

Detailed Unexploded Ordnance (UXO) Risk Assessment

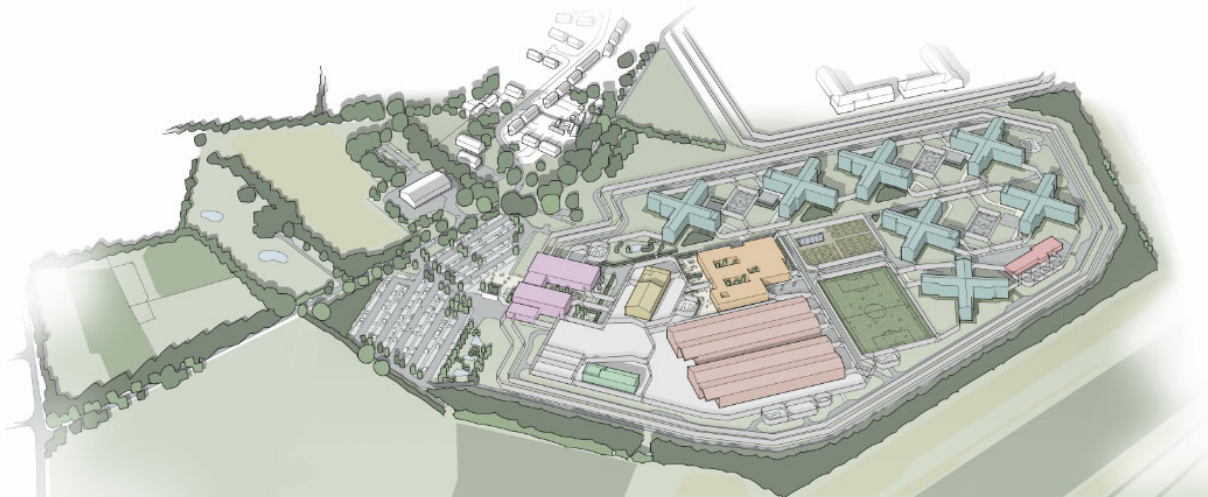
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Project location: Welland Avenue, Gartree, LE16 7RW

Client: Wates Construction

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This desk study has been produced by Bombs Away for Wates Construction and meets the requirements of CIRIA C681 (2009) "Unexploded Ordnance (UXO), A Guide For The Construction Industry". It has been provided solely for the purpose of assessment and evaluation of the specified project and construction methodology described herein. It should not be used by anyone other than the client, for any purpose other than that specified. Any liability arising out of third party use of this document, shall be the responsibility of that party, who shall indemnify Bombs Away Ltd against all claims, costs, damages and losses arising out of such use.

Bombs Away Ltd	Kemp House, 152-160 City Road, London, EC1V 2NX
Email	Office@BombsAway.Ltd
Web	www.BombsAwayUXO.com
Phone	0871 268 4400
Company registration	11054420
VAT registration	GB 285 0961 78

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About Bombs Away

Bombs Away Ltd was formed by Marc Owen BSc MBA MCIQB MInstRE TIEpE. He is a former commissioned officer in the Royal Engineers with 20 years of subsequent experience working in the construction industry.

He is a subject matter expert regarding UXO on construction sites and key member of the steering group for the Construction Industry Research and Information Association's latest guidance on UXO, lecturing for them several times. He undertook ground-breaking research published by the Institution of Civil Engineers, to establish the probability of discovering unexploded bombs on building sites and has been interviewed on the national news in response to the discovery of unexploded ordnance.

Bombs Away Ltd is unlike any other UXO risk assessment consultancy because:

- We specialise in providing a project specific assessment that gives a realistic indication of discovering UXO,
- We provide risk assessments for the benefit of the construction industry, not the UXO clearance industry,
- We are independent of every UXO clearance contractor,
- We do not offer site-based investigation services,
- We will not recommend unnecessary mitigation measures.

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Section 1. Executive Summary

A detailed unexploded ordnance (UXO) risk assessment has been completed on the site known as Gartree 2.

The result of the risk assessment is that this area is considered to pose a **low risk** of harm from UXO for the proposed construction works. For the purpose of complying with the Health and Safety at Work Act (1974), it is not considered appropriate for intrusive site surveys to be completed nor to employ a specialist UXO banksman.

An emergency plan detailing actions to be taken if UXO is discovered should be developed. It is considered appropriate that any person who is working in the ground (for example site investigation surveyors, piling contractors, groundwork contractors and similar) should undertake a UXO briefing as part of their initial site induction and for toolbox talks to be regularly completed.

A template for the emergency response plan and a toolbox talk can be downloaded for free from the “download” page at www.BombsAwayUXO.com

All parties must be fully aware that industry guidance for UXO on construction sites (CIRIA C681) accepts that there will be a risk of UXO remaining on a site. The guide states that “no current UXO detection survey technology can provide complete assurance that every buried UXO item has been detected, located and removed. Even the most reasonably practicable method, other than shifting all the soils beneath a site will leave some level of residual risk.” Even when a clearance certificate has been provided, it does “not constitute a guarantee that the site is clear of UXO”.

This assessment does not consider the client’s attitude to *commercial risk*. The client may still consider undertaking intrusive UXO surveys if they feel that the unexpected discovery of UXO (or suspected UXO) may cause an unacceptable delay to the project, cause reputational damage, or cause disruption to other services for which the client may be held responsible.

On several occasions, the Ministry of Defence have permitted the destruction of WW2 air dropped weapons by military bomb disposal teams *in-situ*, within built up areas, without attempting to remove the weapon’s explosive. This increases the risk of damage to adjacent property and the liability for such an event may lie with private insurers, as the Government have refused to accept responsibility for the damage.

Section 2. Introduction

The Health and Safety at Work Act, 1974, requires steps to be taken to reduce risks so far as is reasonably practicable. This means balancing the level of risk against the measures needed to control the real risk; it is not necessary to take action if it would be disproportionate to the level of risk.

Regulation 3 of the Management of Health and Safety at Work Regulations 1999 creates the legal requirement to complete risk assessments. Guidance is provided by the Construction Industry Research and Information Association (CIRIA) publication C681, “Unexploded Ordnance (UXO), A Guide for the Construction Industry”.

CIRIA propose a four-stage process:

Stage 1 - Preliminary risk assessment. The purpose of the initial risk assessment is to place a site in a historical context to assess potential risk from UXO and to identify whether more detailed assessment is required. The assessment is based on data obtained from a desktop review of historical information regarding site location, previous site development, wartime bombing records etc. Following a cursory review of available information, it is sometimes obvious that a detailed risk assessment will be required and this stage may be omitted.

Stage 2 – Detailed risk assessment. If recommended as part of the initial (stage 1) risk assessment, an additional, detailed risk assessment will be completed to estimate the UXO hazard on a site, giving due consideration to the development type and construction methods to be employed.

Stage 3 – Risk mitigation. This process will identify how to reduce risk to an acceptable level, as it will not be possible to eliminate the risk of UXO. A framework will be provided in the detailed risk assessment that provides options for an appropriate and cost-effective risk mitigation programme. Only if necessary and unavoidable, will site investigation works or monitoring be recommended

Stage 4 – Implementation. During this final stage, the appropriate risk mitigation plan (if any) will be implemented.

A preliminary risk assessment (stage 1 of the process above) was produced by 1st Line Defence (dated 04/11/2020, reference EP7854b-00) and provided to Bombs Away Ltd. This identified the requirement for a detailed risk assessment to be completed (stage 2 of the process above), primarily because the site had been used as an airfield during WW2 and there had been aircraft crashes in the area.

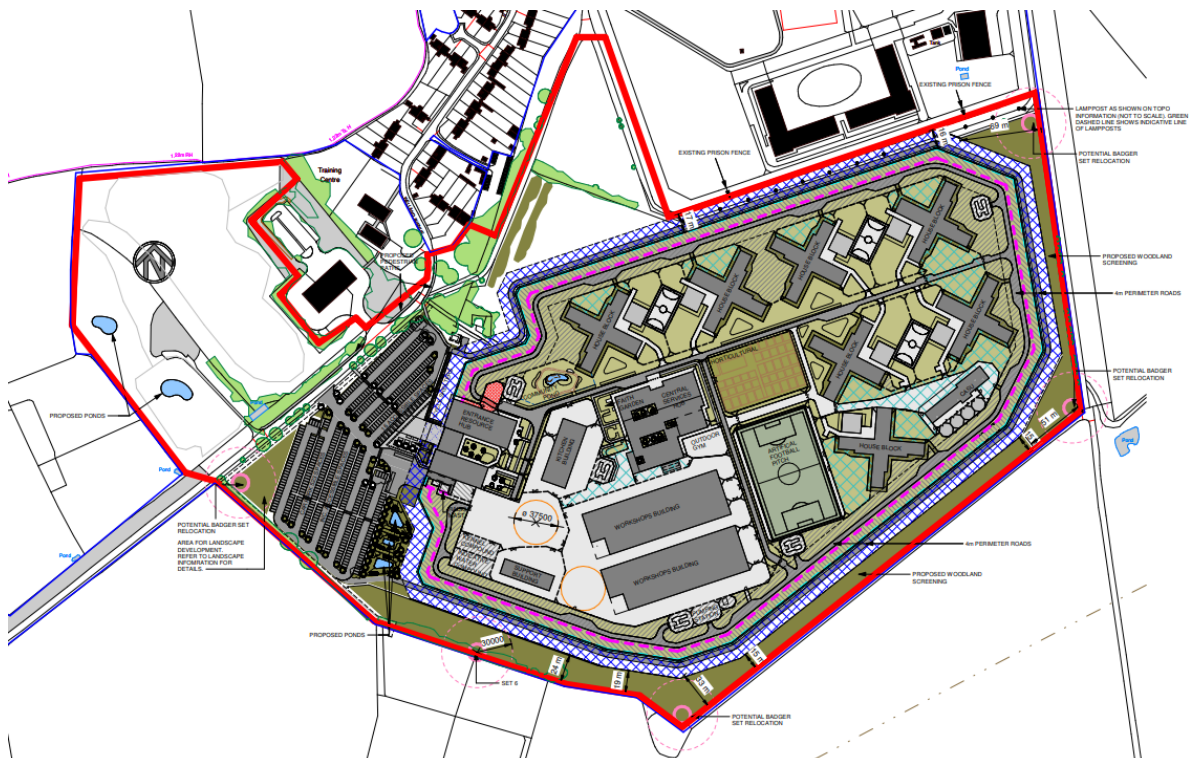
2.1 Scope and limitations

This is a detailed UXO risk assessment for part of the area known as Gartree 2 for Wates Construction. A review of available information was carried out for the area of the site, in order to establish the risk of harm from UXO, in accordance with CIRIA's recommendations contained in their publication C681, Unexploded Ordnance (UXO), A Guide for the Construction Industry.

Unexploded ordnance presents a significant threat to construction projects in parts of the UK, as a result of enemy actions during the two World Wars in the 20th century and historic British and Allied military activity. The assessment is primarily based on the information discovered during the research process. If additional information relating to the potential presence of UXO becomes available to the client, it should be made available to Bombs Away Ltd as soon as possible, so that the risk can be reassessed and the mitigation strategy revised, if necessary.

2.2 Site location

The site is located 2 kilometres northwest of Market Harborough, Leicestershire and the proposed development is shown within the red polygon on the site plan below. To the north of the site there is the existing HMP Gartree, a former training centre, industrial unit and a residential area. The remainder of the site is surrounded by agricultural land. Welland Avenue runs through the site, to the west of the main development area.



2.3 Proposed construction works

An outline planning application for the new prison was made in September 2021, reference 21/01600/OUT. It has been proposed to build a new Category B prison of up to 82,555m², within a perimeter fence, together with parking and landscaping.

2.4 Contemporary research into UXO discovery on construction sites

Research completed by Bombs Away, which has been peer reviewed, was published by the Institution of Civil Engineers in 2019. This research investigated the probability of encountering UXO in London, which was subject to more bombing than the rest of the country combined. This research indicated that in the 12-year period from 2004 to 2015, the probability of encountering an unexploded bomb on a land-based construction site in London was about 1 in 17,600 – an average of 1 each year.

An encounter with unexploded ordnance does not necessarily mean it will detonate. CIRIA acknowledge that the likelihood of detonating unexploded ordnance is “far lower” than encountering it. WW2 German bomb fuzes were electrically initiated and their power supplies were not designed to last more than six weeks, although the battery life was only confirmed to have expired in the 1970s.

Research published by the Institute of Explosive Engineers (King, C) started to make an assessment of the effect of ageing on munitions, an area in which there is little research. It notes that most ammunition components will degrade until they can no longer fulfil their role, but it is extremely hard to accurately predict the effects and time scale of the decay. This research is taken into consideration when recommending the mitigation measures that should be adopted, against the risk of harm caused by UXO on construction sites.

2.5 Types of ordnance

The types of unexploded ordnance that are most likely be encountered on construction sites, can be split into three groups:

- **Aerial delivered bombs.** Mostly dropped by the Luftwaffe (German air force) during WW2, occasionally during WW1. Allied bombs are sometimes discovered; they can be found at aircraft crash sites, when they were released from Allied planes during training or in an emergency and when they were abandoned, if no longer needed.

The size of the weapons can vary from a 1kg incendiary bombs (IB) to high explosive (HE) blast bombs of up to 2.5 tonnes, with many variants in between. The risk posed by these weapons increases with size and large HE bombs have the potential to kill many people.

Hundreds of thousands of small incendiary bombs were dropped during WW2 and the Army deal with about 50 of these devices each year. The large majority of high explosive bombs dropped were 50kg in weight and it is this size of high explosive unexploded bomb that is found most frequently, although a 1000kg bomb was found in Exeter this year.

Small incendiary bombs are usually discovered within the top metre of excavation works (based on the ground level in the 1940s) but larger unexploded bombs can be discovered at depth.

It should be noted that aerial delivered, high explosive unexploded bombs (UXBs) can be found *under* buildings that were constructed prior to WW2, due to their ability to travel underground following impact, a phenomenon known as the 'J curve'. The maximum horizontal distance that a bomb is likely to travel is about 10 metres.

Numerous other types of aerial delivered weapons were dropped on the UK by the Luftwaffe. This included parachute mines, oil bombs and phosphorus bombs (large incendiaries). These weapons were used less frequently than high explosive bombs and their construction using thin sheets of steel meant that they were unlikely to survive impact with hard ground.

Anti-personnel cluster bombs of up to 2kg were also used in limited quantities. They are most likely to be discovered in rural locations in the top metre of the ground, based on the 1940s level.

Hitler's 'vengeance weapons', the V1 and V2 missiles are considered as part of the 'aerial delivered bombs' category. Due to their size, when these weapons did not explode, it was very rare for them to be unnoticed. There has only been one occasion in the recent past when such a weapon (a V1) was discovered unexpectedly and that was found in sewage works.

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- **Anti-aircraft artillery (AAA) weapons.** These shells were intended to destroy enemy planes by exploding on impact or at a specified altitude in the proximity of the aircraft. Many of them did not function properly and fell to earth without exploding.

The maximum height that large calibre AAA round could reach was about 50,000 feet (15km) and so this ordnance could be found anywhere near to the location of wartime AAA batteries. If they are located, it is likely that they would be within the top metre of excavation works, again based on ground level in the 1940s.

- **Small arms and land service ammunition.** This includes munitions such as bullets, mortar shells, grenades and land mines. They are most likely to be discovered on land that has been used by the military, since 1900. CIRIA estimate that 20% of the UK (12 million acres) has been used by the armed forces at some stage.

2.6 Potential locations of unexploded ordnance

Whilst UXO could be found in virtually any location within the UK, there is a higher prevalence of it occurring in certain locations. These are:

- Locations formerly used by the military. This includes training areas, firing ranges, ammunition manufacturing facilities, storage depots, airfields (already noted as a risk for this site), military camps, bombing decoy sites, fortifications and defences,
- Aircraft crash sites (also noted as a risk for this site)
- In the proximity of WW2 bombing target areas,
- On routes to and from bombing targets,
- In water features, such as streams, rivers, marshes and reservoirs,
- Sewage works,
- Cemeteries.

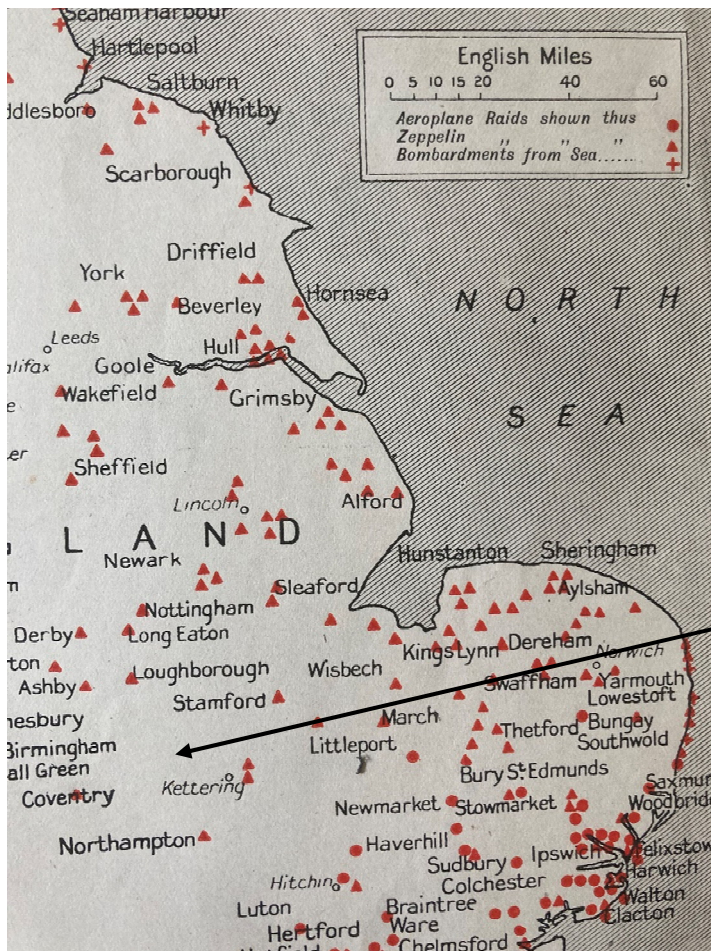
Section 3. Site specific research

This research considers each of the following:

- WW1 aerial delivered ordnance
- WW2 aerial delivered ordnance
- Site with former military use & contamination by Allied UXO
- Aircraft crash sites

3.1 WW1 aerial delivered ordnance

The relatively low number of bombs that were dropped during WW1, their small size and low technology meant that unexploded ordnance was quickly discovered, as its ability to penetrate the ground was limited.



Records of WW1 bombing are imperfect, however shortly after WW1, the publisher Harmsworth printed a map detailing all the air raids and naval bombardments that had occurred. An extract is shown to the left, with the site location marked.

We have found no other information to suggest that the area was bombed during WW1.

There was a Territorial Army (TA) drill hall in Coventry Road, Market Harborough, used by E Company of the 1st/5th Battalion of the Leicester Regiment, but no evidence of WW1 military history has been found at the site.

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3.2 WW2 aerial delivered ordnance

A review of information listed below has been completed. Areas of research include:

- Abandoned bombs
- Contemporary Ordnance Survey mapping, bomb damage maps, bomb impact records etc
- Anecdotal/ other records

3.2.1 Search of records for abandoned bombs.

Very occasionally, Luftwaffe bombs were not recovered either during the war or the years afterwards, even when their location was known.

Following WW2, significant effort was made nationally to investigate abandoned bombs and minimise their number. We have found no records of an abandoned bomb at the site. Abandoned bombs tend to be located in cemeteries, deep in water-logged marshes, riverbanks, reservoirs, sewage farms, refuse pits and filter beds. This site does not correspond with any of those parameters.

3.2.2 Review of information from ordnance survey maps, bomb damage maps, bomb impact records, academic papers etc.

Immediately prior to WW2, a considerable area of the United Kingdom was surveyed, however the maps were not published until late in the 1940s, omitting developments that occurred during the war. The first map (below) falls into this category and there is no indication that the airfield existed.

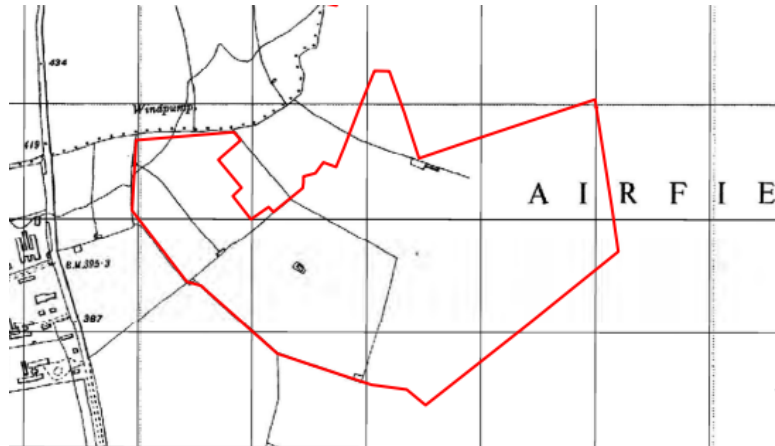
OS map, 1:25 000, published 1949, with the site boundary identified by a red polygon.



This map is very similar to the OS edition published in 1885 (1:10,560), which also showed the area as enclosed farmland, crossed by a footpath.

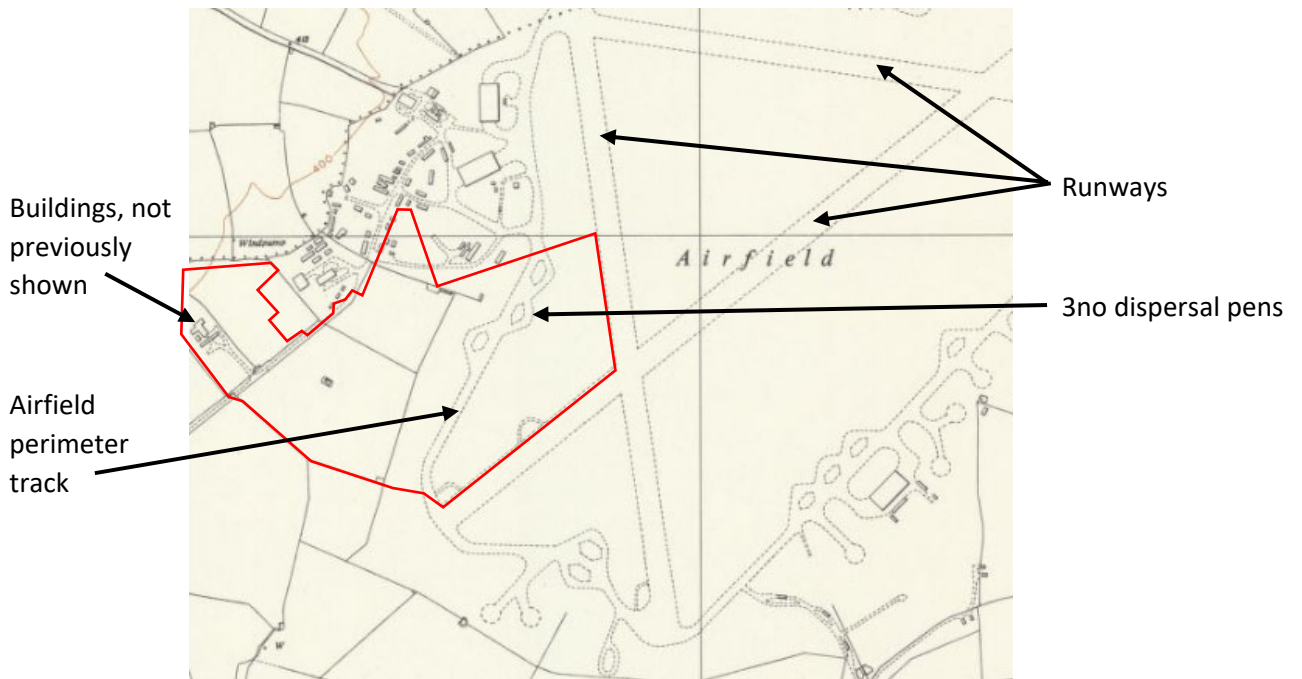
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OS Map, 1:10 560, published 1952



The airfield is now shown, however with no detail to indicate the runways or buildings. At this point in time (considered to be the height of the Cold War), sensitive information was sometimes left off maps to avoid assisting the Soviet Union.

OS Map, 1:10 000, published 1958



By 1958, the airfield is now shown, and has *not* been marked as “disused”. The reason for the site’s shape becomes clearer, as it follows the western edge of two runways and several fence lines. Dispersal pens (aircraft storage areas) on the airfield’s perimeter track can clearly be seen and there are now some buildings within the site boundary. The road forming Welland Avenue is now shown.

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OS map, 1:10 000, published 1968



Ten years on from the previous map, little has changed within the site boundary. The perimeter track and dispersal pens are still shown, but the pre-war footpath has now reappeared. Outside the site, the former perimeter of HMP Gartree is now shown and there is additional housing to the north. The airfield is now marked as "disused".

Aerial view, from 1999



Within the site boundary, there is little change. The dispersal pens now appear to have been partially covered by vegetation. The buildings to the west side of the site have gone, although the access road is still visible.

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Aerial view from 2010



There are no significant changes visible within the site boundary, however HMP Gartree has now been extended, so that it forms the northern boundary of the construction site.

Aerial view from 2021



There are no significant changes visible within the site boundary, but nature appears to be reclaiming the dispersal pens and airfield perimeter track.

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Overlay of 1968 map and aerial view



The overlay confirms the information previously gleaned from the maps, showing the gradual degradation of the former WW2 buildings and infrastructure. The dashed line indicating the footpath crossing the site has been diverted, so that it follows the perimeter.

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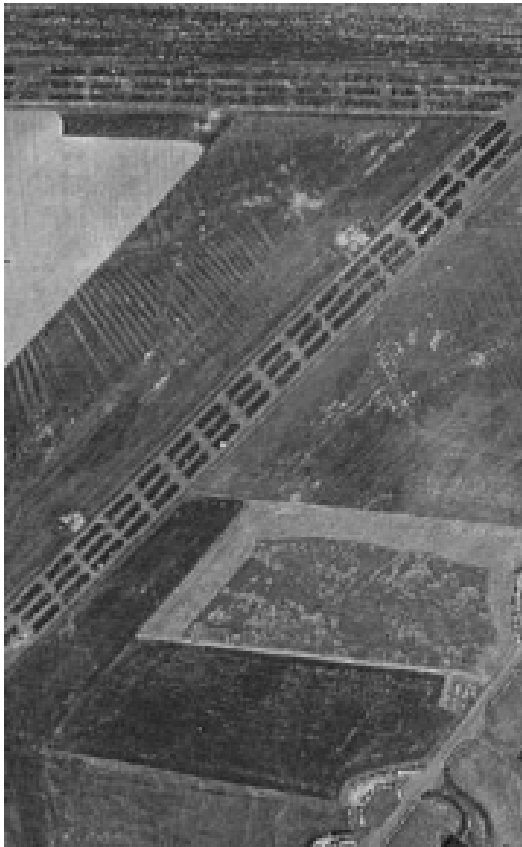
Extract of 1944 airfield plan, from RAF records



An extract of the airfield plan produced during WW2 was obtained and the numbers compared with the plan's key. The area to the west of Welland Avenue, within the site boundary, is noted as the "admin site". Buildings in this area included facilities such as latrines, blast shelters, offices, briefing room, operations block and a picket post. The northern 'wedge' shows more blast shelters, servicing huts, a water tank and gas defence buildings (clothing/ equipment stores and gas defence centres). The final area, close to the dispersal pens, has a blast shelter, general purpose building and latrine shown on the plan.

To the south of the main airfield (not shown on this plan), 500-1000m from the development site, bomb stores are identified.

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Two photos of the airfield (but not of the site itself), dating from 1950, have been located and are reproduced below. They appear to show rows of vehicles in storage on the airfield, which confirms information obtained from other sources, described later.



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The airfield was officially known as RAF Market Harborough, although the locals referred to it as Foxton. Construction by J R Mowlem commenced in 1942 it and opened in May 1943, becoming operational in August 1943, officially closing in 1947, although almost all flying ceased in 1945. It continued to be used by the Army from 1948 until 1960, for storage of surplus vehicles. According to the local Historic Environment Record, some of the buildings on the west side of the site were used after WW2 as a Polish resettlement centre.

In 2017, the Airfield Research Group was commissioned by English Heritage to complete a report on former WW2 airfields and RAF Market Harborough was recorded as having a “B2 function”, meaning it was used as bomber crew training. A different classification was allocated to airfields that were used by operational bombers.

According to our research, units that are known to have occupied the airfield included a: Maintenance Unit, Operational Training Unit (OTU), Air Crew Holding Unit, Bomber Defence Training Flight and a Personnel Reception Centre. No operational squadrons have been listed in any of the records we have located.

‘Medium’ twin engine Wellington bombers were used by the OTU at RAF Market Harborough airfield, before pilots moved elsewhere to train on ‘heavy’ 4 engine aircraft, such as the Lancaster bombers. Other aircraft used at the airfield included Martinets (for towing targets), Airspeed Oxford (bomber trainers) and an Avro Anson (for personnel transport). Obsolete Hurricane fighter planes were also based there to provide bomber crews with the simulated experience of being attacked. After WW2, Horsa gliders were brought to the airfield to be broken up and Miles Aircraft Ltd used it to store planes.

There are no records of V-1 or V-2 strikes close to the site.

Records from the National Archives note that the Rural District of Market Harborough recorded a bombing density of 1.8 HE bombs/ 1000 acres, a total of 83 HE bombs across the whole district. The closest known bombing incidents were at Great Bowden (3km east of the site) when 4nr high explosive bombs were dropped on 26th April 1941 and approximately 2km southwest of the airfield, where 2nr high explosive bombs were dropped.

3.2.3 Search of anecdotal records (including contemporary media reports, war memorials, local history websites etc)

The Commonwealth War Graves Commission's records were searched to identify deaths occurring in the locality. No records of relevance were identified.

A memorial to the crew of a Lancaster bomber that crashed at Foxton, was found in the village, but the aircraft had no link to the airfield.

3.3 Sites with former military use and contamination by Allied UXO

3.3.1 Airfields

The site was a WW2 airfield used for training bomber crews. The fact that it was an airfield means that three significant forms of contamination could have occurred:

- Installation of 'Canadian pipe mines', also known as 'McNaughton tubes',
- Disposal of non-conventional weapons after WW2 and
- Surplus ordnance buried after WW2.

Operation Crabstick was the military response in 1989 to review the post-War clearance operation of Canadian pipe mines. RAF Market Harborough does not feature on the list of airfields where they had been installed. Construction of the airfield commenced when the threat of invasion had passed, which significantly reduces the possibility that pipe mines would have been installed.

Project Cleansweep commenced in 1997 to review the residual contamination as a consequence of chemical warfare agents, principally mustard agent. RAF Market Harborough does not appear on the list of locations.

The disposal of surplus ordnance primarily occurred at bases used by US Air Force bombers. This airfield was not used by the US forces.

3.3.2 Defensive positions and fortifications

Our database, which schedules known positions, has been searched and nothing of significance has been located within 2km of the site. There is no evidence of the Home Guard using the site, indeed, after it became an airfield, it is very unlikely they would have been allowed onto it.

3.3.3 Training areas, firing ranges, Home Guard usage, Auxiliary Unit operating bases etc

Many areas have been used for military training since the turn of the last century and encountering UXO in these areas constitutes a significant risk to safety. These areas were usually located close to military camps for ease of access. The Home Guard (Britain's home defence force during WW2) sometimes used 'informal' training areas, with the permission of local landowners. If ammunition was dropped or abandoned, or if missiles were fired but did not explode, there could be the unexpected discovery of unexploded ordnance.

Auxiliary Units were part of the Home Guard and were intended to act in a similar way to the French Resistance, in the event of a successful invasion by the Germans. Their underground operating bases (OB) contained significant quantities of weapons, ammunition and explosives. Due to the secrecy of their work, records detailing the location of the bases are generally scarce. There were instances when the munitions were not returned to safe locations following the end of hostilities and they were found decades after the end of WW2.

The airfield plan from 1944 was examined and did not show any firing or testing ranges within the site boundary. Buildings within the boundary had administrative roles, unrelated to ordnance.

Gumley Hall (3km west of site) was used to train agents from Special Operations Executive and demolished in 1964. Papillion Hall in Lubenham (3km south of site) was requisitioned and used by the US military, but demolished shortly after WW2. There is no evidence that they operated on the site.

No records of the site being used for training by the army have been located, but it is possible that the farmland was used for this purpose, prior to it becoming an airfield.

3.3.4 Anti-Aircraft Artillery batteries etc

No heavy anti-aircraft batteries have been located within 10km of the site, although records are limited.

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3.3.5 Decoys

Starting in January 1940 (prior to the first bombing raids of WW2 against Britain), significant resources were allocated to the construction of bombing decoy sites. The sole intention of the sites was to divert German bombers from their intended targets and deceive them, so that they would drop their bombs onto unoccupied areas of countryside. Large swathes of land were laid out to resemble genuine targets, to draw away the hostile aircraft.

These decoy sites were used to divert planes from:

- airfields - using night and day decoys (Q and K sites),
- towns & cities - simulating urban lighting (QL sites)
- recently bombed locations, where fires were still burning (airfields - QF sites; petroleum depots - P sites; and urban areas - SF sites)
- factories & other buildings (C sites)

602 locations in the UK were used to provide 839 static decoys, but not all were bombed. There were also mobile decoys, bringing the total number to about 1000.

No records of decoys within 5km of the site have been found.

3.3.6 Munition storage and manufacturing facilities

Owing the poor historic standards of health and safety at these facilities, there could be an increased possibility that UXO will be discovered at locations that have been involved with the storage or manufacture of munitions. No evidence has been found to suggest that the site has been used to store or manufacture munitions.

3.3.7 Cold War usage

A search of Cold War military installations was completed. These were sometimes located in areas that had been occupied by the military in WW2. No installations were found in the area of the site.

3.4 Aircraft crash sites

Historical records were searched to establish if there had been incidents of potential relevance to the site; several were found. These include:

- Oct 1940, Blenheim light bomber crashed near Foxtton village, north of the airfield
- 20th May 1941, Wellington bomber crashed east of the airfield
- 7th Feb 1943, Wellington bomber crashed at the south end of the airfield
- 27th March 1944, Wellington bomber crashed east of the airfield
- 3rd Feb 1945, Wellington bomber crashed southeast of the airfield
- 9th April 1945, Lancaster bomber crashed near Foxtton village, north of the site
- 4th May 1945, Mosquito fighter-bomber crashed near Foxtton village, north of the site.

Section 4. Risk assessment

The risk to health and safety posed by each of the potential sources of UXO contamination, based on the research described in Section 3 is assessed within this section.

4.1 WW1 aerial delivered ordnance

No evidence has been found to suggest that the site was bombed during WW1. Very few examples of aerial delivered ordnance dating from this period are discovered on construction sites and we consider the probability of encountering it to be **very low**.

4.2 WW2 aerial delivered ordnance

No evidence was found to suggest that the site was bombed, although there is no doubt it would have been a potential target. Much of the site was a working airfield during WW2 and searches for unexploded ordnance would have been made, in the event that there had been a raid near-by.

By the time that construction of the airfield had commenced, the worst of German bombing was over, although the 'Baedeker raids' on locations with cultural value continued until 1944 and the 'baby blitz' took place in early 1944, but mostly on targets in southeast England.

If there is German aerial delivered ordnance from WW2, it will be because it landed unnoticed during the war.

In order to make a better assessment of the risk due to WW2 aerial delivered ordnance, it is necessary to consider additional factors. These are:

- an assessment of the depth that an air dropped bomb (of 50kg or more) may penetrate.
- the extent of post-war development, which would have revealed the existence of some UXBs during previous construction works.
- the extent and depth of the proposed intrusive works, which may reduce the chance of encountering UXO.
- the likelihood of discovering UXBs on the site during WW2.

4.2.1 Bomb depth assessment

Our research indicates that the ground is soil above mudstone, with sporadic limestone bands.

Research conducted during WW2 on the penetration depths of 1,328 unexploded bombs, indicates that they are unlikely to exceed a depth of 10-13 metres in most ground conditions. It should be noted that smaller high explosive bombs (eg, 50kg HE) may not penetrate to this depth and are more likely to be found closer to the surface, but in 1943, an 1800kg bomb was discovered in excess of 20 metres below ground level.

We estimate that the maximum likely depth that an unexploded bomb is likely to be found is 12 metres.

Smaller air dropped weapons, such as the 1kg and 2kg incendiary bomblets (IBs), are likely to be found much closer to the surface. Small IBs were not dropped individually, but from containers that would release batches in their hundreds.

4.2.2 Extent of post-war development

After WW2, probably during the 1950s, most of the military buildings on the site were demolished and the site was restored to its former agricultural use. It is likely that any ordnance in the top 300mm of ground would have been found during normal agricultural processes, such as ploughing.

4.2.3 Extent and depth of proposed intrusive works

Part of the risk assessment process is to estimate the quantity of ground that will be disturbed, as this can reduce the assessed risk of an encounter.

4.2.4 Likelihood of detecting unexploded bombs (UXB) during WW2

Three criteria are considered during this process:

- The extent of bomb damage that may have obscured the entry hole of another bomb. There is no evidence to suggest bomb damage occurred to obscure entry holes.
- The extent of ground cover (vegetation) that may have obscured visibility of bomb entry holes.
It is very unlikely that there was unmaintained ground cover on land that was being used as an airfield. Prior to becoming an airfield and for areas of the site outside the airfield's perimeter, the land was likely to have been used for growing crops. We consider it unlikely, but possible, that an entry hole would have been unnoticed in these areas.
- Frequency of access.
There would have been regular access across all areas of the airfield, when it was in use. For areas of agricultural land, there is likely to have been frequent access by farm workers.

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When bombs enter the ground, there is significant vibration transmitted locally and a large, unexploded bomb would cause a considerable amount of damage to the surrounding area without exploding. It was common for lay people to think that a large, unexploded bomb hitting the ground was actually a small high explosive bomb detonating. Prior to the construction of the airfield, Adam's farm was located to the east of the site and it is likely that the occupants of the farm would have been aware of an air raid, if bombs had been dropped.

As such, is it considered possible that a UXB could have been dropped and remain unnoticed, but unlikely. Based on the factors listed above, our estimate is that there was a 5% chance that a UXB would have been unnoticed. This estimate will be used in the calculation that follows.

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4.2.5 Assessment of likelihood on an encounter with WW2 UXB

An assessment methodology to quantify the probability of UXO remaining on the site can be completed using an exemplar within CIRIA's guidance document, C681. This process follows.

Density of high explosive (HE) bombs dropped on the Borough

= 1.8 HE bombs/ 1000 acres (from Section 3.2.2)

= 0.004 448 HE bombs/ hectare

Estimated total area of site

= 28 Ha (excl existing public highway)

Theoretical number of bombs that were dropped on the site during WW2:

= 28 x 0.004 448

= 0.124 541 bombs

It is generally accepted that an average of 10% of bombs that landed, did not explode, so the theoretical number of unexploded bombs (UXB) remaining on the site would be:

= 0.124 541 x 0.1

= 0.012 454

It is the opinion of Bombs Away Ltd, that there is a 95% chance that any large (≥ 50 kg) high explosive unexploded bomb would have been identified (a 5% chance that they would remain). This is because:

- The vast majority of unexploded bombs were found during or immediately after WW2.
- With very few exceptions (abandoned bombs), those that had been located were removed.
- The site was occupied during WW2 and it is likely that there would have been regular access to all areas, especially the airfield.
- There was no known bomb damage in the area to hide entry holes
- There was no known bombing of the immediate area or airfield
- Some areas are likely to have been covered by crops for part of the war, which means that an entry hole could have been missed, in the unlikely event that a bomb was dropped on the field.

As such, the probability of an entry hole caused by an unexploded bomb being unnoticed, is considered to be low and a figure of 5% is used in the calculation below.

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This means that the theoretical number of unexploded bombs remaining on the site is

$$= 0.012\ 454 \times 0.05$$

$$= 0.000\ 623$$

The probability of an unexploded bomb remaining on this site is:

$$= 1/ 0.000\ 623$$

$$= 1 \text{ in } 1,605$$

Expressed another way, this means that if there were 1,605 sites identical to the Wates development, one of the sites would have an unexploded bomb located on it.

An *encounter* with an unexploded bomb is significantly smaller than the probability that there will be a UXB on the site. This can be factored into the calculation by estimating the volume of ground that will be disturbed.

For the purpose of this calculation and to introduce a factor of safety, it will be assumed that all the ground underneath the proposed building footprints will be removed to a depth of 12 metres (in practice, it is typically 15-20%) and the top 1 metre of ground will be disturbed for the remainder of the site.

Footprint of entire site, excl existing public highway

$$= 28 \text{ Ha}$$

$$= 280\ 000\text{m}^2$$

Footprint of proposed buildings, based on information submitted in the planning application

$$= 29\ 769\text{m}^2$$

$$= 30\ 000\text{m}^2 \text{ (rounded up)}$$

Footprint of remaining site

$$= 25 \text{ Ha}$$

$$= 250\ 000\text{m}^2$$

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Total volume of ground below the entire site, to a depth of 12 metres

$$= 280\,000\text{m}^2 \times 12\text{m}$$

$$= 3\,360\,000\text{m}^3$$

Volume of ground disturbed below proposed buildings (to a depth of 12 metres)

$$= 30\,000\text{m}^2 \times 12\text{m}$$

$$= 360\,000\text{m}^3$$

Volume of ground disturbed below remainder of site (to a depth of 1 metre)

$$= 250\,000\text{m}^2 \times 1\text{m}$$

$$= 250\,000\text{m}^3$$

Total volume of ground to be disturbed = $360\,000\text{m}^3 + 250\,000\text{m}^3$

$$= 610\,000\text{m}^3$$

Total volume of ground to be disturbed/ total volume of ground below the entire site

$$= 610\,000\text{m}^3 / 3\,360\,000\text{m}^3$$

$$= 0.18$$

Expressed as a percentage

$$= 18\%$$

The estimated number of UXB on the site previously calculated was

$$= 0.000\,622$$

This figure can be now reduced to reflect the possibility of an *encounter* with a UXB

$$= 0.000\,622 \times 0.18$$

$$= 0.000\,113$$

The probability of an encounter with an unexploded bomb is:

$$= 1 / 0.000\,113$$

$$= 1 \text{ in } 8,845$$

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This means that if there were 8,845 sites identical to the Wates development, it would be expected that there would be an *encounter* with an unexploded bomb on one occasion.

It must be accepted that the consequences of a large WW2 bomb exploding would be very significant, however the last confirmed fatality on a UK construction site caused by UXO was in 1949. As also mentioned in Section 2.4 (above), CIRIA accept that the probability of UXO detonating is “far lower” than discovering it.

As such, the risk of harm from a WW2 German bomb of 50kg or more on the site is considered to be **low**.

4.3 Sites with former military use and contamination by Allied UXO

No evidence has been found that the site itself was used for any military purpose, other than an airfield before, during or after WW2. Records have been searched to check if the site was fitted with Canadian pipe mines or used for storage/ disposal of non-conventional weapons and none were found. Dumping of surplus ordnance is very unlikely on the site, as the airfield was used for training purposes by UK forces, rather than operational bombing by the US Air Force. When Allied bombs have been found on airfields, they tend to be close to the original bomb storage areas, which were to the south of the former airfield, over 500m from the site.

It is possible that ammunition may have been inadvertently dropped during WW2 on the site, perhaps by guards patrolling the airfield, although the risk posed by such items is low.

As such, the risk of harm from small arms ammunition and land service ammunition is considered to be **low**.

4.4 Aircraft crash sites

No evidence was located to suggest that an aircraft crash occurred on the site itself. As such, it is not considered likely that this possible event would pose a significant UXO risk to future works.

The risk of discovering munitions related to aircraft crashes is considered to be **low**.

Section 5. Summary and recommendations

The four key areas that have been assessed are all considered to be low or very low risk, as summarised below:

- WW1 aerial delivered ordnance – **very low risk**
- WW2 aerial delivered ordnance – **low risk**
- Former military use & Allied ordnance – **low risk**
- Aircraft crash site – **low risk**

It is recommended that the site produces an emergency plan detailing actions to be taken if UXO is discovered. It is considered appropriate that any person who is working in the ground (for example site investigation surveyors, piling contractors, groundwork contractors and similar) to undertake a UXO briefing as part of their initial site induction and for toolbox talks to be regularly completed.

A template for the emergency response plan and a toolbox talk can be downloaded for free from the “download” page at www.BombsAwayUXO.com

It should still be noted that CIRIA acknowledges that it is impossible to say with absolute certainty that an area is clear of UXO, as “no current UXO detection survey technology can provide complete assurance that every buried UXO item has been detected, located and removed. Even the most reasonably practicable method, other than shifting all the soils beneath a site will leave some level of residual risk.” Even when a clearance certificate has been provided, it does “not constitute a guarantee that the site is clear of UXO”.

Whilst not a formal recommendation, Clients may also consider acquiring a copy of CIRIA’s publication *Unexploded ordnance (UXO) risk management guide for land-based projects (C785)*, which is an accessible aide memoire for site management.

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 0871 268 4400
 Office@BombsAway.Ltd
 www.BombsAwayUXO.com

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 0871 268 4400
 Office@BombsAway.Ltd
www.BombsAwayUXO.com

Section 7. Glossary & guide to abbreviations

AA	Anti-aircraft
AAA	Anti-aircraft artillery
BD	Bomb Disposal
C681	CIRIA publication: Unexploded Ordnance (UXO), A Guide for the Construction Industry
CIRIA	Formerly, the Construction Industry Research & Information Association
HE	High explosive
Home Guard	Originally known as the Local Defence Volunteers, this military unit was the UK's militia intended to defend the country, in the event of a German invasion during WW2.
IB	Incendiary bomb
Luftwaffe	German air force
RAF	Royal Air Force
Shells	Hollow projectiles, usually containing explosive, but without internal propellant
SI	Site investigation
UXB	Unexploded bomb
UXO	Unexploded ordnance
WW1	World War 1 (Great War or First World War)
WW2	World War 2 (Second World War)