Defence Infrastructure Organisation

DEFENCE ESTATE OPTIMISATION PORTFOLIO

Penally Training Camp Phase 1 Land Quality Assessment

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Penally Training Camp Phase 1 Land Quality Assessment

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Land Quality Statement

Background	The Ministry of Defence (MOD) require an assessment of the land quality at Penally Camp to support the disposal for commercial/industrial and/or residential potential future uses of the land.
Purpose of the report	The purpose of the report is to assess the land quality of the site for potential disposal or redevelopment. The report therefore considers future commercial and residential end use but does not include consideration of detailed design of any future development.
Site description and activities	Penally Camp occupies an area of approximately 5.83 hectares (ha) across two locations, separated by the A4139. The main site (PTCR01) is on the northern edge of the A4139 and consists of a range of buildings with several areas of open grassland, all enclosed within a fence line occupying an area of 5.8ha. The site is accessed by two connections from the A4139, with several gates for foot traffic around the boundary. An area of woodland in the northeast containing a dilapidated water tank is outside of the main site fence but within the site boundary. A demolished sewage treatment works (PTCR00) is separated from the main site by the A4139 in a grassed area occupying approximately 0.18ha. There is no fence around the boundary, although the vegetation is overgrown around the periphery.
Site history	Penally Camp was established as a musketry camp in the 1860s, expanding during WW1 to incorporate additional accommodation and facilities, with two additional fields purchased in 1913/1914. Several of the original buildings are still present, although many have been demolished with replacement in the same location. The sewage treatment works in the south appears to have been built in the 1930s and is now demolished. The parade square was established as an MT Section in 1943, with the surrounding area used for trench training. Many of the accommodation buildings in the east of the camp were replaced in the early 2000s.
Site sensitivity	The site is underlain by a Secondary A Aquifer comprising interbedded limestone, mudstone and sandstone horizons. A Principal Aquifer is present in the south of the site only. There is very limited superficial cover in the south of the site. Groundwater depth and quality information is unknown. There are no nearby abstractions although groundwater may provide baseflow to nearby watercourses. Groundwater is assessed to be of moderate sensitivity. There are no on-site surface water features, although a spring is possibly present in the north of the site which occasionally causes flooding of the site. The underlying geology has potential to provide baseflow to nearby streams and ditches, the closest being 150m southeast. The coast is 500m to the south. There are no nearby abstractions. Surface water sensitivity is assessed as Low. The site is not within any ecologically designated sites, with the nearest SSSI and SAC both located 250m to the south of the site. Ecological sensitivity is assessed as low.
Previous investigations	A Phase One LQA was undertaken at the site in 2013 by SKM Enviros. No other land quality investigations have been identified.
Potential sources of contamination	The assessment of the site identified the following key potential sources of contamination (with their source number). Note not all have been taken forward to the risk assessment if of limited potential for contamination. A14 Shooting in box A15 Indoor range B01 Underground fuel tanks B04 Refuelling area (no tanks) C02 Infilled ground including pits/ponds C03 Bund / stockpiled mounds C05 Waste compound / scrapyard D01 Burning ground D03 Incinerators D04 Tip and burning area E01 Vehicle maintenance E02 Range workshops E05 Other workshops

	F01	Hazardous material storage including minor fuel storage
	G01	Demolished buildings and structures
	J01	Respirator test chamber
	M01	Substation
	N01	Vehicle washdown
	Q01	Ammunition and explosive storage area
	Q02	Armoury
	R01	Cess pit / septic tank
	R02	Sewage treatment works
	X06	Helicopter landing site

Risk Assessment	**Potential Source**	**Potential Pollutant**	**Future Residents (R1)**	**Future Commercial users (R2)**	**Groundwater (R3)**	**Surface Water (R4)**	**Future site buildings (R5)**	**Future site infrastructure (R6)**
	B01 Underground fuel storage	Hydrocarbons (diesel, gasoline), lead	M	M/L	M/L	L		M/L
	B04 Refuelling area (no tanks)	Hydrocarbons	M/L	L	M/L	L		M/L
	C02-1 Infilled pit – off-site	Soil gas (carbon dioxide, methane)	M	M			M	
	D01 Burning ground D04 Tip and burning area	Heavy metals, TPHs PAHs, asbestos, cyanide	M	M/L	L	L		M/L
	E01 Vehicle maintenance	Heavy metals, hydrocarbons, PAHs	L	L	L	L		N
	G01 Demolished buildings and structures C02-2 Infilled ground C03 Bund / stockpiled material D03 Incinerators E01-2 Vehicle repair shop E02-2 range workshops J01-2 Gas hut	Heavy metals, hydrocarbons, PAHs, asbestos	M	M/L	L	L		
	C02-2 Infilled ground	Soil gas (carbon dioxide, methane)	M	M			M	
	M01 Substations	Transformer oils, polychlorinated biphenyls (PCBs)	L	L	L	L		L
	N01 Vehicle washdown	Detergents, hydrocarbons	L	L	L	L		
	R02 Sewage treatment works	Heavy metals, asbestos, cyanides, hydrocarbons.	M	M/L	L	L		L
		Soil gas (methane, CO_2, H_2S)	M	M			M	
Conclusions	Moderate risks to future residential users have been identified from the potential presence of hydrocarbons associated with underground fuel storage tanks; as well as heavy metals, hydrocarbons and asbestos in burning grounds, demolished buildings (including the incinerator, gas hut, range workshops and vehicle repair shop), tips and burning areas, infilled ground,							

	stockpiled bunds and the sewage treatment works; and from potential soil gas from the sewage treatment works, infilled ground and off-site landfill. Moderate risks to future commercial users have been identified from potential soil gas from the sewage treatment works, infilled ground and off-site landfill. Moderate risks to future site buildings have been identified from potential soil gas from infilled ground and the off-site landfill. Moderate/low risks to future residential users have been identified from the potential presence of hydrocarbons associated with the refuelling area. Moderate/low risks to future commercial users have been identified from the potential presence of hydrocarbons associated with below ground fuel storage; from heavy metals, hydrocarbons and asbestos in burning grounds, demolished buildings (including the incinerator, gas hut, range workshops and vehicle repair shop), tips and burning areas, infilled ground, stockpiled bunds and the sewage treatment works. Moderate/low risks to groundwater have been identified from contaminants associated with fuel storage tanks and refuelling areas. Moderate/low risks to future site infrastructure have been identified the potential presence of hydrocarbons associated with fuel storage tanks and refuelling areas; as well as heavy metals and hydrocarbons from the burning ground and tip and burning area. All other risks were assessed as low or negligible. The conceptual model does not consider risks to construction /site maintenance workers on the basis that risks to workers will be dealt with under the Health and Safety at Work Act (1974) and regulations made under the act. Site-specific contamination data should be included in the pre-construction information for any proposed below ground works, to enable any contractors to address as necessary in their risk assessments and method statements.
Suitability for use (land quality)	This report assesses the risks in regard to future commercial and residential end uses following site redevelopment. The moderate human health risks identified relate to change of use in a future redevelopment and do not reflect the ongoing risk to the current site users. With regard to future development for mixed commercial and residential use a number of contaminant sources exist which will require consideration of further detailed investigation and / risk mitigation.

CONTENTS

TABLES

FIGURES

APPENDICES

1 INTRODUCTION

Terms of Reference	The Ministry of Defence (MOD) requires an assessment of the land quality at Penally Camp to support the understanding of the risks and liabilities to environmental and human receptors under future use of the land. WSP UK Limited (WSP) was commissioned by the Defence Infrastructure Organisation (DIO) to undertake a Phase One Land Quality Assessment of the site.
Purpose of the Report	The purpose of the report is to assess the land quality of the site for potential disposal or redevelopment. The report therefore considers future commercial and residential end uses but does not include consideration of the detailed design of any future development. WSP has assumed that all information and/or documents provided by the client in connection with the preparation of this report are accurate, complete and not misleading.
Aims and Methodology	The scope of works for the Phase One LQA comprised: ▪ acquisition and interpretation of factual information from site, MOD and public domain sources; ▪ a site visit undertaken on 17th October 2023; and ▪ preparation of a report and technical note to present information gathered, interpret the implications for land quality and provide advice on further works if appropriate. The findings of the study are based on the information made available to WSP by the MOD site personnel, together with information obtained from public domain sources. The aims of the Phase One LQA were to collate and review desk study information on the likely ground and contamination conditions at the site and provide a risk assessment for commercial/industrial and residential land use.
Limitations	The conclusions reached and advice given in this report are based in part upon information and/or documents that have been prepared by third parties. In view of this, we accept no responsibility or liability of any kind in relation to such third-party information and no representation, warranty or undertaking of any kind, expressed or implied, is made with respect to the completeness, accuracy or adequacy of such third-party information. As the focus of the assessment is on MOD's liability in relation to land contamination, only information pertinent to this assessment has been considered. In preparing this report we have assumed that all information provided by the Client is complete, accurate and not misleading.
Layout of the report	Chapter 2 provides a description of the site and site activities and associated potential sources; Chapter 3 summarises the results of the review of regulatory information. Chapter 4 discusses the site's history, Chapter 5 details the previous investigations and Chapter 6 gives the environmental setting of the site in relation to the geology, hydrogeology, hydrology and ecology. Chapter 7 provides a conceptual site model and qualitative risk assessment addressing the significance of any sources of potential contamination identified at the site. Chapter 8 provides a summary of overall land quality at the site. Supporting information is provided in Appendices.

2 SITE DETAILS AND OVERVIEW

2.1 SITE DETAILS

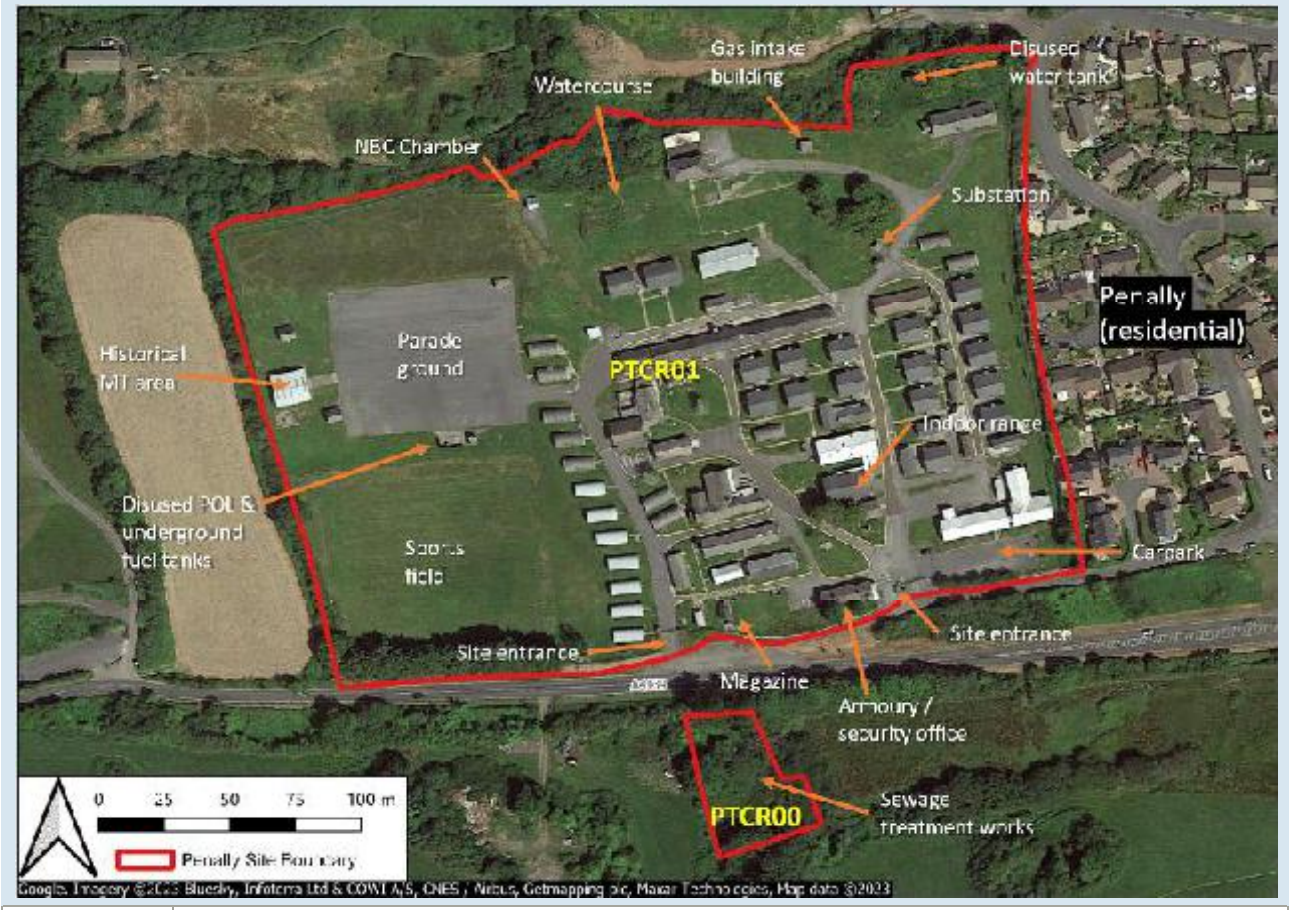
<table>
<tr><td>Site Location</td><td colspan="3">Penally Training Camp (the site) is located approximately 2.5km to the southwest of Tenby, Pembrokeshire, on the southwestern coast of Wales. The site is in the village of Penally, with the associated Penally Firing Range located on the other side of the A4139 and railway line. Carmarthen Bay is approximately 400m to the south.

Figure 1 in Appendix A and Figure 2.1 below show the site location and the location of local villages and roads.

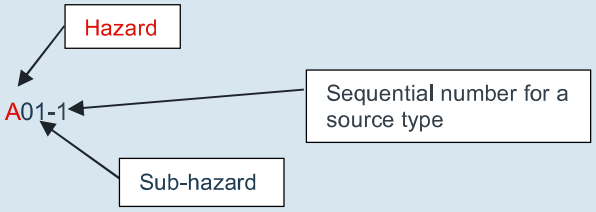
Figure 2.1 Plan showing site location
 
</td></tr>
<tr><td>Site Address</td><td colspan="3">Penally Camp, Penally, Pembrokeshire, SA70 7QW</td></tr>
<tr><td>Grid Reference</td><td colspan="3">The site is centred on approximately National Grid Reference 210950, 198950</td></tr>
<tr><td rowspan="5">Boundaries (Land uses and relevant features)</td><td></td><td>Adjacent</td><td>Beyond (within 200 m)</td></tr>
<tr><td>North</td><td>Farmland</td><td>Farmland</td></tr>
<tr><td>East</td><td>Penally – residential</td><td>Penally</td></tr>
<tr><td>South</td><td>A4139</td><td>Farmland, railway, Penally firing range</td></tr>
<tr><td>West</td><td>Farmland</td><td>Farmland, farm building, campsite</td></tr>
<tr><td>Site description</td><td colspan="3">Penally Camp occupies an area of approximately 5.83 hectares (ha) across two locations, separated by the A4139. The main site (PTCR01) is on the northern edge of the A4139 and consists of a range of buildings with several area of open grassland, all enclosed within a fence line occupying an area of 5.8ha. The site is accessed by two connections from the A4139, with several gates for foot traffic around the boundary. An area of woodland in the northeast containing a dilapidated water tank is outside of the main site fence but within the site boundary.</td></tr>
</table>

	A demolished sewage treatment works (PTCR00) is separated from the main site by the A4139 in a grassed area occupying approximately 0.18ha. There is no fence around the boundary, although the vegetation is overgrown around the periphery. Figure 2.2 shows the site areas and labels key site features.
Surface covering	The site is primarily landscaped with areas of woodland around the boundaries, and a sports field in the southwest. The sports field has been flattened with areas of cut and fill providing a bank to the south and to the north. Buildings are mostly concentrated in the southeast corner of the site, connected by a network of tarmac and concrete roads. There are several parking areas near the buildings and a concrete parade ground occupying an area of 0.4ha in the northwest.

Figure 2.2 Plan showing site features



Site Activities	The site is currently unused awaiting disposal, with all salvageable material removed for reuse elsewhere. The buildings are mostly empty and some are out of bounds due to the presence of asbestos. Site presence is restricted to part-time attendance from maintenance staff to maintain the landscaping and facilities. It is understood that all services have been disconnected. The foul water drainage connects to mains sewerage to the south of the site, but due to the electric disconnection the pumping chamber is now manually emptied by a third-party contractor. A gas intake building is located in the north and a substation with a switchgear room nearby. A large steel water tank is located in woodland to the north of the site, outside of the main site boundary, and all outlet and inlet pipes have been disconnected. Historically the site was used primarily as a transit camp for accommodating military personnel training in the area. This included training on the nearby Penally Range, as well as Manorbier Air Defence Range and Templeton Fieldcraft Training Area. The site was frequently used by cadets and the territorial army (TA) and could accommodate up to 430 troops. In recent history there was no fieldcraft training undertaken on the site, although the parade square and sports field would have been used for drill.

	Buildings were mostly used for accommodation, with additional mess buildings, kitchens, lecture rooms, stores, a laundrette and administrative buildings. The armoury and magazine were in the south of the site, with an indoor range in the centre. A military transport (MT) maintenance section and workshop were located to the west of the parade square, and a POL store to the south. Two underground storage tanks (UST) were present in the POL store, historically used to refuel vehicles. There were several minor workshops on the site which were used mostly for minor repairs and maintenance. Several storage buildings were also located around the camp, used for storing equipment, furniture and general camp items. An NBC chamber in the north of the site was used for gas mask training with CS pellets. The sewage treatment works to the south of the site are no longer present and the area is heavily overgrown. It is not known when this was last used. It was confirmed during the walkover to be a separate parcel of land which is fully accessible to the public, although access to the area is unlikely due to its location. Site staff confirmed during the walkover that there were no tenants present on the site, and no historical third-party use of the site.
Site Walkover	A site walkover was carried out on the 17th October 2023 which provided further information on the site activities. Information gathered from this walkover has been used in conjunction with information from the previous reports at the site, as well as information gathered by WSP for Penally Range as part of the Defence Training Estate Hazard Mapping project. This includes: ▪ SKM Enviros, Phase One Desk Study Penally Camp Pembrokeshire, March 2013 [1] ▪ WSP Environment & Infrastructure Solutions UK Limited, Penally Range Phase 1 Land Quality Assessment, October 2022 [2] ▪ Brimstone Site Investigation, UXO Preliminary Risk Assessment - Penally Range in support of LQA Phase 1 & 2 Works, July 2022 [3] ▪ Cadw and Dyfed Archaeological Trust, FIRST WORLD WAR The Militarised Landscape Interim Report Year 1, March 2015 [4] A Hazard ID has been given to each source of contamination (hazard) which includes both the site's land parcel and the source type (HAZUNIID). Where sources are identified, a source number has been allocated. This comprises the following:  The labelling is consistently applied across the entire site, for instance, all firing ranges with stop butts would be labelled A01 as hazard and sub-hazard. Not all sources will be present on each site, therefore there will be Hazards and Sub-Hazards that are not present on individual sites. For example, for a site with no workshops (given Hazard letter E), there would be no reference within the report or mapping to a Source Hazard E. Further details of the numbering are included in Appendix B. The sources are also shown on Figures 2 and 3 in Appendix A.
Site Constraints	An MoD representative accompanied WSP staff during the site visit. The site has been mostly cleared so evidence of prior use was limited. Several buildings were inaccessible due to damage to the entrance or the presence of asbestos. Documentation and plans were no longer present on site. Site information was requested prior to the site visit to inform the walkover and following the walkover. No information on demolition carried out and tank decommissioning was available.

2.2 RANGES AND DEMOLITION GROUNDS (SOURCE A)

Source Type	Hazard	Description
A14 Shooting in box	A14-1	A shooting in butt located along the southern boundary, in between the armoury and the magazine. During the walkover, the sand bay was covered by a tarpaulin, meaning the condition could not be assessed. Site staff were unsure if the sand had been removed or deleaded prior to this and did not recall the box being used for unloading weapons in recent history.  *Photo 1 Shooting in box*
A15 Indoor range	A15-1	An indoor firing range located to the north of the armoury. This is disused and currently infested by bees. A stage for holding targets was visible to the west, although no targets or firing points were evident. It was labelled on a site map as a store (building 56) indicating the use has changed at some point. It was likely primarily used by cadets visiting the site and may have been converted for this purpose.  *Photo 2 Indoor range*

2.3 FUEL STORAGE (SOURCE B)

Source Type	Hazard	Contents and capacity	Current Status	Description
B01 Underground Storage Tanks	B01-1	DERV (diesel oil for road vehicles) 2000 gallons 9092 litres	Unknown	A POL point was located at the edge of the parade square, installed in 1976 [5] and comprising two USTs. The associated office is now used to store minor quantities of fuel (F01-1). The remains of the kerbside POL point pumps were present in 2013 but were not observed by WSP. Areas of replaced concrete indicate where these features were originally.
	B01-2	Leaded gasoline 5000 gallons 22730 litres	Unknown	A sign on the wall states the tanks contained leaded gasoline, with the wording implying that the tanks are still present but have been emptied; this has not been confirmed and the current condition of the tanks is unknown. Anecdotal evidence collected by SKM Enviros indicates there were no spill prevention systems in place and spillages would have run straight to ground [1]. Drainage grates were observed in the concrete, as well as a linear drain following the kerb. The Landmarc utilities plan [6] describes these drains as 'soak away gullies' indicating drainage flowed straight to ground. The installation plan [5] shows the two drainage grates flowing to a three chambered interceptor to the east of the POL point prior to flowing to a soakaway to the south. The linear drain discharged straight to the soakaway.

Photo 3 Fuel storage tank location

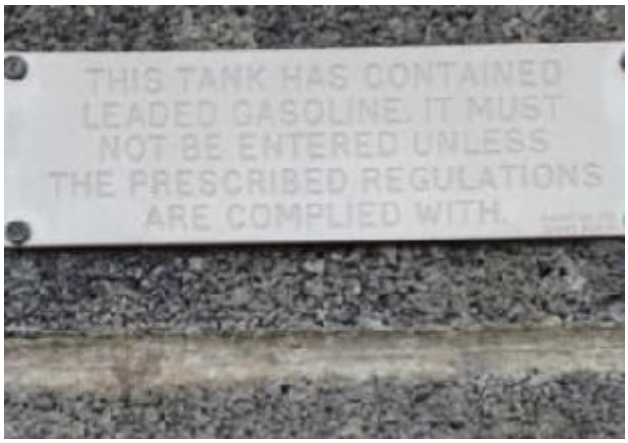


Photo 4 Fuel tank label

Photo 5 Drainage grates

Photo 6 Removed POL point

Source Type	Hazard	Contents and capacity	Current Status	Description
B04 Refuelling Area (no tanks)	B04-1	Troop-provided fuel	Disused	The parade square was historically used for vehicle parking and anecdotally for refuelling vehicles by visiting troops. Bulk POL was located off-site at Castlemartin [1], but troops bringing fuel onto site would store it within the POL store (F01-1). Any modern-day refuelling would have been undertaken subject to spill prevention measures. The parade square is on hardstanding and areas of drainage were observed at the edges, notably in the southern edge by the POL store (F01-1).

2.4 WASTE DISPOSAL (SOURCE C)

Source Type	Hazard	Description
C02 Infilled ground including pits / ponds	C02-1	Former quarry to the west of the sewage treatment works (R02-1) lies 30m off site to the west of the sewage works. The Envirocheck [7] lists this area as a BGS Recorded Mineral Site, described as an opencast limestone quarry which is no longer active. The site name is 'Penally Barracks', indicating it was operated by the site. The area has been infilled, although materials are unknown. Likely historically used for disposal of material from camp and ranges [1]. Currently occupied by a farm and satellite imagery indicates the area is used for waste storage or movement. Unable to access during the walkover, although the area was observed to be raised above ground level and vegetated. Stated to be a landfill quarry in HER record [8].  *Photo 7 Possible infilled quarry. View from sewage works (R02-1) to the east*
	C02-2	An area of grassland in the west of the site which was historically used for training. Features resembling a slit trench network are visible on historical aerial photography [9] from 1946 which has not been reproduced due to copyright permissions. This feature is not visible on current satellite imagery or during the walkover, and part of it is now covered by the parade square.
C03 Infilled ground including pits / ponds	C03-1 C03-2 C03-3	Three grassed banks of soil which are likely to be a result of the earthworks undertaken to create a level platform for the tiered sports field and parade ground are present around the sports field and parade ground. These are described as 'cut and fill' in a previous LQA [1]. Source of soil is unconfirmed but likely to have been site-

Source Type	Hazard	Description
		won. Potential for made ground and building rubble in soil due to multiple on-site demolished buildings.
	C03-4 C03-5	Two areas of 'cut and fill' identified in the previous LQA, likely resulting from clearing ground for building construction. Due to the proximity to historical buildings these likely contain building rubble, although this is not confirmed. The mounds were all observed to be grassed during the walkover, with no evidence of soil composition observed.
C05 Waste Compound / Scrapyard	C05-1 C05-2	Waste compounds used for temporary storage of waste from site are located adjacent to kitchens and previously stored bins. Waste was removed from site under a third-party contract. Areas were underlain by hardstanding.  *Photo 8 Waste storage compound by kitchen*

2.5 BURNING AREAS (SOURCE D)

Source Type	Hazard	Description
D01 Burning Ground	D01-1	The Enviros LQA [1] identifies an historical burning ground in the west of the site, beyond the parade ground and close to the MT workshop (E01-1), although the exact location is uncertain. It is possible that burning occurred on the parade square itself. No information on this burning ground is available and no evidence was observed during the walkover.
D03 Incinerators	D03-1	An incinerator was noted by Enviros [1] to have been present in the west of the site and was marked on a 1943 site plan [10]. It was absent in the site plan from 1978 [11] and the walkover did not identify any evidence of this feature.
D04 Tip and Burning Area	D04-1	The sports field in the west of the site is a flat piece of ground with a steep bank sloping down in the south (C03-1) and another sloping up in the north (C03-2) towards the parade square. The previous LQA [1] states that this area was historically used as

Source Type	Hazard	Description
		both a burning ground and dumping area, indicating that the presence of made ground is highly likely.  *Photo 9 Sports field*

2.6 WORKSHOPS (SOURCE E)

Source Type	Hazard	Description
E01 Vehicle Workshops	E01-1	A former MT garage, Building 48, lies to the west of the parade square. It was not possible to access the building during the walkover, although site staff confirmed in recent history it was used for just storage of vehicles and there were no maintenance bays.
	E01-2	A vehicle repair shop was present in the south of the site, between the magazine (Q01-1) and armoury/guard room (Q02-1), as shown on the 1943 site map [10]. This is no longer present and is in an area of landscaping adjacent to the shooting-in box (A14-1). A hand-annotated map from 1958 [12] shows this building to have been crossed out in pencil, indicating it was demolished around this time.
E02 Range workshops	E02-1	Main camp workshop used for maintenance of equipment and storage. It would have included a COSHH locker and been used for the storage of small quantities of paints and possibly oils. Like the rest of the camp, the building was mostly empty during the walkover. Two barbeques and a metal drum which possibly contained oil were stored in an attached shed, although site staff did not know what the drum contained or where it came from. This was historically the RE (possibly stands for Royal Engineers, although not defined in drawing) workshop (Building 479/80) as shown on the site plan from 1943 [10].

Source Type	Hazard	Description
		 *Photo 10 Courtyard of disused maintenance workshop (E02-1)*
	E02-2	An historical repair shop in the southeast of the site shown on a site plan from 1943 [10] as Building 48. The building numbers on this plan do not align with current-day building numbers. It is assumed this was used for camp repair work. It is now demolished and is covered by hardstanding used for parking.  *Photo 11 Demolished repair shop now a car park (E02-2)*

2.7 HAZARDOUS MATERIAL STORAGE (SOURCE F)

Source Type	Hazard	Description
F01 Hazardous materials including fuel storage	F01-1	A small brick building adjacent to the parade square used for storing small quantities of fuel whilst the camp was active. Jerry cans were used by facilities management for equipment refuelling. The building was self-contained, and no gaps were visible around the floor, with a raised lip at the doorway likely preventing spills from escaping the building. The building was empty during the walkover. No staining was visible although the storage conditions whilst in use are unknown.  *Photo 12 Interior of small scale fuel storage building*
	F01-2	A building in the north of the site, which has been present since the 1890s, was used during WW2 (1943 site plan [10]) as a coal and fuel store used for the nearby NAAFI building (G01-1). This is currently out of bounds due to asbestos, although site staff identified it as a stable. It is not known what fuel (other than coal) was stored there and when this storage ceased.

2.8 DEMOLISHED BUILDINGS (SOURCE G)

Source Type	Hazard	Description
G01 Demolished buildings and structures	G01-1	An area of flat grassland in the north of the site with a brick wall and hardstanding along the northern edge, indicating a historical building now demolished. An aerial photo from 1946 [9] shows a building in this location, and the 1943 plan [10] identifies it as the NAAFI, and states it was constructed of corrugated iron. It is not clear when this was demolished or what happened to the materials.

Source Type	Hazard	Description
		 *Photo 13 Building foundations and flattened grass (G01-1)*
	G01-2	The current accommodation buildings in the east of the site have been built in the same location as several demolished buildings (G01-2) which were mostly constructed of wood and corrugated iron [10]. This occurred in the early 2000s (planning application 00/0266/PA).
	G01-3	Water supply tanks [10] in the north of the site which are no longer present, and appeared to have been removed by 1978 [11].
	G01-4	Five buildings in the south of the site labelled Number 81 to 85 in 1943 [10], used as the Officers' Quarters and ancillary buildings, which had been demolished and replaced by three buildings in the same location by 1978 [11].
	G01-5	A bath house in the centre of the site during WW2, constructed of brick and half-timber [10], which had been demolished by 1978 [11].
	G01-6	Two banks of six rectangular buildings (twelve total) along the southern edge of the site, at what is now the sports field (D04-1). These are shown on a 1946 aerial photo [9] and are shown but faded on the 1943 site plan received from site [10]. It is unclear if they are faded because of the age of the map or because they were deliberately erased. They are not present on the 1958 map [12]. These are likely to be Nissen huts as they resemble the nearby line of Nissen huts (which are still present now), and the site plan lists 26 Nissen huts on site, of which 12 are not shown. It is possible these have been worked into the surrounding soil when demolished.

Source Type	Hazard	Description
	G01-7	During the walkover a concrete platform was observed adjacent to a pedestrian gate in the western fence, behind the MT garage (E01-1). It's not clear what was here, or when it was demolished, but it potentially held a sentry building for the adjacent gate.  *Photo 14 Concrete platform adjacent to pedestrian gate*
	G01-8	Line of buildings visible in 1943 site plan [10] and 1968 map [7], immediately south of the incinerator (D03-1), and now demolished. This included an ablutions block.
	G01-9	Building shown on a map from 1907 [7] which is no longer present.
	G01-10	A 'Gas Plant' shown on the 1943 site map [10] in the north of the site, and now demolished. It was located close to a soil drainage pipe, a water supply pipe, ablutions block and a dining hall. The 1943 plan shows a gas main running close to the gas plant and it is considered likely that the building was associated with this infrastructure rather than being related to CWA. The 2013 LQA [1] notes that this building became an LPG store, which could indicate its continued use as a gas infrastructure facility following demolition. However, it is noted that there is uncertainty regarding the historical use of this building, and SKM Enviros [1] state that it could potentially have been used for CWA storage or training.

2.9 CHEMICAL WARFARE AGENT (SOURCE J)

Source Type	Hazard	Description
J01 Respirator test chambers	J01-1	A brick building in the north of the site historically used for training with respirators, confirmed by site staff to only use CS pellets. Unable to access during the walkover.

Source Type	Hazard	Description
		 *Photo 15 Respirator test chamber (J01-1)*
J01 Chemical warfare agent – other	J01-2	A demolished building adjacent to the MT garage (E01-1) shown on the 1943 map [10] as a 'Gas Hut'. It is unclear what this means but the Enviros LQA [1] states it is potentially related to the storage and use of WW2 gas training kits (small vials of mustard and other agents). The map[10] shows this to be surrounded by a dedicated fence and it is located away from all other buildings. Aerial photography from 1946 [9] shows a network of trenches (C02-2) connected to this building. It is likely that this was the WW2 era respirator test chamber and may have involved training incorporating the trench system.  *Photo 16 Building rubble from historical 'gas hut'*

UXO Estate Intelligence [13] provided by DIO for Penally Ranges as part of the Training Estate Hazard Mapping project states that "*UK Army legacy CW records describe Penally as a former store or training area*

and claim the site was declared cleansed and closed on 05/07/1947". Whilst the estate intelligence was produced for the ranges it also includes information related to the camp and this statement does not clarify which area is referred to. This indicates that CWA training was undertaken on the site during and/or prior to WW2. It is possible that this involved storage of material or related training at the features marked on the 1943 map [10] as a 'gas hut' (J01-2) in the west of the site. This building has been demolished. A network of trenches (C02-2) shown on an aerial photograph from 1946 [9] were connected to the Gas Hut (J01-2) and it is possible that these were used for training with CWA. WW2 gas training kits included small vials of mustard and other agents. Whilst it cannot be ruled out it is most likely that the test kits were used and stored within the test chamber rather than in the trench network itself. Potential CWA training would have used small volumes of agent only and estate intelligence [13] indicates any CWA present on the site was removed by 1947. As such it has not been considered further.

The 2013 Phase One LQA [1] identified the demolished 'Gas Plant' (G01-10) in the centre of the site as potentially being related to training or storage of WW2 gas training kits. WSP consider it more likely that this related to historical gas infrastructure, considering the gas pipe shown to pass nearby on the 1943 site plan [10] and the proximity of the dining hall.

2.10 RADIOACTIVITY (SOURCE K)

The previous LQA [1] included a Dstl radiological records search at the site, and the nearby range, dated 17 August 2012. It states that "*the only records Dstl identified were those relating to routine radon gas surveys carried out on the site; the results showing that levels of radon gas are below regulatory concern. Dstl did not identify any records of radioactive sources being held on the site or any radioactive contamination issues*".

2.11 SUBSTATIONS (SOURCE M)

Source Type	Hazard	Description
M01 Substations	M01-1 M01-2	Two substations are located in the centre of the camp, adjacent to one another. A concrete block building housed an older substation (M01-1) with the newer building (M01-2) adjacent to it. These are both understood to have been disconnected from the mains and no longer active. They are adjacent to a brick switchgear room.

Photo 17 Old substation (M01-1)

Photo 18 Newer substation (M01-2)

2.12 VEHICLE WASHDOWN (SOURCE N)

Source Type	Hazard	Description
N01 Vehicle washdown	N01-1	A vehicle washdown point in the east of the parade square. A tap allows connection to mains water for connecting a hosepipe. A concrete bay is built into the side of the square with a central drainage grate collecting runoff. During the walkover this was

Source Type	Hazard	Description
		observed to be blocked with debris. It is possible that during use, the wider parade square was also used for washing vehicles.  *Photo 19 Vehicle washdown bay (N01-1)*

2.13 ORDNANCE STORAGE (SOURCE Q)

Source Type	Hazard	Description
Q01 Ammunition and explosive storage area	Q01-1	Site magazine located in Building 78, near the unloading box (A14-1). This building was in the same location from site plans dated to 1867 [14], and does not appear to have changed. During recent use it would not have been used as a permanent magazine and instead stored ammunition brought onto site by training units. The building is currently empty.  *Photo 20 Magazine building*

Source Type	Hazard	Description
Q02 Armoury	Q02-1	The camp armoury was located at the site entrance, adjacent to the guardroom.  *Photo 21 Shelving inside armoury building.*

2.14 SEWAGE / WATER TREATMENT (SOURCE R)

Source Type	Hazard	Description
R01 Cess pit / septic tank	R01-1	Foul water drainage at the site was previously connected to the mains sewerage system. It was disconnected recently, along with other utilities, when the camp was cleared. The connection in the south of the site, behind the magazine (Q01-1) required power to pump into the sewers, which is no longer possible. As such, the foul water discharge chamber has become a holding tank and is manually emptied by a third-party contractor.

Source Type	Hazard	Description
		 *Photo 22 Drainage outflow point*
R02 Sewage treatment works	R02-1	Historical sewage treatment works located to the south of the main camp, across the A4139 road. A site plan dated to 1913 [15] shows the layout of the sewage treatment works, featuring two filter beds, a bank of settling tanks and what appears to be a soakaway system. Two foul water drainage routes were shown to connect the camp to the system, one of which was labelled 'stormwater'. The outlet pipe discharged to an off-site drainage channel [16]. It was labelled as a 'sewage farm' in 1978 [11] and was disused by 1991 [17]. The area is now heavily overgrown and there is little evidence of prior use. The current utility plan [6] does not show any historical services connecting to this area.

Source Type	Hazard	Description

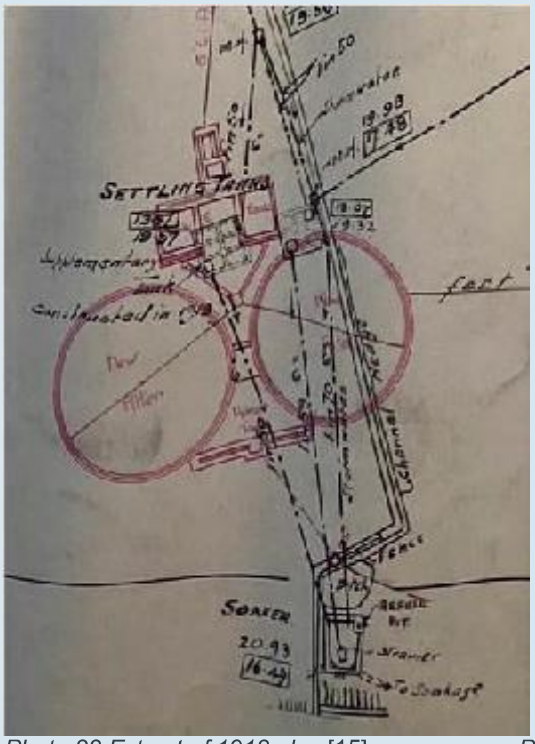


Photo 23 Extract of 1913 plan [15]

Photo 24 Historical sewage treatment works area

2.15 OTHER FEATURES (SOURCE X)

Source Type	Hazard	Description
X06 Helicopter landing sites	X06-1	A helicopter landing area is shown on the site plans produced by Landmarc [6] in the northeast corner of the playing field, which is in the southwest of the site. During the walkover site staff indicated that there was not a formal landing spot, stating that helicopters could use the entire playing field and were likely to have also used the parade ground to the north. There is no evidence that refuelling of helicopters took place at the site.

Source Type	Hazard	Description
		 *Photo 25 Sports field used as a helicopter landing site.*

3 PLANNING AND REGULATORY INFORMATION

3.1 REGULATORY INFORMATION

A review of regulatory information has been undertaken from a review of data source available including an Envirocheck report [7] (attached as Appendix D), the Magic Website [18], Natural Resources Wales Public registers [19], UK Radon information from PHE [20] and the gov.uk database [21].

Activity	Details
Landfill	The Envirocheck report [7] did not identify any current or historical landfills within 1km of the site. One potential infilled pit from 1986 was located 130m to the west of the site in 1986, adjacent to an opencast quarry (usage ceased) at Little Crackwell Cottage. The opencast quarry to the south of the site (C02-1) is not included in the Envirocheck [7] as infilled land, although the site walkover indicates it has been infilled.
Waste exemptions	No waste exemptions on the Natural Resources Wales website [19] have been identified near the site boundary.
Environmental Permits	One historical discharge consent was located 350m to the east of the site, operational from 1976 to 1994, for discharging water to land. No other permits or consents were identified in the Envirocheck [7] or Natural Resources Wales public registers [19] within 500m of the site.
Radon	The site is in an area with elevated radon potential, meaning 10 to 30% of homes are above the Action Level. This is based on 1km grid squares, and this means that some parts of these 1km grid squares are in bands of elevated radon potential. This is a moderate risk where full radon protection measures are likely to be required by building control regulations [20]. It is also noted that a radiological search undertaken in 2012 by Dstl [1] identified "*routine radon gas surveys carried out on the site; the results showing that levels of radon gas are below regulatory concern*". The locations the surveys were undertaken at are not provided, and the report combines Penally Camp with Penally Ranges.

3.2 PLANNING APPLICATIONS

A review of the Pembrokeshire Planning Portal has identified the following planning applications related to the site:

Application Number and Date Registered	Description	Comments
23/0367/PA 20 July 2023	Residential development of 7 houses with associated access road, parking and external works	Located adjacent to northeastern site corner. Contains an ecology report.
22/0335/PA 18 July 2022	Residential development of 8 houses with associated access road, parking and external works	Located adjacent to northeastern site corner. Superseded by 23/0367/PA
19/1350/PA 09 Apr 2020	Internal alterations to existing guardhouse & replacement of existing gable end timber extension including provision of ramped access	On-site. No relevant documents found
18/0232/CL 31 May 2018	Certificate of Lawful Development - Residential development.	Located adjacent to northeastern site corner. Superseded by 23/0367/PA
13/0852/PA 06 Jan 2014	Demolition of military buildings (linked to 13/0752/PN)	On-site. No documents included
13/0880/PN 06 Jan 2014	Demolition of military buildings (linked to 13/0752/PN)	On-site. No documents included

13/0752/PN **02 Dec 2013**	Demolition of old military buildings – Penally Camp	On-site. Application rejected. Buildings proposed for demolition were still present during walkover.
00/0454/PA **04 Sep 2000**	Emergency Water Storage Tank – Penally Camp	On-site. No relevant documents included
00/0266/PA **30 Jun 2000**	Notice under Welsh Office Circular 37/84 - proposed replacement living accommodation	On-site. Plans show replacement accommodation buildings in east of camp (G01-2)
96/0907/PA **11 Nov 1996**	Proposed Demolition And Reconstruction Of Building No 48	On-site. No documents included
D3/0120/95 **05 Jun 1995**	Pitched roof in place of flat roof on building 52.	On-site. No documents included
D3/0371/94 **07 Oct 1994**	Erection of security fencing.	On-site. No documents included

4 SITE HISTORY

An historical review of the development of the site and surrounding area has been undertaken principally using the following sources:

- Historical maps from 1885 to 2022 [22]
- Information from site staff on the site walkover
- Previous Phase One LQA [1]
- Google Earth historical satellite imagery [23]
- Envirocheck report [7]

The information below describes the significant historical activities on the site. It should be noted that sites with a military or defence connection were often not included on OS maps during and between the World Wars and subsequent Cold War for reasons of national security.

1860 – 1913
The site was first acquired in 1860 for use as a musketry camp, associated with the nearby Penally Range, following the Crimean War [24]. Plans from 1867 and 1869 held at the National Archives [14] shows the layout of the initial hutted camp, which was confined to the eastern half of the current site and could support a total of 123 troops. The buildings present included the guard house and surgery, magazine, officer's mess, kitchens, storage building, soldiers' quarters, cookhouse, canteen and hospital. All of these buildings are still present although the uses have changed over time. The plan also details the site layout including ground cover, water tanks and service runs. Drainage flows to settling tanks south of the site; these are not shown on the map but are likely in the location of the sewage works (R02-1). A well was present in the north of the site, in an area that is now heavily vegetated.

OS Mapping from 1889 [7] shows the site to be occupied by '*Penally Barracks (Musket Depot)*', with several buildings within the site boundary (including E02-1, Q01-1 and Q02-1), all of which are still present. Two additional buildings were present on mapping from 1907 which appear to have since been demolished (G01-3 and G01-9), and a tank is shown in the south of the site although this is likely a precursor to the sewage works (R02-1) later built in the same place and may represent the settlement tanks described above.

Property conveyance documents held by DIO [25] for the purchase of the nearby ranges detail that the camp had been used for several users Penally Barracks and was formally acquired in 1909.

Off-site
The site was surrounded by agricultural land with several cottages and farms in the area. OS Mapping from 1889 [7], a quarry (C01-2) was located 30m from the site boundary. A limekiln was located 50m to the south of the site, adjacent to a railway line trending west to east. Penally Ranges were shown 850m to the east of the site, and the village of Penally was 500m east of the site.

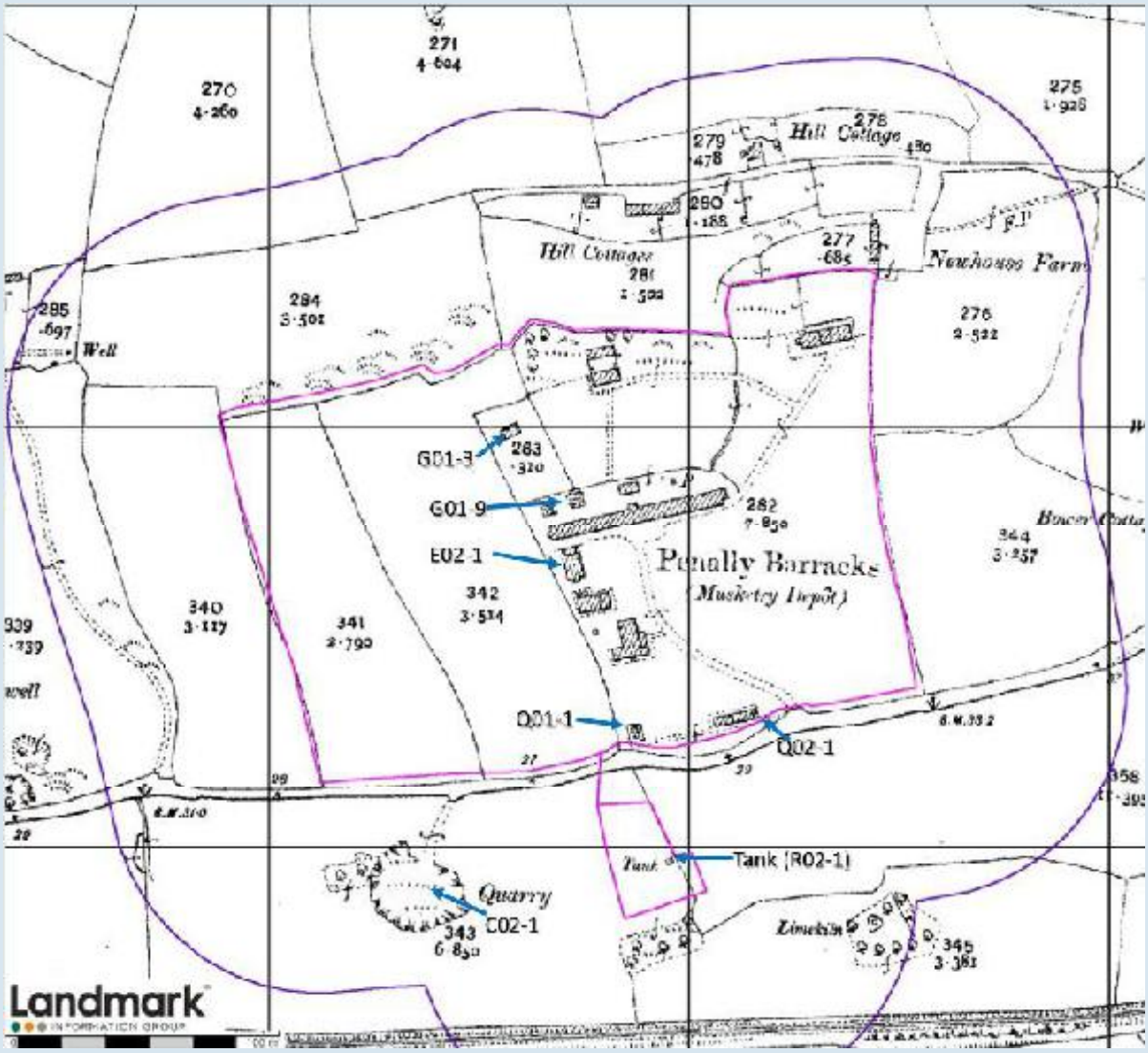


Figure 4-1 - Extract of 1907 OS map (1:2,500 scale)

1913 – 1938
The site was expanded during WW1 with two fields acquired in 1913 and 1914 for use as temporary camps [15]. These fields make up the western half of the current-day site, beyond the main camp area. A newspaper article available online [26] stated that additional accommodation huts were constructed in 1915, typically using timber frames in galvanised steel sheeting. There was also a new hand grenade room, anti-gas room, musketry rooms and a lecture hall, although locations are not provided.

A second conveyance document from 1930 [16] includes a map showing the sewage works (R02-1) and connections, as well as describing the layout of the facility. A 6" drain pipe was shown to connect to the barracks in the north, using drains to the west of the magazine (Q01-1). The 6" outlet pipe flowed towards a surface water ditch to the east of the site, which also collected storm water drainage from the site.

Off-site
There are no major changes observed from previous maps. The limekiln was no longer labelled although the enclosure was still present.

1938 – 1964
During 1942, the site was used for specialised training including Home Guard courses, the Royal Marine Sniper School and Royal Marine Brigade Artillery Group [26]. This prompted an expansion with a total of 31 huts built in 1942, constructed with corrugated asbestos cement sheeting [27] described as 'Turner's Curved Asbestos huts' which resemble Nissen huts [26]. The sewage works (R02-1) was built around 1942, as was the MT section (now the parade square). The land to the north and west of the parade square was used for training trenches (C02-2) [26] visible on

1946 aerial photography. A 1943 site plan [10] shows a site layout similar to the current day, with noted buildings including workshops (E01-2, E02-2), a gas hut (J01-2), gas plant (G01-10) and an incinerator (D03-1). It also provides a list of building uses and construction materials, including a bank of demolished Nissen huts (G01-6) to the west of the current huts.

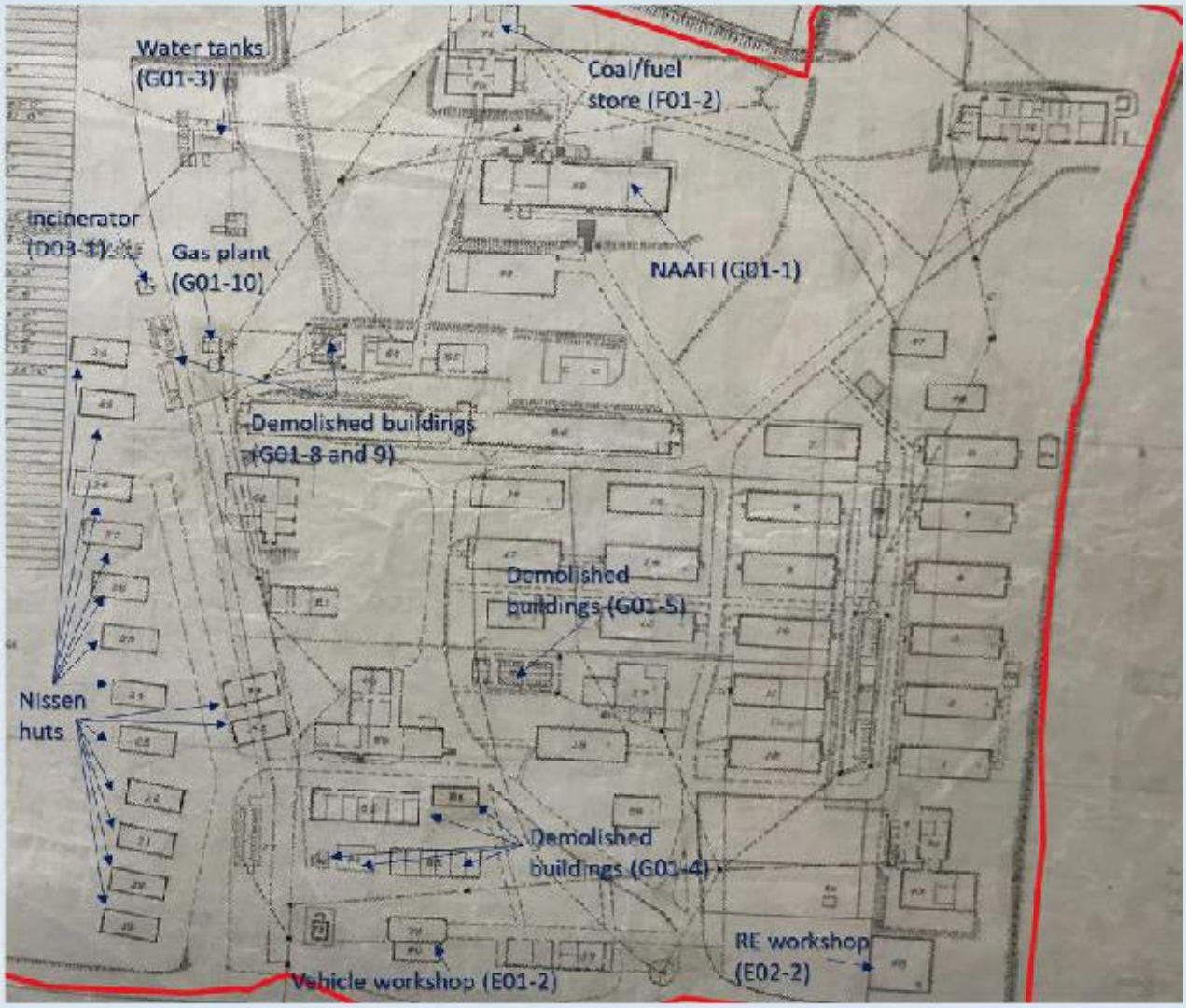


Figure 4-2 - Extract of 1943 site plan [10]

The next available OS mapping is dated to 1953 [7] and shows significant expansion to the camp from the 19th Century maps. Structures, likely resembling temporary camps and huts, were visible in the main camp (G01-2, 4, 8 and 9), as well as one in the north (G01-1). Several other buildings were constructed which appear to still be present. The sewage works (R02-1) is present in this map for the first time. There is little change by 1967/68.

Off-site

There are no major changes observed from previous maps. The quarry off-site is still shown as unfilled (C02-1).

1964 – 1994

The first small-scale OS mapping available since 1907 is dated to 1967/1968 [7] and shows the site to broadly resemble the modern layout. The parade ground (B04-1) was present in the west, as well as the MT garage (E01-1) and nearby building (G01-8). A tank is marked in the northeast corner of the site, although this was confirmed during the walkover to be a water tank. The structures in the northwest of the camp (centre of the site) (G01-3 and 9) are no longer present, although a line of buildings replaced G01-9 – these are likely the current Nissen huts. A plan from 1991 [17] details drainage routes, with a handwritten annotation that "all building gullies and hardstanding to be connected to S/W drainage" and another describing the sewage farm as "old" indicating it was disused at this time.

Off-site

OS mapping up to 1966 shows minimal changes from previous editions. Maps from 1970 show the nearby village of Penally to have expanded towards the camp, following the main road and encompassing several pre-existing cottages, ending 100m east of the site. The limekiln was labelled as 'Kiln (disused)'. Crackwell Farm to the northwest was expanded to include several structures. By 1986 the village of Penally had expanded up to the eastern boundary of the site and by 1994 grew to match the current layout of the village, along the full length of the eastern boundary of the site. The quarry is still present as an open excavation (C02-1).

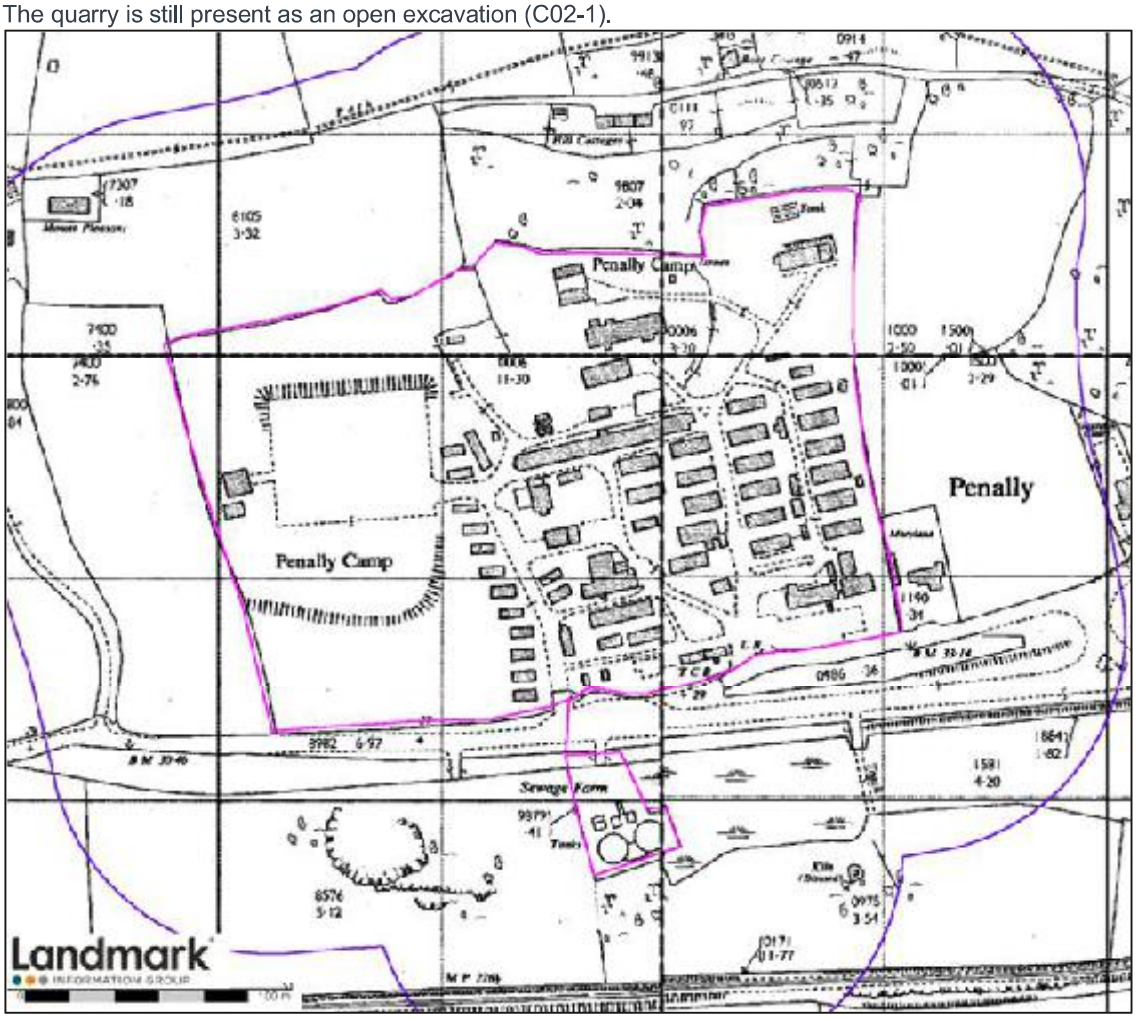


Figure 4-3 - Extract of 1967/68 OS map (1:2,500 scale)

1994 – Present

There is a lack of detailed mapping available until 1994 [7], which shows the site to be unchanged from the 1967 map. The sewage works were still present. The majority of buildings in the east of the camp (G01-2) were replaced in 2000, as described by planning application 00/0266/PA. Aerial photography from 2003 [7] shows the current day site layout, with no evidence of the sewage works (R02-1) visible.

The Home Office utilised the site for housing asylum seekers from September 2020 until March 2022 [24], at which point it was returned to the MOD and has been out of use since, with the MOD announcing site closure in December 2022 [24].

Off-site

Minimal changes are visible on OS mapping to the surrounding land. The off-site quarry (C02-1) is understood to be inactive and infilled, potentially used by the military for waste disposal [1]. Current LIDAR data [28] shows the area to comprise uneven ground, indicating it has not been completely infilled. Current satellite imagery [23] shows the area to be heavily vegetated and potentially in use for waste storage.

5 PREVIOUS WORK AT THE SITE

5.1 REPORTS RELATING TO THE SITE

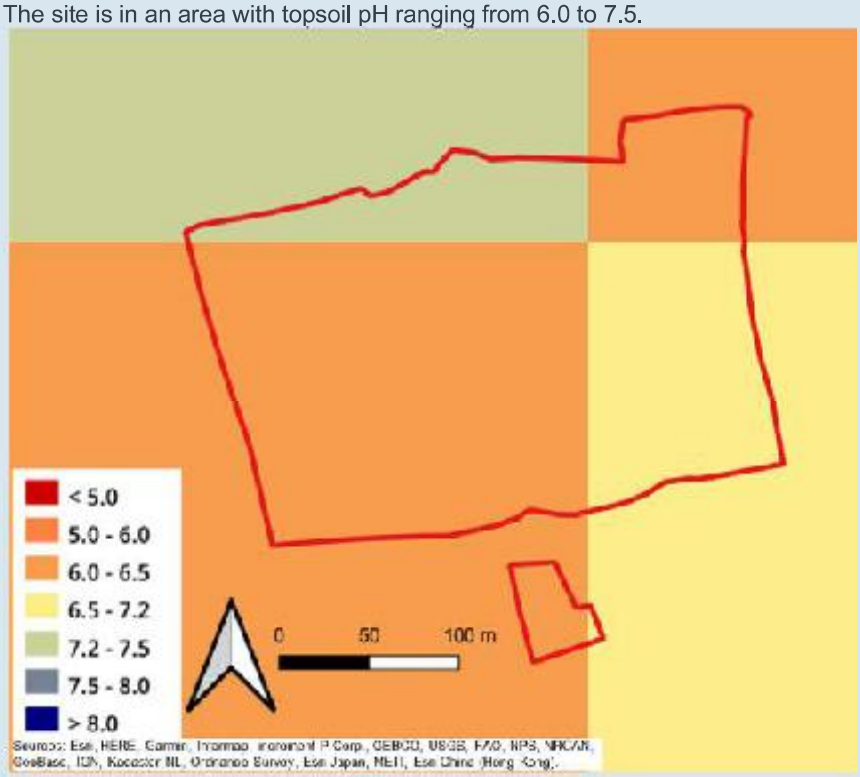
The following land quality assessments have been identified related to the site. The previous hazard mapping for the Defence Training Estate has also been reviewed to provide additional data on the site.

- SKM Enviros, Phase One Desk Study Penally Camp Pembrokeshire, March 2013 [1]
- WSP, Penally Range Phase 1 Land Quality Assessment, October 2022 [29]

The information from the above reports have been used to inform the current LQA. No other land quality assessments have been identified.

6 ENVIRONMENTAL SETTING

Sources of information	Information on the site's environmental setting has been obtained from the following sources: ■ British Geological Survey (BGS) Digital Geological map, 1:50,000 scale, Sheet 244/245 (Pembroke and Linney Head., 1977) [30], BGS GeoIndex [31] and the BGS Lexicon [32] ■ The Natural Resources Wales (NRW) Water Watch Wales Map Gallery [33] ■ The NRW environmental data services [34] ■ DataMapWales [28] ■ The MAGIC website [18] which provides geographic information about the natural environment. ■ Archwilio Historic Environment Record of Wales [35] ■ Previous LQA reports (section 5) ■ Envirocheck [7]. The groundwater and surface water sensitivity has been based on The Guidance for the Safe Development of Housing on Land Affected by Contamination R&D66: 2008 [36].
Topography	Topography at the site slopes upwards from south to north, with a low point of approximately 10m above Ordnance Datum (AOD) in the south and a high of 45mAOD in the northeast. The northern boundary features a steep incline, with the site appearing to be cut into the hill. The sports field in the southwest and parade square in the northwest have both been cut into the slope to make tiered levelled areas, with banks of cut and fill to the north and south of each of these features.
Geology	 **Figure 6.1 Summary of geology**

Strata	Location	Description	Aquifer Type, average thickness (m), and approximate water level
Made Ground	Majority of site likely, specifically in built up areas	Made ground comprising building rubble (including asbestos) is anticipated across much of the site, although has not been proven and is not noted on BGS mapping.	Unknown. No ground investigation data is available for the site.
Alluvium	Southeastern boundary of PTCR02	Intermixed clay, silt, sand and gravel	Secondary A Aquifer. Thickness unknown, although anticipated to be limited.
Bedrock			
Black Rock Subgroup and Gully Oolite Formation (Undifferentiated)	Southern tip of PTRC02 A limestone quarry was located to the south of the main site	Limestone with subsidiary dolomitic limestone and dolostone.	Principal Aquifer, thickness unknown. Groundwater details unknown
Avon Group (Lower Limestone Shale [30]**)**	Across most of the site	Interbedded limestone and dark grey to black shale.	Secondary A Aquifer 30m thick in a borehole located 560m east of the site [37]. Rest water level in 1890 was 11.7mbgl (550m east of site) [37]
Skrinkle Sandstone Formation	Northern edge of site. Anticipated to underlie Avon Group	Interbedded grey quartzitic and red lithic sandstones, conglomerates, red mudstones and siltstones.	Secondary A Aquifer Exceeds 20m thickness in borehole 560m east of the site [37] (underlies Avon Group). Groundwater details unknown.
Geochemistry	The site is in an area with topsoil pH ranging from 6.0 to 7.5.  **Figure 6-2 - Summary of pH data**		

Hydrogeology	There have been no on-site ground investigations, meaning there is no site-specific information available. A possible spring was observed in the north of the site during the walkover, indicating groundwater is relatively shallow at the site. The NRW classify the superficial deposits (alluvium) and most of the bedrock (Avon Group and Skrinkle Sandstone Formation) as Secondary A Aquifers [7], which are described as permeable layers capable of supporting water supplies at a local scale and provide an important source of baseflow to rivers. The Black Rock Subgroup and Gully Oolite Formation at the southern boundary is classified as a Principal Aquifer. It is likely that regional groundwater movement is towards the coast in the south, although this may vary locally. The site is located to the south of the Ridgeway Anticline, which is shown by a BGS cross-section [30] drawn to the west of the site to cause strata to dip near-vertically. This is less extreme around the site, with rocks in the area recorded to dip between 35 and 40° towards the south [30]. The Skrinkle Sandstone Formation is anticipated to underlie the entire site at depth and is overlain by the Avon Group across most of the site. The Black Rock Subgroup is only shown to outcrop along the southern boundary of the site and also dips towards the south. As such the principal aquifer of the Black Rock Subgroup is only present in the very south of the site, at the tip of PTCR02, and the rest of the site is underlain by Secondary A Aquifers. It is therefore unlikely that the Principal Aquifer will be impacted by activity on the main site. Groundwater at the site is considered to be at high vulnerability, reflecting the lack of superficial cover and fracture flow mechanics of the bedrock [7]. Groundwater information is scarce, with the only nearby groundwater level data identified dating to the 19th Century [37]. Considering the lack of superficial cover, precipitation across the site will provide recharge direct to groundwater. The nearest Source Protection Zone (SPZ) is 1,700m to the west of the site. No groundwater abstractions were identified within 1km of the site by the Envirocheck [7]. WSP have been made aware [38] of a possible sinkhole appearing on land at the nearby firing range, within an area leased to a golf club. This is located approximately 930m to the east of the site. This is a geotechnical hazard and lies outside the scope of this report.
Groundwater Sensitivity	Groundwater Sensitivity: Moderate The site is underlain by a Secondary A Aquifer comprising interbedded limestone, mudstone and sandstone horizons. A Principal Aquifer is present in the south of the site only. There is very limited superficial cover in the south of the site. Groundwater depth and quality information is unknown. There are no nearby abstractions although groundwater may provide baseflow to nearby watercourses. SOIL VULNERABILITY There are insufficient superficial deposits to provide protection to the underlying aquifer. The on-site aquifer is anticipated to primarily utilise secondary porosity (fracture flow), allowing vertical and horizontal migration of contamination.
Hydrology	A summary of the hydrology for the area is shown within Figure 6.3. There are no rivers within a 500m radius of the site, and the nearest surface water feature is a ditch 150m to the southeast which was historically used as the discharge point for on-site storm water drainage and the demolished sewage works (R02-1) [16]. During the walkover, site staff described a stream entering the site at the northern boundary which occasionally overflowed and had historically resulted in water covering the north of the site. A marshy slightly highly vegetated area was observed in this location during the walkover but has not been observed in historical or current mapping. Satellite imagery and LIDAR data show a slight depression running from this location to the north, ending in a circular depression in a field 300m to the north. This may be a man-made drainage ditch for the fields and indicates a shallow water table. The site is within the River Ritec (headwaters to tidal limit) catchment [33, 39], within the Cleddau and Pembrokeshire Coastal Rivers Management Catchment. In 2018 it received a moderate ecological quality classification. The chemical quality was assessed as high. No data on individual chemicals or metals have been observed. The River Ritec is 1.5km to the north of the site, and the coast (Carmarthen Bay) is 500m to the south.

	A single surface water abstraction was identified within 1km of the site by the Envirocheck [7], approximately 500m to the west. This was licensed for agricultural spray irrigation – storage, related to a reservoir at Bubbleton Farm. The majority of the site is not located within an area susceptible to fluvial or tidal flooding. Part of the sewage works (R02-1) is within an area allocated a high risk of flooding from rivers [7]. This unoccupied part of the site has a chance of flooding of 3.3% a year. The site is not at risk of flooding from seawater. It has a limited potential for groundwater flooding across the part of the site correlating with the Avon Group, and the south of the site is considered to have 'potential for groundwater flooding of property situated below ground level' [7].  **Figure 6.3 Summary of Hydrology**
Hydrological Sensitivity	Surface Water Sensitivity: Low There are no on-site surface water features, although a spring is possibly present in the north of the site which occasionally causes flooding of the site. The underlying geology has potential to provide baseflow to nearby streams and ditches, the closest being 150m southeast. The coast is 500m to the south. There are no nearby abstractions.
Ecology	The site is approximately 250m to the north of the Lydstep Head To Tenby Burrows SSSI and Lydstep Head To Tenby Burrows SAC, 275m to the west of Penally Marsh SSSI, and 400m north of the Bristol Channel Approaches SAC. There are no other ecologically designated areas within 500m of the site.

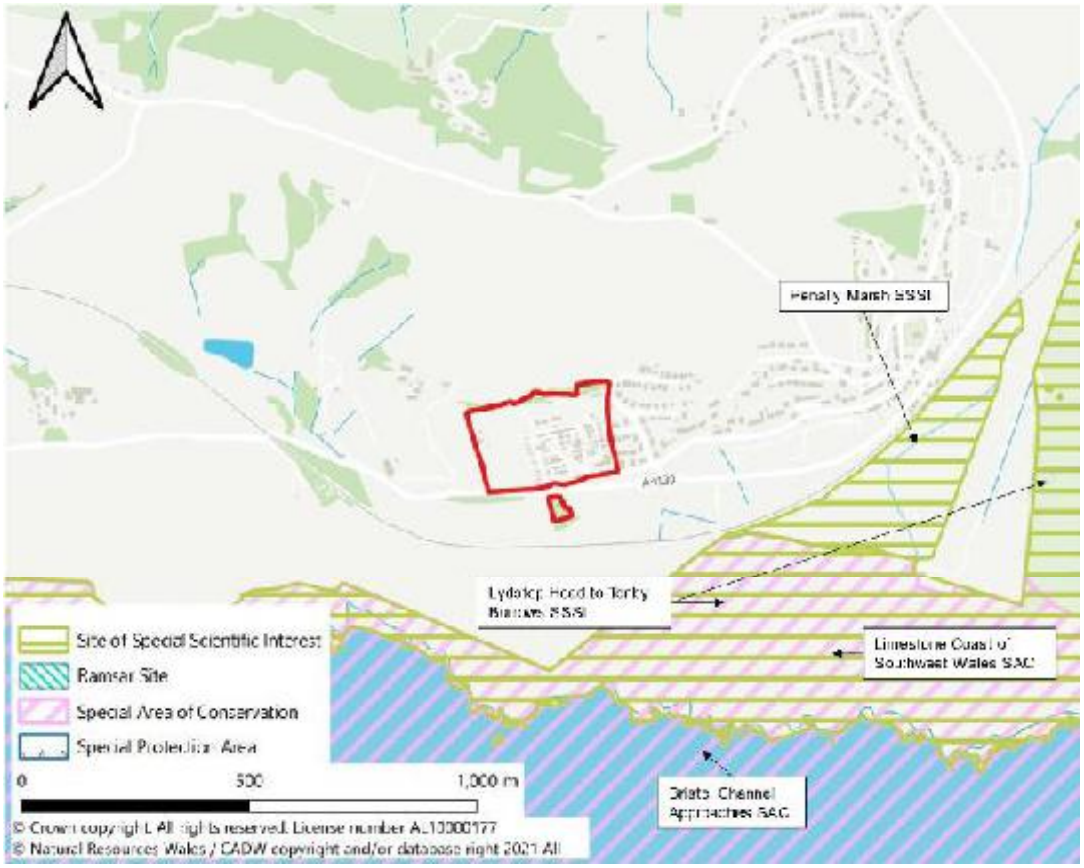


Figure 6-4 - Summary of ecologically designated areas

Ecological Sensitivity	Ecological Sensitivity: Low The site is not within any ecologically designated sites, with the nearest SSSI and SAC both located 250m to the south of the site.
Archaeology and Heritage	No heritage or archaeologically significant features, or listed buildings, have been identified by Cadw within the site boundary. The closest Scheduled Monument is the First World War Practice Trenches [40] 250m to the southeast.

7 PRELIMINARY RISK ASSESSMENT

7.1 CONCEPTUAL MODEL

This chapter presents the preliminary conceptual site model (CSM) developed for the site and identifies the presence of any potentially unacceptable risks. The conceptual model is a representation of the relationship between contaminant sources, pathways and receptors developed on the basis of hazard identification. Unique identification numbers or letters are allocated to each source, pathway and receptor; these are then carried forward to the risk assessment. The CSM provides a graphical representation summarising the key features of the sites, along with the plausible pathways and any sources (as detailed in full in Chapters 2 to 7) of relevance to the risk assessment. This conceptual model is shown schematically in Figure 3 along with the contaminant sources detailed below. The land use for which the assessment has been undertaken is redevelopment of the site for residential and commercial land use.

7.2 POTENTIAL CONTAMINANT SOURCES

A number of potential sources of contamination have been identified at the site. These are shown on Figure 2 in Appendix A.

Table 7.1 Sources of Contamination

Hazard No	Potential Source	Associated Contaminants	Comment
A14	Shooting in box	Heavy metals (lead, antimony, copper, nickel, zinc)	Uncertain if sand is still present, although understood to have had little use in recent memory. Small scale, material is enclosed and covered, and limited contamination potential. *Not considered further.*
A15	Indoor range	Heavy metals (lead, antimony, copper, nickel, zinc)	Indoor range. Limited contamination potential, contained within a building. *Not considered further*
B01	Underground fuel tanks	Hydrocarbons (diesel, gasoline), lead	Petrol and diesel tanks and infrastructure located at former MT area, disused. Uncertain if they have been decommissioned, removed or cleaned. Potential to still be present underground.
B04	Refuelling Area (no tanks)	Hydrocarbons	Historical refuelling of vehicles at the parade square / historical MT area, adjacent to fuel pump area (B01-1 and 2). No fuel kept on site for this purpose, troops would bring in required fuel. Potential for historical spills to flow over hardstanding into drainage or straight to ground. Drainage in local area to a soakaway via an interceptor.
C02	Infilled ground including pits / ponds	Heavy metals, hydrocarbons, asbestos, soil gas (carbon dioxide, methane)	C02-1 is located off-site, 30m from site boundary, infill material is unknown but may contain historical site material. C02-2 is an historical training trench network, potentially infilled with building rubble. *Assessed as part of Source G01*
C03	Bund / stockpiled mounds	Heavy metals, hydrocarbons, asbestos	Several areas of cut and fill used to create level platforms for building construction. Uncertainty regarding fill material, potential to contain building rubble. *Assessed as part of Source G01.*
C05	Waste Compound / Scrapyard	Heavy metals, hydrocarbons, asbestos	Area covered with hardstanding; small scale use only, contained waste material in bins removed from site under contract, and no longer in use. *Not considered further.*

D01	Burning ground	Heavy metals, TPHs PAHs	Historical burning ground possibly present in west of the site. No details available on its use or what was burned. Presence not confirmed.
D03	Incinerators	Heavy metals, TPHs PAHs, cyanide	Former incinerator, no longer present but used during WW2. Uncertain what was burned here, or when it was removed, but considered unlikely to contain radioactive material. Dstl report did not identify radiation on site. *Assessed as part of Source G01*
D04	Tip and burning area	Heavy metals, TPHs PAHs, cyanide, asbestos	Sports field possibly used as a burning and dumping area. Made ground possible beneath grass.
E01	Vehicle Maintenance	Heavy metals, hydrocarbons, PAHs	Vehicle maintenance historically undertaken at the MT site (E01-1). Uncertainty regarding exact historical use, more recently used for vehicle storage. No maintenance bays present. Historical workshop is demolished. *E01-2 assessed as part of Source G01*
E02	Range workshops	Heavy metals, hydrocarbons, PAHs, asbestos	Workshops used for general site maintenance. Enclosed within buildings, with potential contaminants restricted to small quantities of glues and similar. Limited contamination potential and so *E02-1 – not considered further.* *E02-2 which is demolished – assessed as part of Source G01.*
F01	Hazardous Material Storage including minor fuel storage	Fuels and oils	F01-1 - Small scale POL storage area within a brick building, no longer in use. Jerry cans of fuel stored for use by maintenance facilities only. Contains small quantities of fuel, was well managed and within a locked building with no drainage. *Not considered further*. F01-2 – historical coal store, located on hardstanding and enclosed, not recently used for this purpose. Liquid fuels are unlikely. *Not considered further.*
G01	Demolished Buildings and Structures	Heavy metals, hydrocarbons, PAHs, asbestos	Well documented history of demolition and rebuilding of structures, with several known to have been constructed of asbestos. Likely for building rubble to be in made ground across the site.
J01	Respirator Test Chambers	CS Gas	CS chamber is disused but historically used for training purposes only- Limited contamination potential. 1943 Gas Hut potentially stored and used WW2 gas training kits which may have contained small vials of mustard agent. This is now demolished and "*UK Army legacy CW records describe Penally as a former store or training area and claim the site was declared cleansed and closed on 05/07/1947*" [13]. *J01-1 not considered further.* *J01-2 assessed as part of Source G01.*
M01	Substations	Transformer oils, polychlorinated biphenyls (PCBs)	Two adjacent substations now disconnected and disused. Uncertain if PCBs are present in older building.
N01	Vehicle Washdown	Detergents hydrocarbons	Concrete and brick lined washdown area adjacent to parade square. Blocked drainage grate visible, uncertain where this drained to.
Q01	Ammunition and Explosive Storage Area	Explosive residues	Magazine building constructed in 19th Century. No longer in use and would have been well regulated. In recent memory only used for storage of munitions brought onto site by troops. *Not considered further.*
Q02	Armoury	Explosive residues	Small arms armoury attached to the guardhouse. Present since site inception. Currently empty and only used for storage of weapons. *Not considered further.*

R01	Disconnected foul water discharge pumping chamber	BOD, COD, chloride	Foul water drainage discharge chamber, historically connected to the mains. Now disconnected with no power supply and used as the end-point for on-site foul drainage. Emptied regularly by a third party. Limited contamination potential. *Not considered further*
R02	Sewage Treatment Works	Heavy metals, asbestos, cyanides hydrocarbons; soil gases (carbon dioxide, methane, hydrogen sulphide).	Demolished sewage treatment works. Active during 20th Century, contained two filter beds and settling tanks, discharging to an off-site ditch. Potential for structures to be demolished in-situ and worked into ground.
X06	Helicopter landing site	Hydrocarbons	Dedicated landing site marked on site plans in the sports field, although site staff noted it was not restricted to this small area. Refuelling understood to not take place. *Not considered further.*

7.3 IDENTIFIED RECEPTORS

Potential receptors specific to the site are given below (note: only the receptors considered to be at risk from a source have been included):

Table 7.2 Summary of receptors

Receptor Type	Description
Future residents	Future residents in flats and houses with gardens (R1)
Future commercial users	Future commercial site users (R2)
Groundwater	Principal aquifer in the bedrock and Secondary A in the bedrock and superficial deposits (R3)
Surface waters	Surface water – drains and ditches (R4)
Future infrastructure	Buildings (R5), Water pipes (R6)

7.4 IDENTIFIED PATHWAYS

Potential environmental fate and exposure pathways specific to the site are:

- Direct contact, ingestion or inhalation of contaminated soils and soil dust and vapours (pathway P1);
- Track back of soil into building and direct contact, ingestion or inhalation inside building (pathway P2);
- Leaching of contamination from soils via rainwater infiltration (pathway P3);
- Vertical and lateral migration in groundwater (pathway P4);
- Migration through water pipes (pathway P5);
- Migration of gas and vapours and accumulation in buildings and structures (pathway P6)
- Uptake by and consumption of homegrown vegetables (pathway P7)

7.5 EXCLUSIONS FROM RISK ASSESSMENT

7.5.1. MAINTENANCE AND REDEVELOPMENT WORKERS

The risk assessment does not consider risks to construction or site maintenance workers on the basis that risks to workers will be dealt with under the Health and Safety at Work Act (1974) and regulations made under the act. Site-specific contamination data obtained from all site investigations should be included in the pre-construction information (a requirement of Construction Design and Management Regulations 2015) for any proposed below ground works, to enable any contractors to address potential risk from contamination as necessary in their risk assessments and method statements. Moreover, as the exact details of the method adopted are not currently known, it is not considered appropriate to provide a wide ranging and speculative risk assessment for construction or maintenance workers.

7.5.2. RADON

The Envirocheck report states that the site is in a higher probability radon area (10 to 30% of homes are estimated to be at or above the Action Level). Therefore it is likely that full radon protection measures would be required as part of the development design. This should be confirmed with the Local Authority.

7.5.3. INVASIVE SPECIES

Identification and assessment of invasive species (such as Japanese knotweed and giant hogweed) is outside of this scope of works and so they are not considered within the risk assessment.

7.5.4. UNEXPLODED ORDNANCE (UXO)

Assessment of unexploded ordnance is assessed separately and is not part of the current report.

7.6 PRELIMINARY RISK ASSESSMENT

A preliminary risk assessment has been undertaken for these potential source-pathway-receptor linkages to identify potentially unacceptable risks on a qualitative basis. This approach is based on Department for the Environment Food and Rural Affairs (DEFRA) Statutory Guidance on Contaminated Land [41], Construction Industry Research and Information Association (CIRIA) guidance on risk assessment [42], and the Environment Agency Guidance on Land contamination risk management [43] whilst reference has also been given to the DIO LQA Management Guide Risk [44]. The risk is therefore based on a consideration of both:

- the likelihood of an event (probability – takes into account both the presence of the hazard and receptor and the integrity of the pathway); and
- the severity of the potential consequence (takes into account both the potential severity of the hazard and the sensitivity of the receptor).

Further information on the risk assessment methodology used is given in Appendix C. The method of dealing with identified risks and the level of significance of those risks will be a function of site use. Potentially unacceptable risks identified for future residential and commercial use are considered in Table 7.3.

Table 7.3 Potential environmental risks for redevelopment as residential and commercial land use

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
B01 Underground fuel storage	Hydrocarbons (diesel, gasoline), lead	Two historical underground storage tanks which may still be present and associated infrastructure for a refuelling point. One tank for diesel (9092 litres) and one for leaded gasoline (22730 litres). Potential for historical spills or leaking infrastructure. This activity is no longer undertaken and it is not known when it last occurred.				
		Future Residents in flats and houses with gardens (R1)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P6 Migration of gas and vapours and accumulation in buildings and structures P7 Uptake by and consumption of homegrown vegetables	Health Hazard [Medium]	Likely Unknown whether tanks remain in situ and no information regarding historical leaks. Uncertainty regarding residual infrastructure and its condition. Potential for exposure in areas of soft landscaping if leaks occurred near surface. Potential for vapours to be present and ingress to buildings if hydrocarbons on groundwater and groundwater is relatively shallow. Facility not used for a number of years and so hydrocarbons likely to degrade.	Moderate
		Future Commercial users (R2)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P6 Migration of gas and vapours and accumulation in buildings and structures	Health Hazard [Medium]	Low likelihood Unknown whether tanks remain in situ and no information regarding historical leaks. Uncertainty regarding residual infrastructure and its condition. Potential for vapours to be present and ingress to buildings if hydrocarbons on groundwater and groundwater is relatively shallow. Facility not used for a number of years and so hydrocarbons likely to degrade. Potential for direct contact and ingestion of contaminants would be limited by hardstanding in commercial use scenario.	Moderate/ Low
		Principal aquifer in the bedrock and Secondary A in the bedrock and superficial deposits (R3)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Low likelihood Unknown whether tanks remain in situ and no information regarding historical leaks. Uncertainty regarding residual infrastructure and its condition. Potential for historical leaks to soil, and precipitation could mobilise contamination in soil, particularly after removal of the slab. Potential for contamination in proximity of tanks. Groundwater quality uncertain. Dilution and degradation likely due to potential age of spills. Location is underlain by Secondary A aquifer but no known local abstraction.	Moderate/ low
		Surface water – drains and ditches (R4)	P3 Leaching of contamination from soils via rainwater infiltration	Pollution of Controlled waters	Unlikely Unknown whether tanks remain in situ and no information regarding historical leaks. Uncertainty regarding residual infrastructure and its	Low

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
			P4 Vertical and lateral migration in groundwater	[Medium]	condition. Potential for historical leaks to soil, and precipitation could mobilise contamination in soil, particularly after removal of the slab. Nearest surface water from this area is a ditch located approximately 350m to the southeast, separated by a road. Potential for groundwater migration, although likely for historical spills to have already migrated if present.	
		Future infrastructure (R6)	P5 Permeation of contaminant through water pipes	Tainting of water supply [Medium]	Low likelihood Contamination has not been confirmed. Potential for contamination if present in shallow ground to migrate into buried water pipes.	Moderate/ Low
B04 Refuelling area (no tanks)	Hydrocarbons	Historical use of the parade square for refuelling vehicles, associated with the MT area and refuelling point. No fuel kept on site for this purpose, troops would bring in required fuel. Potential for historical spills to flow over hardstanding into drainage or straight to ground. Hardstanding in refuelling area has drainage to a soakaway via an interceptor.				
		Future Residents in flats and houses with gardens (R1)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P6 Migration of gas and vapours and accumulation in buildings and structures P7 Uptake by and consumption of homegrown vegetables	Health Hazard [Medium]	Low likelihood No evidence of historical spills. Presence of hardstanding and drainage would have limited loss to ground. Potential for exposure in areas of soft landscaping. Potential for vapours to be present and ingress to buildings if hydrocarbons on groundwater and groundwater is relatively shallow. Facility not used for a number of years and so hydrocarbons likely to degrade.	Moderate/ low
		Future Commercial users (R2)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P6 Migration of gas and vapours and accumulation in buildings and structures	Health Hazard [Medium]	Unlikely No evidence of historical spills. Presence of hardstanding and drainage would have limited loss to ground. Potential for exposure in areas of soft landscaping. Potential for direct contact and ingestion of contaminants limited under commercial scenario due to hardstanding. Potential for vapours to be present and ingress to buildings if hydrocarbons on groundwater and groundwater is relatively shallow. Facility not used for a number of years and so hydrocarbons likely to degrade.	Low
		Principal aquifer in the bedrock and Secondary A	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Low likelihood No evidence of historical spills. Presence of hardstanding and drainage would have limited loss to ground. Dilution and	Moderate/ low

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
		in the bedrock and superficial deposits (R3)			degradation likely due to potential age of spills. Location is underlain by Secondary A aquifer but no known local abstraction.	
		Surface water – drains and ditches (R4)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely No evidence of historical spills. Presence of hardstanding and drainage would have limited loss to ground. Dilution and degradation likely due to potential age of spills. Nearest surface water from this area is a ditch located approximately 350m to the southeast. Potential for groundwater migration, although likely for historical spills to have already migrated if present.	Low
		Future infrastructure (R6)	P5 Permeation of contaminant through water pipes	Tainting of water supply [Medium]	Low likelihood No evidence of historical spills. Presence of hardstanding and drainage would have limited loss to ground. Potential for contamination if present in shallow ground to migrate into buried water pipes.	Moderate/ Low
C02-1 Infilled pit – off-site	Soil gas (carbon dioxide, methane)	Off-site quarry which appears to have been infilled. Uncertain what was buried here, but potential for historical dumping of waste from the camp. Approximately 30m from site boundary, so potential for soil gas to migrate towards site.				
		Future Residents in flats and houses with gardens (R1) Future Commercial users (R2)	P6 Migration of gas and vapours and accumulation in buildings and structures	Health Hazard [Severe]	Low likelihood Potential for soil gas generation from waste is unknown. Waste is expected to be over 20 years old, although not confirmed. Potential for exposure if buildings allow gas ingress. Landfill area is at a lower elevation than the site. Open land between which would allow venting. Local geology may inhibit migration dependent on dominance of limestone or mudstone strata.	Moderate
		Future Buildings (R5)	P6 Migration of gas and vapours and accumulation in buildings and structures	Damage to buildings [Severe]	Low Likelihood Potential for soil gas generation from waste is unknown. Waste is expected to be over 20 years old, although not confirmed. Potential for exposure if buildings allow gas ingress. Landfill area is at a lower elevation than the site. Local geology may inhibit migration dependent on dominance of limestone or mudstone strata.	Moderate
D01 Burning ground	Heavy metals, TPHs PAHs,	Historical burning and dumping areas at the sports field and a potential burning ground in the west of the site. Exact locations of these features are not confirmed. There is no current burning at the site, and no evidence of historical burning has been found. Potential for material to be buried in soil in these locations, particularly at the sports field. No evidence of explosives burned at these locations.				

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
D04 Tip and burning area	asbestos, cyanide	Future Residents in flats and houses with gardens (R1)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P7 Uptake by and consumption of homegrown vegetables (not relevant for asbestos)	Health Hazard [Medium]	Likely Presence of contamination has not been confirmed however there is the potential for contaminants to be present. Potential for direct contact and ingestion of contaminants if future development comprises private gardens within these areas.	Moderate
		Future Commercial users (R2)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building	Health Hazard [Medium]	Low Likelihood Presence of contamination has not been confirmed however there is the potential for contaminants to be present. Potential for direct contact and ingestion of contaminants in areas of soft landscaping however this is likely to be limited and infrequent.	Moderate/ Low
		Principal aquifer in the bedrock and Secondary A in the bedrock and superficial deposits (R3)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Presence of contamination has not been confirmed. Potential for leaching of contaminants into groundwater. Area is underlain by a Secondary A aquifer but with no known local abstraction.	Low
		Surface water – drains and ditches (R4)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Presence of contamination has not been confirmed however there is the potential for contaminants to be present. Potential for leaching of contaminants and lateral migration within the groundwater. No nearby formally identified surface water features.	Low
		Future infrastructure (R6)	P5 Permeation of contaminant through water pipes	Tainting of water supply [Medium]	Low likelihood Contamination has not been confirmed. Potential for contamination if present in shallow ground to migrate into buried water pipes.	Moderate/ Low
E01-1 Vehicle maintenance	Heavy metals, hydrocarbons, PAHs	Vehicle maintenance historically undertaken at the MT site (E01-1). Uncertainty regarding exact historical use though likely to have included repair and maintenance. More recently used for vehicle storage and minor maintenance. No maintenance bays present. Attached to the adjacent parade square which was also used for storage and work on vehicles.				
		Future Residents in flats and	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust	Health Hazard [Medium]	Unlikely Presence of contamination has not been confirmed however there is the potential for contaminants to be present but limited by	Low

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
		houses with gardens (R1)	P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P7 Uptake by and consumption of homegrown vegetables		activities having been within a building. Potential for direct contact and ingestion of contaminants if future development comprises private gardens within these areas.	
		Future Commercial users (R2)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building	Health Hazard [Medium]	Unlikely Presence of contamination has not been confirmed however there is the potential for contaminants to be present but limited by activities having been within a building. Potential for direct contact and ingestion of contaminants in areas of soft landscaping however this is likely to be limited and infrequent.	Low
		Principal aquifer in the bedrock and Secondary A in the bedrock and superficial deposits (R3)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Presence of contamination has not been confirmed however there is the potential for contaminants to be present but limited by activities having been within a building. Existing hardstanding will limit migration of contaminants, although infiltration would increase if this was removed during development. Area is underlain by a Secondary A aquifer but with no known local abstraction	Low
		Surface water – drains and ditches (R4)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Presence of contamination has not been confirmed however there is the potential for contaminants to be present but limited by activities having been within a building. Existing hardstanding will limit migration of contaminants, although infiltration would increase if this was removed during development. No nearby formally identified surface water features.	Low
		Future infrastructure (R6)	P5 Permeation of contaminant through water pipes	Tainting of water supply [Mild]	Unlikely Contamination has not been confirmed. Potential for contamination if present in shallow ground to migrate into buried water pipes.	Negligible
G01 Demolished buildings and structures C02-2 Infilled ground	Heavy metals, hydrocarbons, PAHs, asbestos, cyanide	Multiple demolished structures throughout the site, many of which have been rebuilt in the same location. Building rubble may have been included within made ground or used as fill material for infilled pits and bunds. Asbestos is known to be present in many current and demolished buildings. There is potential for made ground comprising building rubble to be present throughout the site.				
		Future Residents in flats and	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust	Health Hazard [Medium]	Likely Presence of contamination has not been however there is the potential for contaminants to be present. Building rubble containing	Moderate

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
C03 Bund / stockpiled material D03 Incinerator E01-2 Vehicle repair shop E02-2 range workshop J01-2 Gas hut		houses with gardens (R1)	P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P7 Uptake by and consumption of homegrown vegetables (not relevant for asbestos)		asbestos may be present. Potential for direct contact and ingestion of contaminants if future development comprises private gardens within these areas.	
		Future Commercial users (R2)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building	Health Hazard [Medium]	Low Likelihood Presence of contamination has not been confirmed however there is the potential for contaminants to be present. Building rubble containing asbestos may be present. Potential for direct contact and ingestion of contaminants in areas of soft landscaping however this is likely to be limited and infrequent.	Moderate/ low
		Principal aquifer in the bedrock and Secondary A in the bedrock and superficial deposits (R3)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Presence of contamination has not been confirmed. Potential for made ground to contain leachable contaminants, although based on age of buildings many of these would have migrated already and would be subject to dilution and degradation. Location is underlain by Secondary A aquifer but no known local abstraction..	Low
		Surface water – drains and ditches (R4)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Presence of contamination has not been confirmed. Potential for made ground to contain leachable contaminants, although based on age of buildings many of these would have migrated already and would be subject to dilution and degradation. Lateral migration within groundwater is possible, which may provide baseflow to rivers. No nearby formally identified surface water features.	Low
C02-2 Infilled ground	Soil gas (carbon dioxide, methane)	Future Residents in flats and houses with gardens (R1) Future Commercial users (R2)	P6 Migration of gas and vapours and accumulation in buildings and structures	Health Hazard (asphyxiation, explosion) [Severe]	Low likelihood Potential for soil gas generation from infilling of trenches which were present in 1946. Nature of infilling is unknown but may contain waste. Potential for exposure if building located on / near to waste allowing gas ingress.	Moderate

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
		Future Buildings (R5)	P6 Migration of gas and vapours and accumulation in buildings and structures	Damage to buildings [Severe]	Low Likelihood Potential for soil gas generation from infilling of trenches which were present in 1946. Nature of infilling is unknown but may contain waste. Potential for exposure if building located on / near to waste allowing gas ingress.	Moderate
M01 Substations	Transformer oils, polychlorinated biphenyls (PCBs)	Two adjacent substations now disconnected and disused. Uncertain if PCBs are present in older building, but potential for leaks and spills if so.				
		Future Residents in flats and houses with gardens (R1)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P7 Uptake by and consumption of homegrown vegetables	Health Hazard [Medium]	Low Likelihood PCBs of low mobility so any potential contamination would be localised. Potential for exposure to contaminants if future development comprises private gardens in these areas.	Low
		Future Commercial users (R2)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building	Health Hazard [Medium]	Unlikely PCBs of low mobility so any potential contamination would be localised. Potential for exposure to contaminants if future development comprises landscaping areas however this is likely to be infrequent.	Low
		Principal aquifer in the bedrock and Secondary A in the bedrock and superficial deposits (R3)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely PCBs of low mobility so any potential contamination would be localised. Location is underlain by Secondary A aquifer but no known local abstraction.	Low
		Surface water – drains and ditches (R4)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely PCBs of low mobility so any contamination will be localised. Groundwater may provide base flow. No nearby formally identified surface water features.	Low
		Future infrastructure (R6)	P5 Permeation of contaminant through water pipes	Tainting of water supply [Medium]	Unlikely PCBs of low mobility so any contamination will be localised. Contamination has not been confirmed. Potential for contamination if present in shallow ground to migrate into buried water pipes.	Low

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
N01 Vehicle washdown	Detergents, hydrocarbons	Concrete and brick lined washdown area adjacent to parade square. Blocked drainage grate visible, uncertain where this drained to. Cut into landscaped area but lined with a brick wall. Overflow water likely to have flown onto parade square, where it would have joined any drainage in this area.				
		Future Residents in flats and houses with gardens (R1)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P7 Uptake by and consumption of homegrown vegetables	Health Hazard [Medium]	Unlikely Localised area on hardstanding, with drainage routes. Potential for runoff to flow into subsurface. Washdown may have mobilised hydrocarbon contamination / leaks from vehicles, but likely to have been limited scale. Detergents, if used, would have degraded over time. Potential for direct contact and ingestion of contaminants if future development comprises private gardens in these areas.	Low
		Future Commercial users (R2)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building	Health Hazard [Medium]	Unlikely Localised area on hardstanding, with drainage routes. Potential for runoff to flow into subsurface. Washdown may have mobilised hydrocarbon contamination / leaks from vehicles, but likely to have been limited scale Detergents, if used, would have degraded over time. Potential for direct contact and ingestion of contaminants if future development comprises landscaping areas however this is likely to be infrequent.	Low
		Principal aquifer in the bedrock and Secondary (A and undifferentiated) in the bedrock and superficial deposits (R3)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Localised area on hardstanding, with drainage routes. Potential for runoff to flow into subsurface. Washdown may have mobilised hydrocarbon contamination / leaks from vehicles, but likely to have been limited scale Detergents, if used, would have degraded over time. Area is underlain by secondary A aquifer but with no known local use.	Low
		Surface water – drains and ditches (R4)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Localised area on hardstanding, with drainage routes. Potential for runoff to flow into subsurface. Washdown may have mobilised hydrocarbon contamination / leaks from vehicles, but likely to have been limited scale Detergents, if used, would have degraded over time. Groundwater may provide base flow but no nearby formally identified surface water features.	Low

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
R02 Sewage treatment works	Heavy metals, asbestos, cyanides, hydrocarbons.	Demolished sewage treatment works. Active during 20th Century, contained two filter beds and settling tanks, discharging to an off-site ditch. Potential for structures to be demolished in-situ and worked into ground. Anecdotally historically used for disposal of waste, though this may be conflated with off-site quarry to the west. Potential for buried sludge in area which may lead to hazardous gas generation [45].				
		Future Residents in flats and houses with gardens (R1)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building P7 Uptake by and consumption of homegrown vegetables (not relevant for asbestos)	Health Hazard [Medium]	Likely Presence of contamination has not been confirmed however there is the potential for contaminants to be present. Building rubble containing asbestos may be present. Potential for direct contact and ingestion of contaminants if future development comprises private gardens within this area.	Moderate
		Future Commercial users (R2)	P1 Direct contact, ingestion or inhalation of contaminated soils and soil dust P2 Track back of soil into building and direct contact, ingestion or inhalation inside building	Health Hazard [Medium]	Low Likelihood Presence of contamination has not been confirmed however there is the potential for contaminants to be present. Building rubble containing asbestos is likely. Potential for direct contact and ingestion of contaminants in areas of soft landscaping however this is likely to be limited and infrequent.	Moderate/ low
		Principal aquifer in the bedrock and Secondary A in the bedrock and superficial deposits (R3)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Presence of contamination has not been confirmed. Potential for made ground to contain leachable contaminants, although based on age of building many of these would have migrated already and would be subject to dilution and degradation. Site lies on a Secondary A aquifer and Principal Aquifer but with no known local use.	Low
		Surface water – drains and ditches (R4)	P3 Leaching of contamination from soils via rainwater infiltration P4 Vertical and lateral migration in groundwater	Pollution of Controlled waters [Medium]	Unlikely Presence of contamination has not been confirmed. Potential for made ground to contain leachable contaminants, although based on age of buildings many of these would have migrated already and would be subject to dilution and degradation. Lateral migration within groundwater is possible. No nearby formally identified surface water features, although possible drain/spring in the north	Low
		Future infrastructure (R6)	P5 Permeation of contaminant through water pipes	Tainting of water supply [Medium]	Unlikely Presence of contamination has not been confirmed. Potential for contamination if present in shallow ground to migrate into buried water pipes.	Low

Potential Source	Potential Pollutant	Potential Receptors	Potential Pathways to Receptors	Associated Hazard [severity]	Likelihood of Occurrence	Risk
	Soil gas (methane, CO_2, H_2S)	Future Residents in flats and houses with gardens (R1) Future Commercial users (R2)	P7 Migration of gas and vapours and accumulation in buildings and structures	Health Hazard (asphyxiation, explosion) [Severe]	Low likelihood Potential for soil gas generation from former sewage works is unknown. Potential for exposure if building located on / near to waste allowing gas ingress.	Moderate
		Future Buildings (R5)	P6 Migration of gas and vapours and accumulation in buildings and structures	Damage to buildings [Severe]	Low Likelihood Potential for soil gas generation from former sewage works is unknown. Potential for exposure if building located on / near to waste allowing gas ingress.	Moderate

The risks from the identified potential sources are summarised below:

Table 7.4 Summary of environmental risks from potential sources associated with redevelopment as residential and commercial land use

Potential Source	Potential Pollutant	Future Residents (R1)	Future Commercial users (R2)	Groundwater (R3)	Surface Water (R4)	Future site buildings (R5)	Future site infrastructure (R6)
B01 Underground fuel storage	Hydrocarbons (diesel, gasoline), lead	M	M/L	M/L	L		M/L
B04 Refuelling area (no tanks)	Hydrocarbons	M/L	L	M/L	L		M/L
C02-1 Infilled pit – off-site	Soil gas (carbon dioxide, methane)	M	M			M	
D01 Burning ground **D04 Tip and burning area**	Heavy metals, TPHs PAHs, asbestos, cyanide	M	M/L	L	L		M/L
E01-1 Vehicle maintenance	Heavy metals, hydrocarbons, PAHs	L	L	L	L		N
G01 Demolished buildings and structures **C02-2 Infilled ground** **C03 Bund / stockpiled material** **D03 Incinerators** **E01-2 Vehicle repair shop** **E02-2 range workshops** **J01-2 Gas hut**	Heavy metals, hydrocarbons, PAHs, asbestos	M	M/L	L	L		
C02-2 Infilled ground	Soil gas (carbon dioxide, methane)	M	M			M	
M01 Substations	Transformer oils, polychlorinated biphenyls (PCBs)	L	L	L	L		L
N01 Vehicle washdown	Detergents, hydrocarbons	L	L	L	L		
R02 Sewage treatment works	Heavy metals, asbestos, cyanides, hydrocarbons.	M	M/L	L	L		L
	Soil gas (methane, CO_2, H_2S)	M	M			M	

M – Moderate; M/L -Moderate/low; L - Low; N – Negligible

8 CONCLUSIONS AND SUITABILITY FOR USE

8.1 LAND QUALITY CONCLUSIONS

Moderate risks to future residential users have been identified from the potential presence of hydrocarbons associated with underground fuel storage tanks; as well as heavy metals, hydrocarbons and asbestos in burning grounds, demolished buildings (including the incinerator, gas hut, range workshops and vehicle repair shop), tips and burning areas, infilled ground, stockpiled bunds and the sewage treatment works; and from potential soil gas from the sewage treatment works, infilled ground and off-site landfill.

Moderate risks to future commercial users have been identified from potential soil gas from the sewage treatment works, infilled ground and off-site landfill.

Moderate risks to future site buildings have been identified from potential soil gas from infilled ground, former sewage worls and the off-site landfill.

Moderate/low risks to future residential users have been identified from the potential presence of hydrocarbons associated with the refuelling area.

Moderate/low risks to future commercial users have been identified from the potential presence of hydrocarbons associated with below ground fuel storage; from heavy metals, hydrocarbons and asbestos in burning grounds, demolished buildings (including the incinerator, gas hut, range workshops and vehicle repair shop), tips and burning areas, infilled ground, stockpiled bunds and the sewage treatment works.

Moderate/low risks to groundwater have been identified from contaminants associated with fuel storage tanks and refuelling areas.

Moderate/low risks to future site infrastructure have been identified the potential presence of hydrocarbons associated with fuel storage tanks and refuelling areas; as well as heavy metals and hydrocarbons from the burning ground and tip and burning area.

All other risks were assessed as low or negligible.

The conceptual model does not consider risks to construction /site maintenance workers on the basis that risks to workers will be dealt with under the Health and Safety at Work Act (1974) and regulations made under the act. Site-specific contamination data should be included in the pre-construction information for any proposed below ground works, to enable any contractors to address as necessary in their risk assessments and method statements.

8.2 SUITABILITY FOR USE (LAND QUALITY)

This report assesses the risks in regard to future commercial and residential end uses following site redevelopment. The moderate human health risks identified relate to a change of use in a future redevelopment and do not reflect the ongoing risk to the current site users.

With regard to future development for mixed commercial and residential use a number of contaminant sources exist which will require consideration of further detailed investigation and / risk mitigation.

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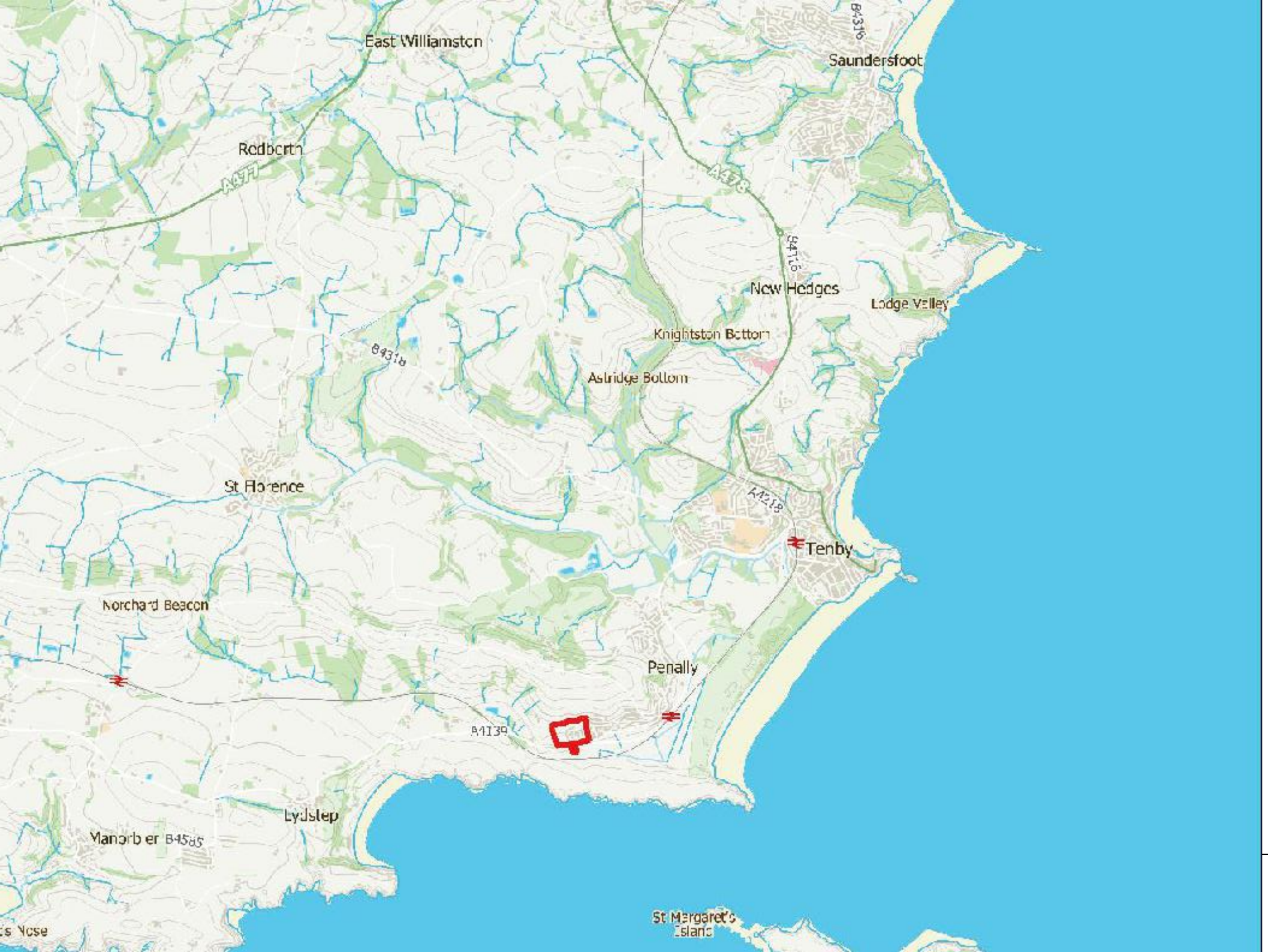
10 GLOSSARY

ACM	Asbestos Containing Material
AOD	Above Ordnance Datum
AST	Above ground [fuel] storage tank
BOD	Biological Oxygen Demand
BGS	British Geological Survey
CIRIA	Construction Industry Research and Information Association
COD	Chemical Oxygen Demand
COSHH	Control of substances hazardous to health
CSM	Conceptual Site Model
CW	Chemical Warfare
CWA	Chemical Warfare Agent
DEFRA	Department for the Environment Food and Rural Affairs
DEOP	Defence Estate Optimisation Portfolio
DIO	Defence Infrastructure Organisation
HER	Historic Environment Records
LPG	Liquid Petroleum Gas
LQA	Land Quality Assessment
MOD	Ministry of Defence
NAAFI	Navy, Army and Air Force Institutes
MT	Military Transport
NBC	Nuclear, biological, chemical
NRW	Natural Resources Wales
OS	Ordnance Survey
PAH	Polyaromatic Hydrocarbons
PCB	Polychlorinated biphenyls
PHE	Public Health England
POL	Petroleum, oils and lubricants
SAC	Special Area of Conservation
SPZ	Source Protection Zone
SSSI	Site of Special Scientific Interest
TA	Territorial Army
TPH	Total Petroleum Hydrocarbons
UST	Underground Storage Tank
UXO	Unexploded Ordnance

Appendix A

FIGURES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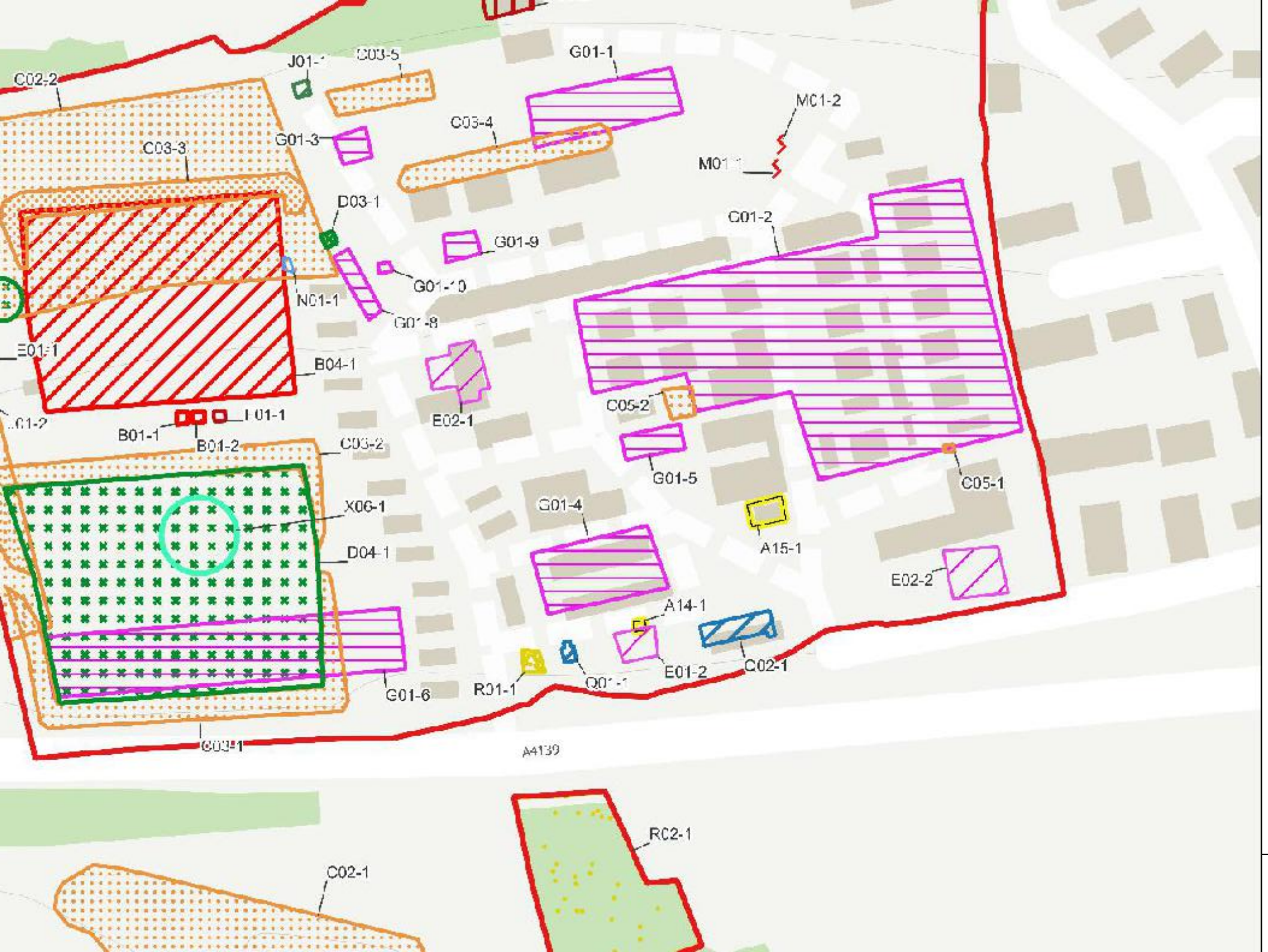
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