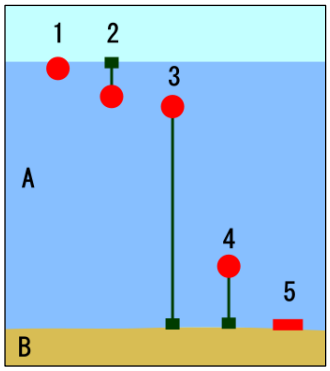
Annex: C3

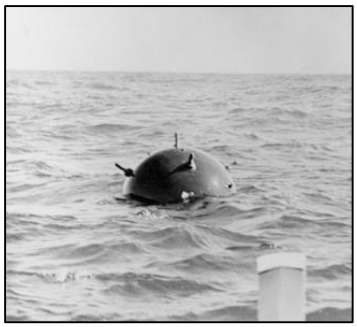


1ST LINE DEFENCE	Client: **Intertek**	**Approximate study area**	N
Unit 3, Maple Park Essex Road, Hoddesdon, Hertfordshire. EN11 0EX **Email:** info@1stlinedefence.co.uk **Tel:** +44 (0)1992 245 020	Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**		
	Ref: **DA2985-01**	Source: NLS Mapping	

1. Position in the Water

- **Bottom mines** are most effective in shallow waters, such as rivers, harbours and tidal areas. These mines rest on the ground or sea bed and are intended to block passageways and prevent amphibious invasion.
- **Moored mines** are used for deep water areas and are designed to float below the surface of the water. They take into account the tidal level to remain out of site below the waterline and are connected via steel cable to an anchor on the sea bed. These mines are intended to inflict damage to valuable marine craft targets, such as aircraft carriers or battleships.
- **Drifting mines** are allowed to float freely in the water. They were generally utilised less frequently and mostly as a deterrence tactic. Moored mines could break from their anchoring cable and become drifting mines.

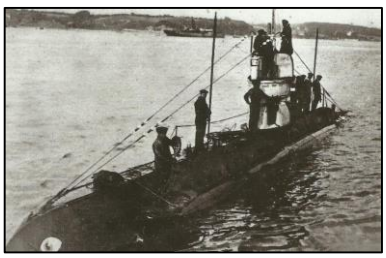




Top left: Diagram displaying mine types. A: Underwater, B: Sea bed 1/2: Drifting Mine, 3/4: Moored Mine, 5: Bottom Mine.
Top right: Photograph of drifting mine. Left: Bottom mine.

2. Delivery Method

- **Aircraft-laid mines** were deployed in the same manner as other aerial delivered items of ordnance, see **Section 11.2.2**. Fins or parachutes were stored in the mine to slow its velocity and reduce its impact when meeting the surface of the water. These mines were later converted to be used on land and are often referred to as parachute mines.
- **Surface-laid mines** are planted by surface marine craft and are used primarily for defensive purposes. The British Navy used these mines within and near Allied waterways to protecting shipping lanes from enemy attack.
- **Submarine-laid mines** are deployed as offensive weapons and are used primarily for defensive purposes. During WWII submarines planted a total of 576 mines resulting in 27 sunk ships and 27 damage. This is approximately one ship sunk or damaged for every 10 mines planted.



Top right: Horned contact mines on the HMS Aurora .

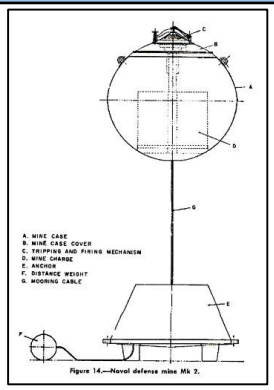
Top left: Photograph of mine loading onto US aircraft. Bottom left: Mine-laying submarine UC-1, which could carry a total of 12 mines.

3. Method of Activation

- **Contact mines** are designed to explode on direct contact with the hull of ship or other marine craft. They were mostly used by German forces during WWI although also saw later deployment. The specifics of this type of mine are fully detailed in **Annex D2**.
- **Influence mines** are trigged by the 'influence' of a ship, submarine or other marine craft rather than by direct physical contact. Advances in technology allowed these mines to utilise a range of sensors that would trigger their explosive filing. These mines are fully detailed in **Annex D3**.

Contact mines

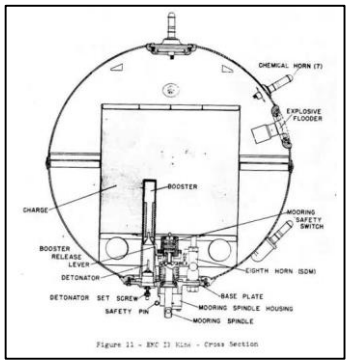
- Earliest form of naval mines used throughout both WWI and WWII. Contact mines need to be touched by the target to detonate, which limits the damage usually to vessel that triggers them. These were used primarily for defensive purposes, such as in the Royal Navy's defence of the English Channel.
- The main distinction in contact mine design was between inertia and Hertz-horn mines. Most adapted the latter during or after WWI; these proved effective as they remained active in water for several years after deployment. The mine's upper half would be studded with hollow lead protuberances, each containing a glass vial filled with sulfuric acid. Upon collision with an vessel the horn would be crushed, cracking the vial and allowing the acid to run down a tube into a lead-acid battery. This energises the battery, and detonates the explosive.
- By the onset of WWI, Germany had large stocks of reliable Hertz horn contact mines, all equipped with automatic anchors that used hydrostats to set mine depth and lock the mooring cables. Britain copied this design in 1917 by capturing a German mine and subsequently produced their first reliable model (Type H Mark II).



Schematics of Navy Spherical Mine Mk 2.

Common types

Name	Type of laying	Diameter	Explosive charge	Notes
Navy Spherical Mine Marks I and II	Moored	Unknown	250 lbs. (113 kg)	British mine using an automatic anchor and an arm-operated firing mechanism. only 4,000 available by the start of World War I.
"Type I" (British designation)	Moored	31.5 in. (80 cm)	180 lbs. (81.6 kg)	WWI-era German "Hertz horn" contact mine.
"Type II" (British designation)	Moored	31.5 in. (80 cm)	290 lbs. (131 kg)	Same as above.
Type H Mark II	Moored	Unknown	320 lbs. (145 kg)	First reliable British "Hertz horn" contact mine, available from 1917 and used in early years of WWII.
EMA	Moored	31.5 in. (80 cm)	331 lbs. (150 kg)	First German mine with a chemical-horn firing system.
UMA	Unknown	31.5 in. (80 cm)	66 lbs. (30 kg)	German mine with five Hertz and three switch horns. Could be moored at either 160 or 320 feet (50 or 100 m).



Left: found July 1917 in Thames Estuary. Centre: found December 1914 in water off Scarborough, identified as "Type I" mine. Right: Schematics of moored contact mine with "Hertz horn" mechanics.

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Ref: **DA2985-01**

Source: Various sources

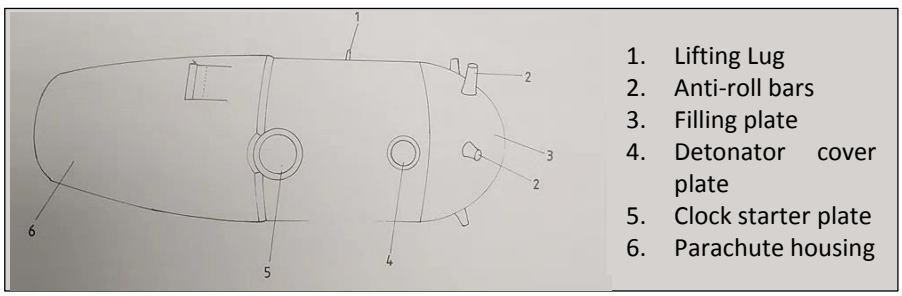
Influence mines

- Influence mines are triggered by influences from external sources, such as a ship or submarine. Common sensors are:
  - **Magnetic sensors** – an induction or needle system detects a displacement of the ambient magnetic field, normally by the introduction of a ferrous metal object (such as a passing vessel), which initiates the detonation sequence.
  - **Acoustic sensors** – any 'positive shift' (i.e. closing) underwater sonar signal may be interpreted as a potential target vessel and so the mine's arming sequence is initiated followed by detonation.
  - **Hydrostatic pressure sensors** – any detected difference in water pressure (i.e. generated by a passing vessel) initiates detonation.
- Magnetic and acoustic mines were developed by German intelligence before the onset of WWII; some 1,500 magnetic mines were available in the Spring of 1940. Pressure mines were developed in 1943 but were not used until the 6-7th June 1944 in the Normandy Invasion area. The Allies developed separately, though utilised these mines largely for defensive purposes in contrast to the offensive approach taken by Axis forces.

An SMA Mine.

Common types

Name	Type of laying	Diameter	Explosive charge	Notes
SMA (British designation "GO"	Moored	46 in. (177 cm)	772 lbs. (350 kg)	German moored influence mine laid by Type VIID and XB U-boats, introduced in 1942. Made of a aluminium alloy shell to reduce detection. Could be moored either 219 fathoms (400 m) or 328 fathoms (600 m) deep.
TMA (British designation "GT"	Moored	21 in. (5cm)	507 lbs. (230 kg)	German moored influence mine laid from the TT of U-boats. Used an aluminium alloy shell and used a 82 fathom (150 m) or 148 fathom (270 m) cable.
LMA	Floating	26 in. (66 cm)	661 lbs. (300 kg)	German magnetic mine, later converted to be aircraft-deployed. See **Annex X** for an example of one of these converted items.
Mark XVII	Moored	Unknown	320 lbs. (145 kg), later upped to 500 lbs.	British moored acoustic mine for use against S and R-boats.
M Mark III	Ground	Unknown	1,500 lbs. (680 kg), later upped to 1,750 lbs. (794 kg).	British CR magnetic mine, designed for laying from wide-track mine-layer rails in 6-20 fathoms (11-37 m). First deliveries in 1941.



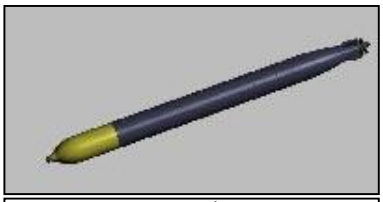
1. Lifting Lug
2. Anti-roll bars
3. Filling plate
4. Detonator cover plate
5. Clock starter plate
6. Parachute housing

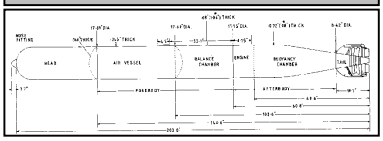
Left: Schematic of an LMA early pattern airborne parachute ground influence mine. Right: Mines aboard HMS Apollo ca 1945, likely to be M Mark I mines.

Examples of Torpedoes

British 18in Mark XII

Deployed by	Aircraft
Date of design/service	1935/1937
Weight	1,548 lbs. (702kg)
Overall length	16 ft 3 in (4.95m)
Explosive charge	388 lbs. (176kg) TNT
Range / speed	1,500 yards (1,370m)/40 knots or 3,500 yards (3,200 m)/37 knots
Remarks	Standard British airborne torpedo for the first half of WWII and still in limited use at the end.

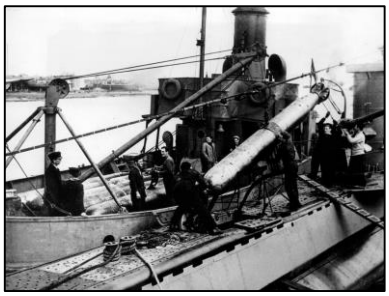




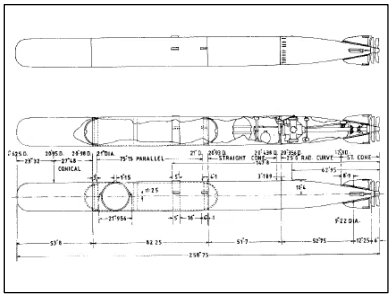
Left: A Mark XII torpedo fitted to a Bristol Beaufighter. Top right: Model of the torpedo. Bottom left: schematics.

British 21in Mark VIII**

Deployed by	All submarines from the "O" class on and MTBs
Date of design/service	About 1925/1927
Weight	3,452 lbs. (1,566 kg)
Overall length	21 ft 7 in (6.58 m)
Explosive charge	722 lbs. (327 kg) TNT
Range / speed	5,000 yards (4,570 m) / 45.5 knots
Remarks	First burner-cycle torpedo. Used more than any other British torpedo, accounted for 56.4% of torpedoes fired by September 1944 (3,732 fired in this period).



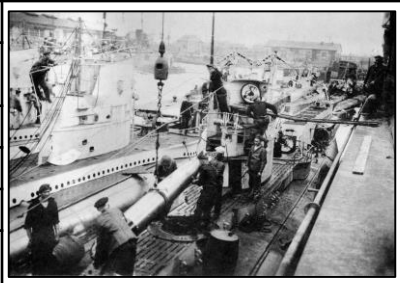
Mark VIIIs loading to Polish Navy submarine ORP Sokół



Schematics of a 21in MKVIII tornado

German 45cm (17.7") C/06

Deployed by	U-boats, starting with U-3
Date of design/service	1906/1907
Weight	1,704 lbs. (773 kg)
Overall length	222 in (5.65 m)
Explosive charge	270 lbs. (122.6 kg) TNT
Range / speed	1,640 yards (1,500 m)/34.5 knots 3,380 yards (3,000 m)/26 knots
Remarks	First German torpedo which received a 4-cylinder instead of a 3-cylinder engine.

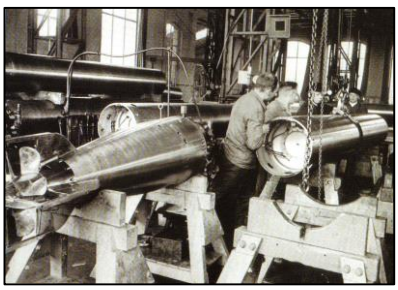


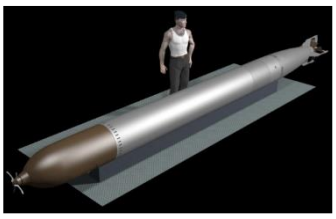
Loading torpedoes aboard a U-Boat of the German Flanders Flotilla at Bruges

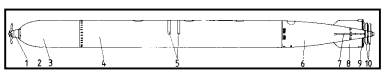
A German Flotilla in port.

German 53.3cm (21") G7a T1

Deployed by	Surface ships and submarines
Date of design/service	1930/1938
Weight	3,369 lbs. (1,528 kg)
Overall length	23 ft. 7 in. (7.186 m)
Explosive charge	617 lbs. (280 kg) Hexanite
Range / speed	6,560 yards (6,000 m) / 44 knots 8,750 yards (8,000 m) / 40 knots 15,000 yards (14,000 m) / 30 knots
Remarks	Issued throughout WWII and considered to be very reliable.







Left: G7a Torpedoes being repaired at Ostende in 1940. Top right: Model of the torpedo. Bottom right: Schematics.

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Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

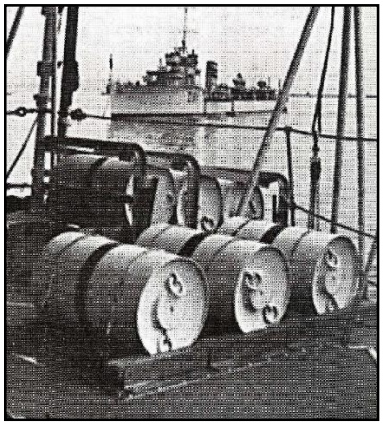
Ref: **DA2985-01**

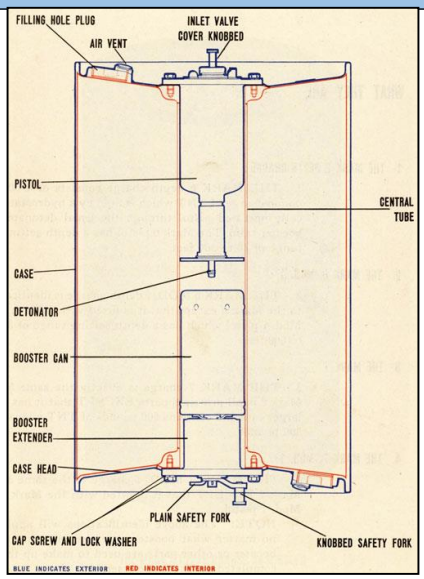
Source: Various sources

Examples of Anti-Submarine Weapons

Depth Charge. Mk VII

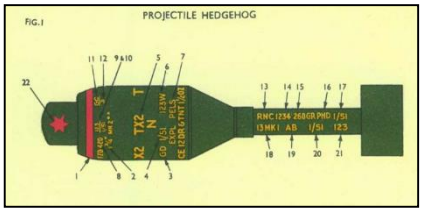
Shape	Cylindrical, drum shaped
Explosive Weight	132 kg
Fuze Type	Hydrostatic pistol
Dimensions	70 cm long, 45 cm diameter
Use	Amatol charge was estimated to be capable of splitting a 2.2 cm submarine pressure hull at a distance of 6.1 m. Torpex (or Minol) explosives used post 1942 were reported to increase this distance to 7.9 and 15.8 m.
Remarks	The Mk VII was little changed from the WWI Type D. Initially the depth charge was simply dropped from the attacking vessel but from late 1940 /early 1941 a launcher was used which projected the weapon some 35 m.





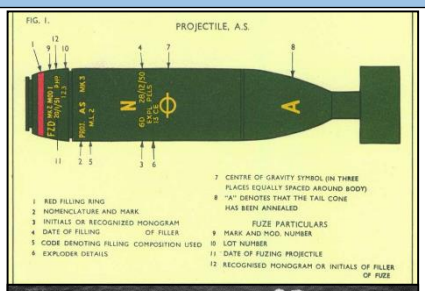
"Hedgehog" Spigot Mortar

Weight	29 kg
Explosive Weight	14 kg
Dimensions	118 cm long, 17.8 cm diameter
Fuse Type	Contact fuze
Use	Fired from a launcher on the attacking ship, these projectiles were fired in an arc and were designed to land in an elliptical pattern in the water to hit enemy submarines.
Remarks	This weapon was invented in order to address the issue of "instantaneous echo" when an enemy submarine was so close to the attacking ship that it could not be accurately plotted by a sonar operator and was effectively invisible.



"Squid" Mortar

Weight	200 kg
Explosive Weight	94 kg
Diameter	30.5 cm diameter
Fuse Type	Timer fuze
Use	Fired from a launcher on the attacking ship, these projectiles were fired in an arc and were designed to land in a triangular pattern in the water to hit enemy submarines.
Remarks	Reportedly nine times more effective than standard depth charges in post-war trials, these bombs were designed to fall on either side of a submarine, with the resulting pressure wave crushing the enemy vessel.



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Source: Various sources

Examples of Land Service Ammunition finds in the UK

Annex: E1

Unexploded Second World War bomb discovered under Somerset footpath

By Western Daily Press | Posted: January 21, 2014

The unexploded bomb was found in Somerset

Comments (0)

An unexploded bomb dropped in Britain during the Second World War has finally been discovered – underneath a popular footpath in Somerset.

23 August 2014 Last updated at 15:01

Unexploded WW2 bomb found at Kenfig Pool, Bridgend

Dean Smith believes the shell was made in Germany

Bomb experts have been called to a south Wales nature reserve after an unexploded World War Two shell was discovered by a walker in Bridgend.

Dean Smith, 38, of Pyle, was walking near Kenfig Pool on Saturday when he saw a fin sticking out of the sand.

He reached down to pick it up, but ending up falling and landed with the 2ft-long (0.6m) bomb on top of him.

The site has been cordoned off by police and the Royal Logistics Corps will carry out a controlled explosion.

Related Stories

'Panic' as dog nearly thrown grenade

WW2 bomb found at wind farm exploded

WWII bomb found in kitchen cupboard

Mortar thought to be from WWII found on Oshawa's Camp-X grounds

August 24, 2016 | 5:42 am

What is believed to be a World War II mortar has been discovered in south Oshawa. A man out in Intrepid Park, the site of the Camp-X Second World War training grounds, discovered the round with his metal detector on Tuesday evening. Durham police are held the scene overnight awaiting military officials from Trenton to come and properly detonate the mortar.

Unexploded bomb found in farmer's field

17 May 2010

A live Second World War mortar shell was blown up by Army experts after a farmer found it in his field.

The discovery was made in the field alongside the A20 between Folkestone and Dover.

The mortar shell, which was around a foot long and 3in in diameter, was around 50ft from the main road.

The farmer alerted police and PC Trevor Moody and PCSO Michelle Brady went to the field.

PC Moody contacted the Army who sent in a bomb disposal unit.

An Army officer confirmed the live shell was from the Second World War and was packed with high explosives.

They moved it a safe distance away from the A20 and carried out a controlled explosion.

PC Moody said: "Given that we live in an area that saw much action during the Second World War, it is not uncommon for us to be alerted about unexploded bombs."

The incident was on Thursday.

Click here for more news from Kent.

Royal Navy bomb disposal experts remove a World War Two shell discovered in a nature reserve

- A World War Two bomb was discovered in a Plymouth nature reserve
- Amateur metal detector found the shell and partially dug it up
- Royal Navy experts carried the explosive away before disposing of it

By VALERIE EDWARDS FOR MAILONLINE
PUBLISHED: 01:29, 13 January 2016 | **UPDATED:** 09:51, 13 January 2016

Share 338 shares 10 View comments

A World War Two bomb was reportedly found at Efford Nature Reserve in Plymouth after a member of the public was metal detecting and partially dug it up.

The Royal Navy Bomb Disposal team was called in to remove the bomb and police have closed off Military Lane, with the possibility of Military Road also being closed.

Police were called at around 1.30pm yesterday after what appeared to be a shell was discovered and partially dug up near Military Lane, Efford.

Holiday beach cordoned off after landslip 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

© Jonathan Pow

Bomb Beach Alley: Rockets were found after a landslide on Mappleton beach in 2012

Army bomb disposal team called to Blacksole Bridge in Herne Bay

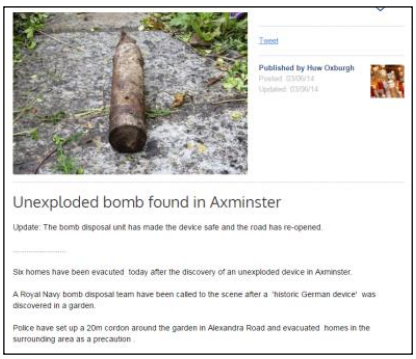
by Aidan Barlow abarlow@thekmgroup.co.uk 08 July 2015

It was like a scene from Dad's Army when Army bomb disposal experts found wartime explosives made by the Home Guard in makeshift bottles.

A team was called to the Blacksole Bridge in Herne Bay after the wartime bombs were found.

The team from the Royal Logistics Corps set up a 30 metre exclusion zone for pedestrians around the railway embankment after the suspected homemade phosphorous bombs were found.

The scene at Blacksole Bridge after wartime explosives were found in the railway cutting



Tweet

Published by Huw Oxburgh

Posted: 03/09/14

Updated: 03/09/14

Unexploded bomb found in Axminster

Update: The bomb disposal unit has made the device safe and the road has re-opened.

Six homes have been evacuated today after the discovery of an unexploded device in Axminster.

A Royal Navy bomb disposal team have been called to the scene after a "historic German device" was discovered in a garden.

Police have set up a 20m cordon around the garden in Alexandra Road and evacuated homes in the surrounding area as a precaution.

Storms and floods unearth unexploded wartime bombs

By Claire Marshall
BBC environment correspondent

There has been a dramatic increase in the number of wartime bombs unearthed because of the winter storms and flooding.

Bomb disposal teams in the South West have dealt with double the number of unexploded ordnance than in the same period last year.

Since mid December, the Royal Navy's Southern Dive Unit has recovered or disposed of 244 items of ordnance.

During the same period last year, they dealt with just 108 items.

The storms have uncovered a lethal past

Almost 70 years after the end of WWII, one legacy of that conflict continues to turn up on beaches and harbours around Britain.

Unexploded shells, bombs and mines continue to be discovered every year, and the Royal Navy's Southern Dive Unit is tasked with making these devices safe.

Its area of responsibility stretches for some 2,250km (1,400 miles). It begins from the highwater mark in Hull and proceeds seaward to the territorial limit, and then runs clockwise around the British Isles - including the Isle of Wight, Channel Islands, and Isles of Scilly - to finish in Liverpool.

Related Stories

Ancient trees revealed by storms

Land Service Ammunition (LSA) resulting from historic military activity is commonly encountered across the UK by the public and construction industry alike. Such finds are much more common in rural areas than in urban environments, and can often be anticipated in areas such as former RAF stations or ranges. However, many such items are encountered entirely by surprise where the landowner or developer has no knowledge of any previous military use of the land.

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Project:	**HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**		
Ref:	**DA2985-01**	Source:	Various news sources

Examples of Offshore UXO finds in the UK

30th April 2010

renewable energy focus.com

Bomb at Sheringham Shoal offshore wind site

A 250lb air-dropped German WWII bomb has been safely detonated on the Sheringham Shoal Offshore Wind Farm site.

Wind farm developer, Scira Offshore Energy Ltd commissioned an unexploded ordnances (UXO) survey as part of its reconstruction preparations and the bomb was found at the site of one of its foundation locations in the north-west of the offshore wind farm site.

A total of 52 targets were investigated by divers and using a remote operated vehicle (ROV). While most of the targets were debris or geological concentrations, several anchors and an old canon were found, as well as the unexploded bomb.

The bomb was found by divers from diving specialists Red7Marine and verified and detonated with explosives by disposal experts MACC International, earlier this month.

Project Director Rune Rønvik says safety is a priority during construction of the offshore wind farm and the discovery of the bomb full justified the use of such a technically precise survey, despite the additional time it required.

19th March 2014

BBC NEWS

Plans to explode WW2 bombs found in seabed at Gwynt y Mor wind farm

Preparations are under way to remove three unexploded bombs found on the sea bed at a wind farm site off the north Wales coast.

The World War Two bombs were discovered three weeks ago during ongoing construction at the Gwynt y Mor wind farm in Liverpool Bay.

Specialist contractors will carry out controlled explosions when the conditions are right in the next few weeks, RWE Innogy UK said.

9th August 2016

Worthing Herald

Unexploded WW2 ordnance found during wind farm construction to be detonated

Two unexploded WW2 devices will be detonated in a controlled explosion this week as works continue on the Rampion offshore wind farm.

Thought to date from the Second World War, the devices are located on the seabed, 3km off Lancing Beach at a depth of 13m.
They were discovered during unexploded ordnance (UXO) surveys which are carried out as protocol during offshore construction.

30th August 2017

The Guardian UK edition

Third WWII bomb found in Bristol Channel near Hinkley Point

A half-mile (1km) exclusion zone has been set up in the Bristol Channel near the Hinkley Point nuclear power stations after a third unexploded second world war bomb was discovered in as many weeks.

Bomb disposal experts will carry out a controlled explosion on the 250lb (113kg) ordnance on Wednesday, two miles north-west of the power plants.

On 8 August, a 500lb device was discovered 2.5 miles from the coast. On 16 August, a 250lb bomb was found less than half a mile from the power station. Both were destroyed in controlled explosions.

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Ref: **DA2985-01**

Source: Various news sources

NEWS

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WW2 German sea mine washes up near Bognor Regis

20 May 2018 Share

Paul Austin found the device about 500 yards from his front door

A live German sea mine from World War Two washed up on the Sussex coast has been towed out to sea and blown up.

The large metal device measuring about 6ft (1.8m) and thought to weigh about 1,000kg was found on Saturday.

The Maritime and Coastguard Agency (MCA) said the mine was "safely detonated" at about 17:10 BST.

Earlier, residents were alerted as a precaution and vessels were told to steer clear of the mine off Elmer Beach, near Bognor Regis.

A mile-wide maritime and air exclusion zone was in force, with coastguards broadcasting to vessels in the area.

26th February 2015

Made for minds.

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Unexploded WWII bomb found near Dortmund's Signal Iduna Park

An unexploded Second World War bomb was found near the Signal Iduna Park in Dortmund on Thursday morning. The bomb was defused safely midway through the afternoon.

Just hours before Dortmund head coach Jürgen Klopp was due to give his press conference ahead of the derby against Schalke, a 250-kilogram (550-pound) unexploded bomb of British origin was discovered near Borussia Dortmund's stadium, the Signal Iduna Park. The bomb was difused at just after 15:00 local time (14:00 UTC), whereupon it was taken to a temporary holding in Hagen before it will later be destroyed in a disassembly plant in North Rhein-Westphalia.

With a 250-meter safety radius, both the stadium and the fan world were evacuated as well as everyone living in the area.

25th December 2016

The Guardian

UK edition

German city evacuated after discovery of unexploded RAF bomb

Residents of 32,000 households in Augsburg allowed to return after 1.8-tonne second world war bomb is successfully defused

▲ A police roadblock in Augsburg at the site where the unexploded RAF blockbuster bomb was discovered. Photograph: Tobias Hase/EPA

Explosives experts have defused a large second world war bomb in the German city of Augsburg, clearing the way for thousands of evacuated residents to return and hold their Christmas celebrations at home.

City police tweeted that they had "good news at Christmas" just before 7pm local time (18.00 GMT). Before that, they had been unable to say how long residents would have to stay away due to the sensitive explosives work being done.

1st September 2017

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Frankfurt to evacuate 70,000 after British WW2 bomb found

1 September 2017 Share

World War Two

The British bomb was found on Wismarer Strasse, which is close to the city centre

German police will evacuate about 70,000 people from their homes on Sunday after an unexploded World War Two bomb was discovered in Frankfurt.

It will be one of the biggest operations of its kind carried out in Germany since the war.

April 20th 2018

The Washington Post

Democracy Dies in Darkness

An unexploded WWII bomb forced a mass evacuation in Berlin. There will be more to come.

By Rick Noack April 20 Email the author

Police evacuated an area in the heart of Berlin April 20, as bomb disposal experts prepared to defuse a World War II bomb. (Reuters)

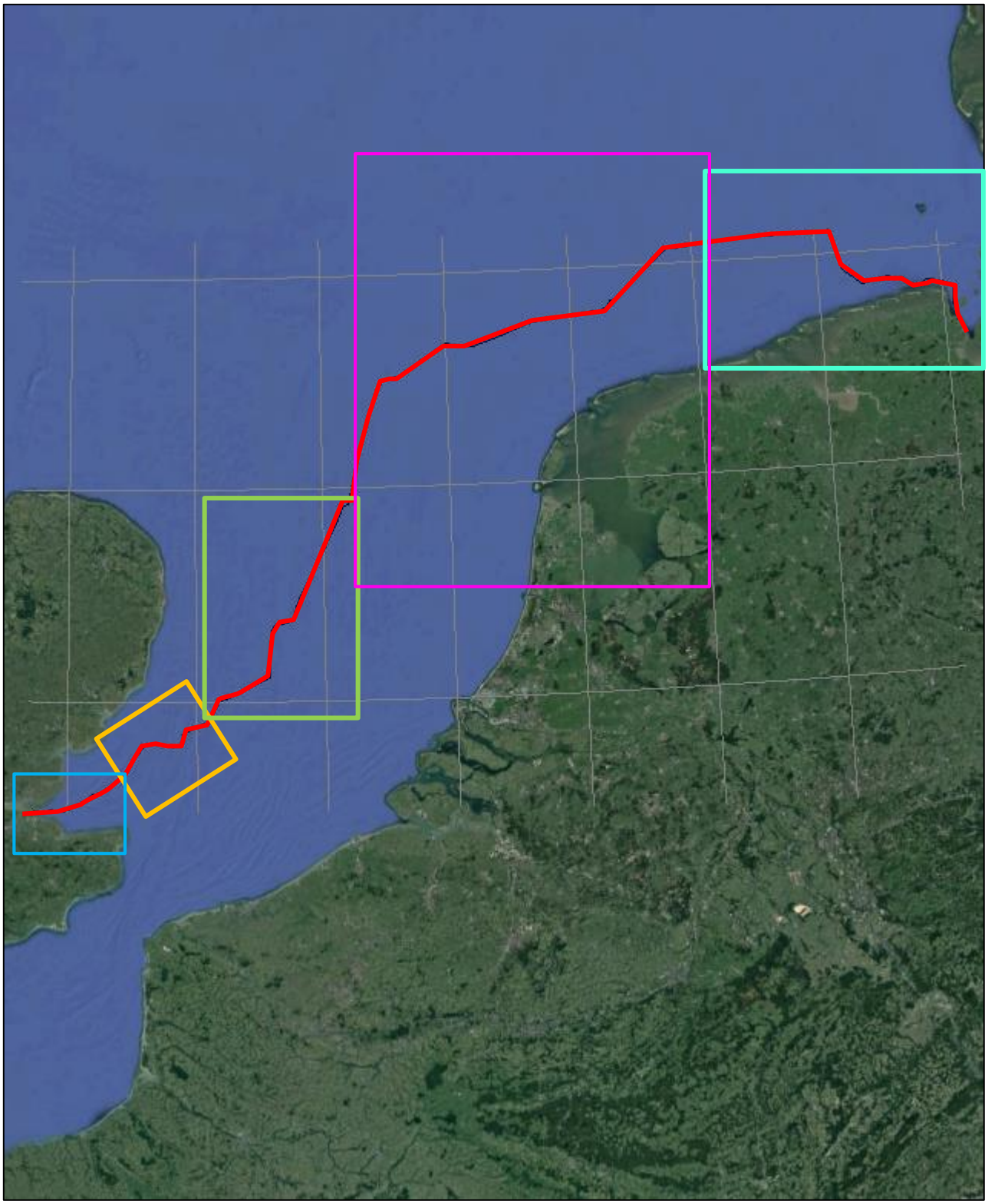
BERLIN — Other countries may have hurricanes, blizzards or flooding that regularly shut down major transport hubs. Germany, meanwhile, is still dealing with the legacy of a war the country launched itself: thousands of unexploded bombs, hidden beneath one of Europe's busiest cities in a nation now at peace.

Germany's main railway station in Berlin was forced to shut down on Friday in preparation for the defusing of one such a bomb, as authorities evacuated parts of the capital's city center until early afternoon local time.

The 1,000-pound, British-made bomb was successfully defused. Train services have since resumed, and workers are being allowed back into the city center, but it may not be long until the next large-scale evacuation here.

Overlay of Wreck Sites

Annex: **F1**



Thames Estuary

British Waters 1

British Waters 2

Dutch Waters

German Waters

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Approximate study area

N

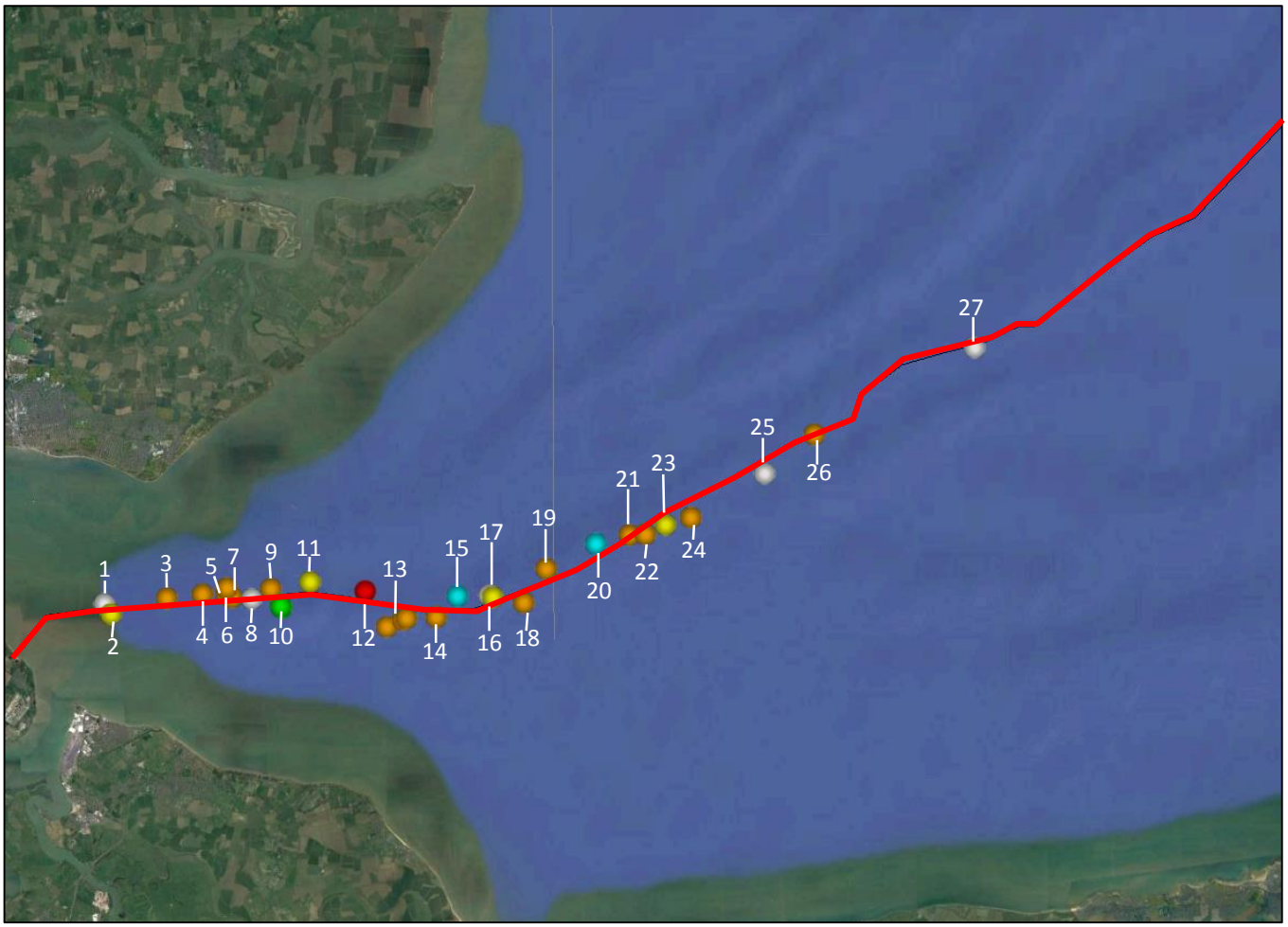
Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Wrecksite.eu

Overlay of Wreck Sites – Thames Estuary

Annex: F2



1. Castor
2. Jeffie
3. SS Belvedere
4. SS Malrix
5. MV Araby
6. SS Inver
7. SS Beneficient
8. Van Tromp
9. MV Arinia
10. SS Herland (In two parts)
11. SS Bolbec
12. Unknown War Aircraft
13. HMS Vimiera (In three parts)
14. HMT Capricornus
15. SS Letchworth
16. Donald
17. HMS Truculent
18. HMS Devon County
19. HMT Ash
20. East Oaze Light Vessel (LTV No.60)
21. HMY Aisha
22. MV Actuality
23. MV Sigrun I
24. HMT Kennymore
25. Yelding
26. SS Margam Abbey
27. Consul

Key:

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft

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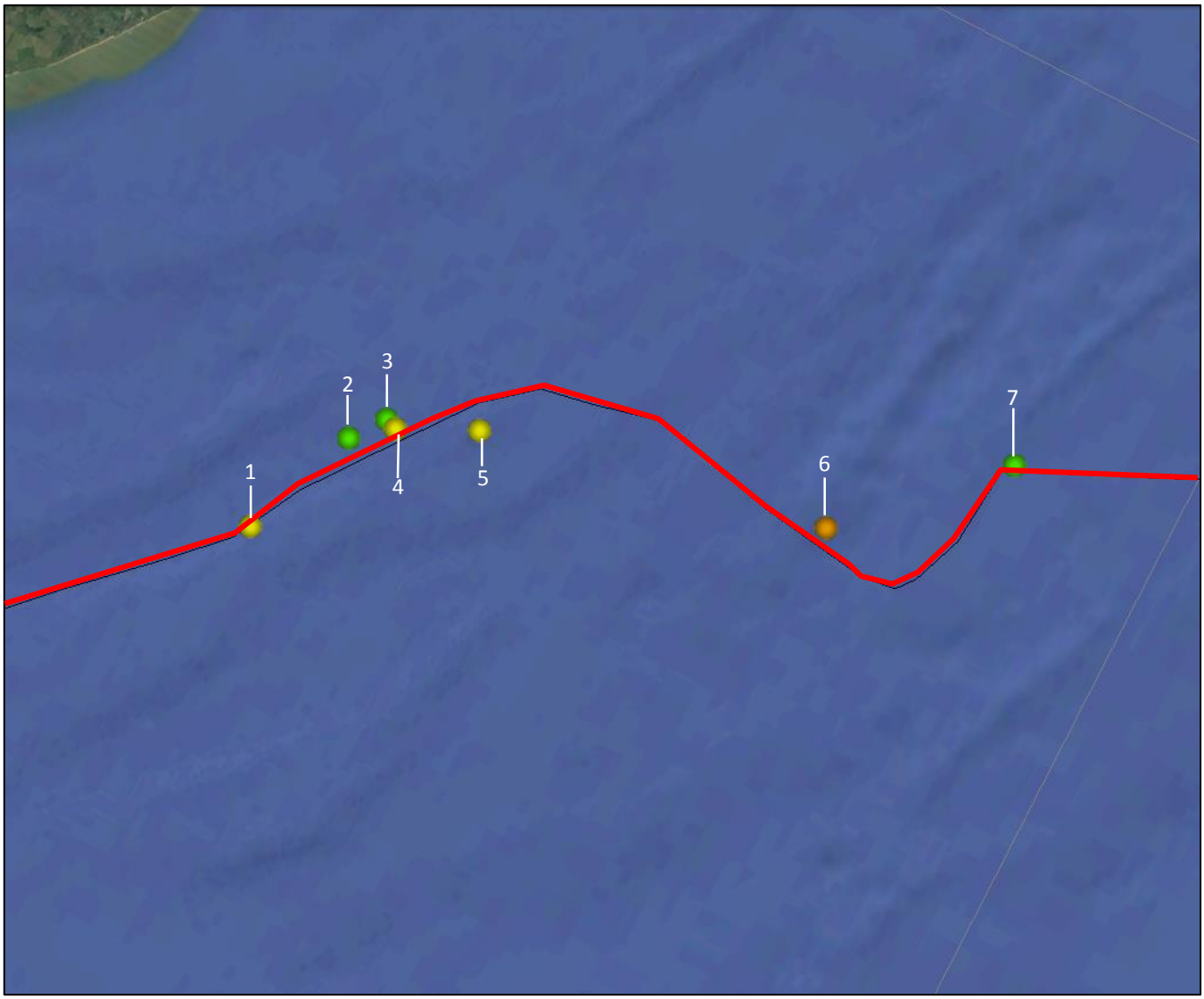
Source: Wrecksite.eu

Approximate study area

N

Overlay of Wreck Sites – British EEZ 1

Annex: **F3**



1. SS Greenhill
2. HMS Coquette
3. SS Salerno
4. SS Iris
5. SS Peregrine
6. SS Haytor
7. SS Hendonhall

Key:

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft

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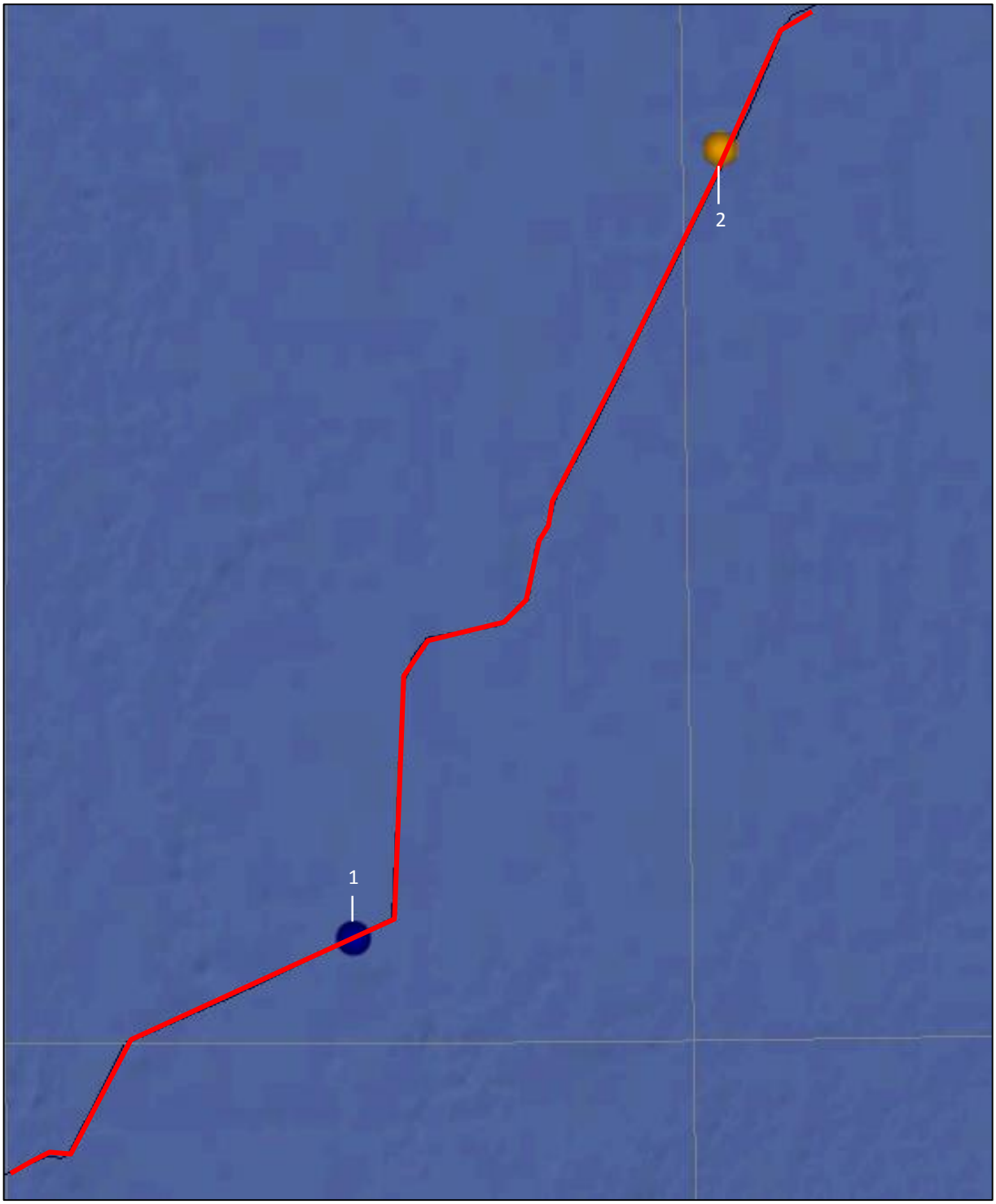
Source: Wrecksite.eu

Overlay of Wreck Sites – British EEZ 2

Annex: **F4**



1. SS Kaunas
2. U-31

Key:

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft

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Approximate study area

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Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Wrecksite.eu

Overlay of Wreck Sites – Dutch EEZ

Annex: **F5**

1. HMS Ivanhoe
2. Ivan
3. S-22

Key:

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft

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Client: **Intertek**

Approximate study area

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

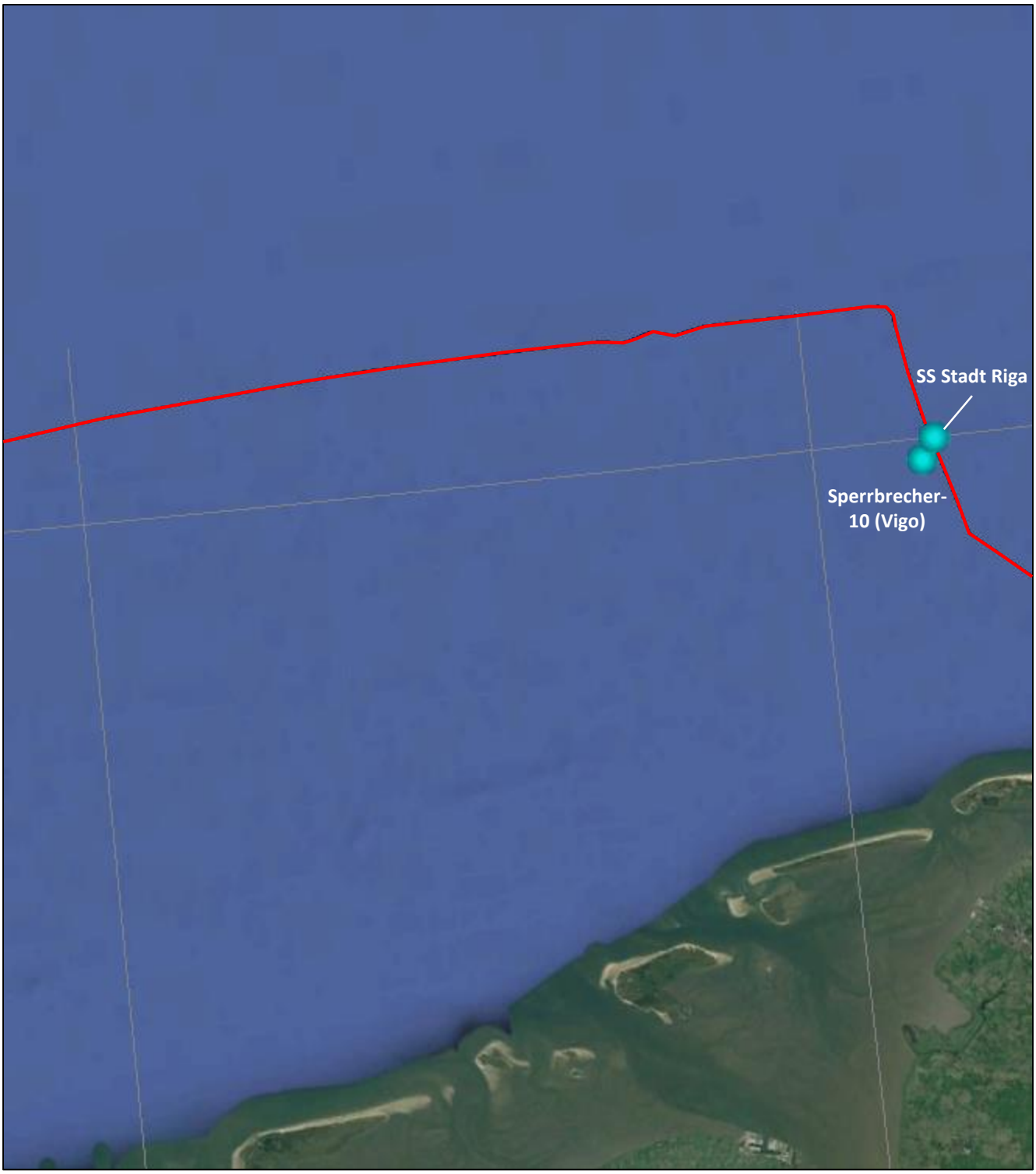
N

Ref: **DA2985-01**

Source: Wrecksite.eu

Overlay of Wreck Sites – German Waters

Annex: F6



Key:

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft

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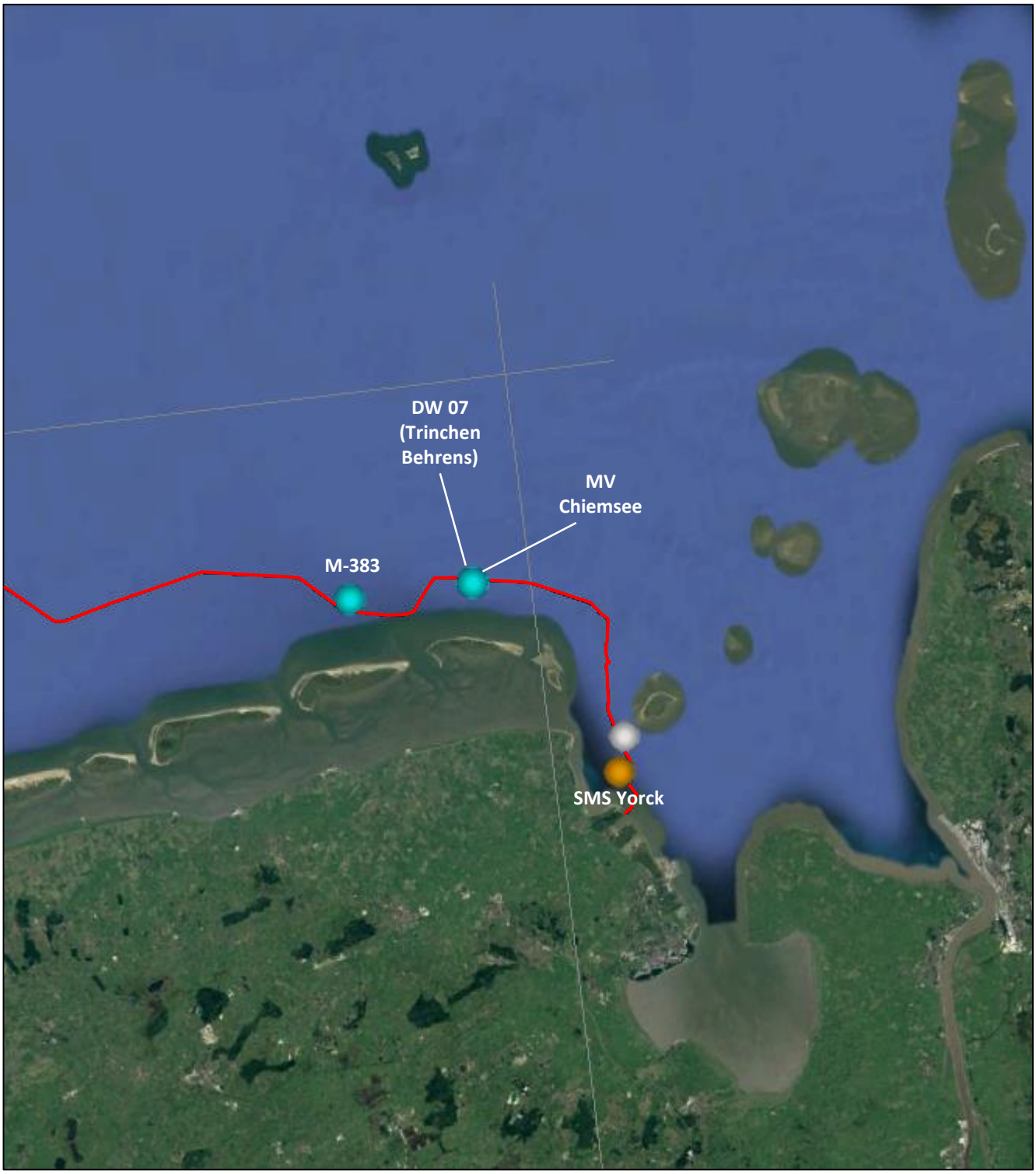
N

Ref: **DA2985-01**

Source: Wrecksite.eu

Overlay of Wreck Sites – German Waters

Annex: F7



Key:

Mine | German Mine | Torpedo | Gunfire | WWII-era air raid | Not specified

WWI/WWII-era wreck – sunk circumstances unrelated to explosive ordnance | Crashed aircraft

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Ref: **DA2985-01**

Source: Wrecksite.eu

Ship name	Type of ship	Armaments	Date of wreck	Reason given	Location
Castor	Not specified	Not specified	1916	Not specified	Within 220m N
Jeffie	Barge, lighter	Not specified	1923	Foundered	Within 20m S
SS Belvedere	Cargo ship	Not specified	17/12/1940	Sunk by a mine	Within 290m N
SS Malrix	Transport	Not specified	17/12/1940	Sunk by a mine	Within 300m N
MV Araby	Cargo ship	Not specified	27/12/1940	Sunk by a mine	Within 450m N
SS Inver	Coal cargo ship	Not specified	17/12/1940	Sunk by a mine	Within 230m N
SS Beneficient	Cargo ship	Not specified	17/12/1940	Sunk by a mine	Within 90m N
Van Tromp	Not specified	Not specified	Not specified	Not specified	Within 40m S
MV Arinia	Tanker	Not specified	19/12/1940	Sunk by a mine	Within 280m N
SS Herland (In two parts)	Cargo ship	Armed merchant ship	07/11/1940	Sunk by a German mine	Within 380m and 450m S
SS Bolbec	Cargo ship	Not specified	09/01/1943	Collision, foundered	Within 460m N
HMS Vimiera (In three parts)	Destroyer	4 x 4", 2 x 2 pdr. A.A. or 1 x 12 pdr., 2 x 21" twin T.T.	09/01/1942	Sunk by a mine	Within 350m, 440m, 800m S
HMT Capricornus	Minesweeper	1 x 6 pounder AA gun	07/12/1940	Sunk by a mine	Within 220m S
SS Letchworth	Coal cargo ship	Not specified	01/11/1940	Air Raid	Within 550m N
Donald	Barge, lighter	Not specified	1920	Not specified	Within 300m NW
HMS Truculent	Submarine	6 bow, 4 external torpedo tubes, 16 torpedoes, QF 4 inch gun	12/01/1950	Collison	Within 200m NW
HMS Devon County	Drifter	1 x 6pdr gun	01/07/1941	Sunk by a mine	Within 400m N
HMT Ash	Minesweeper	1x 12 pdr gun, 2x 0.5 inch machine guns, 4 x Lewis guns	05/06/1941	Sunk by a mine	Within 460m NW
East Oaze Light Vessel (LTV No.60)	Lightship	Not specified	01/11/1940	Air Raid	Within 500m NW
HMY Aisha	Leisure yacht	Not specified	11/10/1940	Sunk by a mine	Within 130m NW

MV Actuality	Cargo ship	Not specified	08/12/1940	Sunk by a mine	Within 190m SE
MV Sigrun I	Cargo ship	Not specified	04/06/1916	Capsized	Within 330m SE
HMT Kennymore	Minesweeper	Not specified	25/11/1940	Sunk by a mine	Within 530m SE
Yelding	Not specified	Not specified	1924	Not specified	Within 380m SE
SS Margam Abbey	Cargo ship	Not specified	25/04/1940	Sunk by a mine	Within 110m NW
Consul	Barge, lighter	Not specified	Not specified	Not specified	Within 40m SE
SS Greenhill	Cargo ship	Not specified	16/12/1917	Ran aground	Within 60m E
HMS Coquette	Destroyer	1 × QF 12-pounder gun 1 x QF 6-pdr gun 2 × single tubes for 18" torpedoes	07/03/1916	Sunk by a mine from a German submarine	Within 1km NW
SS Salerno	Passenger/ Cargo ship	Not specified	18/10/1915	Sunk by a mine from a German submarine	Within 1.1km NW
SS Iris	Cargo ship	Not specified	25/12/1917	Ran aground	Within 900m NW
SS Peregrine	Passenger/ Cargo ship	Not specified	29/12/1917	Ran aground	Within 1.1km SE
SS Haytor	Cargo ship	Not specified	26/07/1940	Sunk by a mine	Within 350m N
SS Hendonhall	Cargo ship	Not specified	01/05/1916	Sunk by a mine from a German submarine	Within 100m SE
SS Kaunas	Cargo ship	Not specified	17/11/1939	Torpedoed by U-57 (a German submarine)	Within 300m SE
U-31	German U-boat	6 torpedoes, 4 T.T. 2 fwd and 2 aft, 1 x 105 mm gun	13/01/1915	Sunk by a mine	Within 700m NW

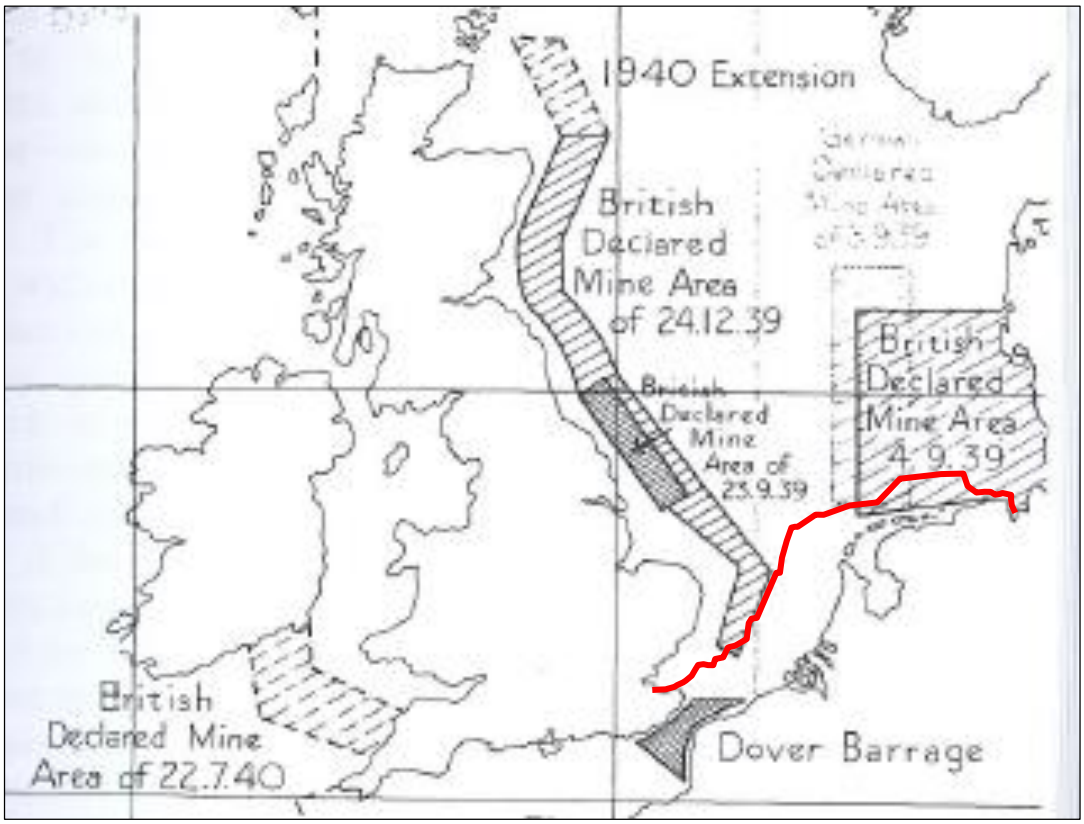
Ship name	Type of ship	Armaments	Date of wreck	Reason given	Location
HMS Ivanhoe	Destroyer	4 x 4.7", 8 x .5", A.A., 10 x 21"T.T. (5x2), 60 mines	01/09/1940	Sunk by a mine	Within 280m SE
Ivan	Not specified	Not specified	24/10/1949	Sunk by a mine	Within 600m N
S-22	Torpedo Boat	2 x 8.8 cm guns, 4 x 50 cm T.T., 18 mines	26/03/1916	Sunk by a mine	Within 1.45km S

Dutch EEZ

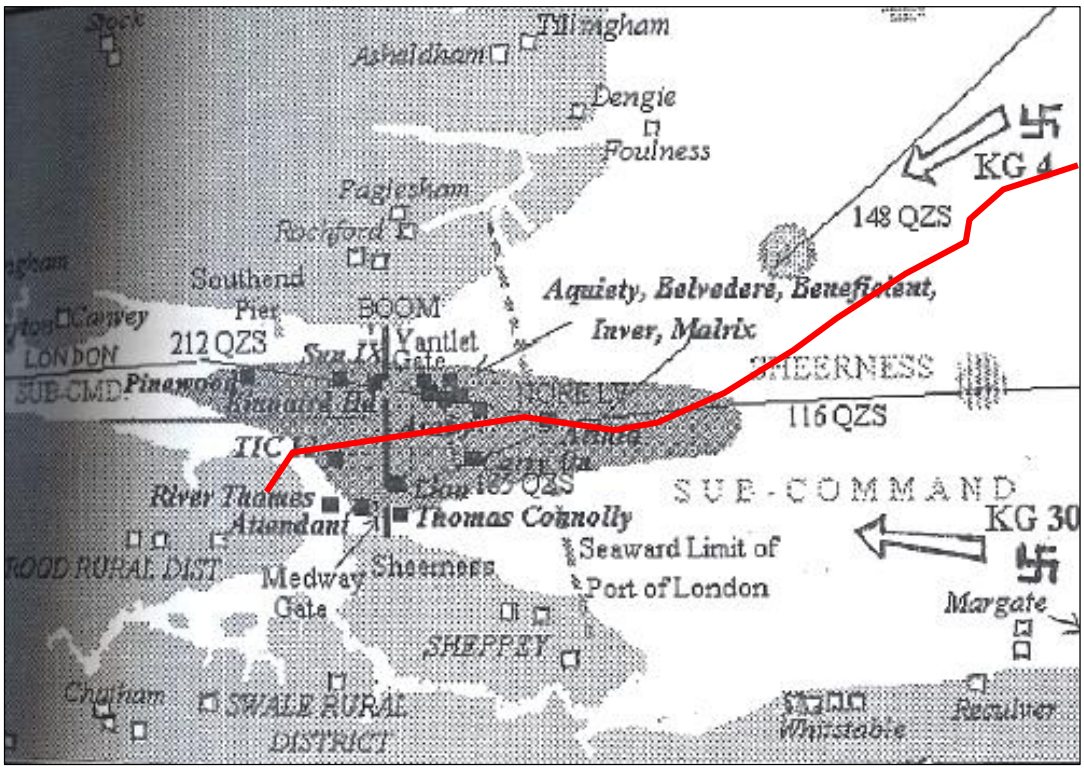
Ship name	Type of ship	Armaments	Date of wreck	Reason given	Location
SS Stadt Riga	Cargo ship	Not specified	06/07/1944	Air raid: This ship was sunk by British torpedo bombers near Borkum.	Within 400m E
Sperrbecher-10 (Vigo)	Minesweeper	Not specified	07/03/1944	Air Raid: The Vigo sank after a mine hit before Norderney.	Within 1.3km W
M-383	Minesweeper	Not specified	13/08/1944	Air Raid: The German minesweeper M-383 was sunk in an air raid off Langeroog by RAF aircraft	Within 1km N
MV Chiemsee	Cargo Ship	Not specified	15/10/1944	Air Raid: Allied air attack by Beaufighters	Within 240m S
DW 07 (Trinchen Behrens)	Patrol boat	Guns: 2 x 30 mm + 1 x 20 mm AA + 3 x 15 mm AA	30th June 1944	Air Raid: Sank after hitting a mine launched by a British plane at N of Wangerooge,	Within 230m S
Unknown	Sailing ship	Not specified	1919	Not specified	Within 660m E
SMS Yorck	Cruiser	4 x 8.3", 10 x 5.9", 14 x 3.5", 4 x 18" torpedo tubes	4th Novemeber 1914	Mine: Cruiser made a navigational error in heavy fog and accidentally sailed into a German defensive minefield.	Within 850m NW

German EEZ

British and German Declared Mine Areas 1939-1940



German Air Minelaying in the Thames Estuary 8-15th December



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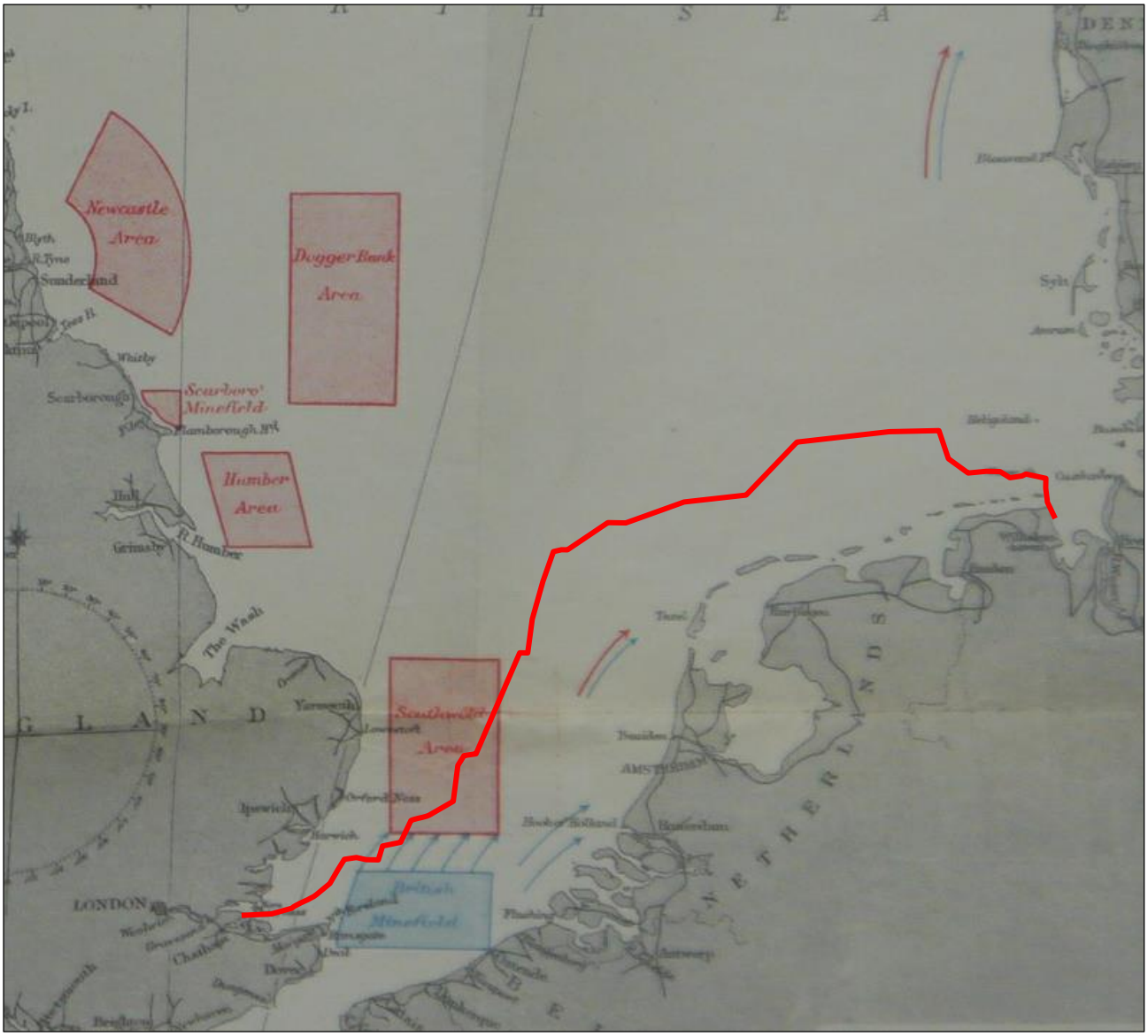
Ref:	**DA2985-01**
Source:	*The War at Sea* and *The Battle of the East Coast*

Approximate Positions of Minefields 7th January 1915

Annex: G2



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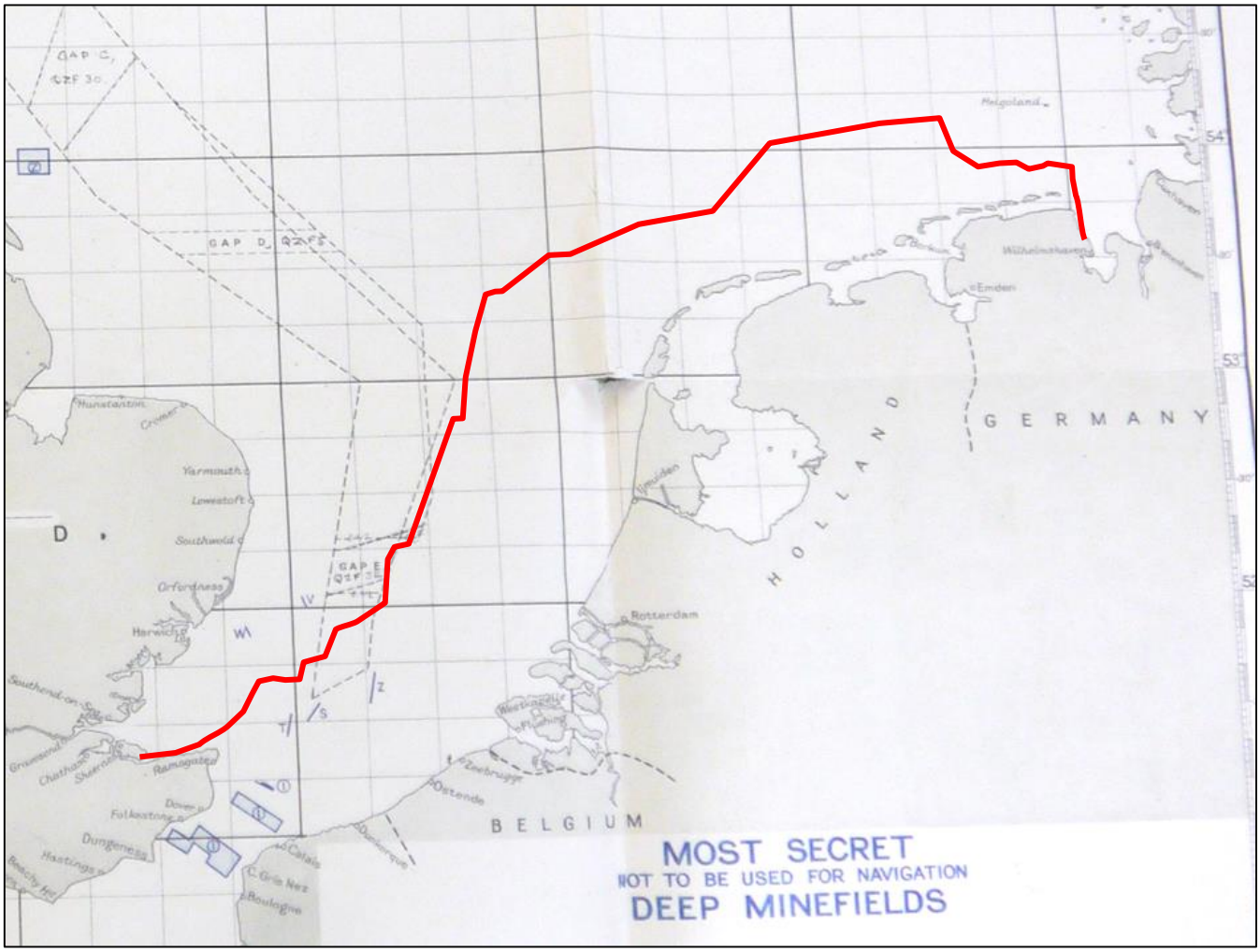
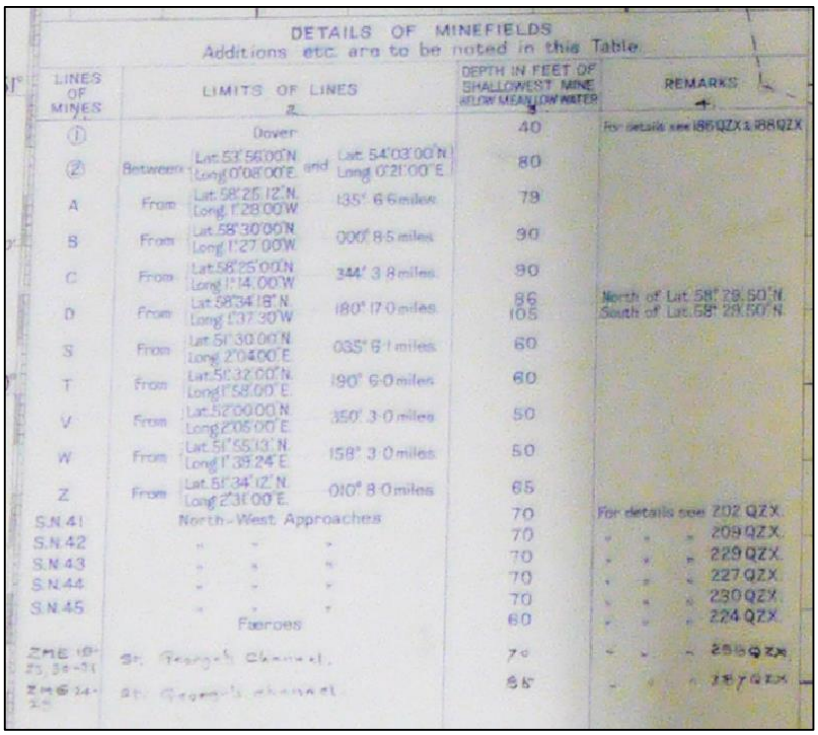
Ref: **DA2985-01**

Source: The National Archives, Kew

Approximate study area

N





DETAILS OF MINEFIELDS
Additions etc. are to be noted in this Table

LINES OF MINES	LIMITS OF LINES		DEPTH IN FEET OF SHALLOWEST MINE BELOW MEAN LOW WATER	REMARKS
①	Dover		40	For details see 186 QZX & 188 QZX
②	Between Lat. 51° 56·00' N. Long 0° 08·00' E.	and Lat. 54° 03·00' N. Long 0° 21·00' E.	80	
A	From Lat. 58° 25·12' N. Long 1° 28·00' W.	135° 6·6 miles	79	
S	From Lat. 58° 30·00' N. Long 1° 27·00' W.	000° 8·5 miles	90	
C	From Lat. 58° 25·00' N. Long 1° 14·00' W.	344° 3·8 miles	90	
D	From Lat. 58° 34·18' N. Long 0° 37·30' W.	180° 17·0 miles	86 105	North of Lat. 58° 28·50' N. South of Lat. 58° 28·50' N.
S	From Lat. 51° 30·00' N. Long 2° 04·00' E.	035° 6·1 miles	60	
T	From Lat. 50° 32·00' N. Long 1° 58·00' E.	190° 6·0 miles	60	
V	From Lat. 52° 00·00' N. Long 2° 05·00' E.	350° 3·0 miles	50	
W	From Lat. 51° 55·13' N. Long 1° 39·24' E.	158° 3·0 miles	50	
Z	From Lat. 51° 34·12' N. Long 2° 31·00' E.	010° 8·0 miles	65	
S.N.41	North-West Approaches		70	For details see 202 QZX
S.N.42	" " "		70	" " " 209 QZX
S.N.43	" " "		70	" " " 229 QZX
S.N.44	" " "		70	" " " 227 QZX
S.N.45	" " "		70	" " " 230 QZX
	Faeroes		60	" " " 224 QZX
ZME 10	St. George's Channel		70	" " " 256 QZX
ZME 24	St. George's Channel		55	" " " 255 QZX

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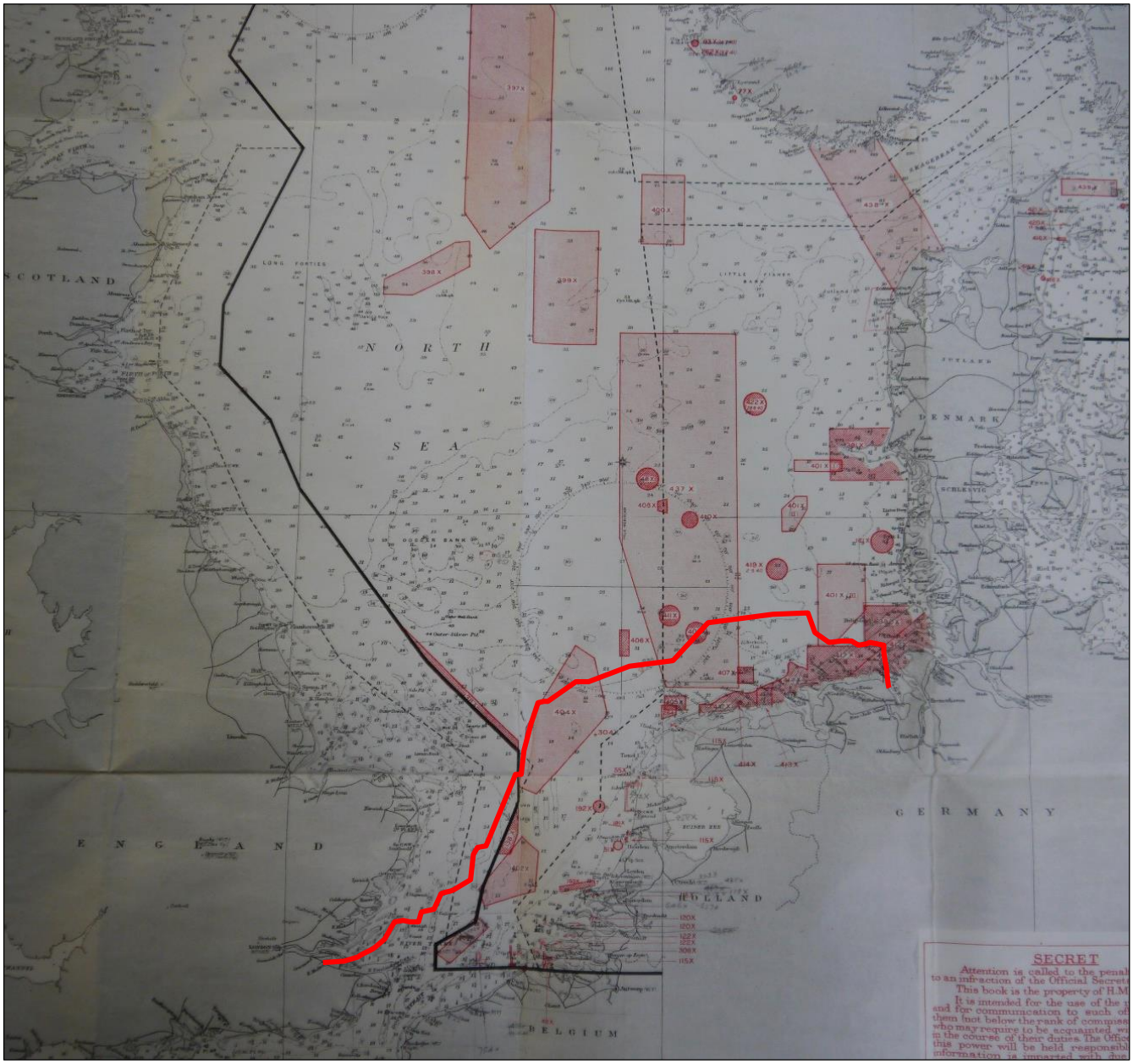
Source: The National Archives, Kew

Approximate study area

N



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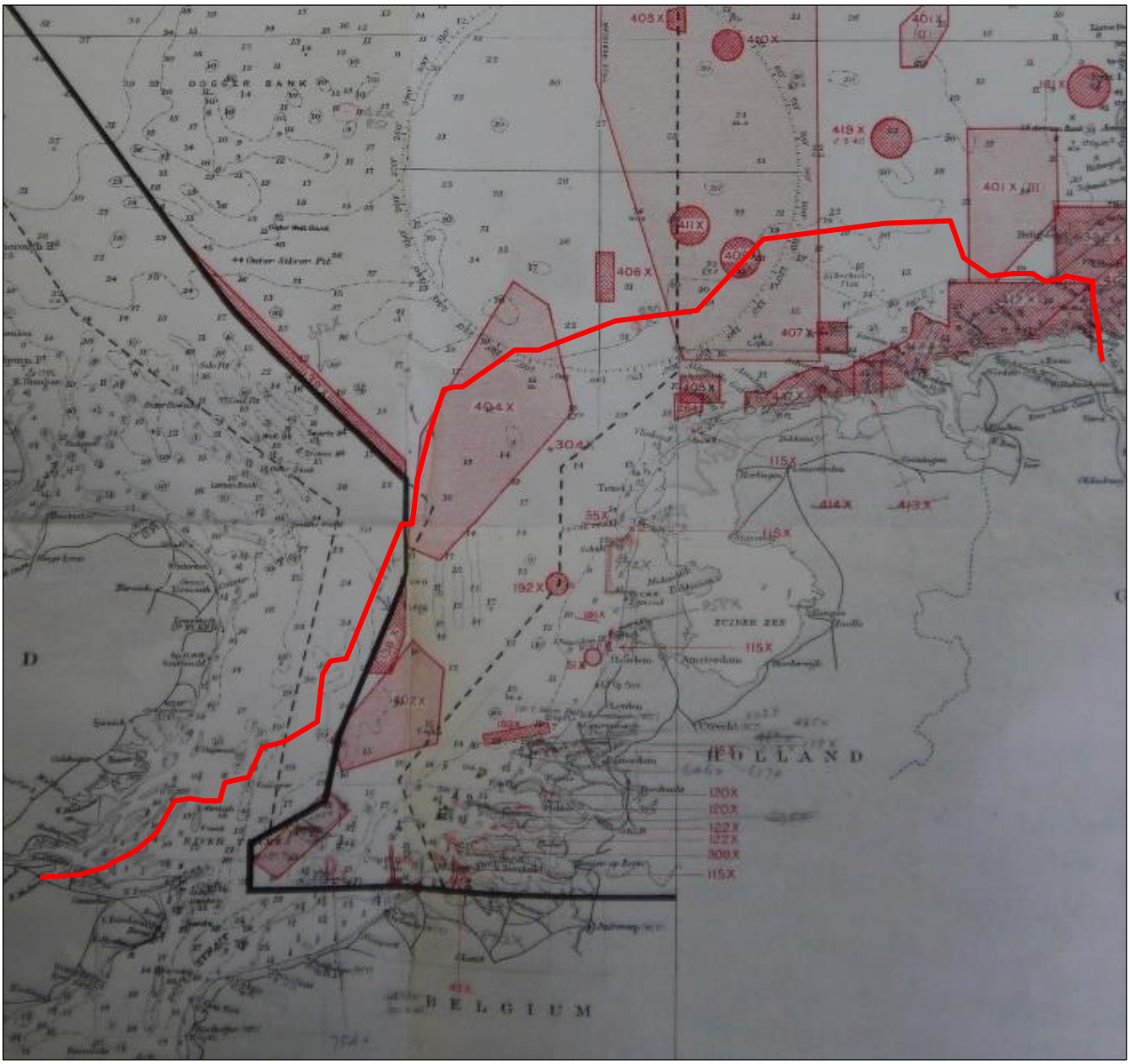

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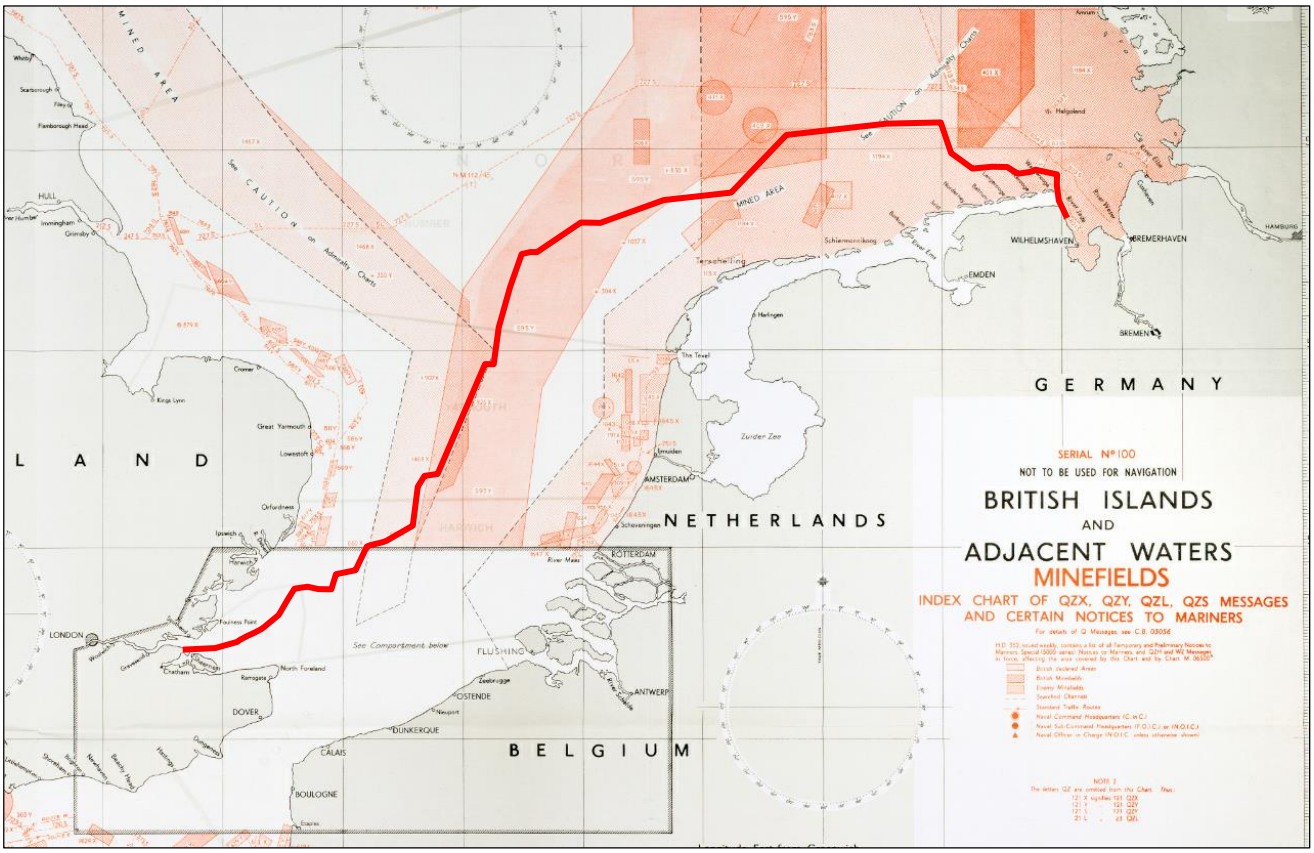
N

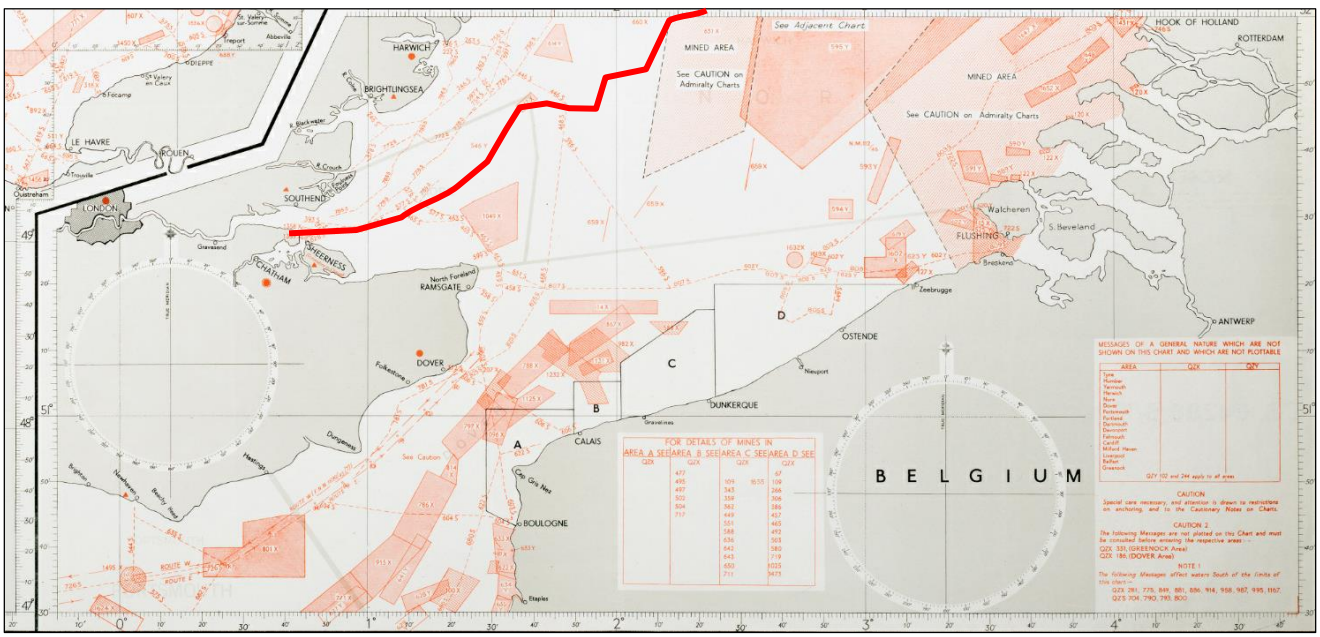
Ref: **DA2985-01**

Source: The National Archives, Kew

British Islands and Adjacent Waters Minefields – July 1945

Annex: G6





British declared Areas
British Minefields
Enemy Minefields
Searched Channels
Standard Traffic Routes
Naval Command Headquarters (C. in C.)
Naval Sub-Command Headquarters (F.O.I.C.) or (N.O.I.C.)
Naval Officer in Charge (N.O.I.C. unless otherwise shown)

Approximate study area

N

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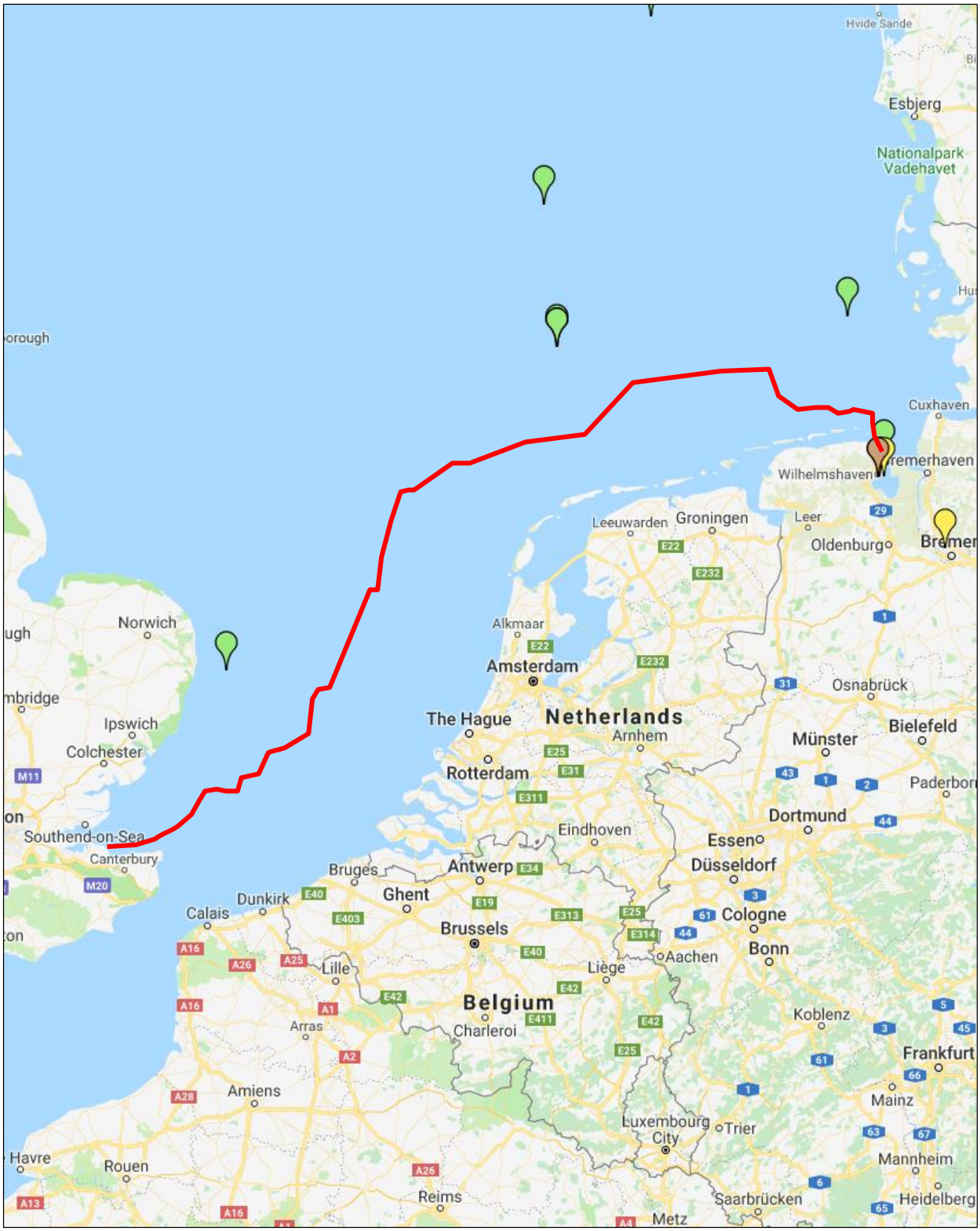
Ref: **DA2985-01**

Source: UKHO

Overlay of WWII-era U-boat losses in the North Sea

Annex: H



Key:

1940 1944 U-Boat Flotilla Base

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Client: **Intertek**

Approximate study area

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

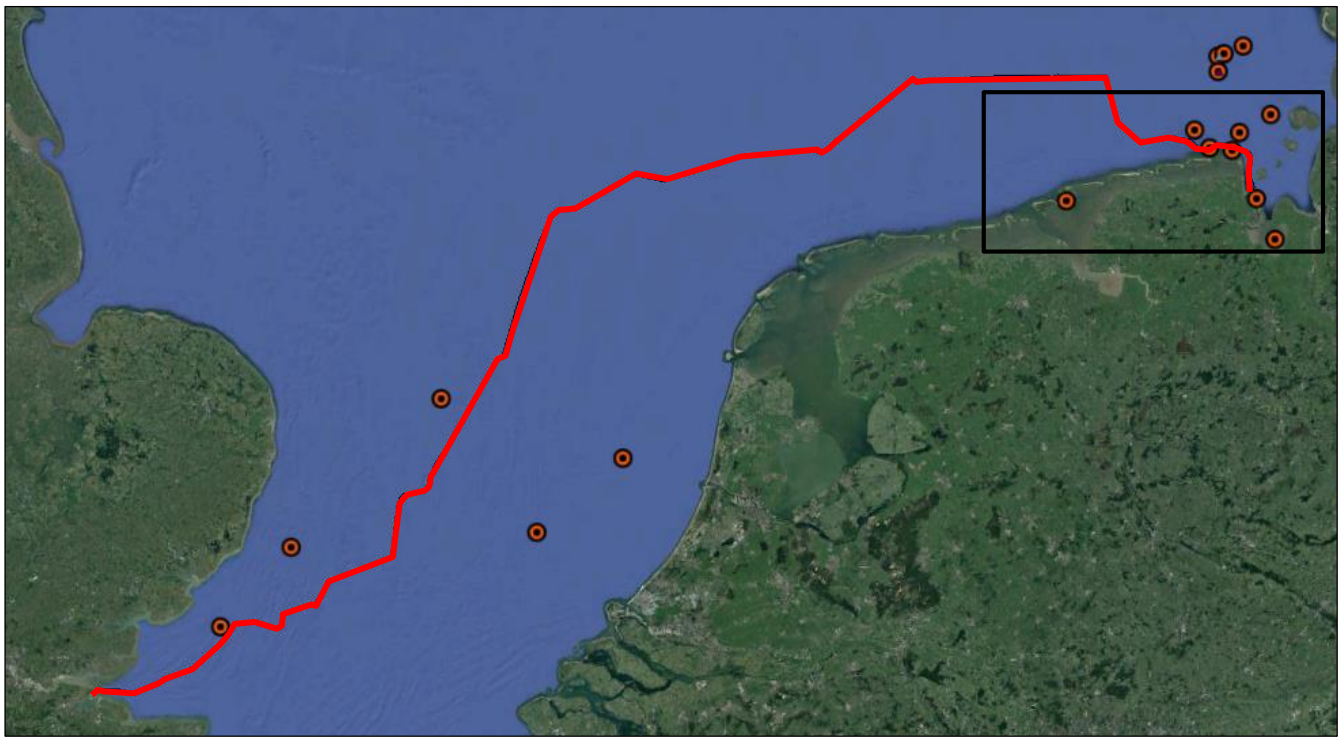
N

Ref: **DA2985-01**

Source: https://uboat.net/maps/north_sea.htm

Overlay of OSPAR Marine Munition Dumpsite Locations

Annex: I



Key:

Conventional Munitions Dumpsite

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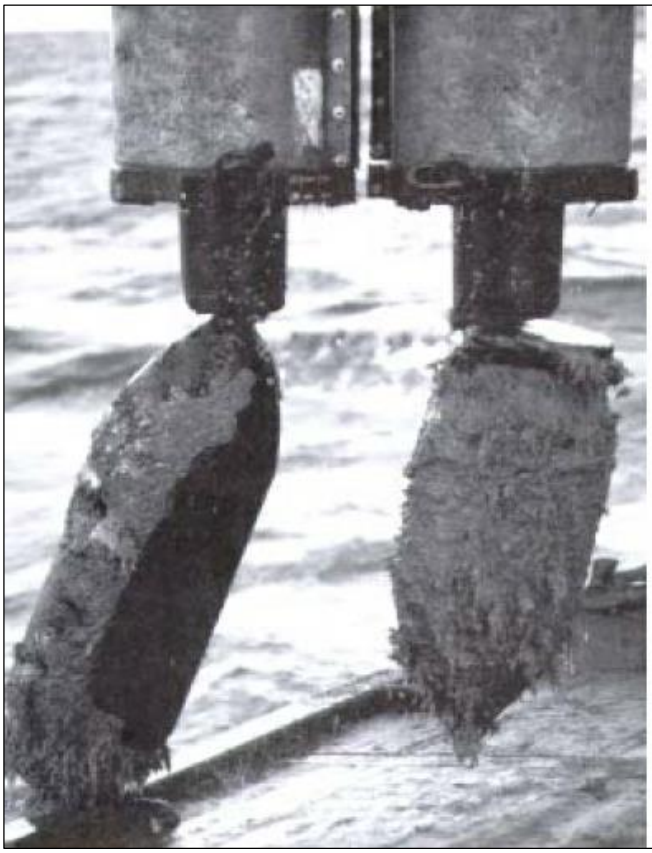
Ref: **DA2985-01**

Source: OSPAR



Recovered Ammunition at the Wilhelmshaven Plant, 1952

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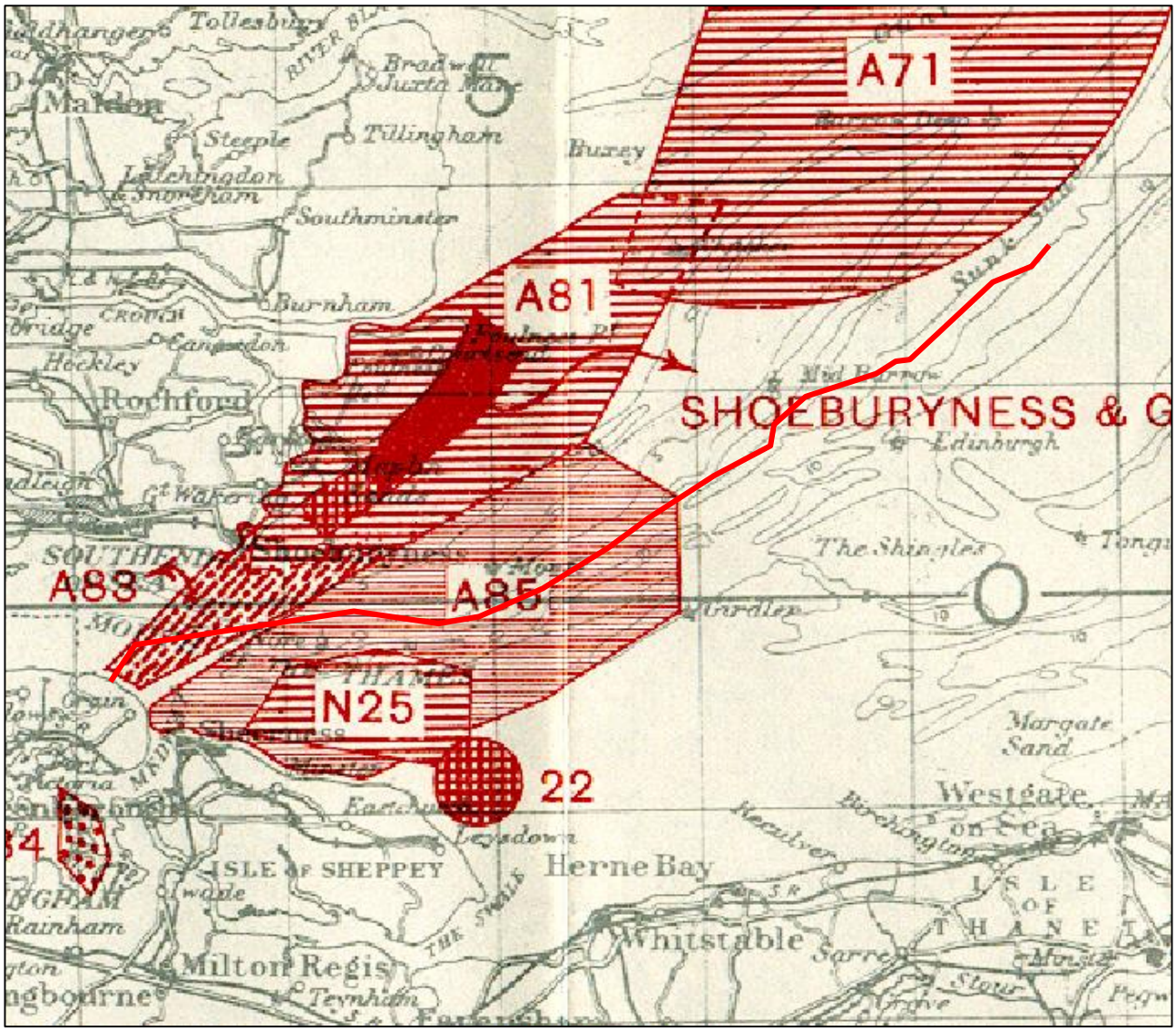
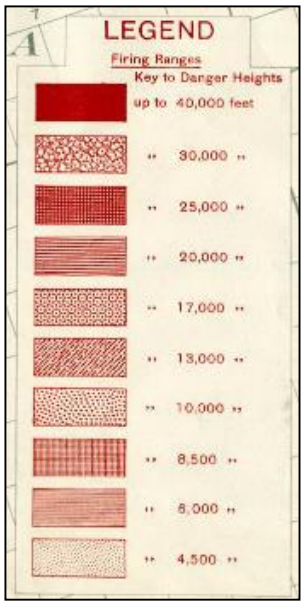
WWII-era Armament Training Areas Mapping

Annex: K





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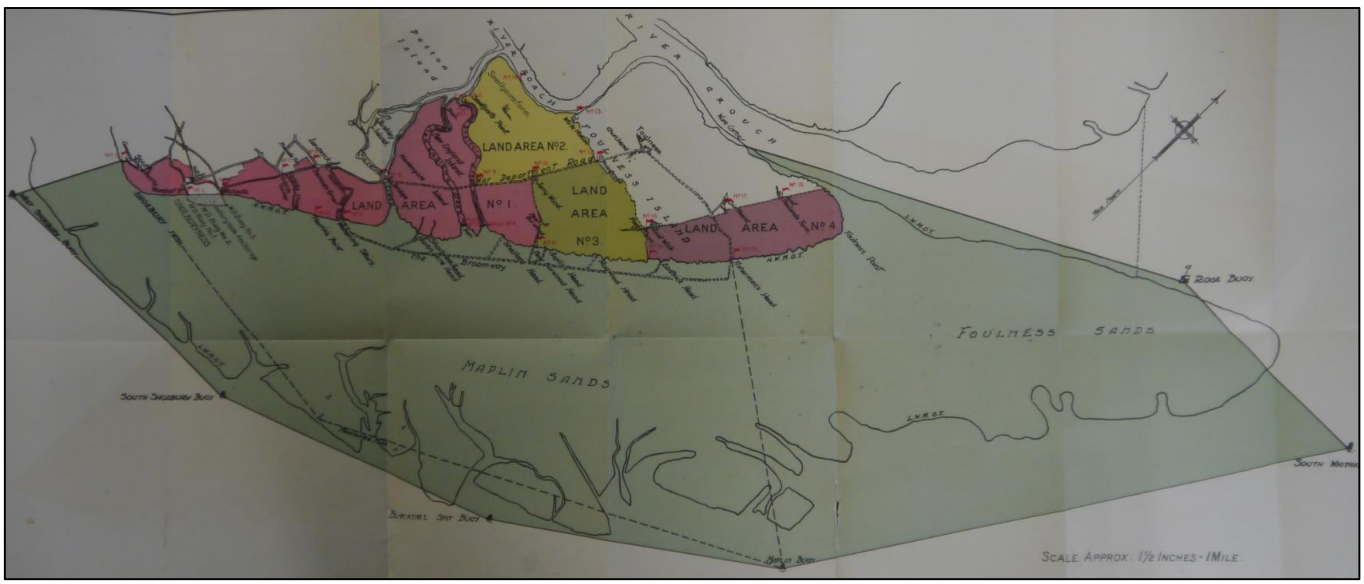
Source: The National Archives, Kew



Mapping showing the extent of Shoeburyness Artillery Ranges, based on 1936 byelaw documentation.

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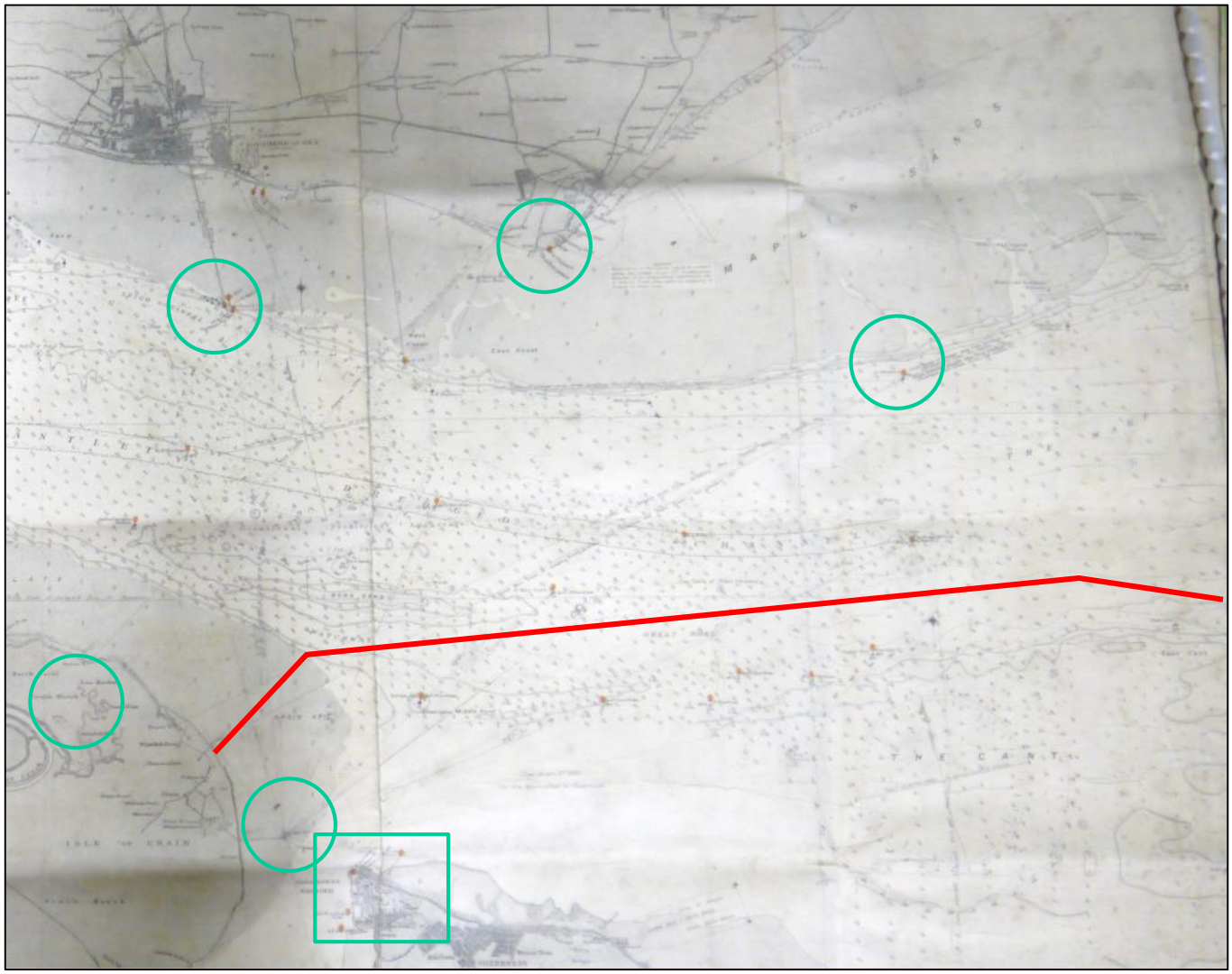
Ref: **DA2985-01**

Source: The National Archives, Kew

Range Mapping - Thames Estuary Firing Range Lines

Annex: L2



WWII-era mapping showing the firing points of artillery ranges in the Thames Estuary. Any firing points of particular interest are highlighted in green.

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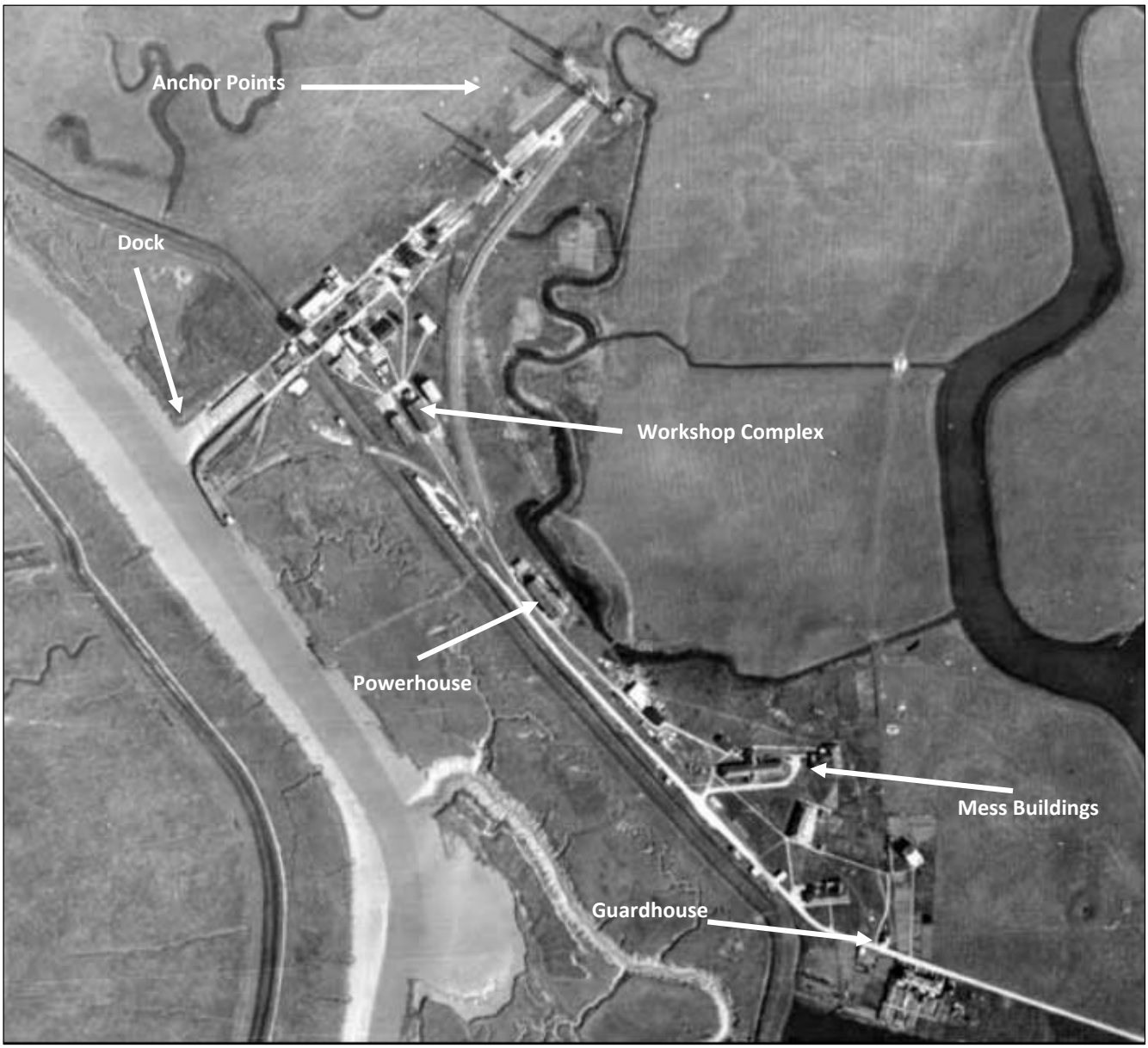
Source: The National Archives, Kew



1946 aerial imagery of the Yantlet firing point main complex, situated approximately 1.5km west of the western endpoint of the study area. Railway firing points (and the rail tracks leading up to them), gun emplacements and gantry paths can all be identified surrounding this image.

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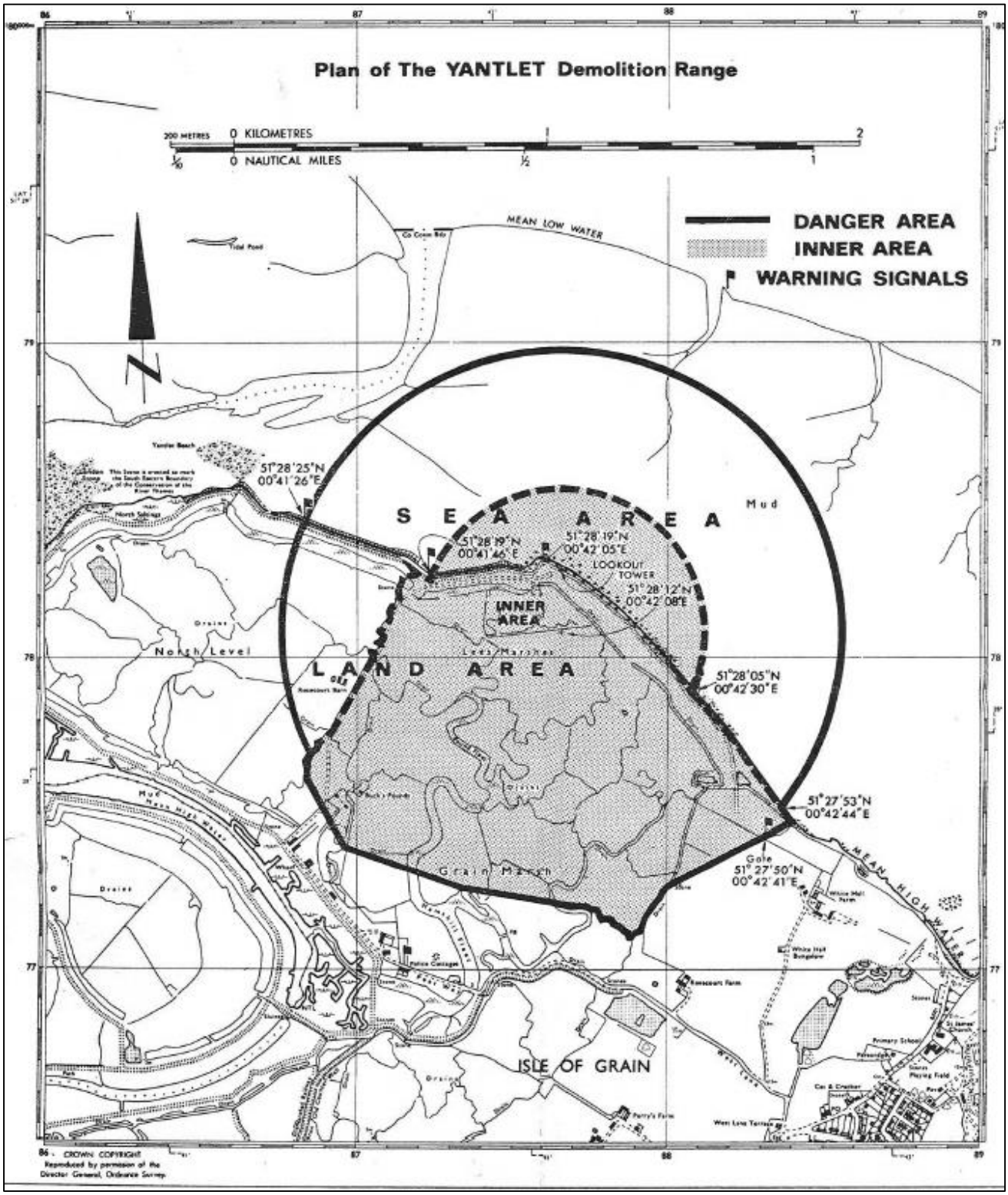
Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)



Post-war mapping showing the inner and outer danger areas of Yantlet Demolition Range.

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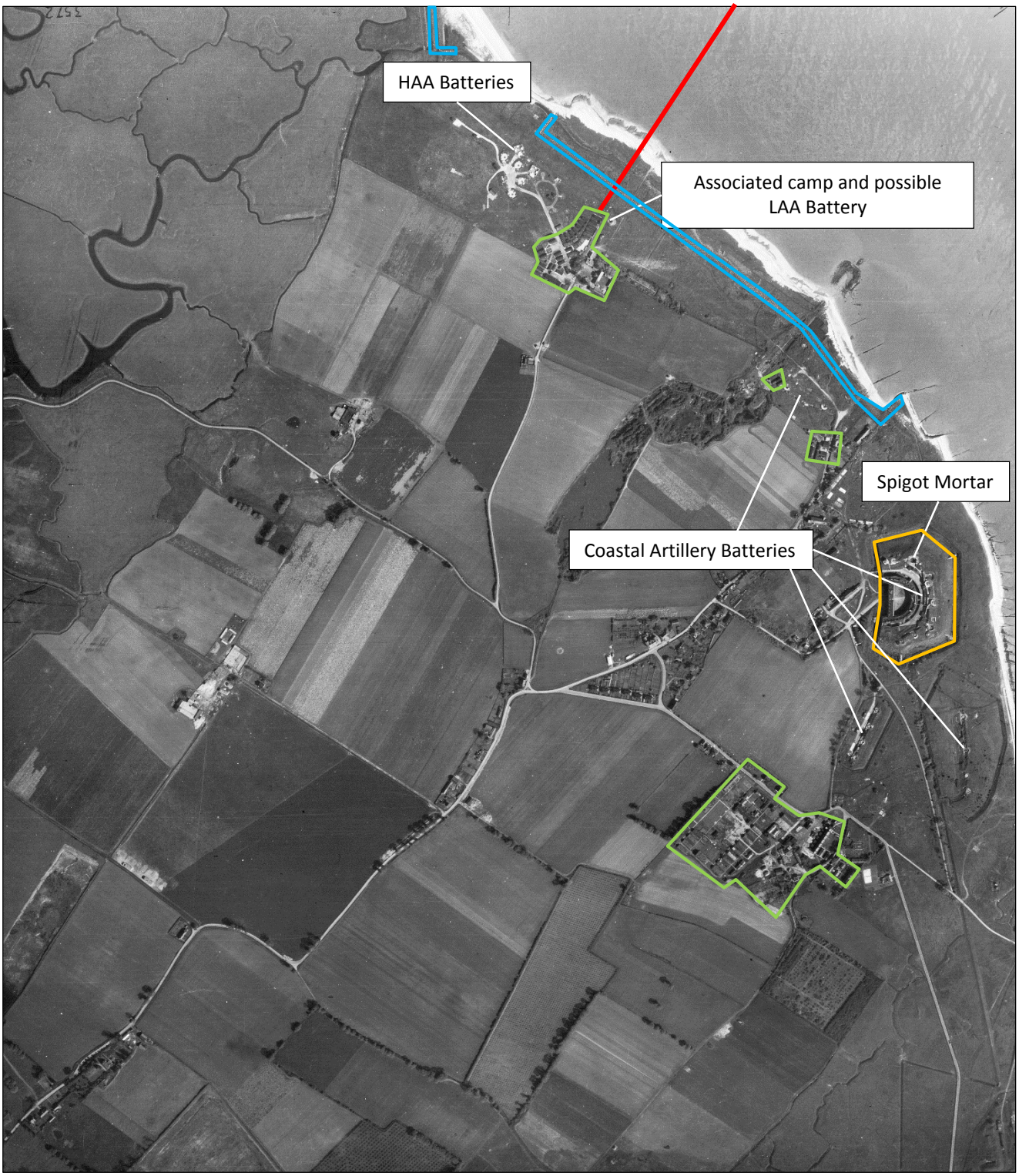
Source: Historic England

N

Isle of Grain Military Features Overlay

Annex: **N1**



Military Structures

Grain Fort

Dragons Teeth (Anti-tank defences)

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Source: National Monuments Record Office (Historic England)

Examples of UXO Found in the Thames Estuary

4” Solid Shot

Anti-Tank Mine

1.5 inch HE Hopkiss

2 Inch Solid Shot

2 X 12mm Solid Shot

Cannonball

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Source: 1st Line Defence

Examples of UXO Found in Thames Estuary

Mills Hand grenade

HE Fuze

20mm Shell Casing

14 Inch Projectile

3 Inch Projectile

Various Items

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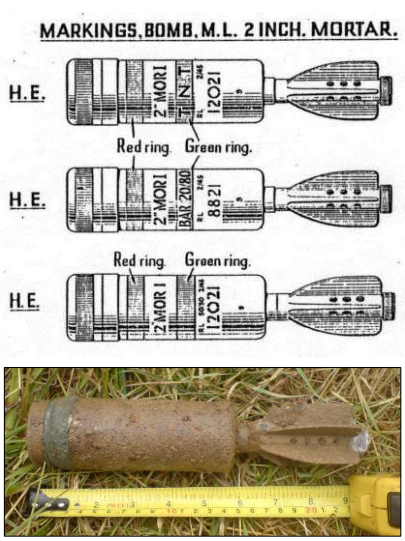
Project:	**HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**
Ref:	**DA2985-01**
Source:	1st Line Defence

Examples of Land Service Ammunition – Mortars

2 inch Mortar High Explosive

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	It had greater range and firepower over hand and rifle grenades, and was used to attack targets behind cover with high explosive rounds.
Identification	HE has a rounded edge to a flat back. Can either be a black body colour with red and yellow band or dark green with yellow band. Brass cap on top. Practice will have hole all the way through the top.



2 inch Mortar Smoke

Weight	910g (2lb)
Maximum Range	460m (500yards)
Filling	White phosphorus and smoke fill
Dimensions	51 x 290mm (2in x 11.4 in)
Fuze Type	An impact fuze which initiates a bursting charge. This ruptures the mortar bomb's body and disperses the phosphorus filler
Identification	Smoke mortars have a recess and emission holes. May still see light green body paint. Look for stained ground around munition.
Use	As a screening devices for unit movement or to impair enemy field of vision.

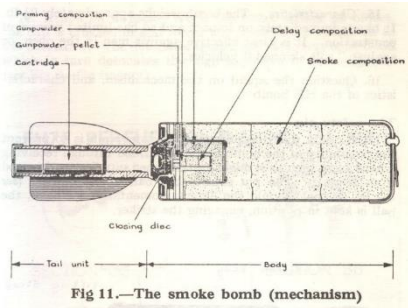
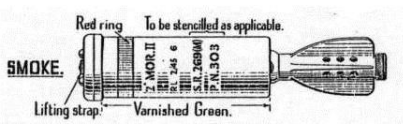
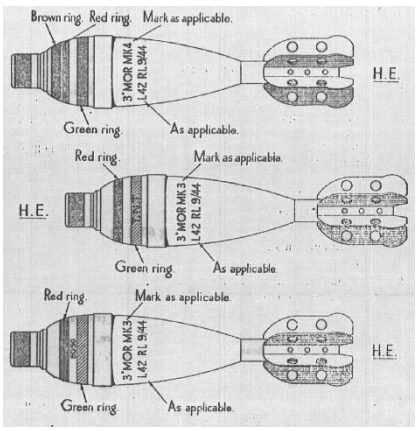


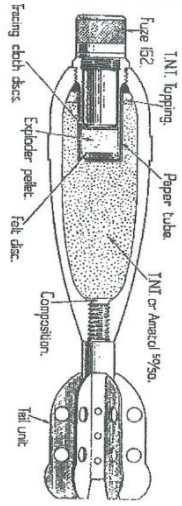
Fig 11.—The smoke bomb (mechanism)



3 inch Mortar High Explosive

Weight	4.5kg (10lb)
Maximum Range	1,460 (Mk1) – 2,560m (Mk2) (1,600 – 2,800yds)
Dimensions	81mm (3in)
Filling	Amatol
Firing Mechanism	Drop, fixed striker
Remarks	Fin-stabilised bomb fired by means of a charge consisting of a primary cartridge in the tail and four secondary cartridges
Identification	An old style mortar. No way of telling if HE or practice so treat as HE





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Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

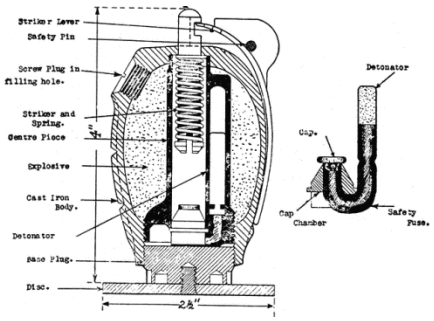
Ref: **DA2985-01**

Source: Various sources

Examples of Land Service Ammunition – Grenades

No. 36 'Mills' Grenade

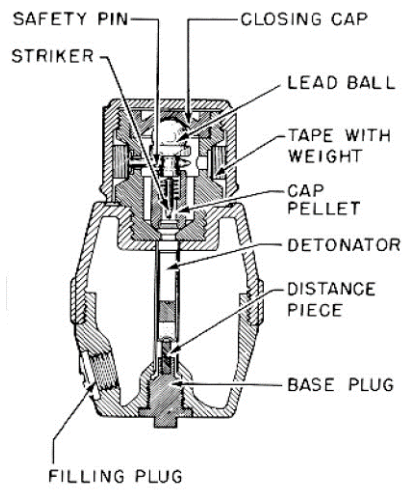
Weight	765g filled (1lb 11.25oz)
Explosive Weight	71g (2oz) filling.
Fuze Type	4-7 second delay hand-throwing fuze. No. 6 Detonator
Dimensions	95 x 61mm (4 x 2.4in)
Use	Fragmentation explosive at approx. 30m range 100m range of damage.
Remarks	First introduced in 1915 its classic grooved, cast-iron 'pineapple' design was designed to provide uniform fragmentation. The detonator is inserted before use after removing the base plug.



Left: baseplate and detonator removed

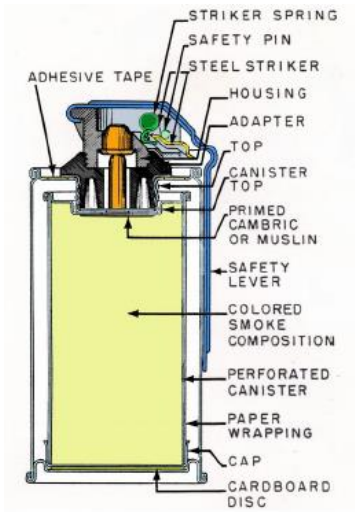
No. 69 Grenade

Weight	383g (13.5oz)
Fill 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	115 x 60mm (4.5 x 2 .4 in)
Use	A blast grenade for use as an offensive weapon. Detonator was inserted before use.
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. 62 x 140mm (2.44 x 5.5 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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Ref: **DA2985-01**

Source: Various sources

Examples of Land Service Ammunition – Projectiles

Examples of Projectiles

From left to right: a 6 pounder 8 cwt; 3 pdr 2 cwt; 2 pdr No. 2; 6 pdr 7 cwt.

Ordnance QF 2-Pounder Gun

Total weight	Between 1.86lb and 2.69lb
Calibre	40 mm (1.575 in)
Remarks	British anti-tank and vehicle mounted gun, used early in WWII.

Firing practise against beach obstacles in 1942

Ordnance QF 3-Pounder Gun

Total weight	3lb 4oz
Calibre	47-millimetre (1.85 in)
Remarks	British tank gun based on earlier naval gun, mounted on Vickers Medium Tanks in the 1920s and 1930s

Vickers Medium Mk II (special) tank

Ordnance QF 6-Pounder Gun

Total weight	Between 6lb 4 oz and 7lb 2oz
Calibre	2.24 in (57 mm)
Remarks	Primarily an anti-tank gun incorporated subsequently on a number of armoured fighting vehicles. First tank to go into action armed with the 6 pounder gun, was the Mark III version of the Churchill tank, in the Dieppe Raid of August 1942.

6-pounder platoon

Ordnance QF 20-Pounder Gun

Total weight	20lb
Calibre	84 millimetres (3.31 in)
Remarks	British tank gun introduced in 1948 and used the Centurion main battle tank, Charioteer medium tank, and Caernarvon Mark II heavy tank.

British Centurion Mk.3

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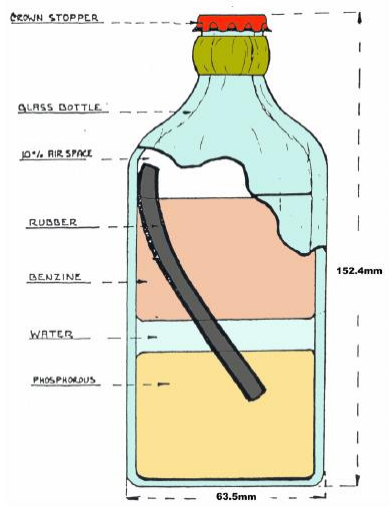
Source: Various sources

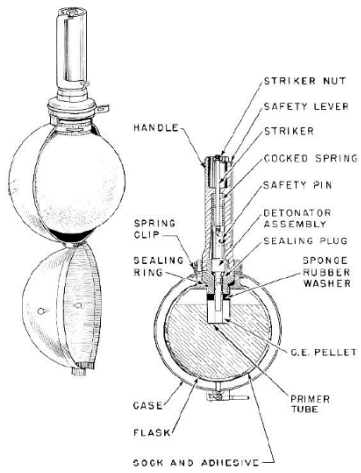
No. 76 Self Igniting Phosphorous (SIP) Grenade

Weight	1lb 3oz
Filling	White Phosphorous and Benzene
Design	The filling was contained in a ½ 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 and encountered post-war. In all cases, the grenades are still found to be dangerous.



No. 74 Grenade ("Sticky Bomb") Mk1

Weight	Approx. 1.1kg (2.25lb)
Filling	Approx. 600g Nobel's No.283 (Nitro-glycerine) (1.33lb)
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	Timer fuze was located in the handle. This would explode after 3-6 secs. 9.5in Long 4.5in Diameter



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.

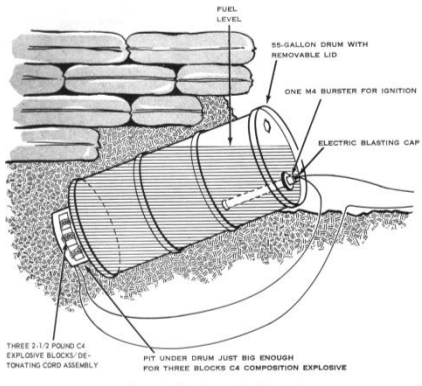


Figure 22. Flame fougasse (55-gallon drum).

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Ref: **DA2985-01**

Source: Various sources

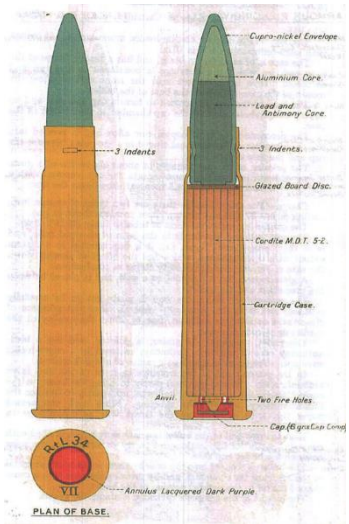
Examples of Small Arms Ammunition

Examples of British Small Arms Ammunition

.303 Rifle

Bullet Diameter	7.92mm
Case length	56.44mm
Overall length	78.11mm
Type	Rifle Ammunition
Propellant	Originally black powder. Later Cordite followed by Nitrocellulose
Remarks	First produced in 1889 and still in use today, the .303inch cartridge has progressed through ten 'marks' which eventually extended to a total of around 26 variations.

Bullet Type	Colour of tip	Colour of Annulus
Armour Piercing	Green	Green
Ball	None	Purple
Incendiary	Blue	Blue
Observing	Black	Black
Proof	None	Yellow
Tracer Short Range	White	Red
Tracer Dark Ignition	Grey	Red
Tracer Long Range	Red	Red



Buried and Decayed Ammunition

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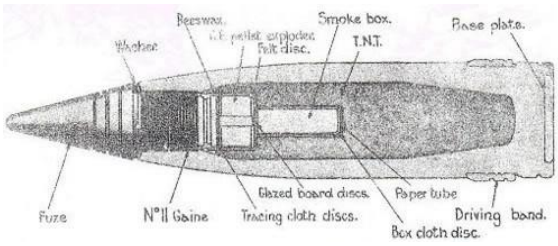
Source: Various sources

Examples of Anti-Aircraft Projectiles

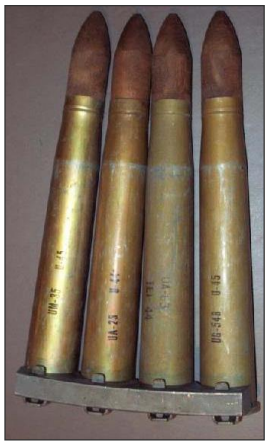
3.7 Inch QF Anti-Aircraft Projectile

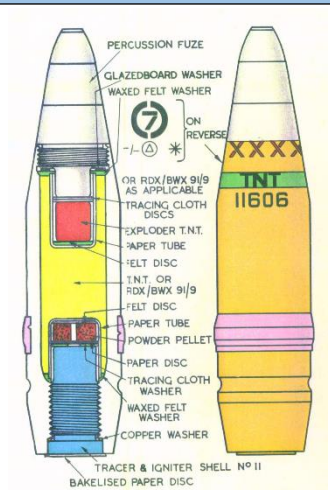
Projectile Weight	28lb (12.6 kg)
Explosive Weight	2.52lbs
Fuze Type	Mechanical Time Fuze
Dimensions	3.7in x 14.7in (94mm x 360mm)
Rate of Fire	10 to 20 rounds per minute
Use	The 3.7in AA Mks 1-3 were the standard Heavy Anti-Aircraft guns of the British Army.
Ceiling	30,000ft to 59,000ft



40mm Bofors Projectile

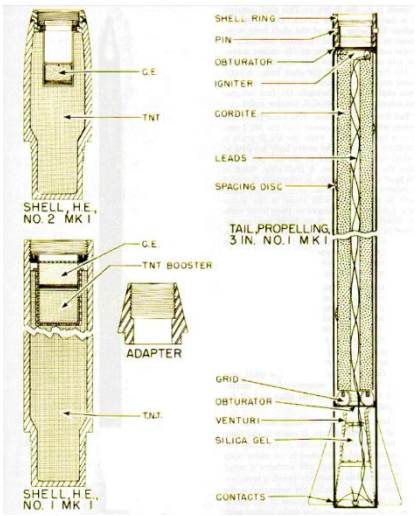
Projectile Weight	1.96lb (0.86kg)
Explosive Weight	300g (0.6lb)
Fuze Type	Impact Fuze
Rate of Fire	120 rounds per minute
Projectile Dimensions	40 x 180mm
Ceiling	23,000ft (7000m)
Remarks	Light quick fire high explosive anti-aircraft projectile. Each projectile fitted with small tracer element. If no target hit, shell would explode when tracer burnt out. Designed to engage aircraft flying below 2,000ft





3in Unrotated Projectile (UP) Anti-Aircraft Rocket ("Z" Battery)

HE Projectile Weight	3.4kg (7.6lb)
Explosive Weight	0.96kg (2.13lb)
Filling	High Explosive – TNT. Fitted with aerial burst fuzing
Dimensions of projectile	236 x 83mm (9.29 x 3.25in)
Remarks	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. Shell consists of a steel cylinder reduced in diameter at the base and threaded externally to screw into the shell ring of the rocket motor



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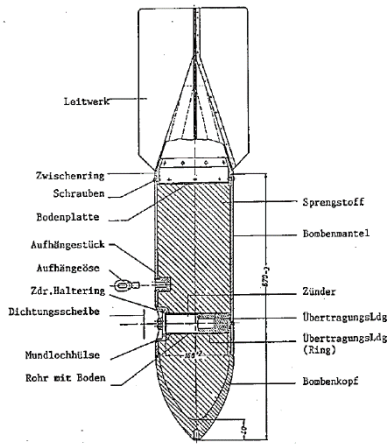
Source: Various sources

Examples of German Air-Delivered Ordnance

Annex: R1

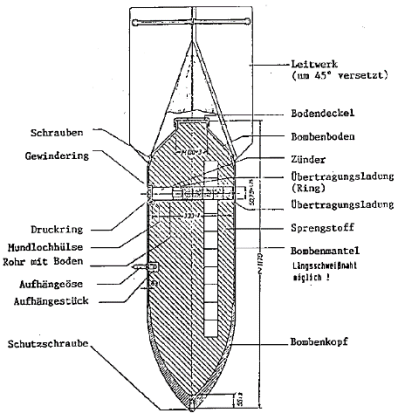
SC 50kg High Explosive Bomb

Bomb Weight	40-54kg (88-119lb)
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 High Explosive Bomb

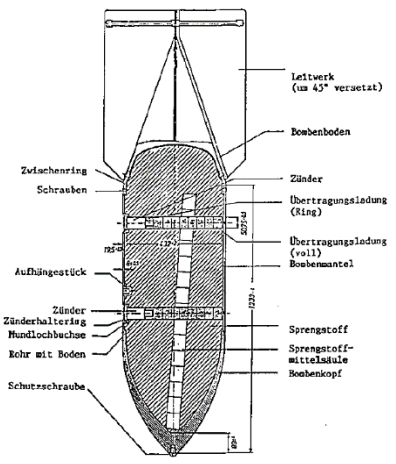
Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground 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).

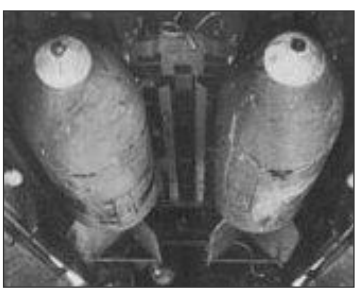


SC250 bomb being loaded onto German bomber

SC 500kg High Explosive Bomb

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 Trialen filling have cylindrical paper wrapped pellets 1-15/16 in. in length and diameter forming





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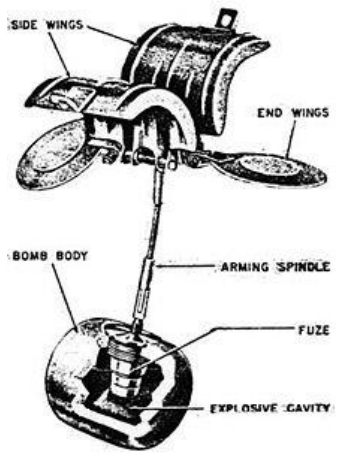
Source: Various sources

Examples of German Air-Delivered Ordnance

Annex: R2

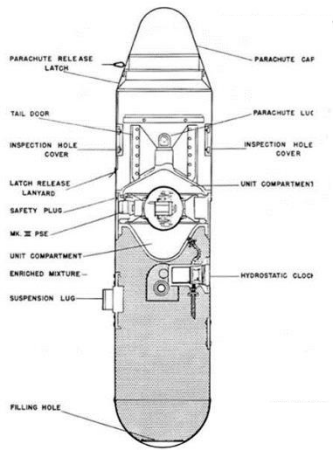
SD2 Anti-Personnel 'Butterfly Bomb'

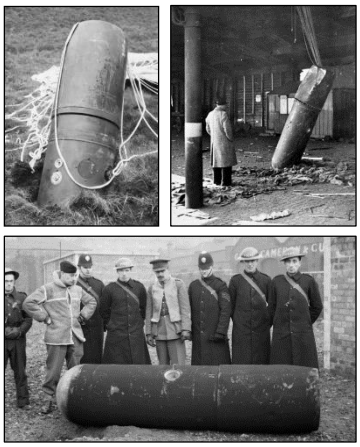
Bomb Weight	2kg (4.41lb)
Explosive Weight	7.5oz (225 grams) of Amatol surrounded by a layer of bituminous composition.
Fuze Type	41 fuze (time) , 67 fuze (clockwork time delay) or 70 fuze (anti-handling device)
Body Diameter	3in (7.62 cm) diameter, 3.1in (7.874) long
Use	Designed as an anti-personnel/ fragmentation weapon. They were delivered by air, being dropped in containers of 23-144 sub-munitions that opened at a predetermined height, thus scattering the bombs.
Remarks	Very rare. First used against Ipswich in 1940, but were also dropped on Kingston upon Hull, Grimsby and Cleethorpes in June 1943, amongst various other targets in UK. As the bombs fell the outer case flicked open by springs which caused four light metal drogues with a protruding 5 inch steel cable to deploy in the form of a parachute & wind vane which armed the device as it span.



Parachute Mine (Luftmine B / LMB)

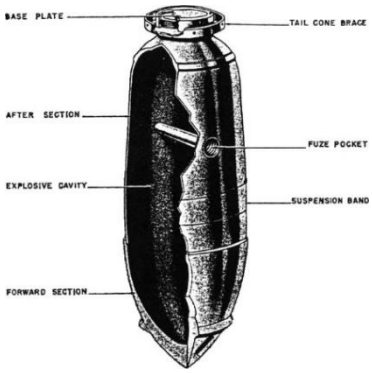
Bomb Weight	Approx. 990kg (2176lb)
Explosive Weight	Approx. 705kg (1,554lb)
Fuze Type	Impact/ Time delay / hydrostatic pressure fuze
Dimensions	2.64m x 0.64m (3.04m with parachute housing)
Use	Against civilian, military and industrial targets. Used as blast bombs and designed to detonate above ground level to maximise damage to a wider area.
Remarks	Deployed a parachute when dropped in order to control its descent. Had the potential to destroy a whole street of housing in a 100m radius.





SC 1000kg

Bomb Weight	993-1027kg (2,189-2,264lb)
Explosive Weight	530-620kg (1168-1367lb)
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 (110 x 25.8in)
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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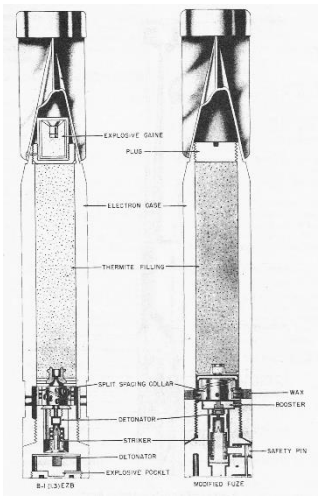
Source: Various sources

German Incendiary Bombs

Annex: R3

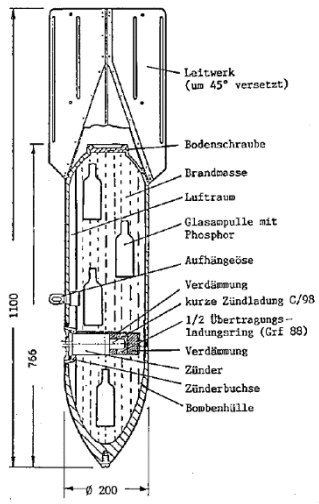
1kg Incendiary Bomb

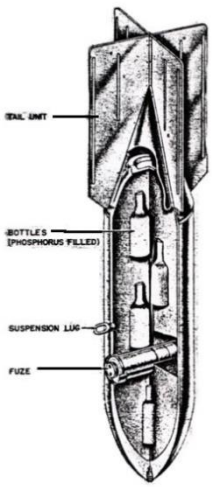
Bomb Weight	1.0 and 1.3kg (2.2 and 2.9lb)
Explosive Weight	680g (1.3lb) Thermite 8-15gm Explosive Nitropenta
Fuze Type	Impact fuze
Bomb Dimensions	350 x 50mm (13.8 x 1.97in)
Body Diameter	50mm (1.97in)
Use	As incendiary – dropped in clusters against towns and industrial complexes
Remarks	Magnesium alloy 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

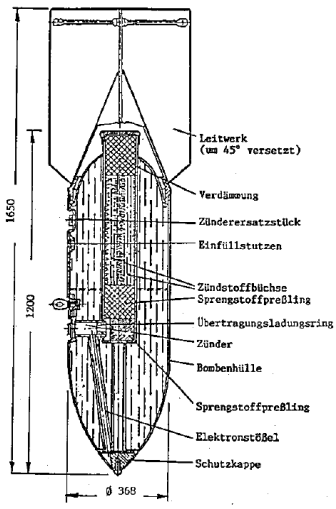
Bomb Weight	c41kg (90.4lb)
Explosive Weight	0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against all targets where an incendiary effect is required
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 ground troops, against troop barracks and industrial installations. Thin casing – not designed for ground penetration



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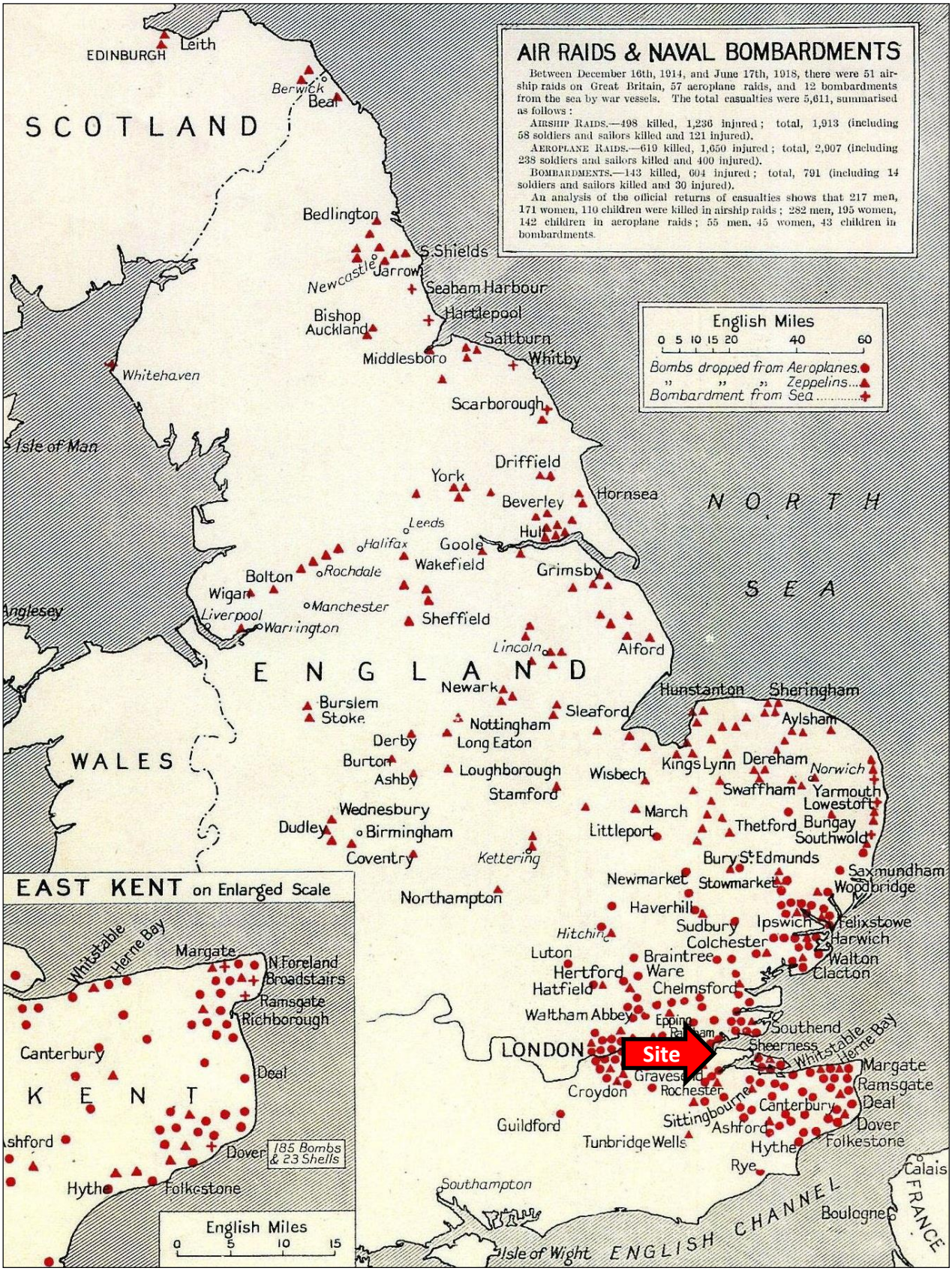
Source: Various sources

WWI Map of Air Raids and Naval Bombardments

Annex: S



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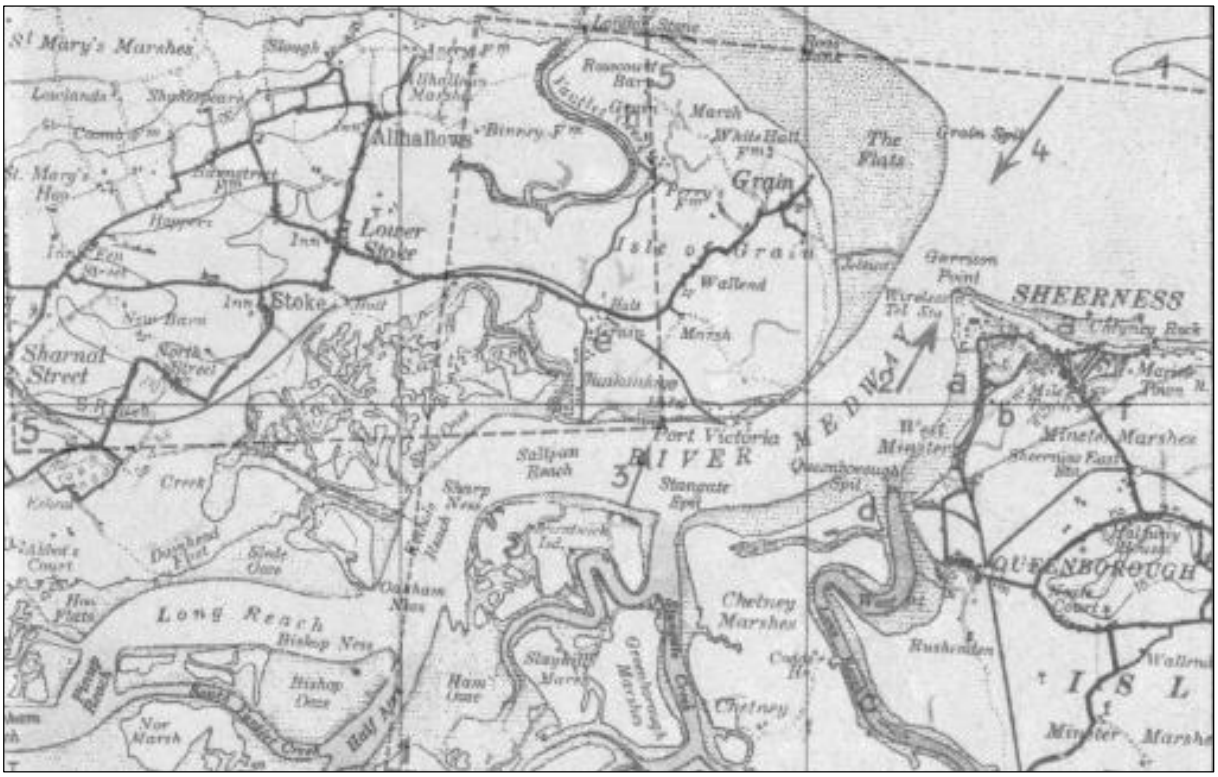
Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 245 020

Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

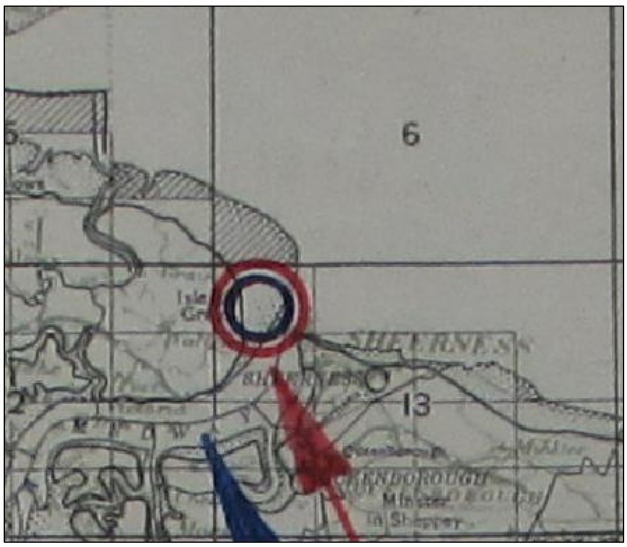
Source: J. Morris, *German Air Raids on Britain*



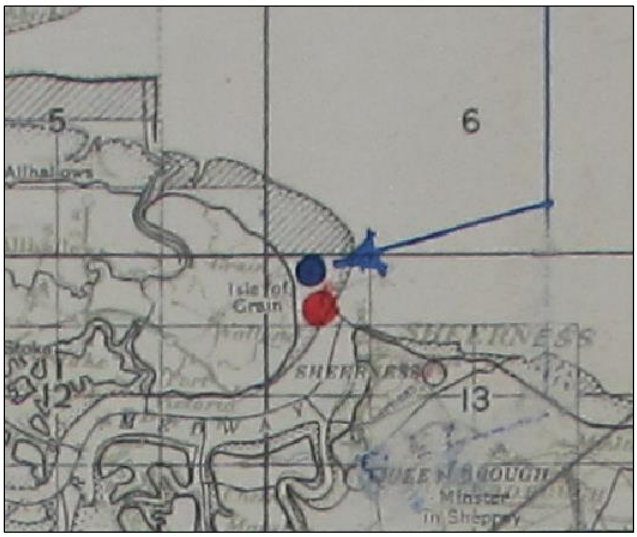
Luftwaffe aerial photograph of Pembroke Dock, a) b) c) d) e) f) g) h)

Kent ARP Daily Bomb Mapping

Annex: **U1**

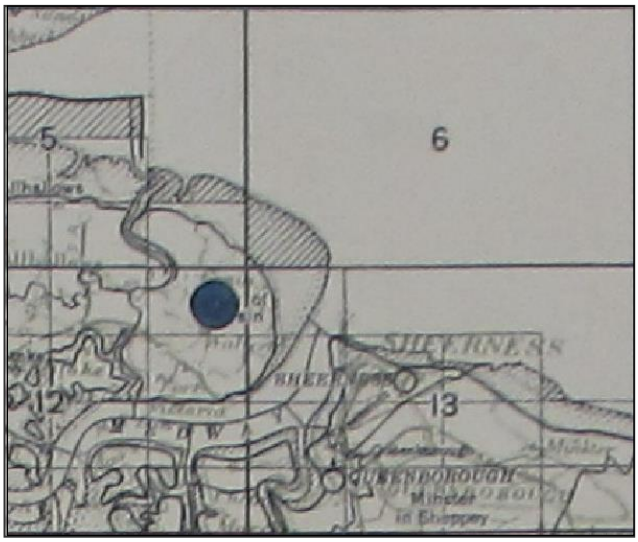


11th July 1940



10th August 1940

30th August 1940



11th September 1940

Incendiary Bomb H.E Bomb German Plane

1ST LINE DEFENCE

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

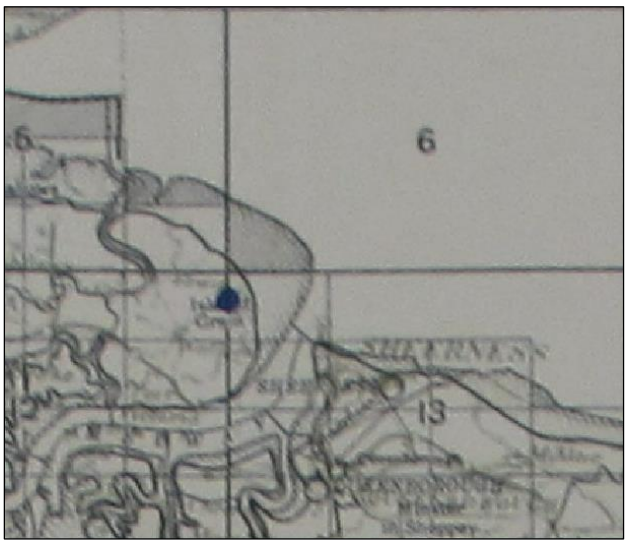
Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

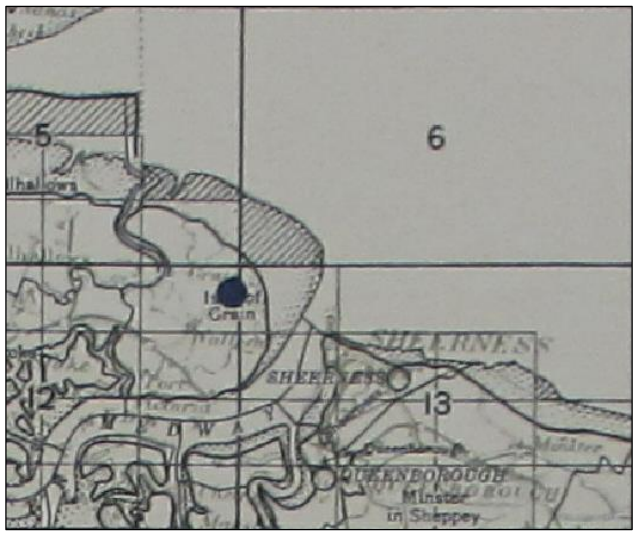
N

Ref: **DA2985-01**

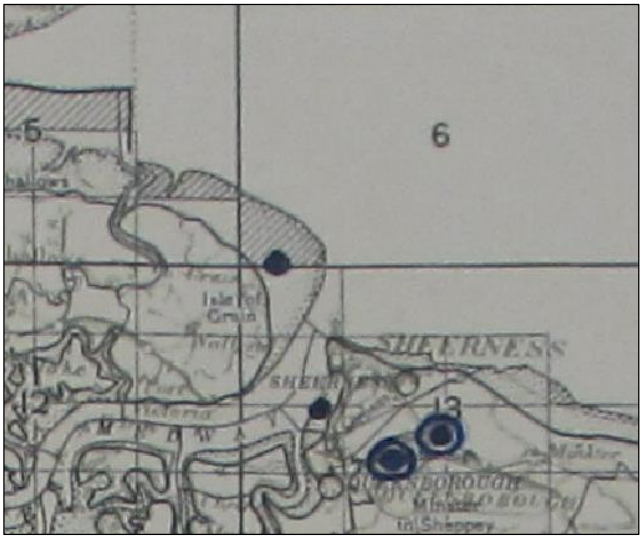
Source: Kent Archives



7th October 1940



17th October 1940



18th October 1940

17th November 1940

Incendiary Bomb

H.E Bomb

1ST LINE DEFENCE

Unit 3, Maple Park
Essex Road, Hoddesdon,
Hertfordshire. EN11 0EX
Email: info@1stlinedefence.co.uk
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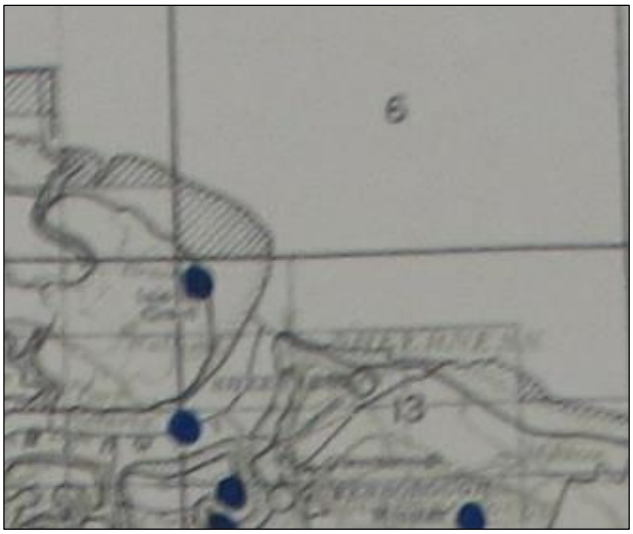
Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

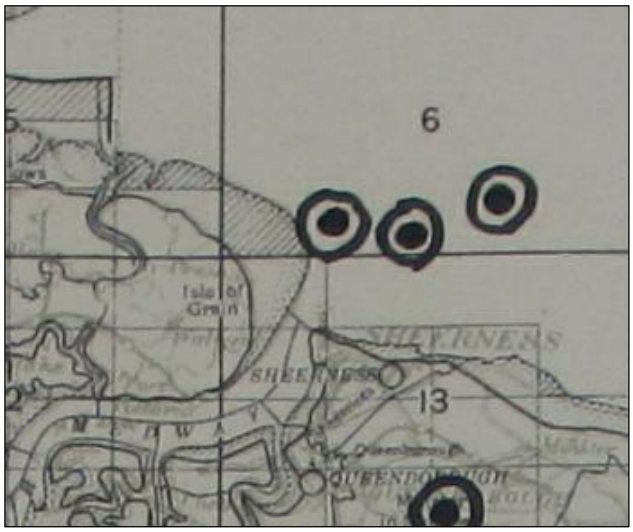
N

Ref: **DA2985-01**

Source: Kent Archives

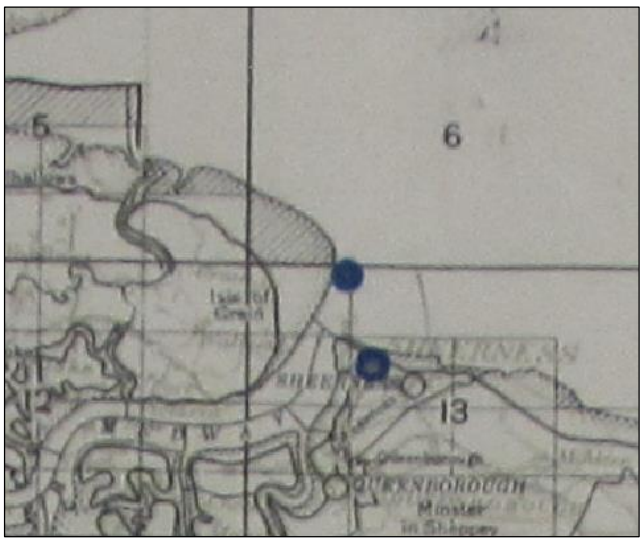


27th November 1940



13th December 1940

19th April 1941



1st June 1941

Incendiary Bomb H.E Bomb Parachute Mine

1ST LINE DEFENCE

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

Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: Kent Archives

RAF Aerial Photography 28th August 1942

Annex: **V1**

1ST LINE DEFENCE

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

Client: **Intertek**

Approximate study area

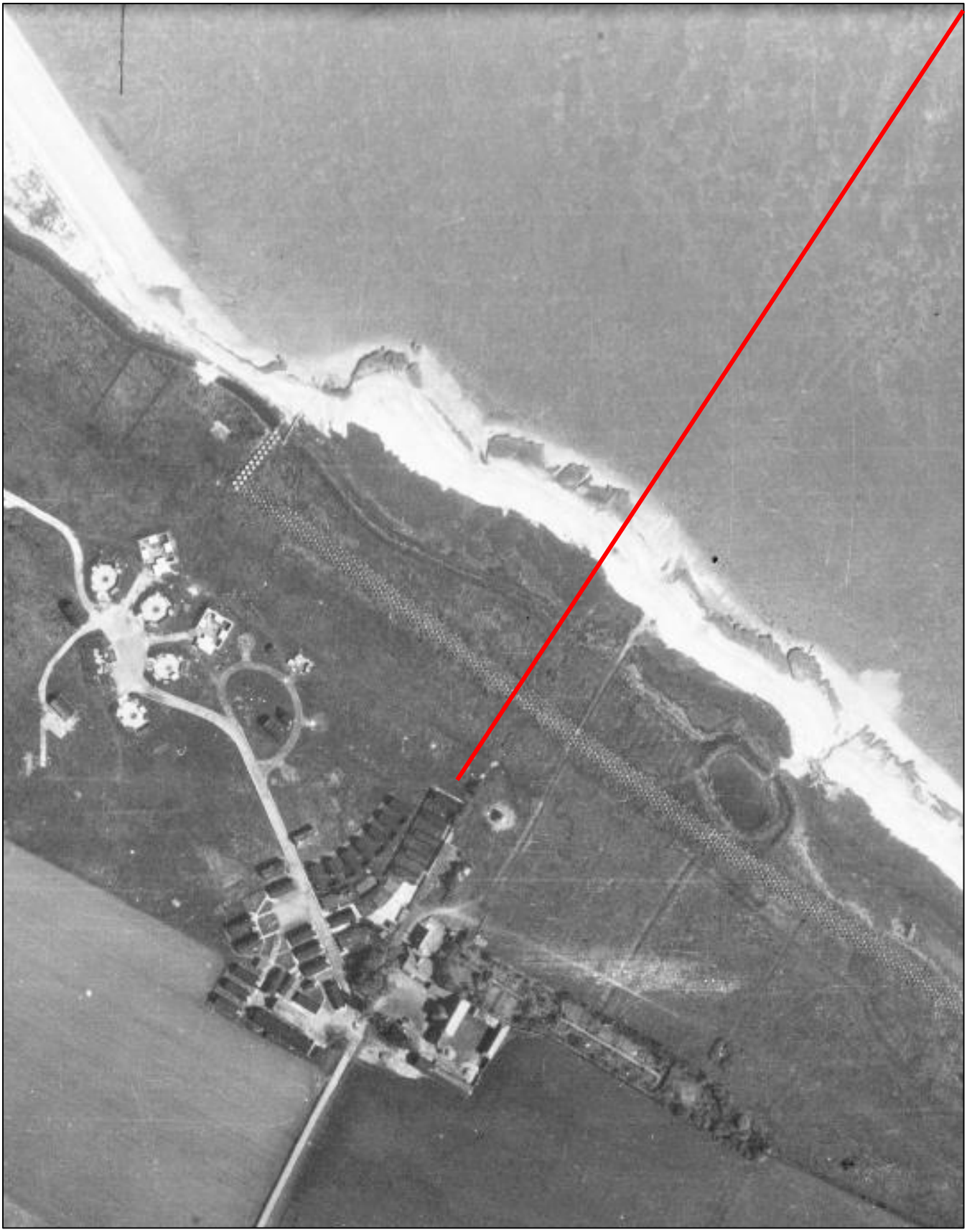
Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

RAF Aerial Photography 1st May 1946

Annex: **V2**



1ST LINE DEFENCE

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

Client: **Intertek**

Approximate study area

N

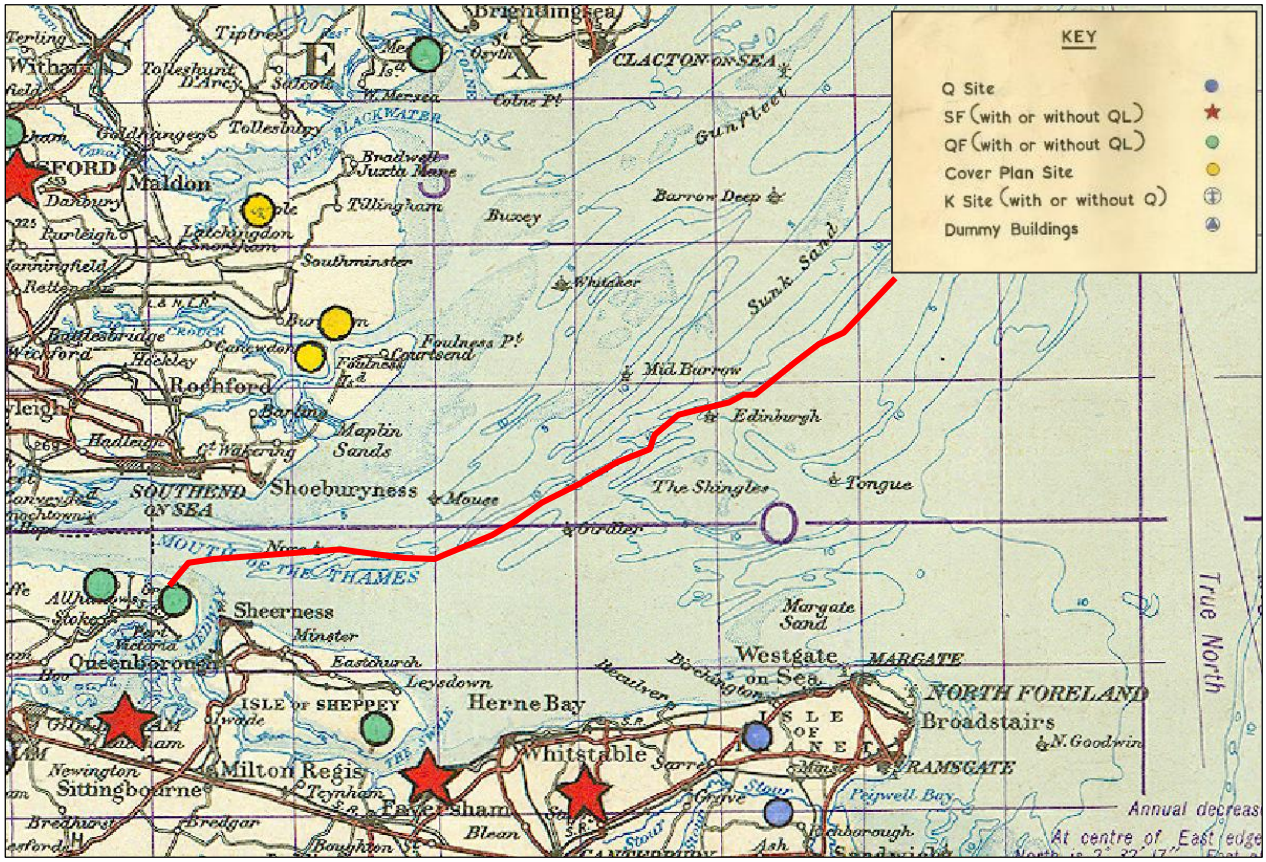
Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

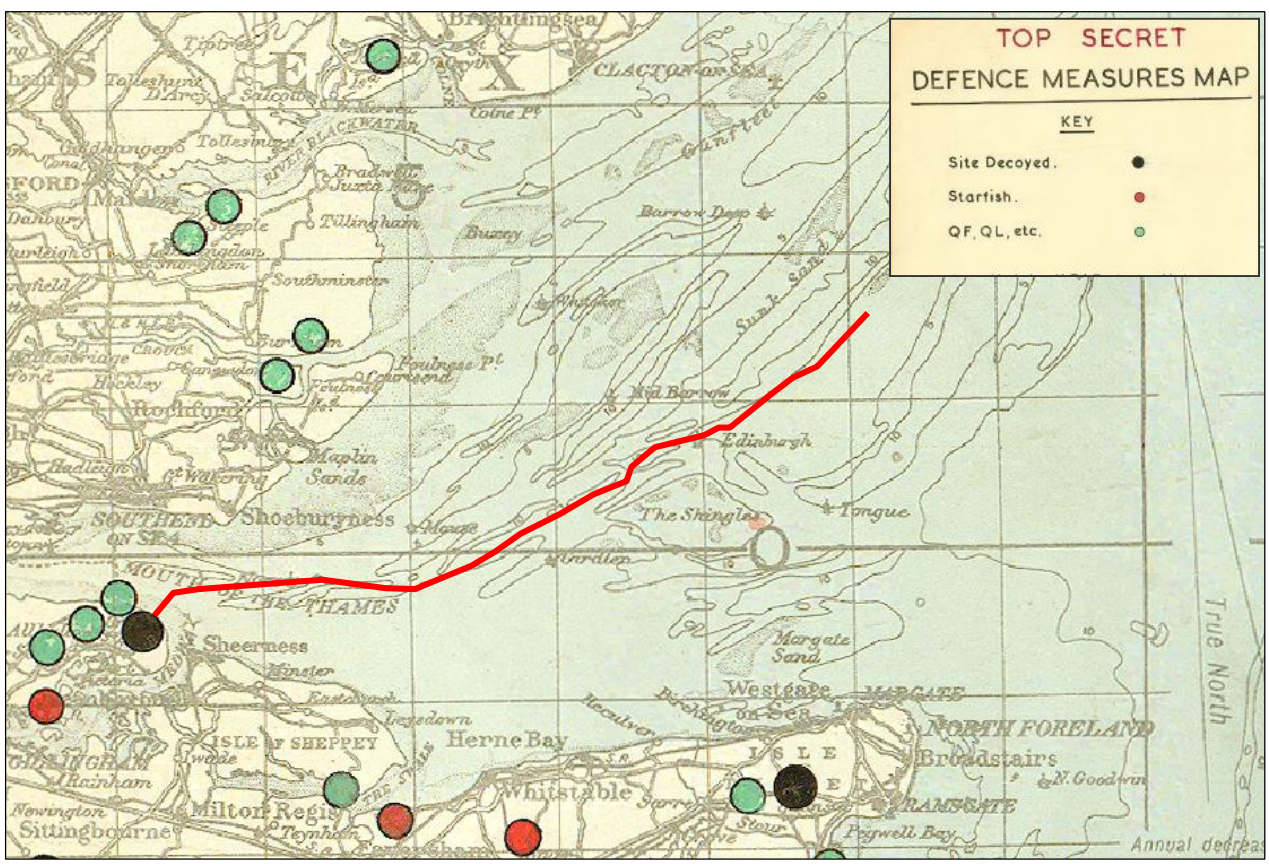
Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

Decoy Site Mapping

Annex: **W**





1ST LINE DEFENCE

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

Client: **Intertek**

Approximate study area

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

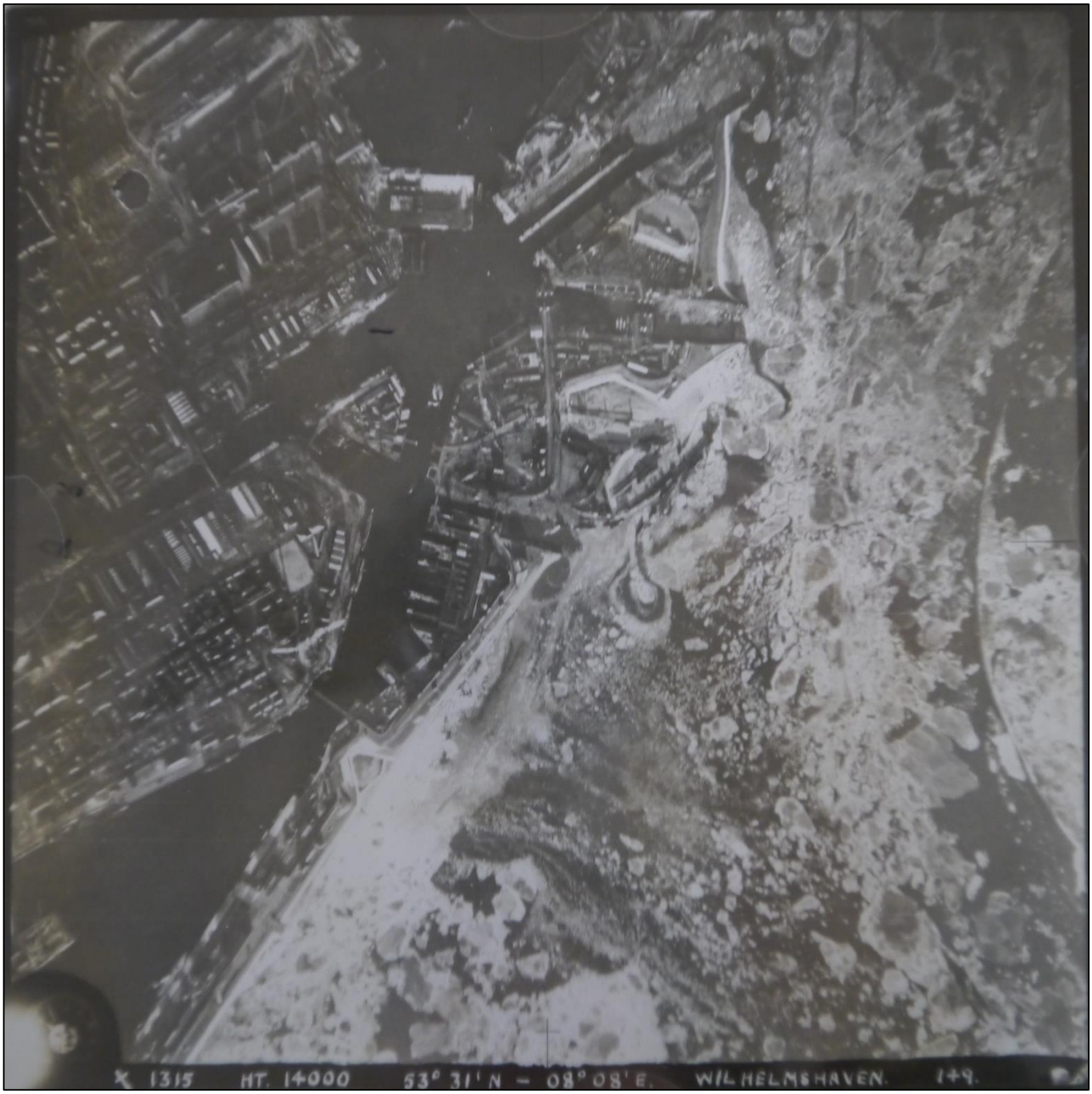
N

Ref: **DA2985-01**

Source: The National Archives, Kew

Allied Target/Reconnaissance Photography of Wilhelmshaven

Annex: **X1**



1ST LINE DEFENCE

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

Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: The National Archives, Kew

Allied Target/Reconnaissance Photography of Wilhelmshaven

Annex: **X2**

1ST LINE DEFENCE

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

Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

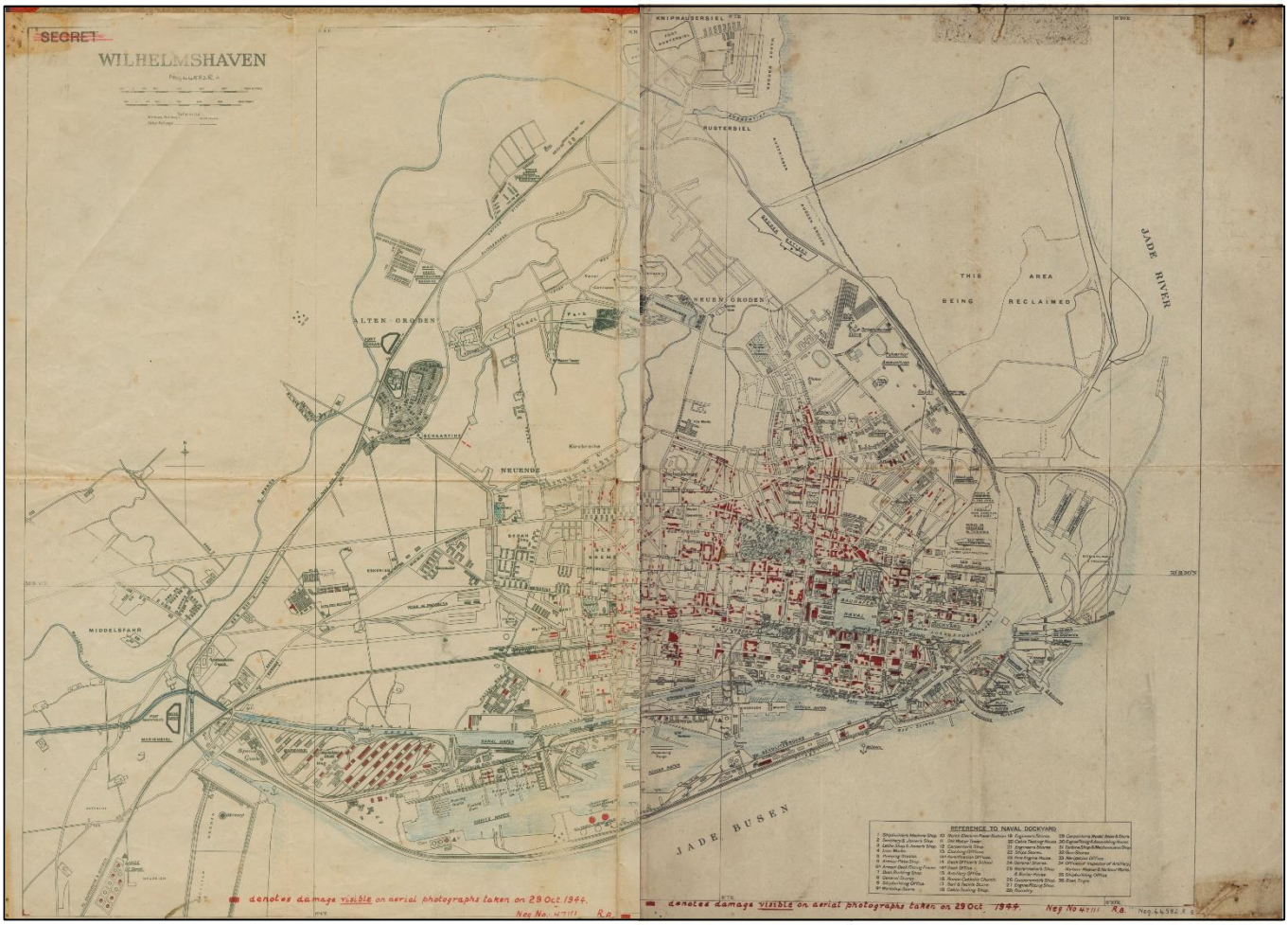
N

Ref: **DA2985-01**

Source: The National Archives, Kew

Damage Mapping - Allied Bombing of Wilhelmshaven

Annex: Y



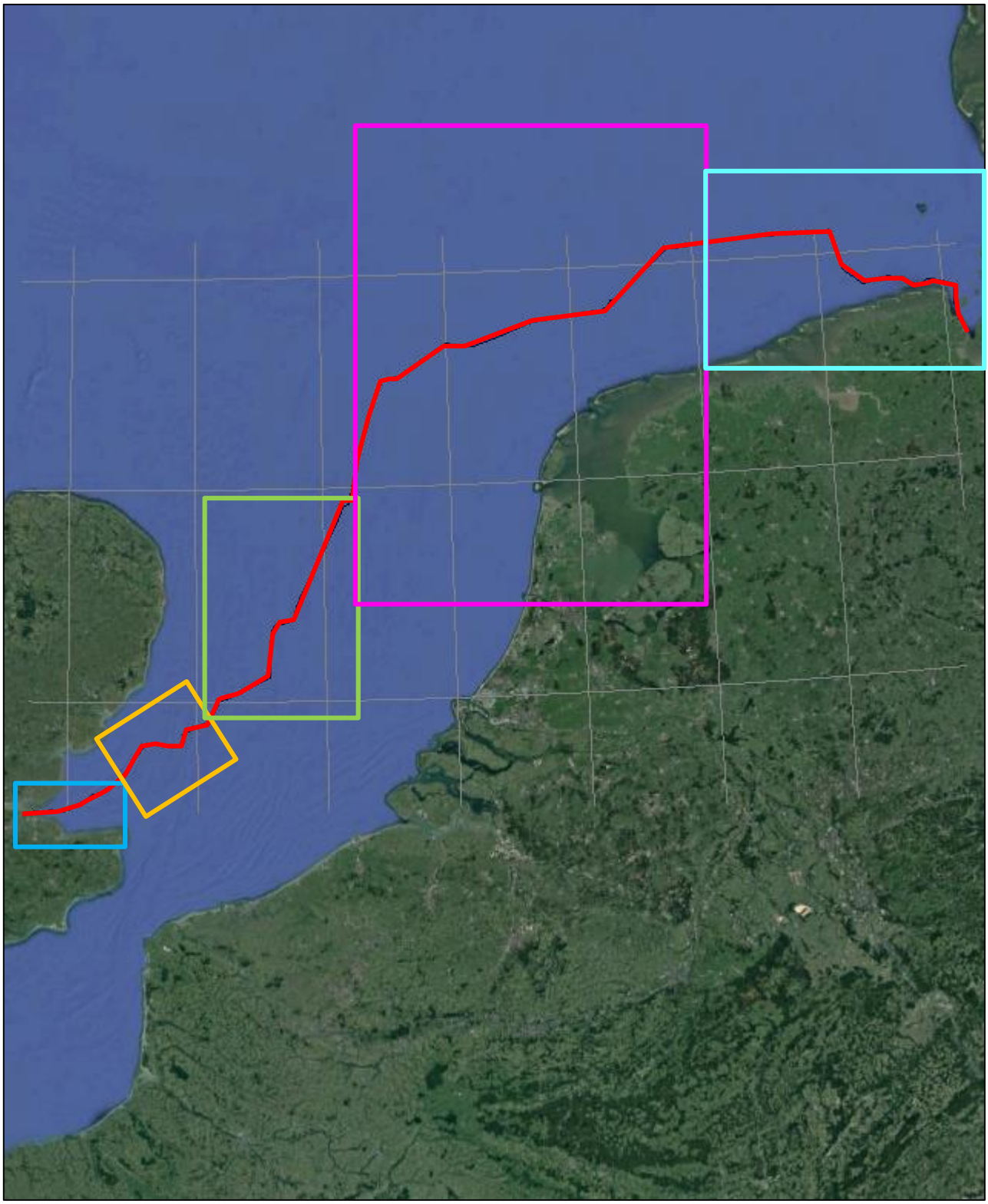
1ST LINE DEFENCE

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

Client:	**Intertek**
Project:	**HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**
Ref:	**DA2985-01**
Source:	The City of Wilhelmshaven Archives

OSPAR Munition Encounters

Annex: **Z1**



1ST LINE DEFENCE

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

Client: **Intertek**

Approximate study area

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

N

Ref: **DA2985-01**

Source: Wrecksite.eu

OSPAR Munition Encounters

Annex: **Z2**

Key:

Conventional

Unknown

1ST LINE DEFENCE

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

Client: **Intertek**

Approximate study area

N

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Wrecksite.eu

OSPAR Munition Encounters

Annex: **Z3**

Key:

Conventional

Unknown

1ST LINE DEFENCE

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

Client: **Intertek**

Approximate study area

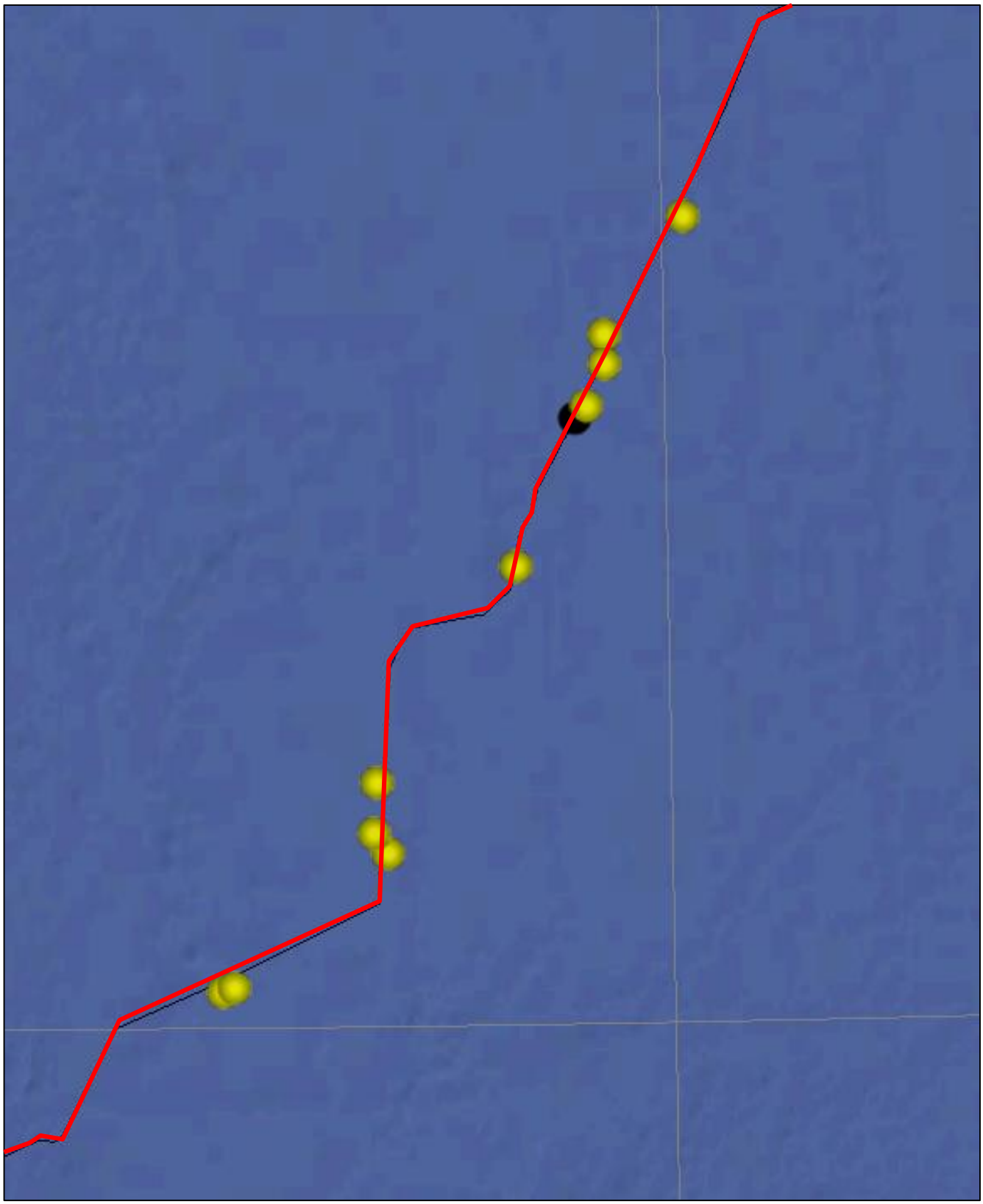
Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Wrecksite.eu

OSPAR Munition Encounters

Annex: **Z4**



Key:

Conventional

Unknown

Approximate study area

N

1ST LINE DEFENCE

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

Client: **Intertek**

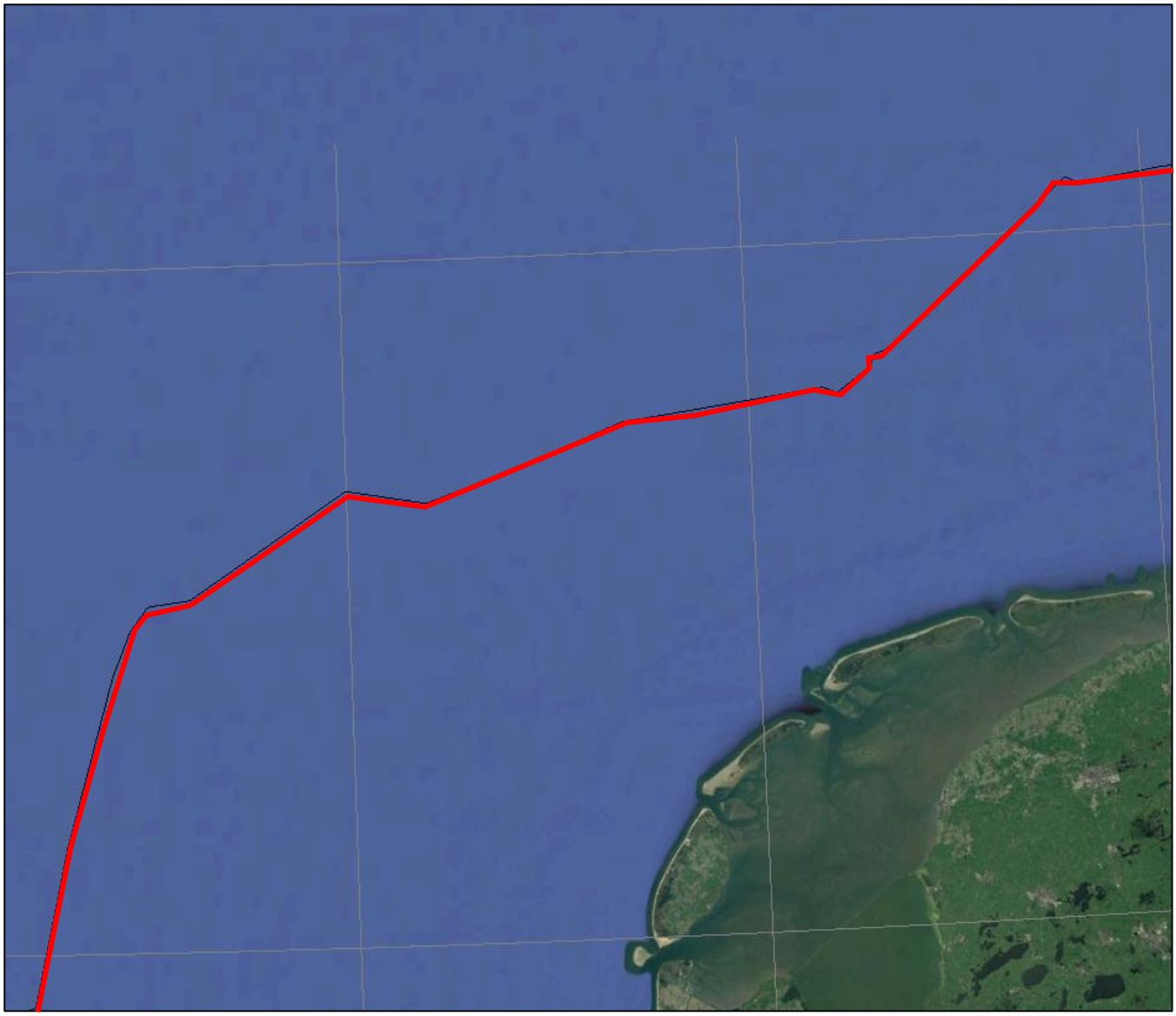
Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Wrecksite.eu

OSPAR Munition Encounters

Annex: Z5



Key:

Conventional

Unknown

1ST LINE DEFENCE

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

Client: **Intertek**

Approximate study area

N

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Wrecksite.eu

Key:

Conventional

Unknown

1ST LINE DEFENCE

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

Client: **Intertek**

Approximate study area

N

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA2985-01**

Source: Wrecksite.eu

OSPAR Encounters with Dumped Conventional Munitions							
Ref	**Lat/Long**	**Distance**	**Nature of find**	**Date**	**Action taken**	**State of munitions**	**Remarks**
503	51.58-0.785	On route	Other	May 25, 2004	Disposed of on land	Heavily corroded	None
2119	51.481 -0.816	On route	Entanglement in nets	July 13, 2006	Destroyed	Partly corroded	Cylindrical float smoke
2753	51.46-0.8405	>0.75km	Entanglement in nets	April 8, 2011	Destroyed	Partly corroded	None
1340	52.033 -2.333	>1.1km	Entanglement in nets	Nov 7, 2006	Unknown	Unknown	None
1082	52.034 -2.339	>1.1km	Entanglement in nets	Nov 6 2006	Unknown	Unknown	None
2760	52.158 -2.58	>0.8km	Entanglement in nets	May 14, 2009	Unknown	Unknown	None
2717	52.176 -2.559	>0.8km	Entanglement in nets	Feb 24, 2009	Unknown	Unknown	None
2819	52.221 -2.564	>0.7km	Entanglement in nets	Oct 28,2009	Unknown	Unknown	None
1091	52.416 -2.775	On Route	Entanglement in nets	Nov 23, 2006	Unknown	Unknown	Smoke float Mk5,
2366	52.55-2.866	>0.1km	Entanglement in nets	Sep 2, 2008	Detonated by EODU	Unknown	Unexploded mine trawled by fishing vessel.
1940	52.55-2.866	>0.1km	Entanglement in nets	Sep 3, 2008	Collected by EODU and destroyed	Unknown	Unexploded naval shell
458	52.598 -2.911	>0.4km	Entanglement in nets	Nov 29, 2005	Destroyed	Unknown	None
922	52.625 -2.912	>0.9km	Entanglement in nets	April 24, 2006	Destroyed	Unknown	None
218365	52.783 -3.068	>0.5km	Entanglement in nets	Sep 14, 2010	Released at sea	Unknown	icked and dropped by FV Morgenster. Marked with Sonar buoy. Explosive o 31 on Dutch chart. 70*25cm with 1 detonator

OSPAR Encounters with Dumped Conventional Munitions							
Ref	**Lat/Long**	**Distance**	**Nature of find**	**Date**	**Action taken**	**State of munitions**	**Remarks**
1593	53.816 -7.8	>0.3km	Found on Shore	April 17, 2007	Disposed of on land	Heavily Corroded	None
1979	53.816 -7.91	>2.5km	Found on Shore	26 Nov, 2007	Disposed of on land	Heavily Corroded	None
2753	53.816 -7.91	>2.5km	Found on Shore	Jan 1, 2006	Disposed of on land	Heavily Corroded	None
2003	53.816 -7.91	>2.5km	Found on Shore	Jan 1, 2006	Disposed of on land	Heavily Corroded	None
2004	53.816 -7.91	>2.5km	Found on Shore	Jan 1, 2007	Disposed of on land	Heavily Corroded	None
2005	53.816 -7.91	>2.5km	Found on Shore	Jan 1, 2008	Disposed of on land	Heavily Corroded	None
1965	53.816 -7.91	>2.5km	Found on Shore	15 April, 2007	Disposed of on land	Heavily Corroded	None
2593[1]	53.616 -8.129	>3km	Dredging	Aug 31, 2009	Disposed of on land	Partly Corroded	None

[1] This munitions encounter is one of approximately 60 munitions encounters recorded at this grid reference.

1ST LINE DEFENCE
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EN11 0EX
Tel: 01992 245020

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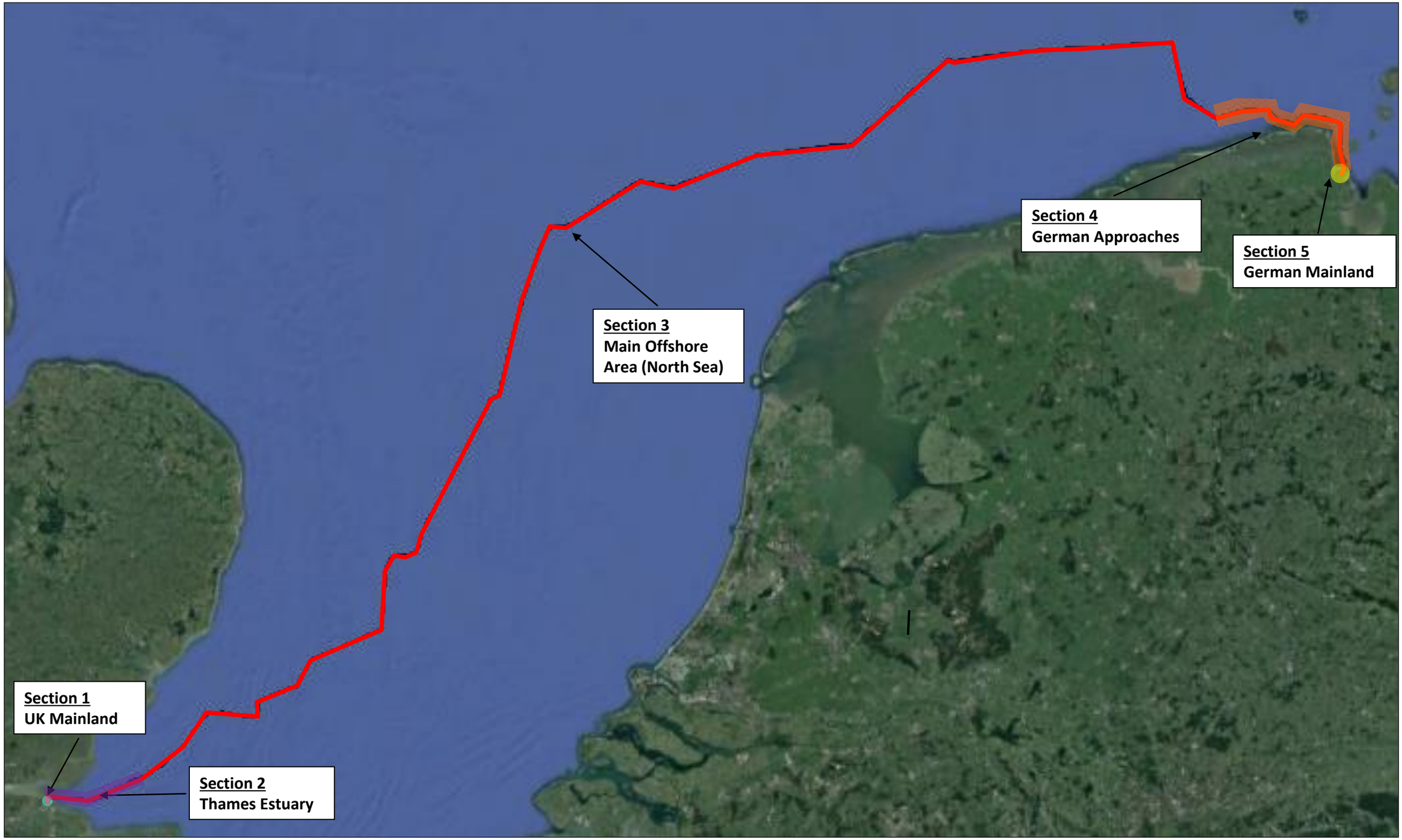
1ST LINE DEFENCE

Sections of the Study Area

Appendix: i



1ST LINE DEFENCE

Unit 3, Maple Park
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Email: info@1stlinedefence.co.uk
Tel: +44 (0)1992 446 974

Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA6316-01**

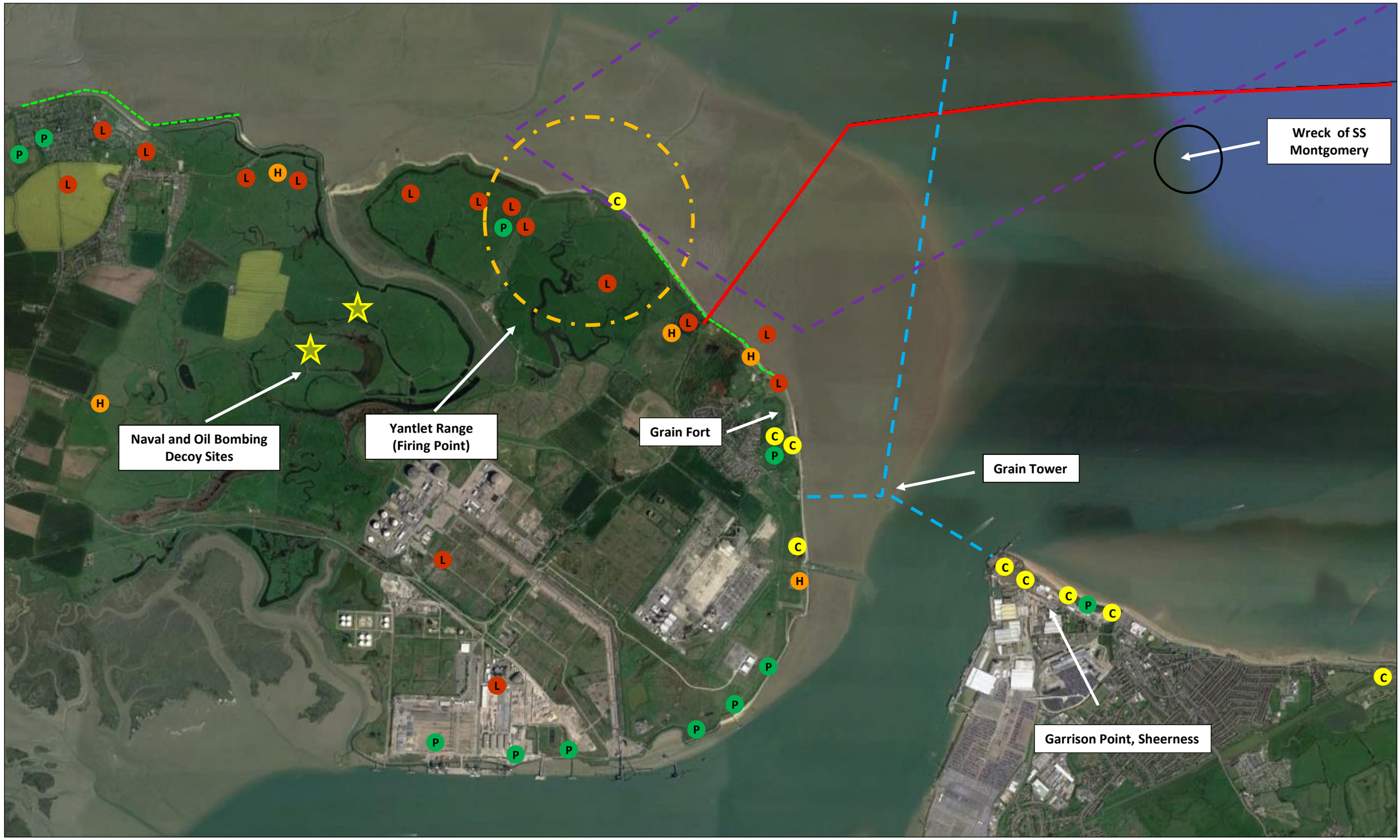
Approximate study area

N

Source: 1st Line Defence

Overlay of Significant UXO Features - UK Mainland (Hoo Peninsula)

Appendix: ii



H Heavy Anti-Air Battery

L Light Anti-Aircraft Battery

P Pillbox

C Coastal Artillery Gun

Extents of:

- Yantlet Demolition Range
- Yantlet Range
- Boom Defence
- Anti-Tank Lines
- **Approximate study area**

N

1ST LINE DEFENCE

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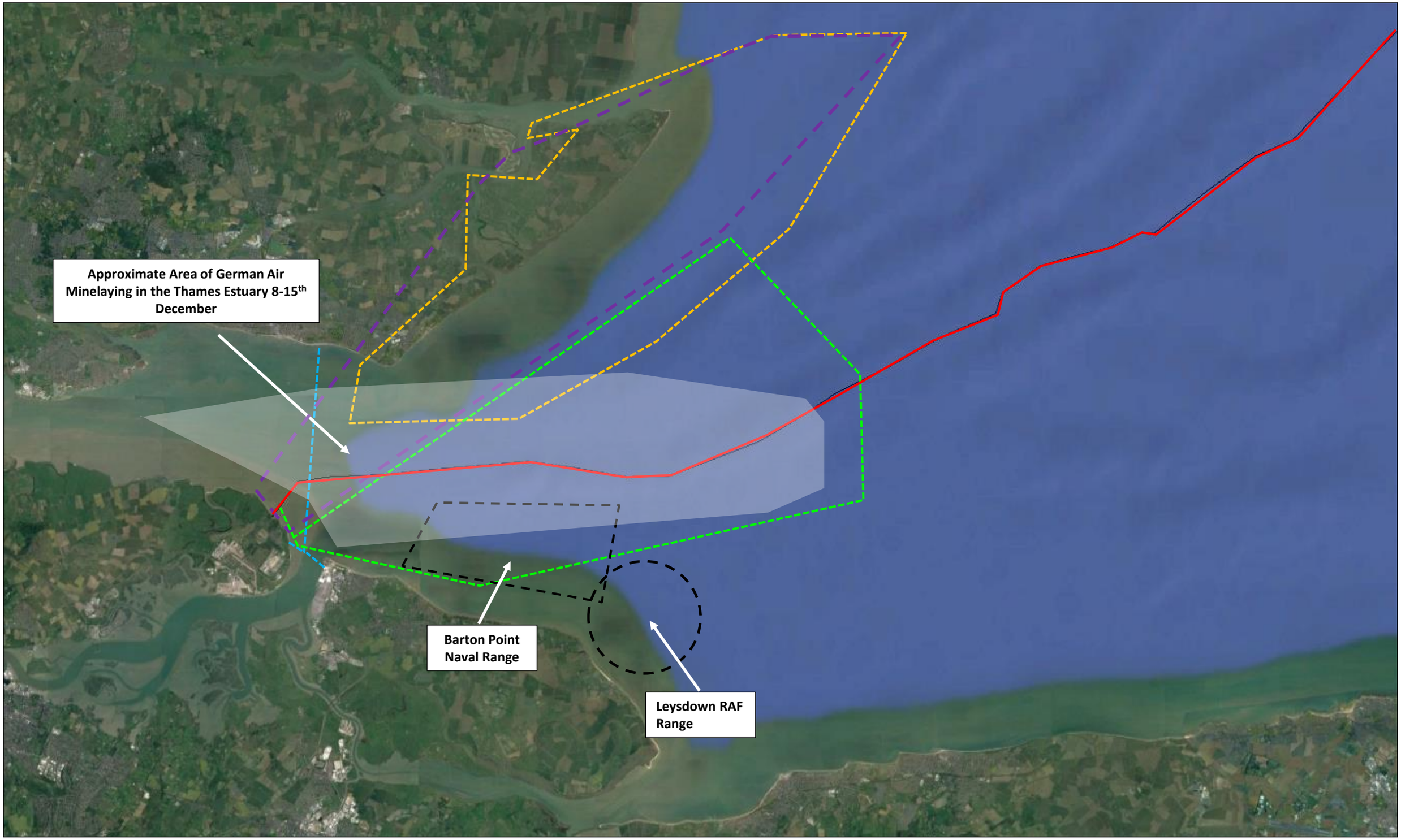
Ref: **DA6316-01**

Source: 1st Line Defence

Overlay of Significant UXO Features - Thames Estuary

Appendix: iii



Extents of:

Yantlet Range | Shoeburyness Range | Grain and Sheerness Range | Boom Defence

1ST LINE DEFENCE

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Ref: **DA6316-01**

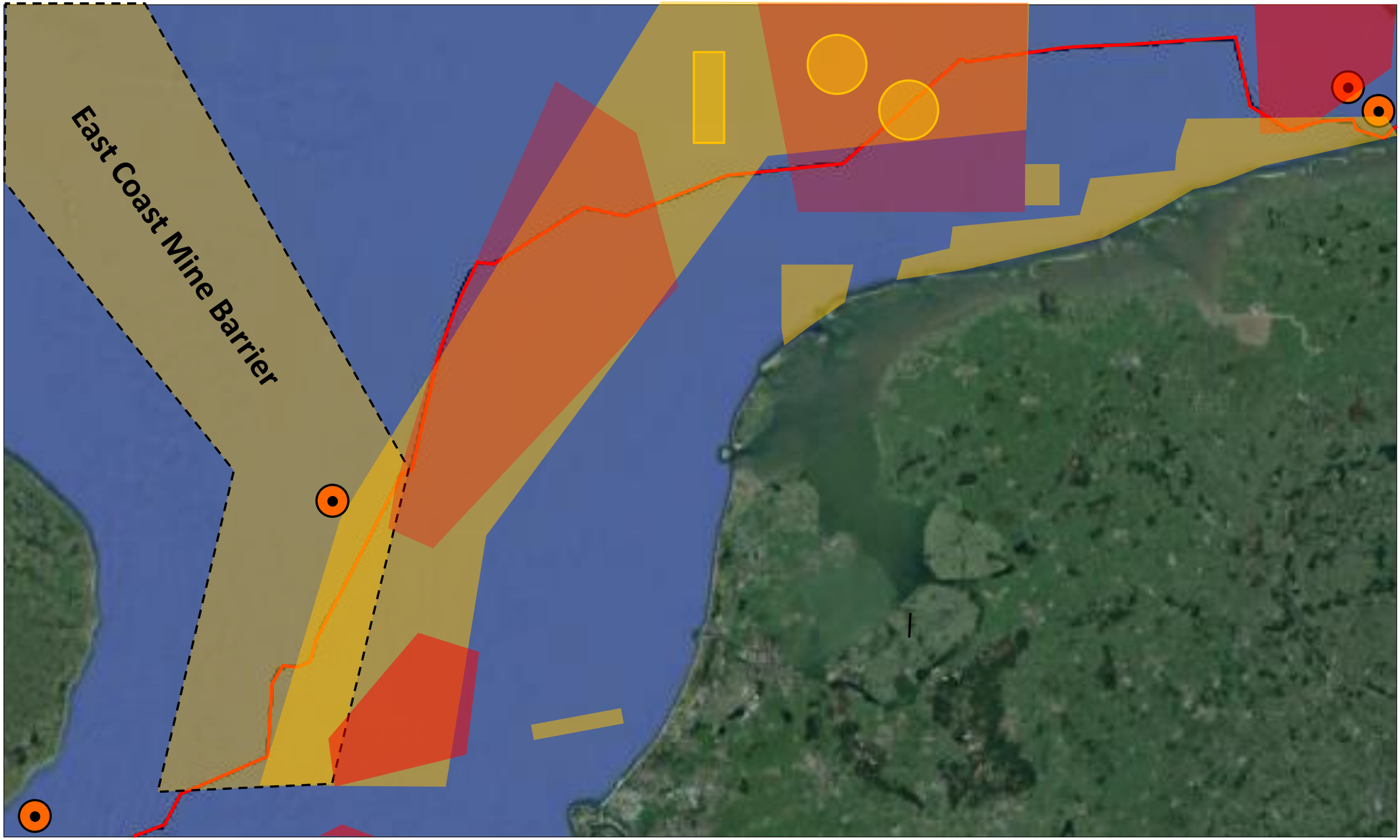
Approximate study area

N

Source: 1st Line Defence

Overlay of Significant UXO Features - Main Offshore Area

Appendix: iv



WWII-British Mine Area

WWII-German Mine Area

Conventional Munitions Dumpsites

Approximate study area

N

1ST LINE DEFENCE

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Tel: +44 (0)1992 446 974

Client: **Intertek**

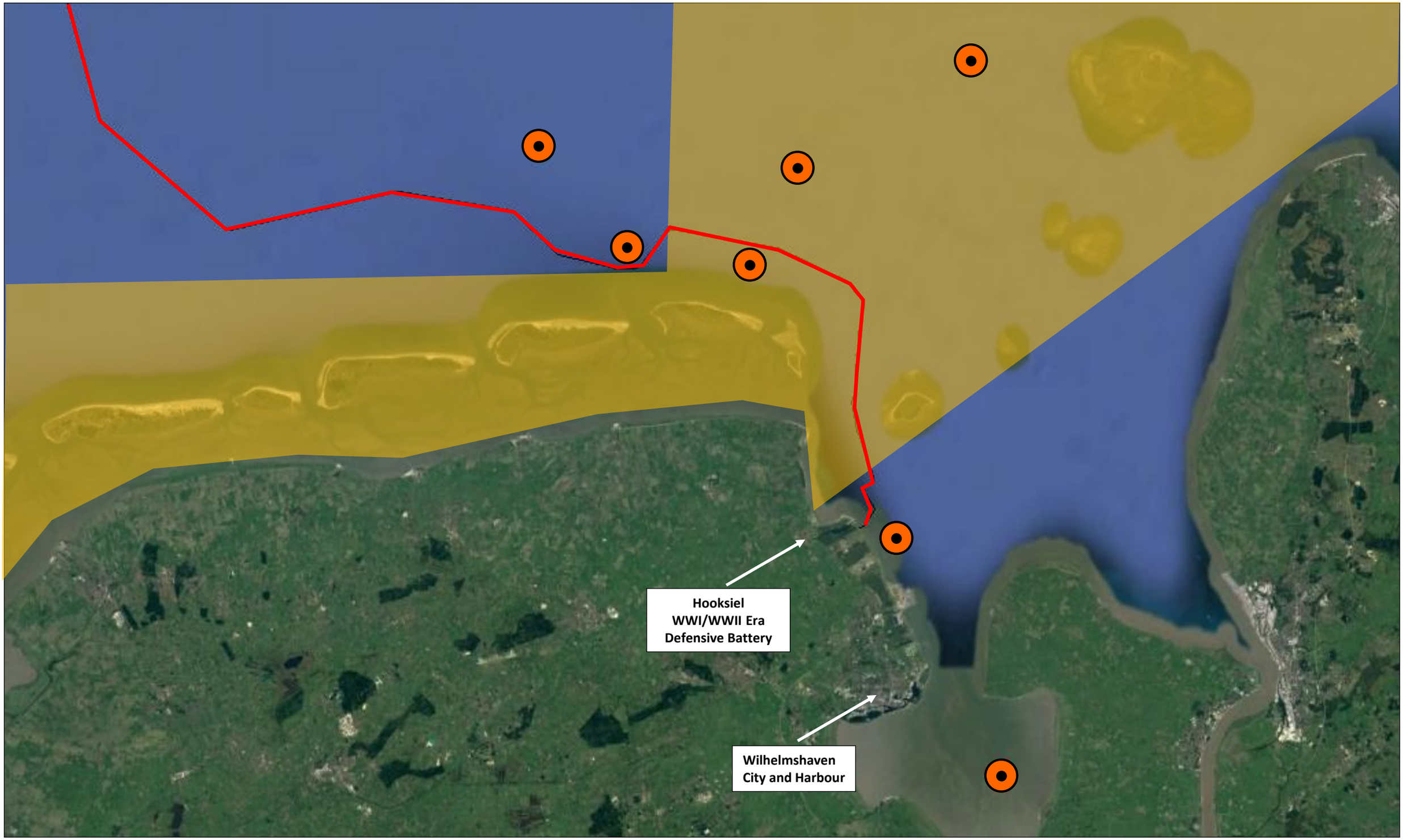
Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA6316-01**

Source: 1st Line Defence

Overlay of Significant UXO Features - German Approaches/German Mainland

Appendix: v



WWII-British Mine Area

Conventional Munitions Dumpsites

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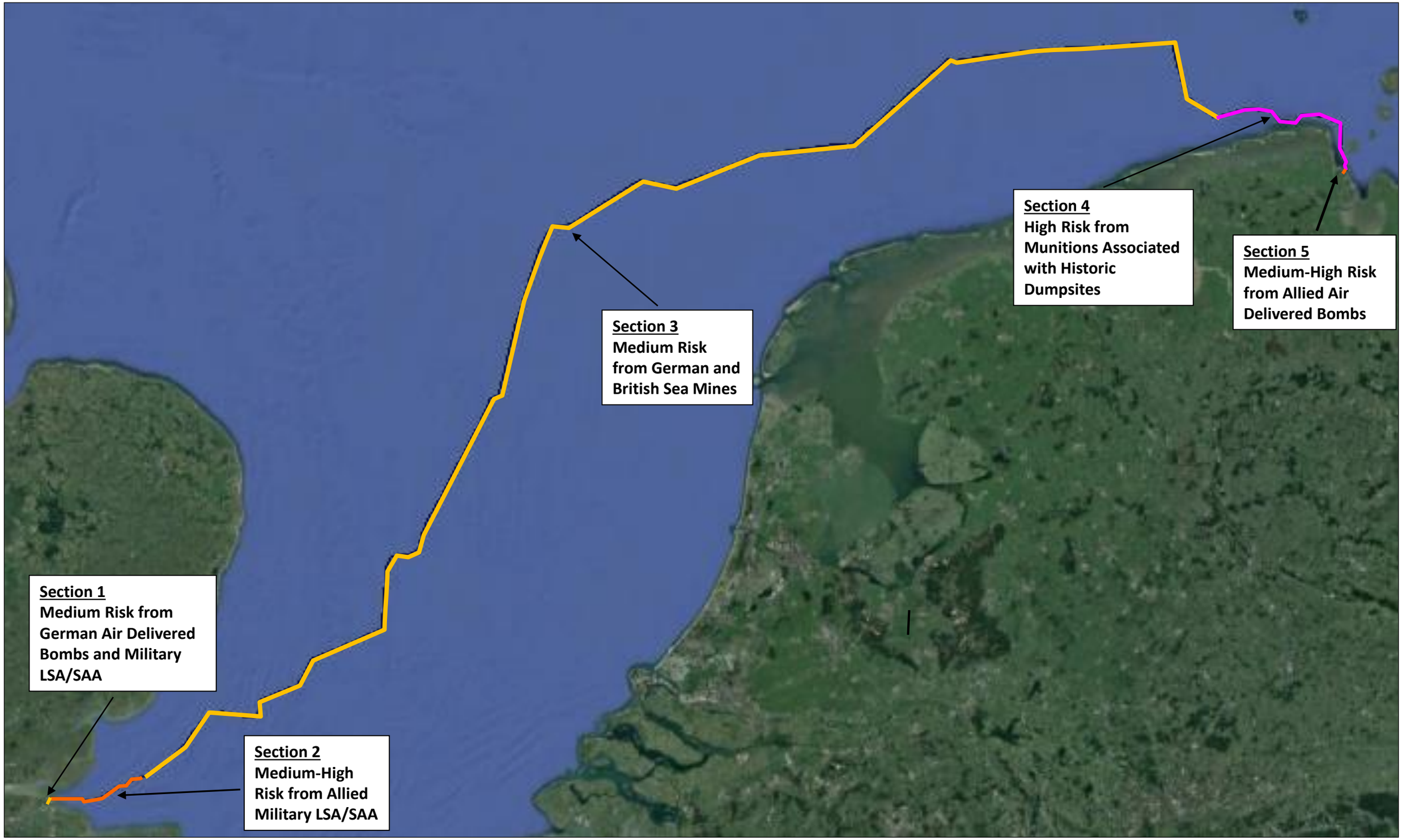
Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA6316-01**

Approximate study area

N

Source: 1st Line Defence



Low Risk Medium Risk Medium-High Risk High Risk

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Client: **Intertek**

Project: **HVDC Electricity Transmission Interconnector between the Isle of Grain, UK and Wilhelmshaven, Germany**

Ref: **DA6316-01**

Approximate study area

N

Source: 1st Line Defence