GREENLINK
MARINE ENVIRONMENTAL STATEMENT- WALES

APPENDIX L

Marine Detailed UXO Risk Assessment

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Greenlink Interconnector
- connecting the power markets
in Ireland and Great Britain

Greenlink
INTERCONNECTOR

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Detailed Unexploded Ordnance (UXO) Risk Assessment

Project Name	Greenlink
Client	Intertek
Site Address	Pembrokeshire, Wales to County Wexford, Ireland
Report Reference	DA2985-01
Date	15th April 2019
Originator	MN

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Executive Summary

Description and Location of Study Area

The Greenlink project is a proposed subsea and underground cable interconnector, with associated convertor stations, between existing electricity grids in Wales and Ireland.

The project is designed to provide significant additional energy interconnection between Ireland, the UK and continental Europe with the aim of delivering increased security of supply, fuel diversity and greater competition. It is also designed to provide additional transmission network capacities, reinforcing the existing electricity grids in south-east Ireland and south Wales.

The study area is approximately 160km in length and spans the St George's Channel, including areas of landfall in Ireland and Wales. Its westernmost section intercepts the Hook Peninsula in County Wexford and the easternmost section incorporates an area of land surrounding Freshwater West Beach in Pembrokeshire. The western half of the study area branches and re-joins the main route line at several points, while the eastern half comprises one singular route line.

It is situated between the approximate OS grid references: **SL 6524661908** (at its westernmost point) and **SM 8871100290** (at its easternmost point) but does not connect between these points in a straight course.

Proposed Works

The proposed works comprise a pre-construction marine survey campaign and the subsequent subsea cable installation.

The pre-construction marine survey campaign is proposed for a suitable period between summer 2018 and summer 2019. It is understood that the primary purpose of the campaign is to acquire appropriate 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. This will include a range of geophysical, geotechnical and environmental surveys. Designed to create detailed mapping of nearshore shallow geological and seabed character; reconnaissance level mapping of seabed relief and features along offshore sections; and baseline environmental mapping along the route corridor.

Intrusive activities during the subsequent cable installation are believed to include:

• Use of anchors – set potentially up to 1km distant from the route's centre line.

• Cable trenching equipment e.g. ploughs, jet trenchers, rock trenchers to install the cable into the seabed.

• Pre-lay grapnel run. Equipment dragged along seabed to hook any debris.

• Boulder removal plough to pushes boulders along the route's centre line to one side.

• Mass flow excavator to transport sand, in order to bury the cable in sand sediments.

• Dredging

• Placement of rock and/or concrete mattresses on the seabed.

It should be noted that the width of the initial survey is understood to be 500m in total. Though the width of the survey corridor is 1km in total to allow for the manoeuvre of the route's centreline, where necessary. A 1km buffer zone either side of this survey corridor has also been included for the purpose of this report.

Seabed Geology

The British Geological Survey (BGS) map, the Geological Survey Ireland (GSI) map 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 westernmost section of the study area, on the Irish mainland, to be underlain by the Ballysteen Formation – dark muddy limestone, shale.

The bedrock geology of the easternmost section of the study area, on the Welsh mainland, is underlain by the Millford Haven Group – conglomerate with superficial deposits of blown sand - sand. The bedrock geology of the coastline was underlain by the Aber Mawr Shale Formation – mudstone and contains Marine Beach Deposits – sand of the Quaternary Period.

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

- Sandstone
- Limestone
- Rock, siliciclastic, argillaceous with sandstone (undifferentiated) and limestone
- Mudstone and sandstone (undifferentiated) and limestone

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UXO Risk Assessment

1st Line Defence has assessed a potential risk within the location of the study area from UXO contamination. This assessment is based on the following factors:

- The Castlemartin training area, a 6,000 acre former and current military range, with a danger area extending up to 14 miles, is situated within the immediate surroundings of the easternmost section of the proposed Greenlink route. Predominantly used by the RAC (Royal Armoured Corps) as a tank range, the Castlemartin area has been used extensively by both British and West German armed forces since its requisition in 1938. Its usage is also recorded to include infantry training, such as small arms training and naval aerial bombing, which is indicated to have taken place within an area immediately bordering Freshwater West Beach.
- The presence of Castlemartin range significantly increases the likelihood that items of Allied ordnance could have been expended, through training exercises, or discarded, through poor housekeeping within the easternmost section of the study area. This includes any part of the study area within Freshwater West Beach and the surrounding offshore danger area. Such items will include LSA (Land Service Ammunition) and SAA (Small Arms Ammunition) but may also include larger, aerially delivered bombs, due to the presence of an air to land training. Explosive Ordnance Clearance tasks undertaken within Castlemartin ranger in the 1980's and 1990's are documented to have recovered thousands of expended items of ordnance and hundreds of live items.
- The island of Grassholm, approximately 7km to the north, is also recorded as a training range during WWII and was used by the USAF (Unites States Air Force) for target practice. The presence of the former Grassholm range is considered to have had less of an impact than Castlemartin though US aerially deployed ordnance, such as practice bombs, deployed in its surroundings waters could have migrated within the study area.
- An extensive British mine area, believed to comprise over 6,000 mines and several significant minefields, was laid in the St George's Channel in 1940 to protect naval and merchant shipping in the Irish Sea from German U-boat attacks. Historical mine mapping of UK waters shows the former location of this mine area to include a significant portion of the western/Irish side of the study area. References to several smaller minefields, including a WWI-era German minefield and two WWII-era German minefields have been found on and in the general proximity of the eastern/Welsh side of the study area. These appear to have been deployed to restrict British naval activity originating from important military sites at Milford Haven and Pembroke Dock.
- A precise assessment of the current risk from mines within the St Georges Channel is difficult to ascertain. Efforts were made by the Royal Navy at the end of the war to clear/make safe mined areas. However such clearance tasks are not considered to guarantee the complete removal of all mines within a danger area, especially if such items have the potential to migrate or became covered due to sediment and tidal action over a period of time. It is therefore not possible to discount the possibility of encountering surface or submarine laid sea mines across any location of the study area.
- 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, off the coastlines of both Ireland and Wales, and often demonstrate the presence of both sea mines and torpedoes during WWI and WWII. The majority of these wrecks are also British cargo ships, though military vessels are recorded within the area during both world wars, including an unnamed German warship in 1917, the German submarine UC-44 in 1917, the British warship HMS Arbutus in 1917 and the British warship HMS Minicoy in 1941. 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 and anti-submarine weaponry were commonly deployed in the waters around Britain on account of German U-Boat activity during both world wars. The Irish Sea, including the St George's Channel was particularly affected by U-boats during WWI due to the high volume of merchant shipping travelling to and from important docks such as Liverpool and the Clyde from the south-west approaches, leading the region to be subsequently dubbed 'U-Boat alley'. Anti-submarine weapons, most commonly depth charges, were deployed by Royal Navy vessels to combat this threat, with Hedgehog and Squid spigot mortars put into operation from 1942. Although generally deployed in low numbers when compared to other types of munitions, it is not possible to discount the presence of such items at the site location, due to their recorded usage in the wider area.
- Three munitions dumps are recorded within the wider surrounding area, off the Pembrokeshire coastline. These are believed to have operated in conjunction with surrounding military sites and to have been used in the immediate post period. These dumps are not anticipated to pose a significant risk to the study area, unless its location is altered and situated on or in their immediate proximity. It is also possible that dumped munitions may have either been deposited outside the designated areas or have else migrated within the region over time.
- The likelihood of encountering historic Allied ordnance, such as Land Service Ammunition (LSA) and Small Arms Ammunition (SAA) is considered to be elevated within parts of the study area on and surrounding the former premises of RAF Angle or any coastal defences. This is because of the presence of a number of features associated with ordnance usage and disposal, such as pillboxes, ranges and ammunition stores and the potential for poor

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UXO Risk Assessment

housekeeping, whereby items of ordnance were buried, burnt or otherwise disposed of unrecorded. EOC reconnaissance tasks undertaken in 2000 and 2001 also refer to 'WWII-era coastal defences (barbed wire) reappearing' on Freshwater West Beach and suggest that the area was mined during the war.

- The easternmost section of the study area was situated within an area of Wales that sustained a very low density of bombing throughout the war. Bombing within the rural areas of Pembrokeshire were generally isolated incidents and the result of Luftwaffe bombers travelling to and from more significant targets within the wider region. This infrequency of incidents, combined with the nearby presence of RAF Angle, increases the probability that any bomb strikes within the Freshwater West area would have been recorded and any signs of UXO investigated. It is not possible however to completely discount the possibility of such incidents going unnoticed because of the open, rural nature of the groundcover of Freshwater West and its surrounds.
- Likewise, it is not anticipated that a significant number of aerial bombs were deployed within the St Georges Channel, though several attacks on merchant shipping are recorded within more central areas in 1940 and 1941. Any bombs falling during such raids are not likely to have been well observed or investigated and thus the possibility that aerially delivered UXO may be present within the offshore areas also cannot be discounted, though the likelihood is not considered to be high.
- The risk from items of air delivered UXO within the westernmost section of the study area, within the Irish mainland, is considered negligible. The Republic of Ireland was never subject to a targeted bombing campaign during WWII and instead only sustained bombing by the Luftwaffe on a handful of isolated occasions, none of which are recorded within the study area.
- Based on these findings it has only been possible to confidently reduce the risk from UXO within the section of the study area situated in the Irish mainland, on the Hook Head peninsula. There is a potential risk of encountering UXO across the remainder of the study area, which is significantly elevated on and surrounding the eastern end at Freshwater West, due to the presence of the Castlemartin Training Area and the former RAF Angle.

UXO Risk Mitigation

This report has concluded that there is a potential risk from unexploded ordnance within the study area. The risk from different types of UXO is however not considered to be homogenous. Consequently the study area has been broadly split into the following four zones:

- Irish mainland – no significant risk of UXO identified.
- Western and central offshore – primary risk is from larger items of ordnance, mainly sea mines.
- Eastern offshore – larger items such as sea mines, but also risk from smaller items such as projectiles and other land service ammunition (LSA).
- Welsh mainland – risk from land service ammunition (LSA), small arms ammunition (SAA) and unexploded bombs (UXB's) identified.

Offshore Mitigation

It is recommended that the proposed cable route and areas subject to intrusive investigation techniques (any time when the seabed is being affected) are subject to a UXO survey to identify targets which might be UXO related. It is understood that various survey techniques are already proposed along the survey corridor including side scan sonar and magnetometer survey. It is recommended that these surveys be designed with sufficient resolution to allow for the detection of large items of ordnance across the entire length of the route such as sea mines, bombs and torpedoes. If there is the potential for larger items to become buried due to localised sea bed conditions/sediment, then a magnetometer survey in these areas would be especially recommended. Any anomalies detected with the potential to be UXO related should be inspected as part of an ROV video survey to identify them. If they are found to be UXO related, they can either be avoided or if necessary, moved or disposed of remotely.

Smaller items such as projectiles and other items of LSA pose a lesser risk if encountered on the seabed, and are generally too small to be detected by most survey techniques except visual. These types of items are most likely to be present in the far eastern end of the route, in the vicinity of the firing range and munitions dumps. The main concern regarding smaller items of UXO is if they come into direct contact with personnel – for example if brought on-board on equipment deployed on the seabed, or incorporated within seabed sediment samples. For this reason, it would be prudent to have a UXO Specialist present on board to check over any equipment brought on deck and to check and identify any suspect items found within sediment samples. A UXO Specialist on-board can also review any ROV video footage undertaken to identify any potential UXO on the seabed.

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Onshore/Nearshore UXO Risk Mitigation

Because no significant risk has been identified at the Irish mainland, is it not recommended that any proactive risk mitigation measures are necessary on the landward side at this end beyond UXO Safety and Awareness Briefings.

For onshore/nearshore works at the eastern end of the route, it is recommended that proactive support is provided. It is recommended that trial pits are supported by a UXO Specialist and that all proposed boreholes are subject to a magnetometer survey. All operatives should receive UXO Safety and Awareness Briefings. It may be viable to undertake a non-intrusive magnetometer survey and target investigation on the beach area for the cable trench as it goes onshore.

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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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Contents

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Annexes

List of Report Annexes	
Annex A	Site Location Maps
Annex B	Recent Aerial Photography
Annex C	Historical Mapping
Annex D	Example of Naval Mines, Anti-Submarine Weapons and Torpedoes
Annex E	Examples of Offshore UXO Incidents
Annex F	Overlay of Wreck Sites
Annex G	Minefield Mapping of the St Georges Channel
Annex H	Overlay of U-boats lost in the Irish Sea in WWII
Annex I	Overlay of Conventional Munitions Dumpsites
Annex J	Armament Training Areas and 'Danger Area' Mapping
Annex K	RAC Castlemartin Range Documentation and Plans
Annex L	Examples of LSA and SAA
Annex M	RAF Angle Site Plan
Annex N	1942 RAF Aerial Photography
Annex O	1946 RAF Aerial Photography
Annex P	Examples of Anti-Aircraft Projectiles
Annex Q	Luftwaffe Reconnaissance Imagery
Annex R	Examples of German Air Delivered Ordnance
Annex S	LOP (Look Out Post) Logbook – Hook Head
Annex T	Decoy Site Mapping
Annex U	OSPAR Munition Encounters

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Appendices

List of Report Appendices	
Appendix i	Sections of the Study Area
Appendix ii	Overlay of Significant UXO Features[1]
Appendix iii	Overlay of UXO Features on Welsh Mainland

[1] Please note that this appendix has been based on a final version of the route of the proposed study area. This route was provided following the completion of this report and for all other purposes the original study area proposed has been used.

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Detailed Unexploded Ordnance (UXO) Risk Assessment

Site: Greenlink
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 along the proposed Greenlink interconnector route.

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'.

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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 proposed Greenlink route. 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 German 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, the National Archives of Ireland, Dublin, the Irish Military Archives, County Wexford Archives and Pembrokeshire Record Office.
- The UK Hydrographic Office, OSPAR Commission and Wrecksite.eu
- The RAF Museum, Hendon.
- The Central Register of Air Photography for Wales
- 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.

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- Open sources such as published books and internet resources.

Research involved a visit to The National Archives, Kew 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:

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- 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 Consultants and The Authorities

4.1. Commercial UXO Consultants

The role of a commercial UXO consultant is to provide a qualified assessment of the prospective risks posed by UXO and to help develop a suitable risk management strategy during the pre-construction phases of a project. If required the UXO consultant may also identify and deliver the most appropriate risk mitigation measures and provide additional support, such as the sign-off of documentation, post appointment.

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

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.

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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 addition cordons and evacuations. Following the removal of an item of UXO, the military authorities will only undertake further investigations or clearances in high risk situations.

5. The Study Area

5.1. Background

The Greenlink project is a proposed subsea and underground cable interconnector, with associated convertor stations, between existing electricity grids in Wales and Ireland.

The project is designed to provide significant additional energy interconnection between Ireland, the UK and continental Europe with the aim of delivering increased security of supply, fuel diversity and greater competition. It is also designed to provide additional transmission network capacities, reinforcing the existing electricity grids in south-east Ireland and south Wales.

5.2. Location of the Study Area

The study area is approximately 160km in length and spans the St George's Channel, including areas of landfall in Ireland and Wales. Its westernmost section intercepts the Hook Peninsula in County Wexford and the easternmost section incorporates an area of land surrounding Freshwater West Beach in Pembrokeshire. The western half of the study area branches and re-joins the main route line at several points, while the eastern half comprises one singular route line.

It is situated between the approximate OS grid references: **SL 6524661908** (at its westernmost point) and **SM 8871100290** (at its easternmost point) but does not connect between these points in a straight course.

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

5.3. Description of the Study Area

The westernmost section of the study area, situated on the Irish mainland, typically comprises open agricultural land within the Hook Peninsula but includes the hamlets of Yoletown, Carnivan and Harrylock, as well as transport infrastructure in-between. The easternmost section of the study area, which occupies the Welsh mainland, is also predominantly occupied by open agricultural land

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surrounding Freshwater West Beach. This area is intersected by the B4319 and the B4320 and is situated within part of the Pembrokeshire Coast National Park.

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

5.4. Ordnance Survey Historical Maps

WWII-era 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.

Hook Peninsula, Ireland	
Date	**Description**
1940	This map shows the westernmost section of the site to intercept the Hook Head Peninsula, in Ireland, in two areas. This includes an area of land leading to Hook Head, which contains Lumsdins Bay, Woarwoy Bay and Sandeel Bay. The other section occupies an area centred around Baginbun Head and includes land of the periphery of the village of Fethard. Both sections appear relatively rural in nature, despite the presence of structures and roadways. The remaining visible section of the study area is occupied by the open waters of St Georges Channel.

Pembroke, Wales	
Date	**Description**
1946	This map shows the easternmost section of the site, on the Welsh mainland, to be occupied by Freshwater Beach and its surrounds. This includes *Jeffersonwalls*, *Middlehill*, *Little Furzenup*, a monument and a series of burrows. This area is intercepted by the B4319 and the B320 and appears to be largely rural in nature. The remaining visible section of the study area is occupied by the open waters of St Georges Channel.

6. Scope of the Proposed Works

6.1. General

The proposed works comprise a pre-construction marine survey campaign and the subsequent subsea cable installation.

The pre-construction marine survey campaign is proposed for a suitable period between summer 2018 and summer 2019. It is understood that the primary purpose of the campaign is to acquire appropriate 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.

This will include a range of geophysical, geotechnical and environmental surveys, designed to create detailed mapping of nearshore shallow geological and seabed character; reconnaissance level mapping of seabed relief and features along offshore sections; and baseline environmental mapping along the route corridor. Data acquisition and coverage requirements will be split into the following survey areas:

- The land/intertidal survey: from 50m landward of the high water mark (HWM) to the charted low water mark (LWM) of each shore landing
- The shallow water survey: from LWM seawards to the first 10m lowest astronomical tide (LAT) water depth.

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- The offshore survey: Seawards of the first 10m LAT water depth to a 12 nautical mile limit and onwards to median line.

6.2. The Survey Campaign and Cable Installation

The scope of the Greenlink survey campaign is detailed in the table below:

Marine Survey		
Objective	**Method**	**Specifications**
Bathymorphology Wide area bathymetry and seabed features mapping for cable route engineering evaluation and environmental characterisation	Swath bathymetry, sidescan sonar, sub bottom profiler	Nominal 1km wide corridor
Target & Crossings Investigation Unidentified seabed anomaly characterisation and archaeological assessment Confirmation of alignment and character of existing cables / pipelines	Sidescan sonar, magnetometer, ROV	Target list graded by significance
Geotechnical Sampling	Vibrocore & cone penetrometer tests (CPT)	Spaced approximately 1500 m apart along the route. Vibrocores will penetrate up to 6m.
Seabed Sampling Environmental sampling for confirmation of biotope and seabed characterisation for environmental baseline mapping	Environmental grab	Sampling locations selected from preliminary interpretation of sidescan sonar data, nominally 5km interval
Seabed Imagery Visual confirmation of biotope and seabed characterisation	Drop-down video camera	Not specified
Landfall Survey (Nominal 3-15m Water Depth)		
Objective	**Method**	**Specifications**
Geotechnical borehole Confirmation of geology to ground truth geophysical and shallow geology for purposes of determining HDD feasibility	25m deep borehole	Four geotechnical boreholes up to 25m deep at 250m spacing from beach. Furthest core will be approx. 1km from landfall along route. Boreholes will likely be drilled from a jack-up barge.
Trial pits	Mechanical digger, hand excavated	Maximum depth will be 5m. Will be dug on beaches at Freshwater West, Boyce's Bay and Baginbun Beach.

Intrusive activities during the subsequent cable installation are believed to include:

- Use of anchors – set potentially up to 1km distant from the route's centre line.

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- Cable trenching equipment e.g. ploughs, jet trenchers, rock trenchers to install the cable into the seabed. (Note this might be deeper in areas of sand waves).
- Pre-lay grapnel run. Equipment dragged along seabed to hook any debris.
- Boulder removal plough to push boulders along the route's centre line to one side. This normally clears a swathe up to 10m wide.
- Mass flow excavator to transport sand, in order to bury the cable in sand sediments.
- Dredging
- Placement of rock and/or concrete mattresses on the seabed.

It should be noted that the width of the initial survey is understood to be 500m in total. Though the width of the survey corridor is 1km in total to allow for the manoeuvre of the route's centreline, where necessary. A 1km buffer zone either side of this survey corridor has also been included for the purpose of this report.

7. Ground Conditions

7.1. General Geology

The British Geological Survey (BGS) map, the Geological Survey Ireland (GSI) map 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 westernmost section of the study area, on the Irish mainland, to be underlain by the Ballysteen Formation – dark muddy limestone, shale.

The bedrock geology of the easternmost section of the route, on the Welsh mainland, is underlain by the Millford Haven Group – conglomerate with superficial deposits of blown sand - sand. The bedrock geology of the coastline was underlain by the Aber Mawr Shale Formation – mudstone and contains Marine Beach Deposits – sand of the Quaternary Period.

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

- Sandstone
- Limestone
- Rock, siliciclastic, argillaceous with sandstone (undifferentiated) and limestone
- Mudstone and sandstone (undifferentiated) and limestone

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 the marine environment, primarily as a result of historic military activity. 'Poor housekeeping' by armed forces also led to the loss or deliberate dumping of items of UXO within UK shores and waters. The United Nations distinguishes these activities into the following categories: defensive military activity, offensive military activity and AXO (Abandoned

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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 the marine environment 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 might also 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 the UK, 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.

UXO Initiation Mechanisms

UXO Initiation

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

	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	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

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	can cause larger forces to be exerted on items or sediments present on the sea bed.	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.

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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 both WWI and WWII, as each side attempted to defend their territories from invasion and to hold and reinforce certain key points and areas overseas. Such activity also played a significant part in the economic survival of each nation during these periods, with large number of munitions and vessels regularly deployed to defend merchant shipping from attack. Defensive sea mines were first used by the UK in WWI and in WWII a major defensive minefield was laid in the southern section of the St Georges Channel, between Ireland and Wales, to close the approach to shipping routes to Liverpool and the Clyde from German vessels. Post-war mine laying continued in UK waters, until its recorded cessation in 1992.

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 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. No major naval engagements are recorded to have taken place within the St George's Channel during either period due to its location in relation to the continent, but it was identified as an area of strategic value by German U-Boats during WWI. This was due to the volume of naval and merchant shipping that travelled between the major ports of Ireland and Great Britain in the region to destinations across the Atlantic. The regular success of U-Boat attacks on merchant and naval ships led to the region to be dubbed as 'U- Boat Alley' and contributed to the 1,763 shipwrecks recorded in the Irish Channel during the four years of WWI.

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 study in Britain is the wreck of the SS Richard Montgomery, an American liberty ship, which ran aground on a sandbank in the Medway in August

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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. During this time the British Army designated over 1.2 million tons of ordnance to be disposed of, 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 British waters during WWI and WWII, predominantly as a result of U-boat activity and 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 weapon which were deployed in an area – whether they were bombed, torpedoed or mined for example – and therefore the nature of the threat which might still exist.

Some wrecks can pose a direct threat due to their particular cargo – those in use by the military or responsible for the transportation of weapons and explosives can still pose a threat today. Sea-bed 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 which has fired but failed to detonate.

10.2. Shipwrecks in the St Georges Channel

Records of shipwrecks in the St Georges Channel were obtained from Wrecksite.eu and the UKHO. An overlay showing the location of recorded wrecks on aerial imagery presented in **Annex F**. Shipwrecks recorded within the study area and in the immediate surroundings have been included and are discussed in the table below.

Ship name	Type of ship	Armaments	Date of wreck	Reason given	Location
SS Hermione	British cargo	Armed merchant ship	14/04/1917	Struck by a mine laid by the German submarine UC-33	Within 150m NW
Name unknown	German warship	Not specified	05/08/1917	Blown up by own mines	Within 1km NW
HMT Loch Eye	British trawler	Not specified	20/04/1917	Sunk by a mine from the German submarine UC-33	**On study area, NW**
HMT George Milburn	British minesweeper	Armed trawler	12/07/1917	Sunk by a mine from the German submarine UC-42	**On study area, NW**
UC-44	German submarine	Not specified	04/08/1917	Sunk by own mines.	**On study area, NW**

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Ship name	Type of ship	Armaments	Date of wreck	Reason given	Location
SS Trafford	British cargo	Not specified	16/06/1915	Scuttled (gunfire – shelled) by the German submarine U-22	**On study area, NW**
SS Fingal	British cargo	Not specified	01/09/1917	Foundered	**On study area, NW**
SS Etal Manor	British cargo	Not specified	19/09/1917	Torpedoed by German submarine UC-48	Within 100m NW
SS Carlo	British cargo	Defensively armed	13/11/1917	Torpedoed by U-95	**On study area, NW**
FV Guard	British fishing	Not specified	17/03/1917	Sunk by the German submarine UC-48	Within 1km NW
SS Rhodesia	British cargo	Defensively armed	11/10/1917	Torpedoed by German submarine U-61	Within 1km NW
SS Candidate	British cargo	Not specified	06/05/1915	Captured then torpedoed by German submarine U20	**On study area, centre**
SS Cairo	British cargo	Not specified	13/08/1915	Sunk (gunfire – shelled) by the German submarine U-24	Within 100m, centre
SS Empire Frost	British cargo	Not specified	13/03/1941	Aerial bombing	Within 5km, centre
FV Valeria (LT156)	British trawler	Not specified	18/08/1940	Aerial bombing	Within 3.5km, centre
SS Thorold	Canadian cargo	Not specified	22/08/1940	Aerial bombing	Within 3km,centre
HMS Arbutus	British war	2 × 4 in (100 mm) guns, 1 or 2 × 12-pounder guns, Depth charge throwers	16/12/1917	Torpedoed by German submarine UB-65	Within 300m, SE
MV Empire Beacon	British cargo	Not specified	05/04/1942	Detonated a British mine	Within 2.3km, SE
SS Drina	British ocean liner	Not specified	01/03/1917	Sunk by a mine from the German submarine UC-65	Within 300m, SE
SS Inishowen Head	British cargo	Armed merchant ship	14/02/1917	Sunk by a mine from the German submarine UC-65	**On study area, SE**
SS Gisella	British cargo	Defensively armed	18/11/1917	Torpedoed by the German submarine UC-77	**On study area, SE**
Hannah Croasdell	British sailing	Not specified	26/02/1917	Sunk by a mine from the German submarine UC-65	Within, 2km SE
SS Saint Jacques	French cargo	Not specified	15/09/1917	Sunk by a mine from the German submarine UC-51	**On study area, SE**
LCG-15 Landing Craft	British war	Not specified	25/04/1943	Sank in gale force winds	**On study area, SE**

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Ship name	Type of ship	Armaments	Date of wreck	Reason given	Location
HMS Minicoy	British war	Not specified	14/05/1941	Mined while being used as a harbour defence vessel	Within 2.2km, SE
MFV Helene	Belgian trawler	Not specified	04/12/1940	Sank after hitting a German mine	Within, 2.5km SE
SS Johanna Caroline	British minesweeper	Not specified	28/04/1941	Detonated a German mine	Within 3km, SE

10.3. Aircraft Crashes in the St Georges Channel

During WWII, many hundreds of aircraft were shot down and lost over British waters. 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 RAF Fighter Command were most significant during the four months of the Battle of Britain, during which 234 aircraft are documented to have crashed within British waters.

Given the relatively low speed of impact in many cases, aircraft which crashed at sea were often largely intact as they came to rest on the sea floor and may have remained so, though 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.

No evidence could be found to suggest the presence of any aircraft crash sites directly within the study area in Wrecksite.eu or the available UKHO records. RAF Log Books for RAF Angle (see section 16.3) do however reference several aircraft crashes in the general proximity. It is anticipated that a large section of the study area would have been patrolled by RAF aircraft during WWII, which may have been undertaking reconnaissance tasks or defending merchant shipping in the Irish Channel.

10.4. Deductions

A total of 15 wrecks recorded on or near the westernmost and easternmost sections of the study area, off the Irish and Welsh coastlines, are labelled to have been 'sunk by mines from German submarines'. Eight torpedo related wrecks are recorded, with the majority also situated in the easternmost and westernmost sections of the study area, in shallower waters. Three wrecks in the central section are accounted for by WWII-era aerial bombing, two wrecks are referenced to have been sunk as a result of 'gunfire' and the two remaining wrecks were brought down by 'circumstances unrelated to explosive ordnance'.

These wrecks demonstrate the potential presence of sea mines, torpedoes, aerial bombs and projectiles within the study area, each of which will be examined in turn over the course of this report.

It should also be noted that the majority of wrecks recorded on or near the study area are British cargo ships, though military vessels are recorded within the area during both WWI and WWII. These include an unnamed German warship in 1917, the German submarine UC-44 in 1917, the British warship HMS Arbutus in 1917 and the British warship HMS Minicoy in 1941. Two British minesweeper vessels are also recorded to have sunk in 1917 and 1941, as well as the British landing craft LCG-15 in 1943. Although specific armaments are only referenced on the HMS Arbutus all of these military related vessels have the potential to have been carrying items of unexploded ordnance at the time of their loss.

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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 coast of the UK, 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. Whilst 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 'influence' 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. Mines in the St Georges Channel

Historical accounts of minelaying operations in the St Georges Channel were found in both online and written texts, including *The War at Sea* by S W Roskill and *Royal Navy Minelaying Operations* by Geoffrey B Mason. One particular text, *The History of the Great War-Naval Operations* by Sir Julian Corbett and Henry Newbolt, references a German minefield laid off the south-west coast of Wales in WWI, which is believed to have been designed to disrupt shipping travelling to and from important naval sites at Pembroke Dock and Milford Haven. No original mapping of this minefield could be obtained to illustrate its exact location, but from its description it is anticipated that this minefield intercepted the section of the study area off the Pembrokeshire coastline.

No major British minefields were laid in the St George's Channel or the wider area, otherwise known as the 'south-west approaches', before 1940, because of a lack of resources and the extensive use of these areas by merchant shipping. However after the German occupation of France merchant ships using the St George's Channel were diverted and had to enter the Irish Sea from the north, through the North Channel. During this period over 6,000 mines were laid across the south-west approaches to deter U-Boat activity and as an anti-invasion measure, with the St George's Channel declared a 'British Mine Area' from the 22nd July 1940. The mine area incorporated a significant portion of the channel and spanned between Devon and the coast of Ireland, with gaps to allow use by Allied and neutral coastal shipping. It remained in place for the remainder of the war and was reinforced in 1945.

11.2.1. Mine Mapping

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During this report the UKHO was contacted for any resources concerning the potential presence of historic mines in the St Georges Channel. According to information provided by their Mine Warfare Team Leader no detailed minelay maps exist that specifically cover the St. George's Channel. A WWII-era sea minefield map covering the whole of the British Isles and adjacent waters was however provided, with the relevant section presented in **Annex G1**. This map, compiled in 1945, shows the western section of the study area to run through a British minefield, which forms part of a much larger mined area between the south coast of Ireland and the western coast of Great Britain. (This mined area is understood to have been laid in 1940 and is described in more detail in the section above.) A section of the east of the study area is occupied by a much smaller British minefield. Two circular 'enemy minefields' are present in the wider vicinity of the site, off the Pembrokeshire coast and a number of searched channels are also labelled within this region.

Additional mine mapping covering the St Georges Channel Mine Area was acquired from the National Archives, Kew and is presented in **Annex G2**. This mapping shows the location of the designated danger area in more detail than the aforementioned mine map and includes the location of a 'secret gap' near the Irish coastline and the 'southern gap' off Devon. It is dated between 1940-1943 and 1944, with the latter map edition showing the 'secret gap' widened to accommodate for both inward and outward shipping routes.

It should be noted that the position of the aforementioned mine danger area depicted within the St George's Channel is based on navigational practices and equipment dating to WWII. Due to the limited navigational accuracies of the units laying mines at this time their true positions may differ.

11.2.2. Parachute Mines

Home Office Statistics record a total of 10 Parachute Mines dropped over the Rural District of Pembroke during WWII. Many of these would have been sea mines that had been modified with impact fuzes to act as conventional high explosive weapons, and it is likely that those recorded were dropped over targets on land. This statistic demonstrates the potential for additional aerial mines to have been deployed within the waters surrounding Pembrokeshire, where records of aerial bombing were limited. Luftwaffe minelaying was common across parts of the UK waters with the intention of disrupting shipping.

11.3. Deductions

An extensive British mine area, believed to comprise over 6,000 mines and several significant minefields, was laid in the St George's Channel in 1940 and later reinforced in 1945. The former location of this mined area is considered to include a significant portion of the Irish side of the study area. References to several smaller minefields, including a WWI-era German minefield and two WWII-era German minefields have been found on and in the general proximity of the Welsh side of the study area, surrounding Milford Haven.

Efforts were made by the Royal Navy post-war to remove or make safe the areas mined during the war. However such clearance tasks did 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 (with the mine sinking later) many mines will not have been detonated by the shooting, and many 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.

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While aerial delivered parachute mines could well have fallen within the St Georges Channel undetected, they were not dropped in any great numbers, so the likelihood of one being present within the study area is not considered to be as high as for ship laid mines.

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 over in this way 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 damaged its keel, and 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 recently 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 Saint Georges Channel

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.

Information obtained from Wrecksite.eu and the UKHO indicate that eight vessels in the general proximity of the study area were sunk by torpedo attacks from German U-boats during WWI. The majority of these vessels were cargo ships, but included one fishing ship and one naval vessel, the HMS Arbutus. The majority of these wrecks are recorded in the general vicinity of the Irish coastline and the Welsh coastline, with only one wreck recorded in a more central area of the study area, within deeper waters. No WWII-era torpedo related shipwrecks were recorded in this region.

12.3. Deductions

Torpedoes were deployed in UK waters during both WWI and WWII, although their numbers were relatively low when compared with other types of munitions. Historical records indicate that shipping within the Irish Channel (including the St Georges Channel) was subject to a large number of torpedo attacks during WWI, leading the region to be dubbed as ‘U-Boat Alley’. Torpedo attacks by U-Boat resumed in WWII but were smaller in number, owing to better defences and the presence of the St Georges Channel minefield from 1941. This is correlated by the available data concerning wreck sites, which indicates that a number of WWI-era torpedo related wrecks are situated in the vicinity of the study area, especially within areas of shallower waters.

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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 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 St Georges Channel

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 Irish Channel. This corresponds with an overlay of U-boat losses presented in **Annex H,** which records four U-boat losses in the general surrounding area. Three of these U-boats are labelled as 'sunk by depth charges' from British and Canadian frigates in 1945.

13.3. Deductions

Anti-submarine weapons were commonly deployed by Allied naval vessels in the home waters of Great Britain during both 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, such as off the east and south coast of the English mainland.

Historical records indicate that depth charges were deployed to combat German U-boats in the Irish Channel during both WWI and WWII, with other anti-submarine weapons, such as the Hedgehog and Squid spigot mortars put into operation from 1942. Information concerning German U-boat losses suggest that anti-submarine weaponry was at its most effective towards the end of WWII, with a number of vessels sunk by depth charges in the Irish Channel in 1945. Although no evidence could be found to suggest that any shipwrecks related to anti-submarine weaponry are situated within the study area it is therefore not possible to discount the presence of such items at the site location due to their usage in the wider area.

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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 St Georges Channel

The overlay provided in **Annex I** shows the approximate location of historic munitions dumpsites recorded by OSPAR in the region of the site. Three conventional munitions dumpsites are recorded off the coast of Pembrokeshire, in the surroundings of the easternmost section of the study area. Little further information could be found concerning the age of these sites, their extent or the nature of items deposited.

The presence of munitions dumps off the coastline of West Pembrokeshire is also correlated by a series of Marine Character Reports on the region, compiled by Natural Resources Wales. Which state: 'Historically a large area in the south of the MCA (West Pembrokeshire Islands) and an area at Hats and Barrels have been used to dump disused explosives, marked as Explosives Dumping Grounds on the marine charts. Military use within the MCA continues today with part of the Aberporth firing range and military practice area located to the northeast and part of the Castlemartin firing range area located to the south[2].

14.3. Deductions

The three munitions dumps depicted are not considered to be of close enough proximity to pose a direct risk to the study area, and no evidence has been found to suggest that any other official or unofficial munition dumps were present in the vicinity. However if the location of the study area was to be altered and to be situated on or near to these munitions dumps, then a significant risk from UXO may be posed by the presence of these features.

15. Coastal Armament Training Areas

15.1. General

[2] *https://naturalresources.wales/media/674497/mca-19-west-pembrokeshire-islands-bars-and-inshore-waters_final.pdf*

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There are several historic armament firing ranges located along the Welsh coastline, many of which were in operation during WWII. 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/ Danger Area Mapping

Four maps were acquired from the National Archives showing the location of historic armament training areas and designated danger areas present in the UK in relation to the study area. These maps are included in **Annexes J1-J3** and are described below.

Military Range Maps – Annexes J1-J3	
Date Range	**Comments**
Restricted Flying Areas, Defended Areas & Balloon Areas – March 1941	The majority of the study area passes through red and green areas. Its easternmost section intersects a heavy AA and inner artillery zone, which surrounds the town of Pembroke.
Restricted Flying Areas, Defended Areas & Balloon Areas – March 1943	There is little significant change across the majority of the study area between this map and the previous map edition. The easternmost section of the site, near the Pembrokeshire coastline, now intercepts a coastal armament training area.
Restricted Flying Areas, Defended Areas & Balloon Areas –July 1944	This map also shows little significant change across the majority of the study area since the previous map edition. A USA armament training area is however now labelled to the north of the eastern section, surrounding the island of Grassholm.
'Notices to Airmen' Danger Areas in the UK – Date Unknown	This map shows areas used for firing or bombing practice and for air to air firing practice, including both active and inactive locations. The easternmost section of the study area, in Pembrokeshire, intercepts two inactive firing or bombing ranges and is situated in the general proximity of an active firing or bombing range, situated further east. It should be noted that from the quality of the mapping available that it is not possible to identify the names or exact locations of firing/bombing practices in the wider area of the site and that discrepancies are present between this source and both the Armament Training Areas and Restricted Flying Areas mapping covering the region.
Armament Training Areas – May 1945	This map, presented in **Annex J3**, shows that the easternmost section of the study area to intercept three WWII-era armament training areas. N104 and N105 are both classified as Milford Haven Approaches and are documented to have included naval guns and both heavy and light anti-aircraft. Both firing ranges have a designated 'danger area' up to 20,000ft. A222 Milford Haven is labelled as a coastal artillery range and has a designated 'danger area' up to 10,000ft. A smaller range is also denoted approximately 7km the north of this section of the study area, surrounding the island of Grassholm. This range is classified as a USA live bombing range, under the jurisdiction of the RAF. It has a designated 'danger area' up to 25,000ft.

15.3. RAC Castlemartin Range

The Castlemartin training area is a 6,000 acre historic and current military range, with a danger area extending up to 14 miles out to sea. A small portion of the easternmost section of the study area, at Freshwater West Beach and Gupton Barrows, is situated within the land perimeter of this range. A more sizeable portion of the study area, in the bay of Freshwater West, is situated within the range's oversea danger area.

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Castlemartin was first requisitioned by the military for use as a training range in 1938, as part of the build-up of the armed forces in the run up to WWII. During the war it was predominantly used as a tank range by the RAC (Royal Armoured Corps) and was briefly returned to agricultural use at the end of the conflict in 1945, before being requisitioned once again at the start of the Korean War in 1950. From this period onwards the range retained its predominant usage as a tank range and was frequently used by German Armoured Units of the FRG (Federal Republic of Germany) during the Cold War. In 1995 training activities were broadened to include additional infantry and small arms training and in 1999 the area was reorganised under the Defence Training Estate. Today it forms one of the twelve Army Training Estates (ATEs) in the British Isles.

War Office records from the post-war period, discussing the usage and composition of the Castlemartin Training area were obtained from the National Archives, Kew, examples of which are presented in **Annex K.** These records confirm that the majority of the training area was used as a tank and armoured car weapons range during the post-war era, with reference to training involving tank gunneries, troop battle runs and small arms. These record sets also suggest that the north-west corner of the training area, which includes part of the study area, was designated as a 'naval aviation bombing range'.

15.3.1. Types of Ordnance Employed at RAC Castlemartin

Detailed information concerning the exact specifications and types of weaponry fired within Castlemartin is difficult to obtain. Parliamentary records discussing the usage of the training area between 1959-1989 have however been found to suggest that at least the following guns were deployed during this period within the tank range:

British Tank Training	
Date Range	**Weapon Type**
1959–64	Centurion 20 pounder gun
1965–72	Centurion 105 mm gun
1970–date of record	Centurion 120 mm gun
Federal Republic of Germany Tank Training	
Date Range	**Weapon Type**
1961–67	M48 90 mm gun
1968–69	Leopard 1 105 mm gun
1970–73	M48 90 mm gun
1974–75	Leopard 1 105 mm gun
176-1979	M48 90mm gun
1980–85	Leopard 1 105 mm gun
1986–date of record	Leopard 2 120 mm gun

15.4. Grassholm

Armament training mapping, danger area mapping and local historic accounts indicate that the island of Grassholm, situated approximately 7km north of the study area was used as a bombing range by the USAF (Unites States Air Force) during the latter years of WWII. COFLEIN (the Royal Commission of Ancient and Historical Monuments of Wales) have provided the following description of its operation:

Grassholm Island was used as a target for bombing practice by the United States Air Force during the Second World War, leaving small bomb craters and shrapnel across the surface. The sites of these craters, some with metal fragments, have been recorded in the past by Douglas Hague. During a field

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visit on 14th October 2016 the nose cone of a projectile was recorded still embedded in the ground surface at the NGR (National Grid Reference) of the record. The lack of small fragments around it suggested to military historian Mark Kahn that it may have been a rocket projectile but a practice round, rather than a fragmentation round. Numerous other small craters or likely craters can still be seen on the eastern side of the islet.

This account would suggest that activity by the USAF was extensive and included a range of aerial delivered bomb types. Any further details about the usage of the range, including its date of closure, could not be obtained during the production of this report and are likely held by US based sources.

15.5. Deductions

Items or ordnance used at Castlemartin will include LSA and SAA but may also include larger, aerially delivered bombs, due to the presence of the recorded air to land range. The smallest type of LSA typically used by British forces during the WWII-era and therefore likely to have been used at Castlemartin 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. Examples of LSA are presented in **Annex L.**

Based on the available War Office record covering the post-war operation of Castlemartin it is anticipated that both live and practice ammunition has been employed during its operation. In the case of the former, items of ordnance fired within the sea danger area are not anticipated to have always detonated on impact with the water and have the potential to remain live and settle within the seabed.

The presence of Castlemartin range also increases the likelihood that items of Allied ordnance could have been expended, through training exercises, or discarded, through poor housekeeping within the easternmost section of the study area. This includes the section within Freshwater West Beach and the surrounding sea danger area. The presence of the former Grassholm range 7km north is anticipated to have a less direct impact on the easternmost section of the study area. It is possible however that US aerially deployed ordnance, such as practice bombs, were deployed in the surroundings waters of the Island and migrated within the proposed site area.

16. RAF Angle

16.1. General

RAF Angle was developed in 1941 as a RAF Coastal Command Operational Satellite. Its location was chosen to support its predominant function, which was to provide support to both maritime and aircraft conveys across British waters, especially over the Irish Channel. Between 1941 and 1943 the airfield was occupied by a number of fighter squadrons, flying Hurricanes, Whirlwinds and Spitfires, operating on three to four month cycles. During 1943 the airfield also saw usage by the Fleet Air Arm of the Royal Navy, with two units flying a mix of aircraft types, operating as a Naval Air Firing Unit.

Following the cessation of fighter rotations in 1943 the airfield was occupied by a Coastal Command Development Unit (CCDU) until January 1945, which was tasked with the improvement of coastal operations. Following this period the airfield was declared surplus to requirements by the RAF and was finally disposed of in the 1950's, its grounds returning to agricultural use.

16.2. RAF Site Plans

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A WWII-era site plan of RAF Angle was obtained from the RAF Museum Hendon and is presented in **Annex M**. This plan, dated 1943, indicates that the airfield was predominantly characterised by three hard surfaced runways, a single T.2 Hanger and four blister hangers.

The easternmost section of the study area occupied the southern section of the airfield which, amongst other features, is labelled to have contained a machine gun range, a cannon test butt, flight offices, dispersal pens and a section of the outer taxiway. The main technical area is situated further north. Several external accommodation areas, situated to the far east of the airfield, are also labelled within the study area. These include the No.2, No.3 and No.4 communal sites strung along what is now the B4320. Each communal site is relatively similar in composition and predominantly comprises barracks huts, recreational buildings and air raid shelters.

16.3. RAF Operations Record Books

Written records regarding the daily life and operation of RAF Angle have been obtained from the National Archives. In general, logbooks recorded the day to day operations of an airfield and incidents of note, including aircraft crashes and enemy bombing raids. Relevant entries in the book to this assessment are transcribed below.

RAF Operations Record Books	
Date Range	**Comments**
20th March 1942	A Junkers 88 probably destroyed by No. 312 (Czech) Squadron.
26th April 1942	A demonstration was given by a Demonstration Rifle Flight of the R.A.F. Regiment.
6th July 1942	Enemy air activity in district from 03.00 to 03.45 hours. Bombs or mines dropped but not in vicinity of station or aerodrome. Suspected minelaying in Milford Haven.
7th July 1942	Enemy air activity in district 03.15 to 03.40. No mines or bombs dropped in the vicinity of the station or aerodrome. Suspected minelaying in Milford Haven.
8th July 1942	Enemy air activity between 03.10 and 03.50 hours. Suspected minelaying in Milford Haven.
26th August 1942	Two Spitfires of 152 Squadron missing from patrol. Sgt. Pilots Shaw and Woolrich missing.
28th August 1942	Sgt. Pilot Shaw, whose body was recovered from the sea, was buried at Carew Cheriton (152 Squadron).
3rd November 1942	Lockheed AN. 646 (No. 407 Squadron) crashed at KIlpaison, near Angle at 1710 hours whilst engaged on practice bombing in Angle Bay. Aircraft caught fire and was burnt out.
21st December 1942	Body of Pilot Officer J. Doucha (117613) recovered from sea at Freshwater West, Angle. It was ascertained that his parent Unit was No. 310 (Czech) Squadron. Medical Officer estimated body had been in sea at least 3 or 4 weeks.
5th January 1943	A U.S. Army Air Force Liberator forced landed here during bad weather en route from Gibraltar to Portreath. It proceeded to Portreath on 6th January 1943.
25th April 1943	About 1930 hours it was reported that bodies were being washed up by the sea in Freshwater Bay. 12 bodies of Royal Naval and Royal Marine personnel were recovered. From early 26th April until 12.00 hours a further 11 bodies were recovered. An officer and a Sergeant of the Royal Marines saved themselves by climbing the rocks during the early morning of 26th April. The circumstances of the accident or accidents are not known but it is believed that Tank Landing or Assault Craft were capsized by very heavy seas, which were running on 25th April and 26th April during a gale. The 23 bodies were transferred to the Royal Naval Depot, Milford Haven on 26th April.

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16.4. Deductions

The likelihood of encountering historic Allied ordnance, such as Land Service Ammunition (LSA) and Small Arms Ammunition (SAA) is considered to be elevated within parts of the study area on and surrounding the former premises of RAF Angle. This is because of the presence of a number of features associated with ordnance usage and disposal, such as ranges, ammunition stores and dispersal pans and the potential for poor housekeeping, whereby items of ordnance were buried, burnt or otherwise disposed of unrecorded. This criteria is considered to apply to any land within and immediately surrounding any of the external accommodation areas depicted on RAF site plans, which are situated off what is now the B4320.

17. Coastal Defences

17.1. 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.

In comparison, the Irish coastline was largely unprotected. This was due to the country's neutrality during the war, and location beyond Britain's own defences. Nevertheless, Ireland maintained an observation service to ensure the country was alert in case of invasion.

17.2. Defence of Pembrokeshire

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 east end of the study area in Wales.

In general, defensive positions can be split into two categories – anti-invasion and anti-aircraft. These will be discussed 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 **Annexes N and O**.

17.2.1. Anti-Invasion Defences

Anti-invasion lines were intended to slow the advance of enemy troops in case of land invasion. In most cases these were static and therefore were not employed during the war period, though defensive positions could be armed if associated with military training or related activity in the wider area.

Anti-Invasion Defences	
Type of Installation	**Summary**
Pillbox	Concrete dug-in guard post, normally equipped with loopholes through which to fire weapons. As a result, LSA/SAA was often stored in this fortification. Present in both WWI and WWII. One pillbox is recorded on site in the Carters Green area, near the former location of RAF Angle.

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Observation Posts	Fixed position from which soldiers can watch enemy movements, to warn of approaching soldiers (such as in trench warfare) or to direct artillery fire. Three observation posts are recorded on site on the Welsh coastline, >1.7km west of Freshwater West beach, near the former location of RAF Angle.
Weapon Pits	Potential location of explosive ordnance storage or disposal, likely associated with other defensive positions located nearby. Three weapon pits are recorded on site. Two of these are plotted on the Welsh coastline approximately 1.7km west of Freshwater West beach, neighbouring the plotted location of an observation post. Another is recorded at the north of Freshwater West beach (Gravel Bay).

17.2.2. 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. Two HAA batteries are recorded on site – one at Whetstone Hill near what is now the B4319 roadway, and another at Bangeston, near the former location of RAF Angle.
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. Two of the weapon pits recorded on site (as referenced in the previous subsection) are stated to have been associated with Lewis LAA guns dug into the 'eastern rampart of Pickard Bay Iron-age promontory fort'. It is conceivable that additional LAA emplacements, such as portable 40mm Bofors guns, were employed in the defence of RAF Angle and were situated within this section of the study area.
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. One machine gun emplacement is recorded on site at The Warren, Carters Green, Angle. This is stated to have included ammunition recesses, later infilled.

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

17.3. Defence of County Wexford

Under the Marine and Coastwatching Service (established 1939), a network of 83 Look Out Posts (LOPs) were built around the coast of Ireland and manned by members of the Local Defence Forces (LDF) between 1939-1945. The Coastwatchers were responsible for identifying and reporting on shipping and aircraft movements and also on any communications between ships and the shore.

Records held by the Defence Forces Ireland Military Archives confirm that a LOP was located near the western end of the study area, at Hook Head. The logbook for this LOP is currently only possible to view digitally covering the period 1st July to 1st October 1940 and could not be obtained in full during

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the production of this report. However, no references could be found within this document to defensive features or any other military presence within this section of the study area.

17.4. Deductions

It is likely that the defensive positions on and surrounding the east end of the study area, on the Welsh mainland, were manned for at least a period of the war and may have been maintained by the Home Guard. 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 and weaponry was no longer required and would have needed disposal. This is particularly prevalent due to the proximity of RAF Angle, which may have led to the transport of explosive ordnance from the airfield to defensive positions located across the area.

No evidence could be found to suggest that any defensive positions were established on or surrounding the Irish coastline in the west end of the study area during WWII.

18. Aerial Delivered Iron Bombs

18.1. World War I

During WWI Britain was targeted and bombed by Zeppelin Airships as well as Gotha and Giant fixed-wing aircraft. However, the limited range and capability of such aircraft during this period meant that targets within Wales and Ireland were generally too far to be viably considered by the German military. No evidence could be found to suggest that Pembrokeshire was ever subject to German aerial delivered bombing or was the location of any aerial engagements in WWI.

18.2. World War II

18.2.1. 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. Wales, alongside large parts of the west of Britain, was not considered to be within the range of Luftwaffe bombers at the start of WWII. This estimation changed following the German invasion of France and the Luftwaffe's acquisition of new airfields, in much greater proximity to Great Britain.

During WWII the easternmost section of the study area was situated within the Rural District of Pembroke, which sustained a very low density of bombing. It is anticipated that the area was not expressly targeted by the Luftwaffe on account of its isolated position, away from most flightpaths used to attack major cities, and its relatively rural nature. Though RAF Angle may have formed a potential target within the region it is considered likely that the majority of bombs recorded were the by-products of raids on Pembroke Dock, situated approximately 8km north-east. Pembroke Dock, see Luftwaffe Reconnaissance Photography in **Annex Q**, was of significance because it contained a number of military installations, including the naval dockyard, Llanion Barracks and RAF Pembroke Dock. The town subsequently suffered regular night attacks between 1940 and 1941, with the raid on the Llanreath naval oil depot in August 1940 widely reported to have created extensive damage and a blaze that lasted for 18 days.

18.2.2. Ireland

The Republic of Ireland was officially neutral during WWII and it is commonly held that the state was never intently bombed by the Luftwaffe. Nevertheless Ireland did sustain several isolated air raids, mostly due to navigational errors or mistaken targets; including raids on Dublin in January and May

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1941. One such raid is recorded to have taken place within County Wexford, when five bombs were dropped at the village of Campile, approximately 13km north of the western end of the study area. However, no other air raids are documented within this section of the Irish mainland.

18.2.3. Offshore

In contrast any records concerning Luftwaffe activity over British and Irish waters 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 Luftwaffe pilots to target both merchant and naval shipping with aerial bombardment. Is also possible that bombs could have been aerially deployed within the waters surrounding the UK because of aerial engagements between Axis and Allied pilots, as well as the deliberate dumping of munitions by pilots attempting to return home.

18.3. WWII 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 Rural District of Pembroke between 1940 and 1945. Note this record is not believed to cover any offshore areas.

Record of German Ordnance Dropped on the Rural District of Pembroke		
Area Acreage		**48,860**
Weapons	High Explosive bombs (all types)	165
	Parachute mines	10
	Oil bombs	0
	Phosphorus bombs	0
	Fire pots	0
	Pilotless aircraft (V-1)	0
	Long range rocket bombs (V-2)	0
Total		**175**
Number of Items per 1,000 acres		**3.6**

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**.

18.4. Written Incident Records

Written records of bombing incidents in Britain, detailing the calibre of a bomb strike, the number of any injuries and fatalities and the extent of any damage caused were often compiled by the Air Raid Precautions wardens and collated by the Civil Defence Office. Some other organisations, such as the port authorities and railways, maintained separate records. These records were often analysed to identify more information about German bombing strategies and bomb types, as well as to predict where future raids might take place.

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18.4.1. RAF Log Books

Operation log books for RAF Angle were reviewed in relation to any information concerning aerial bombing within and surrounding the St Georges Channel. This record set is not believed to provide a comprehensive account of Luftwaffe activity in the region but does reference 'enemy air activity' during the nights of the 6th- 8th June 1942. On all three of these occasions bombs are believed to have been dropped in the region, though not in the vicinity of the station. These descriptions also refer to possible minelaying within Milford Haven.

18.4.2. Pembrokeshire Air Raid Precautions Records

No comprehensive set of written ARP records could be obtained for the Rural District of Pembrokeshire during the production of this report. A series of major incident files for this district, collated by the Mistry of Home Security, were reviewed at the National Archives but no reference could be found to Freshwater West or its surrounding area.

18.4.3. Irish Coastal Log Books

As previously referenced in Section 17.3, a portion of a logbook was obtained for the LOP (look out post) located at Hook Head, within the west of the study area. This covers the period 1st July 1940 to 1st October 1940. One entry was found within this document to a German bombing raid in County Wexford, Ireland; a scan of which can be viewed in **Annex S**. This states that on 26th August 1940 'explosions (were) heard 12 miles north of LOP. Informed… that they (sic) were bombs dropped from the passing aircraft'. A note is also given that the location of the incident was Campile, approximately 13km north of the western end of the study area, as is consistent with anecdotal information. No other references are present within this document to bombing raids in the region.

As previously noted, the remainder of this record set is not yet available digitally and was not possible to review within the time of the production of this report.

18.5. Bombing Decoy Sites

The decoy principal – drawing German bombers away from their designated targets onto dummy sites five or six miles away – began in 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.

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

Records indicate that several WWII-era bombing decoy sites were present in the general proximity of the easternmost section of the study area, on the Welsh mainland. N-Series naval decoy sites for Milford Haven are recorded at Sawdern Farm and East Popton Farm, situated approximately 1.5km and 3km north-east respectively; as well as across the waterway at South Hook Farm, Herbrandston Farm and Sandy Haven Farm to the north. Decoy site mapping, presented in **Annex T**, also labels these sites as Starfish and QF (fire based) decoys.

18.6. Abandoned Bombs

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

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

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

18.7. Inland Bomb Disposal Tasks

The information service from the Explosive Ordnance Disposal (EOD) Archive Information Office at 33 Engineer Regiment is currently facing considerable delay. It has therefore not been possible to include any updated official information regarding bomb disposal tasks with regards to this site. A database of known disposal tasks has been referred to which does not make reference to such instances occurring within the site of proposed works. If any relevant information is received at a later date Intertek will be advised.

Bomb Disposal Tasks (From 33 Engineer Regiment)	1st Line Defence could find no official evidence of bomb disposal tasks within the site boundary or immediate area.

18.8. Deductions

The easternmost section of the study area was situated within an area of Wales that sustained a very low density of bombing throughout the war, especially when compared to the major cities within the south-east of the country, such as Cardiff or Swansea. Bombing within the rural areas of Pembrokeshire were generally isolated incidents and the result of Luftwaffe bombers travelling to and from more significant targets within the wider region. This infrequency of incidents, combined with the nearby presence of RAF Angle, increases the probability that any bomb strikes within the Freshwater West area would have been recorded and any signs of UXO investigated. It is not possible however to completely discount the possibility of such incidents going unnoticed because of the open, rural nature of the groundcover of Freshwater West and its surrounds.

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Likewise it is not anticipated that a significant number of aerial bombs were deployed within the St Georges Channel, though several attacks on merchant shipping are recorded within more central areas in 1940 and 1941. Any bombs falling during such raids are not likely to have been well observed or investigated and thus the possibility that aerially delivered UXO may be present within offshore areas also cannot be discounted, though the likelihood is again not considered to be high.

The risk from items of air delivered UXO within the westernmost section of the study area, within the Irish mainland, is considered to be negligible. The Republic of Ireland was never subject to a targeted bombing campaign during WWII and was only subject to accidental bombings by the Luftwaffe on a handful of isolated occasions. These incidents are relatively well documented with the closest occurring at Campile, approximately 13km north of this section of the study area.

19. Munitions Encounters in the St Georges Channel

19.1. 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 1879 encounters were reported by Belgium, France, Germany, Ireland, the Netherlands, Spain, Sweden and the UK. Of the 1879 munitions encounters reported, 1595 (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 location of offshore munition encounters (reported by fishermen and other users of the sea and its coastline), as recorded by OSPAR since 2004, is presented in **Annex U**. This covers the OSPAR maritime area, including the 'Celtic Seas', which encompasses the St George's Channel and therefore the proposed site. Due to the nature of its compilation, this record should not be considered to be comprehensive.

One offshore munition encounter is indicated directly within the study area at the location of Freshwater West Beach, with six additional munition encounters denoted to the north of this location, within the Milford Haven Waterway. The munitions found are all of the conventional type. Data related to these encounters is transcribed below.

OSPAR Encounters with Dumped Conventional Munitions							
Ref	**Lat/Long**	**Distance**	**Nature of find**	**Date**	**Action taken**	**State of munitions**	**Remarks**
5678.0	51.6519 - 5.0522	On site	Found on shore	Jul 25, 2014	Destroyed	Heavily corroded	JSEODU destroyed object at 261235UTC
5650.0	51.6847 - 5.1516	>2.7km	Found on shore	Feb 15, 2014	Disposed of on land	Heavily corroded	None
5654.0	51.7011 - 5.0511	>2.9km	Found on shore	Mar 1, 2014	Destroyed	Partly corroded	None
2644.0	51.6982 - 5.1189	>3.5km	Other	Oct 23, 2009	Destroyed	Unknown	Located and destroyed by Royal Navy on

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							routine survey duties
2731.0	51.71 - 5.0583	>3.8km	Found on shore	Jan 17, 2011	Destroyed	Unknown	Gas bottle to safe storage @ Pembrokeshire Yacht club by FRS. County Council wiil collect
721.0	51.704 333 - 5.1381 67	>4.5km	Other	Jul 26, 2005	Destroyed	Heavily corroded	None
637.0	51.68 - 4.95	>6.6km	Found on shore	Apr 2, 2005	Disposed of on land	Heavily corroded	Found on farmland at Wrangle. Land was reclaimed from sea in 70s. Land was tilled to a fair depth to harvest potatoes. Land used to be a coastal artillery range.

19.2. 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. This is understood to not be comprehensive. Three EOC tasks are recorded within the east of the study area, on Freshwater West beach. Data related to these tasks is transcribed below.

EOC Tasks on Site				
DBID	**Lat/Long**	**Date**	**UXO live/exploded**	**Notes given**
EOC 2328	51.649906158, -5.0615592003	Jan 31st, 2000	None stated	WWII coastal defences reappearing (barbed wire). Area mined during WWII.
EOC 2488	51.650299072, -5.0616288185	July 10th, 2001	None stated	Dump of wartime barbed wire to be removed by Princes Trust Volunteers; minefields in vicinity.
EOC 4536	51.651721954, -5.0636048317	July 18th, 2001	None stated	None

In addition to these, over 75 EOC tasks are recorded in the 'Danger Area' of Castlemartin range. This includes four tasks in the 'naval aviation bombing range' area adjacent to the study area to the south. Data related to the tasks in this area is transcribed below.

EOC Tasks in Castlemartin Range 'Danger Area'				
DBID	**Lat/Long**	**Date**	**UXO live/exploded**	**Notes given**
EOC 3544	51.641151428, -5.052295208	July 3rd to April 27th 1989	120/1363	At RAC Range, Castlemartin.
EOC 3546	51.636627197, -5.053437233	January 21st to February 1st 1991	19/61	At RAC Range, Castlemartin.

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EOC 3552l	51.639583588, -5.0435171127	January 3rd to April 29th 1996	115/242	At RAC Range, Castlemartin.
EOC 4620a	51.635448456, -5.0468530655	July 7th to August 22nd 1997	74/4976	At RAC Range, Castlemartin.

19.3. Media Reports

Three media reports have been identified relating to naval mine finds in the Milford Haven waterway area, located north of the study area. One of these is 'thought to have been a WWII-era Mark XIX anti-ship mine' according to a spokesman for the coastguard. In addition, a report in 2014 highlights that there had been a 'dramatic increase in the number of wartime bombs unearthed', largely due to storms and flooding. This resulted in double the amount of finds in the South West in comparison to the previous year. These reports are presented in **Annex E**.

19.4. Anecdotal Accounts

Anecdotal evidence has however been provided by the client to suggest that a bomb was discovered and detonated by the EOD within Milford Haven Waterway, to the north of the study site, in recent years. No further information regarding the location and nature of this bomb find was provided.

19.5. Deductions

The documented munition encounter on Freshwater West Beach, as well as several additional encounters across Milford Haven Waterway, could be attributed to the presence of several significant nearby historic military features, such as Pembroke Dock, RAF Angle and RAC Castlemartin Range. These encounters demonstrate the potential for other such items to be present within the region.

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20. 1st Line Defence Risk Assessment

20.1. 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.

20.2. The Risk that the Site was contaminated with UXO

After considering the following facts, 1st Line Defence believes that there is a risk that the location of the study area may have been contaminated with UXO:

- The Castlemartin training area, a 6,000 acre former and current military range, with a danger area extending up to 14 miles, is situated within the immediate surroundings of the easternmost section of the proposed Greenlink route. Predominantly used by the RAC (Royal Armoured Corps) as a tank range, the Castlemartin area has been used extensively by both British and West German armed forces since its requisition in 1938. Its usage is also recorded to include infantry training, such as small arms training and naval aerial bombing, which is indicated to have taken place within an area immediately bordering Freshwater West Beach.
- The presence of Castlemartin range significantly increases the likelihood that items of Allied ordnance could have been expended, through training exercises, or discarded, through poor housekeeping within the easternmost section of the study area. This includes the section at Freshwater West Beach and the surrounding offshore danger area. Such items will include LSA and SAA but may also include larger, aerially delivered bombs, due to the presence of an air to land training. EOC tasks undertaken within Castlemartin range in the 1980's and 1990's are documented to have recovered thousands of expended items of ordnance and hundreds of live items.
- The island of Grassholm, approximately 7km to the north, is also recorded as a training range during WWII and was used by the USAF (Unites States Air Force) for target practice. The presence of the former Grassholm range is considered to have had less of an impact than Castlemartin though US aerially deployed ordnance, such as practice bombs, deployed in its surroundings waters could have migrated within the study area.
- An extensive British mine area, believed to comprise over 6,000 mines and several significant minefields, was laid in the St George's Channel in 1940 to protect naval and merchant shipping in the Irish Sea from German U-boat attacks. Historical mine mapping of UK waters shows the former location of this mine area to include a significant portion of the western/Irish side of the study area. References to several smaller minefields, including a WWI-era German minefield and two WWII-era German minefields have been found on and in the general proximity of the eastern/Welsh side of the study area. These appear to have been deployed to restrict British naval activity originating from important military sites at Milford Haven and Pembroke Dock.
- A precise assessment of the current risk from mines within the St Georges Channel is difficult to ascertain. Efforts were made by the Royal Navy at the end of the war to clear/make safe mined areas. However, such clearance tasks are not considered to guarantee the complete

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removal of all mines within a danger area, especially if such items have the potential to migrate or became covered due to sediment and tidal action over a period of time. It is therefore not possible to discount the possibility of encountering surface or submarine laid sea mines across any location of the study area.

- 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, off the coastlines of both Ireland and Wales, and often demonstrate the presence of both sea mines and torpedoes during WWI and WWII. The majority of these wrecks are also British cargo ships, though military vessels are recorded within the area during both world wars, including an unnamed German warship in 1917, the German submarine UC-44 in 1917, the British warship HMS Arbutus in 1917 and the British warship HMS Minicoy in 1941. 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 and anti-submarine weaponry were commonly deployed in the waters around Britain on account of German U-Boat activity during both world wars. The Irish Sea, including the St George's Channel was particularly affected by U-boats during WWI due to the high volume of merchant shipping travelling to and from important docks such as Liverpool and the Clyde from the south-west approaches, leading the region to be subsequently dubbed 'U-Boat alley'. Anti-submarine weapons, most commonly depth charges, were deployed by Royal Navy vessels to combat this threat, with Hedgehog and Squid spigot mortars put into operation from 1942. Although generally deployed in low numbers when compared to other types of munitions, it is not possible to discount the presence of such items at the site location, due to their recorded usage in the wider area.
- Three munitions dumps are recorded within the wider surrounding area, off the Pembrokeshire coastline. These are believed to have operated in conjunction with surrounding military sites and to have been used in the immediate post period. These dumps are not anticipated to pose a significant risk to the study area, unless its location is altered and situated on or in their immediate proximity. It is also possible that dumped munitions may have either been deposited outside the designated areas or have else migrated within the region over time.
- The likelihood of encountering historic Allied ordnance, such as Land Service Ammunition (LSA) and Small Arms Ammunition (SAA) is considered to be elevated within the sections of the study area on and surrounding the former premises of RAF Angle or any coastal defences. This is because of the presence of a number of features associated with ordnance usage and disposal, such as pillboxes, ranges and ammunition stores and the potential for poor housekeeping, whereby items of ordnance were buried, burnt or otherwise disposed of unrecorded. EOC reconnaissance tasks undertaken in 2000 and 2001 also refer to 'WWII-era coastal defences (barbed wire) reappearing' on Freshwater West Beach and suggest that the area was mined during the war.
- The easternmost section of the study area was situated within an area of Wales that sustained a very low density of bombing throughout the war. Bombing within the rural areas of Pembrokeshire were generally isolated incidents and the result of Luftwaffe bombers travelling to and from more significant targets within the wider region. This infrequency of incidents, combined with the nearby presence of RAF Angle, increases the probability that any bomb strikes within the Freshwater West area would have been recorded and any signs of UXO investigated. It is not possible however to completely discount the possibility of such incidents going unnoticed because of the open, rural nature of the groundcover of Freshwater West and its surrounds.
- Likewise, it is not anticipated that a significant number of aerial bombs were deployed within the St Georges Channel, though several attacks on merchant shipping are recorded within more central areas in 1940 and 1941. Any bombs falling during such raids are not likely to have been well observed or investigated and thus the possibility that aerially delivered UXO

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may be present within offshore areas also cannot be discounted, though again the likelihood is not considered to be high.

- The risk from items of air delivered UXO within the westernmost section of the site, within the Irish mainland, is considered to be negligible. The Republic of Ireland was never subject to a targeted bombing campaign during WWII and instead only sustained bombing by the Luftwaffe on a handful of isolated occasions, none of which are recorded within the study area.
- Based on these findings it has only been possible to confidently reduce the risk from UXO within the section of the study area situated in the Irish mainland, on the Hook Head peninsula. There is a potential risk of encountering UXO across the remainder of the site location, which is significantly elevated on and surrounding the eastern end at Freshwater West, due to the presence of the Castlemartin Training Area and the former RAF Angle.

20.3. 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. However, no evidence could be found during the production of this report to suggest that any significant or regular dredging operations have occurred in the study area, increasing the likelihood of UXO remaining in situ.

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 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 works area. As physical processes, such as currents and tidal action can result in UXO being moved significant distances from their point of origin.

20.4. 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:

20.4.1. Historical Context

1st Line Defence has identified several potential historical sources of UXO contamination within the proposed Greenlink 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. A more significant risk from Allied Land Service Ammunition (LSA) of various age and calibre has been identified in the area surrounding Freshwater West. This site history will also affect the prospective distribution and positions of items of UXO, as well as its initiation failure rates.

20.4.2. 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.

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20.4.3. 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 survey campaign and the subsequent cable installation. Intrusive works within the marine survey includes geotechnical sampling, consisting of vibrocore and cone penetration tests and seabed sampling, consisting of environmental grabs. Trial pits and boreholes are proposed within the landfall survey.

Intrusive activities during the subsequent cable installation include the usage of pre-lay grapnel runs and removal ploughs to clear boulders and debris; 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.

20.5. 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.

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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.

20.5.1. 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.

20.6. 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.

20.7. 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 risk across the Greenlink route has therefore been divided into the following four areas, which are outlined in **Appendix i**.

Section 1: The Irish Mainland

Ordnance Type	Risk Level			
	Negligible	Low	Medium	High
Air Delivered Bombs		✓		

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

Section 2: West and Central Offshore Area

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		✓		
UXO from Wrecks/Crashed Aircraft		✓		
Munitions Dumpsites		✓		

Section 3: Eastern Offshore Area (including the Castlemartin Danger Area)

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		✓		
UXO from Wrecks/Crashed Aircraft[3]		✓		

[3] *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.*

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Munitions Dumpsites[4]		✓	

Section 4: The Welsh Mainland

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

21. UXO Risk Mitigation

21.1. General

This report has concluded that there is a risk from unexploded ordnance along the proposed Greenlink route corridor. The risk has been broadly split into four different zones with slightly varying risks:

- Irish mainland – no significant risk of UXO identified.
- Western and central offshore – primary risk is from larger items of ordnance, mainly sea mines.
- Eastern offshore –risk from both larger items such as sea mines and from smaller items such as LSA and SAA. (The smallest item of LSA is anticipated to be a three pounder projectile.)
- Welsh mainland – risk from LSA, SAA and UXB's identified.

21.2. Offshore UXO Risk Mitigation

It is recommended that the proposed cable route and areas subject to intrusive investigation techniques (any time when the seabed is being affected) are subject to a UXO survey to identify targets which might be UXO related. It is understood that various survey techniques are already proposed along the survey corridor including side scan sonar and magnetometer survey. It is recommended that these surveys be designed with sufficient resolution to allow for the detection of large items of ordnance across the entire length of the route such as sea mines, bombs and torpedoes. If there is the potential for larger items to become buried due to localised sea bed conditions/sediment, then a magnetometer survey in these areas would be especially recommended. 1st Line Defence would recommend the use of Geometrics G-882 marine magnetometers used in an array. This equipment can detect an item the size of a grenade (similar to a 3 pounder projectile) at 3m (0.5 to 2 nT).

Any anomalies detected with the potential to be UXO related should be inspected as part of an ROV video survey to identify them. If they are found to be UXO related, they can either be avoided or if necessary, moved or disposed of remotely.

Smaller items such as projectiles and other items of LSA pose a lesser risk if encountered on the sea bed, and are generally too small to be detected by most survey techniques except visual. These types of items are most likely to be present in the far eastern end of the route, in the vicinity of the firing

[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.*

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range and munitions dumps. The main concern regarding smaller items of UXO is if they come into direct contact with personnel – for example if brought on-board on equipment deployed on the seabed, or incorporated within seabed sediment samples. For this reason, it would be prudent to have a UXO Specialist present on board to check over any equipment brought on deck and to check and identify any suspect items found within sediment samples. A UXO Specialist on-board can also review any ROV video footage undertaken to identify any potential UXO on the seabed.

21.3. Onshore/Nearshore UXO Risk Mitigation

Because no significant risk has been identified at the Irish mainland, is it not recommended that any proactive risk mitigation measures are necessary on the landward side at this end beyond UXO Safety and Awareness Briefings.

For onshore/foreshore works at the eastern end of the route, it is recommended that proactive support is provided. It is recommended that trial pits are supported by a UXO Specialist and that all proposed boreholes are subject to a magnetometer survey. All operatives should receive UXO Safety and Awareness Briefings. It may be viable to undertake a non-intrusive magnetometer survey and target investigation on the beach area for the cable trench as it goes onshore.

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 **15th April 2019**

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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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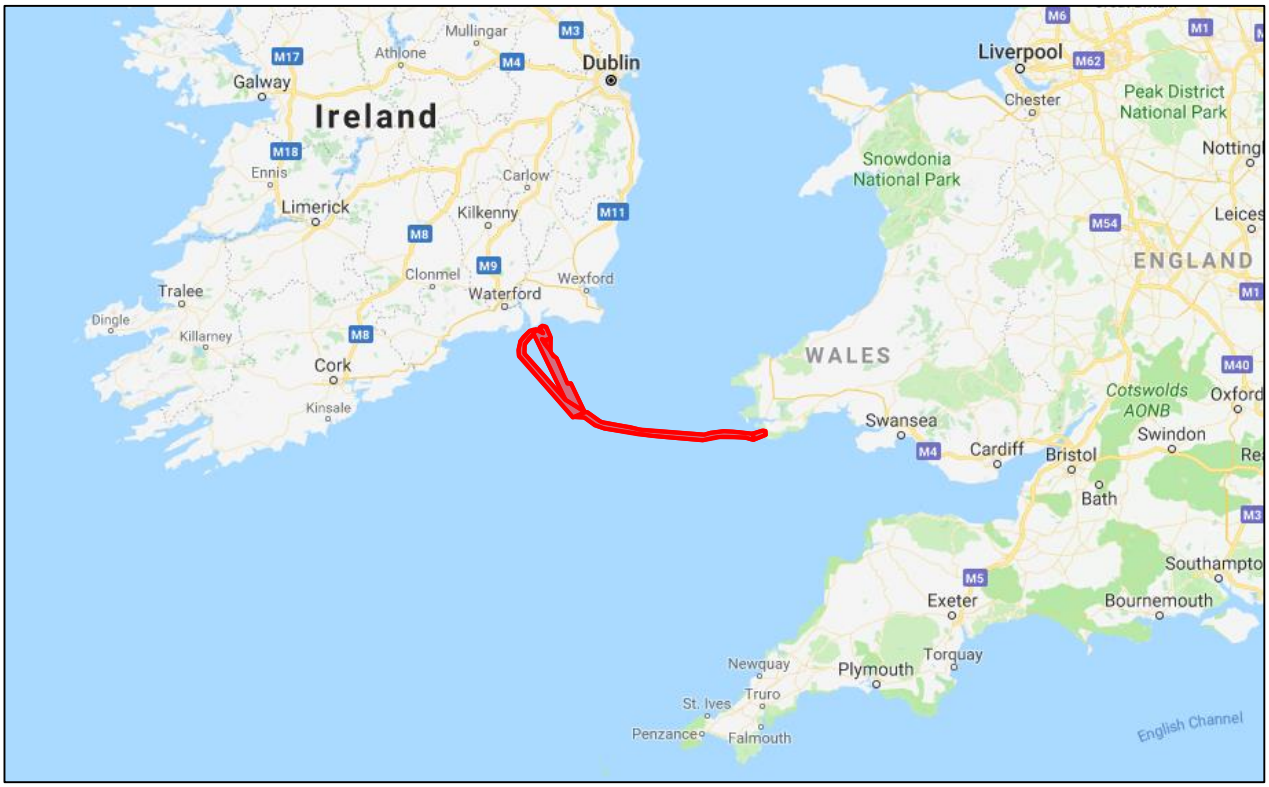
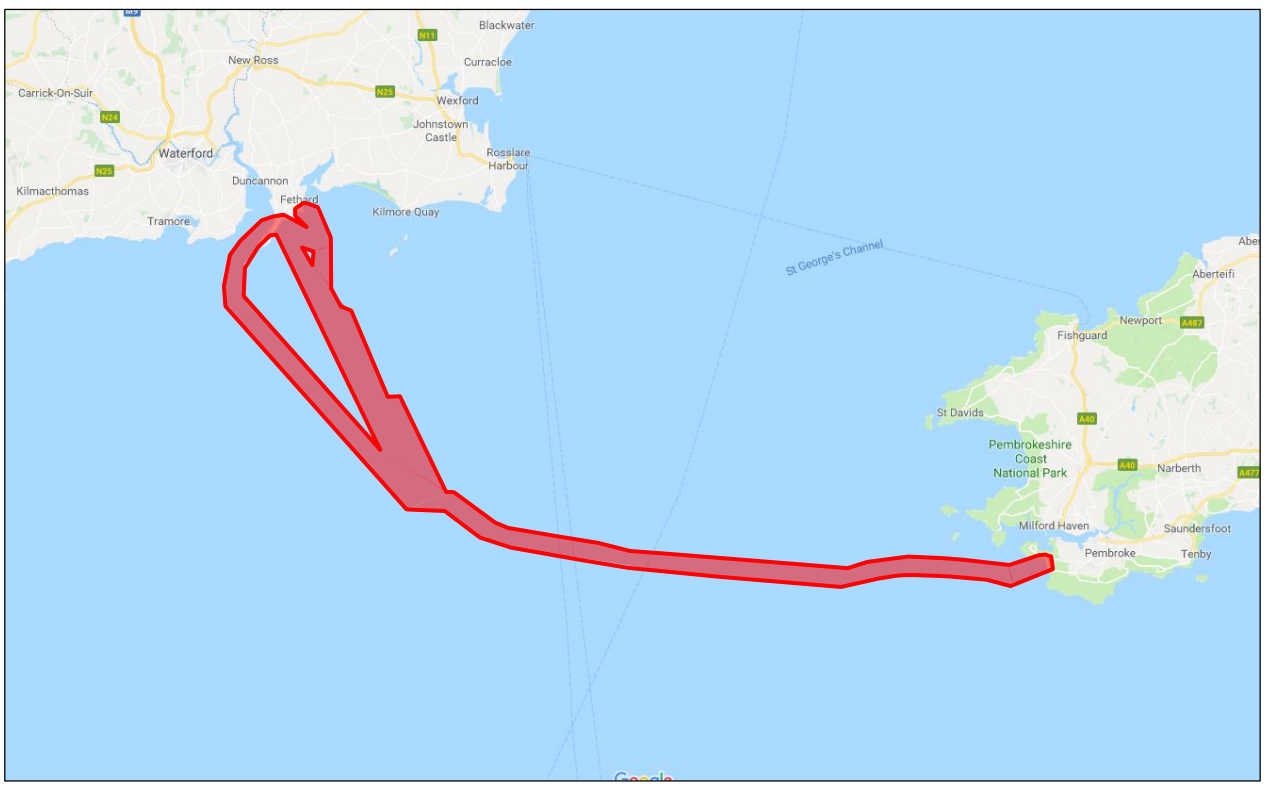
Study Area Location Maps

Annex: **A**





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Project: **Greenlink**

Ref: **DA2985-01**

Source: Google Maps

Approximate study area

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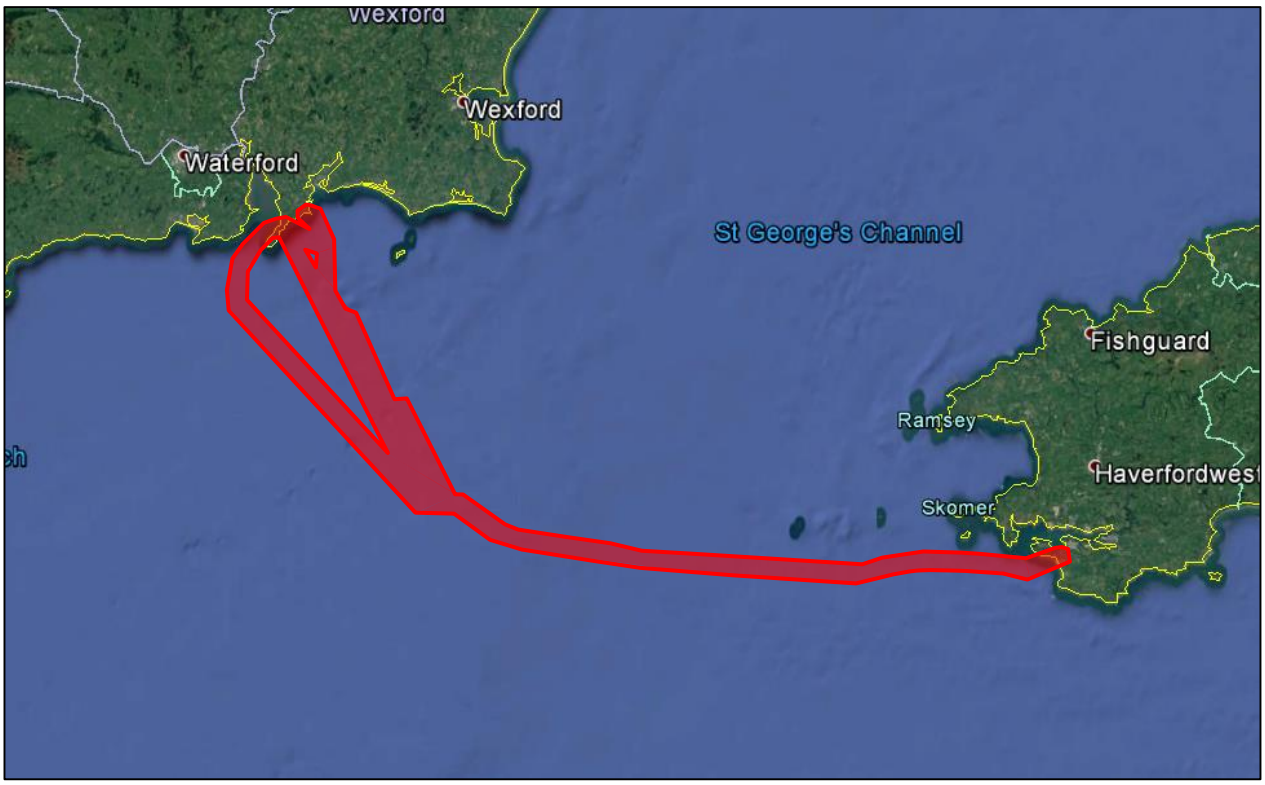
Recent Aerial Photography

Annex: **B**



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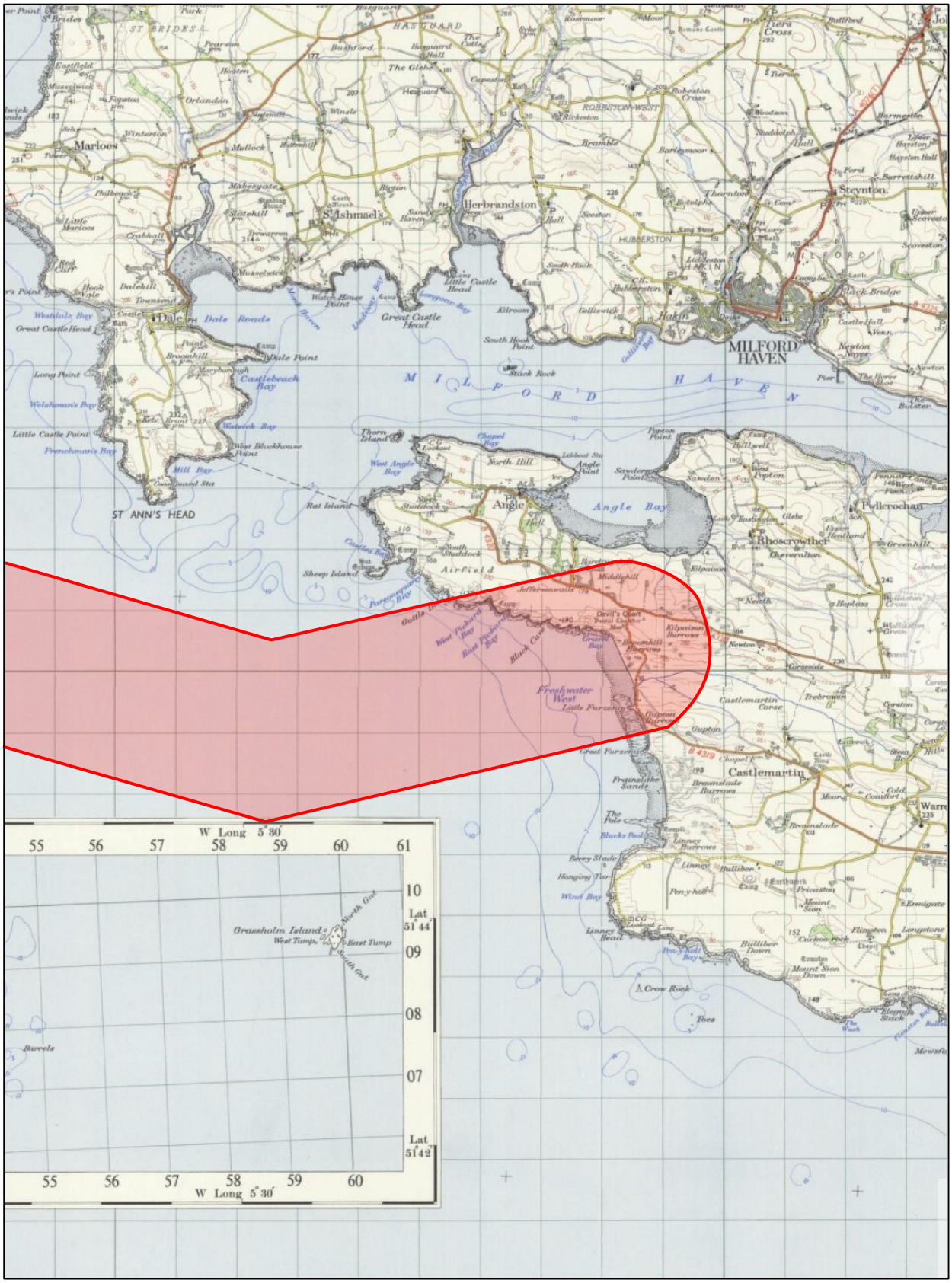
1952- 1961 Historical Map

Annex: C1



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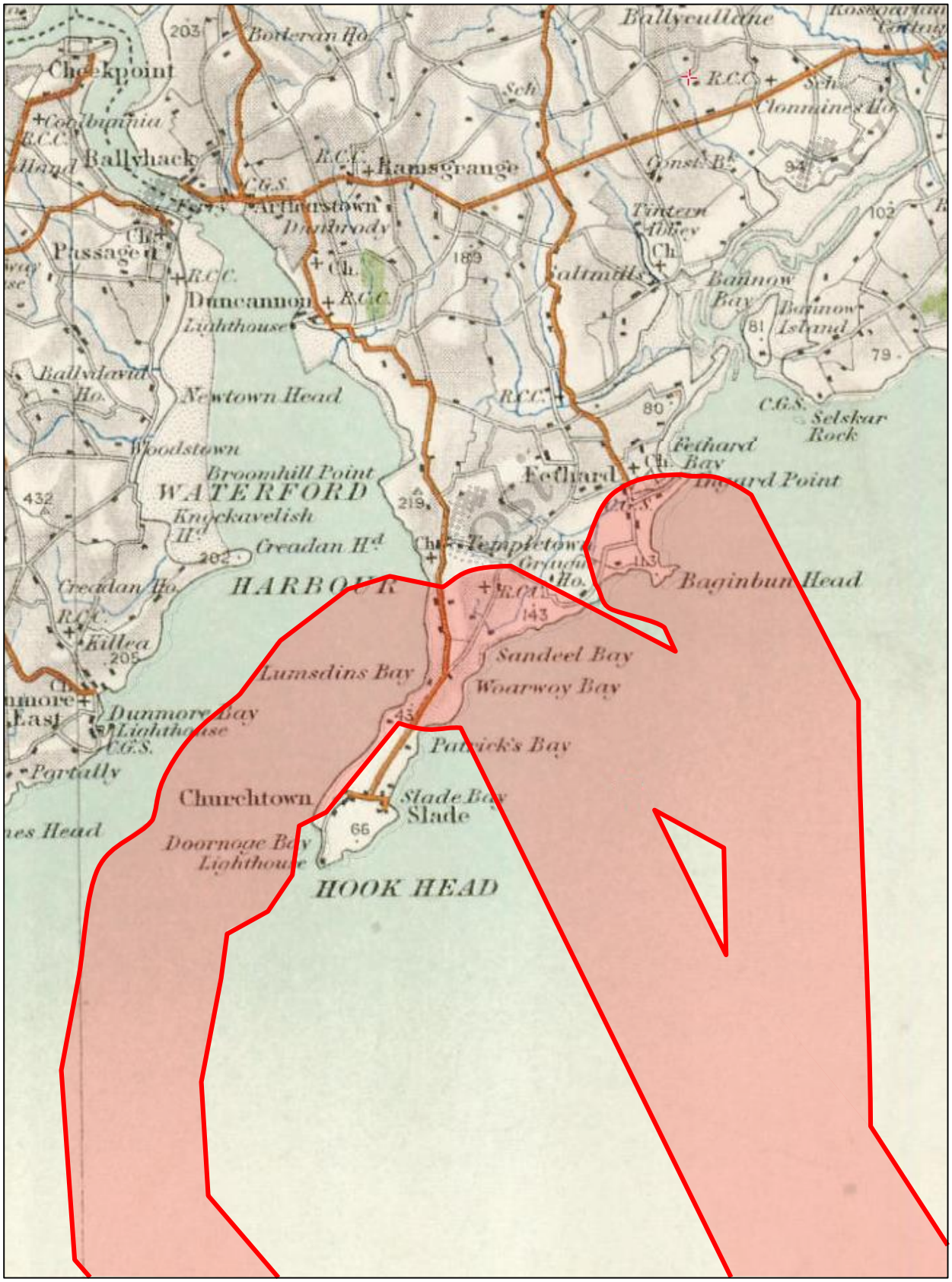
1940 Historical Map

Annex: **C2**



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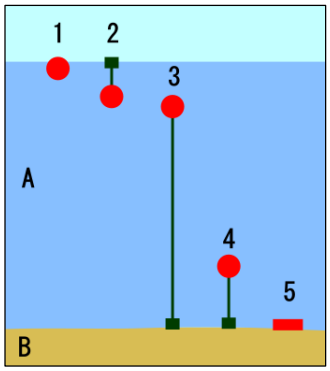
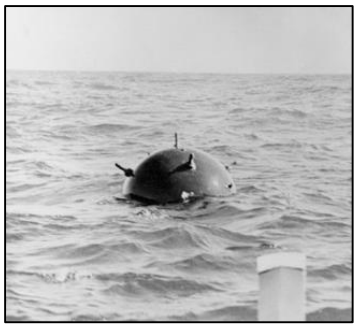
1. Position in the Water

- **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.

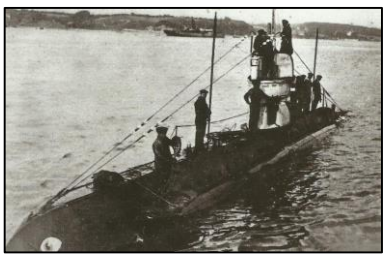




Top left: Diagram displaying mine types. A: Underwater, B: Sea bed 1/2: Drifting Mine, 3/4: Moored Mine, 5: Bottom Mine.
Top right: Photograph of drifting mine. Left: Bottom mine.

2. Delivery Method

- **Aircraft-laid mines** were deployed in the same manner as other aerial delivered items of ordnance, see S**ection 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**.

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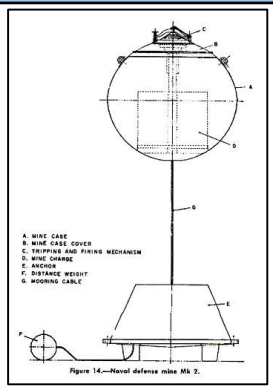
Contact mines

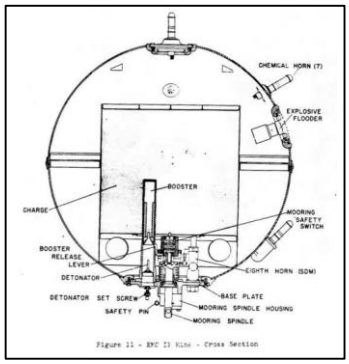
- Earliest form of naval mines used throughout both WWI and WWII. Contact mines need to be touched by the target to detonate, which limits the damage usually to vessel that triggers them. These were used primarily for defensive purposes, such as in the Royal Navy's defence of the English Channel.
- The 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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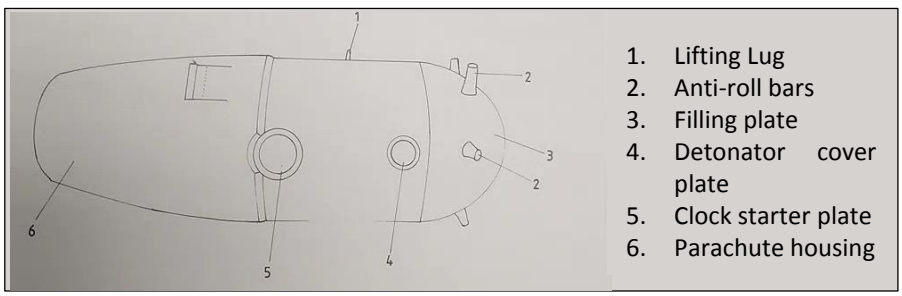
Influence mines

- 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.

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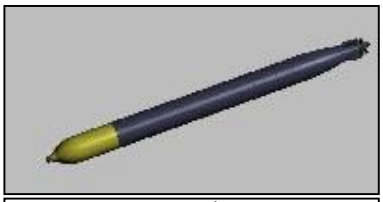
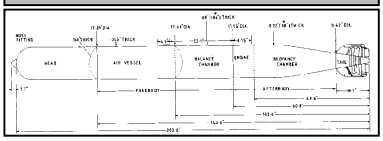
Examples of Torpedoes

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.

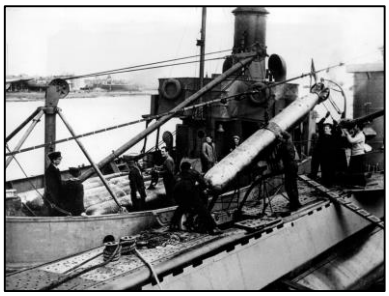




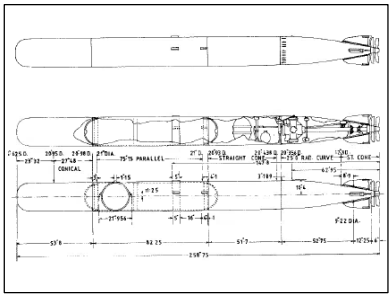
Left: A Mark XII torpedo fitted to a Bristol Beaufighter. Top right: Model of the torpedo. Bottom left: schematics.

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).



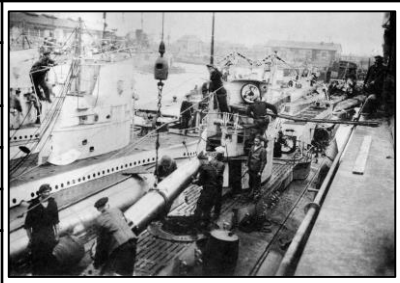
Mark VIIIs loading to Polish Navy submarine ORP Sokół



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.

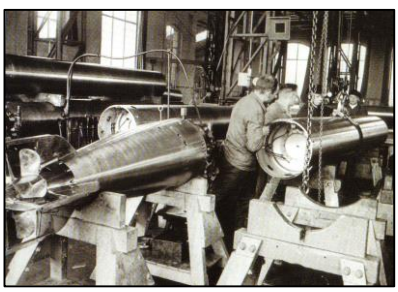


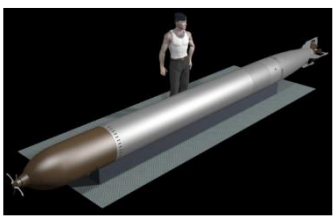
Loading torpedoes aboard a U-Boat of the German Flanders Flotilla at Bruges

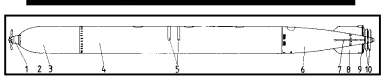
A German Flotilla in port.

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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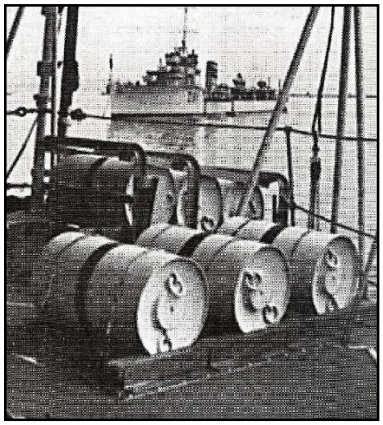
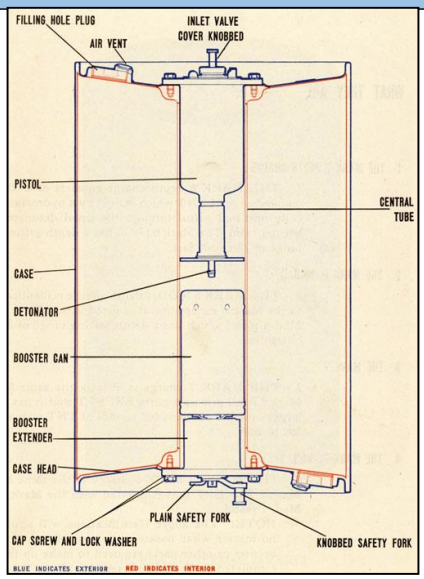
Examples of Anti-Submarine Weapons

Annex: D5

Depth Charge. Mk VII

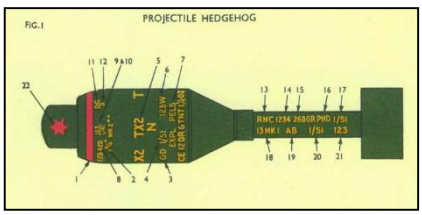
Shape	Cylindrical, drum shaped
Explosive Weight	132 kg
Fuze Type	Hydrostatic pistol
Dimensions	70 cm long, 45 cm diameter
Use	Amatol charge was estimated to be capable of splitting a 2.2 cm submarine pressure hull at a distance of 6.1 m. Torpex (or Minol) explosives used post 1942 were reported to increase 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.





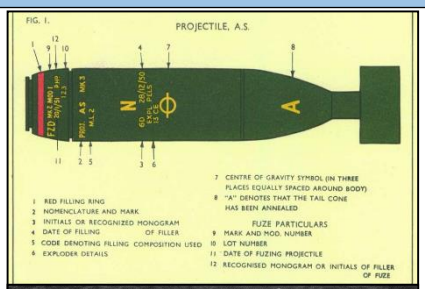
"Hedgehog" Spigot Mortar

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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Project: **Greenlink**

Ref: **DA2985-01**

Source: Various sources

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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

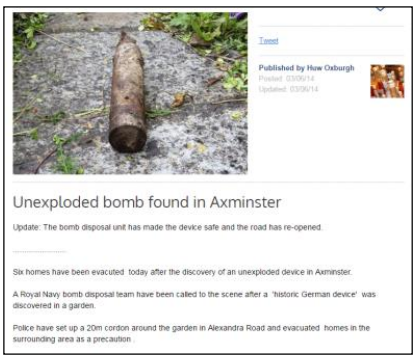
by Aidan Barlow abarlow@thekmgroup.co.uk 08 July 2015

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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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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23rd October 2009

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NEWS LIVE BBC NEWS CHANNEL

Page last updated at 18:23 GMT, Friday, 23 October 2009 19:23 UK

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WWII naval mine found near port

A routine survey exercise of the Milford Haven waterway has uncovered a World War II naval mine.

Milford Haven port will be temporarily closed while the mine is made safe

The discovery was made by the Royal Navy as it scoured the seabed on the approach to the haven.

Officials say the mine poses no threat to shipping, however the port will be temporarily closed while the unexploded device is made safe.

Milford Haven Port Authority said the Royal Navy was now co-ordinating efforts to dispose of the old mine.

Milford Haven port is the largest in Wales, and home to a giant liquefied gas terminal and petrochemical plants.

During WWII, Milford Haven port was an important naval base, playing a major role in the D-Day landings.

It was also a target for German naval mines, leading to an Australian naval officer, Leon Goldsworthy being awarded the George Cross in 1944 after he defused an acoustic mine that had been in the waterway for more than two years.

12th June 2012

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Milford Haven: WWII mine in waterway blown up

12 June 2012 Share

Bomb disposal experts have carried out a controlled explosion on a German World War II mine found by a diver near Milford Haven port in Pembrokeshire.

The controlled explosion took place shortly after 17:00 BST on Tuesday

The device was discovered on the bed of Milford Haven waterway just off Watwick Point, near Dale, at the weekend.

The controlled explosion took place late on Tuesday afternoon.

Milford Haven Port Authority worked with the coastguard, police and a Royal Navy bomb disposal team.

Two port authority patrol boats and two police patrol boats were sent to the area to ensure people remained safe during the detonation.

The authority also issued a navigational warning for all sailors.

Earlier, it said three ships were due to sail out of Milford Haven before the controlled explosion.

The authority said it understood the coastal path around Watwick Point was closed temporarily while the mine was disposed of.

18th February 2014

Western TELEGRAPH

WWII mine found on beach

BIG BANG THEORY: Bomb disposal crews visited Watwick Beach after a suspected mine was discovered.PICTURE: Gareth Reynolds

THE discovery of a suspected bomb at Watwick Bay, near Dale, on Saturday (February 15) led to the beach being cordoned off by police.

Surfer Ryan Sheppard, from Milford Haven, had been making the most of the first sunny day all week when he and his friend Gareth Reynolds discovered two suspicious objects on the beach.

A controlled explosion of one of the items was carried out by Explosive Ordnance Disposal (EOD) early on Sunday morning, covering the beach in shrapnel.

A spokesman for the coastguard said the detonated object is thought to have been a Mark XIX anti-ship mine, used in the Second World War.

28th February 2014

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NEWS

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Science & Environment

Storms and floods unearth unexploded wartime bombs

By Claire Marshall
BBC environment correspondent

28 February 2014 Share

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

The storms have uncovered a lethal past

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.

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.

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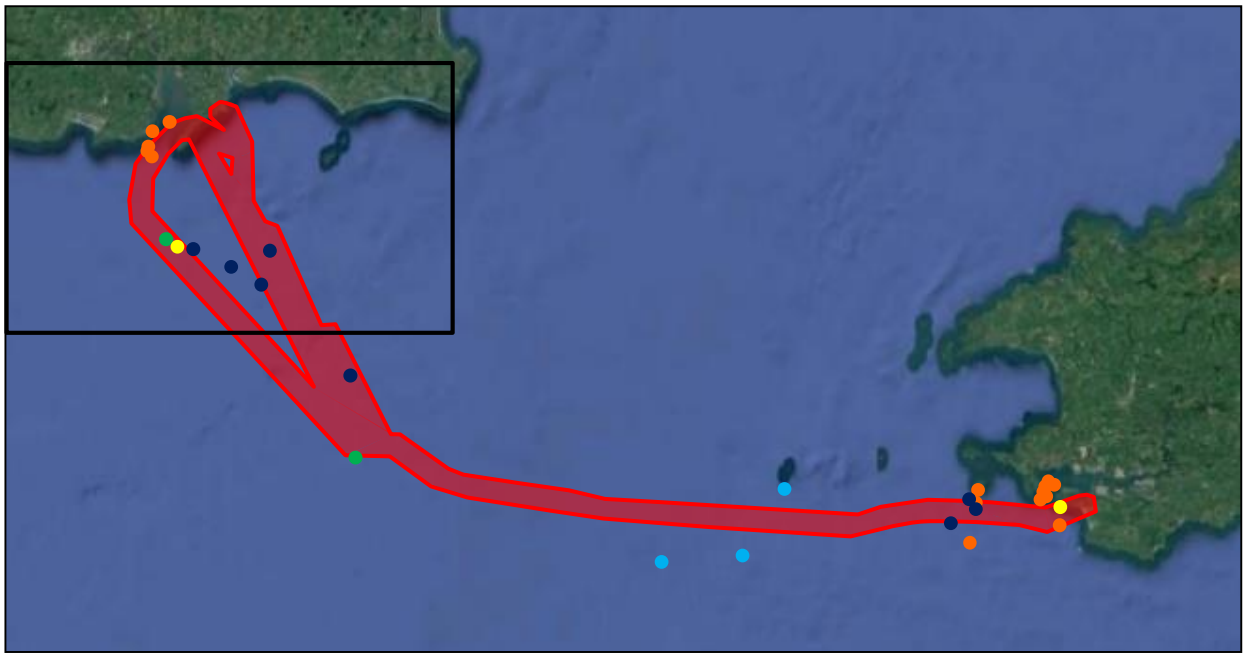
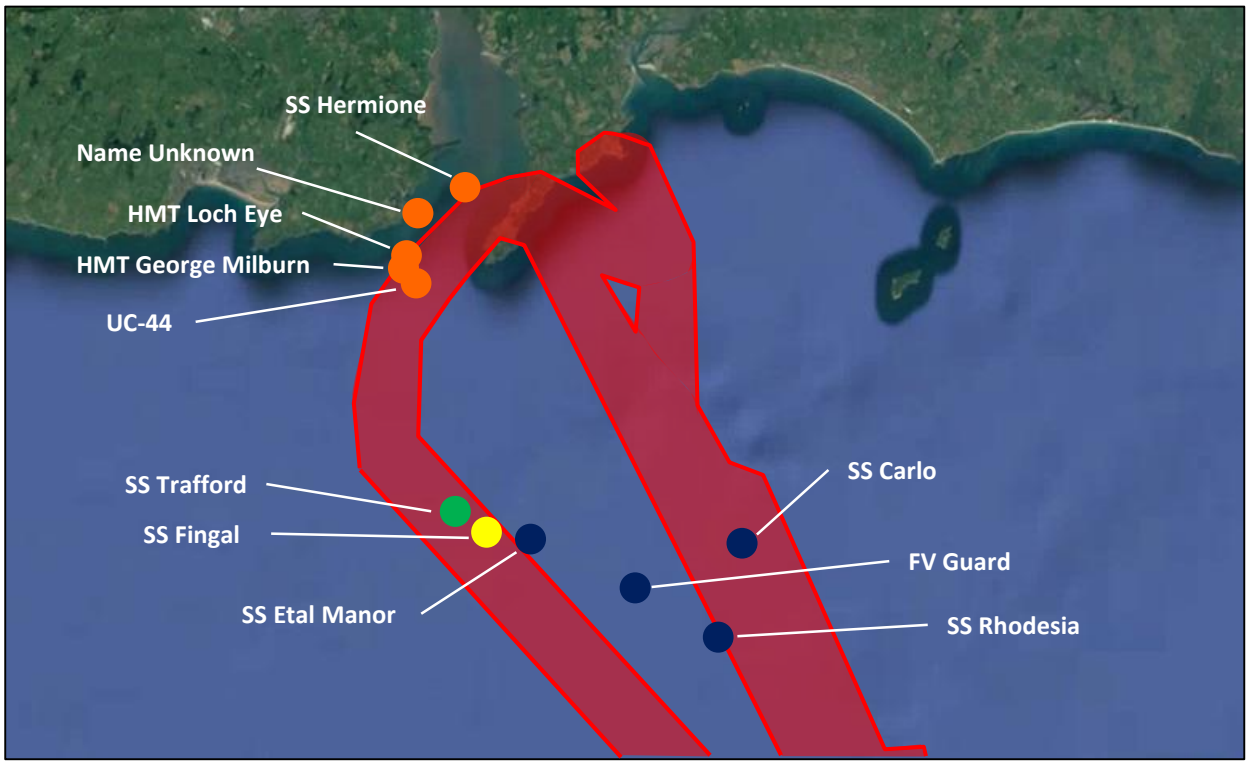
Overlay of Wreck Sites – Irish Waters

Annex: **F1**





Key:

Mine | Torpedo | Gunfire | WWII-era air raid

WWI/WWII-era wreck – brought down in circumstances unrelated to explosive ordnance

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Approximate study area

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Project: **Greenlink**

Ref: **DA2985-01**

Source: Wrecksite.eu

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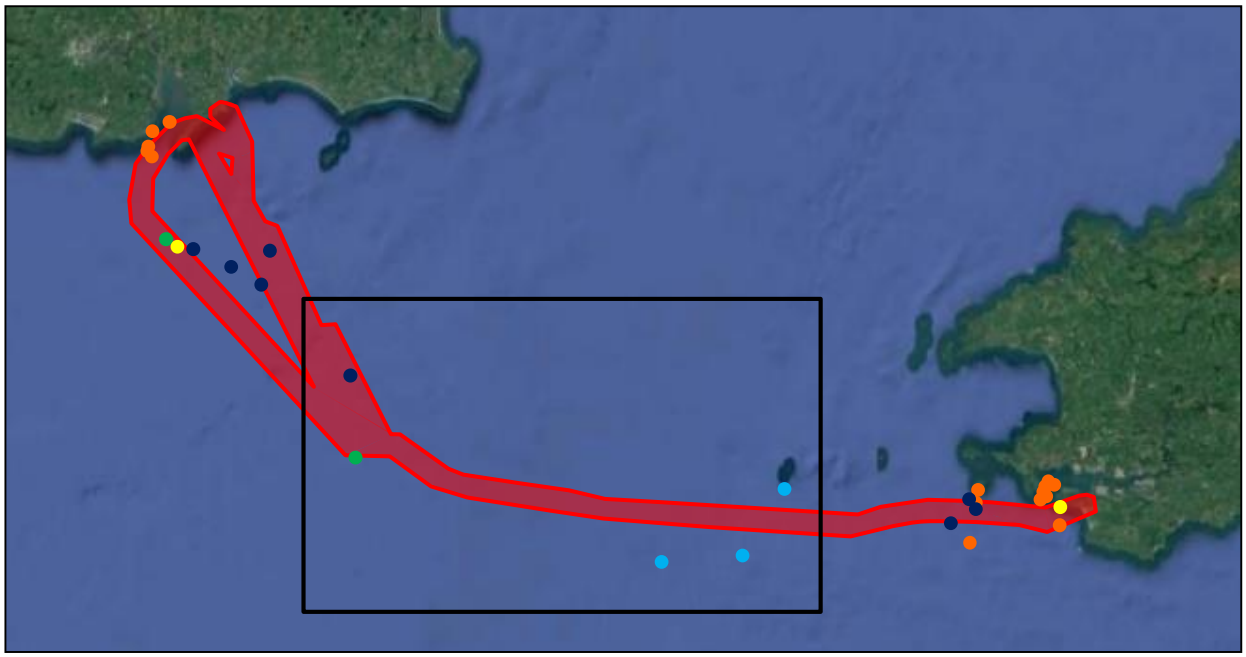
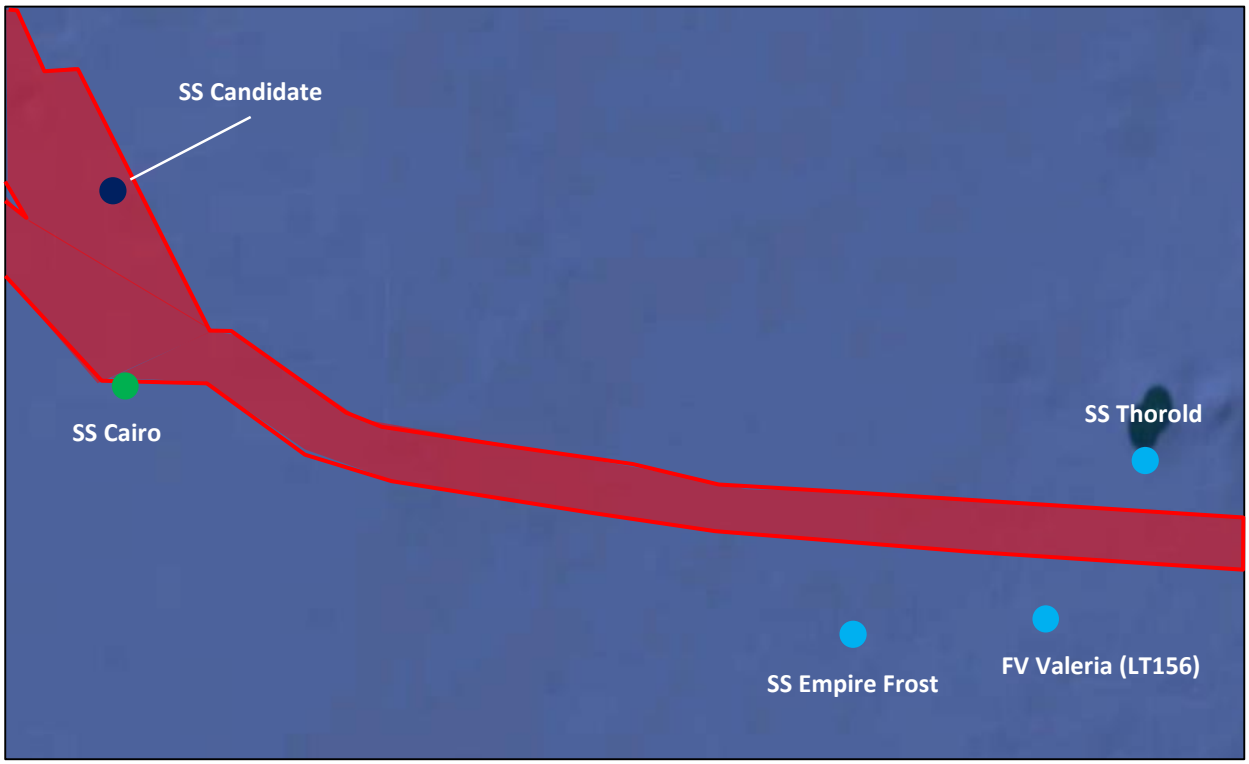
Overlay of Wreck Sites – Intervening Waters

Annex: **F2**





Key:

Mine | Torpedo | Gunfire | WWII-era air raid

WWI/WWII-era wreck – brought down in circumstances unrelated to explosive ordnance

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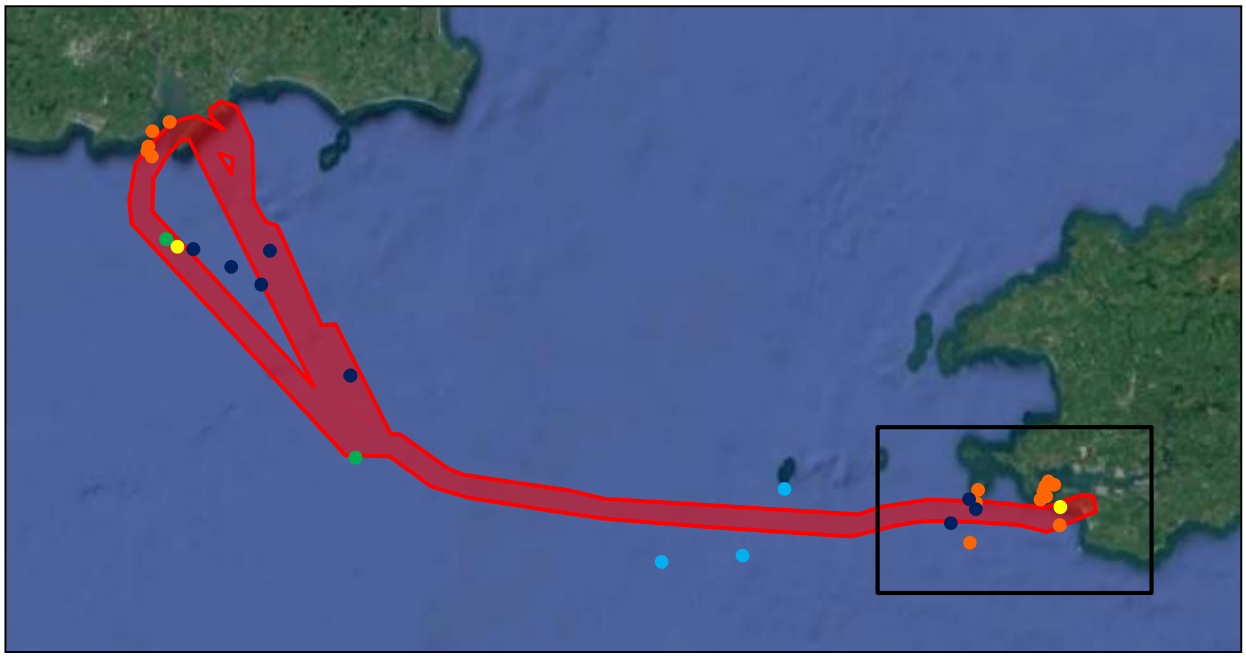
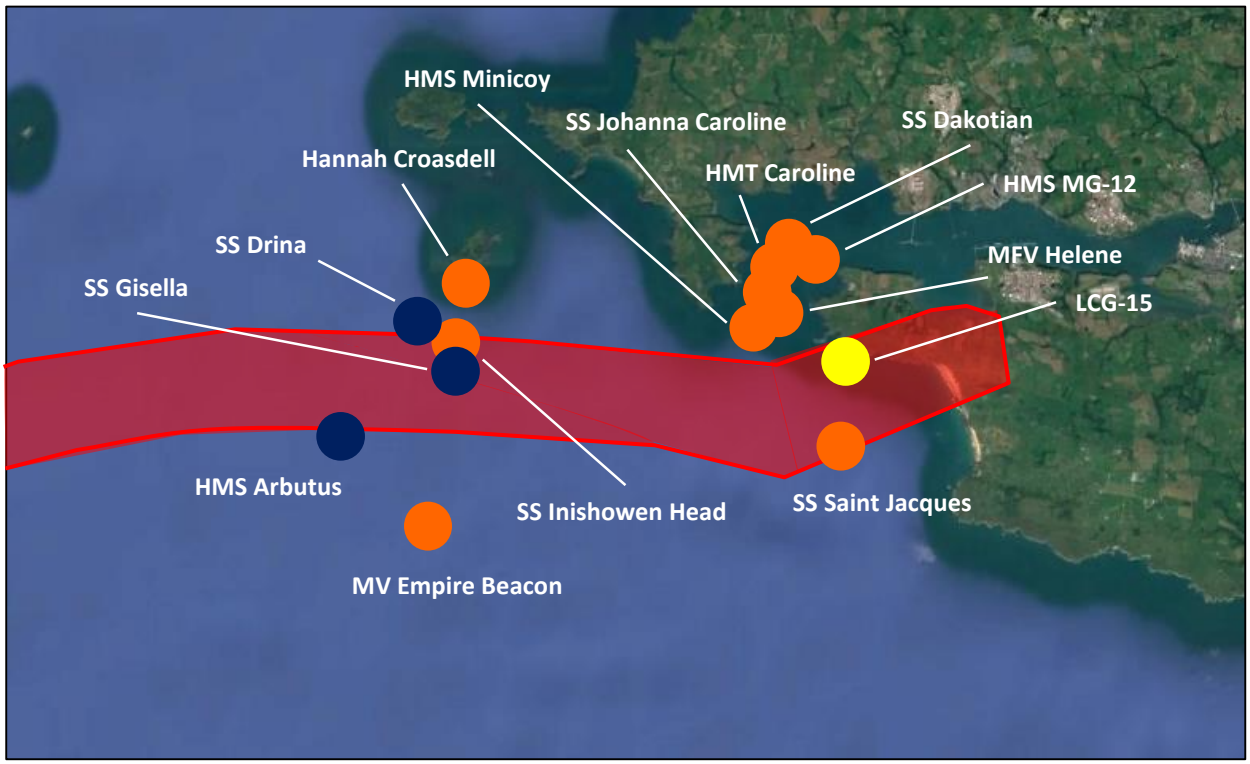
Overlay of Wreck Sites – Welsh Waters

Annex: **F3**





Key:

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WWI/WWII-era wreck – brought down in circumstances unrelated to explosive ordnance

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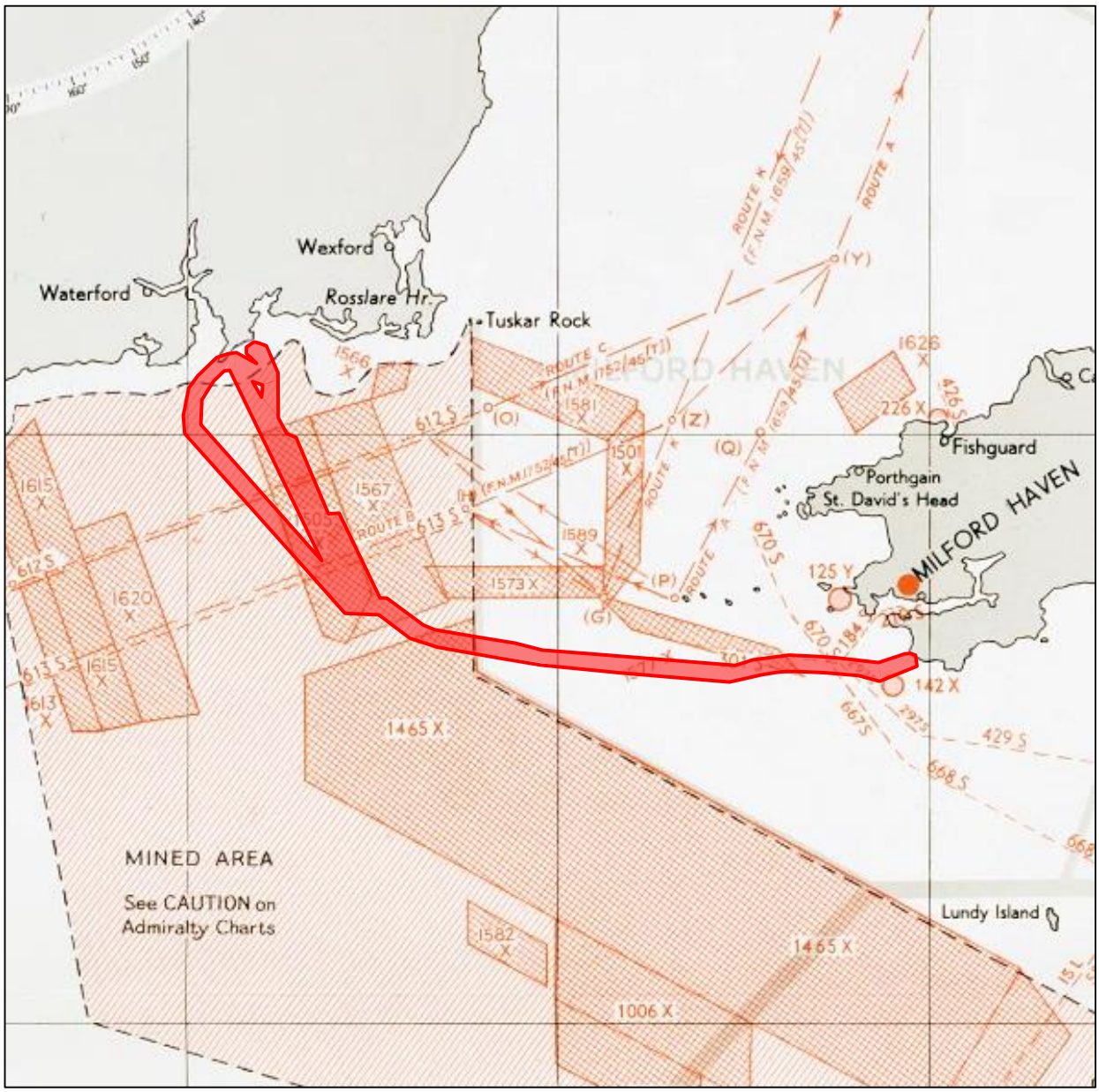
Offshore Minefield Map

Annex: **G1**



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)

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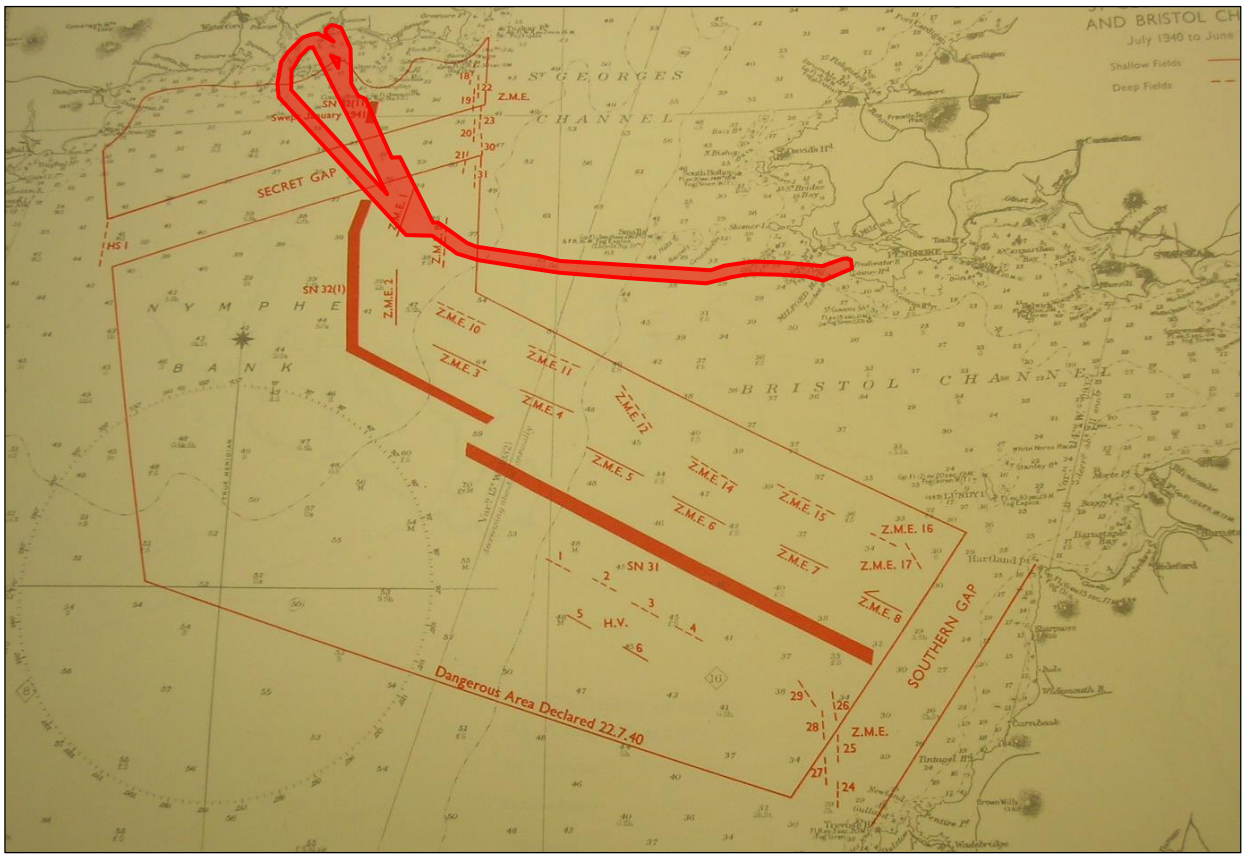
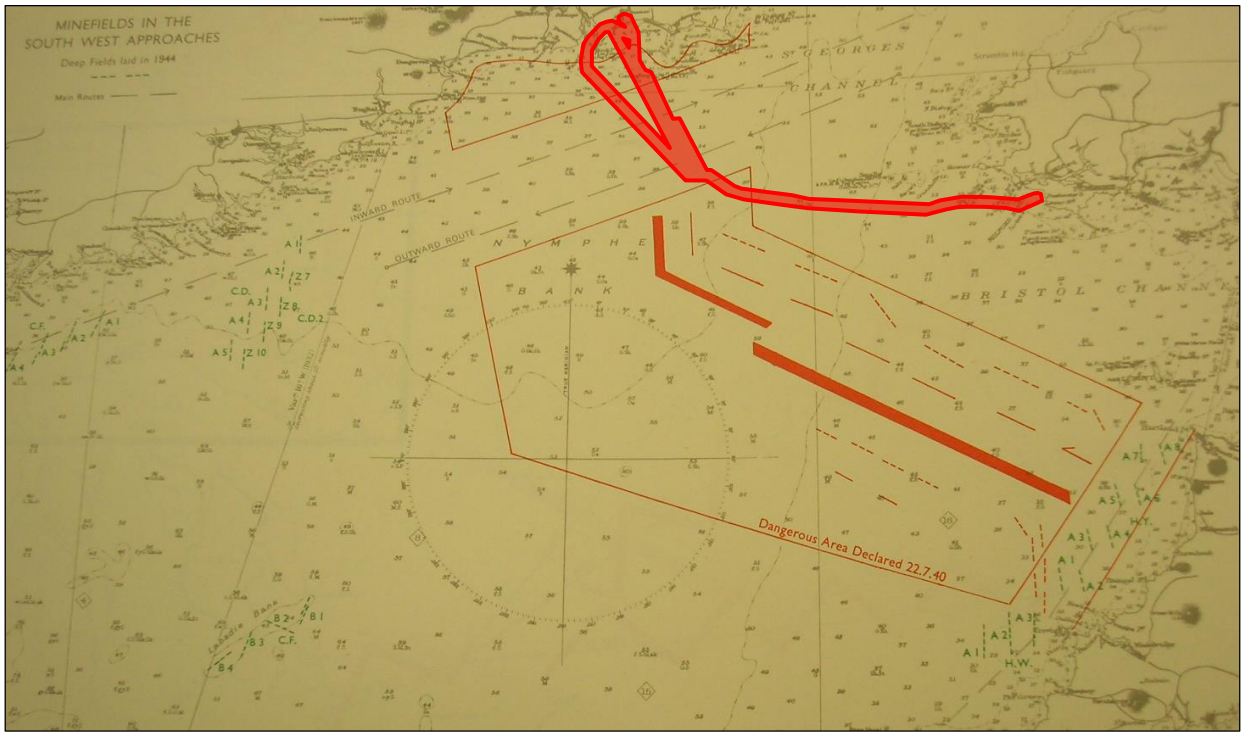
July 1940 to June 1943



1944



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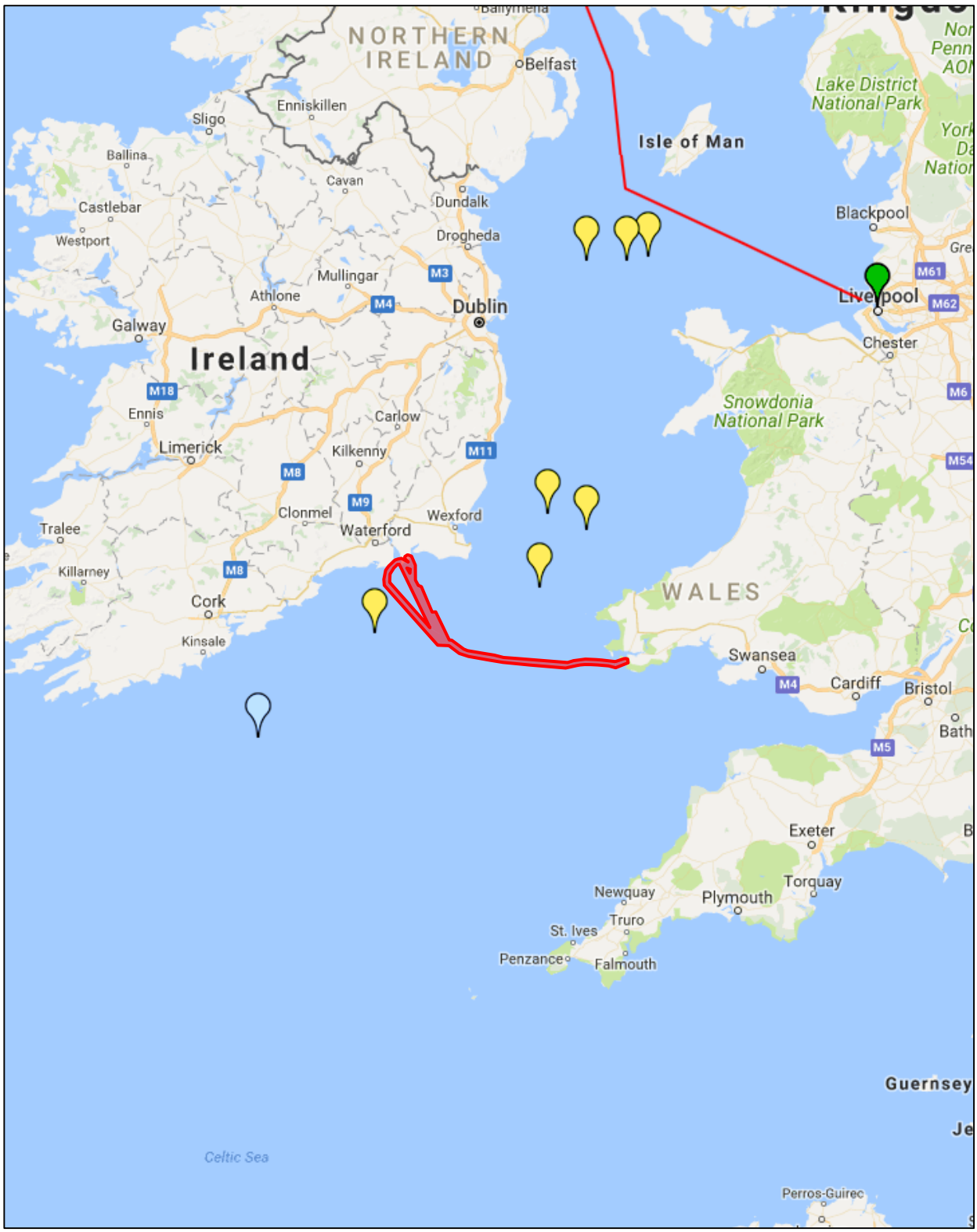
Overlay of U-boats lost in the Irish Sea in WWII

Annex: H



Key:

1940 1944 1945

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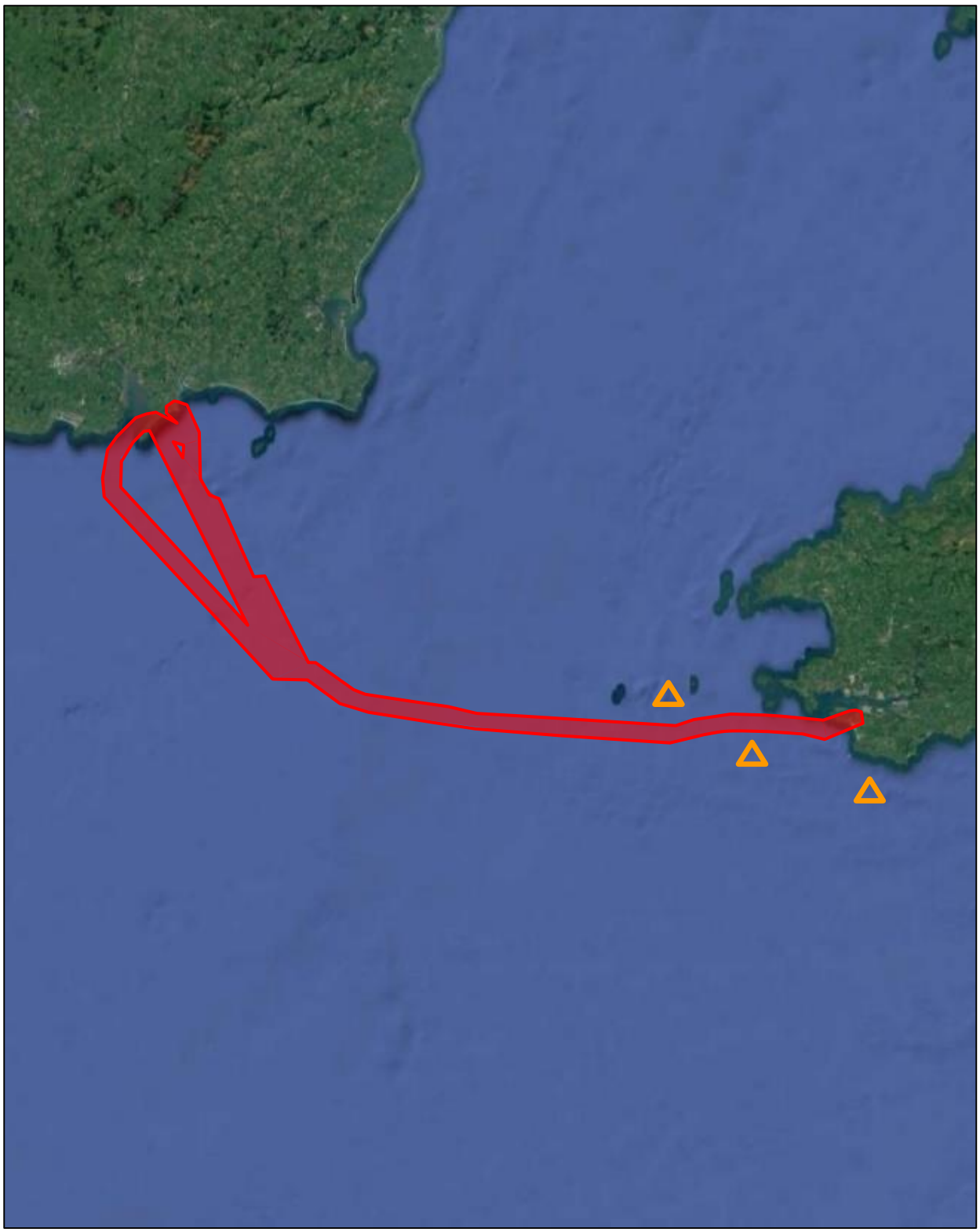
Overlay of Conventional Munitions Dumpsites

Annex: I



Key:

Conventional Munitions Dumpsite

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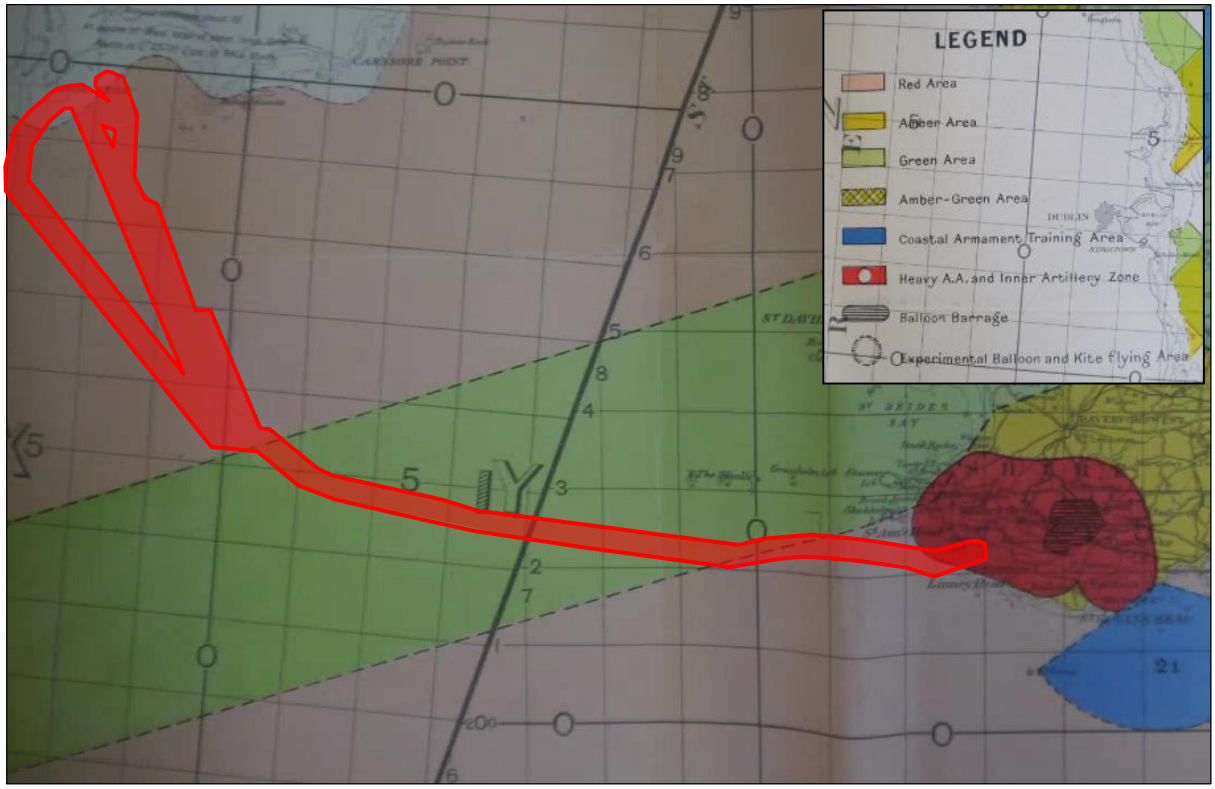
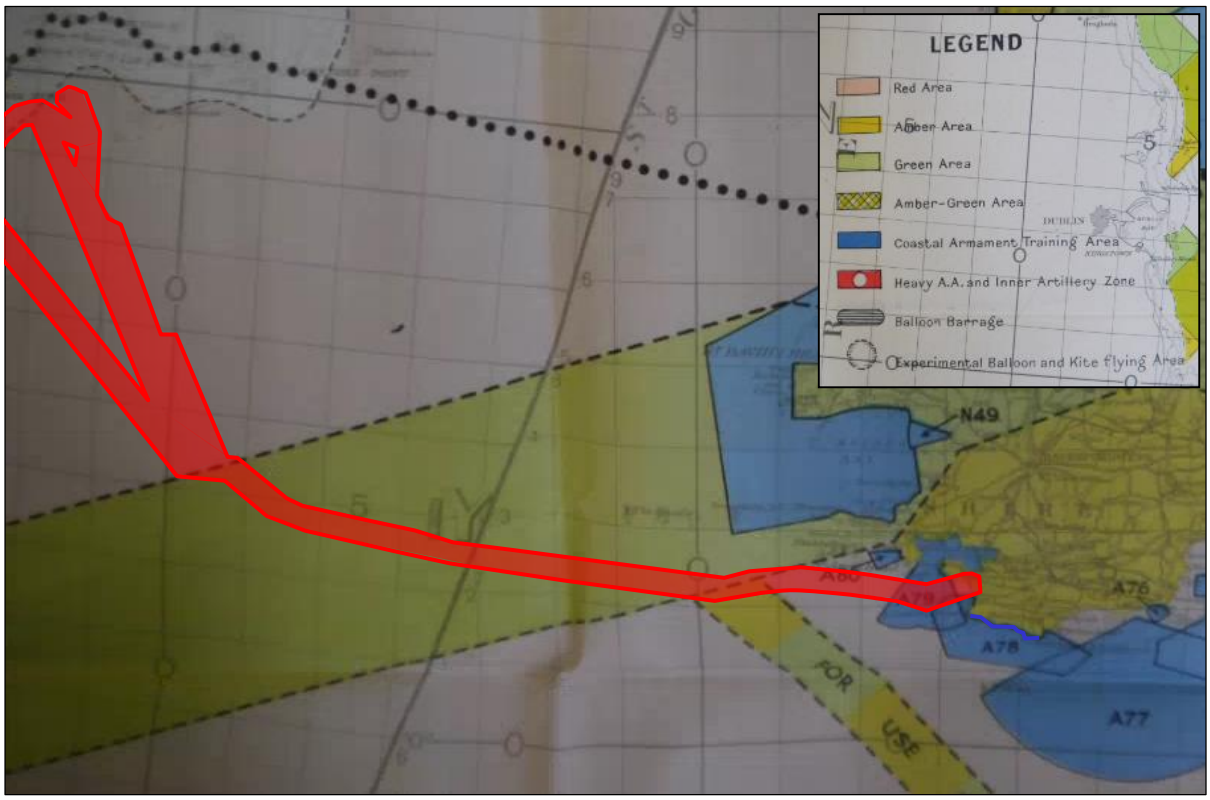
Restricted Flying Areas, Defended Areas & Balloon Areas

Annex: J1

March 1941



March 1943



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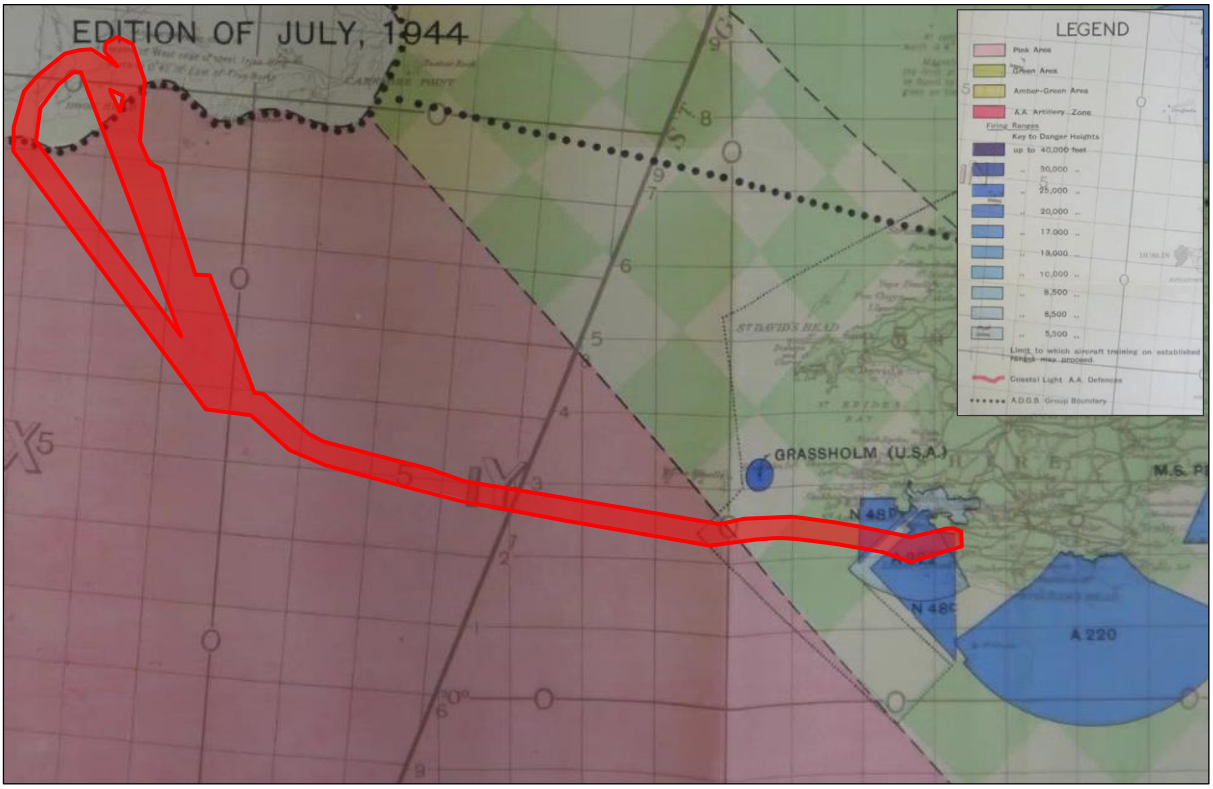
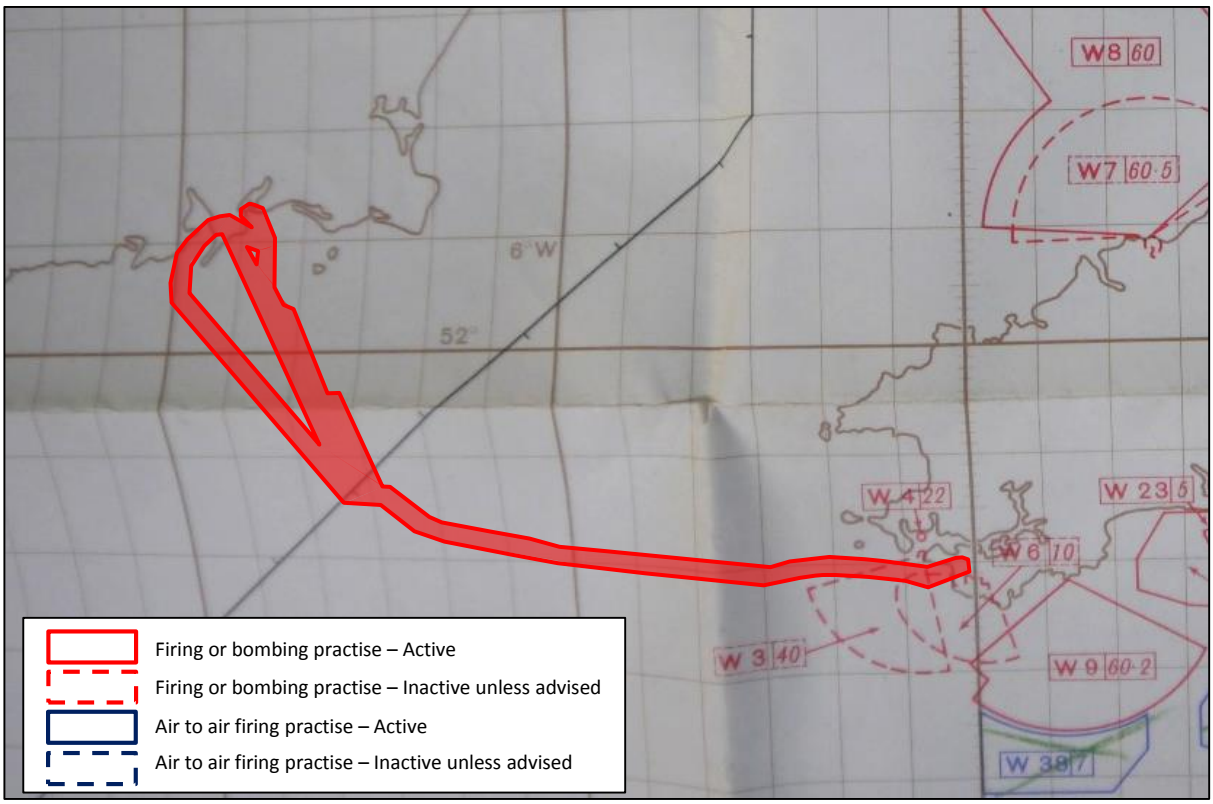
July 1944



'Notices to Airmen' – Danger Areas in the UK, Date Unknown



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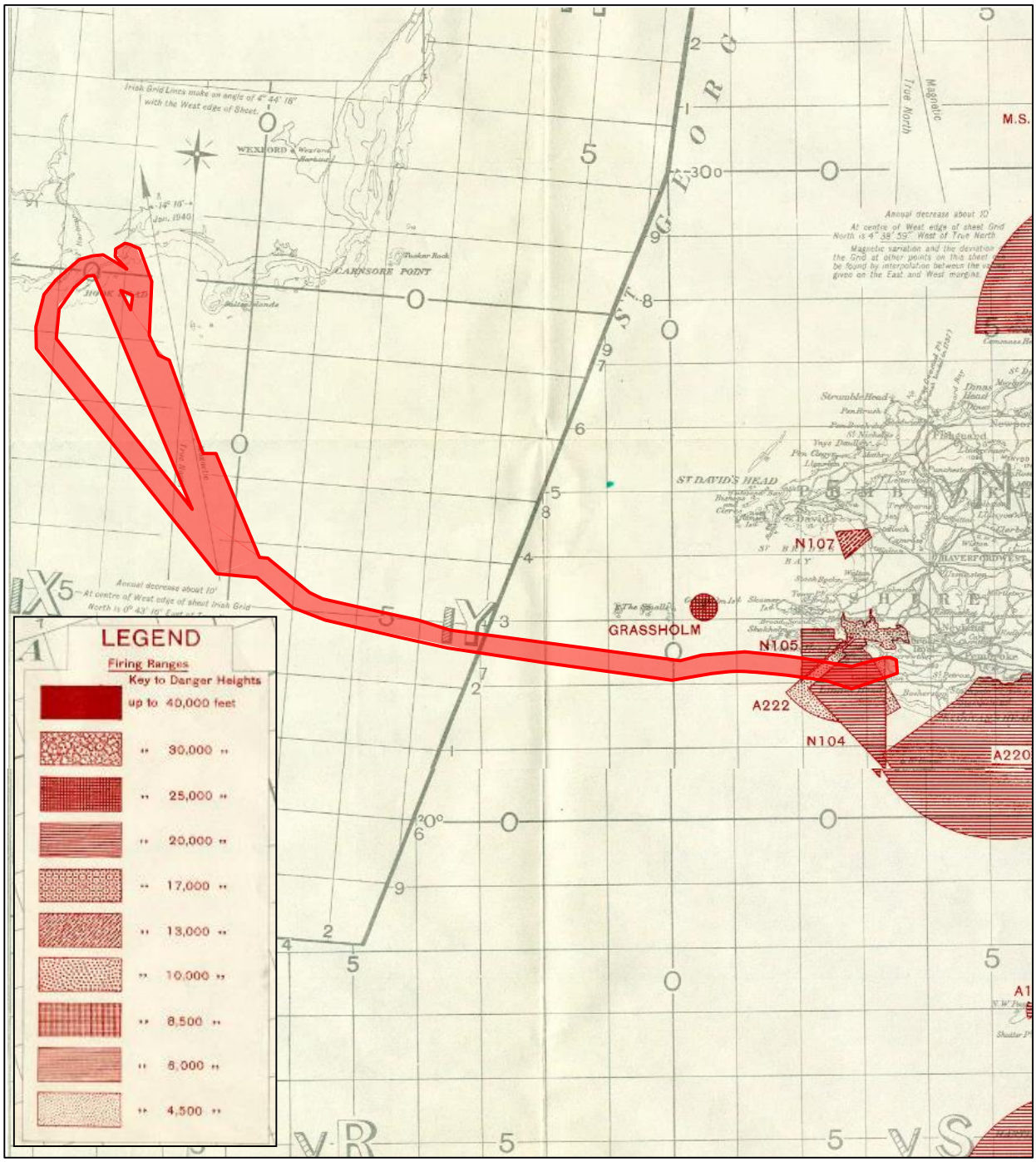

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Client: **Intertek**

Approximate study area

N

Project: **Greenlink**

Ref: **DA2985-01**

Source: The National Archives, Kew

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DETAILS OF FIXED AFV FIRING POINTS
CASTLEMARTIN RAC RANGE

FIRING POINT		
1	Main Armament up to 3,400 M.	Hard Standing 90^{x} x 30^{x}
2	Main Armament up to 3,400 M. Broadside Mover at 750 M.	Hard Standing 150^{x} x 30^{x}
4	MG and Main Armament up to 1,800 M)	Hard Standing 90^{x} x 30^{x}
5	Troop Battle Run. Approx 2 miles.	
6	MG, DST/PRAC and SH PRAC up to 850 M. Broadside Mover 700 M.	
7	MG and Main Armament, DST/PRAC, SH PRAC only. Broadside Mover Oblique 900-1260 M. Travelling Distance of Mover 800 M.	Hard Standing 100^{x} x 30^{x}
8	MG only up to 700 M. Broadside Mover 600 M.	
9	Small Arms only.	
10	Single Tank Battle Run, firing from fixed positions. Length of Run approx 1 mile.	
10A	Single Tank Battle Run (NIGHT), firing from fixed positions. Length of Run approx ¾ mile.	

Night firing will only take place on Ranges 7, 8 or 10A, limited to two nights in one week not consecutively.

There are two concrete Stab Runs Range 6 which affords limited Stab shooting up tp 1,000 M and Range 8 MG only up to 650 M.

When Ranges 1 and 2 are being used simultaneously, the firing of MG from Range 1 is forbidden.

When the Mover is being used on Range 2 and firing is also taking place on Range 1, delays may occur due to changing of Mover Target.

APDS will not be fired on Battle Runs or Night Firing.

* * * * * *

THE FOLLOWING COMBINATIONS OF FIRING POINTS CAN BE USED SIMULTANEOUSLY:

1 - 2 - 4 - 8 - 9
1 - 2 - 6 - 8 - 9
1 - 2 - 7 - 8 - 9
1 - 2 - 8 - 9 - 10
5 - 8 - 9
7 - 8)
10A) NIGHT FIRING

STAB RUNS ARE NOT INCLUDED IN THESE COMBINATIONS

CASTLEMARTIN 1970
(All previous details to be cancelled)

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Castlemartin as a Site for the Proof & Experimental Establishment now at Shoeburyness

(Note by Ministry of Defence)

Introduction

1. The Castlemartin range is divided into two separate parts. The bulk of it is a tank and armoured car weapons range, but the south eastern corner is used as an air-to-ground range. The whole range has been held by the MOD since World War II and is an area designated a National Park in 1952. It consists of some 6,000 acres plus a danger area extending 14 miles out to sea. The tank range is not used for about four months in the year because of bad weather and in order to let the ground recover. During this period it is used for grazing of sheep from the Prescelly Mountains.

Present and Future Military Use

Tank Range

2. The facilities on the tank range provide for tank and armoured car gunnery practice and are unique in combination in UK. They provide the only place in the UK where the annual gunnery continuation training of unit tank and armoured car crews in UK can take place. The bulk of these units are stationed in the South of England. With the introduction of new equipment the use of the range by British troops will intensify in the near future.

3. Under an agreement dating from 1962 a German Army (FRG) Corps fires at Castlemartin for six months each year. They make intensive use of the range and consider it superior to and less restrictive than the ranges in Germany used by all NATO troops. They have recently confirmed their wish to continue using Castlemartin for the foreseeable future.

Air-to-Ground Range

4. Apart from Pembrey, Castlemartin is the only air-to-ground land range in the South-West of UK and is required for weapon firing by Naval helicopters of the training and front line Commando Squadrons based in the South-West. There is also a strong likelihood that Army helicopters will, in future, require use of the range to fire the weapons with which they are being armed.

5. As a result of pressure on regional policy grounds to retain a Defence presence in Brawdy it has been decided that an RAF Jaguar operational training unit should be based there from 1972. This decision is conditional on there being available a suitable air-to-ground weapons range within economic flying

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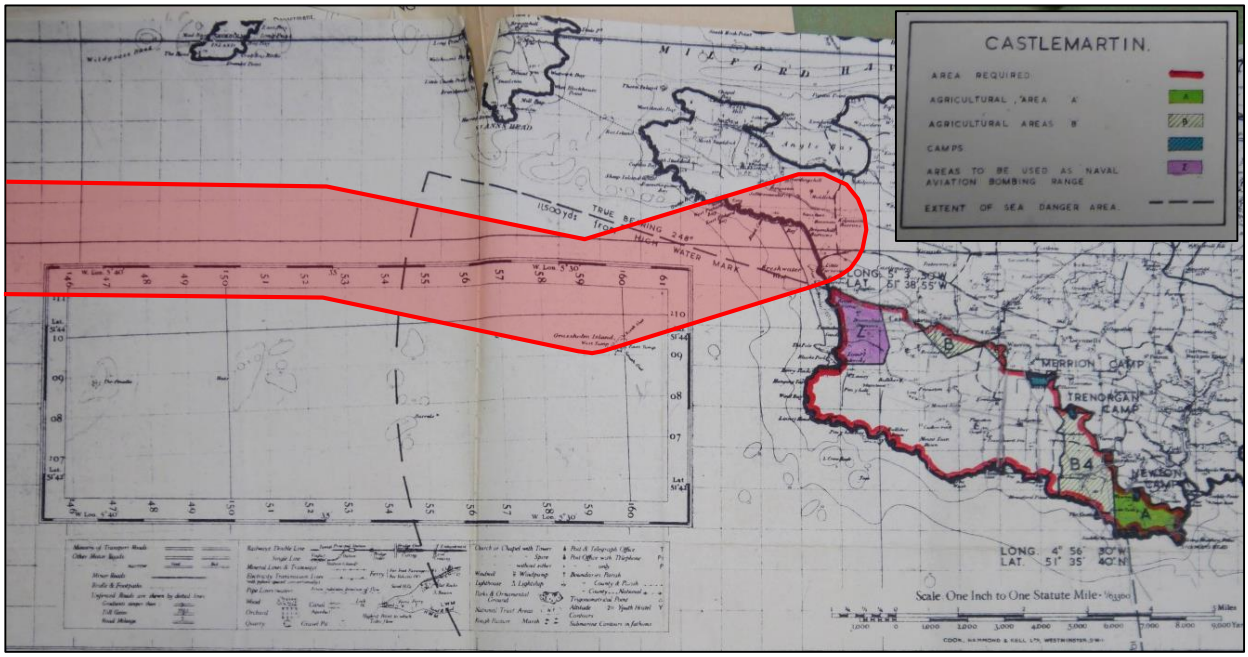

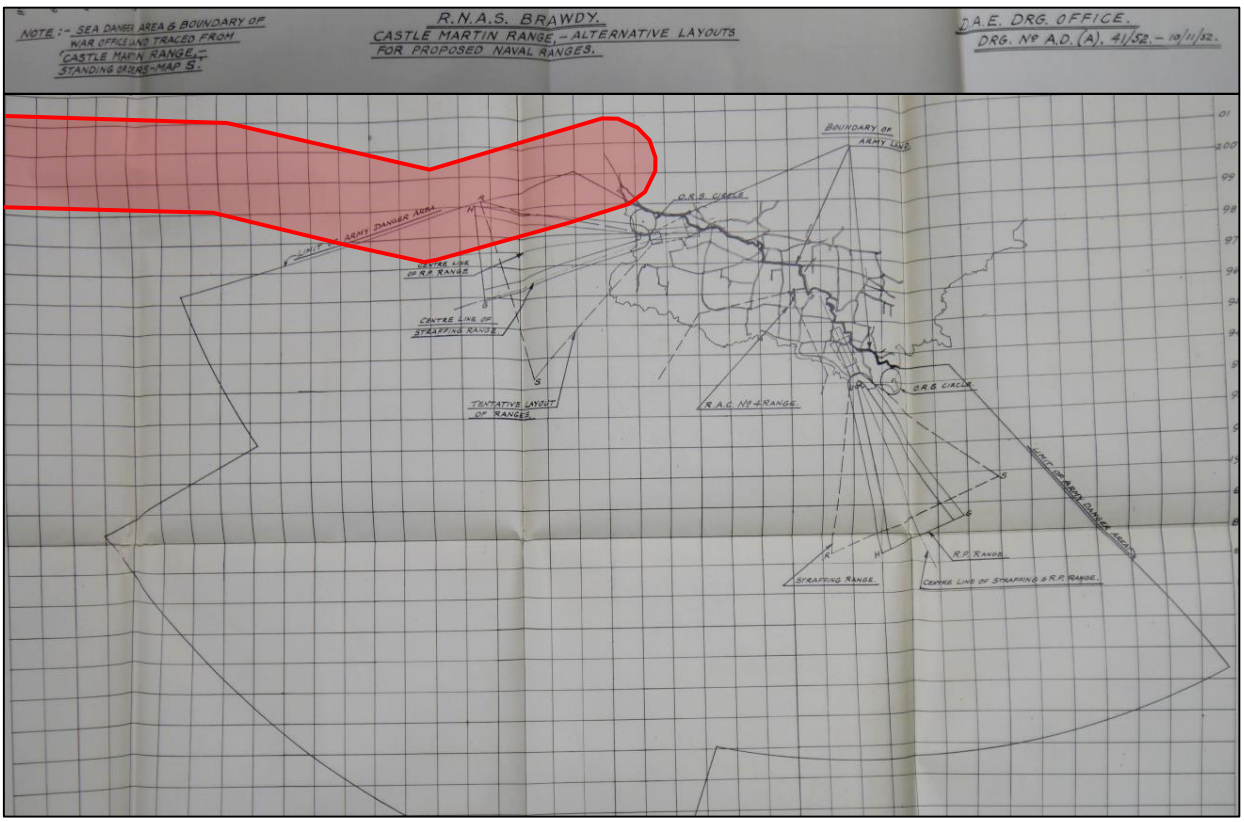

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Project: **Greenlink**

Ref: **DA2985-01**

Source: The National Archives, Kew

Approximate study area

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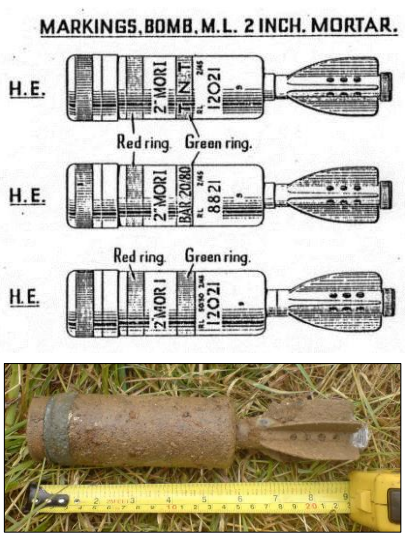
Examples of Land Service Ammunition – Mortars

Annex: **L1**

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.

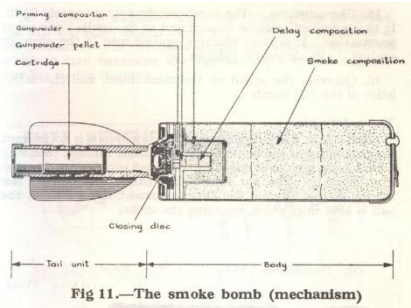
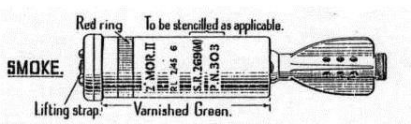
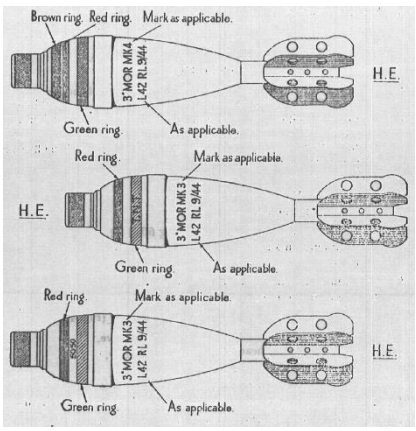


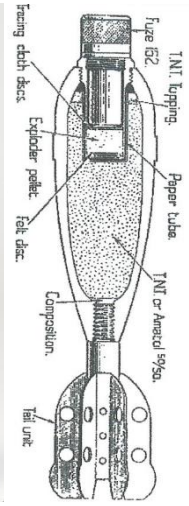
Fig 11.—The smoke bomb (mechanism)



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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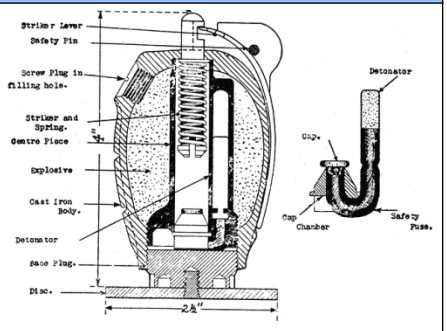
Examples of Land Service Ammunition – Grenades

Annex: L2

No. 36 'Mills' Grenade

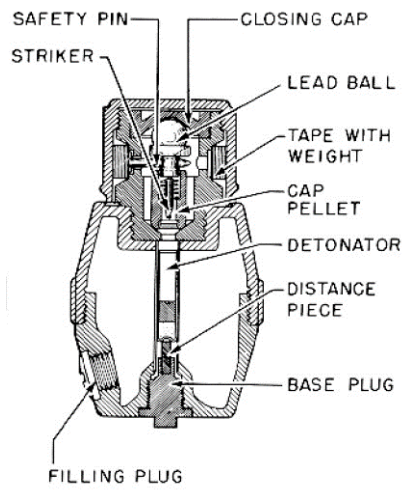
Weight	765g filled (1lb 11.25oz)
Explosive Weight	71g (2oz) filling.
Fuze Type	4-7 second delay hand-throwing fuze. No. 6 Detonator
Dimensions	95 x 61mm (4 x 2.4in)
Use	Fragmentation explosive at approx. 30m range 100m range of damage.
Remarks	First introduced in 1915 its classic grooved, cast-iron 'pineapple'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



Left: baseplate and detonator removed

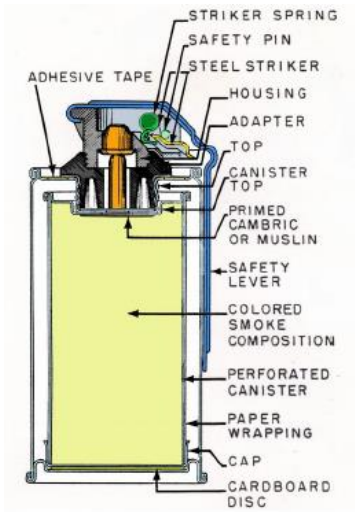
No. 69 Grenade

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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Source: Various sources

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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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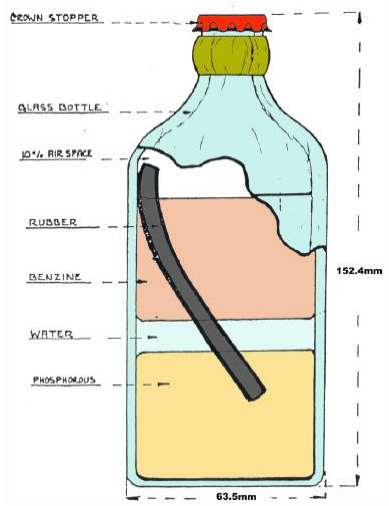
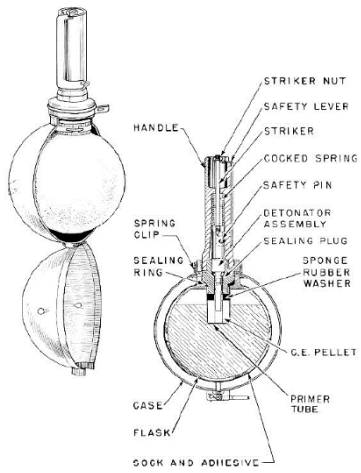
No. 76 Self Igniting Phosphorous (SIP) Grenade

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.

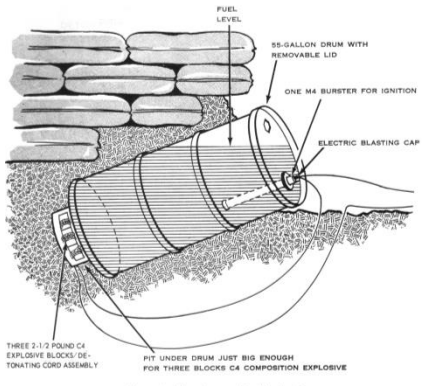


Figure 22. Flame fougasse (55-gallon drum).

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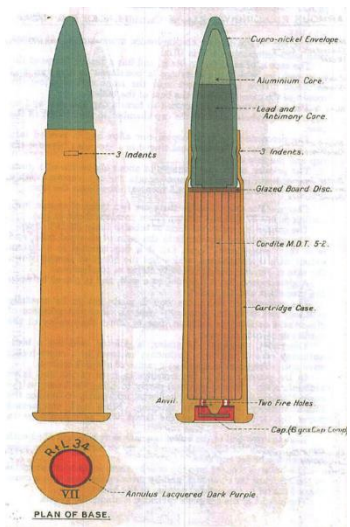
Examples of Small Arms Ammunition

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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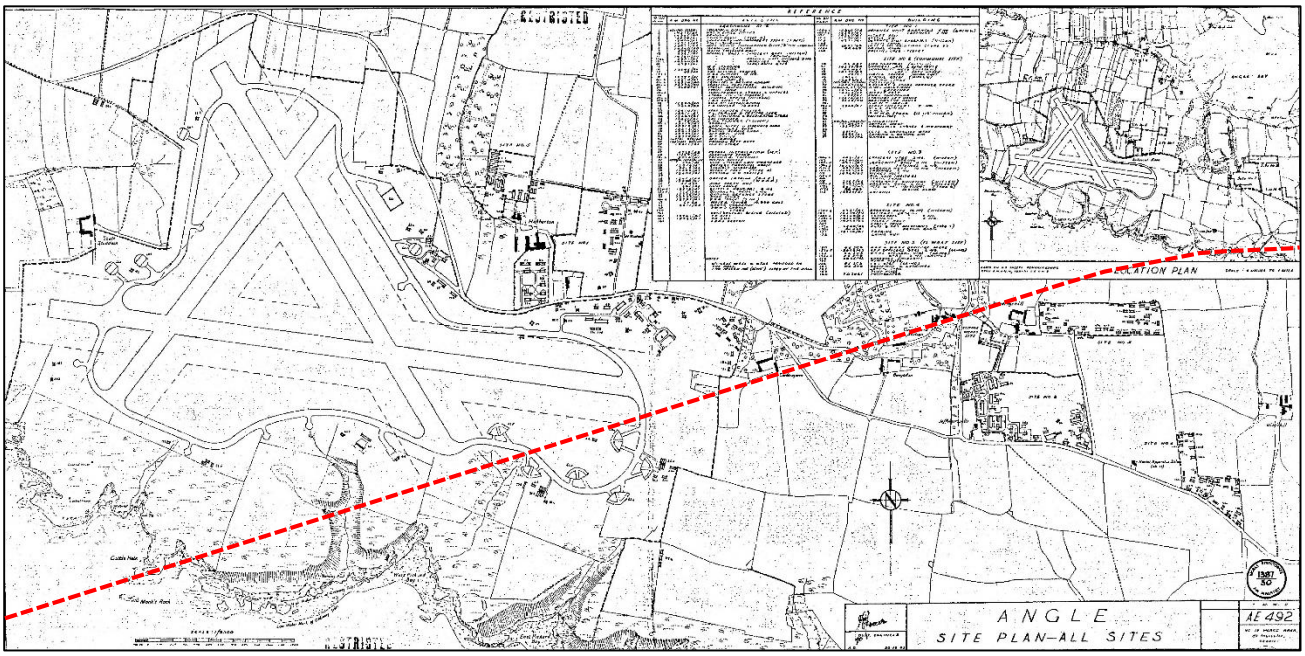
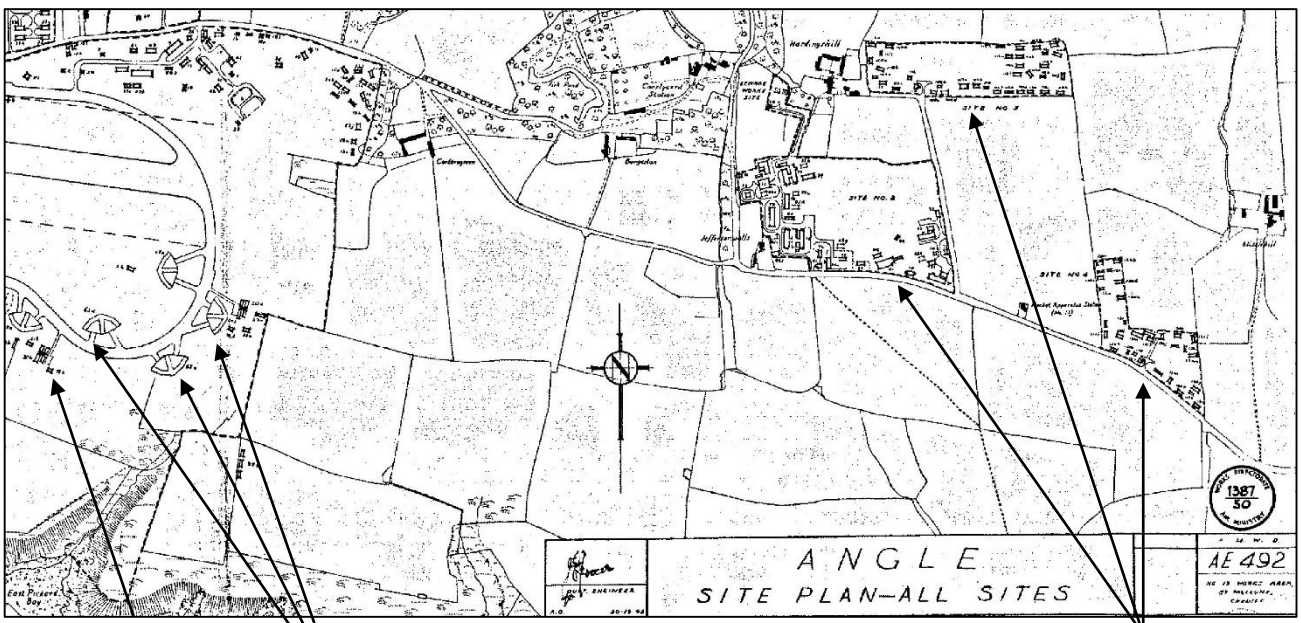
RAF Angle Site Plan

Annex: **M**



Above: Land south of boundary indicates route coverage. *Below*: Enlarged and annotated.



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Source: RAF Hendon

Approximate study area boundary

N

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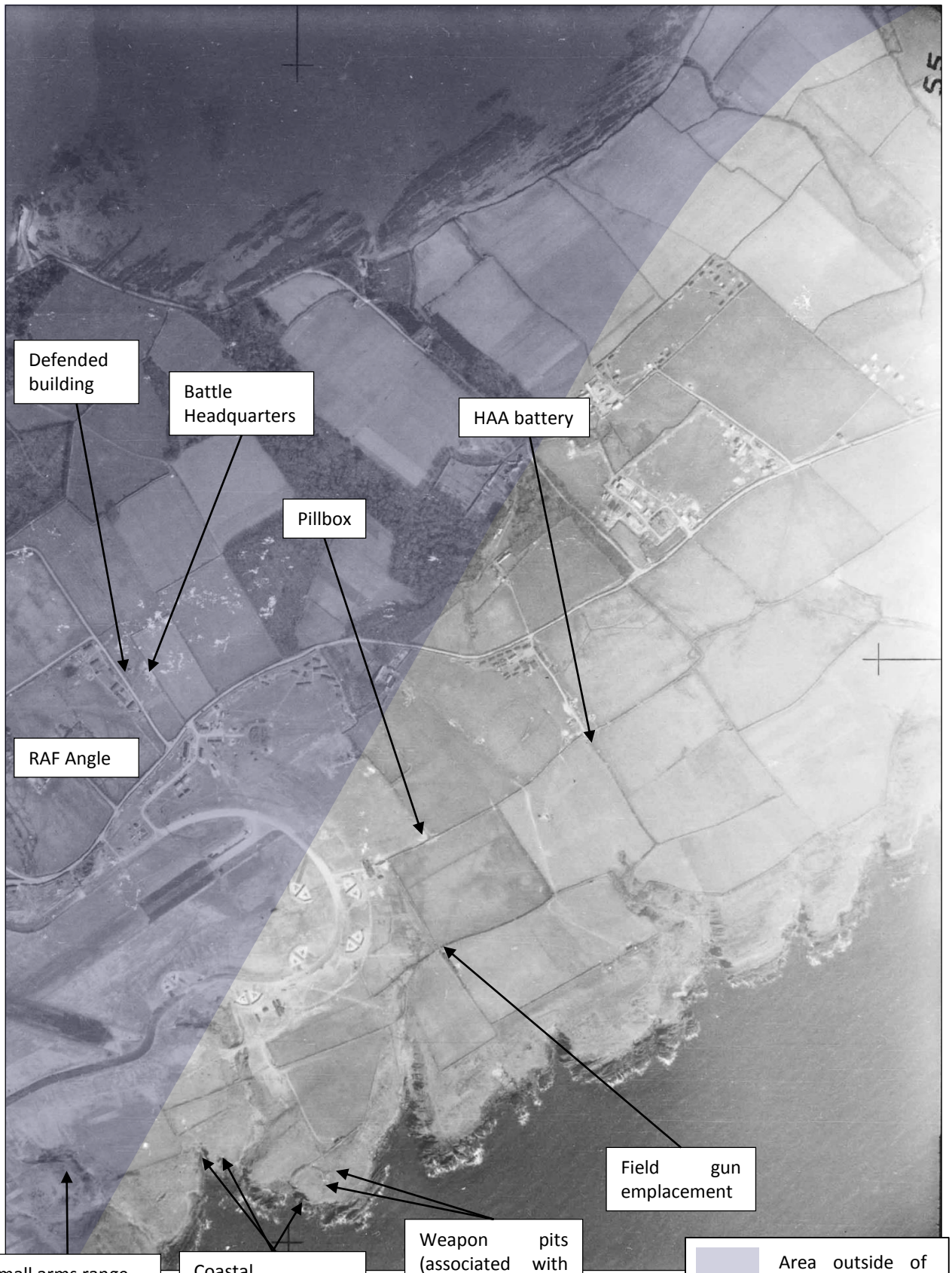
RAF Aerial Photography 23rd March 1942

Annex: **N1**



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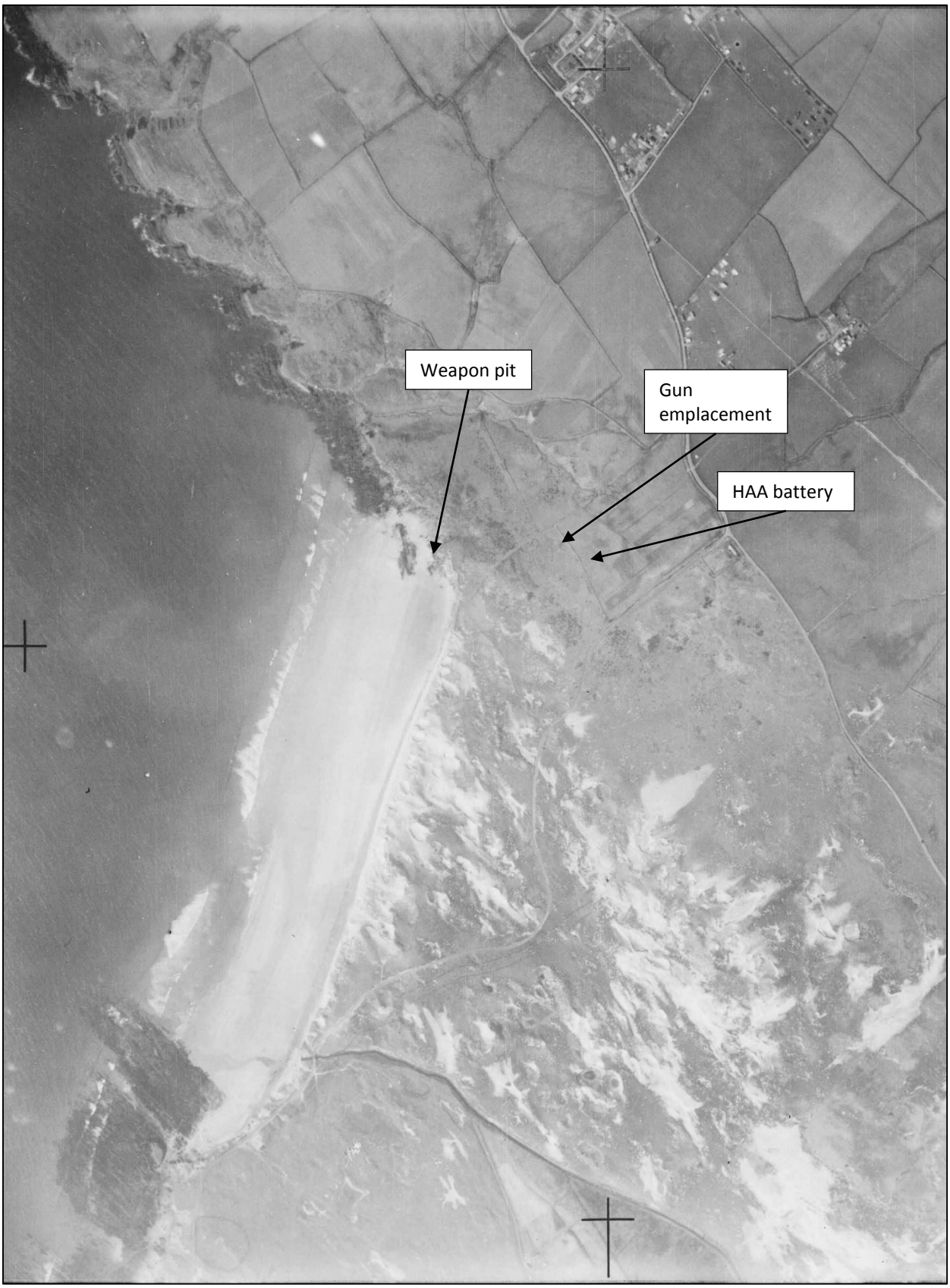
RAF Aerial Photography 23rd March 1942

Annex: **N2**



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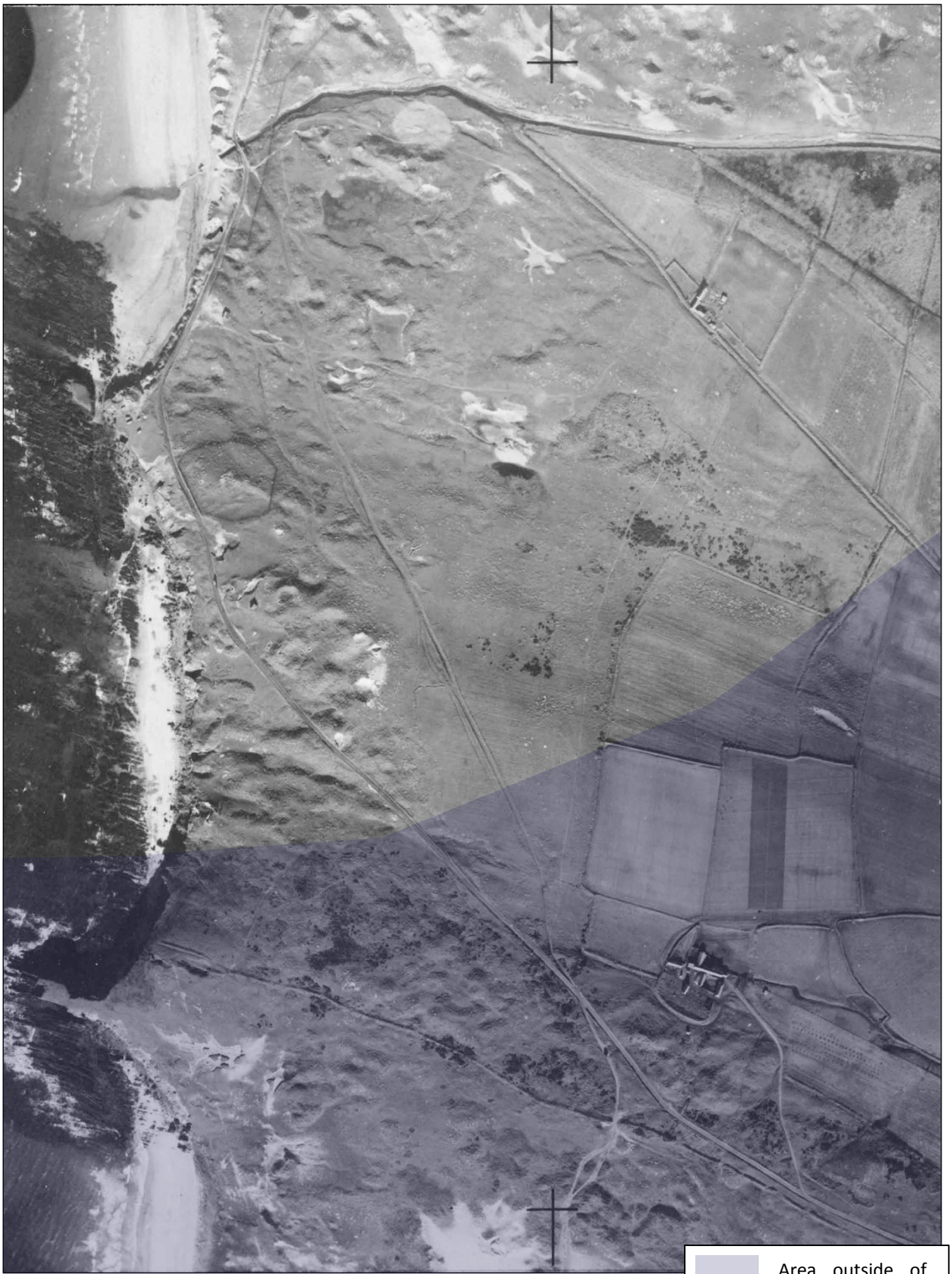
RAF Aerial Photography 10th February 1942

Annex: **N3**



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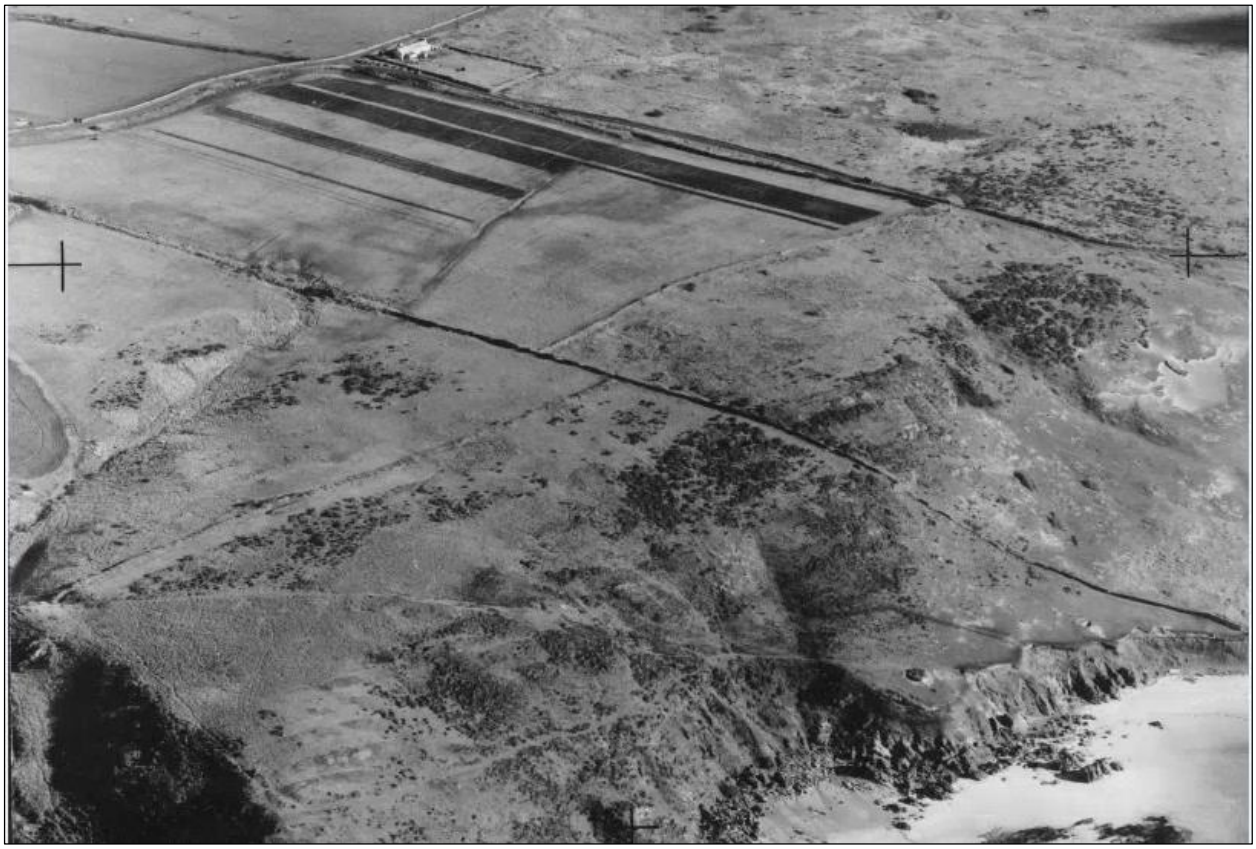
Annex: **N4**



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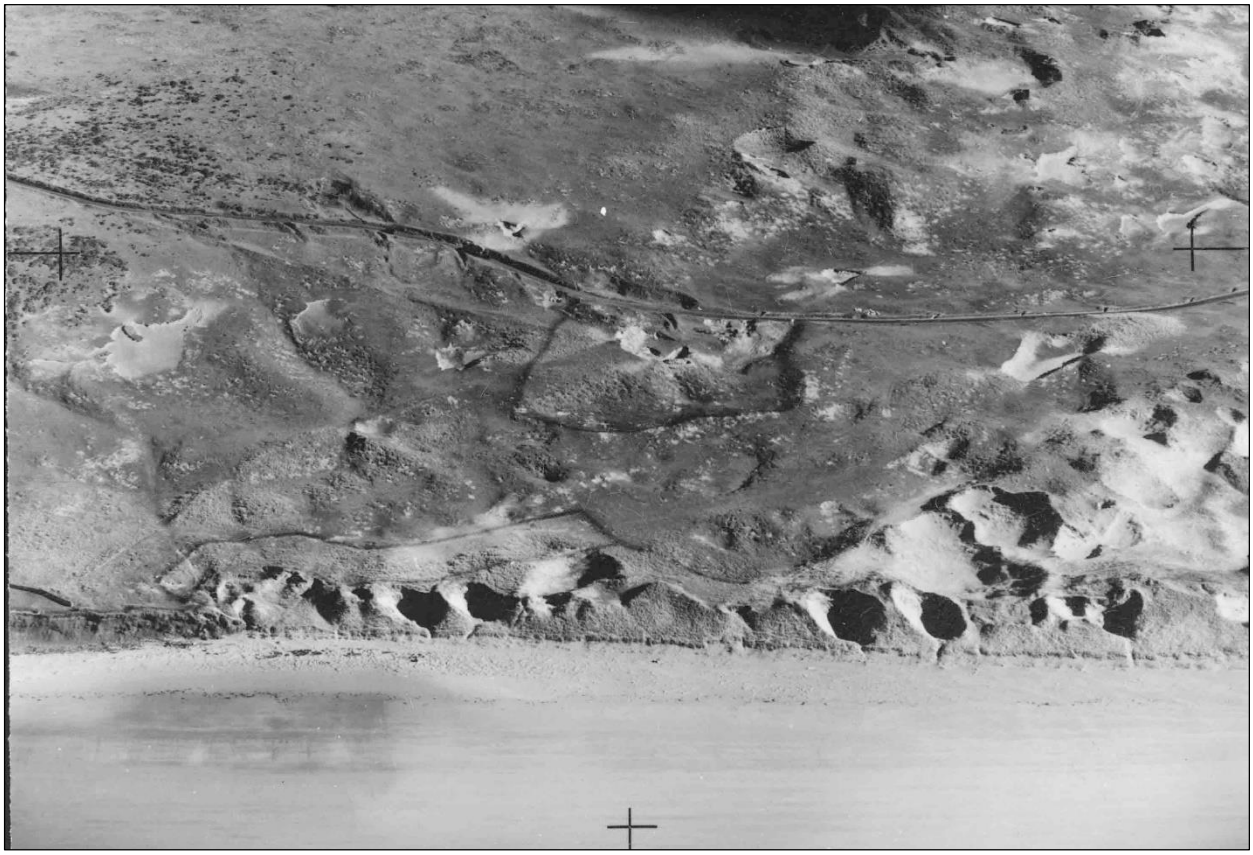

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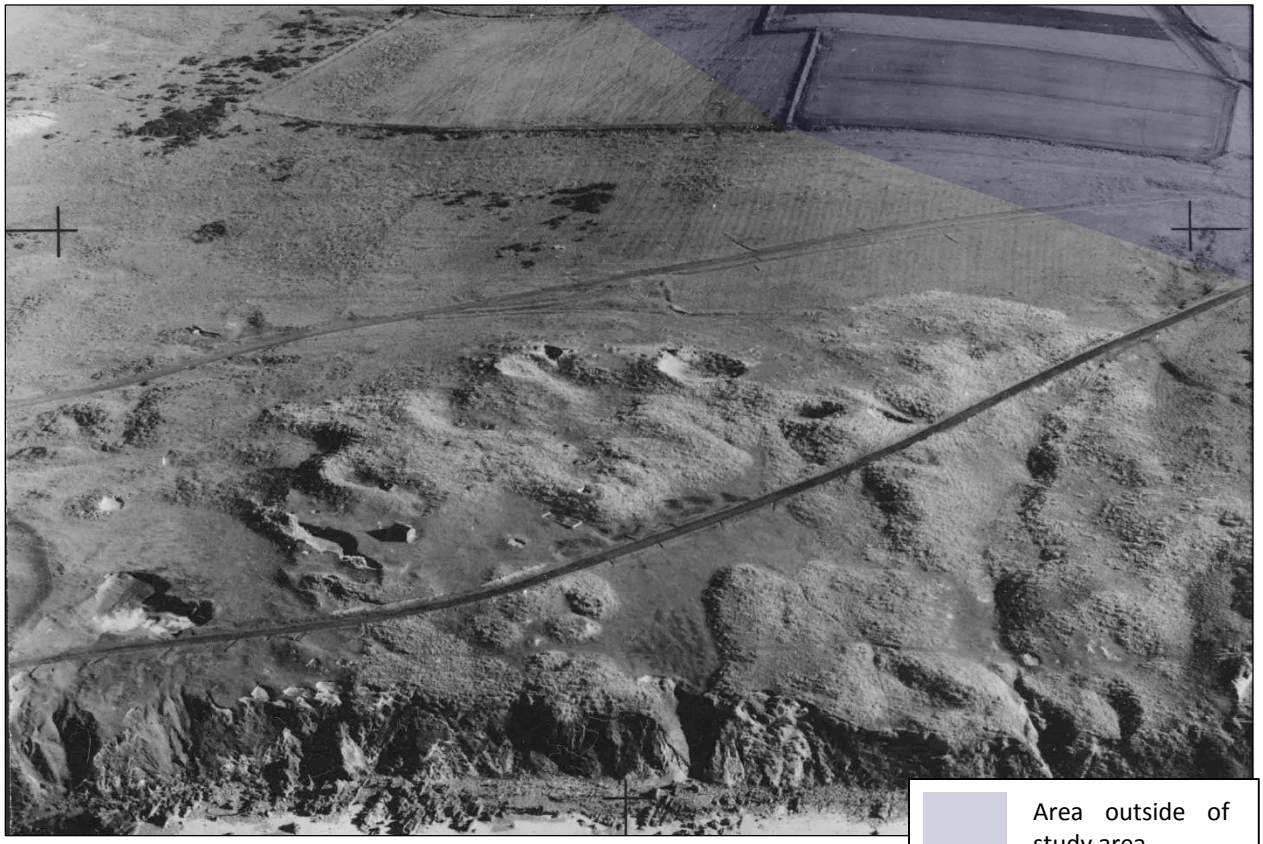
RAF Aerial Photography 10th February 1942

Annex: **N7**



Area outside of study area

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Client: **Intertek**

Project: **Greenlink**

Ref: **DA2985-01**

Source: National Monuments Record Office (Historic England)

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RAF Aerial Photography 7th July 1946

Annex: **O1**

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RAF Aerial Photography 7th July 1946

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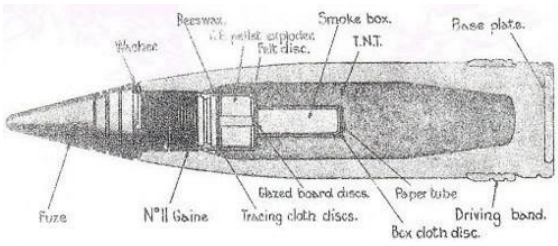
Examples of Anti-Aircraft Projectiles

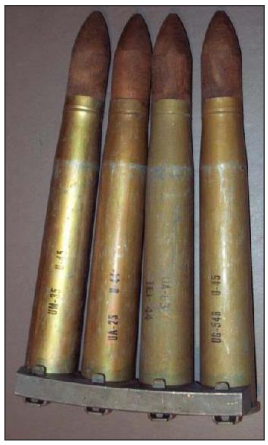
3.7 Inch QF Anti-Aircraft Projectile

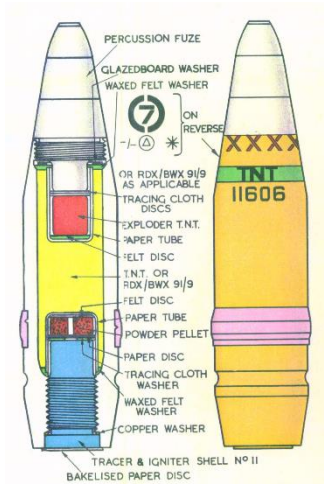
Projectile Weight	28lb (12.6 kg)
Explosive Weight	2.52lbs
Fuze Type	Mechanical Time Fuze
Dimensions	3.7in x 14.7in (94mm x 360mm)
Rate of Fire	10 to 20 rounds per minute
Use	The 3.7in AA Mks 1-3 were the standard Heavy Anti-Aircraft guns of the British Army.
Ceiling	30,000ft to 59,000ft



40mm Bofors Projectile

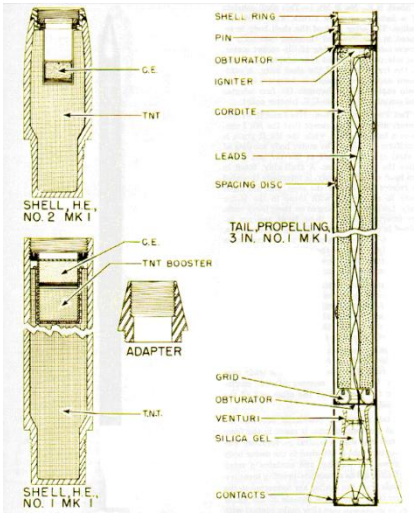
Projectile Weight	1.96lb (0.86kg)
Explosive Weight	300g (0.6lb)
Fuze Type	Impact Fuze
Rate of Fire	120 rounds per minute
Projectile Dimensions	40 x 180mm
Ceiling	23,000ft (7000m)
Remarks	Light quick fire high explosive anti-aircraft projectile. Each projectile fitted with small tracer element. If no 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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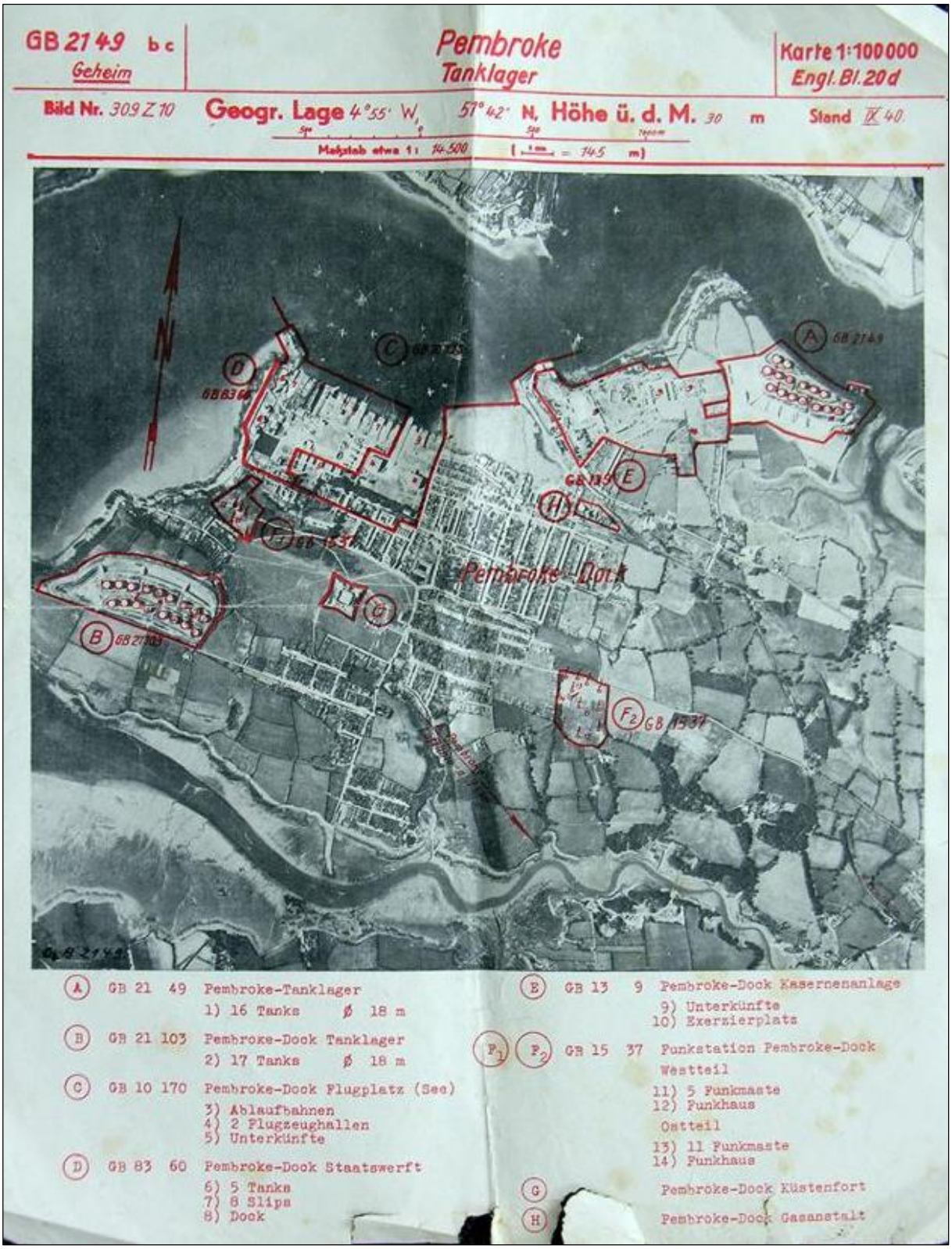

Luftwaffe aerial photograph of Pembroke Dock, 1940. The military installations have been marked and identified. This document was retrieved from a German airbase in Schleswig Holstein in late 1945, by Reg McKenzie while he was serving with the Royal Corps of Signals.

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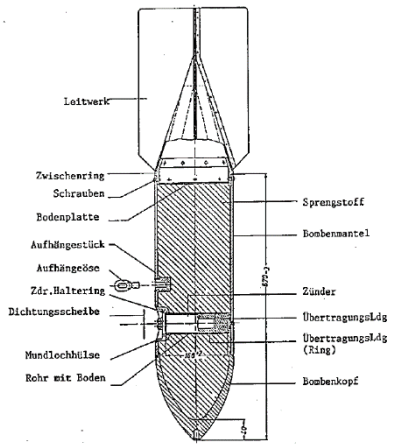
Examples of German Air-Delivered Ordnance

Annex: **R1**

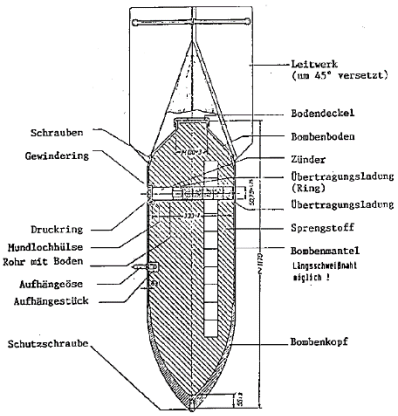
SC 50kg High Explosive Bomb

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

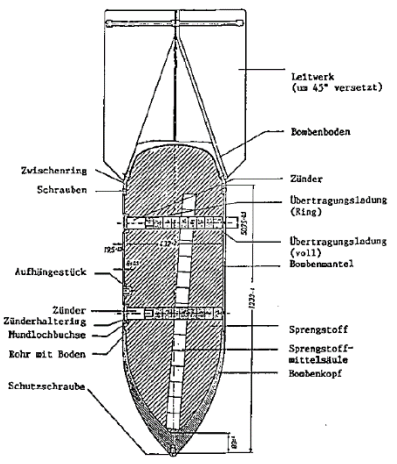
Bomb Weight	245-256kg (540-564lb)
Explosive Weight	125-130kg (276-287lb)
Fuze Type	Electrical impact/mechanical time delay fuze.
Bomb Dimensions	1640 x 512mm (64.57 x 20.16in)
Body Diameter	368mm (14.5in)
Use	Against railway installations, embankments, flyovers, underpasses, large buildings and below-ground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

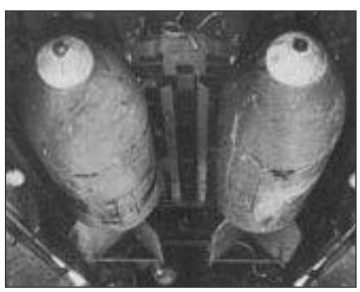


SC250 bomb being loaded onto German bomber

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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Project: **Greenlink**

Ref: **DA2985-01**

Source: Various sources

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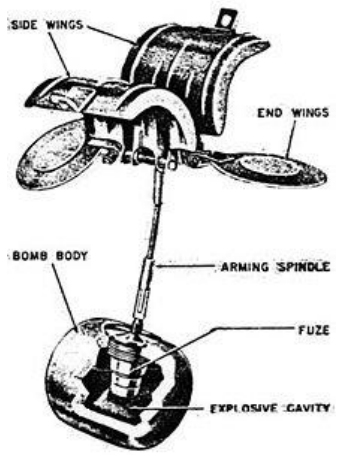
Examples of German Air-Delivered Ordnance

Annex: R2

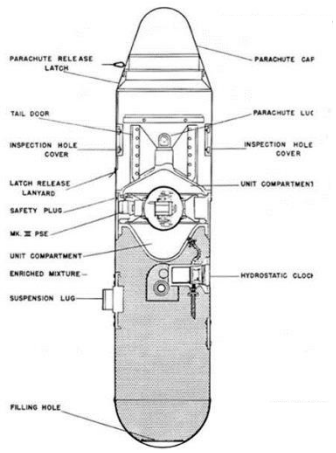
SD2 Anti-Personnel 'Butterfly Bomb'

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.



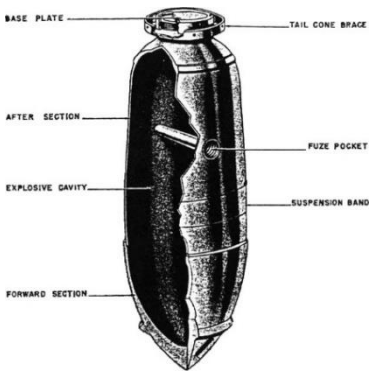
Parachute Mine (Luftmine B / LMB)

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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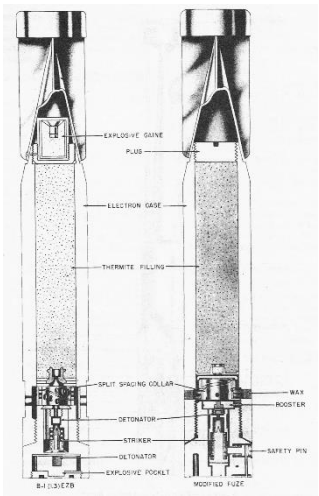
German Incendiary Bombs

Annex: R3

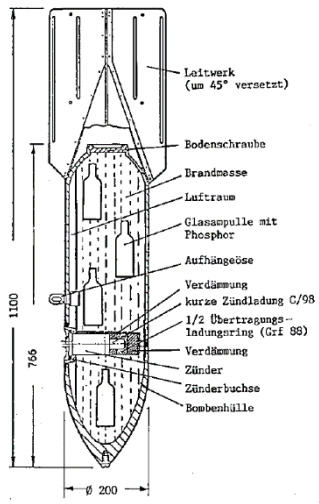
1kg Incendiary Bomb

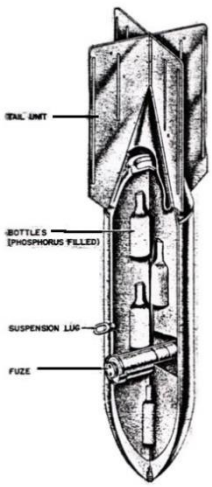
Bomb Weight	1.0 and 1.3kg (2.2 and 2.9lb)
Explosive Weight	680g (1.3lb) Thermite 8-15gm Explosive Nitropenta
Fuze Type	Impact fuze
Bomb Dimensions	350 x 50mm (13.8 x 1.97in)
Body Diameter	50mm (1.97in)
Use	As incendiary – dropped in clusters against towns and industrial complexes
Remarks	Magnesium alloy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

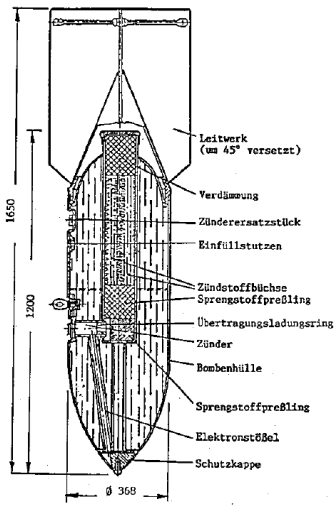
Bomb Weight	c41kg (90.4lb)
Explosive Weight	0.03kg (0.066lb)
Incendiary Filling	12kg (25.5lb) liquid filling with phosphor igniters in glass phials. Benzine 85%; Phosphorus 4%; Pure Rubber 10%
Fuze Type	Electrical impact fuze
Bomb Dimensions	1,100 x 280mm (43.2 x 8in)
Use	Against all targets where an 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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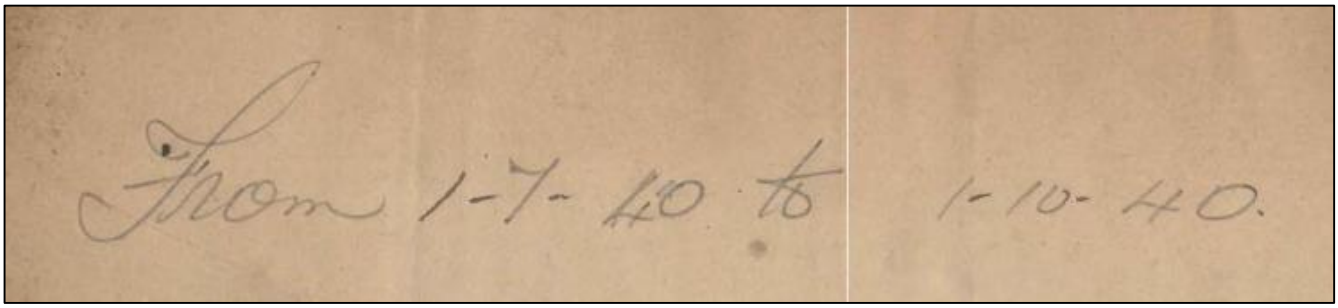
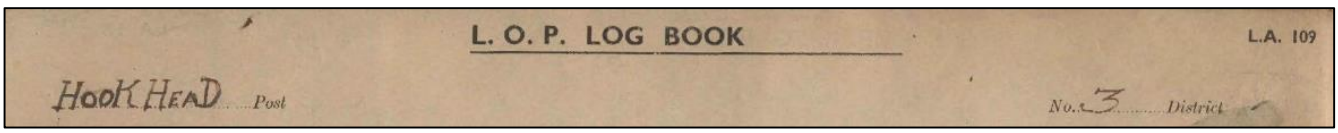
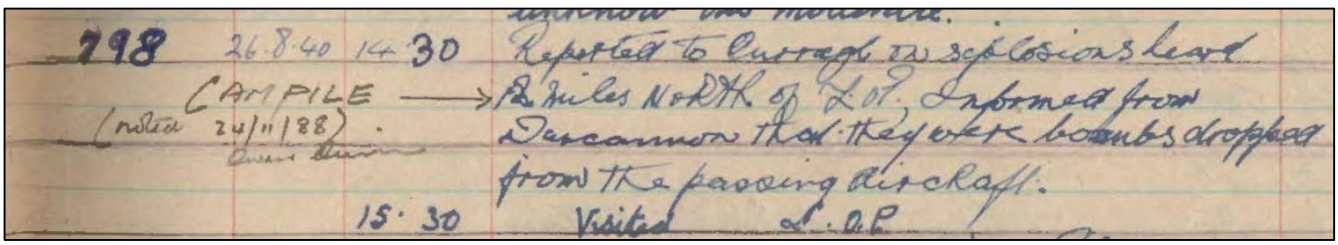
Title page of document





Relevant entry – 26th August 1940



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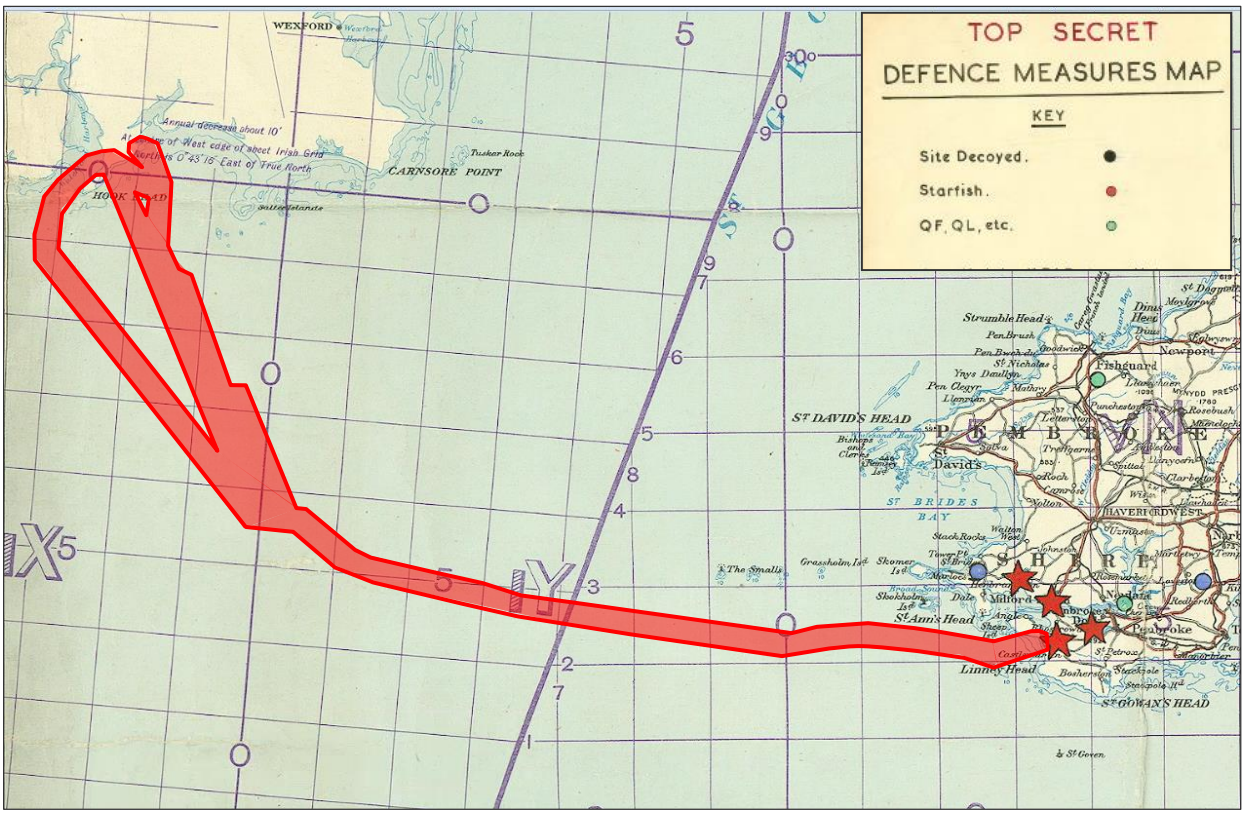
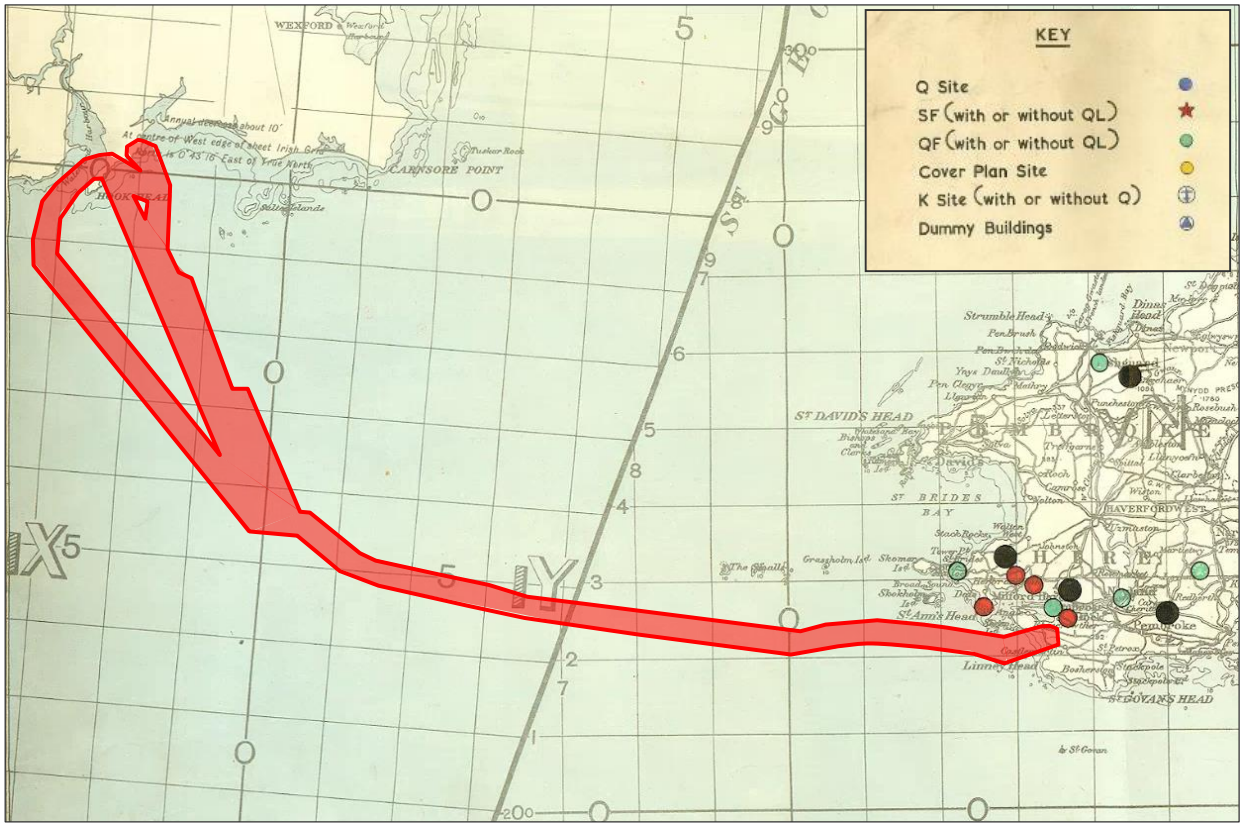
Decoy Site Mapping

Annex: T





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Project: **Greenlink**

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Source: The National Archives, Kew

Approximate study area

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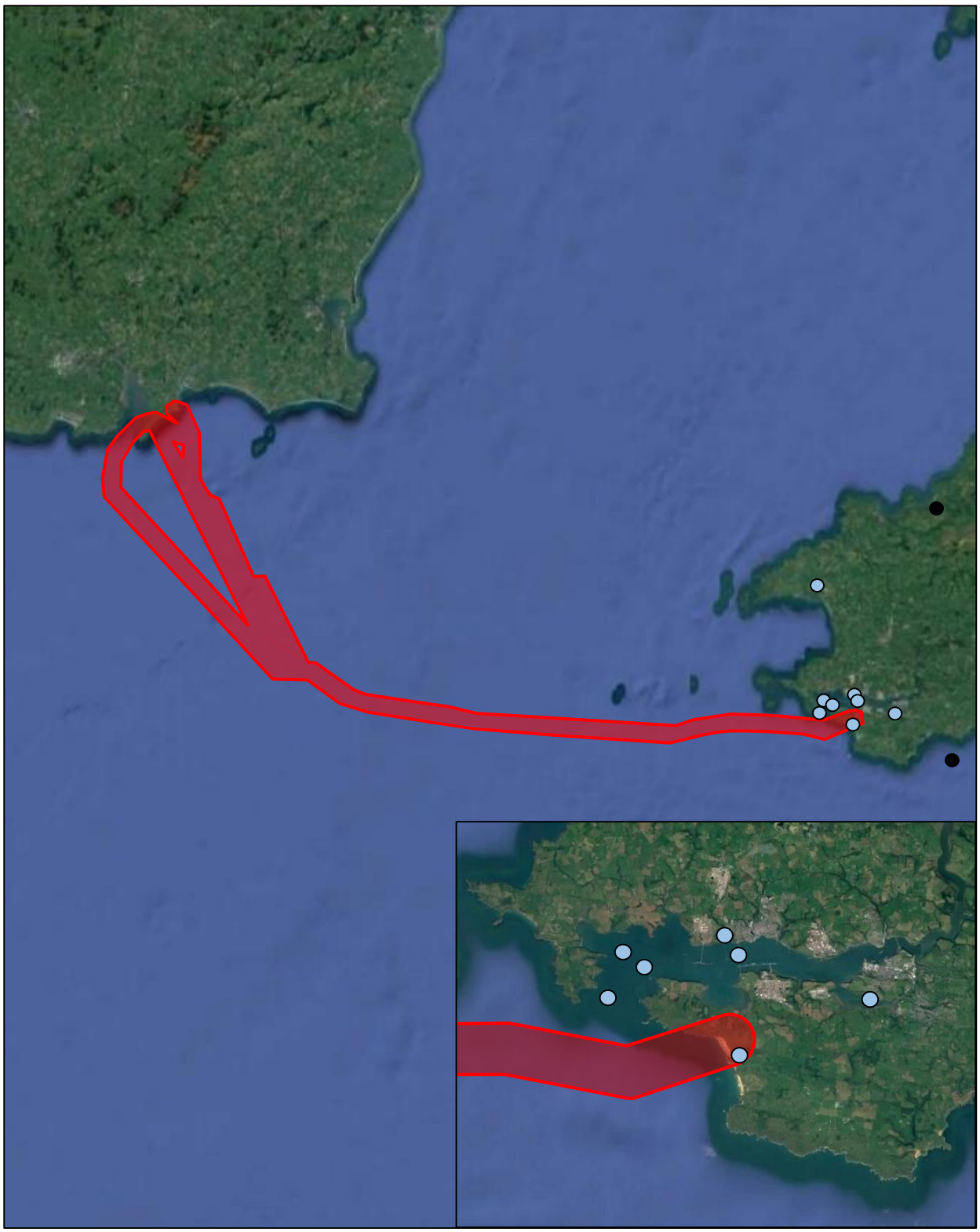
OSPAR Munition Encounters

Annex: U



Key:

Conventional

Unknown

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Project: **Greenlink**

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Source: OSPAR

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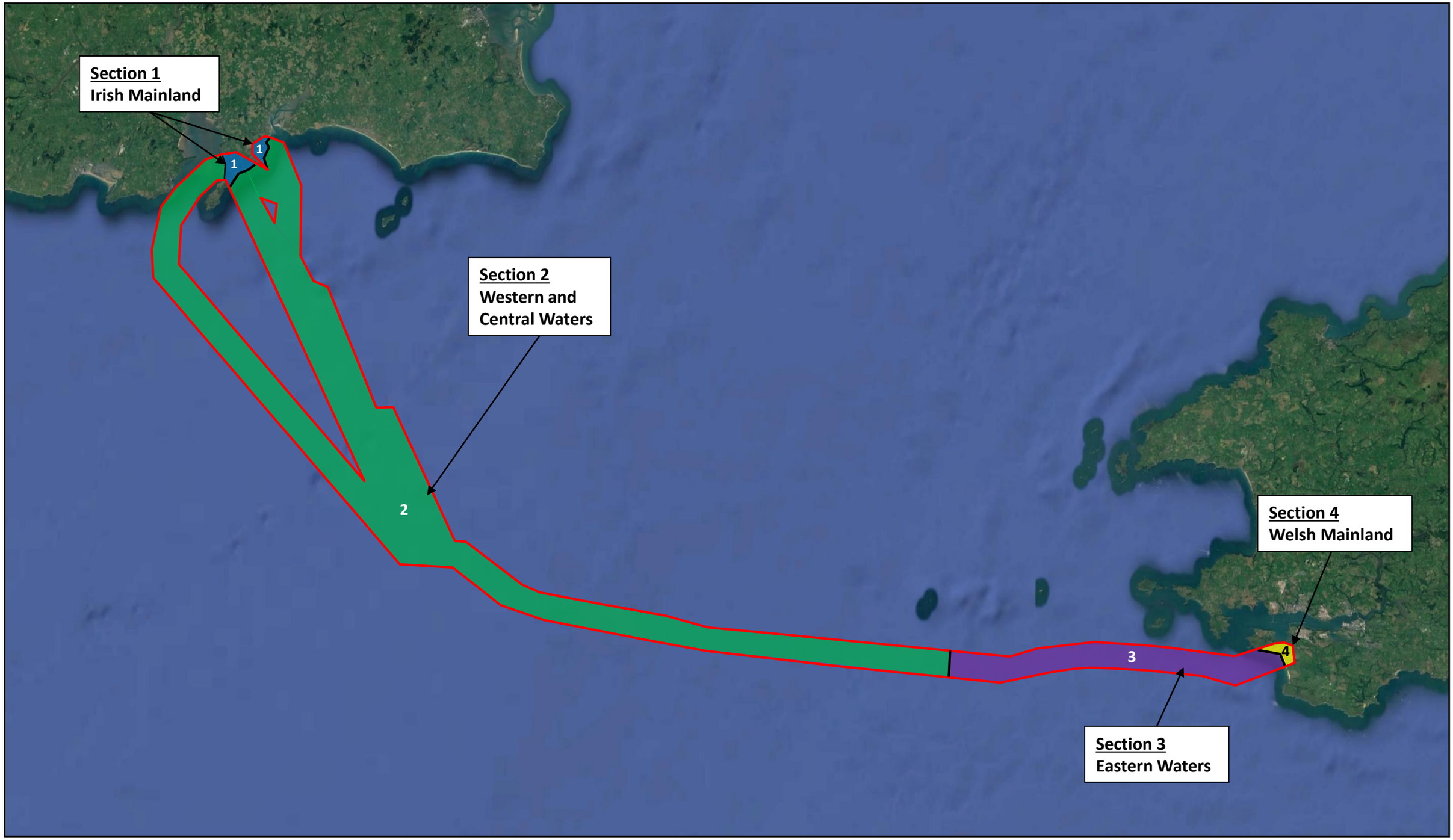
Sections of Study Area

Appendix: i



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Overlay of Significant UXO Features

Appendix: ii

Please note that this appendix has been based on a final version of the route of the proposed study area. This route was provided following the completion of this report and for all other purposes the original study area proposed has been used.

LOP (Look Out Post) Hook Head

'Secret Gap' noted in 1940-1943 Offshore Minefield Chart (later extended in 1944)

Grassholm Range

RAF Angle

Castlemartin Range

WWII British declared area continues southwards and westwards

'Danger Area' continues eastwards and southwards

Key:

- Reported WWI German Minefield. *Not geographically accurate. Extents based on historical literature and recorded wrecks caused by WWI German mines.*
- WWII British Minefield
- WWII Enemy Minefield
- WWII British Declared Areas
- Extent of WWII Armament 'Danger Area' Associated with Training
- Recorded Munitions Dumpsite

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Overlay of UXO Features on Welsh Mainland

Appendix: iii

Key:

C	Coastal observation point	S	Small arms range	W	Weapon pit	F	Field gun emplacement
H	HAA battery	D	Defended building/battle HQ	P	Pillbox		

Extents of:

- RAF Angle
- Castlemartin Naval Aviation Bombing Range

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