Land Contamination:
Technical Guidance on Special Sites:
MoD Land

R&D Technical Report P5-042/TR/01

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Statement of use

This report (P5-042/TR/01) is one of a series providing technical guidance on the complexities and characteristics of Special Sites as defined under the Contaminated Land (England) Regulations 2000 for Part IIA of the Environmental Protection Act 1990. Principally this document is for use by Agency staff carrying out regulatory duties under Part IIA, however this technical guidance contains information that may be of value to other regulators and practitioners dealing with Special Sites.

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FOREWORD

Part IIA of the Environmental Protection Act 1990 sets out a regulatory regime for the identification and remediation of land where contamination is causing unacceptable risks to defined receptors. The Environment Agency has a number of regulatory roles under this regime. Where land is designated as a Special Site, as defined in the Contaminated Land (England) Regulations 2000, the Agency will act as the enforcing authority. It is expected that a similar regime will be introduced in Wales during 2001, but the reader should check whether definitions of Special Sites in the Welsh regulations are the same as in the English ones.

The Environment Agency's approach to carrying out its regulatory responsibilities is set out in its Part IIA Process Documentation, available on the Agency website (www.environment-agency.gov.uk). This documentation sets out how the Agency intends to carry out its responsibilities under Part IIA of the Environmental Protection Act 1990, which came into force in England on 1 April 2000.

Users of the Part IIA process documentation should first refer to the Part IIA Process Handbook to obtain a clear understanding of the activities involved in the Part IIA regime, and with which Agency officer responsibility for particular tasks lies. The Procedures support the individual activities, and provide detailed step by step guidance on the necessary tasks. The Procedures are supported by Internal Standards which focus on the technical and legal aspects of the Part IIA regime. Other relevant advice is provided in Agency R&D documents and technical publications and in authoritative technical materials published by others including the Department of the Environment, Transport and the Regions.

This document is one of seven technical reports that provide background information about the categories of land designated as Special Sites identified in Regulation 2 of the Contaminated Land (England) Regulations 2000. The reports focus on the complexities and characteristics of the Special Site categories, and in particular, contamination types found specifically on these sites. The reports are not intended to provide regulatory or procedural guidance, but they aim to provide technical information to assist both Agency staff and others dealing with Special Sites in carrying out their work.

In the interests of transparency and openness, Part IIA process documentation, including this series of technical reports are made available to persons outside the Agency. They have particular relevance to local authorities, SEPA, DoE NI and to those affected by regulation under Part IIA.

GLOSSARY

Specific Technical Terms

The following glossary includes terms and acronyms used in reference to military related activities, with the potential for contamination, occurring in the United Kingdom. Historical terms and definitions are also included where they are likely to be encountered as a legacy within current MoD land. The glossary cannot be regarded as comprehensive due to the large number of terms and acronyms used by military services and the degree of variation in meaning that has occurred over time.

AA	Anti-Aircraft, used when referring to defence systems and units designed to counter the threat of enemy aircraft. Also used by the British Army to refer to Administrative Assistant.
AAC	Army Air Corps, the aviation arm of the British Army. Mainly equipped with helicopters used for transport, reconnaissance and ground attack.
AAOD	Anti-Aircraft Ordnance Depot, storage area for anti-aircraft shells.
AD	Air Defence, army terminology used in preference to Anti-Aircraft.
AFV	Armoured Fighting Vehicle, term applied to all military vehicles designed for frontline use that have some degree of armour and armament.
Amatols	Pourable mixtures of ammonium nitrate and trinitrotoluene of varying compositions.
AP	Armour Piercing, suffix used for any munitions designed to penetrate the armour of a target. Penetration is achieved by either the use of directed explosive charges within the munition or by the use of a high velocity high density metallic slug.
APDS	Armour Piercing Discarding Sabot, an earlier version of APFSDS ammunition which used a spinning motion to improve range and accuracy instead of stabilising fins.
APFSDS	Armour Piercing Fin Stabilised Discarding Sabot, a sub calibre round encased by disposable sabots that enable the round to be fired from large calibre guns to achieve maximum velocity. The round relies upon high velocity, high density and minimal surface area to penetrate the target. High density metals (such as tungsten alloys and depleted uranium) are favoured for the warhead manufacture.
Armd	Armoured, term used by British Army to refer to any vehicle

	having a protective covering. Also used to describe units of the army that are predominately equipped with such vehicles.
Arty	Artillery, term used to describe both guns and mortars with a calibre greater than 20mm and units of the army equipped with such weapons.
AVGAS	Aviation grade gasoline used by propeller aircraft, hence most commonly associated, but not limited to, historic airfield sites.
AVTUR	Aviation Turbine Fuel.
Azides	Salts of hydrazoic acid (N_3H).
Base Dumps	Area of a military site used for the disposal of site generated wastes.
BFI	Bulk Fuel Installation.
BG	Burning Ground.
Biological Warfare	The utilisation of living organisms, typically pathogens, to cause incapacity, injury or death to humans, animals or crops.
Booster	Used in an explosive train between a detonator and high explosive charge (see also primer).
Bty	Battery, term used to describe a group of large calibre guns, missile launchers, searchlights or torpedo tubes of a similar type and size that operate together as a single entity. Also used to describe a tactical unit of artillery consisting of two or more troops each armed with two, three or four guns.
Bullet	The small, usually metallic, projectile encased in a cartridge of small arms ammunitions. An individual bullet does not contain explosives or propellant.
Bunding	The process of constructing barriers to prevent the potential migration of pollutant liquids.
Burning Ground	The area of land used for the incineration of waste arising at a military site (including explosive, radioactive waste, excess fuel and clinical waste).
Butts	Banks of earth built to stop stray bullets at the end of a firing range.
BW	Biological Weapon. Any weapon designed to deliver a harmful biological entity, normally a human pathogen but also includes weapons designed to attack flora and fauna.

CAD	Central Ammunition Depot.
Calibre	The diameter of a shell or bullet, also the internal diameter of the bore of a firearm or gun.
Cartridge	A general term which can have a wide range of usage. It usually refers to a package or assembly of propellant explosive although it can sometimes describe a complete round of ammunition. In commercial explosives it is a general term for an individual explosive package.
CE	Composition Exploding, a term sometimes used when referring to Tetryl explosive.
Charge	A bagged, wrapped or cased quantity of explosive without its own integral means of ignition.
Chemical Shell	Ammunition primarily filled with a Chemical Warfare Agent.
Chemical Warfare	The use of chemical compounds to cause incapacitation, damage or lethal effects to humans, flora, fauna or materials.
Chemical Warfare Agents	Compounds used in chemical warfare. Includes asphyxiating and nerve gases, poisons, defoliants and choking agents.
Chemical Weapons	Munitions which contain chemical warfare agent.
Class A, B, C explosives	American classification: A: explosives which possess detonating or otherwise maximum hazard such as, but not limited to, dynamite, nitroglycerine, lead azide, blasting caps and detonator primers. B: explosives which possess flammable hazard such as, but not limited to, propellant explosives, photographic flash powders and some special fireworks. C: explosives which contain class A or B explosives or both components in restricted quantities.
COD	Central Ordnance Depot.
Cordite	Historical name for double base (nitroglycerine / nitrocellulose) gun propellants in the UK.
CW	Chemical Weapon.
CWA	Chemical Warfare Agents.
Deflagration	Reaction where materials decompose at a rate much below the sonic velocity of the material without any access of atmospheric

	oxygen being required. It is propagated by the liberated heat of reaction.
DE	Defence Estates.
DEO	Defence Estates Organisation (former name for DE – see above).
DNAPL	Dense Non Aqueous Phase Liquid.
Depleted Uranium	A form of uranium containing less of the isotope uranium-235 than occurs in the natural form of uranium. Used as the principle component in some armour piercing rounds due to its high density.
Detonation	A form of reaction given by an explosive substance in which the chemical reaction produces a shock wave. High temperature and pressure gradients are created in the wave front so that the chemical reaction is initiated by the shockwave.
DRPS	Defence Radiological Protection Service.
Sympathetic detonation	The initiation of an explosive charge without a priming device by the detonation of another charge in close proximity.
Detonator	The component within an explosive train which, when detonated by the primer, in turn detonates a less sensitive but larger high explosive (usually the booster) or when containing its own primer, initiates the detonation.
DU	Depleted Uranium.
EAM	Equipment Ammunition Magazine.
Explosion	Chemical reaction or change of state effected in an exceedingly short period of time with the generation of a high temperature and generally a larger quantity of gas. An explosion produces a shock wave in the surrounding medium (see also detonation and deflagration).
Explosive train	A train of combustible and explosive elements arranged on order of decreasing sensitivity. The explosive train accomplishes the controlled augmentation of a small impulse into one of suitable energy to actuate the main charge.
Figure of insensitiveness (F of I)	A figure determined by a Rotter Impact Test which is a measure of the sensitiveness of an explosive to an impact. The higher the result, the less sensitive the explosive.

Firing Point	The point from which an armament is fired on a testing range.
Firing range	Area of land used to practice or assess munitions firing. A firing range may be used for basic training purposes, or for the assessment and development of new projectiles.
Flare	Pyrotechnic device designed to produce a single source of intense light.
Flash over	Sympathetic detonation/deflagration from a cartridge to another one adjacent to it.
FMAS	Forward Maintenance Ammunition Section.
FOD	Forward Ordnance Depot.
Fuel	Any substance capable of reacting with oxygen and oxygen carriers with the evolution of heat.
Fuze	Device with explosive or pyrotechnic components designed to initiate a train of fire or detonation.
Gains	Small explosive charge that is sometimes placed between the detonator and the main charge to ensure ignition.
Grenade	A small container filled with either explosives or chemicals (such as smoke or tear gas) that is thrown by hand or fired from a rifle or grenade launcher.
Hangfire	The non-ignition or partial ignition of a propellant charge or cartridge within a gun chamber.
HE	High explosive.
IAD	Intermediate Ammunition Depot.
IB	Incendiary Bomb, weapon designed to cause fires and ignite flammable supplies instead.
IFV	Infantry Fighting Vehicle, relatively new term used to describe a vehicle that both transports infantry into battle and subsequently continues to fight alongside and in support of the infantry. Typically tracked, lightly armoured and armed with light cannons (20 mm to 30 mm calibre).
Impact point	The point at which a projectile lands on a firing range.
Incendiary	A highly exothermic composition or material that is primarily used to start fires.

Jerry Can	Military term for a flat sided can used to carry and store up to 5 gallons of fluids, typically water and fuel.
LNAPL	Light Non Aqueous Phase Liquid.
Magazine	Any building or structure approved for the storage of explosive materials. A removable case holding several rounds or cartridges used in some types of firearms.
MARU	Mobile Ammunition Repair Unit.
Mech	Mechanised, term used to describe military combat units that have sufficient vehicles (usually tracked) to be able to transport the whole unit and sufficient combat supplies all at once. Also short for Mechanical when referring to engineering processes.
MIGU	Mobile Industrial Gas Unit.
MLRS	Multiple Launch Rocket System, an artillery weapon that uses several long range rockets, each carrying a warhead containing hundreds of mini-bomblets or grenades that are released at height over the target area to ensure maximum coverage and collateral damage. Operates in a manner similar to a cluster bomb. Due to the large number of bomblets used it is not uncommon for unexploded bomblets to be deposited.
Mortar	Short barrelled, muzzle loaded cannon that fires low velocity shells in a high trajectory over a short range. Often designed to be man portable. Sometimes used to refer to the individual shells fired by such a device.
Mortar Shell or Bomb	The correct term for the munition fired by a mortar.
Motor	Term for a propellant gas generator or rocket propulsion unit.
NBC	Nuclear Biological and Chemical, term used when making reference to warfare or protective measures that involve nuclear, biological or chemical weapons.
NRPB	National Radiological Protection Board.
NRPS	Naval Radiological Protection Service.
OFP	Ordnance Field Park.
Oxidiser	Chemical or mechanical incorporation of oxygen into the explosive reaction/ material.
PAD	Port Ammunition Detachment also Passive Air Defence.

Pellets	Explosives in the form of round shaped granules, e.g. TNT. Also refers to small spherical charges of Tetryl.
Percussion caps	Serve as primers of propellant charges.
Phosphorous	Chemical used in bombs, shells, grenades and mortar shells that ignites upon exposure to air. Used to generate smoke as both a visual aid and to obscure enemy vision and as a weapon. Immersion in water will prevent or extinguish ignition however the phosphor will re-ignite when exposed to a new source of air, hence it is very difficult to treat casualties.
PIAT	Projector Infantry Anti-Tank, a man portable rocket launcher designed to destroy enemy tanks. Used during the Second World War but now obsolete.
POD	Port Ordnance Detachment.
POL's	Petrols, Oils and Lubricants. Covers a range of organic compounds including chlorinated solvents and hydrocarbons. The use of mobile POL tankers creates the potential for POL contamination across a site.
POW	Prisoner Of War, a person, especially members of armed forces, captured and held by the enemy in time of war.
Primary explosive	A sensitive explosive which is normally detonated by simple ignition from such means as spark, flame, impact or electrical charge.
Primer	A primary initiating device to produce a hot flame (see booster).
Proofing range	Firing ranges used specifically for the assessment of newly developed projectile armaments.
Propellant	Explosive material with a lower rate of combustion (deflagration), solid or liquid that will burn smoothly at uniform rate after ignition without depending on interaction with atmosphere.
Pyrotechnics	A group of explosive devices designed to produce light or smoke for signalling or visual purposes rather than to cause destructive effects, includes flares and smoke grenades.
RA	Royal Artillery, branch of British Army primarily responsible for large calibre guns and rocket launcher systems.
RAC	Royal Armoured Corps, collective term for units of the British Army predominantly equipped with armoured fighting vehicles.

RAF	Royal Air Force, branch of British military services responsible for aerial warfare and defence, including anti-aircraft batteries.
RCAF	Royal Canadian Air Force.
RCOC	Royal Canadian Ordnance Corps.
REME	Royal Electrical and Mechanical Engineers, branch of the British Army responsible for the maintenance and repair of most military equipment.
Rifle	Firearm with a long barrel and spirally grooved interior to impart spin to bullets to improve range and accuracy.
RLC	Royal Logistics Corps, branch of British Army responsible for providing support and supplies to the other sections of the army. Formed from the amalgamation of several separate units including the transport corps and ordnance corps.
Round	Term for a single unit of ammunition, typically used only when referring to small arms ammunition.
Secondary explosives	Explosives in which the detonation is initiated by the detonation impact of a primary explosive.
Shell	A projectile containing an explosive charge intended to burst it, fired from a gun or rocket launcher.
Shock wave	Intense compression wave produced by the detonation of explosives.
Small arms ammunition	Ammunition with a calibre up to 20 mm.
SMG	Sub-Machine Gun, portable automatic, semi-automatic or fully automatic firearm with a short barrel, designed to be fired from the hip or shoulder.
Sniff kits	Vials containing small amounts of chemical weapon agents, used to train servicemen, air raid wardens and the home guard in the recognition of chemical weapons.
Sub-Machine Gun	See SMG.
Tracers	Slow burning pyrotechnic compositions used in tracer bullets, signalling charges, tracer rockets etc. Colour is due to the presence of added salts such as sodium, barium, and strontium etc.
USAAF	United States of America Air Force, now replaced by USAF.
USAF	United States (of America) Air Force.

USAFE	United States (of America) Air Force in Europe.
UXB	Unexploded Bomb, sub-group of UXO.
UXO	Unexploded Ordnance, any munition that has not achieved full detonation and retains the potential to explode at a later date.
Warhead	The part of a missile, rocket or other projectile that contains explosives or other destructive device (e.g. chemical agents).

1. INTRODUCTION

1.1 Background

This report is one of a series of technical guidance documents relating to Special Sites that are part of the statutory regime for contaminated land introduced by the implementation of s.57 of the Environment Act 1995 that added Part IIA into the 1990 Environmental Protection Act (EPA 1990). The application of this primary legislation is via the Contaminated Land (England) Regulations 2000 and the accompanying DETR Circular 02/2000.

This report provides technical information relevant to Ministry of Defence (MoD) Land.

Within the Contaminated Land (England) Regulations 2000 this category of Special Site is defined as:

– *land owned or occupied by or on behalf of the Secretary of State for Defence; the Defence Council; an international headquarters or defence organisation; or the service authority of a visiting force.*

This report serves as a supplement to, and should be used in conjunction with, the following Environment Agency documents to provide supporting information relevant to the discharge of Environment Agency responsibilities for Special Sites:

- Part IIA EPA 1990 Process Documentation ; and

- DETR/Environment Agency. CLR11. Model Procedures for the Management of Contaminated Land (in preparation).

In addition, the reader is directed to other documents published by the Environment Agency, the DETR and others in the references and bibliography section of this report.

1.2 The Role of the Environment Agency in Relation to Special Sites

Full details of Environment Agency regulatory roles, responsibilities and procedures for dealing with Special Sites are provided in the Part IIA process documentation, and only a brief overview is included here.

The principal regulators for Part IIA (EPA 1990) are Local Authorities. The Environment Agency has an important complementary regulatory role with specific responsibilities including the provision of information and advice, and acting as enforcing authority in relation to Special Sites.

Local Authorities are responsible for identifying land in their areas which meets the statutory definition of contaminated land under Part IIA (EPA 1990). In doing so, Local Authorities will seek information from the Environment Agency, and advice in respect of pollution of controlled waters. Part IIA (EPA 1990) provides for certain land that meets the definition of contaminated land to be designated as a Special Site, if it meets one of a number of categories of land prescribed in the Contaminated Land (England) Regulations 2000. In cases where a

Local Authority believes that land, if found to be contaminated land, would subsequently be a Special Site, it will normally ask the Environment Agency to carry out a site inspection on its behalf, prior to determination of that land as contaminated land. However, the responsibility for formal determination of any land as contaminated land remains with the Local Authority in all cases.

Once land has been determined to be contaminated land, and where the Environment Agency and Local Authority agree (or the Secretary of State decides) that the land is also a Special Site, the Environment Agency will take over the role of enforcing authority from the Local Authority. Remediation of the site may include further investigation and assessment (assessment action), action to remedy the unacceptable risks identified (remedial treatment action) or monitoring (monitoring action). The Agency is responsible for maintaining a public register of regulatory action for Special Sites.

1.3 How to Use this Technical Guidance

This series of reports on Special Sites is primarily intended to provide Environment Agency Officers with the specialist technical information required when dealing with Special Sites under Part IIA (EPA 1990). Thus, every effort has been made to minimise the overlap with other guidance on generic aspects of contaminated land identification, assessment and management. In practice, it is likely that the reports will also prove useful to Local Authority officers, and others, when dealing with these types of sites.

The reports focus on the categories of land identified by Regulation 2 of the Contaminated Land (England) Regulations 2000. Separate guidance has been developed for those sites that are Special Sites by virtue of the seriousness of pollution of controlled waters (defined by Regulation 3 of the Contaminated Land (England) Regulations 2000).

The information contained in each report is arranged and presented so that it can easily be drawn upon when using other relevant guidance such as the Part IIA EPA 1990 process documentation. It begins with background information on, for example, the industrial process and facility description; further sections describe key issues that should be considered during the characterisation, evaluation, remediation and validation stages for each category of Special Site. References and a bibliography are also provided, together with a glossary of terms (both general contaminated land industry terms and also those specific to the individual technical field).

The format adopted in the report aims to assist the reader in the practical use of the technical information it contains by the inclusion of, where appropriate, selected checklists, diagrams, photographs, case studies and the highlighting of key technical information. In addition, at the start of each of the sections, a list of the key questions is included that highlight the issues covered by the section. The key issues that are addressed in the various sections of this report are as follows.

SECTION 2: FACILITY DESCRIPTION

1. What are MoD sites?

2. What contaminants are likely to be present?

3. What is the likely distribution of contaminants within the ground across the site?

4. How can the most significant contaminative processes that were undertaken on the site be identified and located?

5. Should other processes/contaminants be suspected which are not obvious from available records?

SECTION 3: PHYSICAL AND CHEMICAL CHARACTERISTICS OF CONTAMINANTS

1. What are the principal contaminants likely to be associated with specific processes?

SECTION 4: SITE CHARACTERISATION

1. Which additional information sources should be used for a desk study?

2. What are the main differences from a conventional contaminated land investigation?

3. Are special sampling and sample handling procedures required?

4. What should be analysed for and when?

SECTION 5: SITE EVALUATION

1. What are the primary pollutant linkages that should be assessed?

2. Which pollutant linkages are likely to be the most significant?

3. When is it appropriate/inappropriate to apply conventional risk assessment methods to this category of Special Sites?

SECTION 6: REMEDIATION ASPECTS

1. Which remediation technologies could be appropriate?

2. What are the main constraints and advantages to each of the applicable remediation technologies/engineering methods?

3. What are the anticipated perception/community impacts of the remediation technologies?

4. How can the remediation process be validated?

SECTION 7: HEALTH AND SAFETY

1. What legislation specific to MoD Land is relevant?

2. What working methods should be adopted for MoD sites?

3. What specialist equipment is required?

1.4 Risk Communication Issues

Public awareness of contamination issues , together with the general perception of associated risks and the potential for harm (in the conventional sense) has increased during the 1980s and 1990s. Useful guidance with respect to risk communication issues can be found in Environment Agency R&D Technical Report P142 "Communicating Understanding of Contaminated Land Risks" (SNIFFER 1999).

1.5 Linkages Between the Guidance Reports and the Special Site Categories

Many of the Special Site categories are likely to include technical aspects that are incorporated into more than one of the seven individual guidance reports. A matrix showing the links that may be relevant between the guidance reports and the Special Site categories is given below in Table 1.1.

Table 1.1 - Linkage between guidance reports and Special Site categories

Special Sites Categories *(for full definitions see the Contaminated Land (England) Regulations 2000)*	**Reports in This Series of Particular Relevance to Each Special Sites Category**						
	P5-042/TR/1 MOD Land	*P5-042/TR/2 Chemical Weapons*	*P5-042/TR/3 Explosives Manufacturing*	*P5-042/TR/4 Acid Tar Lagoons*	*P5-042/TR/5 Petroleum Refineries*	*P5-042/TR/6 Nuclear Establishments*	*P5-042/TR/7 Prescribed Processes Designated for Central Control*
Regulation 3 Land	land to which Regulation 3 applies is dealt with separately from this series of reports						
Acid Tar Lagoons				√	√		
Petroleum Refineries				√	√		√
Explosives Manufacturing or Processing Sites	√	√	√			√	√
Prescribed Processes Designated for Central Control			√		√		√
Nuclear Licensed Sites	√	√	√			√	
Current Naval, Military and Air Force Land	√	√	√		√	√	
Chemical Sites	√	√	√				
AWE Sites	√		√			√	
S.30 of the Armed Forces Act Land	√		√			√	

2. FACILITY DESCRIPTION

KEY QUESTIONS ANSWERED IN THIS SECTION

1. What are MoD sites?
2. What contaminants are likely to be present?
3. What is the likely distribution of contaminants within the ground across the site?
4. How can the most significant contaminative processes that were undertaken on the site be identified and located?
5. Should other processes/contaminants be suspected which are not obvious from available records?

2.1 Scope

This section presents an overview of the key aspects of MoD Land and the types of sites and their distribution and extent in the UK. It also provides a description of the main processes and activities that have occurred on MoD Land which are likely to have resulted in ground contamination. Whilst MoD land may contain a wide range of contaminant sources, this section mainly concentrates on those contaminants which are peculiar to such sites. Where relevant, some reference is made to land which was formerly MoD Land. This is included for general information purposes only as land owned historically by the MoD is not specified within the Contaminated Land (England) Regulations 2000.

2.1.1 What are MoD sites?

General points regarding MoD Land include the following:

- MoD Land encompasses an extremely wide range of activities from administration through storage to manufacture. All of these activities are related to the UK and world-wide operation of the British armed forces and the activities of visiting forces in the UK. This document deals with the unique issues relating to MoD Land and not conventional uses such as administration;

- the MoD is a relatively new title. Its historical predecessors include the former ministries of supply, munitions, air, admiralty, works and war office;

- a wide range of contaminants is likely to be encountered on many of these sites dependent on the activities present;

- many of the contaminant sources encountered on MoD Land will be similar to those for other categories of industrial land;

- lack of availability of records concerning military sites is a major problem. Information relating to site layout, processes and materials used/produced (especially at R&D sites) may not be readily available. The main reason for this is a past desire to keep such sites secret, especially during war time (e.g. military sites were not shown on OS maps until the late

1980s). Information concerning these sites was often lost or dispersed after the wars or as a result of reorganisation of Government departments;

- the MoD is in the process of undertaking a series of Land Quality Assessments (LQA's) leading to Land Quality Statements (LQS's) for all land within the defence estate using a combination of it's own technical specialists and external consultants;

- whilst former MoD Land may have been subsequently used for other purposes, the decommissioning and remediation standards employed in the past are unlikely to meet present day requirements. In addition, inadequate research or inexperience may have meant that potential contaminant sources may not have been identified. (Note that former MoD Land is not strictly included within the MoD Special Site definition but may fall within one of the other categories of Special Site);

- many MoD sites are very large in extent. Consequently much of the land area of these sites can be generally uncontaminated with only localised contaminated areas linked to specific processes or activities.

2.2 Distribution and Extent of MoD Land in the UK

2.2.1 Key points

- MoD sites range in size from small office establishments to large airbases or training ranges. Landholdings have changed markedly over the years (especially around the two World Wars. Current MoD landholdings extend to 240,000 hectares. This total is reducing due to a current programme of land sales;

- there is no particular pattern of distribution of MoD Land, some counties have large expanses of MoD Land while others contain very little. The distribution is the result of historical decisions made in some cases several hundred years ago. The current rationalisation of the defence estate will have a significant effect on MoD landholdings and their distribution.

2.2.2 Uncertainties

- Historical records for MoD Land can be very difficult to obtain from normal sources. Certain information may even be misleading (e.g. omission of MoD land from OS maps implies continuation of the site's former use);

- information may be found in public records. However, much is retained in various MoD or private company sources. The primary (but not the only) organisation dealing with the MoD estate is Defence Estates (formerly known as the Defence Estates Organisation (DEO)). Many public records are incomplete due to loss or destruction during closure of sites and various Government department reorganisations;

- even when records seem to be relatively complete, variations in working practices need to be addressed (e.g. disposal of wastes during wartime operations). In addition records of sensitive operations or processes may have been highly classified and the records stored

separately. Some records may still have UK government security classification (see section 4.2.2 for further details);

- a number of MoD sites have a very long history with several generations of use and development. It is often not clear what remains of these previous uses. Frequently the new operations were built on top of the old foundations, which may have resulted in the trapping of previous contamination.

2.2.3 Unidentified sites

All current MoD land should be identifiable from existing records held by Defence Estates. For some sites, it may be difficult to identify their former uses for the reasons given above. This is often the case with sites that were demolished many years ago, such as those that were closed after the end of the world wars but which may still be owned by the MoD.

2.3 Key Site Features

The principal types of MoD Land are as follows:

- RAF Bases;
- Royal Navy Establishments;
- Army bases;
- US and other visiting forces bases;
- research and development sites (such as chemical and biological weapons research);
- ranges (which may or may not be present on the bases themselves);
- disposal and incineration areas;
- bulk fuel depots and site refuelling facilities;
- maintenance and repair workshops;
- storage areas - for vehicles, fuels, ammunition, food, supplies, spare parts, chemicals, fuels etc;
- production facilities - explosives and munitions, chemical weapons (historical activities which may have been present on some current MoD sites);
- nuclear facilities - including AWE sites, reactors, submarine storage sites and weapons storage sites.

These can be grouped into the following categories:

- military bases;
- R&D sites;
- ranges;
- storage sites;
- maintenance & engineering sites;
- production sites; and
- nuclear sites.

Within each of these types of sites significant contamination risk may be associated with the following processes or features:

- bulk chemical storage;
- chemical plant;
- explosive filling and assembly (historical activity);
- weapon and combat training;
- stores (including magazines and underground bunkers);
- laboratories;
- nuclear production facilities;
- mechanical engineering;
- pest and weed control;
- fuel storage and distribution;
- airfield operations – fire training, de-icing etc.;
- railway network;
- water features (e.g. ponds or canals);
- disposal sites;

- burning grounds;
- ranges;
- on-site heat & power stations and electrical substations;
- laundries;
- chemical weapon production (historical activity); and
- luminising workshops in old airfields and instrument workshops (historical activity).

The following matrix provides an initial indication of which of these features is likely to be of concern on each of the site types.

Table 2.1 – Matrix of key site features and site types

	Site Types						
Feature	Military Bases	R&D Sites	Ranges	Storage Sites	Maintenance & Engineering	Production Sites	Nuclear Sites
Bulk chemical storage	*	*	-	*	*	**	*
Chemical plant	*	*	-	*	*	*	*
Explosive filling & assembly	*	*	*	*	-	*	*
Weapon & combat training	**	*	**	*	*	-	*
Storage inc. magazines	**	*	**	**	-	**	*
Laboratories	*	**	-	-	-	*	*
Nuclear facilities	*	*	-	-	-	*	**
Mechanical Engineering	*	*	-	*	**	**	*
Pest & weed control	**	*	*	*	*	*	*
Fuel storage & distribution	**	*	*	**	*	*	*
Airfield operations	*	*	-	-	*	*	-
Railway network	*	-	-	*	-	*	-
Disposal sites	**	*	*	*	*	*	*
Burning grounds	*	*	*	**	-	*	*
Ranges	*	*	**	-	-	*	
Heat & power production	**	*	*	*	*	*	*
Laundries	*	-	-	-	-	*	*
Chemical weapon production	-	*	-	-	-	*	-
Luminising workshops	*	*	-	*	*	*	-

- Usually absent
* Sometimes present
** Usually present

Each of these categories is described in greater detail in the following sections.

2.3.1 Bulk chemical storage

The storage of bulk chemicals could be for a range of applications related to explosives, engineering, airfield activities or just storage for another MoD site.

It is of key importance to understand what processes the chemicals were stored and used for. This will give the researcher an idea of the potential volumes, type, form and location of potential spill areas.

2.3.2 Chemical plant

As with bulk chemical storage, the chemical plant could be for a range of applications related to the production of explosives, processing and recovery of waste materials, water treatment, engineering, or R&D.

Box 2.1 Scenario

Many MoD sites were closed and decommissioned to standards of the day which may not have been consistent with current standards. Such sites may still be within MoD ownership. Historically surveys were conducted which concentrated on live munitions on the surface, but such surveys may not have addressed fully the potential risks from residual raw materials or from buried munitions.

A survey of an Armament Depot revealed that the majority of process buildings had been closed without decommissioning the plant, which was found to be contaminated with explosive residues. Soils surrounding the process buildings were found to contain explosive residues. At the time of investigation, this site was in MoD ownership.

2.3.3 Munitions filling and assembly

This is mainly an historical activity as almost all such activity is now carried out by private companies. However, the MoD undertakes a significant amount of testing and maintenance work which is carried out on certain stores sites. Key points relating to munitions filling and assembly on explosives manufacturing sites are included in Environment Agency R&D Technical Report P5-042/TR/03 dealing with explosives manufacturing and processing sites.

2.3.4 Storage (including magazines)

Key points relating to storage on MoD sites will relate to whether storage is general (such as central stores) or for a particular site operation. The range of materials stored is both large in type but often also in volume. It is important to establish the type of stores and the likely

materials involved. Stores may be either above ground or less commonly below ground such as in tunnels or former mines.

For key points relating to the storage of munitions (ranging from, for example, small arms munitions to large calibre and chemical weapons) within magazines, refer to Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

2.3.5 Laboratories

As with storage facilities, the potential for contamination from laboratories relates to the operations of the site, whether production or R&D. A wide range of contaminants may be present particularly if a laboratory was involved in a series of different R&D requirements. Key issues relating to more specialised laboratories are included in Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

2.3.6 Nuclear facilities

Radioactive material may be present at sites associated with nuclear weapons/reactors or as a result of the use of specialist military equipment. Key points relating to nuclear facilities are dependent on the category of the site. Three site categories exist as follows, AWE sites involved in research and development and the production and assembly of nuclear weapons, reactors, and naval dockyards which have been used for the refit and storage of nuclear submarines and other related weapons systems.

The MoD has nuclear facilities for the management of spent fuel rods and reactor wastes as well as for the development and production of nuclear weapons. The materials handled on these sites are strictly controlled and monitored. On non-nuclear sites, particularly in the past, radioactive materials may not have been subject to rigorous control. For example, airfields and related engineering facilities commonly have some degree of radium contamination due to the use of luminescent paints on aircraft instruments (see section 2.3.10 for further details). For key points relating to nuclear facilities refer to Environment Agency R&D Technical Report P5-042/TR/06.

Box 2.2 Scenario

A land quality assessment conducted on an operational defence site revealed an area of waste ground where overalls and other clothing had been buried. These items of clothing had all been used by workers on a nuclear engineering project. Subsequent analysis of this waste showed it to be contaminated with low level radiation.

Radioactive contamination is strictly excluded from the Part IIA regime but would need to be considered with respect to general health and safety.

2.3.7 Mechanical engineering

Key points over and above guidance for mechanical engineering on conventional sites is the awareness of more specialised materials that may have been worked with for defence

purposes. For example, radium from luminescent paints or depleted uranium from specialist munitions manufacture may give rise to radioactive contamination on engineering sites. In addition, inspection facilities may have used X-ray techniques. Although X-rays were generally produced by electrical energy, the presence of a radioactive source cannot be totally discounted. Current use and storage of radioactive materials is normally well documented and subject to internal MoD/DRPS inspections. In some instances, machining of unusual metals such as beryllium may have been undertaken.

2.3.8 Pest & weed control

Large quantities of pesticides and herbicides are or have been commonly used as part of the maintenance for MoD sites. Key points to look for are the storage areas where local spillages may have occurred.

2.3.9 Fuel storage and distribution

Aviation fuel, petroleum, diesel, heating fuel and heavy fuel oil are likely to have been stored at many sites, in above or below ground tanks. Historically, the former tended to be poorly bunded and leakage from the latter could easily go undetected for long periods. Consequently surrounding soils and groundwater may be contaminated by hydrocarbons. In addition to the more common hydrocarbons, specialist fuels may also have been stored such as aviation or certain rocket fuels. For further detail refer to Environment Agency R&D Technical Report P5-042/TR/05.

2.3.10 Airfield operations

Key points relating to military airfields (excluding their fuel storage areas) are the potential presence of ammunition, chemical warfare weapons and radioactive contaminants. These materials (including air defence ammunition) were historically buried on site on occasions, or disposed of in burning grounds, often in areas which present little surface evidence today. The MoD has an ongoing programme of research and investigation into the use of specialised munitions at RAF sites.

Explosive charges may still be present under or near to runways. These are a legacy from the last war when charges were placed underneath runways in order to destroy them if they came under attack.

Box 2.3 Scenario

In the late 1990s during the construction of a new waste water treatment plant on a former WWII airfield in Southern England a series of intact ‘pipe bombs’ were discovered beneath the former runway. Although this site was non-operational, similar operational sites with runways may have similar issues.

De-icing agents and solvents may have been in use for many years and have penetrated the soil through rainwater drains and soakaways.

Radioactive contamination is potentially derived from aircraft parts such as the thorium constituent of certain specialist aluminium alloys and more commonly luminescent radium paints from dials. Such contaminants are likely to be historical, but still present on an operational base particularly in areas of aircraft crashes or aircraft 'graveyards'. Aircraft 'graveyards' are locations where aircraft were buried, often close to crash sites.

Box 2.4 Scenario

Recreational areas on MoD sites can also give rise to contamination issues. Gun clubs are common on many sites. A study conducted at a site in the UK showed elevated concentrations of lead (both available and total) within the upper soils around the gun club.

It should be noted, that gun clubs have often occupied various locations within the boundaries of a site and as such a full historical appraisal should be conducted.

2.3.11 Railway network

Key points relating to internal railway networks on MoD sites include:

- spillages are often associated with such networks and have been known to become mixed with rail ballast and surrounding soil – especially at loading points, bends and junctions;
- in some sites boiler ash was routinely used as railway ballast.

2.3.12 Disposal sites

Key points relating to disposal sites on MoD Land include:

- until the last decade or so the general practice on MoD sites was to retain and dispose of all wastes on site wherever possible. Sites may often contain areas where wastes were tipped. A wide range of contaminants can be present, these will reflect the operation of the site at the time of disposal;
- some sites have been found to contain large quantities of waste materials accumulated over many years. Some, but not all, of these wastes may be present as backfill to former quarries and other similar excavations which may date from the original development of the site;
- where a series of new locations has been used throughout a site's operation, each area may contain different types of contamination if site use has changed.

2.3.13 Burning grounds

Unwanted materials were commonly disposed of at MoD sites by burning in specified areas known as "burning grounds". Some limited use of this disposal method still takes place e.g. for munitions. The types of material that are likely to be encountered in these areas include:

- unburnt explosives;
- unexploded munitions;
- excess unburnt fuels from the burning process;
- packaging and partially burnt packaging potentially contaminated with explosives;
- radioactive contaminants;
- wastes from workshops;
- asbestos and metal residues from pyrotechnic devices;
- metal plating wastes;
- paint strippings and paint waste (possibly including radium paint residues).

For additional key points relating to burning grounds refer to Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

2.3.14 Ranges

There are a number of range types on MoD Land, the most common being:

- small arms generally 25 m sub machine gun (SMG) or pistol ranges that are often sited in or close to camp areas;

- longer small arms ranges up to 600 m for rifle training. Often to be found in remote locations such as moorland or heathland and only manned when in use;

- exercise ranges for the deployment and firing of a wide range of weapons and of large numbers of troops and vehicles including heavy armoured vehicles;

- research, development and proofing ranges (see R&D sites below), generally used for the firing of large numbers of munitions of all types;

- ranges involving firing out to sea. On some of these, ammunition was fired into tidal areas enabling recovery at low tide.

Principal areas of contamination are:

- support and storage areas;

- firing points;

- impact points;

- main range area;

- burning grounds.

Key contaminants will be metals (including the possibility of depleted uranium), explosives and more importantly the potential for unexploded ordnance. For additional key points relating to ranges refer to Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

Box 2.5 Scenario

As part of the infrastructure work for a neighbouring residential area, a number of trenches were being excavated across part of a former MoD range. Excavation work along this narrow corridor uncovered approximately 150 unexploded munitions, of which approximately 20 were filled with chemical weapon agents. Care should be taken on firing ranges as a variety of munition types were fired, not just training rounds as might be expected.

2.3.15 On site heat and power stations and electrical substations

Many MoD sites have (or at some stage in their history had) boiler houses. Key issues are the potential for:

- ash tips and the spreading and use of boiler house ash on site e.g. as a base for paths and roads on sites with coal fired boilers;
- asbestos from insulation;
- old underground storage tanks for oil prior to the changeover to gas - some will remain in the ground and may have localised hydrocarbon contamination; and
- coal pits for storage of fuel for boilers;
- sites which had electrical substation equipment in the 1970s or earlier may have PCB residues around places where PCBs were used or stored.

2.3.16 Laundries

Many MoD sites have (or had) their own in-house laundries. Contaminants associated with these are generally those anticipated for any laundry plus residues from the site processes (e.g. explosives).

2.3.17 Chemical weapon production

For key points relating to chemical weapon production refer to Environment Agency R&D Technical Report P5-042/TR/02 in this series.

2.3.18 Luminising workshops in old airfields and instrument workshops

Luminescent paints containing radium were in general use by the end of WWI and peak usage was during the 1930s. General use started to cease with the introduction of the Radioactive Substances Act (1960) with the end of the general use of luminescent paints in 1968. Many military instruments (in particular aircraft instruments) employed these paints. Sites where such instruments were repaired, tested or used have often been found to retain residual radium contamination in workshops, stores and even paths between such buildings. Remains of such

instruments and associated radium contamination have been found in waste disposal areas and aircraft crash or burial sites. Refer to Environment Agency R&D Technical Report P5-42/TR/06 for further details on radioactive contamination.

2.4 Summary of Principal Potential Pollutant Linkages

None of the potential pollutant linkages that could be derived for MoD Land are totally specific to MoD Land alone. Many are covered within other guidance documents in this series or by existing guidance documents already utilised for conventional sites. The table below details some of the main issues associated with MoD Land, but **should not be considered a complete list** of potential pollutant linkages.

Table 2.2 - Principal potential pollutant sources, probable contaminants and processes

Principal Potential Pollutant Source	Associated Contaminants	Process/Activity
Harm		
Explosives, chemical warfare and radioactive contaminated shallow soils or building fabric – threat to humans		
-acute hazard (fire or explosion)	Wide range of explosive compounds in high (localised) concentrations – especially under locally dry conditions.	1. Explosives chemical plant. 2. Ammunition filling. 3. Disposal areas. 4. Airfields
-toxicological hazard	Wide range of explosive, chemical warfare compounds.	1. Any of the processes where explosives are used including burning grounds and disposal areas and where chemical warfare agents may have been disposed of.
-radioactive hazard	Wide range of potential contaminants particularly related to munitions, aircraft engineering & maintenance and instrument workshops.	1. Primarily as a result of engineering or munitions use of radioactive metals such as depleted uranium in armour piercing rounds or radium in luminescent paints in instrument dials.
Explosives, chemical warfare or radioactive contaminated underground utilities or deep soils – possible threat to humans especially maintenance or redevelopment workers.	Explosives in the form of liquids, slurries or in solution, chemical warfare agents either within intact shells or as globules in moist soil, or radioactive materials associated with aircraft parts or in ash.	1. Any process involving explosive pipelines and drains. 2. Any process where there is a pathway to contaminate deeper soils. 3. Disposal of radioactive aircraft parts by burial. 4. Burning of wastes can concentrate radioactive materials such as radium. 5. General site disposal operations.
Buried munitions – acute threat to humans.	Wide range of ammunition and related devices, including chemical warfare agents.	1. Ammunition assembly and filling. 2. Disposal areas.
Asbestos release to atmosphere – threat to humans.	Asbestos from buildings, services or soil	1. Any process involving heat including steam lines. 2. Building insulation material. 3. General site waste disposal.
Pollution of controlled waters		
- contaminated soil	Fuels, some explosives, chemical warfare degradation products under certain conditions can be found in solution. Fuels can also be present as phase separated material (LNAPL or DNAPL see Glossary for explanations).	1. Power and heat generation or general fuel storage. 2. Manufacture of more soluble explosives such as nitroglycerols (DNAPLs), picric acid or tetryl. 3. Chemical warfare agents such as S-Mustard have soluble degradation products that may be derived from leaking buried shells. 4. Contamination from general waste disposal operations.

2.5 Typical Site Layouts

The layout of MoD sites will vary dependent on their current or past use. Although common designs were often used for sites of similar types, material differences can occur due to historical or local factors. Due to the types of activities involved many MoD sites are large in expanse, such as airfields, central stores, ranges and explosive establishments. Other sites can be small such as administration centres, some barracks and local stores. Certain sites such as those operating explosive processes, chemical weapons, nuclear operations will have layout particular to them. These are detailed further in the other relevant reports in this series.

Box 2.6 Example of an MoD site layout

Airfields have a common layout of three runways, primarily two main and one minor. Associated with these, is an infrastructure that is present in almost all cases comprising:

- aircraft dispersal areas
- fire training pit
- ammunition disposal site
- munitions magazines
- base dump (general waste disposal area)
- fuel storage areas
- maintenance area
- accommodation and offices

A selection of photographs which illustrates the range of MoD sites is presented at the end of this section.

Plates 1–7 selected views of MoD sites

Plate 1 **Former Proof And Experimental Establishment, Cold Meece, Staffordshire**

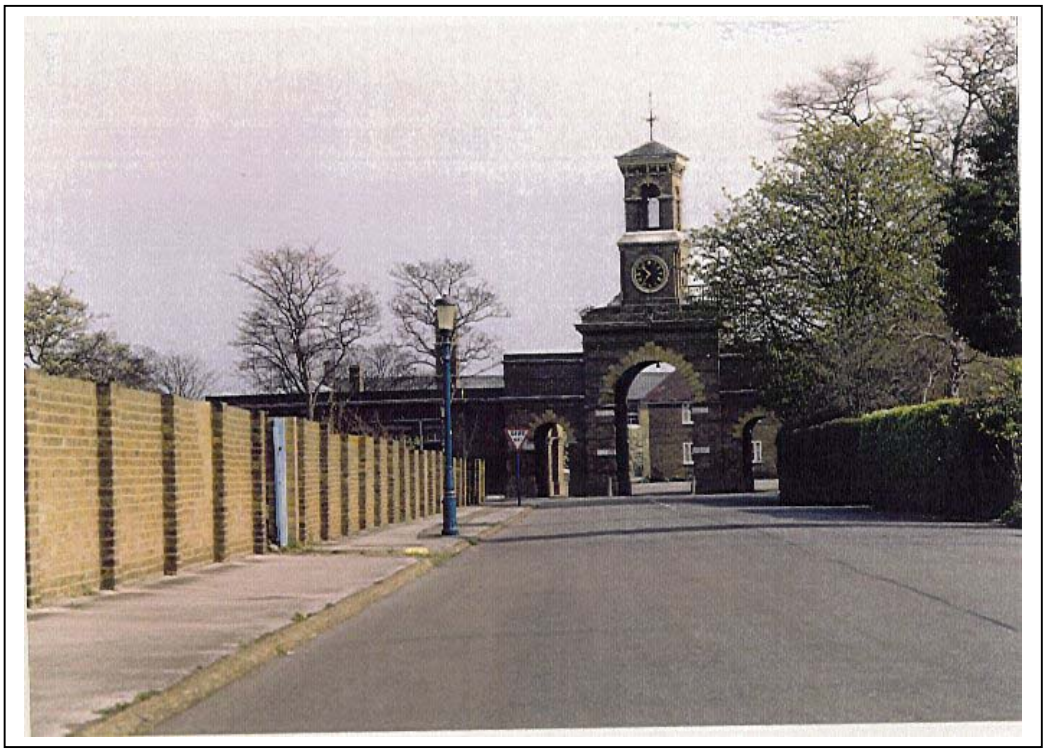

Plate 2 **Old Ranges And Barracks, Shoeburyness, Essex**

Plate 3 Hadleigh Storage Depot, Near Ipswich, Suffolk

Plate 4 Gosport, Hampshire

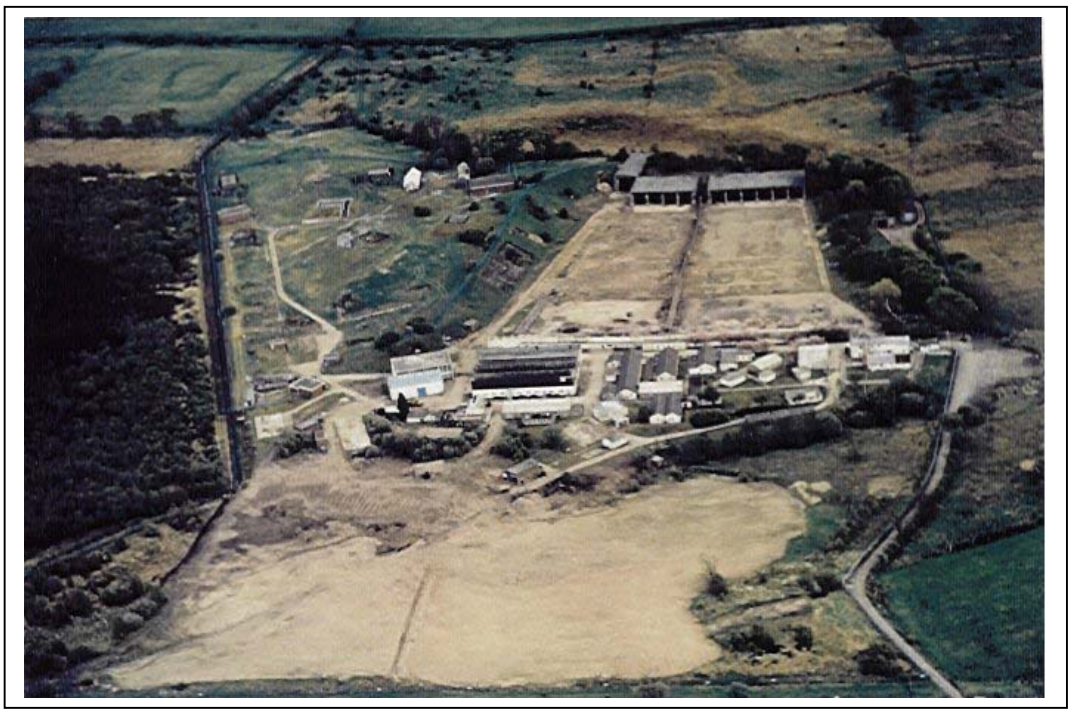

Plate 5 Former Proof And Experimental Establishment, Inchterf, Kirkintilloch, Glasgow, Scotland

Plate 6 Hilton Depot, Derbyshire

Plate 7 Old Barracks, Dover Kent

Plate 8 Unearthed 50kg Air Dropped Bomb

3. CHEMICAL AND PHYSICAL CHARACTERISTICS OF THE PRINCIPAL CONTAMINANTS

KEY QUESTION ANSWERED IN THIS SECTION

1. What are the principal contaminants likely to be associated with specific processes?

3.1 Scope

It is not within the scope of this document to discuss in detail all of the contaminants that may be found on MoD Land. The types of sites which comprise the MoD Land Special Site category are very varied and will generally be contaminated by a mix of conventional types of contaminants e.g. hydrocarbons, together with more specialist contaminants such as explosives or radioactive materials. For the conventional contaminants associated with MoD sites extensive published guidance exists and hence is not repeated within this report.

3.2 Principal Contaminants

The following table provides a summary of the principal contaminants which may be associated with the various processes which are undertaken (or may have been during their history) on MoD sites.

Table 3.1 - Matrix of processes and principal contaminants

Process	Principal Contaminants
Bulk chemical storage	Sulphuric, nitric and other acids Pesticides, herbicides and fungicides Chlorinated and non-chlorinated solvents Paints, asbestos
Chemical plant	Sulphuric, nitric and other acids Chlorinated and non-chlorinated solvents, asbestos
Explosive filling & assembly	Explosives Chemical warfare agents Unexploded ordnance Radioactive contamination Asbestos
Storage inc. magazines	Chemicals such as solvents Paints Explosives and unexploded ordnance Chemical warfare agents Metal powders Fuel and lubricating oils
Laboratories	Chemicals including solvents, acids Explosives Chemical warfare agents

Process	Principal Contaminants
	Radioactive sources
Nuclear facilities	Radioactive sources Radioactive contamination Metals (including possibly beryllium)
Mechanical Engineering	Metals Solvents and degrading agents Lubricating oils Acids Paints Radioactive sources
Pest & weed control	Pesticides, herbicides and fungicides
Fuel storage & distribution	Fuel and lubricating oils
Airfield operations	Fuel and lubricating oils Radioactive contamination Chemical warfare agents Explosives Unexploded ordnance Metals Solvents – degreasing agents. De-icers Detergents
Railway network	Hydrocarbons – lubricating oils and PAHs Explosives
Disposal sites	Explosives Chemical warfare agents Radioactive contamination Metals Fuel and lubricating oils Asbestos Wastes reflective of site operations
Burning grounds	Explosives Unexploded ordnance Solvents Fuel oils Asbestos Radioactive contamination
Ranges	Explosives Unexploded ordnance Asbestos Radioactive contamination Metals
Heat & power production	Fuel and lubricating oils Acids (primarily sulphuric) Asbestos Heavy metals Residual PAHs and PCBs Radioactive contamination

Process	Principal Contaminants
Laundries	Bleaches Detergents Chlorinated solvents (dry cleaning) Explosives
Chemical weapon production	Chemical warfare agents Explosives Unexploded ordnance
Luminising workshops	Radium

The following table is intended to provide the reader with an easily accessible link between the various processes which have been undertaken on MoD sites and the relevant DoE Industry Profiles.

Table 3.2 – Matrix of processes and relevant DoE Industry Profiles

Process	Principal DoE Profiles
Bulk Chemical Storage	Chemical Works: fine chemicals manufacturing works Chemical Works: inorganic chemicals manufacturing works Chemical Works: organic chemicals manufacturing works Chemical works: pesticides manufacturing works
Chemical Plant	Chemical Works: fine chemicals manufacturing works Chemical Works: inorganic chemicals manufacturing works Chemical Works: organic chemicals manufacturing works Chemical works: pesticides manufacturing works
Explosive filling and assembly	Chemical Works: explosives, propellants and pyrotechnics manufacturing works Engineering Works: mechanical engineering and ordnance works Metal Manufacturing, refining and finishing works: electroplating and other metal finishing works
Storage inc. magazines	Chemical Works: explosives, propellants and pyrotechnics manufacturing works Engineering Works: mechanical engineering and ordnance works
Laboratories	Chemical Works: explosives, propellants and pyrotechnics manufacturing works
Nuclear facilities	N/A
Mechanical engineering	Engineering Works: mechanical engineering and ordnance works Engineering Works: aircraft manufacturing works Engineering Works: shipbuilding, repair and shipbreaking (including naval shipyards) Engineering works: vehicle manufacturing works
Pest and weed control	N/A
Fuel storage and distribution	Oil refineries and bulk storage of crude oil and petroleum products Road vehicle fuelling service and repair: garages and filling stations Road vehicle fuelling service and repair: transport and haulage centres

4. SITE CHARACTERISATION

KEY QUESTIONS ANSWERED IN THIS SECTION

1. Which additional information sources should be used for a desk study?
2. What are the main differences from a conventional contaminated land investigation?
3. Are special sampling and sample handling procedures required?
4. What should be analysed for and when?

4.1 Scope

This section provides information on the specific approach that should be followed when conducting desk studies and site investigations on MoD Land. The overall approach to characterisation of such sites is, in the main, similar to that for conventional sites. Any such generic guidance is excluded from the scope of this section that relates solely to the particular issues associated with MoD Land.

4.2 Desk Study

4.2.1 Key issues

The following issues are of particular importance in relation to the desk study phase, when considering MoD Land:

- lack of information from conventional sources may be a major barrier to obtaining details of the activities carried out and the contaminants which may be encountered. However, in the first instance, reference should be made to Defence Estates; and the commanding officer of the specific site;

- a lack of information does not mean that certain operations are not present. Enquiries to MoD often result in a response that they do not have any records of certain operations or processes on a site. Reliable negative or positive evidence should be sought if possible;

- knowing where to look for the relevant information, and how to interpret the information which is available are important considerations, and as with other MoD sites, this will often mean that specialist assistance should be sought from organisations familiar with MoD Land;

- many former MoD sites were disposed of with an accompanying Explosives Ordnance Disposal certificate. Historically the explosives clearance procedures which will have resulted in the issue of these certificates will often have concentrated on the stockpiles of raw explosives and any munitions that may have been present on the ground surface. Until recently such certificates rarely covered the potential for buried munitions or explosive contamination (for instance on redundant plant) and consequently should not be relied upon as evidence of full decommissioning or remediation. Explosives certificates issued since the mid 1990s are more likely to have covered buried munitions and

explosive contamination of process plant. However, a cautionary approach should always be adopted in the interpretation of these certificates;

- further reference should be made to Environment Agency R&D Technical Report P5-042/TR/02, R&D Technical Report P5-042/TR/03 and R&D Technical Report P5-042/TR/06.

Box 4.1 Scenario

A land quality assessment was conducted for a non-operational (yet still MoD owned) Armament Depot. Although the assessor referred to conventional research material, defence related records were overlooked. The assessor was also not experienced in the typical processes and contaminants that may be present on such a site. Based on the information the assessor had acquired it was considered that there were no barriers to development.

Later research of the operational records and plans of the site revealed a number of contamination issues that presented a high risk to development. Asbestos registers on the depot recorded large areas where bulk asbestos had been buried. Several waste tips were also recorded within the site boundary. Many of the remaining buildings had not been adequately decommissioned and still contained potentially explosively contaminated plant.

Box 4.2 Scenario

A free from explosive certificate was issued for a former Armament Depot. On closer examination the certificate was issued with only a 60 % clearance rate in some areas. An engineer trained in ordnance recognition conducted a walkover of the site and within two days uncovered four devices on the ground and a waste tip containing hundreds of cartridges. A moat surrounding one of the magazines was also reported to contain hundreds of detonators and fuses.

4.2.2 Security classification

Some information (e.g. concerning MoD explosives sites) due to its sensitivity may still be classified as restricted or secret. In many cases the information may be made available for viewing or declassified at request after review. Where viewing or declassification is not possible, specific questions on environmental issues can be asked and information provided where it is considered that such information is in the "public interest".

The Environment Agency is developing a Memorandum of Understanding with the Ministry of Defence, and this sets out normal routes of communication between the two organisations. A further appendix is to be developed dealing specifically with land contamination, and this will be made available within the Environment Agency when completed.

4.2.3 Operational time periods

The period of site operation is an important factor in determining which contaminants may be present. Over time the development of military equipment and greater environmental awareness has lead to a change of materials used on MoD Land.

The evolution of chemical warfare agents and explosives are detailed in Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

4.2.4 Common mistakes/pitfalls when characterising MoD Land

- Site assessors often assume that no records mean no operation. This is often not the case and specialist experience and further research is often required to identify previous site uses accurately. Former MoD sites that were requisitioned during the Second World War and subsequently handed back to their original owners may not have any records available to confirm this within MoD (Note: as former MoD land such sites will not fall within this category of Special Site).

- Many assessors are both unaware and often disbelieving of some of the practices that may have operated on MoD sites. Issues such as crown immunity and war time exigencies enabled such practices to be conducted.

- Not accounting for high volume of activity during wartime and the poor practices that may have operated during the exigencies of war.

- Inadequate time allowed for desk study research on such sites can lead to poor desk study conclusions and subsequently to inadequate investigations. Desk study research should be allowed to address a range of issues but also pursue negative results confirming that certain site operations have not taken place.

- The assumption that a site that has had no real military activity such as a direct use by the armed forces and as such has no explosives present or other MoD related issues. However many MoD sites, including those involved in apparently innocuous uses, have armed security with an armoury, ranges and magazines.

- As most MoD sites that operated during the war were military targets, there is often an issue of unexploded ordnance even though other explosive issues may not be present from normal site operations.

- Numerous mistakes on incorrect identification or interpretation can be made, particularly where security issues are designed to deliberately confuse and misinform. Sites can be deliberately misnamed, reference to this is made in Environment Agency R&D Technical Report P5-042/TR/03. Security issues may render some information difficult to obtain.

- Not recognising that buildings may have been reused for other than their original purpose e.g. aircraft hangars may have been used for a range of purposes requiring a large open building.

- Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03 give further examples of common mistakes associated with MoD land.

4.2.5 Specialist interpretation

As a result of unfamiliarity with MoD sites, structures and site layouts are often misinterpreted by the non-specialist assessor. A trained specialist can often establish a site use and individual building use from its structure and general site layout. Many sites will have operations that may not be readily identifiable from documented evidence. Specialist interpretation can however indicate where, for example, explosive disposal, fire training pits, aircraft graveyards and the like may be located on an airfield site.

This indicates the need for, as a minimum, some peer review or input during the desk based review by a specialist consultant with appropriate training, experience, and knowledge. Defence Estates may also be prepared to assist in this process.

4.2.6 Desk study check-list for MoD Land

This check-list is intended to supplement the check-lists for Phase 1a Risk Assessment contained in DETR (1997) and DoE (1994). Reference should also be made to Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03

Specialist information sources

- MoD – Army Historical Branch
- MoD – Navy Historical Branch and in-house contaminated land specialists
- MoD – Airforce Historical Branch and in-house contaminated land specialists
- MoD – Defence Estates
- MoD – Library Whitehall
- MoD – Safety Services*
- Public Record Office
- Aerial photographs from non-standard sources
- Local Libraries and Historical Archives
- Specialist commercial organisations in the defence sector – Historical Archives
- Specialist Consultants

* Services such as DRPS (Radioactive substances), EOD (Explosive Ordnance Disposal), DERA/CAMR (Porton Down), etc.

These specialist information sources do not all offer a commercial information service like local authorities or statutory bodies. Enquiries can be difficult to make and replies can take several weeks. Many of the information sources may require a personal visit.

4.3 Site Inspection and Investigation

Reference should also be made to Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

4.3.1 Site inspection

The site inspection visits should always be based on the maximum available information that can possibly be obtained from the desk study phase. The site inspection may be conducted in two parts where a return visit is conducted if the initial visit identifies areas that required further documentary research.

Site inspection staff will need to be equipped with the relevant level of PPE (personal protective equipment) and should have appropriate training and experience (see Section 7 for health and safety aspects).

At operational sites, access may be restricted due to site safety or security procedures and site specific procedures may need to be followed when carrying out inspection or intrusive works.

4.3.2 Site investigation

The DETR (1997) and DoE (1994) documents describe the generic aspects of site investigations.

Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03 should also be referred to for particular investigation requirements.

Approach to Site Investigations

The approach should depend on the potential hazards identified by the desk study. Acute risks will need to be identified and addressed as part of a safety risk assessment.

Where site investigation work is required in the context of Part IIA the MoD may prefer to undertake the required work directly in consultation with the Environment Agency.

Investigation Design

Prior to any investigation a full safety briefing should be given to all site operatives and will require the full co-operation and appropriate participation by MoD personnel. Depending on the anticipated risk, the works can either be conducted by contractors under direct supervision of a specialist or by a specialist contractor. Under no circumstances should the work be attempted by persons who do not have appropriate training, experience or insurance to conduct such work.

The design of the investigation of an MoD site should in many instances be very similar to that conducted for conventional contaminated sites. The exceptions relate to those sites where specialist forms of contamination, such as explosives, buried munitions, chemical weapons, radioactive materials or biological weapons, require certain restrictions on conventional methods of intrusive investigation or the use of specialist techniques.

As an example, where unexploded ordnance or explosive substances are suspected conventional borehole drilling may not be appropriate. In such circumstances it is appropriate to prioritise the possible risk which may mean that until the greatest risk is mitigated (e.g. the clearance of explosives), no other forms of site investigation should take place.

The distribution of exploratory points on an MoD site may differ from a conventional site where those areas shown to be more remote or apparently unused may be investigated to a much lesser degree than an area of obvious industrial activity. Consideration should be given to allocating a higher priority than normal to such areas where:

- there are doubts concerning the completeness of desk study information on an MoD site; and

- given the experiences of investigators in finding unexpected problems in remote or apparently natural areas of such sites.

Alternatively appropriate geophysical scanning techniques may be used in such areas to determine whether there is evidence of ground having being disturbed.

Reference should be made to Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03 for the applicability of investigation techniques to the principal potential pollutant linkages.

Sampling Techniques

In general, those techniques employed for conventional site investigations can be used. Where the risk of military related contaminants are identified such as explosives, chemical warfare agents or radioactive contamination, reference should also be made to the specialist requirements within Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

Chemical Analysis

There is a wide range of contaminants that may be encountered on MoD sites. The relevant DoE Industry Profiles can be used to assist in the choice of the contaminant suite. For guidance on the analysis of specialist contaminants, such as explosives and chemical warfare agents, reference should also be made to Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

5. SITE EVALUATION

KEY QUESTIONS ANSWERED IN THIS SECTION

1. What are the primary pollutant linkages that should be assessed?
2. Which pollutant linkages are likely to be the most significant?
3. When is it appropriate/inappropriate to apply conventional risk assessment methods to this category of Special Sites?

5.1 Scope

This section is intended to supplement the relevant Model Procedures (DETR (in preparation)) and DoE (1994)) and associated guidance on risk estimation and risk evaluation. Further details are provided in Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

5.2 Pollutant Linkages

5.2.1 Principal issues

Any risk assessment should be conducted in line with the Model Procedures (DETR, in preparation). For assessments of MoD Land the special considerations given below should also be addressed.

5.2.2 Acute risks

Given the wide variety of possible risks associated with MoD Land, the principal pollutant linkages will vary between different sites. In general the risk from explosives (including explosive devices), and chemical weapons agents will outweigh the risk from conventional contaminants where these types of contaminants are present. The acute risk to human health is therefore paramount.

Acute risks on MoD Land will result mainly from significantly contaminated soils/residues or from explosive devices contained in shallow soils or incorporated into the fabric of buildings. In assessing risk, it is important to consider all the likely current and future receptors which can be identified within the current permitted uses.

5.2.3 Chronic risk

Human Health

In most instances conventional contaminants on MoD sites are not present in sufficiently elevated concentrations to present an acute risk. Hence the potential chronic risks associated with this type of contamination are frequently the main priority. Explosives, radioactive and chemical weapons agents at low concentrations should also be considered to present a chronic risk. Reference should be made to the specific risks identified in Environment Agency R&D Technical Report P5-042/TR/02 and R&D Technical Report P5-042/TR/03.

Water Environment

Many MoD sites will be associated with the presence of mobile or water soluble contaminants, notably hydrocarbon contamination resulting from the use and storage of fuels. Hence, depending on the hydrological and hydrogeological contexts, there may be a significant risk of surface water or groundwater pollution associated with MoD sites. Many MoD sites are located over major aquifers. For example many of the airbases in East Anglia are located over the chalk, which is the main source of potable water for the area.

It is appropriate to use conventional risk assessment models and frameworks to assess the risk of such contaminants to the water environment.

Ecological Systems

Pollutant linkages relating to harm to flora and fauna are an important issue with MoD sites as these installations are often located in open and remote areas and the vegetation may not have been subjected to agricultural methods. Also, the large size of many MoD sites raises the possibility that several different habitat types could fall within the boundaries of the land. Key considerations include:

- the potential for MoD sites to be located near to (or even to be included within their boundaries) sensitive ecological sites such as SSSI's (Sites of Special Scientific Interest);

- given the remoteness and sparse layout of explosives sites, it is common to have a variety of wildlife habitats on a site. Some habitats have formed or survived only because the site has been securely fenced to exclude human intervention for many years. Common fauna found on MoD sites (including operational sites) can include: badgers, deer, rabbits, newts, bats, birds of prey, foxes and grass snakes.

The main risk to ecological systems from MoD sites is likely to be associated with water pollution (see above).

Buildings

Contamination within buildings should be addressed based on their former and current use.

It is important to prioritise any buildings which have been used for explosives processing or storage as the building may have become impregnated with explosives and may offer an explosive risk. Reference should be made to Environment Agency R&D Technical Report P5-042/TR/03.

Radioactivity

Particular attention should be paid to the potential presence of radioactive sources and radioactive contamination. Radioactive sources may be present within instruments and equipment, particularly within laboratories. Former luminising workshops may be radioactively contaminated.

Radioactive contamination may be present within waste materials, ash and clinker. If found in large enough concentrations, these may offer an unacceptable risk to site occupants. It must be remembered that radioactive materials are not defined as "substances" under Part IIA (EPA 1990) but nevertheless must be considered from a health and safety standpoint if inspecting a site under Part IIA.

5.3 Site Evaluation Check-list

Have the specific uncertainties associated with explosives, radiation, biological & chemical weapons been considered?
Is there an explosion risk and if so has this been evaluated to both on site and possible off site receptors?
Is there an unacceptable radiation risk ?
Is there a toxicological risk and if so has this been evaluated against appropriate guideline values?
Is the consultant/contractor conversant with legislation relevant to MoD sites (see Section 7)?
Given the risk on-site, does the consultant/contractor have insurances that specifically cover working with explosives, chemical warfare agents or radiation?
Does the consultant/contractor have appropriate licences to work with explosives, chemical weapon agents or radiation?
Do MoD Safety Services need to be informed of the potential site works? (Note: The HSE does not have jurisdiction over MoD sites)?
Has a risk assessment been conducted that specifically addresses all of the anticipated risks e.g. explosives, chemical weapon agents and radiation?
Have the relevant authorities been informed, for example Police, Joint Services Explosive Ordnance Disposal and Emergency Planning departments as required?
Have non-intrusive or remote techniques been considered where an acute risk exists?
Is on site screening/analysis required?
Are there any other receptor groups at risk and if so have they been evaluated?
Is laboratory testing addressing the potential acute risks in the correct order (generally explosives, radiation and then biological/chemical warfare agents)?
Do specialist laboratories need to be used?
Is specialist assistance/knowledge required ?

6. REMEDIATION ASPECTS

KEY QUESTIONS ANSWERED IN THIS SECTION

1. Which remediation technologies could be appropriate?
2. What are the main constraints and advantages to each of the applicable remediation technologies/engineering methods?
3. What are the anticipated perception/community impacts of the remediation technologies?
4. How can the remediation technology be validated?

6.1 Scope

This section is intended to provide details on the most applicable remediation technologies which are currently available (or are likely to be available in the near future) on a commercial scale within the UK. In essence, remediation requirements are likely to be those detailed for other conventional sites or other categories of Special Sites. On current MoD sites, where remediation work is required, it is likely, in practice, to be undertaken directly by the MoD.

6.2 Special Considerations for Remediation of MoD Land

As stated in Section 6.1, actual remediation requirements and work is unlikely to differ for MoD Land from other conventional or Special Sites. Some situations may require more consideration and may restrict some site activities.

Special consideration should be given to the operational status of much MoD Land. Day to day military activities will generally continue regardless of other work on site. Disruption to military activities is generally not tolerated except under special circumstances. Consideration should be given to the requirements of site security and general site operations.

The wide range of activities on MoD Land may also lead to a wide range of contaminants that require remediation. This may require a series of remedial techniques to be employed and a single technique is unlikely to be suitable for the wide range of circumstances which may be encountered.

6.3 Explosive Ordnance Disposal

Where ordnance has been identified as being present, only specialised consultants/contractors holding appropriate licences, insurances and trained personnel should be commissioned to conduct such work. Further details on explosive contamination is given in Environment Agency R&D Technical Report P5-042/TR/03.

6.4 Social Concerns and Perceptions

Contaminated land can be an emotive issue with the general public particularly for MoD establishments. This concern is often driven by a lack of knowledge and understanding of the facts.

When an MoD site has been suspected by sections of the local population of being contaminated or is being remediated in preparation for closure or disposal it is important to answer these social concerns and perceptions. This can be addressed by a mix of technical and managerial actions such as:

- a communication plan should be developed to ensure that background and historical facts about the site are clear to prevent rumour;
- it may be necessary to demonstrate the successful remediation of other similar sites; and
- the remediation plan standards may have to take some account of public concerns.

6.5 Validation

The process of validating the success of a remediation exercise on an MoD site is, in principle, no different to the approach used for validating other remediation projects and hence no specialist guidance is required in this respect. Where specialist contaminants are involved reference should be made to Environment Agency R&D Technical Report P5-042/TR/02, R&D Technical Report P5-042/TR/03 R&D Technical Report P5-042/TR/06.

7. HEALTH AND SAFETY

KEY QUESTIONS ANSWERED IN THIS SECTION

1. What legislation specific to MoD Land is relevant?
2. What working methods should be adopted for MoD sites?
3. What specialist equipment is required?

7.1 Scope

Health and safety considerations are a statutory obligation for work on all contaminated sites. Within this section only the specific health and safety guidance which relates to work on MoD Land is included.

General guidance on health and safety issues for work on contaminated sites can be found in HSE (1991); CIRIA (1996); Thomas Telford (1993); and BDA (1992).

7.2 Specialist Legislation

Specialist legislation relating to MoD sites may include:

- the Ionising Radiation Regulations 1985;
- the Radioactive Substances Act 1993;
- the Explosives Act (1875) and (1923);
- the Control of Explosives Regulations (COER) 1991 & amendments;
- the Manufacturing & Storage of Explosives Regulations. (2000), (currently in draft which is intended to replace the Explosive Acts);
- the Packaging of Explosives for Carriage Regulations (PEC) 1992;
- the Classification and Labelling of Explosives Regulations 1983; and
- the Road Transport (Carriage of Explosives) Regulations 1989.
- Reference should also be made to Environment Agency R&D Technical Report P5-042/TR/02, R&D Technical Report P5-042/TR/03 R&D Technical Report P5-042/TR/06.

7.3 Specialist Working Methods and Equipment

The overriding messages in the following sections are:

- the need for use of safety risk assessment as a standard tool;

- those carrying out risk assessments and work on MoD Land should be experienced and trained in dealing with explosives, radiation and chemical and biological weapons and be conversant with the peculiarities of MoD sites;

- those working on operational sites should be aware of the Health and Safety Plan specific to the particular site; and

- approval should be sought from the appropriate MoD authority on the site who will advise on the restrictions regarding health and safety.

7.3.1 Working methods

The following points give an indication of the issues associated with working on these types of site:

- CDM (Construction Design and Management) Regulations require that operatives are 'competent' and trained in safety management. Operatives carrying out investigative and remedial works on sites where explosives, radiation and chemical and biological weapons may be encountered should have experience of this type of investigation, and be familiar with the issues relating to such contamination;

- those carrying out investigations on sites with any risk from explosives, radiation and chemical and biological weapons should have training and experience in the recognition and safe management of such issues;

- a great deal of care and experience is needed when choosing the type of equipment for the investigation and the implications this has for the health and safety of those using it, particularly where a combined risk of explosives, radiation and chemical and biological weapons may exist;

  – Without prior investigation work, the use of boreholes on an explosive site is not an acceptable method of ground investigation.

  – Greater emphasis should be given to the use of specialist non-intrusive investigation techniques on MoD Land principally to reduce the risk associated with explosives and unexploded ordnance.

  – Non-sparking tools are particularly important for explosive sites, along with the prohibition of use of equipment containing radio transmitters or the like.

  – Further details are given in Section 4;

- of primary importance is the need to be vigilant, particularly conditions change or unusual substances/items are encountered. In these circumstances the work should stop to allow a review of the situation and procedures. The health and safety plan should then be amended accordingly;

- a contingency plan detailing the procedures which should be followed in the event of uncovering a substance/item such as unexploded ordnance during the investigation should be included as part of the overall health and safety plan. Contingency plans should also detail procedures for the evacuation of a site, as well as a designated safety support engineer;

- smoking should not be permitted anywhere on these sites, including sites where processes may no longer be active;

- the investigation of buildings requires a specific approach and this should be highlighted in any health and safety plan if there are buildings on-site that are to be investigated;

- during investigation or remediation work unauthorised persons should be excluded. Suitable and sufficient fencing and signs should be established to provide a safe working area and to minimise the number of workers;

- handling of samples is important. With respect to explosives contamination, care should be taken not to accumulate materials since this would pose a greater risk;

- for more specific information on chemical weapons, explosives, and radiation refer to Environment Agency R&D Technical Report P5-042/TR/02, R&D Technical Report P5-042/TR/03 and R&D Technical Report P5-042/TR/06.

7.3.2 Equipment

The level of PPE (personal protective equipment) required will vary according to the results of the desk study and risk assessment. In general the PPE is the same as that which would be required for the investigation of a site with any organic contamination. It is essential that all operatives conducting the investigation have specialist training in the use of PPE.

If the desk study/risk assessment finds adequate evidence of a fire hazard (e.g. a site contaminated with white phosphorus) the use of fireproof overalls should be considered.

For more specific requirements relating to sites where chemical weapons, explosives, and radiation are anticipated refer to Environment Agency R&D Technical Report P5-042/TR/02, R&D Technical Report P5-042/TR/03 and R&D Technical Report P5-042/TR/06.

7.3.3 Health and safety check-list

Has a risk assessment been conducted which specifically addresses the health and safety issues associated with the site in question - i.e. are explosives, radiation or chemical & biological weapons anticipated?
Has a competent person been involved in the production / review of the risk assessment?
Will any of the specific legislation associated with explosives, radiation or chemical and biological weapons apply to the proposed works?
Have health and safety issues been communicated to all appropriate bodies responsible for activities on the site?
Does the Health and Safety Plan address the various contingencies in dealing with explosives, radiation or chemical and biological weapons ?
Is there a means of communicating all health and safety issues to all operatives, e.g. the importance of not handling any suspicious items and application of the ‘no smoking’ rule?
Are there any issues that require specialist assistance?

8. REFERENCES AND BIBLIOGRAPHY

Construction Industry Research and Information Association (1996) Report 132. A guide to safe working on contaminated sites. CIRIA, London.

Department of the Environment (1994) Documentary Research on Industrial Sites. Contaminated Land Research Report No. 3, Department of the Environment, London.

Department of the Environment (1996) Industry profile. Profile of miscellaneous industries, incorporating charcoal works, dry-cleaners, fibreglass resins, glass, photographic processing, printing and bookbinding works.

Department of the Environment (1996) Industry profile. Waste recycling, treatment and disposal sites: landfills and other waste treatment or waste disposal sites.

Department of the Environment (1996) Industry profile. Road vehicle fuelling, service and repair: transport and haulage centres.

Department of the Environment (1996) Industry profile. Road vehicle fuelling, service and repair: garages and filling stations.

Department of the Environment (1995) Industry profile. Oil refineries and bulk storage of crude oil and petroleum products.

Department of the Environment (1995) Industry profile. Engineering works: vehicle manufacturing works.

Department of the Environment (1995) Industry profile. Engineering works: aircraft manufacturing works.

Department of the Environment (1996) Industry profile. Chemical works: inorganic chemicals manufacturing works.

Department of the Environment (1995) Industry profile. Airports.

Department of the Environment (1995) Industry profile. Power stations (excluding nuclear power stations).

Department of the Environment (1995) Industry profile. Metal manufacturing, refining and finishing works: electroplating and other metal finishing works.

Department of the Environment (1995) Industry profile. Engineering works: shipbuilding, repair and shipbreaking (including naval shipyards).

Department of the Environment (1995) Industry profile. Chemical works: organic chemicals manufacturing works.

Department of the Environment (1995) Industry profile. Chemical works: pesticides manufacturing works.

Department of the Environment (1995) Industry profile. Engineering works: railway engineering works.

Department of the Environment (1995) Industry profile. Railway land.

Department of the Environment (1995) Industry profile. Animal and animal products processing works.

Department of the Environment (1995) Industry profile. Chemical works: explosives, propellants and pyrotechnics.

Department of the Environment (1995) Industry profile. Chemical works: fine chemicals manufacturing works.

Department of the Environment (1995) Industry profile. Engineering works: mechanical engineering and ordnance works.

Department of the Environment (1995) Industry profile. Gas works, coke works and other coal carbonisation plants.

Department of the Environment, Transport and the Regions. CLR 11. Model Procedures for the Management of Contaminated Land. Contaminated Land Research Report (in preparation).

Environment Agency (2000) - Contaminated Land Part IIA Environmental Protection Act 1990 (England). Process Documentation. The Environment Agency, Bristol.

Environment Agency (2001) R&D Technical Report P5-042/TR/2 Land Contamination Technical Guidance on Special Sites: Chemical Weapons Sites, Produced by WS Atkins for the Environment Agency, Bristol.

Environment Agency (2001) R&D Technical Report P5-042/TR/3 Land Contamination Technical Guidance on Special Sites: Explosives Manufacturing Sites, Produced by WS Atkins for the Environment Agency, Bristol.

Environment Agency (2001) R&D Technical Report P5-042/TR/5 Land Contamination Technical Guidance on Special Sites: Petroleum Refineries, Produced by WS Atkins for the Environment Agency, Bristol.

Environment Agency (2001) R&D Technical Report P5-042/TR/6 Land Contamination Technical Guidance on Special Sites: Nuclear Sites, Produced by WS Atkins for the Environment Agency, Bristol.

Health and Safety Executive (1991) Protection of workers and the general public during the development of contaminated land, HSE Guidance note HS (G) 66, Stationery Office, London.

SNIFFER (1999) *Communicating Understanding of Contaminated Land Risks*. Environment Agency R&D Technical Report P142.

Thomas Telford (1993) Guidelines for the Safe Investigation by Drilling of Landfills and Contaminated Land. *Site Investigations Steering Group Publications No.4,* Thomas Telford, London.