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Explosive Ordnance Threat Assessment in respect of M4 Corridor around Newport

for
Hyder Consulting (UK) Limited

5750TA

21st November 2014

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This Report has been produced in compliance with the Construction Industry Research and Information Association guidelines for the preparation of Detailed Risk Assessments in the management of UXO risks in the construction industry.

Glossary of Terms

AAA	Anti-Aircraft Artillery
ARP	Air-raid Precautions
BDO	Bomb Disposal Officer
EOD	Explosive Ordnance Disposal (current term for "bomb" disposal)
HE	High Explosive
HG	Home Guard
IB	Incendiary Bomb
kg	Kilogram
LCC	London County Council
LM	Land Mine
LSA	Land Service Ammunition (includes grenades, mortars, etc.)
Luftwaffe	German Air Force
m bgl	Metres Below Ground Level
MoD	Ministry of Defence
OB	Oil Bomb
PM	Parachute Mine
RAF	Royal Air Force
SI	Site Investigation
SAA	Small Arms Ammunition (small calibre cartridges used in rifles & machine guns)
UXB	Unexploded Bomb
UXO	Unexploded Ordnance
V-1	"Doodlebug" the first cruise type missile, used against London from June 1944. Also known as 'Flying Bomb'.
V-2	The first ballistic missile, used against London from September 1944
WWI	First World War (1914 -1918)
WWII	Second World War (1939 – 1945)

Executive Summary

The Route: The study area it located within Monmouthshire, south-east Wales. It stretches from M4 Junction 29 in the west, continuing east though Newport Docks (to the south of the city), then passing immediately adjacent to the south of Llanwern Steelworks, before merging with the existing M4 Junction 23A at Magor.

The majority of the route passes though agricultural land, however it also follows the existing M4 route at the eastern and western extents. In addition it passes through the Steelworks' settlement ponds and also occupies brownfield land, existing commercial property, the dock basin and the River Usk, within the docklands area.

Proposed Works: The scheme involves construction of a three lane motorway to the south of Newport. Significant earthworks and structures will be required as part of the proposed scheme. These are likely to comprise preparatory excavation works along the whole route, as well as piling works through the soft soils within the docks area.

Risk Assessment Methodology: In accordance with CIRIA guidelines this assessment has carried out research, analysed the evidence and considered the risks that the study area has been contaminated with unexploded ordnance; that such items remained within the route; that they could be encountered during any future works and the consequences that could result. Appropriate risk mitigation measures have been proposed.

Explosive Ordnance Risk Assessment: BACTEC concludes the site includes zones of **Low**, **Low-Medium**, **Medium** and **Medium-High Risk** from unexploded ordnance (UXO). This is based on the following factors:

German UXO

- The bombing density across the route will have been variable. Newport was subjected to at least 20 small scale air raids during the war and the neighbouring rural district, within which the majority of the route was situated, sustained 366 HE bomb strikes.
- Within the latter district, eight of the 13 Monmouthshire bombing decoy sites were positioned within 3km of the route and therefore it is quite possible that a proportion of the 366 bombs fell in relative close proximity, if not within, the route corridor.
- The route passes through Newport Docks, which would have been considered the main bombing target for enemy aircraft in the wider Newport area. Consequently records indicate that bombing incidents occurred at the docks during at least seven separate air raids, although the exact locations are unknown. This higher density of bombing is also suggested by a possible HE bomb crater identifiable on a 1945 aerial photograph of the docks.
- Conversely, in agricultural land, away from these decoy sites and Newport itself, the bombing density will have been lower. Note however an Abandoned German UXB Register records such weapons in open ground to the south of Newport, highlighting the possibility of German UXO remaining in open countryside, away from bombing targets or decoys.
- During WWII the vast majority of the route comprised agricultural fields in a sparsely populated setting. Therefore it is conceivable that any UXB strikes within this part of the route corridor, could have occurred unobserved. Especially since many of the German air raids in the wider Newport area took place at night.
- Furthermore, had such an incident occurred, the resulting evidence could have easily become obscured within dense crops growth, long grass or ploughed soil. Note that the entry hole of an SC50 UXB (the most commonly deployed German HE bomb) may have been as little as 20cm in diameter.
- Small portions of the study area were however occupied by hard-standing, buildings, railway lines and minor hard-surfaced roads; particularly within the docks complex. A UXB falling on these undamaged areas, would have caused considerable damage even without detonating and consequently is more likely to have been noted and dealt with at the time, especially since these buildings and their immediate environs would have been regularly accessed by dock workers.

British / Allied UXO

- Three HG Battalions were based in Newport during WWII. As a coastal location, it is considered highly likely that anti-invasion training took place in the wider area, however no records of the localities of such activity were identified.
- Two pillboxes are known to have been strategically constructed along a main road approximately 70m and 340m from the route boundary, near Llandevenny. In addition a HAA battery was constructed immediately south of the route at Pye Corner. These positions would have been manned by HG personnel who would have been issued with small arms and land service ammunition and therefore the possibility of UXO contamination in this locality is slightly elevated.
- 11 HAA batteries were constructed within 6km of the route at the beginning of WWII. These batteries would have engaged Luftwaffe formations in the region on numerous occasions. With four guns per battery firing several rounds per minute, AA batteries could expel numerous shells in even the shortest engagements. Unexploded AA projectiles could land several kilometres from their batteries and therefore, due to the undeveloped nature of much of the site, there is considered to be an elevated risk of unexploded AA shell contamination.

- Although it is known that a considerable quantity of ammunition passed through the docks during the preparations for Operation Overlord, the 1944 D-Day landings, there is not considered to be a direct UXO risk associated with this activity.

Within the locations of post-war constructed buildings / roads, levelling for hard-standing and shallow excavations for the installation of services, the risk from shallow buried UXO (especially LSA, SAA, AA projectiles and 1kg German incendiaries) will have been partly mitigated, as any such items may have been encountered and removed during these works.

The vast majority of the route will have been subject to ploughing post-war, however this activity will not have extended deep enough into the WWII-era topsoil level to completely mitigate the risk from shallow buried UXO.

Recent aerial photography suggests that there are no substantial high-rise buildings within the route corridor and therefore, although this possibility cannot be ruled out, it is considered unlikely that any extensive, deep piling works have occurred on site post-war.

Consequently the risk from deep buried German HE UXBs will not have been mitigated to any substantial degree within the study area.

Bomb Penetration Assessment: Taking into account the complex and varied geology across the entire route, the max penetration depth will vary across the route. However within the majority of the route, it has been calculated that a 500kg bomb would have an approximate maximum bomb penetration depth of up to **12m** below WWII ground level.

Penetration depth could potentially have been greater if the UXB was larger (though only 4% of German bombs used in WWII over Britain were of that size). Note that UXBs may be found at any depth between just below the WWII ground level and the maximum penetration depth. This assessment has been made using generic geological information.

Risk Mitigation Measures: BACTEC believes the following risk mitigation measures should be deployed to support the proposed works along the M4 route. Note that although the majority of the study area has been classified as Low Risk, the threat from UXO cannot be completely ruled out due to the lack of comprehensive historical sources and the undeveloped nature of the land.

Therefore BACTEC recommends proactive risk mitigation measures - *A* and *B* - for works carried out across the entire site – see below.

All Risk Zones - Prior to All Works

- *A)* Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works.
- *B)* The Provision of Unexploded Ordnance Site Safety Instructions.

Low-Medium, Medium and Medium/High Risk Zones only

- *C)* Non-Intrusive Magnetometer Survey ahead of any intrusive works on greenfield land only.
- *D)* Explosive Ordnance Disposal (EOD) Engineer presence on site to supervise any open excavations – an alternative to a Non-Intrusive Magnetometer Survey, where this option is not possible.
- *E)* Down-Hole Intrusive Magnetometer Survey of any borehole and / or pile locations, down to the maximum bomb penetration depth.
- *F)* Jack up Barge Intrusive Magnetometer Survey of any borehole and / or pile locations, down to the maximum bomb penetration depth, within river or dock basin localities – if required.

The Risk Map, illustrating the locations of the various Risk Zones, is presented in Annex P, at the back of the report

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Explosive Ordnance Threat Assessment

In Respect of

M4 Corridor Around Newport

1. Introduction

1.1. Background

Hyder Consulting (UK) Limited has commissioned BACTEC International Limited to conduct an Explosive Ordnance Threat Assessment for the M4 Corridor around Newport route, Monmouthshire.

Unexploded Ordnance (UXO) presents a significant threat to construction projects in parts of the UK as a result of enemy actions during the two 20th Century World Wars as well as historic British and Allied Army, RAF and Naval military activity.

One of the legacies of former British/Allied military use of the landscape and the conflicts of war is buried items of Land Service Ammunition (LSA), Small Arms Ammunition (SAA). It is estimated that over 20% of the UK landmass has been used for military training at some point and between 2006 and 2009, over 15,000 items of ordnance (excluding small arms ammunition) were found on UK construction sites (CIRIA).

It is commonly accepted that the failure rate of enemy air-dropped munitions and British anti-aircraft projectiles was approximately 10% and, depending on their shape, weight, velocity and ground conditions many penetrated the ground and came to rest at depth. Intensive efforts were made during and after the war to locate and render safe all UXO but, unsurprisingly, not all were found and dealt with. This is evidenced by the regular, on-going discoveries of unexploded ordnance during construction-related intrusive ground works.

As a result of a generally increased risk awareness amongst professionals involved in ground engineering works and proactive health and safety measures, the threat to life and limb from unexploded ordnance has been minimised. However even the simple discovery of a suspected device during on-going works can cause considerable disruption to production and cause unwanted delays and expense.

Such risks can be more fully controlled by a better understanding of the site-specific threat and the implementation of appropriate risk mitigation measures.

2. Construction Industry Duties and Responsibilities

2.1. The UK Regulatory Environment

There is no specific legislation covering the management and control of the UXO risk in the UK construction industry but issues regarding health and safety are addressed under a number of regulatory instruments, as outlined below.

In practice the regulations impose a responsibility on the construction industry to ensure that they discharge their obligations to protect those engaged in ground-intrusive operations (such as archaeology, site investigation, drilling, piling or excavations) from any reasonably foreseeable UXO risk.

2.2. The Health and Safety at Work Act, 1974

The Act places a duty of care on an employer to put in place safe systems of work to address, as far as is reasonably practicable, all risks (to employees and the general public) that are reasonably foreseeable.

2.3. Construction (Design and Management) Regulations 2007

This legislation defines the responsibilities of all parties (primarily the client, the CDM Co-ordinator, the Designer and the Principal Contractor) involved with works.

Although UXO issues are not specifically addressed the regulations effectively place obligations on all these parties to:

- Ensure that any potential UXO risk is properly assessed.
- Put in place appropriate risk mitigation measures if necessary.
- Keep all parties affected by the risk fully informed.
- Prepare a suitably robust emergency response plan.

2.4. Other Legislation

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

3. The Role of the Authorities and Commercial Contractors

3.1. The Authorities

The Police have the responsibilities for co-ordinating the emergency services in the case of an ordnance-related incident on a construction site. They will make an initial assessment (i.e. is there a risk that the find is ordnance or not?) and if they judge necessary impose a safety cordon and/or evacuation and call the military authorities (JSEODOC - Joint Services Explosive Ordnance Disposal Operations Centre) to arrange for investigation and/or disposal. In the absence of an EOD specialist on site many Police Officers will use the precautionary principle, impose cordon(s)/evacuation and await advice from the JSEODOC.

The priority given to the request by JSEODOC will depend on their judgement of the nature of the threat (ordnance, location, people and assets at risk) and the availability of resources. They will respond immediately or as resources are freed up. Depending on the on-site risk assessment the item of ordnance may be removed or demolished (by controlled explosion) in situ. In the latter case additional cordons and/or evacuations may be necessary.

Note that the military authorities will only carry out further investigations or clearances in very high profile or high risk situations. If there are regular ordnance finds on a site the JSEODOC may not treat each occurrence as an emergency and will encourage the construction company to put in place alternative procedures (i.e. the appointment of a commercial contractor) to manage the situation and relieve pressure from the JSEOD teams.

3.2. Commercial Contractors

In addition to pre-construction site surveys and follow-on clearance work, a commercial contractor is able to provide a reactive service on construction sites. The presence of a qualified EOD Engineer with ordnance recognition skills will avoid unnecessary call-outs to the authorities and the Contractor will be able to arrange for the removal and disposal of low risk ordnance. If high risk ordnance is discovered actions will be co-ordinated with the authorities with the objective of causing the minimum possible disruption to site operations whilst putting immediate, safe and appropriate measures in place.

4. This Report

4.1. Aims and Objectives

The aim of this report is to examine the possibility of encountering any explosive ordnance during the proposed works along the M4 Corridor around Newport route. Risk mitigation measures will be recommended, if deemed necessary, to eliminate or reduce the threat from explosive ordnance during the envisaged works. The report follows the CIRIA Guidelines.

4.2. Risk Assessment Methodology

The following issues will be addressed in the report:

- The risk that the route was contaminated with UXO.
- The risk that UXO remains on along the route.
- The risk that ordnance may be encountered during any future works.
- The risk that ordnance may be initiated.
- The consequences of initiating or encountering ordnance.

Risk mitigation measures, appropriate to the assessed level of risk and site conditions, will be recommended if required.

4.3. Approach

In preparing this Explosive Ordnance Threat Assessment Report, BACTEC has considered general and, as far as possible, site specific factors including:

- Evidence of German bombing and delivery of UXBs.
- Site history, occupancy and conditions during WWII.
- The legacy of Allied military activity.
- Details of any known EOD clearance activity.
- The extent of any post war redevelopment.
- Scope of the current proposed works.

4.4. Sources of Information

BACTEC has carried out detailed historical research for this Explosive Ordnance Threat Assessment including accessing military records and archived material held in the public domain and in the MoD.

Material from the following sources has been consulted:

- The National Archives, London.
- Gwent Archives, Monmouthshire.
- F!ND Maps.
- The Council for British Archaeology.
- The MOD.
- Relevant information supplied by Hyder Consulting (UK) Limited.
- Available material from 33 Engineer Regiment (EOD) Archive.
- BACTEC's extensive archives built up over many years of research and hands-on Explosive Ordnance Disposal activities in the UK.
- Open sources such as published books, local historical records and the internet.

4.5. Reliability of Historical Records

4.5.1. General Considerations

This report is based upon research of historical evidence. Whilst every effort has been made to locate all relevant material BACTEC cannot be held responsible for any changes to the assessed level of risk or risk mitigation measures based on documentation or other information that may come to light at a later date.

The accuracy and comprehensiveness of wartime records is frequently difficult or impossible to verify. As a result conclusions as to the exact location, quantity and nature of the ordnance threat can never be definitive but must be based on the accumulation and careful analysis of all accessible evidence. BACTEC cannot be held responsible for inaccuracies or gaps in the available historical information.

4.5.2. Bombing Records

During WWII considerable efforts were expended in recording enemy air raids. Air Raid Precautions (ARP) wardens were responsible for making records of bomb strikes either through direct observation or by post-raid surveys. However their immediate priority was to deal with casualties and limit damage, so it is to be expected that records are often incomplete and sometimes contradictory. Record keeping in the early days of bombing was not comprehensive and details of bombing in the early part of the war were sometimes destroyed in subsequent attacks. Some reports may cover a single attack, others a period of months or the entire war.

Records of raids that took place on sparsely or uninhabited areas were often based upon third party or hearsay information and are not always reliable; records of attacks on military or strategic targets were often maintained separately from the general records and have not always survived.

5. The Route

5.1. Route Location

The study area it located within Monmouthshire, south-east Wales. It stretches from M4 Junction 29 in the west, continuing east though Newport Docks (to the south of the city), then passing immediately adjacent to the south of Llanwern Steelworks, before merging with the existing M4 Junction 23A at Magor.

Route location maps are presented in Annex A.

5.2. Present Day Route Description

The route corridor varies in size, but has an approximate average width of 150m. Recent aerial photographs of the route (west to east) are presented in Annex B and are described below.

5.2.1. Western Section

The western section is mainly set in agricultural land and woodland; The Wentlooge Levels. The western extent is represented by the motorway junction. The route then follows Percoed Lane, crosses several minor roads, a railway line and two rivers. On approaching Newport Docks, the corridor encroaches on The Docksway Landfill site before passing through brownfield land, hard-standing and warehousing. A northern spur of the route propagates north to the A48, passing through unused wasteland and some commercial sites.

5.2.2. Central Section

After crossing the North Dock / Alexandra Dock bottleneck, the route passes over the River Usk, through commercial property / woodland / wasteland and over several minor roads. The central third of this section is dominated by the Caldicot Levels; a network of tide locked freshwater drains, locally known as Reens. The corridor then passes through settlement

lagoons associated with the neighbouring Llanwern Steelworks. Note that a spur propagates north to a separate parallel corridor, occupied by a stretch of Queen's Way (A4810) and an adjacent canal.

5.2.3. Eastern Section

The western part of this section is again occupied by Reens / farmland. As the route bends north-east it follows the A4810, crosses a railway line and covers the M4 / A4810 junction, whilst also encroaching on the north-western edge of Magor town. The corridor then continues east again, following the M4 through agricultural land before terminating at the M48 junction.

6. Scope of the Proposed Works

The scheme involves construction of a three lane motorway to the south of Newport city. Significant earthworks and structures will be required as part of the proposed scheme. These are likely to comprise preparatory excavation works along the whole route, as well as piling works through the soft soils within the docks area.

A number of new junctions are proposed along the new section of motorway:

- BACTEC's At the western end, a free-flow interchange will provide a connection between the A48(M), the new section of motorway and the existing motorway.
- A new grade-separated roundabout junction will be provided immediately to the west of the River Usk, within the Newport Dock area, providing a connection onto the motorway from the Southern Distributor Road (SDR).
- A new grade-separated roundabout junction will be provided connecting the motorway onto the Southern Distributor Road, in the Glan Llyn area.
- A new grade-separated roundabout junction will be provided at Magor, providing a connection between the existing M4, the M48, the B4245, and the new section of motorway.

7. Ground Conditions

Information provided by Hyder Consulting (UK) Limited states the following: Within the study area of the scheme, the solid geology consists of Mercia Mudstone (formerly Keuper Marl) and it's Marginal Facies (Dolomitic Conglomerate), Carboniferous Limestone Group (which includes the Avon Limestone and Blackrock Limestone subgroups), and Devonian Tintern Sandstones (St Maughan's Group and Raglan Marl Group).

The majority of the solid geology is covered by varying depths of alluvial and glacial deposits. These include fluvial alluvium, estuarine alluvium, river terrace deposits, head deposits and morainic drift. Buried channels and valleys are also present at some locations.

8. Historical OS Mapping of The Route

8.1. Pre-WWII

1922 OS maps are presented in Annex C. These show the study area in the pre-WWII period. Note however no coverage was available for the eastern Magor section of the route. Additional WWII-era OS mapping (not included) for this area was reviewed, however no significant observations were made.

The maps show that prior to the outbreak of WWII, the vast majority of the route corridor occupied agricultural land and small areas of woodland, like today. Numerous farmsteads were positioned along the route also.

The *Great Western Railway* line is shown to pass through the corridor on the Wentlooge Levels and the only significant residential concentrations are two small villages - Castleton and *Pye Corner* - both immediately south of the corridor. Note, it is known that during this period, Magor was much smaller than today and did not extend close to the eastern extent of the

route, as it does today. Note also the absence of Llanwern Steelwors; known to have been constructed in the early 1960s.

The Docks area is the only part of the site to be significantly developed prior to WWII. Dockside development within the corridor includes *Timber Ponds*, *Timber Yards*, *Workshops*, *Cranes* and a *Graving Dock*. Numerous railway sidings have been laid on shallow embankments in the western dock area to transport coal to the ships. Note that within this section of the route, the *Ebbw River* followed a different course historically.

On the eastern bank of the adjacent *River Usk*, the corridor incorporates two *Dry Docks*, with associated ancillary structures.

Parts of the dock complex (occupied by sidings) are shown to be rough grassland, whereas some areas are blank, possibly indicating hard-standing.

8.2. Post-WWII

A 1949 post-WWII OS map of the Docks area is also presented in Annex C. This map shows the site generally as it appears on the previous map. No cleared buildings, often indicative or WWII-era bomb damage, are apparent within the route corridor or immediately surrounding area.

Additional early post-WWII OS mapping (not included) for the remainder of the site was reviewed, however no other significant observations were made.

Over both pre and post-WWII maps, no military style structures or censored areas were observed. Note that the latter relates to sensitive military installations, censored in the interests of national security.

9. The Threat from Aerial Bombing

9.1. General Bombing History of Monmouthshire

9.1.1. First World War

London and Eastern England suffered aerial bombardment during WWI. However Wales did not experience any such raids and consequently the threat from WWI UXBs is considered low and will not be further addressed in this report.

9.1.2. Second World War

At the start of WWII, the Luftwaffe planned to destroy key military installations, including RAF airfields and Royal Navy bases, during a series of daylight bombing raids in east and south-east England, East Scotland and south Wales.

After the Battle of Britain these tactics were modified to include both economic and industrial sites all over Britain. Targets included dock facilities, railway infrastructure, power stations, weapon manufacturing plants and gas works. As a result of aircraft losses, daylight raids were reduced in favour of attacking targets under the cover of darkness. During this period merchant navy convoys were also targeted in the narrow mine swept coastal channels but also whilst in dock.

As the war progressed the strategy changed to one of attempting to destroy the morale of the civilian population by the "carpet bombing" of London and several other major British cities, including Swansea and Cardiff. In Wales the vast majority of ordnance was dropped on West Glamorgan, however many other towns and isolated targets also experienced air raids, including parts of Monmouthshire and Newport.

By May 1941, concentrated attacks on both land targets and shipping ceased as the Luftwaffe was diverted east to prepare for 'Operation Barbarossa', the invasion of the Soviet Union. By the end of the war 984 people had been killed and 1,221 seriously injured in Wales.

9.2. Aerial Delivered Ordnance in the Second World War

9.2.1. Generic Types of WWII German Air-delivered Ordnance

The nature and characteristics of the ordnance used by the Luftwaffe allows an informed assessment of the hazards posed by any unexploded items that may remain today. Detailed illustrations of German air-delivered ordnance are presented at Annex D.

- HE bombs: In terms of weight of ordnance dropped, HE bombs were the most frequent weapon deployed. Most bombs were 50kg, 250kg or 500kg (overall weight, about half of which was the high explosive) though large bombs of up to 2,000kg were also used. HE bombs had the weight, velocity and shape to easily penetrate the ground intact if they failed to explode. Post-raid surveys would not always have spotted the entry hole or other indications that a bomb penetrated the ground and failed to explode and contemporary ARP documents describe the danger of assuming that damage, actually caused by a large UXB, was due to an exploded 50kg bomb. Unexploded HE bombs therefore present the greatest risk to present–day intrusive works.
- Blast bombs/parachute mines: Blast bombs generally had a slow rate of descent and were extremely unlikely to have penetrated the ground. Non-retarded mines would have shattered on most ground types, if they had failed to explode. There have been extreme cases when these items have been found unexploded, but this was where the ground was either very soft or where standing water had reduced the impact. BACTEC does not consider there to be a significant threat from this type of munition on land.
- Large incendiary bombs: This type of bomb ranged in size from 36kg to 255kg and had a number of inflammable fill materials (including oil and white phosphorus), and a small explosive charge. They were designed to explode and burn close to the surface but their shape and weight meant that they did have penetration capability. If they penetrated the ground complete combustion did not always occur and in such cases they remain a risk to intrusive works.
- 1kg Incendiary Bombs (IB): These bombs, which were jettisoned from air-dropped containers, were unlikely to penetrate the ground and in urban areas would usually have been located in post-raid surveys. However, if bombs did not initiate and fell in water or dense vegetation, or became mixed with rubble in bomb damaged areas they could have been overlooked. Some variants had explosive heads and these present a risk of detonation during intrusive works.
- Anti-personnel (AP) bomblets: AP bombs had little ground penetration ability and should have been located by the post-raid survey unless they fell into water, dense vegetation or bomb rubble.
- Specialist Bombs (smoke, flare, etc.): These types do not contain high explosive and therefore a detonation consequence is unlikely. They were not designed to penetrate the ground.

9.2.2. German Air-delivered Ordnance Failure Rate

Based on empirical evidence, it is generally accepted that 10% of the German HE bombs dropped during WWII failed to explode as designed. This estimate is probably based on the statistics of wartime recovered UXBs and therefore will not have taken account of the unknown numbers of UXBs that were not recorded at the time, and is probably an underestimate.

The reasons for failures include:

- Fuze or gaine malfunction due to manufacturing fault, sabotage (by forced labour) or faulty installation.
- Clockwork mechanism failure in delayed action bombs.
- Failure of the bomber aircraft to arm the bombs (charge the electrical condensers which supplied the energy to initiate the detonation sequence) due to human error or equipment defect.
- Jettison of the bomb before it was armed or from a very low altitude. Most likely if the bomber was under attack or crashing.

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

From 1940 to 1945 bomb disposal teams dealt with a total of 50,000 explosive items of 50kg and over (i.e. German bombs), 7,000 AAA shells and 300,000 beach mines. These operations resulted in the deaths of 394 officers and men. However, UXO is still regularly encountered across the UK (see recent press articles, Annex E-1).

9.2.3. UXB Ground Penetration

9.2.3.1. General Considerations

The actual penetration depth of aerial delivered bombs into the ground will have been determined by the mass and shape of the bomb, the velocity and angle of the bomb on impact (dependent on the height of release) and the nature of the ground and ground cover; the softer the ground, the greater the potential penetration. Peat, alluvium and soft clays are easier to penetrate than gravel and sand. Bombs are brought to rest or are commonly deflected by bedrock or large boulders.

9.2.3.2. The "j" Curve Effect

An air-dropped bomb falling from normal bombing altitude (say 5,000m) into homogeneous ground will continue its line of flight but turn in an upwards curve towards the surface as it comes to rest. This offset from vertical is generally thought to be about one third of the penetration depth, but can be up to 15m depending on ground conditions or the bomb's angle of impact.

9.2.3.3. Second World War Bomb Penetration Studies

During WWII the Ministry of Home Security undertook a major study on actual bomb penetration depths, carrying out statistical analysis on the measured depths of 1,328 bombs as reported by Bomb Disposal, mostly in the London area. They then came to conclusions as to the likely average and maximum depths of penetration of different sized bombs in different geological strata.

The median penetration of 430 x 50kg German bombs in London Clay was 4.6m and the maximum penetration observed for the SC50 bomb was 9m.

They concluded that the largest common German bomb, 500kg, had a likely penetration depth of 6m in sand or gravel but 8.7m in clay. The maximum observed depth for a 500kg bomb was 10.2m and for a 1,000kg bomb 12.7m. Theoretical calculations suggested that significantly greater penetration depths were probable.

9.2.4. Initiation of Unexploded Bombs

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

- Direct impact onto the main body of the bomb: 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 a buried iron bomb. Such violent action can cause the bomb to detonate.
- Re-starting the clock timer in the fuze: Only a small proportion of German WWII bombs employed clockwork fuzes. It is probable that significant corrosion has taken place within the fuze mechanism over the last 60 years that would prevent clockwork mechanisms from functioning, nevertheless it was reported that the fuze in a UXB dealt with by 33 EOD Regiment in Surrey in 2002 did re-commence.
- Induction of a static charge, causing a current in an electric fuze: The majority of German WWII bombs employed electric fuzes. It is probable that significant corrosion has taken

place within the fuze mechanism over the last 60 years such that the fuze circuit could not be activated.

- Friction impact initiating the (shock-sensitive) fuze explosive: This is the most likely scenario resulting in the bomb detonating.

Annex E-2 details UXB incidents where intrusive works have caused UXBs to detonate, resulting in death or injury and damage to plant.

9.3. Second World War Bombing of the Route Area

9.3.1. Newport Overview

Newport was a large town during WWII with a small docks system. Therefore, unlike Swansea to the west and Bristol to the south-east which were larger conurbations, with more extensive docks and associated industries, Newport was not considered to be a high priority target area.

These two cities sustained numerous air raids during the war, including several concentrated Blitz attacks, involving hundreds of enemy aircraft. Although no Luftwaffe aerial target photography for the wider Newport area was available, it can be assumed that the town was specifically targeted as it was raided on at least twenty occasions, although not to the same degree as the former cities.

Although the exact number of aircraft involved in these attacks is unknown, it can be confidently presumed that the majority of these raids were carried out by solitary bombers or small formations.

The likely target area in the town would have been the docks, where a large number of industries such as metal, iron, coal and timber works (which would have been vital to the Allied war effort) were based. In addition, Newport contained widespread and significant rail infrastructure during the war.

9.3.2. Rural District of St. Mellons & Magor

During WWII, in addition to bombing of specific targets, bomb strikes would often occur in open countryside away from any industrial or military facilities. These were often the result of German 'tip and run' tactics.

These bombing incidents occurred when German aircraft, harassed by concentrated anti-aircraft fire and/or fighter interception, would drop their bombs prematurely/indiscriminately in order to escape the combat zone. This also occurred when aircraft became lost over enemy territory.

The relative close proximity of Cardiff and Bristol to the route indicates significant Luftwaffe activity in the wider region and therefore it is likely that such bombing incidents occurred in the Rural District of St. Mellons & Magor, within which the majority of the route was located historically. Note also that at the beginning of the war, nine bombing decoy sites were installed in this area, likely increasing the local bombing density further (see below).

No important military bases were located in close proximity to the route corridor, however in 1940 the Caerwent Royal Naval Propellant Factory became operational, approximately 3.2km north-east of the eastern extent of the study area. This would have been considered a highly prized target and therefore it is possible that this facility attracted additional Luftwaffe aircraft to the area. Note however it is understood that this factory was not bombed during WWII.

Records of bombing incidents in the civilian areas of Monmouthshire were collected by the Air Raid Precautions wardens and collated by the Civil Defence Office. Some other organisations, such as the military or strategic targets and railways, maintained separate records. These records are presented in the following sections, however note that no WWII-era ARP bombing records for the Rural District of St. Mellons & Magor were available.

9.3.3. Monmouthshire Bombing Decoy Sites

A national decoy authority headed by Colonel John Fisher Turner was set up in July 1940, and following earlier experiments in Glasgow and Sheffield, a system of urban lighting decoys was set up. These were known as "Civil" sites; Civil 'QL' for urban lighting simulation, and Civil 'QF' for dummy fires. "Q" - sites were equipped with assorted electrical and pyrotechnical apparatus to simulate the flare given from furnace doors, steel-making, railway marshalling yards, and light given off by inefficient blackout precautions.

Other sites simulated small fires started by incendiary bombs, with oil-storage area fire simulation being developed near large oil installations. A further variation on fire decoy sites was the "SF", or "Special Fires" sites. A larger, longer-burning type of fire was provided at these sites - known as "Starfish" sites - to draw incendiary bombs, and hopefully as a consequence the full enemy payload, from falling on the larger conurbations and defence installations during heavy air raids.

Decoy sites were effective in drawing the Luftwaffe's attacks away from legitimate airfields – in 1940 alone 'Q' and 'Starfish' sites received nearly 200 attacks. However no specific records listing enemy raids over Monmouthshire were located.

The decoy map, presented in Annex F, indicates that nine QF and SF sites were positioned within 5km of the route; three of which were positioned immediately adjacent to the route corridor, within the location of the current Llanwern Steelworks. Had these sites been successful in drawing German bombs away from Newport, these weapons may have fallen within the route corridor.

9.3.4. Second World War Bombing Statistics

During WWII the War Office collected and compiled bombing statistics for almost every Urban and Rural District and Metropolitan and County Borough. The route was formerly located within two administrative areas, which sustained the following:

- County Borough of Newport - *95 high explosive bomb strikes*
- Rural District of St. Mellons & Magor - *366 high explosive bomb strikes*

The latter figure gives a bombing density of 8.3 HE bombs per 1,000 acres, a relatively low density.

Detailed records of the quantity and locations of the 1kg incendiary and anti-personnel bombs were not routinely maintained by the authorities as they were frequently too numerous to record. Although the incendiaries are not particularly significant in the threat they pose, they nevertheless are items of ordnance that were designed to cause damage and inflict injury and should not be overlooked in assessing the general risk to personnel and equipment.

The anti-personnel bombs were used in much smaller quantities and are rarely found today but are potentially more dangerous.

9.3.5. Written ARP Bombing Incident Records

Written ARP reports for Newport were obtained from Gwent Archives. The incidents below are considered to represent a comprehensive list of all bombing within the city boundary during WWII; although note that this cannot be guaranteed, as records may have been lost in the post-war period. Those incidents which occurred in the vicinity of the route have been highlighted.

The approximate locations of the incidents have also been plotted onto a recent Ordnance Survey base map, presented in Annex G.

a. *1940* – Direct hit at 110 Maesglas Avenue, approximately 2km from the site, during an Incendiary raid.

b. *26th June 1940* – 6 high explosive bombs were dropped. St Julians Street and Dewstow Street were hit. In addition one HE bomb fell on the eastern dry docks and another unexploded HE bomb fell in mud on the west side of the River Usk.

c. *12th June 1940* – German bomber seen over Newport, Anti-aircraft artillery in action, bombs landed at the end of Corporation Road.

d. *12th July 1940* – 5 HE bombs were dropped at 16:35 hours. They all fell in the vicinity of Nash Road, 1 landed in the River Usk. The probable target was the Lysaghts Works.

e. *13th July 1940* – 7 HE bombs were dropped over Newport. 3 landed on wasteland at Mendalgief Road near Belle Vue Railway Crossing. ***4 landed in the area of Alexandra Docks.***

f. *14th August 1940* – 7 HE bombs landed in the River near the Eastern Dry Docks and British Aluminium Co's Works.

g. *26th August 1940* – 4 HE bombs were dropped, 1 landed on Dewstow Street the remaining 3 near the Railway Bridge, Stephenson Road and Messrs. Lysaghts Works yard.

h. *29th August 1940* – 5 HE bombs dropped, 1 landed in a builders yard on Raufort Place, 3 landed on Badminton Road and the final bomb hit the playing fields of St. Julian's High School.

i. *13th September 1940* – German bomber crashes at Stow Park Avenue, approximately 1km from the site, caused by barrage balloons.

j. *14th September 1940* – ***At 00.23 hours, 5 HE bombs all landed around Alexandra Docks, near South Lock.***

k. *20th September 1940* – A Heinkel bomber, brought down by barrage balloon cables, crashes on a house at the top of Stow Hill approximately 1km from the site.

l. *October 1940* – German bomber drops a stick of bombs over Pillgwenlly causing damage in a straight line across 6 streets. ***The Alexandra Dock Hotel was also hit.***

m. *9th October 1940* – ***Incendiary bombs dropped*** over Firbank and Hove Avenues and ***around Alexandra Docks***. On the same night ***4 HE bombs were dropped*** landing on Dock Street, George Street, Baldwin Street, and ***on the Alexandra Docks***.

n. *26th February 1941* – 6 HE bombs dropped landing on Ombersley Road, Bassaleg Road, Fields Park Road, Fields Park Avenue, and in a field between Stelvio Road and Cae Brynton Road.

o. *1st March 1941* – 5 HE bombs were dropped around Corporation Road.

p. *31st May 1941* – Raid by solitary aircraft. Bombs land on Fields Park Road, Ridgeway Avenue, and Glasllwch Crescent all of which are within 3km of the site. 23 people killed, 24 injured and 560 houses suffered varying degrees of damage.

q. *30th June 1941* – ***Suspected unexploded mine located in the mud near the docks.***

r. *1st July 1941* – Several parachute mines were dropped over Newport, one landed near Belle Vue Park near the bottom of Waterloo Road. Others landed on Eveswell Street, Beechwood Road, in a field off of Christchurch Road and in the river near the Transporter Bridge, which did not explode.

s. *1st July 1941* – Parachute mines fall on Kensington Place, Beechwood Road, Archibald Street and Eveswell Street, killing 35 and injuring 46.

t. *29th August 1941* – Bombs land on Beaufort Road, Beaufort Place and Badminton Road.

u. *18th May 1943* – 2 HE bombs landed on Nash Road and did not explode.

A secondary source of bombing in Newport was also obtained[1]. This was compiled by a local historian after research at local libraries. Note however this record only lists bombing incidents up to February 1941. Listed below are two incidents located close to the route, which are not recorded above; see Annex G.

- 13th July 1940 – At 00:15 hrs, six HE bombs within the grounds of Alexandra Dock.
- 16th September 1940 – At 21:45 hrs, 2 HE bombs fell at the North Dock Gates and the North Dock Hydraulic Shed.

9.3.6. Newport ARP Bomb Plot Map

An undated bomb plot map for the south-eastern Newport area was obtained from the National Archives. A section of this map, covering a part of the corridor, is presented in Annex H. Note that no further consolidated bomb plot maps, covering the entire war period, are known to exist.

Two unexploded 500kg HE bomb strikes are plotted in open ground approximately 1.26km to the north of the study area.

9.3.7. Anecdotal Evidence of Bombing

Anecdotal evidence of bombing incidents within the route corridor area was sought. Various internet sources and books detailing WWII histories of the local area were reviewed, however no reference to bomb strikes within the countryside east and west of Newport were located.

Furthermore, no reference to bombing associated with the local decoy sites identified. Note however this does not mean bombing did not occur, as confirmed by the bombing statistics for the rural district, which record over three times as many bomb strikes in this area than within the adjacent city perimeter.

9.3.8. Historical RAF Aerial Photography

Historical aerial photography of the route obtained from the Geo Information Group and the Britain From Above project, was reviewed for this report and is presented at Annex I.

A 1926 pre-WWII oblique image of the docks area shows that, although situated within the more developed part of the route, this section is occupied by a large area of unoccupied, unmaintained wasteland.

The 1945 (immediately post-WWII) imagery covers the vast majority of the route, save for the eastern Magor extent. Although the resolution of these photographs is low, it can be said that no significant changes can be observed (within the route corridor) between this source and the 1922 OS map.

No evidence of significant bomb damage to buildings within, or close to the route is identifiable, however a possible HE bomb crater has been highlighted on the southern route boundary, within the docks complex area. Although no other HE bomb craters in open ground are apparent along the route, it should be noted that such features in worked farm land would often only remain temporarily; in-filled and ploughed prior to the available aerial photography.

One potentially significant observation is the presence of a WWII-era heavy anti-aircraft battery, positioned just 270m south of the route boundary, near Pye Corner (village); see Section 10.2

Note that these photographs were taken approximately two and a half years after the cessation of the Luftwaffe campaign in Monmouthshire and therefore the bombing decoy site installations have been removed and the requisitioned land returned to agriculture.

9.3.9. Abandoned German Bombs

A post-air raid survey of buildings, facilities and installations would have included a search for evidence of bomb entry holes. If evidence were encountered, Bomb Disposal Officer teams

[1] *http://www.chs-cwmbran.co.uk/10.html*

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, nor 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.

No such weapons are recorded within the route corridor, however BACTEC's Abandoned Bombs Register lists the following two UXBs in the vicinity.

- AB321 - 1 x 50kg German HE bomb. St. Brides, Monmouthshire. Exact location unknown. Approximately 1.2km south of the route.
- AB323 - 3 x size unknown. Redwick, Monmouthshire. Exact location unknown. Approximately 1.8km south of the route.

Note that these German UXBs, abandoned to the south of Newport, further highlight the possibility of encountering similar weapons within open countryside, away from the city centre.

9.3.10. Site Specific Bomb Penetration Considerations

When considering an assessment of bomb penetration along the M4 Corridor around Newport route, the following parameters would be used:

- Geology – The geology of the route area is complex, with varying thicknesses of soft superficial alluvial and glacial deposits covering the entire corridor.
- Impact Angle and Velocity – 80-90^{O} from horizontal and 267 metres per second.
- Bomb Mass and Configuration – The 500kg SC (General Purpose) HE bomb, without retarder units or armour piercing nose. This was the largest of the common bombs used against Britain.

Taking into account the complex and varied geology across the entire route, the max penetration depth will vary across the route. However within the majority of the route, it has been calculated that a 500kg bomb would have an approximate maximum bomb penetration depth of up to 12m below WWII ground level.

Penetration depth could potentially have been greater if the UXB was larger (though only 4% of German bombs used in WWII over Britain were of that size). Note that UXBs may be found at any depth between just below the WWII ground level and the maximum penetration depth. This assessment has been made using generic geological information.

9.4. Likelihood of Post-raid UXO Detection

Utilising the available historical bombing records as reviewed in sections 9.1 to 9.4, it is possible to make an assessment of the likelihood that evidence of UXO would have been noted on a site during the war and the incident dealt with or recorded at the time. Factors such as bombing density, ground cover, frequency of access, damage and bomb failure rate have been taken into consideration.

9.4.1. Density of Bombing

Bombing density is an important consideration for assessing the possibility that UXBs remain in an area. A very high density of bombs can for example result in increased levels of damage sustained to structures, greater likelihood of errors in record keeping and a higher risk that UXBs fell over the area.

Likely to have been targeted by the Luftwaffe, the docks section of the route was situated in an area of moderate bombing density, as confirmed by official statistics and ARP incident

records. Although no precise locations of bomb strikes were identified, several incidents referencing bombing in the docks areas were noted.

The bombing density across the remainder of the route will have been variable. Within the vicinity of the local bombing decoy sites, the possibility of German bombing incidents is increased. However in agricultural land, away from these sites, the bombing density will have been low, as confirmed by official statistics.

9.4.2. Ground Cover

The degree and type of groundcover present during WWII would have a significant effect on the visual evidence at ground level which may have indicated the presence of buried UXO.

During WWII the route mainly comprised of agricultural fields, in use for cultivation or livestock. Depending on the season, the ground cover may have been pasture, ploughed earth or dense crop growth. In any case, evidence of an air-dropped UXB could have become obscured. Note that the entry hole of an SC50 UXB (the most commonly deployed German HE bomb) may have been as little as 20cm in diameter; as shown by a HE bomb entry hole photograph presented in Annex J.

Furthermore, evidence of a UXB strike to the rivers and associated mud flats/banks that cross the route, would have been immediately obscured and even if such an incident was observed, it is considered highly unlikely that the weapon would have been recovered, due to inaccessibility and lack of any imminent danger to people or buildings.

Also noteworthy is that German 1kg incendiary bombs (known to have been deployed over Newport) were observed to penetrate to a significant depth when dropped into soft ground. As illustrated by the photograph (presented in Annex K) which shows how such a sub-munition, could have fallen on site and remained undetected in the post-war period.

Small parts of the study area were however occupied by hard-standing, buildings, railway lines and minor hard-surfaced roads. A UXB falling on these undamaged areas, would have caused considerable damage even without detonating and consequently is more likely to have been noted and dealt with at the time.

9.4.3. Frequency of Access

UXO at sites where human access was infrequent would have a higher chance of being overlooked than at those sites which were subject to greater occupancy. The importance of a site or facility to the war effort is also an important consideration as such sites are likely to have been both frequently accessed and are also likely to have been subject to post-raid checks for evidence of UXO.

The vast majority of the study area would not have been accessed either regularly or frequently during WWII. Any access to the fields for agricultural purposes would have been seasonal and it is considered possible that a UXB could have fallen within the vast majority of the route boundary unobserved; especially since many of the German air raids took place over Newport at night. Furthermore, agricultural fields would not have been subject to specific post-raid searches for UXO, due to their distance from any built up areas and lack of importance.

Following the bombing incidents within the docks area, the railway sidings would probably have been subject to post-raid checks for bomb damage / buckling and evidence of UXO. Within the sections occupied by dock infrastructure, buildings and the dry dock (on the eastern bank of the River Usk), the frequency of access would have been higher as these facilities would have been vital to the local war effort and therefore would have been kept operational at all costs.

However much of the corridor within the docks complex was occupied by open, apparently unused land and therefore it is considered possible that a UXB could have fallen here unnoticed.

9.4.4. Damage

If structures on a site have been subject to significant bomb or fire damage, rubble and debris are likely to have been present; similarly an HE bomb strike on open ground is likely to have resulted in a degree of soil disturbance. Under such conditions there is a greater risk of the entry holes of unexploded bombs dropped during subsequent raids being obscured and going unnoticed.

No evidence of bomb damage to buildings was noted within the route corridor. However a 1945 aerial photograph of the docks exhibits what could be a HE bomb crater, immediately adjacent to the route boundary.

9.4.5. Bomb Failure Rate

There is no evidence to suggest that the bomb failure rate in the vicinity of the site would have been different from the "approximately 10%" figure normally used.

10. The Threat from Allied Military Ordnance

10.1. General

The following potential military uses have been considered:

- Anti-Aircraft Defences.
- Home Guard.
- Training or firing ranges or the storage of ammunition.
- Military bases.
- Defensive minefields (including pipemines).
- Defensive Positions.
- Manufacture of explosives or ordnance.

The most likely sources of Allied ordnance are from activities at defensive positions, anti-aircraft defences and Home Guard activities, as discussed in the following sections. An image of the route recording potential UXO risk contributors is presented in Annex L.

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10.2. Anti-Aircraft Artillery and Projectiles

At the start of the war two types of AAA guns were deployed: Heavy Anti-Aircraft Artillery (HAA), using large calibre weapons such as the 3.7" QF (Quick Firing) gun and Light Anti-Aircraft Artillery (LAA) using smaller calibre weapons such as 40mm Bofors gun.

During the early war period there was a severe shortage of AAA available and older WWI 3" and modified naval 4.5" guns were deployed alongside those available 3.7" weapons. The maximum ceiling height of fire at that time was around 11,000m (for the 3.7" gun and less for other weapons). As the war progressed improved variants of the 3.7" gun were introduced and, from 1942, large 5.25 inch weapons began to be brought into service. These had significantly improved ceiling heights of fire reaching over 18,000m.

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

The HAA projectiles were high explosive shells, usually fitted with a time delay or barometric pressure fuze to make them explode at a pre-determined height. Before the war all the clockwork fuses used by the Royal Artillery had come from Switzerland. When that source of supply was cut off, Britain had been forced to make its own.

After four years of war, the country still lacked the engineering skills to produce a reliable fuse. This resulted in a considerable number of AA projectiles either exploding prematurely,

killing the gunners or failing to explode at all; falling to the ground as UXBs. In January 1944 more people in London were killed by HAA shells than by German bombs. Details of the most commonly deployed WWII AAA projectiles are shown below:

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

11 HAA batteries were constructed within 6km of the route at the beginning of WWII. These batteries would have engaged Luftwaffe formations in the region on numerous occasions. With four guns per battery firing several rounds per minute, AA batteries could expel numerous shells in even the shortest engagements. Unexploded AA projectiles could land several kilometres from their batteries and therefore, due to the undeveloped nature of much of the site, there is considered to be an elevated risk of unexploded AA shell contamination.

10.2.1. Home Guard

The Home Guard (HG) was a defence organisation of the British Army, operational between 1940 and 1944. It comprised 1.5 million local volunteers, otherwise ineligible for military service, and acted as a secondary defence force, in case of enemy invasion. The HG guarded the coastal areas of Britain and other important facilities such as airfields, factories and explosives stores.

Within the Welsh Border Sub-District the 11th Salop HG Battalion was stationed in Newport. In addition, the Severn Sub-District also included the 2nd and 3rd Monmouthshire HG Battalions, also based in Newport. However it is not clear where these units carried out their training exercises. It should be noted though that records of HG activity were not routinely kept and any extant evidence is usually only anecdotal.

Although no evidence of HG activity within the vicinity of the route was located, it is known that HG units stationed in towns often carried out weapons training on the outskirts of urban areas, in open countryside, sometimes within close proximity to civilian life. Therefore the possibility that such activity occurred within the route corridor cannot be entirely discounted.

Information taken from the Council for British Archaeology's study of the WWII anti-invasion landscape of England, (mapping the locations and types of existing defences around the country) plots two pillboxes approximately 70m and 340m from the route boundary, near Llandevenny (see Annex L). OS mapping suggests that these defences were positioned either side of Bareland Street during WWII, as this was likely considered to be a road used by an invasion force.

Thousands of these concrete fortifications were strategically positioned around the UK during the period of anticipated invasion in 1940. They would have been manned by HG personnel who would have been issued with small arms and land service ammunition. Consequently the possibility of UXO contamination in this area is slightly increased.

It should also be noted that HG personnel were responsible for operating the majority of HAA batteries during WWII. Therefore it is likely that they would have been active at the Pye Corner battery, immediately south of the route.

Today, items of ordnance related to the HG are occasionally encountered by members of the public and the construction industry in the British countryside. Experience has shown that the 'housekeeping' of less disciplined/voluntary HG personnel during WWII was often poor with items of faulty, expended or surplus UXO often burnt, buried, misplaced or otherwise discarded in civilian areas.

10.2.2. WWII Army Activity

In 1942 15,000 American servicemen arrived in, and then were stationed in, the Monmouthshire area. The majority of them were billeted in three Army camps to the north of Newport, as well as a fourth (Llanmartin Camp), approximately 2.3km north-west of the Magor section of the route.

The American GIs in Newport were almost all service and ancillary regiments, including the famous 756th RSB (Railway Shop Battalion). It was not until the immediate weeks and days

preceding D-Day that combat troops assembled at Newport Docks and packed Forge Lane in transport carriers waiting to board ships to take them to the beaches of Normandy. American troops were transported by rail directly onto the ships and hundreds of tanks and lorries previously stored in Forge Lane were loaded and sent to France.

During the two years that these troops were accommodated in Newport they would have carried out regular training exercises. The large number of troops involved however suggests that this activity would have occurred at large established British Army training facilities in the Welsh countryside, such as Sennybridge Army Training Area, many kilometres to the north. Therefore the UXO risk associated with Army training is not considered to be elevated within the route corridor.

10.2.3. D-Day Preparations

During early June 1944, in the days leading up to the D-Day invasion of France, almost 40,000 tons of ammunition was brought by rail into Newport docks and loaded onto 16 coasting vessels and 18 Liberty ships.

Note however, the movement of this vast quantity ammunition within or in close proximity to the route corridor is unlikely to have resulted in UXO contamination, as this operation would have been carefully monitored and had any munitions not been embarked onto the transport vessels, it is unlikely to have become buried within open ground at the docks and any missing munitions would have been recovered due to the presence of many dock workers and military personnel.

10.2.4. Caldicot Firing Range

Approximately 1.3km south-east of the eastern extent of the route is Caldicot Firing Range. This operational range is situated on 27 acres of territorial and Army Volunteer Reserve freehold land and five acres of foreshore. The danger Area extends out over the Bedwin Sands within the Severn Estuary.

This range provides firing facilities for small arms classification at eight targets from 100m to 500m, facing out to sea. It is believed that this range may have been in use during WWII, was decommissioned and then re-opened again in October 1970.

Although this facility may have been indicative of additional training in the immediate Caldicot coastal area during WWII, it is not considered to elevate the risk of British / Allied UXO within the route corridor to a significant degree.

11. Threat Posed By Allied Explosive Ordnance

11.1. Anti-Aircraft Artillery Shells

These shells are frequently mistakenly identified as small German air-delivered bombs, but are differentiated by the copper driving band found in front of the base. Although the larger unexploded projectiles could enter the ground they did not have great penetration ability and are therefore likely to be found close to WWII ground level.

With a HE fill and fragmentation hazard these items of UXO also present a significant risk if encountered. The smaller 40mm projectiles are similar in appearance and effect to small arms ammunition and, although still dangerous, present a lower risk.

Pictures of AAA projectiles are presented in Annex M. Details of the most commonly deployed WWII AAA projectiles are shown below:

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

11.2. Land Service Ammunition (LSA)

11.2.1. General

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

a. Mortars
b. Grenades
c. Projectiles
d. Rockets
e. Landmines

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

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

11.2.2. Mortars

A mortar bomb is a fin-stabilised munition, normally nose-fuzed and fitted with its own propelling charge (primary cartridge). Range is increased by adding extra propellant (augmenting charges). They are either High Explosive or Carrier and generally identified by their tear-drop shape (older variants however are parallel sided) and a finned 'spigot tube' screwed or welded to the rear end of the body housing the propellant charge. A mortar relies on a striker hitting a detonator for explosion to occur.

It is possible that the striker may already be in contact with the detonator and that only a slight increase in pressure would be required for initiation. Discarded augmenting charges are often encountered around mortar firing areas/bases.

11.2.3. Grenades

A grenade is a short range weapon which may be thrown by hand, fired from the end of a rifle or projected/propelled from a special purpose grenade launcher. They are divided into two categories; High Explosive and Carrier (generally smoke). As with mortars, a grenade striker may either be in contact with the detonator or still be retained by a spring under tension, and therefore shock may cause it to function. A grenade can have an explosive range of 15-20m. Common older variants have a classic 'pineapple' shape; modern grenades tend to be smooth-sided.

11.3. Small Arms Ammunition (SAA)

Images of SAA are presented in Annex O. Even if an item functioned, the explosion would not be contained within a barrel and detonation would only result in local overpressure and very minor fragmentation from the cartridge case.

SAA of 20mm calibre and above would have included a small HE or incendiary charge that if handled incorrectly could cause injury. These bullets were used by some RAF and Luftwaffe aircraft, as well as British LAA batteries during WWII and therefore it is possible that such items may have fallen in the vicinity of the route during local dog fights and enemy air raids.

12. Ordnance Clearance and Post-WWII Ground Works

12.1. General

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

12.1.1. EOD Bomb Disposal and Clearance Tasks

BACTEC holds a collection of official explosive ordnance disposal operations during and following WWII, obtained from the Explosive Ordnance Disposal (EOD) Archive Information Office at the 33 Engineer Regiment (EOD) of the British Army.

No such UXO clearance tasks within the route corridor were identified, with the nearest such operations shown to have occurred at the aforementioned Caldicot Firing Range. Three tasks were carried out here in 1992 and 1999, however no items of live or expended UXO were recovered during these operations.

12.2. Post-WWII Redevelopment

The majority of the route comprises agricultural land and woodland, neither of which will have been subject to any significant redevelopment post-war.

With the construction of the Llanwern Steelworks, a road and canal have been constructed through part of the route as well as settlement lagoons immediately to the south. Several other roads, as well as the M4 itself have also been constructed at the western and eastern extents of the route.

Since the 1960's the area to the west of the docks has primarily been levelled and covered in hard-standing. The area has been used for a variety of commercial and industrial uses including storage yards for a variety of materials, car terminals and ship repair.

13. The Overall Explosive Ordnance Threat Assessment

13.1. General Considerations

Taking into account the quality of the historical evidence, the assessment of the overall threat to any future works from UXO must evaluate the following risks:

- That the route was contaminated with UXO.
- That UXO remains along the route.
- That such items could be encountered during any future works.
- That ordnance may be activated by the works operations.
- The consequences of encountering or initiating ordnance.

13.2. The Risk that the Route was Contaminated with UXO

For the reasons discussed below BACTEC believes that there is a risk that the route was contaminated with UXO.

German UXO

- The bombing density across the route will have been variable. Newport was subjected to at least 20 small scale air raids during the war and the neighbouring rural district, within which the majority of the route was situated, sustained 366 HE bomb strikes.
- Within the latter district, eight of the 13 Monmouthshire bombing decoy sites were positioned within 3km of the route and therefore it is quite possible that a proportion of the 366 bombs fell in relative close proximity, if not within, the route corridor.

- The route passes through Newport Docks, which would have been considered the main bombing target for enemy aircraft in the wider Newport area. Consequently records indicate that bombing incidents occurred at the docks during at least seven separate air raids, although the exact locations are unknown. This higher density of bombing is also suggested by a possible HE bomb crater identifiable on a 1945 aerial photograph of the docks.
- Conversely, in agricultural land, away from these decoy sites and Newport itself, the bombing density will have been lower. Note however an Abandoned German UXB Register records such weapons in open ground to the south of Newport, highlighting the possibility of German UXO remaining in open countryside, away from bombing targets or decoys.
- During WWII the vast majority of the route comprised agricultural fields in a sparsely populated setting. Therefore it is conceivable that any UXB strikes within this part of the route corridor, could have occurred unobserved. Especially since many of the German air raids in the wider Newport area took place at night.
- Furthermore, had such an incident occurred, the resulting evidence could have easily become obscured within dense crops growth, long grass or ploughed soil. Note that the entry hole of an SC50 UXB (the most commonly deployed German HE bomb) may have been as little as 20cm in diameter.
- Small portions of the study area were however occupied by hard-standing, buildings, railway lines and minor hard-surfaced roads; particularly within the docks complex. A UXB falling on these undamaged areas, would have caused considerable damage even without detonating and consequently is more likely to have been noted and dealt with at the time, especially since these buildings and their immediate environs would have been regularly accessed by dock workers.

British / Allied UXO

- Three HG Battalions were based in Newport during WWII. As a coastal location, it is considered highly likely that anti-invasion training took place in the wider area, however no records of the localities of such activity were identified.
- Two pillboxes are known to have been strategically constructed along a main road approximately 70m and 340m from the route boundary, near Llandevenny. In addition a HAA battery was constructed immediately south of the route at Pye Corner. These positions would have been manned by HG personnel who would have been issued with small arms and land service ammunition and therefore the possibility of UXO contamination in this locality is slightly elevated.
- 11 HAA batteries were constructed within 6km of the route at the beginning of WWII. These batteries would have engaged Luftwaffe formations in the region on numerous occasions. With four guns per battery firing several rounds per minute, AA batteries could expel numerous shells in even the shortest engagements. Unexploded AA projectiles could land several kilometres from their batteries and therefore, due to the undeveloped nature of much of the site, there is considered to be an elevated risk of unexploded AA shell contamination.
- Although it is known that a considerable quantity of ammunition passed through the docks during the preparations for Operation Overlord, the 1944 D-Day landings, there is not considered to be a direct UXO risk associated with this activity.

13.3. The Risk that UXO Remains along the Route

Within the locations of post-war constructed buildings / roads, levelling for hard-standing and shallow excavations for the installation of services, the risk from shallow buried UXO (especially LSA, SAA, AA projectiles and 1kg German incendiaries) will have been partly mitigated, as any such items may have been encountered and removed during these works.

The vast majority of the route will have been subject to ploughing post-war, however this activity will not have extended deep enough into the WWII-era topsoil level to completely mitigate the risk from shallow buried UXO.

Recent aerial photography suggests that there are no substantial high-rise buildings within the route corridor and therefore, although this possibility cannot be ruled out, it is considered unlikely that any extensive, deep piling works have occurred on site post-war.

Consequently the risk from deep buried German HE UXBs will not have been mitigated to any substantial degree within the study area.

13.4. The Risk that Ordnance may be Encountered during the Works

The most likely scenarios under which UXO could be encountered during construction works is during any piling, drilling operations or bulk excavations. The overall risk will depend on the extent of the works, such as the numbers of boreholes/piles (if required) and the volume of the excavations.

Since an air-dropped bomb may come to rest at any depth between just below ground level and its maximum penetration depth there is also a chance that such an item could be encountered during shallow excavations (for services or site investigations) into the original WWII ground level. A risk of encountering UXO will only present itself if intrusive work is carried out into virgin geology (or WWII-era made ground), outside the volume of post-war foundations.

13.5. The Risk that Ordnance 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. The most violent activity on most construction sites is percussive piling.

As a result items that are shallow buried present a slightly lower risk than those that are deep buried, since the force of impact is usually lower and they are more likely to be observed – when immediate mitigating actions can be taken.

13.6. The Consequences of Encountering or Initiating Ordnance

Clearly the consequences of an inadvertent detonation of UXO during construction operations would be catastrophic with a serious risk to life, damage to plant and a total site shutdown during follow-up investigations.

Since the risk of initiating ordnance is significantly reduced if appropriate mitigation measures are undertaken, the most important consequence of the discovery of ordnance will be economic. This would be particularly so in the case of high profile locations and could involve the evacuation of the public. The unexpected discovery of ordnance may require the closing of the site for any time between a few hours and a week with a potentially significant cost in lost time. Note also that the suspected find of ordnance, if handled solely through the authorities, may also involve loss of production since the first action of the Police in most cases will be to isolate the locale whilst awaiting military assistance, even if this turns out to have been unnecessary.

13.7. BACTEC's Assessment

Taking into consideration the findings of this study, BACTEC considers the risk along the route to be heterogeneous and can therefore be subdivided into **Low, Low-Medium, Medium** and **Medium-High Risk Zones**. These are illustrated in a Risk Map, presented in Annex P, and are described below.

Low Risk Zone – Parts of the site occupied by historically unused, undeveloped agricultural land.

	Level of Risk			
Type of Ordnance	**Negligible**	**Low**	**Medium**	**High**
German HE UXBs		✓		
German 1kg Incendiary UXBs		✓		
British AA Projectiles		✓		
British / Allied LSA and SAA		✓		

Low-Medium Risk Zone – 300m radius centred on the WWII-era Heavy Anti-Aircraft Battery and the pillbox.

	Level of Risk			
Type of Ordnance	**Negligible**	**Low**	**Medium**	**High**
German HE UXBs		✓		
German 1kg Incendiary UXBs		✓		
British AA Projectiles		✓		
British / Allied LSA and SAA		✓		

Medium Risk Zone – 1.5km radius centred on the WWII-era bombing decoy sites.

	Level of Risk			
Type of Ordnance	**Negligible**	**Low**	**Medium**	**High**
German HE UXBs			✓	
German 1kg Incendiary UXBs		✓		
British AA Projectiles		✓		
British / Allied LSA and SAA		✓		

Medium-High Risk Zone - 1.5km radius centred on the docks, which were bombed several times, and 500m radii centred on the three bombing decoy sites, closest to the route.

	Level of Risk			
Type of Ordnance	**Negligible**	**Low**	**Medium**	**High**
German HE UXBs			✓	
German 1kg Incendiary UXBs		✓		
British AA Projectiles		✓		
British / Allied LSA and SAA		✓		

14. Proposed Risk Mitigation Methodology

14.1. General

BACTEC believes the following risk mitigation measures should be deployed to support the proposed works along the M4 Corridor around Newport route. Note that although parts of the study area have been classified as Low Risk, the threat from UXO cannot be completely ruled out here due to the lack of comprehensive historical sources and the undeveloped nature of the land.

Therefore BACTEC recommends proactive risk mitigation measures - ***A*** and ***B*** - for works carried out across the entire route – see below.

14.2. Recommended Risk Mitigation Measures

All Risk Zones - Prior to All Works

- ***A) Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works:*** A specialised briefing is always advisable when there is a possibility of explosive ordnance contamination. It is an essential component of the Health & Safety Plan for the site and conforms to requirements of CDM Regulations 2007. All personnel working on the site should be instructed on the identification of UXB, actions to be taken to alert site management and to keep people and equipment away from the hazard. Posters and information of a general nature on the UXB threat should be held in the site office for reference and as a reminder.
- ***B) The provision of Unexploded Ordnance Site Safety Instructions:*** These written instructions contain information detailing actions to be taken in the event that unexploded ordnance is discovered. They are to be retained on site and will both assist in making a preliminary assessment of a suspect object and provide guidance on the immediate steps to be taken in the event that ordnance is believed to have been found.

Low-Medium, Medium and Medium/High Risk Zones only – Shallow Intrusive Works

- ***C) Non-Intrusive Magnetometer Survey and target investigation ahead of any intrusive works*** – This survey is carried out using caesium vapour magnetometers linked to a data logger. Data is interpreted using advanced proprietary software which is capable of modelling the magnetic anomalies for mass, depth and location, thus providing information which can be used to locate discrete buried objects that may be ordnance. The system will typically locate buried ordnance to a depth of 4m for a 50kg bomb (the smallest HE bomb used by the Luftwaffe) and deeper for larger bombs. Additionally the survey will locate any buried services with a magnetic signature, will indicate areas of gross magnetic "contamination" (which may indicate unknown underground obstructions) and provide information on archaeological features.

In developed areas, including areas of hard-standing, roads, made ground, buildings, etc a Non-Intrusive Magnetometer Survey is inappropriate due to high levels of background 'noise'. In these areas the following is recommended:

- ***D) Explosive Ordnance Disposal (EOD) Engineer presence on site to support shallow intrusive works:*** When on site the role of the EOD Engineer would include; monitoring works using visual recognition and instrumentation and immediate response to reports of suspicious objects or suspected items of ordnance that have been recovered by the ground workers on site; providing Explosive Ordnance Safety and Awareness briefings to any staff that have not received them earlier and advise staff of the need to modify working practices to take account of the ordnance threat, and finally to aid Incident Management which would involve liaison with the local authorities and Police should ordnance be identified and present an explosive hazard.

Low-Medium, Medium and Medium/High Risk Zones only – Deep Intrusive Works

- ***E) Down-hole Intrusive Magnetometer Survey of any borehole and / or pile locations down to the maximum bomb penetration depth:*** BACTEC can deploy a range of intrusive magnetometry techniques to clear ahead of all the pile locations. The appropriate technique is governed by a number of factors, but most importantly the site's ground conditions. The appropriate survey methodology would be confirmed once the enabling works have been completed. A site meeting would be required between BACTEC

and the client to determine the methodology suitable for this site. Target investigation or avoidance will be recommended as appropriate.

Medium/High Risk Zones only – Deep Intrusive Works (River Usk / dock basin – if required)

- ***F) Jack up Barge Intrusive Magnetometer Survey of any borehole and / or pile locations down to the maximum bomb penetration depth:*** Casing will be lowered from a jack up barge or equivalent down to the river bed and into gravels, BACTEC would then drill open hole down to the bomb penetration depth below the base of the casing. All cutting will flow up and out of the casing at barge level, if at any time the flush stops coming out of the casing, drilling works will cease, rods will be removed and casing advanced deeper into the gravels. After drilling works are complete over the position rods and bit are removed, alloy casing lowered to depth and the UXO survey will be conducted.

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, BACTEC should be consulted to see if a re-assessment of the risk or mitigation recommendations is necessary.

BACTEC International Limited 21st November 2014

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The key published documents consulted during this assessment are listed below:

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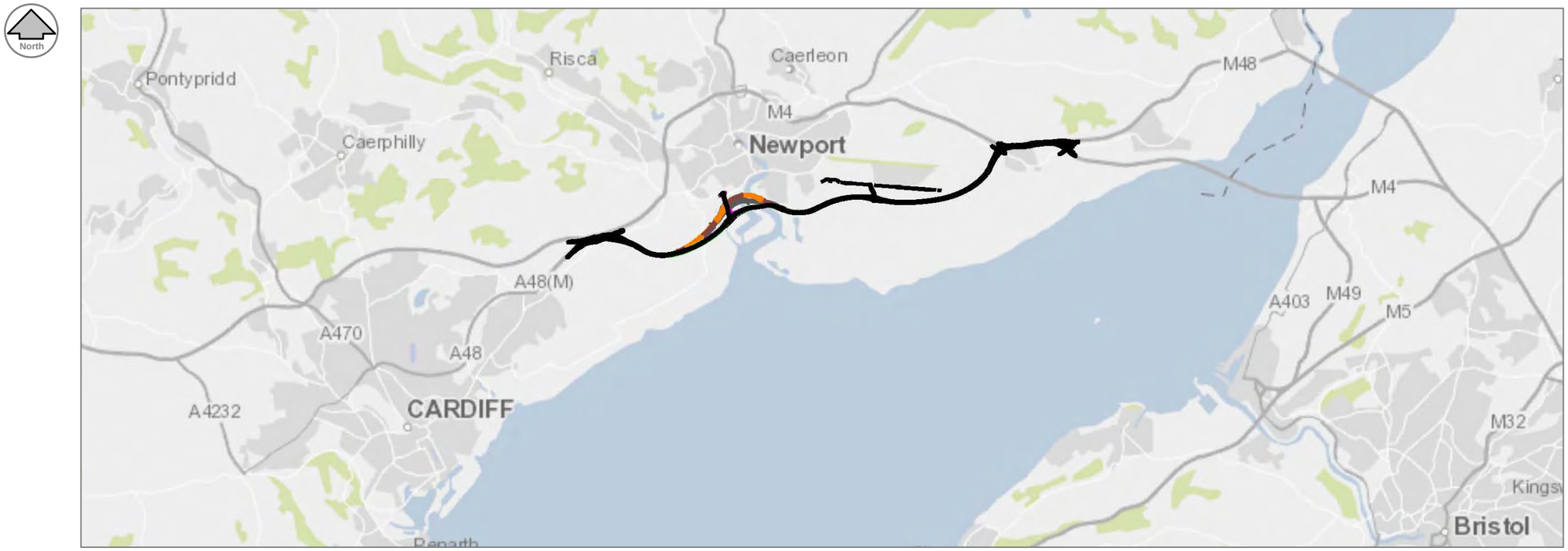
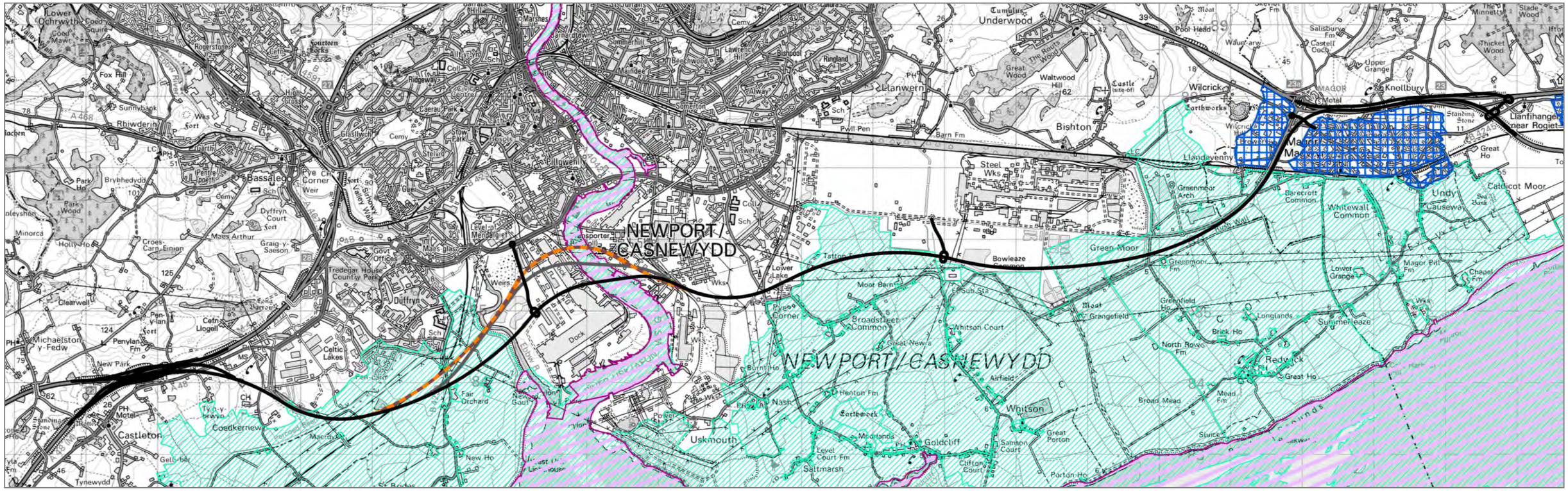




Report Reference:	Client:	
5750 TA	Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	
Source: Hyder Consulting (UK) Limited		

North

Route Corridor – Western Third

Report Reference:	Client:	
5750 TA	Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	
Source: Google Earth ™ Mapping Services		

North

Route Corridor – Central Third

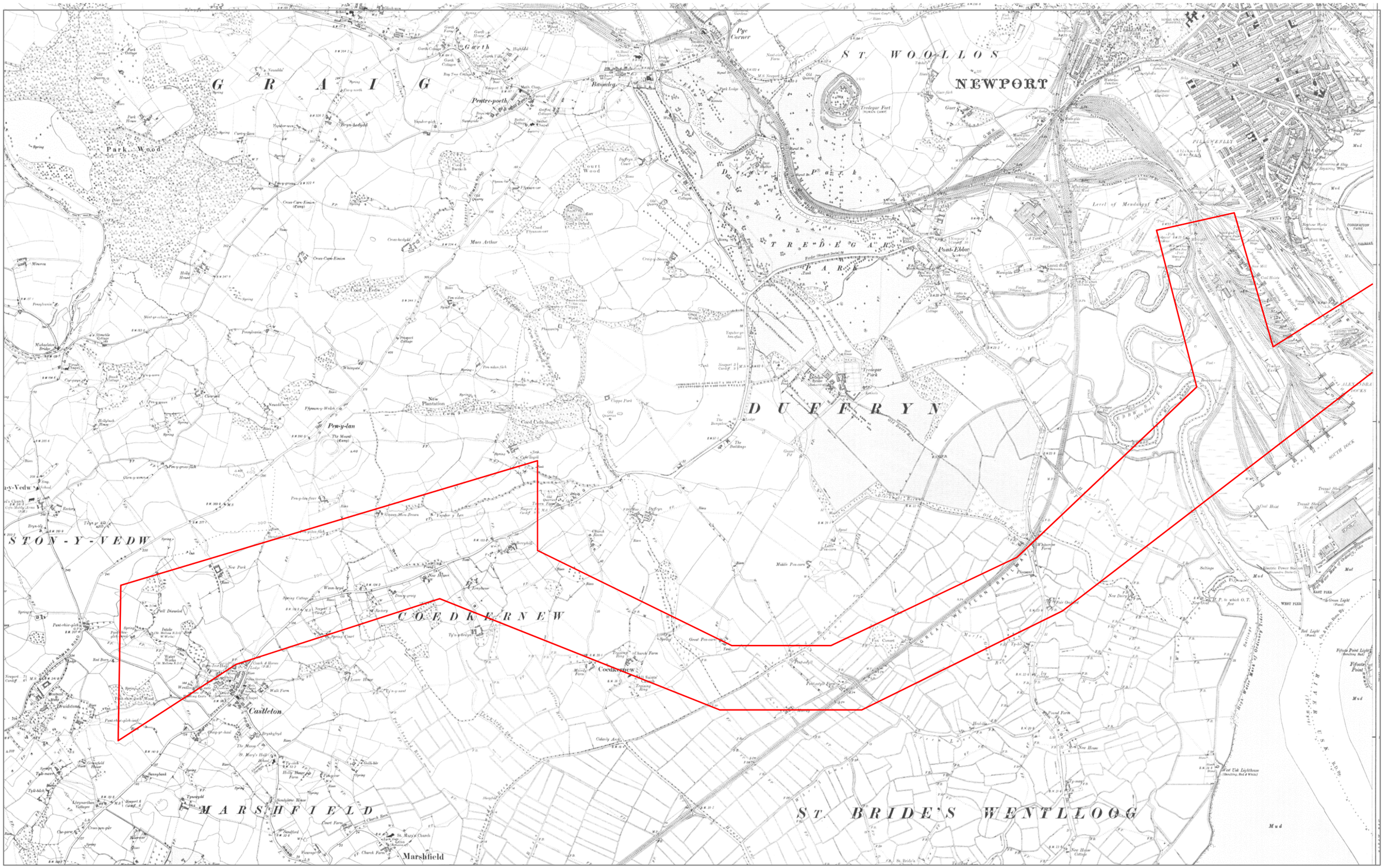
Report Reference: 5750 TA	Client: Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	
Source: Google Earth ™ Mapping Services		

North

Route Corridor – Eastern Third

Report Reference:	Client:	
5750 TA	Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	
Source: Google Earth ™ Mapping Services		

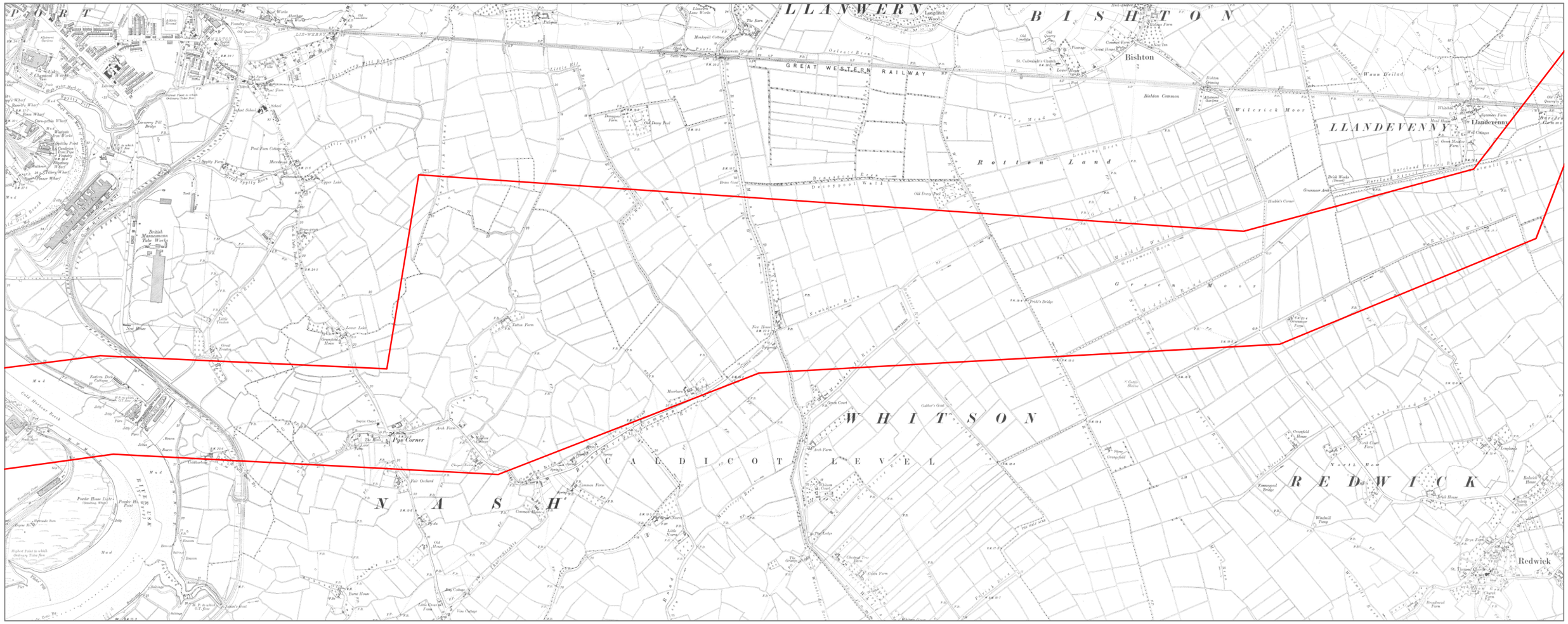
North



General Route Corridor Area – Western Half

Report Reference: 5750 TA	Client: Hyder Consulting (UK) Limited	BACTEC
	Project: M4 Corridor Around Newport	
Source: F!ND Maps		

North



General Route Corridor Area – Eastern Half

Report Reference: 5750 TA	Client: Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	
Source: F!ND Maps		

North

Approximate Route Corridor

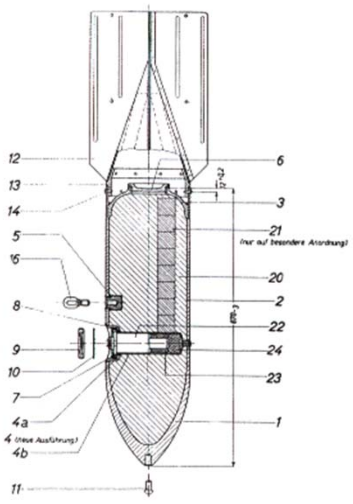
Report Reference: 5750 TA	Client: Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	
Source: F!ND Maps		

SC 50

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

50kg bomb, London Docklands

Minus tail section

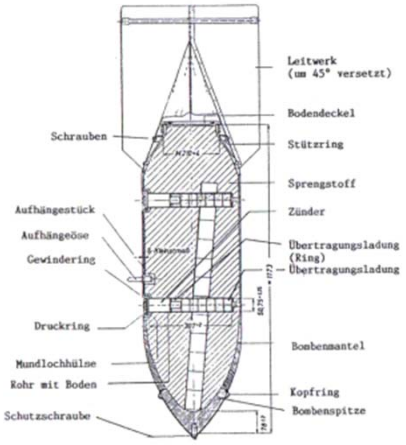


SC-50 JA (Güteklasse 1)

SC 250

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.

250kg bomb, Hawkinge

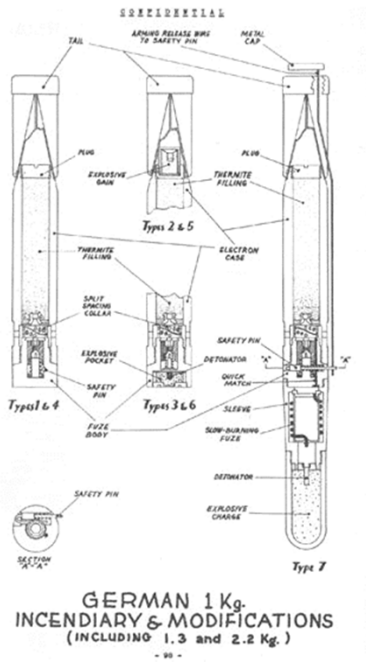


SC-250 JA (Güteklasse I)

1kg Incendiary Bomb

Bomb weight:	1.0 and 1.3kg (2.2 and 2.87lb)
Filling:	680gm (1.3lb) Thermite
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:	Jettisoned from air-dropped containers. Magnesium alloy case. Sometimes fitted with high explosive charge

1. Scaffold pipe
2. Incendiary 1kg bomb
3. Incendiary bomb recently found on site in UK



GERMAN 1 Kg. INCENDIARY & MODIFICATIONS (INCLUDING 1.3 and 2.2 Kg.)

Report Reference:	Client:	
5750TA	Hyder Consulting (UK) Limited	BACTEC
	Project: M4 Corridor Around Newport	

Source: BACTEC International Limited and various historical sources

1st September 2012 News – **Unexploded World War II Device** detonated on Bournemouth beach
An unexploded World War II device has been detonated on Bournemouth beach, according to Dorset Police. The discovery was made on Friday at 19:11 BST near the junction of East Overcliff Drive and Manor Road.
http://www.bbc.co.uk/news/uk-england-dorset-19445172

31st August 2012 News – **Suspected Unexploded Weapon** found on Cornwall's Porthmeor beach
Lifeguards have found what is believed to be a section of an unexploded weapon on a Cornish beach.The object, which witnesses have said looks like a corroded depth charge - an anti-submarine warfare weapon - has been found at Porthmeor Beach, in St Ives, Falmouth Coastguard has said.
http://www.bbc.co.uk/news/uk-england-cornwall-19440291

11th August 2012 News – **Unexploded Bomb** uncovered by workmen in Carlisle
Army bomb disposal experts have been called to Carlisle after what is thought to be an unexploded bomb was dug up. Workmen on a building site at Trinity School uncovered the device earlier. Cumbria Police said a cordon had been put in place and the sports centre on Strand Road had been evacuated as a precaution. A bomb disposal unit from Catterick Garrison, in North Yorkshire, attended the scene.
http://www.bbc.co.uk/news/uk-england-cumbria-19224152

28th July 2012 News – Alert over **'unexploded shells'** in Sheerness Harbour
Thirty-nine people were evacuated from two vessels in Kent after suspected unexploded shells were found. A 100m exclusion zone was also put around Sheerness Harbour on Saturday afternoon after two separate calls. The first call came from a catamaran which had an 18in by 5in shell on its deck at about 14:00 BST. At 15:30 BST, a 90m cable layer reported having a 12in by 4in shell on board. The shells were later declared safe by Royal Navy experts.
http://www.bbc.co.uk/news/uk-england-kent-19034493

10th July 2012 News – **Unexploded WWII Bomb** safely detonated off Kent coast
An unexploded wartime German bomb found off the coast of Kent has been safely detonated, coastguards have said. The 500lb (226kg) device was discovered by a dredger in Dover harbour on Monday but it could not be made safe as the tidal conditions were not right. Dover Coastguard worked with a four-man Royal Navy bomb disposal team from Portsmouth to move it to a remote area. A spokeswoman said it was detonated at 08:45 BST, three-and-a-half miles (5.6km) east of Deal Pier. The World War II explosive was 3.3ft (1m) in length and was said to have had fins which had rusted off.
http://www.bbc.co.uk/news/uk-england-kent-18765547

8th April 2012 News – Huge explosion as experts detonate **large WWII Mine**
Water and ash were propelled more than 120m (390ft) into the air when Royal Navy experts detonated a German mine in the Thames estuary. The 750kg (1,650lb) unexploded World War II (WWII) weapon was placed on the sea bed after it was caught in the nets of a fishing boat earlier in the week. Divers brought it to the surface and then took it to a spot off Kent, during a "delicate" seven-hour operation.
http://www.bbc.co.uk/news/uk-england-kent-17652116

5th March 2012 News – Beach open after **WWII shell found**
A beach in County Londonderry has reopened after an unexploded World War II shell was found on Sunday. The device was discovered lying near the water on Benone beach by a member of the public. The beach was evacuated just before 16:00 GMT, and a controlled explosion was carried out by army bomb experts
http://www.bbc.co.uk/news/uk-northern-ireland-foyle-west-17255505

21st February 2012 News – **Two WWII bombs** detonated near Lincolnshire village
Bomb disposal experts have carried out a controlled explosion on two devices found near Manby in Lincolnshire. Anglian Water found the unexploded World War II shells near the former RAF Manby airfield, opposite the Motorplex building, on Monday. The area was cordoned off and police remained at the scene until experts from the Ministry of Defence explosive ordnance disposal team arrived.
http://www.bbc.co.uk/news/uk-england-lincolnshire-17111021

9th January 2012 News – County Durham road reopens after **WWII shell uncovered**
A road in County Durham was closed after an unexploded WWII shell was found. The shell was found on land at Slaidburn Road, Stanley, near the A693 Chester Road. Durham Police advised people to avoid the area, closing Chester Road and evacuating a local bus depot and nearby garage as a precaution. Catterick's bomb squad carried out a controlled explosion and all cordons have now been lifted.
http://www.bbc.co.uk/news/uk-england-tyne-16473968

13th October 2011 News – **WWII grenades** found near Gatwick Airport
Unexploded World War II hand grenades have been discovered close to Gatwick Airport. Network Rail staff found the explosives while working near Gatwick Airport railway station in West Sussex. A bomb disposal team was called in to carry out a controlled explosion at about 10:50 BST, Sussex Police said. The bomb disposal team found three hand grenades, one four-inch mortar and a smoke grenade in a metal container and identified them as World War II explosives, he added. Outgoing flights from the airport and rail services were halted as a precaution for about 15 minutes but have since resumed. The alert affected train services run by Gatwick Express, Southern, First Capital Connect and First Great Western.
http://www.bbc.co.uk/news/uk-england-sussex-15292719

SKY NEWS Website of the Year — FIRST FOR BREAKING NEWS

M62 Motorway Closed For Detonation Of World War Two Bomb

5:04pm UK, Friday January 04, 2008
A busy motorway has been closed to allow for a wartime bomb to be detonated nearby.


The controlled explosion

Army expertsdestroyed the huge Second World War device in a controlled explosion near the M62.

The motorway was shut in both directions between junctions 37 and 38 as a safety precaution.

The "deeply buried" bomb had lain dormant in an East Yorkshire field for almost 64 years.

The device was discovered by a metal detecting enthusiast on New Year's Eve in a field near the B1230 at Balkholme, near Howden, which was also closed.

An Army bomb disposal team travelled up from Essex to join police, ambulance and fire services and utility companies at the scene.

Captain Tim Ives, of 33 Engineer Regiment, earlier said 10 soldiers would be employed to "reduce the effects of the controlled explosion by packing sand around the device".

Page last updated at 14:45 GMT, Friday, 22 May 2009 15:45 UK
E-mail this to a friend Printable version

Building site WWII bomb exploded

Building site WWII bomb exploded

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

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

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

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

BBC 14:23 GMT, Thursday, 5 June 2008 15:23 UK
E-mail this to a friend Printable version

Unexploded bomb 'started to tick'

An unexploded World War II bomb started to tick and ooze liquid as experts tried to defuse it, police have said.

The large bomb was found in a river at Sugar House Lane, near Bromley-by-Bow Tube station in east London, on Monday.

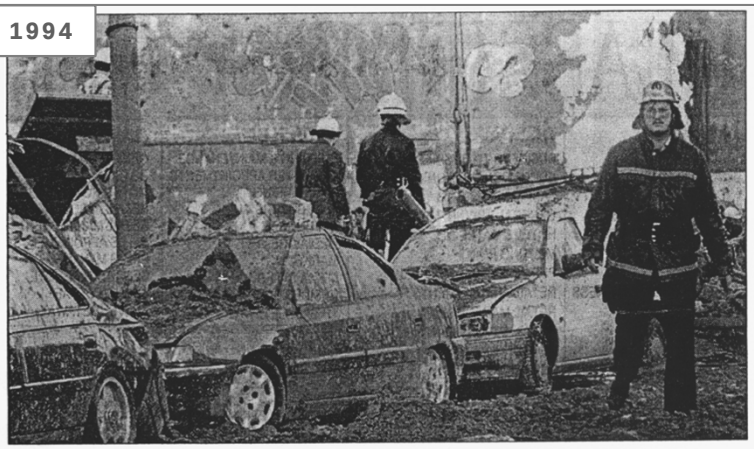
Rush-hour travel was disrupted as overnight work to make the bomb safe continued into Thursday morning.

Police commander Simon O'Brien said: "It started to tick and ooze some pretty horrible substances." It stopped ticking when doused with liquid.

'Hero colleague'

"It measures approximately the size and length of a man, and weighs around 1,000kg (2,200lb).

1994



RESCUE workers search for survivors after a Second World War bomb exploded at a building site in Berlin, killing three people and injuring at least eight others.
A fire brigade spokesman said he feared the final death toll could be higher. One worker was still missing, believed to be trapped under a machine. "We've

Blown up by history

found human remains 100 metres away but we can't tell if they belong to the dead already found," the spokesman said.
The blast, set off by drilling work on Frankfurter Allee, one of east Berlin's busiest avenues, trapped workers under building machinery and sent huge chunks of concrete tumbling through the air.
A large office block was being built on the site of the explosion which sent shoppers scrambling for shelter and paralysed dense afternoon traffic. One eyewitness said: "There was a bang, then silence, and then it started raining stones and dirt."
Dozens of cars within a 250-metre radius were wrecked and the top two floors of a nearby apartment block caved in.
Radio reports claimed that the total number of injured stood at 14.

2008

2006

World War II bomb kills three in Germany

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

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

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

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

2010

2006

WW2 bomb blast kills digger driver in Germany

The bomb went off as the machine lifted up earth and debris

A World War Two bomb has exploded at a construction site near a west German town, killing a man and injuring eight others, police say.

The explosion occurred after a digger accidentally struck the device during excavation work in Euskirchen in the state of North Rhine-Westphalia.

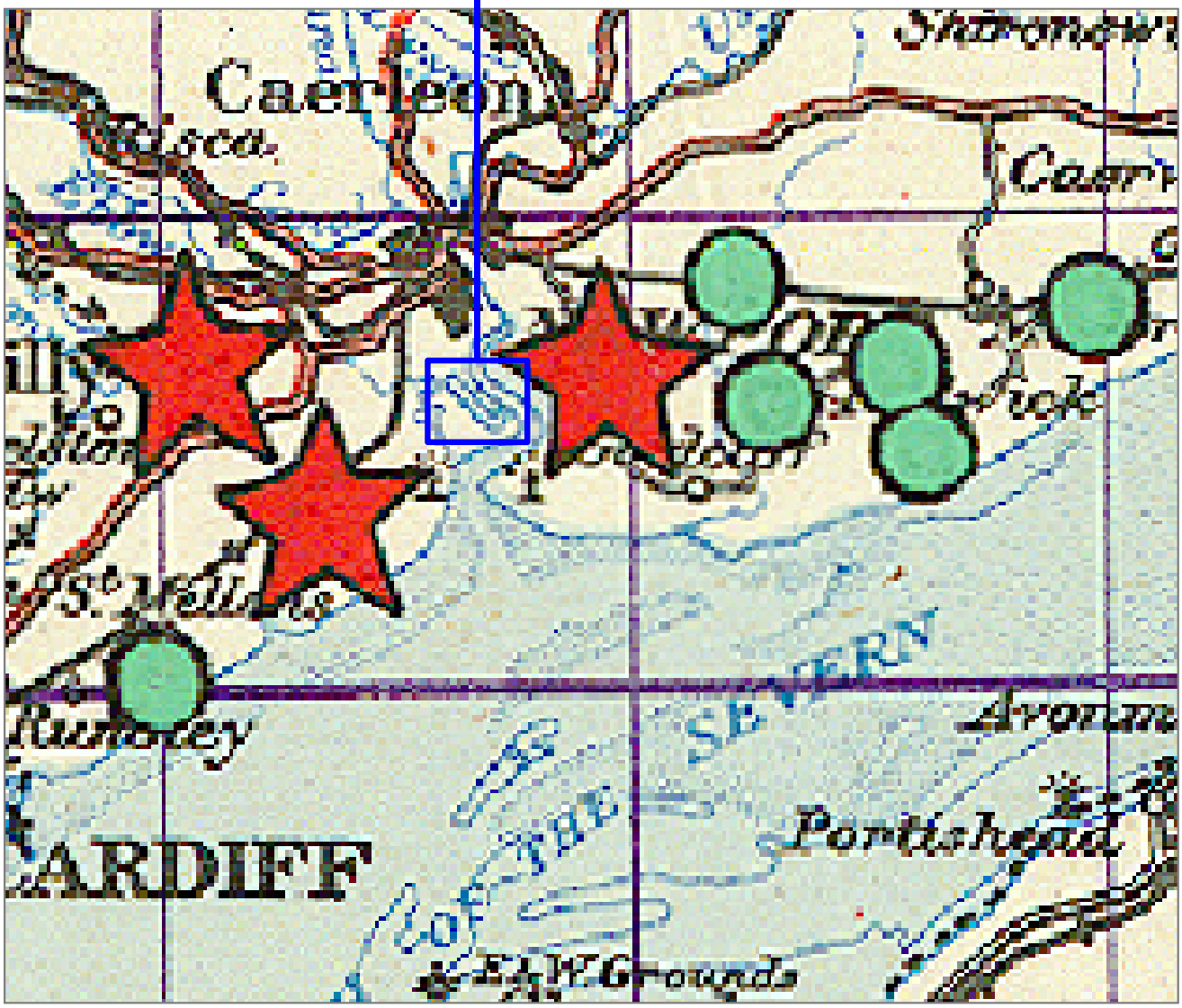
The machine's operator died on the spot. Two of those hurt were critically wounded, the dpa news agency reports.

2014

Top Left: WWII bomb killed 3 and injured 8 in Berlin – 1994.
Middle Left: WWII bomb killed 3 in Goettingen, Germany – 2010.
Bottom Left: Excavator operator killed by WWII bomb in Euskirchen, Germany – 2014.
Top Right: WWII bomb injures 17 at construction site in Hattingen, Germany - 2008.
Middle Right: A highway construction worker in Germany accidentally struck a WWII bomb, killing himself and wrecking several passing cars - 2006.
Bottom Right: Destroyed piling rig and dump truck after detonation of WWII UXB in Austria - 2006.

North

Newport Docks

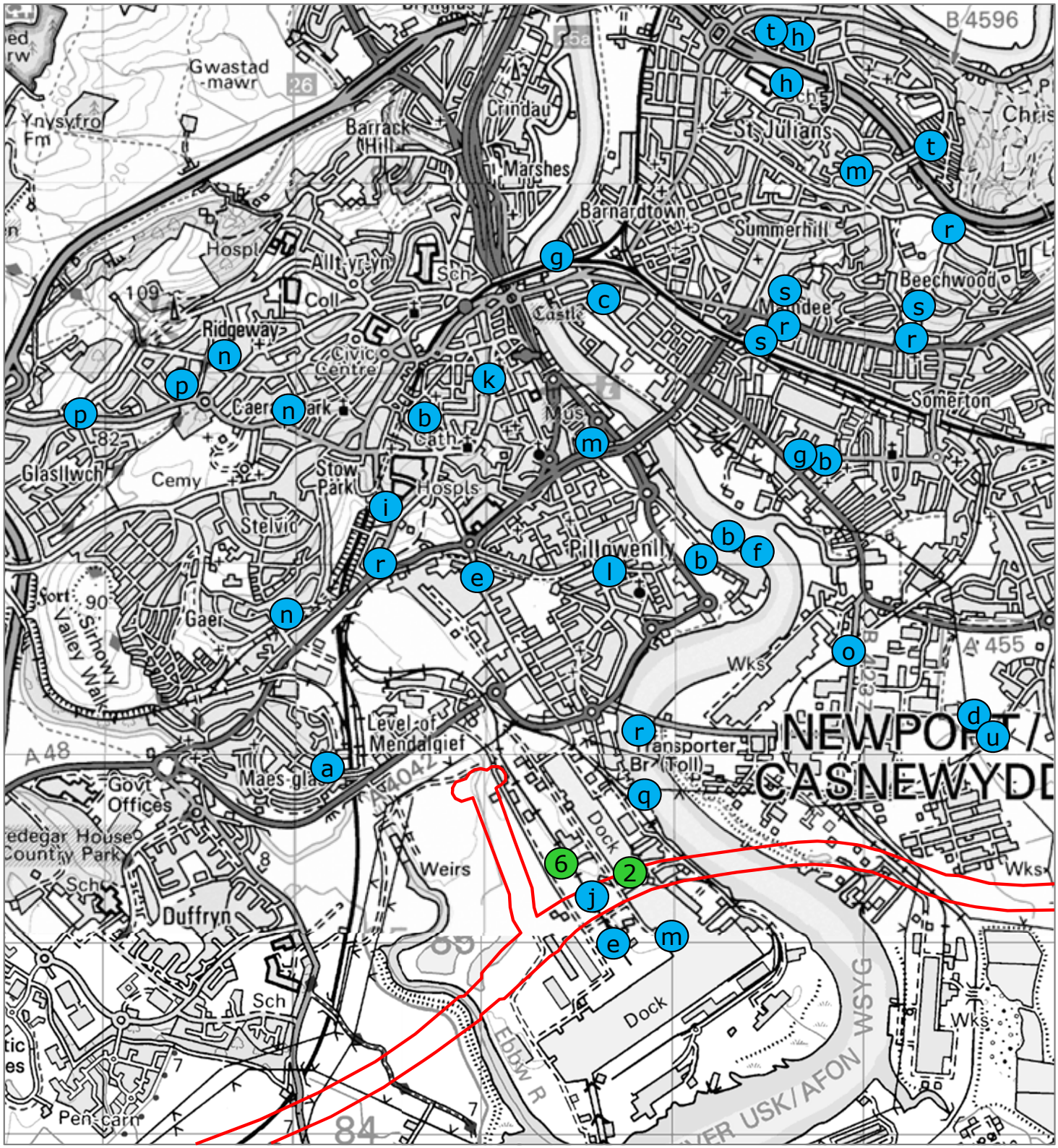


KEY

- Q Site
- SF (with or without QL)
- QF (with or without QL)
- Cover Plan Site
- K Site (with or without Q)
- Dummy Buildings

Report Reference:	Client:	
5750TA	Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	

Source: National Archives



Partial (approximate) Route Corridor

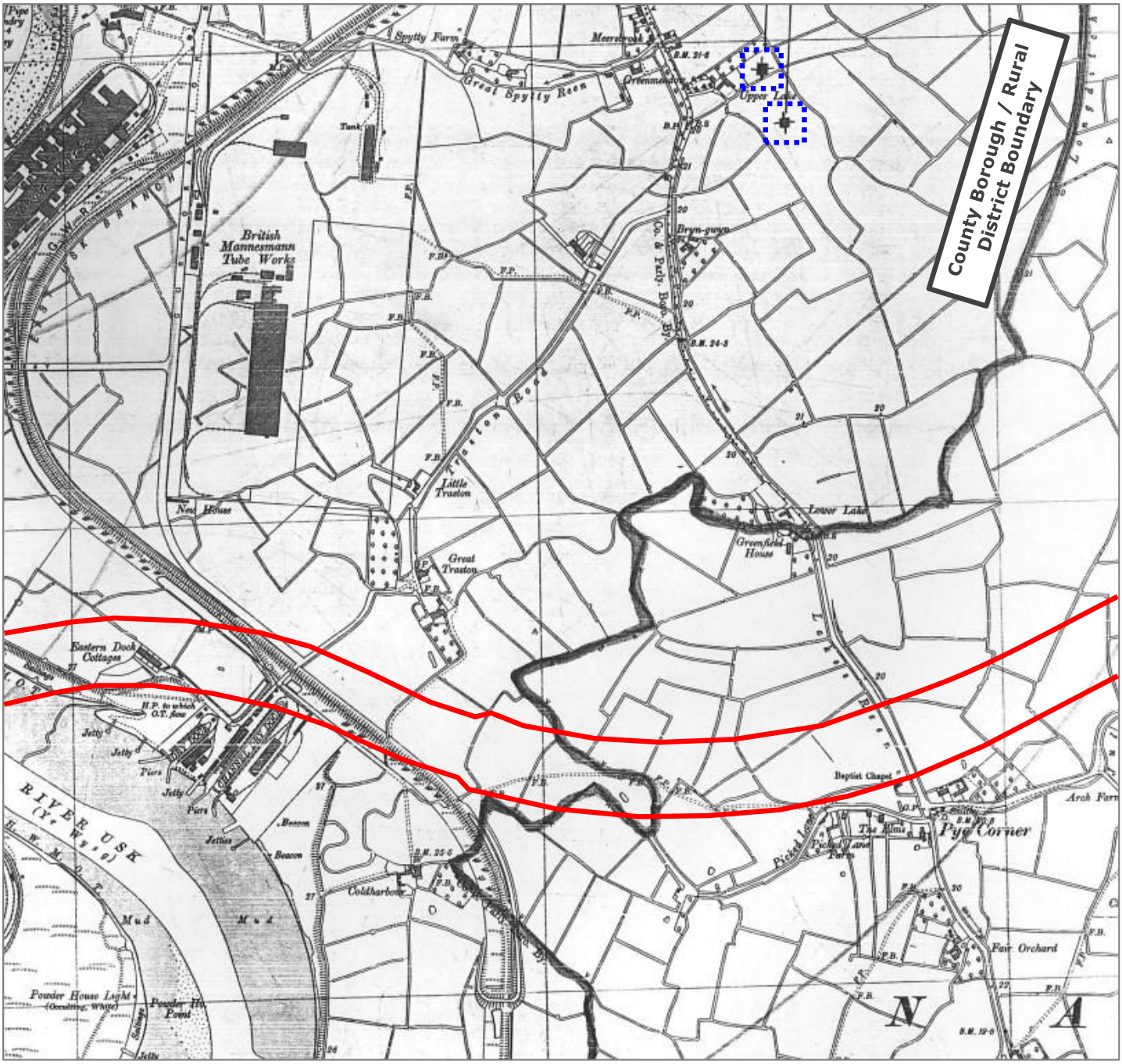
Denotes ARP Written Report of bombing – ***see Section 9.3.5***

Denotes additional anecdotal evidence of bombing – number represents the qauntity of HE

Report Reference:	Client:	
5750TA	Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	

Source: Gwent Archives / Ordnance Survey

North



Partial (approximate) Route Corridor

500kg UXB strike

Report Reference:	Client:	
5750TA	Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	

Source: National Archives

Alexandra Dock – west to east
Alexandra Dock – west to east

North

Route Corridor

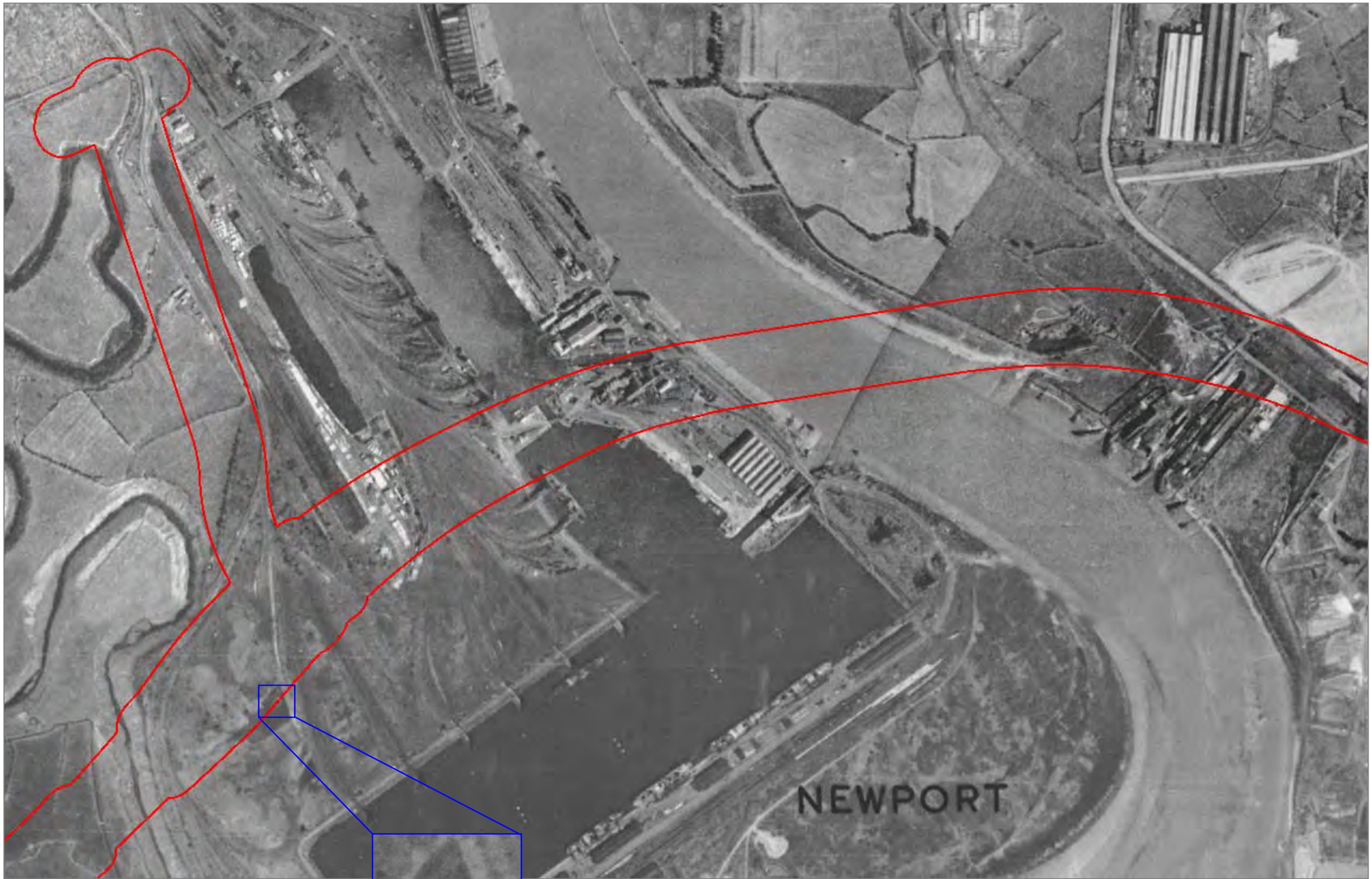
Report Reference:	Client:	Hyder Consulting (UK) Limited	BAC TEC
5750 TA	Project:	M4 Corridor Around Newport	
Source:	The Geo Information Group		

North

Route Corridor

Report Reference:	Client:	
5750 TA	Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	
Source: The Geo Information Group		

North



Route Corridor

Possible HE bomb crater

Report Reference: 5750 TA	Client: Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	
Source: The Geo Information Group		

North

HAA Battery

Route Corridor

Report Reference:	Client:	Hyder Consulting (UK) Limited
5750 TA	Project:	M4 Corridor Around Newport
Source:	The Geo Information Group	

BAC TEC

North

Route Corridor

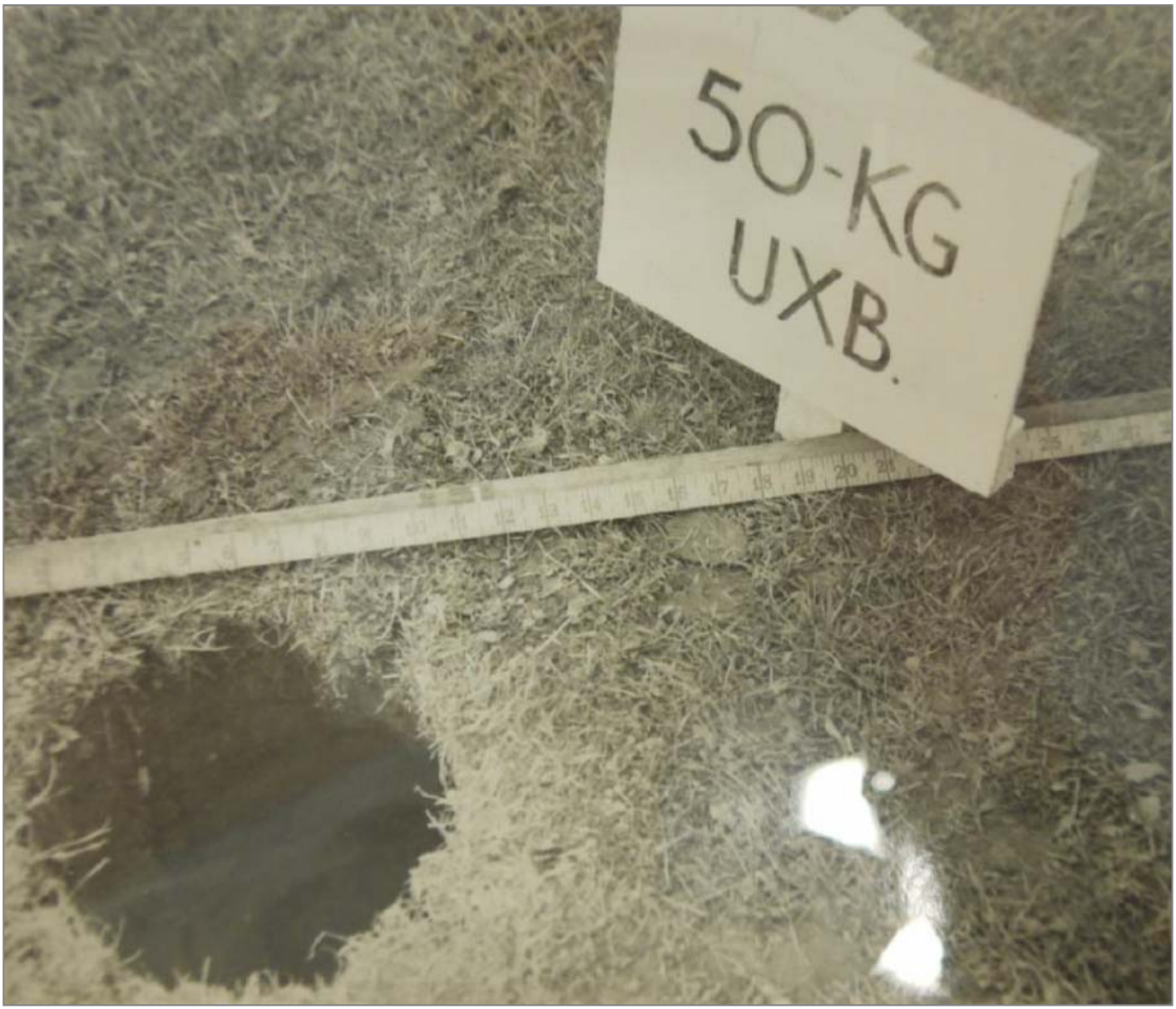
Report Reference:	Client:	
5750 TA	Hyder Consulting (UK) Limited	BAC TEC
	Project: M4 Corridor Around Newport	
Source: The Geo Information Group		

North

NO COVERAGE

Route Corridor

Report Reference: 5750 TA	Client: Hyder Consulting (UK) Limited	BACTEC
	Project: M4 Corridor Around Newport	
Source: The Geo Information Group		


50-KG
UXB.

1kg German Incendiary Bomb next to a 30cm ruler

North

Route Corridor

WWII-era Army Camp

Abandoned WWII-era UXB

WWII-era Bombing Decoy Site

WWII-era Bombing Decoy Site

Historical Army EOD Clearance Tasks – no items of UXO found

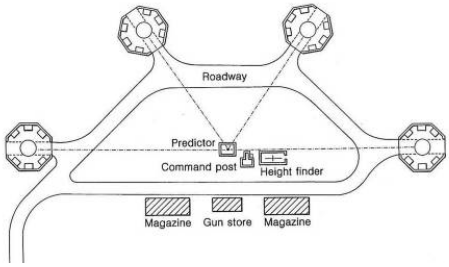
Extant WWII-era Pillbox

Report Reference:	Client:	
5750 TA	Hyder Consulting (UK) Limited	BACTEC
	Project: M4 Corridor Around Newport	
Source: Council for British Archaeology / The MOD		

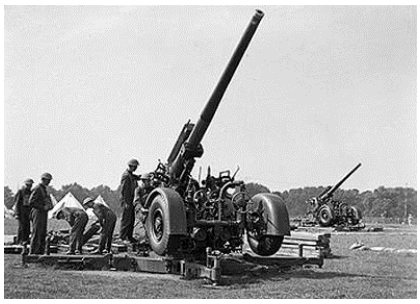
3.7 inch Anti-Aircraft Projectile

Weight:	12.7kg (28lb)
Dimensions:	94 x 360mm (3.7 x 14.7in)
Carriage:	Mobile and Static Versions
Rate of Fire:	10-20 rounds per minute
Ceiling:	9-18,000m (29-59,000ft)
Muzzle Velocity:	792m/s (2,598ft/s)
Remarks:	4.5 inch projectiles were also commonly utilised

This AA shell was uncovered on a construction site in North London in February 2009.



Layout plan for a typical HAA battery site.

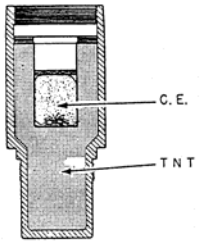


Hyde Park 1939 3.7 Inch QF gun on mobile mounting

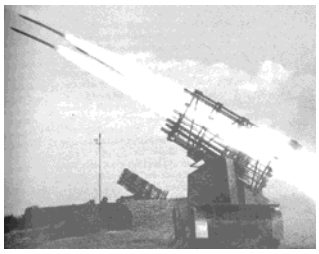
3.7 inch AA Projectile Minus Fuze

Rockets / Unrotated Projectiles

Weight:	Overall: 24.5kg (54lb) Warhead: 1.94kg (4.28lb)
Dimensions:	1930mm x 82.6mm (76 x 3.25in)
Carriage:	Mobile – transported on trailers
Ceiling:	6770m (22,200ft)
Maximum Velocity:	457mps (1,500 fps)

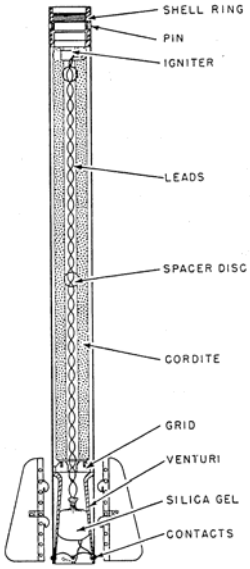


MK II HE Shell (3.5kg)



Rocket Battery in action

Home Guard soldiers load an anti-aircraft rocket at a 'Z' Battery



2" U.P AA Rocket

40mm Bofors Gun Projectile

Weight:	0.86kg (1.96lb)
Dimensions:	40mm x 310mm (1.6in x 12.2in)
Rate of Fire:	120 rounds per minute
Ceiling:	23,000ft (7000m)
Muzzle Velocity:	2,890 ft/s (881m/s)
Remarks:	Mobile batteries – normally few records of where these guns were located

Unexploded 40mm Bofors projectile recovered from a marine environment

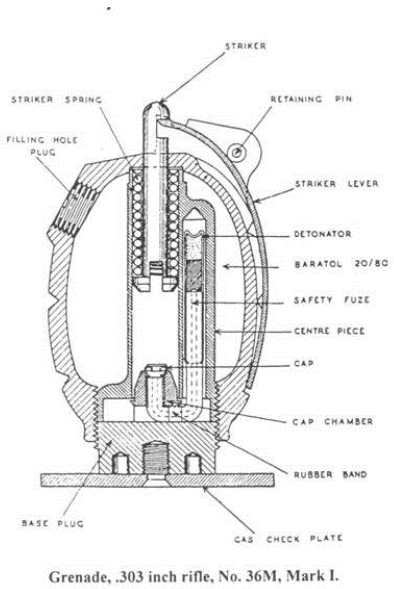
40mm Bofors gun and crew at Stanmore in Middlesex, 28 June 1940.

Report Reference: 5750TA	Client: Hyder Consulting (UK) Limited	BACTEC
	Project: M4 Corridor Around Newport	

Source: BACTEC International Limited and various historical sources

No. 36 'Mills' Grenade

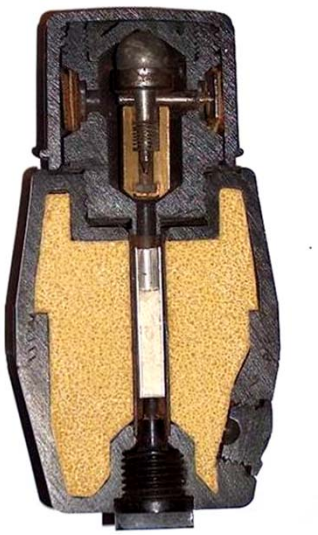
Weight:	0.7kg filled (1lb 6oz)
Type:	Hand or discharger, fragmentation
Dimensions:	95 x 61mm (3.7 x 2.4in)
Filling:	Alumatol, Amatol 2 or TNT
Remarks:	4 second hand-throwing fuse with approximate 30m range. First introduced May 1918.



Grenade, .303 inch rifle, No. 36M, Mark I.

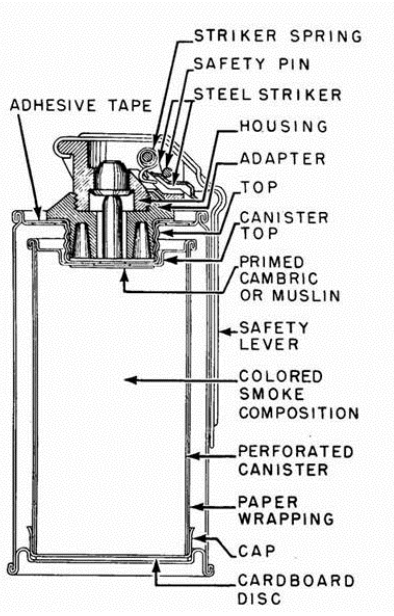
No. 69 Grenade

Weight:	0.38kg filled (0.8lb)
Type:	Percussion/Blast
Date Introduced:	December 1940
Remarks:	Black Bakelite body. Blast rather than fragmentation type. After unscrewing the safety cap, a tape is held when throwing the grenade releasing the safety bolt in the throwing motion. Detection is problematic due to its very low metal content.



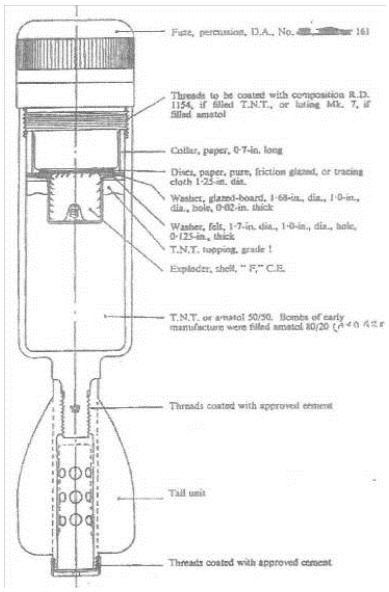
Typical Smoke Grenade

Dimensions:	Approx. 65 x 115mm (2.5 x 4.5in)
Type:	Smoke
Date Introduced:	Current MoD issue
Remarks:	Smoke grenades are used as ground-to-ground or ground-to-air signalling devices, target or landing zone marking devices, and screening devices for unit movement.



Typical 2 inch High Explosive Mortar

Bomb Weight: 1.02kg (2.25lb)
Type: High Explosive
Dimensions: 51 x 290mm (2in x 11.4in)
Filling: 200g RDX/TNT
Maximum Range: 457m (500yds)
Remarks: Fitted with an impact fuze which detonates the fuze booster charge (exploder) and, in turn, the high explosive charge. The main charge shatters the mortar bomb body, producing near optimum fragmentation and blast effect at the target.

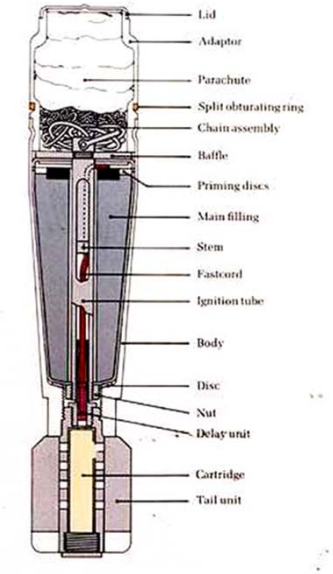


Typical 3 inch Smoke Mortar

Type: Smoke
Dimensions: c490 x 76mm (19.3in x 3in)
Filling: Typically white phosphorous
Maximum Range: 2515m (2,750yds)
Remarks: On impact, the fuze functions and initiates the bursting charge. The bursting charge ruptures the mortar bomb body and disperses the white phosphorous filler. The white phosphorous produces smoke upon exposure to the air.

Typical 2 inch Illuminating Mortar

Type: Illum.
Dimensions: 51 x 290mm
Filling: Various
Remarks: The expulsion charge ignites and ejects the candle assembly. A spring ejects the parachute from the tail cone. The parachute opens, slowing the descent of the burning candle which illuminates the target.



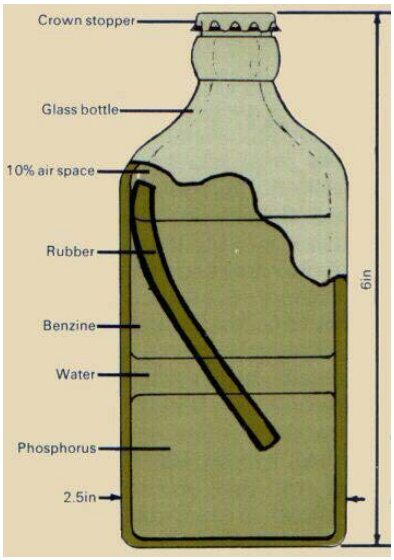
Report Reference:	Client:	
5750TA	Hyder Consulting (UK) Limited	BACTEC
	Project: M4 Corridor Around Newport	

Source: BACTEC International Limited and various historical sources

Self Igniting Phosphorous (SIP) Grenades

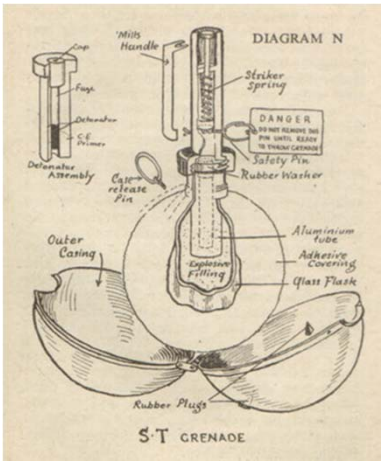
Filling: White Phosphorous and Benzene

Remarks: The grenade comprised a glass bottle with a total volume of approximately one pint. It was filled with White Phosphorus, benzene, a piece of rubber and water. Over time the rubber dissolved to create a sticky fluid which would self ignite when the bottle broke. Fired by hand or Northover Projector. Sometimes called the "A & W" (Albright & Wilson) grenade.



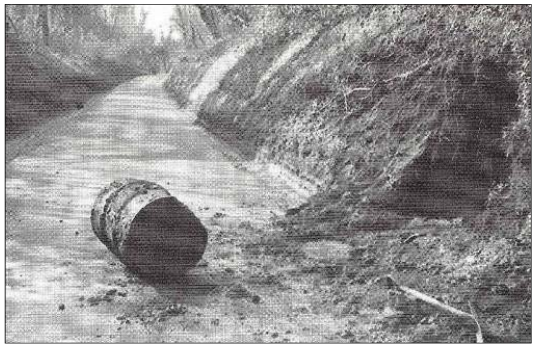
No 74 Grenade (Sticky Bomb)

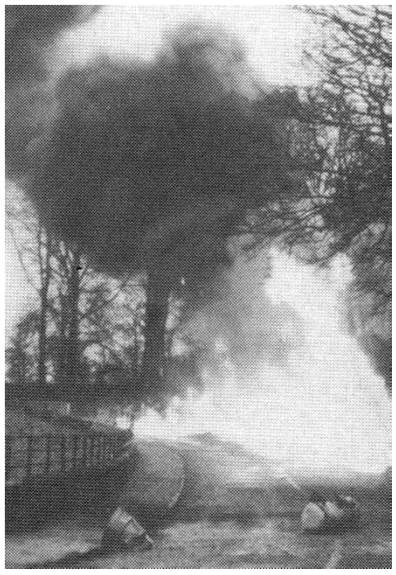
Remarks: Designed as an anti-tank grenade and used by the Home Guard. The grenade consisted of a glass ball on the end of a Bakelite (plastic) handle. Inside the glass ball was an explosive filling whilst on the outside was a very sticky adhesive covering. Until used, this adhesive covering was encased in a metal outer casing.



Flame Fougasse Bomb

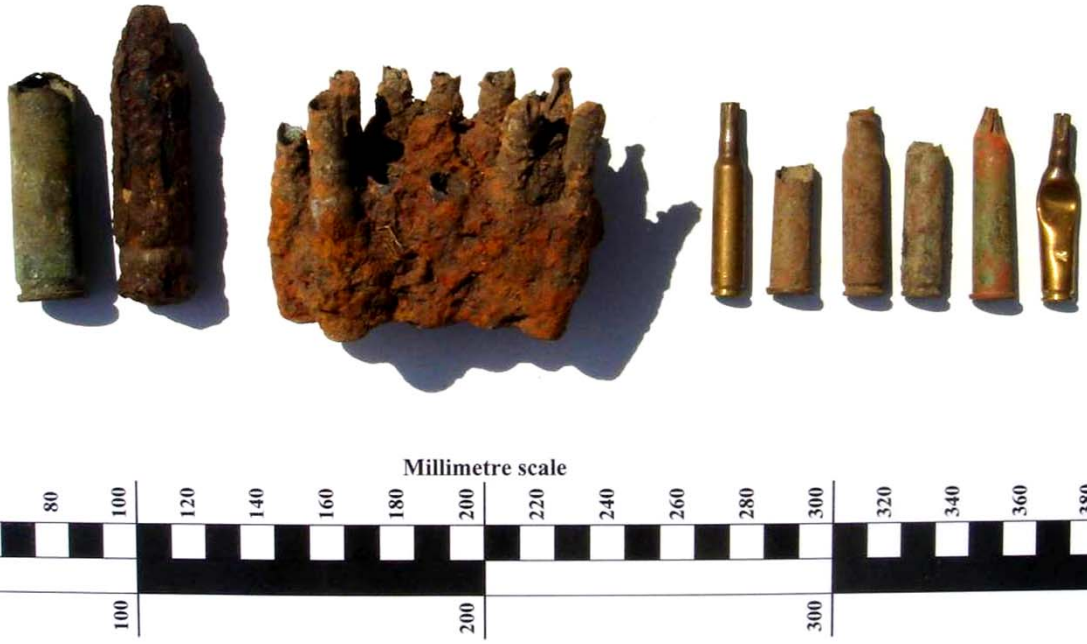
Remarks: A Flame Fougasse was a weapon in which the projectile was a flammable liquid, typically a mixture of petrol and oil. It was usually constructed from a 40-gallon drum dug into the roadside and camouflaged. Ammonal provided the propellant charge which, when triggered, caused the weapon to shoot a flame 3m (10ft) wide and 27m (30 yards) long. Initially a mixture of 40% petrol and 60% gas oil was used, this was later replaced by an adhesive gel of tar, lime and petrol known as 5B.





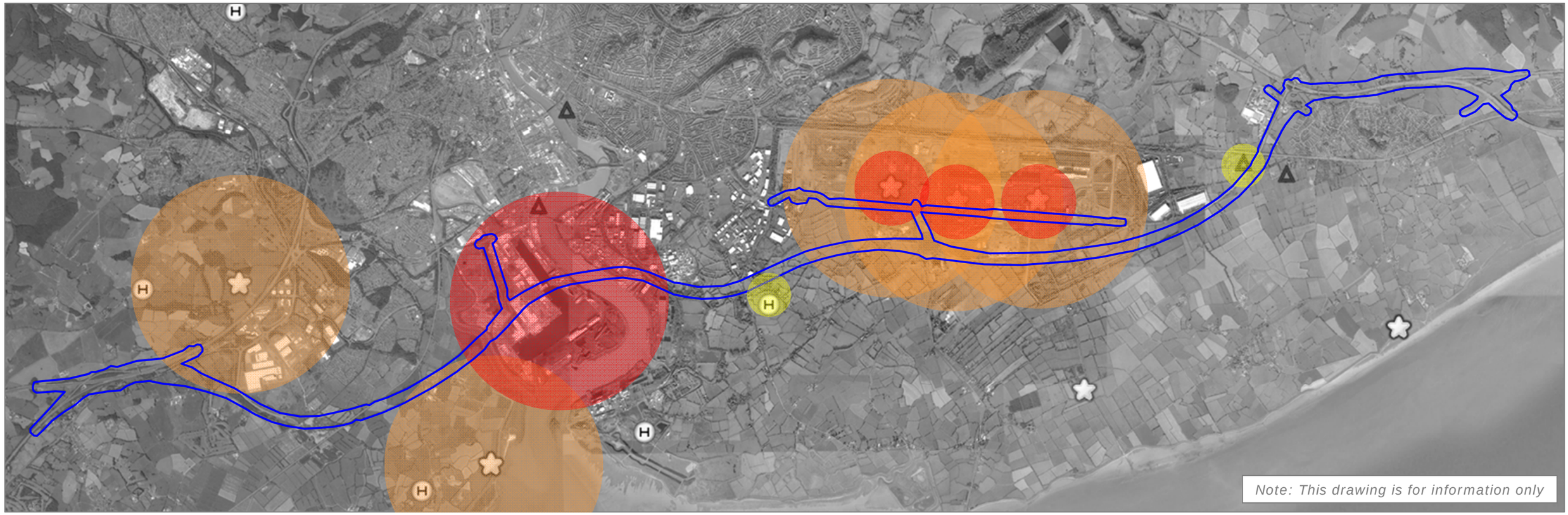
Source: BACTEC International Limited and various historical sources

Small arms ammunition and cannon rounds up to 30mm



Recovered British WWII-era SAA

North



Recommended Risk Mitigation Measures

All Risk Zones - Prior to All Works

Explosive Ordnance Safety and Awareness Briefings to all personnel conducting intrusive works.

The Provision of Unexploded Ordnance Site Safety Instructions.

Low-Medium, Medium and Medium-High Risk Zone only – Shallow Intrusive Works

Non-Intrusive Magnetometer Survey and target investigation ahead of any intrusive works – where appropriate.

Explosive Ordnance Disposal (EOD) Engineer Presence on site to supervise all open excavations.

Low-Medium, Medium and Medium-High Risk Zone only – Deep Intrusive Works (on-land)

Intrusive Magnetometer Survey of any pile/borehole locations and Target Investigation, if necessary. Investigation of Suspect Anomalies, if required.

Medium-High Risk Zone only – Deep Intrusive Works (River Usk / dock basin – if required)

Jack up Barge Intrusive Magnetometer Survey of any pile/borehole locations and Target Investigation, if necessary. Investigation of Suspect Anomalies, if required.

Medium-High Risk Zone
1.5km radius centred on the docks and 500m radii centred on the bombing decoy sites

Medium Risk Zone
1.5km radii centred on the bombing decoy sites

Low-Medium Risk Zone
300m radii centred on the Heavy Anti-Aircraft Battery and the pillbox

Low Risk Zone
The remainder of the site, occupied by historically unused, undeveloped agricultural land

Route Corridor

*Note that the **Low-Medium Risk Zone** is centred around the Pyr Corner HAA Battery facility as a whole (1945 aerial photograph), not just the gun emplacements, as depicted by the 'H' symbol above*

Report Reference:	Client:	
5750 TA	Hyder Consulting (UK) Limited	BACTEC
	Project: M4 Corridor Around Newport	
Source: BACTEC International Limited		

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