7. GROUND CONDITIONS

7.1 Introduction

This chapter of the Defence Exempt Environmental Appraisal (DEEA) provides an assessment of ground conditions in terms of soils and groundwater beneath the Application Site which includes the Proposed Development, construction areas and access / egress routes.

An assessment has been undertaken to ascertain whether, and to what extent, the Proposed Development and the environment may be impacted by the ground conditions regarding potential radiological and chemical contamination from either current or historical use at the site. This assessment has enabled the refinement of a Conceptual Site Model (CSM) showing potential sources, pathways and receptors of identified contaminants and allows the determination of the significance of any impacts for the Proposed Development. Furthermore the risk to construction workers, future site users and environmental receptors has been concluded and assessments of residual and cumulative impacts of the Proposed Development have been made.

This chapter has been written by the RPS Group and URS Corporation and refers to and summarises the technical information and interpretations provided in *Technical Appendix A* of Volume II of this DEEA.

7.1.1 Proposed Development

The Application Site and the Proposed Development is described in detail within *Chapter 5: The Proposed Development* and shown in Figure 7.1. The Proposed Development consists of the following main elements:

1) The permanent features:
   - Operations Building with a Lightning Protection System comprising eight lightning conductor towers in the centre of the Hydrus Development Site;
   - Support Building in the north-east corner of the Hydrus Development Site; and
   - Electrical Substation in the west of the Hydrus Development Site.
2) The use of two existing construction enclaves; the Central Area Construction Enclave (CACE) and the West End Construction Enclave (WECE). These will encompass material lay-down areas, prefabrication areas and a refuelling area, and construction office accommodation for construction management and welfare buildings. Further details of the construction enclaves, can be found in *Chapter 6: Construction Phase* of this DEEA; and
3) The permanent external works which includes a Sustainable Drainage System (SuDS), landscape strategy proposals, access / circulation routes and lighting. Further details can be found within *Chapter 13: Landscape and Visual* of this DEEA.

7.2 Planning Policy and Context

Redevelopment of brownfield land must:

- Take into account the regulatory context of the proposal site and development;
- Provide information that it is fit for purpose; and
- Be in accordance with UK legislation, policy and guidance.

An environmental appraisal of the condition of a site must not only consider the potential receptors of human health and controlled waters but include a review of the relevant legislation and planning policy that applies to the site and its immediate environment.

The following sections discuss regulatory documentation of importance with regards to redevelopment of Brownfield land from a National, Regional and Local government perspective. Further information can be found in C*hapter 3: Planning and Policy Context* of this DEEA.

7.2.1 Legislation

The main legislative drivers for managing risks to human health and the environment from historical land contamination including that of a radioactive nature are:

- Part IIA of the Environmental Protection Act (EPA), 1990 (the “contaminated land” regime) (Ref. 7-1);
- Contaminated Land (England) Regulations, 2006 (Ref. 7-2);
- Radioactive Contaminated Land (Modification of Enactments) (England) Regulations, 2006 (Ref. 7-3);
- Groundwater Regulations, 1998 (Ref. 7-4);
- The Water Resources Act, 1991 (Ref. 7-5);
- The Water Act, 2003 (Ref. 7-6); and
- The Town and Country Planning Act, 1990 and subsequent amendments (Ref. 7-7).

In England, Part IIA of the EPA, as introduced by Section 57 of the Environment Act 1995, (Ref. 7-8) came into effect in England in April 2000 with the implementation of the Contaminated Land Regulations 2000 (now superseded by The Contaminated Land Regulations 2006 and The Radioactive Contaminated Land (Modification of Enactments) Regulations 2006). Under Part IIA of the EPA, sites are identified as ‘contaminated land’ if they are causing, or if there is a significant possibility of causing significant harm, or if the site is causing or could cause pollution of controlled waters. Controlled waters are defined as including both surface waters and groundwater. Once a site is determined to be “contaminated land” then remediation is required to render significant pollutant linkages (i.e. the source-pathway-receptor relationships that are associated with significant harm and/or significant pollution of controlled waters) insignificant, subject to a test of reasonableness.

The Building Act 1984 (Ref. 7-9) and the Building Regulations 2000 (Ref. 7-10) are the two key legislative drivers when considering structural and design aspects of a development in terms of geotechnical properties of the ground and the presence of gas. The Regulations also require that buildings are constructed so that ground movement caused by swelling, shrinkage, freezing, landslip or subsidence of the sub-soils will not impair the stability of any part of the building.

7.2.2 National Planning Policy

7.2.2.1 Planning Policy Statement (PPS) 23: Planning and Pollution Control

Land contamination and its risk to health is a material consideration under planning and development control and apply to the intended use of the site. Existing guidance on assessing risks to health under the Town and Country Planning Acts is limited to the amended Planning Policy Statement 23 (PPS23): Planning and Pollution Control (Ref. 7-11), which more clearly aligns the requirements under planning with those under Part IIA of the EPA. This is consistent with the practical requirements that, under planning, a site for its intended or proposed use should not fail the requirements for classifying a site as contaminated land under ‘Part IIA’ when the site is occupied and in use.

The overall aim of planning and pollution control policy is to ensure the sustainable and beneficial use of land, in particular encouraging the re-use of previously developed land in preference to Greenfield sites.

7.2.3 Regional Planning Policy

The Regional Spatial Strategy (RSS) the South East Plan (Ref. 7-12) provides general guidance for development planning throughout the Region. It states that local authorities and key agencies can play a role in improving the local environment and public health and safety, including restoring derelict and contaminated land.

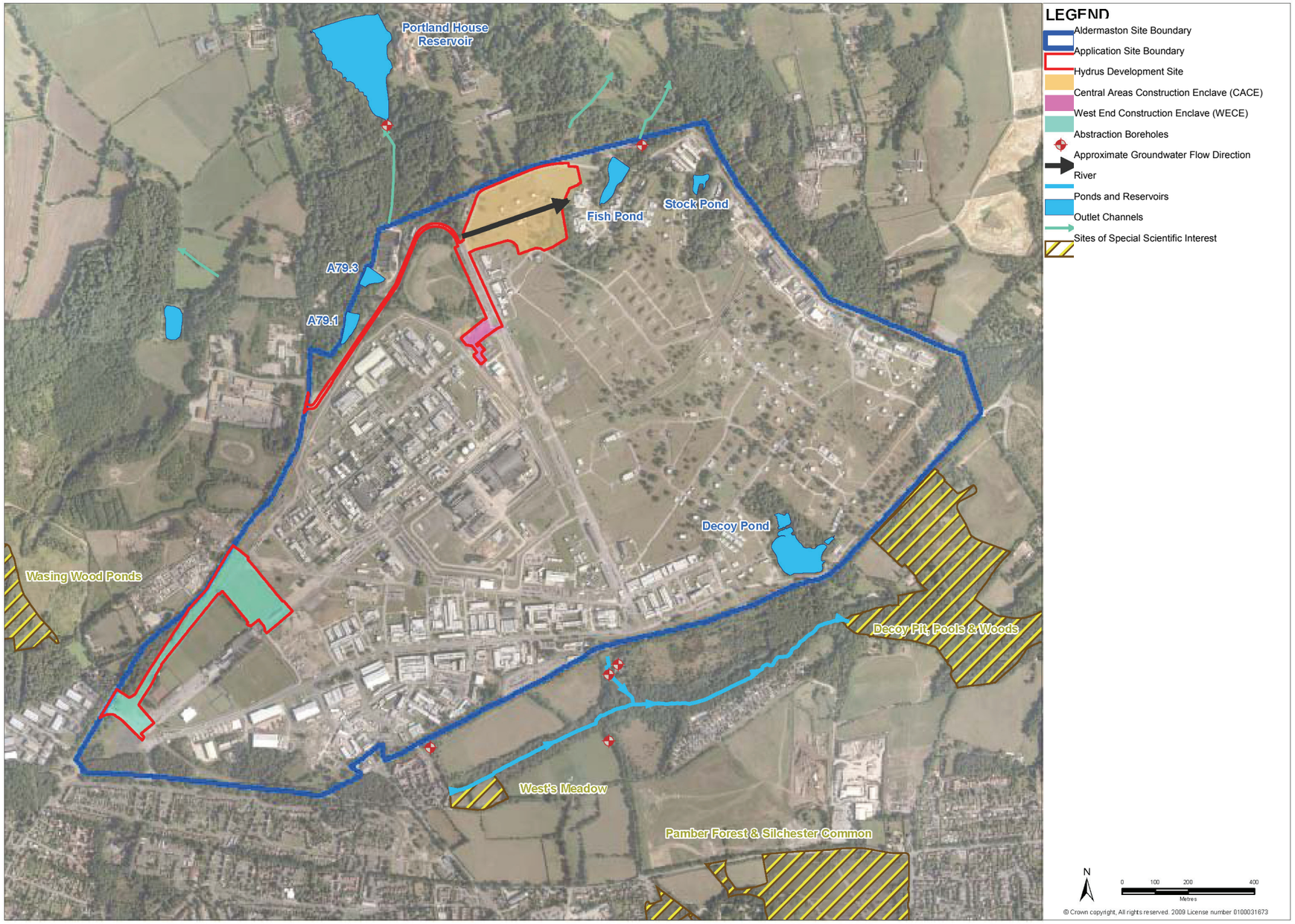
7.2.4 Local Planning Policy

The following local planning documents have been reviewed, but do not contain any specific policies relating to land contamination:

- The adopted West Berkshire District Local Plan 1991-2006 Saved Policies (Ref. 7-13); and
- The newly evolving Local Development Framework (LDF), including documents that will inform the West Berkshire Planning Strategy.

It is therefore considered that the overriding policy document that sets the context for this chapter is PPS 23. However, West Berkshire Council in association with neighbouring Local Authorities has produced a document entitled “The Berkshire Guide to Developing Potentially Contaminated Land” (Ref. 7-14). This document guides developers in the content of contaminated land reports submitted to local planning authorities within the area. Under the Town and Country Planning regime, the responsibility for providing information on whether a site is contaminated rests primarily with the developer.

Figure 7-1: The Application Site



7.2.5 National Guidance

All works proposed on the Application Site shall be undertaken in line with relevant national guidance and best practice, including:

- Pollution Prevention Guideline 6: Working at demolition and construction sites (Environment Agency) (Ref. 7-15);
- Pollution Prevention Guideline 8: Safe Storage and Disposal of Fuel Oils (Environment Agency) (Ref. 7-16);
- Groundwater Protection: Policy and Practice (GP3) (Environment Agency) (Ref. 7-17);
- Construction Industry Research and Information Association (CIRIA) 132: A guide for safe working on contaminated sites (Ref. 7-18);
- CIRIA C665, Assessing risks posed by hazardous ground gases to buildings (Ref. 7-19); and
- CIRIA 73: Role and responsibility in site investigation (Ref. 7-20).

7.3 Assessment Methodology and Significance Criteria

7.3.1 Approach

The assessment of ground conditions has involved the review of available information pertaining to the current condition of the soils and groundwater beneath the Application Site. This information has been used to develop an understanding of baseline conditions for the Application Site. The information has been reviewed in the context of the Proposed Development to create a Conceptual Site Model (CSM) and evaluate the short, medium and long term, direct and indirect, permanent and temporary, adverse and beneficial impacts associated with it.

Ground conditions within CACE have already been assessed as part of the High Explosives Fabrication Facility (HEFF) planning application which was granted planning permission from West Berkshire Council in February 2008 (Planning Reference: 07/02438/COMIND). Ground conditions within WECE have already been assessed as part of the New Office Accommodation (NOA) planning application which was granted planning permission from West Berkshire Council in February 2007 (Planning Reference: 06/02326/COMIND). The Proposed Development does not include any changes to the existing use of the CACE and WECE, and therefore no additional potential impacts will be introduced. Consequently, these areas are not considered in this assessment, which principally focuses on the proposed Hydrus Development Site.

Many intrusive ground investigations have been undertaken at AWE Aldermaston, some of which cover parts of the Application Site and more specifically the Hydrus Development Site. Investigations have provided a database of soil and groundwater chemistry, gas and / or radiological data. The previous investigation and monitoring programmes containing ground investigation information most relevant to the Application Site that have been used in this assessment are summarised in Table 7-1.

Table 7-1: Previous Studies and Investigations

Report	Site Investigation Locations Utilised*	Report Reference
Golder Associates (UK) Ltd. New HR Facility Ground Investigation Fieldwork Report. AWE Aldermaston.	BH0900-0912, BH0926-0929, TP0913, TP0915-0925, TP0930, TP0932-0935	Ref. 7-21
Golder Associates (UK) Ltd. SCRT 2: B Area North Exploratory Investigation Report. AWE Aldermaston.	BH0330-0333, BH0364, BH0396-0398	Ref. 7-22
BAE Systems. Land Quality Assessment Report. B Area North, AWE Aldermaston.	BAEBH1-3, BAETP1-5 (plus numerous building footprint soil samples)	Ref. 7-23
Atkins. Factual Report on Geotechnical Ground Investigation. AWE Aldermaston Project Hydrus.	CP1001-1003, R1001-1007, TP1001-1020, ENV001	Ref. 7-24
RPS. Ground Investigation Interim Factual Report. Project Hydrus, AWE Aldermaston.	BHHYD01-03, WSHYD-04-06	Ref. 7-25
ESIIMS format ground investigation data received from AWE following request for information. Original reports not available for reference.	ST13A, ST14, CACE_TP3, CACE_TP5-8, EBH7, EBH8, EBH8A, EBH11, EBH11A	Not available

* This only includes ground investigation locations that contain sample information remaining at Hydrus Development Site following proposed excavations.

All soil and groundwater, chemical and radiological data used in this assessment has been provided by AWE in an electronic format. Ground investigation information provided has been qualitatively and quantitatively assessed depending on the proposed future use(s) of the Hydrus Development Site as permanent or temporary. This will be further discussed in Section 7.3.3. All relevant technical assessments and supporting analytical datasets are provided in the RPS Ground Conditions Technical Report (GCTR) located within *Technical Appendix A* of this DEEA.

7.3.2 Supporting Information

In addition to the historical reports highlighted, the following data sources have been reviewed:

- Envirocheck Report, AWE Aldermaston (Ref. 7-26);
- BAE Systems Environmental, Verification Report, AWE Aldermaston B Area North Decontamination and Demolition (Ref. 7-27);
- Solid & Drift Geology, 1:50,000 scale, Sheet 268 (Reading), British Geological Survey (Ref. 7-28); and
- Groundwater Vulnerability Map of Upper Thames & Berkshire Downs (Ref. 7-29).

7.3.3 Baseline Assessment Methodology

Baseline conditions regarding chemical and radiological contamination and ground gas was established using the aforementioned information and the appraisal methods set out in the following sections. Additional supporting technical details regarding baseline assessments are provided in *Technical Appendix A* of this DEEA. A Remediation Statement has been prepared for the Hydrus Development Site and remedial measures associated with the Proposed Development are summarised in Section 7.6 of this DEEA. The Remediation Statement is also provided in *Technical Appendix A* of this DEEA. A report detailing the piling activities associated with the development has been prepared and is also provided in Appendix A. The report includes an assessment of the environmental risks associated with piling. The findings of the piling report are summarised in Section 7.6.12. and 7.6.1.3 of this DEEA.

7.3.3.1 Human Health Assessment of Soil Contamination

Human health risk assessment has been undertaken in accordance with regulator approved Contaminated Land Exposure Assessment (CLEA) guidance and associated modelling software. (Ref. 7-30 and Ref. 7-31). The assessment has used Soil Guideline Values (SGVs) (Ref. 7-32) for a commercial industrial land end use to enable consideration of the risks posed by potential chemical contaminants in soil at the Hydrus Development Site. In the absence of SGVs Generic Assessment Criteria (GACs) developed by Land Quality Management (LQM) (Ref. 7-33) have been used as the basis for the assessment.

Some areas of the Application Site are proposed for temporary use(s) during the construction phase, namely the CACE and the WECE. The short-term risk to construction workers becoming exposed to contaminants does not necessarily require the use of CLEA and can be managed through the application of CDM "2007 Regulations" (Ref. 7-34) and the adoption of Safe Systems of Work (SSoW). Consequently, no further assessment of ground conditions within the WECE and CACE areas have been undertaken as part of this DEEA.

7.3.3.2 Assessment of Groundwater Quality

Groundwater quality has been assessed using a Tier 1 assessment which was carried out in line with published guidance (Ref. 7-35). The Tier 1 assessment involves the screening of Contaminants of Concern (COC) against accepted water quality standards in order to identify any potential contaminants requiring further assessment. The water quality standards used within this assessment are as follows:

- Environmental Quality Standards (EQS) (Ref. 7-36) for the assessment of water quality with respect to impact upon freshwater in surface water courses; and
- Revised Drinking Water Standards (DWS) (Water Supply (Water Quality) Regulations (2000)) (Ref. 7-37) for the evaluation of potential human health risks associated with the ingestion of either groundwater or surface water.

Where concentrations exceed the Tier 1 assessment criteria, it is considered there is a risk that controlled waters are potentially being adversely affected by identified COC. This indicates a requirement for further detailed quantitative assessment (DQRA) (Tier 2). This further assessment has involved a detailed review of the spatial and temporal variability of the potential contaminants in groundwater and the identification of any link between observed groundwater source and potential sources within overlying soils, and has identified contaminants for which detailed quantitative risk assessment is required. All technical assessments undertaken with respect to groundwater are presented in the *GCTR* provided in Technical *Appendix A* of this DEEA. Notwithstanding it is important to recognise that the presence of a detectable concentration of any particular contaminant does not necessarily indicate a risk to human health or the environment.

7.3.3.3 Radiological Assessment of Soil and Groundwater

Radiological assessments of soils and groundwater must adhere to current UK guidance and legislation including the Nuclear Installations Act 1965 (Ref. 7-38), Radioactive Substances Act 1993 (RSA 93) (Ref. 7-39), the Radioactive Substances (Substances of Low Activity ((SoLA) (Ref. 7-40) and Phosphatic Substances, Rare Earths etc) Exemption Orders (Ref. 7-41), and Ionising Radiation Regulations 1999 (Ref. 7-42).

AWE considers background gross alpha and beta radioactivity to be 0.7 and 0.6 Becquerels per gram (Bq/g) respectively. Taking into account the 0.4 Bq/g level given by the SoLA Exemption Order (see *Technical Appendix A*), a contamination screening level of 1.1 Bq/g for gross alpha and 1.0 Bq/g for gross beta is used by AWE which can be useful in providing an indication (when compared to known background levels) of the magnitude of any contamination present. Samples with gross alpha activity greater than 1.1 Bq/g or gross beta activity greater than 1.0 Bq/g have been subject to further detailed radiochemistry and gamma spectrometry analysis respectively, to determine the significance of the detected gross alpha and gross beta analysis.

When assessing radioactivity in groundwater, AWE has adopted 'Threshold Levels' for gross alpha (40 Bq/m^3) and gross beta (500 Bq/m^3) radioactivity based on AWE's RSA 93 arrangements for environmental monitoring for radioactivity within and around AWE sites. Any noted exceedances undergo plutonium and uranium isotopes analysis (Uranium-234, Uranium-235, Uranium-238, Plutonium-238, Plutonium-239 and Plutonium-240); with detection of elevated levels requiring notification to the Environment Agency. The World Health Organisation (WHO) drinking water standards (Ref. 7-43) screening level for gross alpha radioactivity is 500Bq/m^3 and for gross beta radioactivity is 1000Bq/m^3, which are both higher and therefore less stringent than AWE's threshold screening levels.

7.3.3.4 Soil Gas Assessment

An assessment to determine the risk posed by ground gases (principally carbon dioxide and methane) has been undertaken in accordance with British Standard BS8485: 2007 (Ref. 7-44) and CIRIA Report C665. To determine the potential risk posed by ground gas, a screening criteria of 1% (by volume) methane and 1.5% (by volume) carbon dioxide has been adopted. Where concentrations exceed these 'threshold' levels, a qualitative risk assessment is undertaken in accordance with the above guidance.

Gas Screening Values (GSVs) are calculated from flow measurements and gas concentrations. Characteristic Situations are then determined from the measured GSV. In accordance with BS8485: 2007, it is also appropriate to consider borehole gas flow rates and concentrations on a location by location basis where there is a comprehensive dataset. Where gas fluxes exceed the criteria set for Characteristic Situation 1, further assessment may be required to assist with detailed design of the mitigation measures.

To provide a robust and defensible gas risk assessment to manage the uncertainty that always exists with soil gas monitoring data, CIRIA Report C665 presents guidance on the number of monitoring rounds and their frequency and duration. The requirement for monitoring is based on the gas generation potential of the identified sources and the sensitivity of the development.

Gases may cause a human health risk from asphyxiation (e.g. carbon dioxide) or from explosion (e.g. methane). Consequentially the most sensitive receptor of soil gas risk relates to the Proposed Development buildings that could allow the potential accumulation of soil gas.

The soil gas assessment utilises historical and recent gas monitoring datasets, which includes six monitoring rounds that encompass atmospheric pressures ranging from 987 – 1015 mb. The number and frequency of monitoring rounds satisfy all UK guidance and therefore provide a robust dataset for the Proposed Development.

7.3.4 Impact Assessment Methodology

A review of baseline conditions for the Application Site was undertaken to enable the nature of potential impacts associated with the Proposed Development to be evaluated. The significance of a potential impact is dependent on the magnitude of the impact and the importance of the attribute (or receptor) affected. The importance of attribute that may potentially be affected by the development are determined in accordance with Table 7-2. The magnitude of the potential impacts, are then assessed above the pre-defined baseline conditions, prior to the consideration of mitigation measures, as set out in Table 7-3. The significance of residual impacts is assessed in accordance with criteria in Table 7-4, and reflects the incorporation of mitigation methods.

7.3.4.1 Importance of Baseline Attributes

The Conceptual Site Model developed for the Hydrus Development Site allows all potential receptors that may be affected by ground conditions on the site to be identified. The importance of identified receptors is then defined, based on an assessment of their quality to both the human and natural environment. Table 7-2 outlines the criteria used to make this judgement and provides examples for each importance rating.

Table 7-2: Importance of Baseline Attributes

Importance	Description	Example
Very High	Attribute with a high quality and rarity on a regional or national scale with limited potential for substitution.	Major aquifer providing a regionally important resource or supporting site protected under wildlife legislation. Source Protection Zone (SPZ) 1.
High	Attribute with a high quality and rarity on a local scale with limited potential for substitution, or attribute with a medium quality or rarity on a regional or national scale with limited potential for substitution.	Major aquifer providing locally important resource or supporting river ecosystem. SPZ2.
Medium	Attribute with a medium quality and rarity on a local scale with limited potential for substitution, or attribute with a low quality and rarity on a regional or national scale with limited potential for substitution.	Aquifer providing water for agricultural or industrial use with limited connection to surface water. SPZ3.
Low	Attribute with a low quality and rarity on a local scale with limited potential for substitution.	Non-aquifer unit.

7.3.4.2 Impact Magnitude Assessment

The magnitude of any predicted impact is determined by consideration of the following:

The temporal scale of individual effects is described as either **short, medium or long-term**; short term relates to the construction phase, medium term extends from 1-5 years from the end of works, and long-term extends beyond 5 years from the end of works.

Direct or Indirect Effect: if the receptor will be affected directly or indirectly.

Temporary or Permanent: effects may occur over the life time of the scheme or may occur for a limited period of time e.g. whilst a specific construction activity is taking place.

Reversible/Irreversible Effect: effects can be reversed by mitigation measures or by natural environmental recovery within reasonable timescales (5-10 years following cessation of operations).

Geographical Scale: whether the effect will be felt at local, regional or national level.

The magnitude of potential impacts (using worst case scenarios) during the operational and construction phases of the Proposed Development have been qualitatively described and categorised based on the terminology in Table 7-3.

Table 7-3: Impact Magnitude Criteria

Impact Magnitude	Criteria	Example / Description
Major	Results in loss of attribute and likely to cause exceedance of statutory objectives and/or breaches of legislation	Contamination of a potable source of water abstraction
Moderate	Results in impact on integrity of attribute or loss of part of attribute possibly with / without exceedance of Statutory objectives or with/ without breaches in legislation.	Reduction in the value of the feature
Minor	Results in minor impact on attribute	Measurable changes in attribute, but of limited size and/or proportion
Negligible	Results in no discernible change or an impact on attribute of insufficient magnitude to affect the use / integrity	Discharges to watercourse but no significant loss in quality of the feature

7.3.4.3 Significance Criteria Assessment

The assessment takes into account any mitigation measures to be applied in the implementation of the development proposals. The criteria for classifying impact significance are summarised in Table 7-4.

Table 7-4: Impact Significance Criteria

Significance	Description
Major Adverse	Considerable detrimental impact (by extent, duration or magnitude) of more than local significance or in breach of recognised acceptability / legislation / policy standards.
Moderate Adverse	Limited detrimental impact (by extent, duration or magnitude) that may be considered significant.
Minor Adverse	Slight, very short or highly localised detrimental impact.
Negligible	No appreciable impact on the attribute, or the attribute of negligible importance
Minor Beneficial	Minor reduction in risk (slight, very short or highly localised impact)
Moderate Beneficial	Moderate reduction in risk
Major Beneficial	Major reduction in risk

The significance of an effect is then determined by considering the magnitude of the effect against the importance of the environmental feature. A matrix is used to combine magnitude and importance to generate the overall significance of the effect, as illustrated in Table 7-5.

Table 7-5: Significance of Impacts

Impact Magnitude	Importance of feature			
	Very High	High	Medium	Low
Major	Major	Major	Major	Moderate/ Minor
Moderate	Major	Major/ Moderate	Moderate	Minor
Minor	Major/ Moderate	Moderate/ Minor	Minor	Negligible
Negligible	Negligible	Negligible	Negligible	Negligible

7.4 Baseline Conditions

The baseline conditions described in this section are the ground conditions currently present within the Application Site and principally the Hydrus Development Site.

7.4.1 Site Setting

The Hydrus Development Site is situated adjacent to the northern boundary of AWE Aldermaston. AWE Aldermaston is situated south of the Kennet Valley, in Berkshire approximately 15 km south-west of Reading, on a broad flat, wooded, east-west trending plateau at an elevation of approximately 100 m AOD. AWE Aldermaston is bounded by A340 to the west and south, Reading Road to the south, Red Lane to the east, and the grounds associated with Portland House and Aldermaston Court to the north.

The Application Site is defined by the red-line boundary of the planning application as shown in *Chapter 1: Introduction* Figure 1-1 of this DEEA. Current land-use within the Hydrus Development Site is dominated by rough grassland with occasional mature trees and some areas of demolition rubble. To the south the land slopes downwards to a surface water drainage channel which drains towards a culvert which continues in an easterly direction.

7.4.2 Site History

During the 18th and 19th century, the Application Site formed part of Aldermaston Court estate. An airfield was opened in the early 1940s on AWE Aldermaston as a whole and was used up until circa 1950 for training of paratroopers, construction of light aircraft, and temporarily as a civil airport. From approximately 1950 onwards the airfield was used by AWE (see also *Chapter 14: Cultural Heritage and Archaeology*).

Prior to the 1950s the Hydrus Development Site was relatively undeveloped with mostly flat open and grassed areas interspersed with woodland. There were some areas of hard-standing, access roads and part of a runway aligned in a north-south direction.

Between 1950 and 1955 a number of buildings were constructed within the Hydrus Development Site including associated access roadways and infrastructure. The main uses of these buildings were associated with defence operations and development of components involving the use of explosive compounds. This development was supported by ancillary buildings housing compressors, a pump house, mess rooms, offices, workshops and garage. The following potential contaminants of concern have been identified in relation to these buildings:

- High Explosives;
- Solvents;
- Plastics including polymers; and
- Hydrocarbons.

There is also the potential for historical ad hoc disposal of chemicals across the Hydrus Development Site.

Between 2007 and 2008 demolition works were undertaken to clear the buildings discussed above, together with surrounding blast bund material, leaving the Hydrus Development Site flat and unoccupied. A topographic survey undertaken in December 2007 identified stockpiles of crushed concrete in the north of the Hydrus Development Site although a later topographic survey undertaken in November 2008 indicated that this material had been removed. It is understood that no further re-profiling/removal of soils has occurred on the Hydrus Development Site. However, subsequent to this survey a permanent water borehole with an associated head works chamber was installed in the north-west of the Hydrus Development Site (under permitted development rights).

7.4.3 Environmental Setting

7.4.3.1 Geology

A summary of the geological sequence underlying the Hydrus Development Site is presented in Table 7-6. This sequence is based on the published geology and the review of available geological logs in and surrounding the Hydrus Development Site as described in the *GCTR* in *Technical Appendix A* of this DEEA. A more detailed description of the site-specific geology is provided in the *GCTR*.

Table 7-6: Geological Sequence Underlying the Application Site

Unit / Formation	Description[1]	Thickness[1] (m)
Top Soil	-	Ranges from absent to 0.4 m
Made Ground	Highly variable composition. Detail provided in *Technical Appendix A-1*	Ranges from absent to 2.65 m
Silchester Gravels (formerly Plateau Gravels)	Dense, orange-brown sand and gravel with variable sand, silt and clay matrix	Ranges from absent to 3.7 m
Bagshot Formation / Transition Zone	Orange-brown grading to dark-grey sand, fine to medium grained with silt and clay lamina	0.2 m to > 17.1 m
London Clay	Firm and stiff dark bluish and grey clay, variably silty, with beds of sand and silt and flint pebble seams; variably glauconitic and shelly	Base not intercepted (maximum thickness encountered of 66.7 m)
Lambeth Group*	Comprises Harwich, Reading and Upnor Formations – typically sand and clay	Not penetrated
Upper Chalk*	Soft white nodular chalk with flint seams	Not penetrated

1 Likely thickness & descriptions taken from geological logs for intrusive locations within the red line boundary.
** Expected stratigraphy based on published geological mapping. This strata was not encountered during any of the intrusive investigations undertaken.*

7.4.3.2 Hydrogeology

The Silchester Gravels and Bagshot Formation are largely granular unconsolidated deposits that constitute a Minor Aquifer unit under the Environment Agency's Policy and Practice for the Protection of Groundwater. This indicates that they cannot support large abstractions but may constitute a locally important water resource. The Silchester Gravel and more granular upper horizons in the Bagshot Formation are generally considered to form a single unconfined aquifer unit that is approximately 5 m thick, although site-specific geological logs suggest a hydraulic distinction between the two units with the latter being more clay rich.

The Hydrus Development Site is covered by soils classified as having high leaching potential. This suggests they are capable of transmitting modest quantities of water and supporting local supplies owing to the '*coarse textured or moderately shallow soils that readily transmit non-absorbed pollutants and liquid discharges but which have some ability to attenuate adsorbed pollutants because of their clay or organic contents*'.

The Upper Chalk is located at depth beneath the Hydrus Development Site and is classed a Major Aquifer of regional importance in terms of water supply. The Chalk is concealed beneath more than 60 m of deposits of the London Clay Formation. The London Clay is considered to represent the hydraulic base to the overlying Minor Aquifer and is considered a non-aquifer. The Chalk aquifer is not considered at risk from surface activities and/or shallow perched groundwater owing to the thickness of the intervening, low permeability, clay deposits. The Chalk aquifer is not therefore considered a receptor of shallow groundwater on the Application Site. Notwithstanding it should be noted that a new water supply borehole has recently been installed in the chalk within the Hydrus Development Site boundary. This is discussed in more detail in Section 7.4.3.5 below.

7.4.3.3 Groundwater Levels and Flow

Over the wider AWE Aldermaston Site, groundwater flow in the shallow unconfined aquifer generally follows the subdued topography, diverging away from a groundwater high in the vicinity of the south-western corner of AWE Aldermaston and ultimately flowing towards the River Kennet and associated tributaries.

The predominant direction of groundwater flow in the shallow aquifer beneath the Hydrus Development Site is to the east, with levels that decline from approximately 98.0 m AOD in the west to approximately 96.6 m AOD in the east. The water table is generally situated at a shallow depth below the ground surface of between 1.4 m bgl and 3.1 m bgl.

All groundwater level data pertinent to the Hydrus Development Site used in this assessment is provided in the *GCTR* within *Technical Appendix A* of this DEEA.

7.4.3.4 Groundwater Quality

Groundwater within the shallow unconfined aquifer underlying the Hydrus Development Site is typically of neutral pH, only moderately mineralised although commonly containing some dissolved metals. The use of the shallow unconfined aquifer as a local source of water supply in the vicinity of the AWE Aldermaston attest to its generally potable nature, although some organic and inorganic contaminants are identified in groundwater as a result of historical land-use practices on the site. This is discussed further in Section 7.4.4 below.

7.4.3.5 Groundwater Abstraction

A total of twelve private and licensed groundwater abstraction sources were identified on or within 2 km of the AWE Aldermaston Site boundary in the Envirocheck Report. (*Technical Appendix A*)

AWE Aldermaston is situated above a Zone 3 (Total Catchment Area) Source Protection Zone (SPZ) defined for an off-site abstraction from the Chalk aquifer. As this SPZ is defined for the Chalk aquifer it is considered hydraulically separated from surface activities and shallow groundwater on the AWE Aldermaston Site by more than 60 m of low permeability clay deposits.

A groundwater borehole has been constructed as permitted development in the north-west of the Hydrus Development Site (see *Chapter 5: The Proposed Development Figure 5-1*). This borehole is completed in the Chalk aquifer and is not considered at risk from surface activities and/or shallow groundwater owing to the presence of more than 60 m of intervening low permeability clay. Notwithstanding suitable mitigation measures will be implemented during the construction phase to minimise any identified risks. This is discussed further in the relevant sections of this chapter.

7.4.3.6 Hydrology

The Hydrology of the Hydrus Development Site is described in detail in *Chapter 8: Water Resources* of this DEEA and summarised in this chapter. AWE Aldermaston is situated within the surface water catchment of the River Kennet. The northern parts of AWE Aldermaston, including the Hydrus Development Site, drain northwards to the River Kennet. No perennial surface water features are present within the Hydrus Development Site although an open drainage channels is present in the south of the Hydrus Development Site. The nearest perennial surface water features to the Hydrus Development Site are indicated in *Figure 7.1* and include:

- The Fish Pond (and Stock Pond) situated approximately 200 m east of the Application Site boundary;
- Portland House Reservoir situated approximately 330 m north of the Application Site; and
- Land drains and ponds situated more than 400m west of the western boundary of the Application Site.

Unnamed outlet channels emanate from each of the ponds and reservoirs identified above. These channels drain to north, ultimately discharging to the drainage network associated with the River Kennet in the valley to the north.

7.4.3.7 Buried Unexploded Ordnance and Explosive Residues

Due to the nature of the operations carried out in the former buildings within the Hydrus Development Site, there is a potential risk from contamination of soils and groundwater with explosive compounds. The results of this analysis are discussed in Section 7.4.4.6 below.

No information pertaining to the detection of buried ordnance has been obtained for the Hydrus Development Site. Despite the history of AWE Aldermaston, the possibility of encountering explosive ordnance is considered low.

7.4.4 Baseline Assessment of Site Data

The results of each baseline assessment of site-specific data is summarised below. Further information can be found within the supporting *GCTR* provided in *Technical Appendix A* of this DEEA.

7.4.4.1 Soil Chemical Analysis Results

Chemical analysis data for soils collected during the numerous investigations undertaken within the Application Site (2003 - 2009) have been reviewed and the magnitude of contaminant concentrations in soils, with respect to its potential impact on human health and controlled waters has been assessed. The investigation locations, sampling suite and chemical data is provided in the *GCTR* in *Technical Appendix A*.

Consideration of the risk posed to future Hydrus Development Site users has been undertaken in line with the methodology outlined in CLR11 for a commercial / industrial land end use scenario. Concentrations of inorganic priority contaminants are substantially below the corresponding SGVs and GACs and therefore are not considered to pose a significant risk to human health for the proposed site end use.

The concentrations of organic contaminants in soils that are to remain in-situ following redevelopment are generally below the available SGV / GAC.

In order to identify any gross contamination in shallow soils that are to be excavated and removed during redevelopment that could potentially represent a significant risk to construction workers, comparison of soil analysis data has been made against SGVs and GACs.

The calculated GAC for benzo(a)pyrene of 14 mg/kg has been exceeded on a single occasion at location BH0901 at 2.00 m bgl where a concentration of 44.64 mg/kg was detected. The risk posed to construction workers from this contamination based on its relatively low concentration and the low timeframes for exposure is considered to be low and mitigation for this is discussed in Section 7.6 of this DEEA.

No fibrous asbestos has been identified in any of the six soil samples subjected to analysis. It is considered that these provide good coverage across the Hydrus Development Site. Notwithstanding and based on the identification of asbestos in shallow soils elsewhere at AWE Aldermaston, the potential for encountering previously unidentified Asbestos Containing Materials (ACMs) during redevelopment cannot be totally discounted.

The risk that soil contamination within the CACE poses to construction workers is considered extremely low considering the ground surface within the CACE will not be disturbed and is predominantly covered in hard-standing which provides a barrier to exposure.

The assessment of soil chemical analysis data does not demonstrate the presence of gross and/or widespread contamination in the Hydrus Development Site that represents a potentially significant risk to human health. However, a detailed review of previous investigations (Golders 2007) identified shallow soil contamination by heavy aromatic hydrocarbons (EC_{21}–EC_{35}) in the north-east corner of the Hydrus Development Site that represents a potentially significant risk to controlled waters. In the absence of suitable monitoring data for down gradient boreholes, remedial targets were derived for soils in this area. This assessment demonstrated that the observed concentrations in soils may represent an unacceptable risk to groundwater quality at the site boundary (See the QRA is presented in *Technical Appendix A*). However, as the soils in this area will be excavated as part of the Proposed Development, this potential risk would be removed. No other remediation was identified for soils on the Hydrus Development Site.

7.4.4.2 Groundwater Contamination - Chemical

The monitoring network from which baseline groundwater quality has been determined together with the supporting dataset and technical assessments provided in the GCTR (*Technical Appendix A-1*). Data has been obtained for thirty-seven boreholes situated up hydraulic gradient, down hydraulic gradient and lateral positions relative to the groundwater flow field on the Hydrus Development Site.

The Method Detection Limit (MDL) was only exceeded for approximately thirty organic substances and thirty-five inorganic parameters measured in groundwater. This dataset has been screened against relevant water quality assessment criteria and the following potential contaminants requiring further assessment were identified:

- Diesel Range Organic (DRO) Hydrocarbons – Specifically Aliphatics ($>C_{21}$-C_{35});
- Polycyclic Aromatic Hydrocarbons (PAHs); and
- Ammoniacal Nitrogen.

The potential contaminants identified in groundwater do not form well defined source areas and cannot be related to historical land use on the Hydrus Development Site. Furthermore, no link has been established between Contamination of Concern (COC) identified in groundwater and contamination identified in overlying and/or up gradient soils.

Following a detailed review of the groundwater quality dataset it was concluded that neither PAHs nor ammoniacal nitrogen constitute a risk requiring further assessment for the following reasons:

- Repeated failures of water quality assessment criteria are seldom observed where time series data is available, with concentrations commonly below the MDL in repeat samples;
- Boreholes showing concentrations above the MDL on a more routine basis are located in off-site boreholes in a lateral position to the groundwater flow field on the Hydrus Development Site; and
- Observed concentrations are generally low relative to the respective assessment criteria.

The detailed review demonstrated that further Quantified Risk Assessment (QRA) was required to determine whether aliphatic ($>C_{21}$-C_{35}) hydrocarbons in groundwater represent a risk to groundwater and surface water receptors down gradient of the Hydrus Development Site. The results of the QRA demonstrate that predicted concentrations of aliphatic ($>C_{21}$-C_{35}) hydrocarbons at the down gradient site boundary remain below the below the assessment criteria. Thus aliphatic ($>C_{21}$-C_{35}) hydrocarbons do not pose an unacceptable risk to groundwater.

7.4.4.3 Soil Radiological Analysis Results

Radiological soil analysis results from forty exploratory holes within the Application Site have been subject to assessment to establish the risk posed to future Hydrus Development Site occupants by radiological contamination at the site. Soil samples have been analysed for a range of determinants including:

- Gross alpha and beta;
- Tritium;
- Americium-241, Beryllium-7, Cobalt-60, Ceasium-137, Potassium-40, Lead-210, Radium-226, Thorium-234;
- Plutonium–238, and 239/240; and
- Uranium– 34, 235 and 238.

Additionally, consideration has been given to the potential risks posed to construction workers from radiological soil contamination within the CACE area and from soils proposed to be excavated within the Hydrus Development Site as part of the site redevelopment.

Risks to Future Site Users

Isolated soil samples originating from natural ground materials (comprising clay and gravels) were identified as exhibiting gross alpha and gross beta activity which were marginally in excess of AWE threshold values of 1.1 and 1.0 Bq/g respectively. Further radiochemical and gamma spectrometry analysis identified that gross alpha and gross beta exceedances were due to the presence of Naturally Occurring Radioactive Materials (NORM) rather than contamination due to current and historical site operations. The risk posed to future Hydrus Development Site occupants posed by the identified activity is considered to be low.

Although no tritium analysis has been undertaken on soils that are to remain in-situ following redevelopment, low tritium activity has been detected in shallow soils that are to be removed during redevelopment. The 95% UCL of 0.11 Bq/g (including the identified outlier) is significantly below the IAEA exclusion, exemption and clearance criterion of 100 Bq/g which the HSE identifies as a suitable level for unrestricted future use in its Delicensing Criterion. In the absence of the known historical use of tritium in the Hydrus Development Site, the detected tritium activity is likely to be due to airborne discharges from elsewhere on site and is therefore likely to be confined to shallow soil. The level of activity detected in shallow soils is low and based on the available data it is considered that the risk posed to future Hydrus Development Site users from any contamination present in soils that are to remain in-situ following redevelopment is very low.

Risks to Construction Workers

Levels of radioactivity in soils within the Hydrus Development Site that are proposed to be excavated during redevelopment are not considered to represent a significant risk to construction workers and are suitable for disposal as non radioactive controlled waste.

7.4.4.4 Groundwater Contamination - Radiological

Radiological groundwater analysis data from twenty-three boreholes within the Hydrus Development Site have been assessed. Twelve out of forty samples were identified as exceeding the AWE gross alpha threshold of 0.04 Bq/L. One of the forty samples exhibited gross beta activity in excess of the gross beta activity threshold of 0.5 Bq/l. When compared to WHO drinking water standards

of 0.5 Bq/L and 1 Bq/L for gross alpha and gross beta respectively, only one sample exceeded the gross beta activity threshold. This was from Borehole BH0909 where a gross beta activity of 1.57 Bq/l was detected on 2nd June 2004. Reanalysis at this location on the 10th June and 19th July 2004 detected activity much lower than the WHO DWS and therefore the exceedance is considered to be an anomalous result.

Eleven out of the twelve groundwater gross alpha threshold exceedances were subject to additional radiochemistry analysis for plutonium and uranium isotopes (including Pu-239/240, Pu-238, U-234, U-235, and U-238) activities. The remaining sample did not undergo radiochemistry analysis, although two other groundwater samples originating from the same location (Borehole BH0900) have on other occasions been scheduled for radiochemistry analysis which have not detected any activity of significance.

The activity of plutonium isotopes was identified to be below the analysis minimum limit of detection and therefore the gross alpha activity threshold exceedances are not considered significant. Additionally, the activity of uranium isotopes are significantly below WHO Drinking Water guidelines, and typically consistent with natural environmental levels and ratios (U-234:U238) and are therefore also not considered significant.

Forty groundwater samples have also been subject to tritium analysis. The activity levels identified are significantly below the UK Drinking Water Inspectorate Guideline of 100,000 Bq/m^3 and the WHO Drinking Water Guideline of 10,000,000 Bq/m^3, and are therefore not considered to represent a significant risk to human health. The levels are in keeping with tritium activities identified within groundwater elsewhere at AWE Aldermaston.

7.4.4.5 Soil Gas

Available soil gas data has been collated and reviewed. This data includes measurements of the following:

- Volatile Organic Compounds (VOCs), using a Photo-Ionisation Detector (PID); and
- Ground gases including methane, carbon dioxide, oxygen, hydrogen sulphide and carbon monoxide during routine gas monitoring of combined gas / groundwater installations.

Soil gas monitoring results indicate that there is the potential for quantities of methane, carbon dioxide and carbon monoxide to be generated by natural soils or Made Ground within the Hydrus Development Site, and only very low or negligible levels of hydrogen sulphide and VOCs which are not considered significant. The CIRIA guidance indicates peak concentrations and flow rates for methane and carbon dioxide within the Hydrus Development Site would classify risk as Characteristic Situation 2 CS2 (Low Risk). It is considered that as carbon monoxide was consistently recorded in previous monitoring rounds, CS2 is an appropriate risk classification.

In areas of the Hydrus Development Site to be used for temporary Portakabin welfare facilities, the risk posed by soil gas is negligible to low as these structures will contain raised floors containing a void space underneath to allow dissipation of any soil gas.

As the assessment undertaken is considered 'worst case' for individual boreholes located on the Hydrus Development Site (incorporating high flow rates and concentrations) it is considered unlikely that existing off-site buildings are at risk. Ground gas is not therefore considered a risk to off-site receptors.

7.4.4.6 Buried Unexploded Ordnance and Explosive Residues in Soils and Groundwater

Risks to Future Site Users

Due to the history of the AWE Aldermaston Site, there is the possibility, although considered low, of encountering explosive residue or ordnance within the Hydrus Development Site. Low concentrations of explosive residues were identified in three soil samples located beneath former building footprints within the Hydrus Development Site which are to remain in situ following redevelopment. Compounds detected included cyclotetramethylene - tetranitramine (HMX) and ranged in concentration from 1.4 to 8.8 mg/kg. All concentrations of explosive compounds measured were identified to be significantly below the AWE explosive threshold level of 0.1%, and significantly below the RPS GAC for HMX of 110,000 mg/kg. At the concentrations identified, the samples should be considered 'Free from Explosive Hazard' (FFEH) and the risk from explosion associated with explosive residues in soils is deemed to be negligible.

Additionally, the chemo-toxic human health risk posed by the detected HMX is considered to be low.

Risks to Construction Workers

Thirty-six soil samples from soils that are to be removed during redevelopment have been analysed for explosive residues. Only HMX was detected in excess of the analysis minimum limit of detection, and in only a single sample (B3A28SLABSW at 0.00 m bgl, 4.5 mg/kg). The concentration detected is less than the AWE explosive threshold of 0.1% and therefore considered to be 'Free from Explosive Hazard' (FFEH) and significantly below the GAC, thus not representing either a significant explosive or chemo-toxic risk to human health.

Ten groundwater samples collected from boreholes during previous ground investigations have been subject to analysis for explosives. No samples have detected the presence of explosive compounds and therefore it is considered that the risk posed from explosive residues in groundwater to human health or the environment is negligible.

7.5 Refined Conceptual Model

In line with CLR11 a refined CSM has been developed, which identifies potential contaminative sources, receptors and pollutant linkages, based on the baseline ground investigation data gathered for the Hydrus Development Site.

7.5.1 Potential Contaminant Sources

Based on the data available and the history of AWE Aldermaston the following potential contaminant sources have been identified,

- Chemical contaminants (inorganic and organic) in soils and groundwater (both on-site and off-site locations);
- Localised area of "heavy end" aromatic hydrocarbons (EC21–EC35) identified in shallow soils in the north-east of the Hydrus Development Site;
- Radiological contamination of soil and groundwater;
- Soil gases (principally methane / carbon dioxide);
- Surface and foul drainage containing possible chemical contamination;
- Localised previously unidentified contamination, including asbestos that could be encountered within proposed excavations, especially within Made Ground; and
- Explosives residues in soils and groundwater, and unidentified buried unexploded ordnance, especially within the Made Ground (relating to historical uses of AWE Aldermaston as an airfield).

The above sources of contamination are most likely to occur in, or be associated with the following structures and / or activities located either on-site or possibly up gradient of the Application Site:

- French drains (surface water drainage), particularly around buildings and demolished buildings, where contaminants may have entered the surface water drainage system);
- Buried / infilled areas of demolition rubble;
- Releases to ground from buildings and associated drains;
- Isolated pockets of unidentified contamination within the ground;
- Natural soils or man made soils with the potential to generate landfill gas;
- Leakage from storage tanks (although none have been identified during baseline research); and
- Storage areas (e.g. for machinery, oils, fuels, solvents).

No significant contamination by organic or inorganic substances or radiological contamination has been identified in groundwater beneath the Hydrus Development Site. Furthermore, no link between observed soil and groundwater contaminants has been established.

7.5.2 Potential Key Sensitive Receptors

The following receptors that may be at risk from potential contamination in soils and groundwater at the Hydrus Development Site are the following:

- AWE staff and visitors;
- Ground workers and construction staff;
- Groundwater beneath the Proposed Development;
- Groundwater contained in the aquifer immediately down hydraulic gradient of the Hydrus Development Site;

- New water supply borehole installed in the Chalk aquifer within the Hydrus Development Site boundary; and
- Surface waters fed by groundwater (most notably the Fish Pond).

In line with the criteria presented in Table 7-2 groundwater underlying and down gradient of the Hydrus Development Site is considered to be of medium importance in terms of water resources and abstraction. The importance of surface water receptors and impacts there on are considered in *Chapter 8: Water Resources* of this DEEA.

Table 7-7: Potential Pollutant Linkages and Risk Level (Hydrus Development Site)

Potential Pollutant Linkage	Risk	Comments
Inhalation, dermal contact and ingestion of previously unidentified contaminants in soils and groundwater (both chemical (inc. asbestos) and radiological) by construction staff	Low	Low levels of chemical contamination observed and reasonable sample coverage. Levels of radioactivity largely indicative of background levels rather than contamination. Levels of tritium detected are not considered to represent a risk. Limited potential for exposure with respect to groundwater.
Inhalation, dermal contact and ingestion of previously unidentified contaminants in soils and groundwater (both chemical (inc. asbestos) and radiological) by future site occupiers and users	Negligible to Low	No levels of contamination have been identified that represent a significant risk to future site users
Direct exposure to radiological contamination in soils and groundwater by construction staff	Low	Levels of tritium detected are not considered to represent a risk.
Direct exposure to radiological contamination in soils and groundwater by future site occupiers and users	Negligible	-
Leaching of contaminants in soils by infiltrating rainfall and migration into shallow groundwater	Negligible to Low	Assumes excavation and disposal of shallow soils in north-east corner of the Hydrus Development Site.
Leaching of previously unidentified contaminants in soils and groundwater to the new water supply borehole installed in the Chalk aquifer	Negligible to Low	Assumes competent well construction and implementation of robust environmental management procedures during the construction phase.
Off-site transport of existing sources of groundwater contamination within the Proposed Development area	Low	As determined by technical assessments for principal COC (i.e. aliphatic (>C21-C35) hydrocarbons, PAH and ammoniacal nitrogen)
Explosion associated with soil contaminated with explosive residues and/or ordnance during construction and maintenance	Low	-
Migration and accumulation of soil gas within the foundations of the Proposed Development, posing a risk to future site users	Low	-
Asphyxiation from VOCs	Negligible to Low	-

7.5.3 Potential Pathways, Potential Pollutant Linkages

Table 7-7 outlines potential pollutant linkages identified in the risk assessments, and the likely risks associated with the pollutant linkages occurring have been qualitatively assessed.

7.5.4 Summary

Several pollutant linkages have been identified in Table 7-7. Mitigation measures have been proposed where non-negligible risks have been identified. These measures are described in Section 7.6 and manage the following risks:

- Risk of soil gas (principally methane and carbon dioxide) identified from soil gas monitoring impacting the Proposed Development;
- Risk of encountering previously unidentified contamination during construction;
- Residual risk of encountering previously unidentified live ordnance and explosive contamination within the Proposed Development site during earthworks activities; and
- Risk of contamination polluting groundwater and other water bodies.

7.6 Potential Impacts and Mitigation Measures

Based on the development proposal and the refined CSM, an assessment of the potential impacts of the Proposed Development has been completed. Mitigation measures have been derived to reduce the significance of the potential impacts from land contamination and other relevant site activities during construction and operational phases.

7.6.1 Construction Phase

This assessment is based on the details of the construction phase presented in *Chapter 6: Construction Phase* of this DEEA. During the Hydrus Development Site construction phase there are a number of potential impacts, relating to the geology, hydrogeology or contaminated land that may have a direct or an indirect impact on sensitive receptors. The potential impacts during construction will generally relate only to the construction period itself and will be temporary in nature.

All construction works will be undertaken under the control of a Construction and Environment Management Plan (CEMP). The CEMP will ensure that all the relevant national guidance and current UK best practice identified in this assessment is adhered to during construction and that specific issues and/or mitigations are implemented. The CEMP shall include the mitigation measures and associated works as identified in the Remediation Statement provided in *Technical Appendix A*.

7.6.1.1 Soil and Groundwater Contamination

Typically the concentration of chemical determinands and level of radioactivity in soil and groundwater are low and are not considered to represent a significant risk to construction workers. The concentrations of benzo(a)pyrene detected at Borehole BH901 that will be encountered during redevelopment, although in excess of the risk assessment threshold, are not considered to represent a significant risk to construction workers based on the relatively low concentrations and low timeframes of exposure. The risk will be further reduced by implementation of a Safe System of Work (SSoW) as outlined in the Remediation Statement (*Technical Appendix A*).

It is considered unlikely that significant amounts of previously unidentified contamination will be encountered during redevelopment, due to the coverage of ground investigation work completed to date at the Hydrus Development Site. Thus the risk that previously unidentified contamination identified during construction represents to construction staff and ground workers, AWE operatives and persons off-site, is considered to be low, and will be minimised through implementation of a SSoW.

The detailed QRA indicates that current soil and groundwater conditions (without disturbance from construction activities) identified on site will not have an adverse impact on controlled waters (principally groundwater) at the site boundary, assuming shallow soils in the north-east corner of the Hydrus Development Site (i.e. in the vicinity of the Support Building) are excavated as outlined in the Remediation Statement (*Technical Appendix A*).

The disturbance of contaminated soils during construction within the Hydrus Development Site has the potential to mobilise contaminants into groundwater and subsequently surface waters situated down hydraulic gradient of the site. Considering the low levels of contamination identified in soils on the site, the likelihood of this occurring is low and is not considered a represent a significant risk to groundwater quality beneath the site.

Precautionary measures will be put in place to protect any construction workers involved in earthworks for the Proposed Development. This will be delivered through the Health and Safety Plan and SSoW to be included in the CEMP and will comply with the Construction, Design and Management (CDM) Regulations 2007 that require the implementation of safe working procedures to prevent exposure to contaminated soils during construction works.

All soils excavated during construction shall be classified in terms of their appropriateness for on site reuse and/or waste classification for off-site disposal as specified in the Remediation Statement (*Technical Appendix* A).

The Proposed Development will result in a temporary change in land-use from uncovered rough ground to hard-standing and temporary built areas over approximately half of the Hydrus Development Site. A change to hard-standing will result in reduced recharge to the underlying aquifer in these areas. A temporary reduction in recharge over such a small area will have little impact to groundwater levels and / or flow beneath the Hydrus Development Site and negligible impact to groundwater dependent receptors situated down hydraulic gradient from the Proposed Development.

7.6.1.2 Foundation Construction & Dewatering

A detailed dewatering strategy has been produced for the Hydrus Development Site to enable the safe construction of the foundations required for the Operations Building and eight associated lighting masts.

Shallow raft foundations are proposed for the structures within the Proposed Development. The foundations of the Operations Building are the deepest but do not generally exceed 3.0 m bGL equivalent to an elevation of approximately 97.0 m AOD. Groundwater levels beneath the Hydrus Development Site are approximately 96.8 m AOD to 97.8 m AOD. In the centre of the Operations Building, localised excavations of up to 4.0 m bGL will be required.

The proposed strategy involves dewatering an area contained within a cofferdam constructed around the entire footprint of the Operations Building (diameter c. 140 m). The cofferdam will be constructed from interlocking sheet piling which will hydraulically isolate groundwater within, from the natural groundwater system outside of the cofferdam. Dewatering will result in a large, albeit short-term (1 year), lowering of groundwater levels within the cofferdam. Groundwater levels will be reduced to the base of the Silchester Gravels across the entire area and locally lowered to the top of the London Clay in the vicinity of the deepest foundation structures. All groundwater within the most permeable strata underlying the site will therefore be removed and discharged to a SuDS scheme included in the dewatering strategy, in addition to direct precipitation to the excavation area. Appropriate mitigation measures shall be included in the SuDS design to ensure that water abstracted from the dewatering system does not have an adverse impact on surface water receptors on the Hydrus Development Site. The potential impact of abstracted groundwater on surface waters is considered in detail in *Chapter 8: Water Resources* of this DEEA.

Reduced water groundwater level within the cofferdam represents a localised loss of groundwater resource beneath the Hydrus Development Site. However the groundwater in this localised area is of limited resource value and is not utilised for abstraction. Furthermore the proposed dewatering will remove all of the potentially contaminated groundwater currently identified beneath the facility and any areas of potential shallow soil contamination.

The low levels of contamination (chemical and radiological) identified in groundwater indicates that short-term exposure to groundwater and accidental ingestion during construction does not represent a risk to the health of construction workers.

The adoption of appropriate groundwater management precautions will be required to mitigate the risk posed by the dewatering and excavation associated with foundation construction, both to human health and controlled waters. Detailed groundwater management precautions to be used on Hydrus Development Site will be specified in a Groundwater Management Plan (GWMP) produced by a suitably qualified specialist. The GWMP will be included as part of the CEMP and shall be based on the dewatering strategy proposed for the Hydrus Development Site. Discharge arrangements will be specified within the GWMP developed for the Proposed Development.

The eight masts included in the Lightning Protection System will be supported on piled concrete pad foundations with a finished height of 100.3m AOD. Eight 15 m deep bored piles will be constructed in each pad. In addition to the LPS, two tower cranes will be installed during construction, each crane will be supported by a concrete pad with six 15 m deep bored piles. Each pile will terminate within the London Clay, which is greater than 60 m deep on the Hydrus Development Site. The construction of pile foundations has the potential of creating of new pathways that may facilitate the transport of existing or new sources of contamination to groundwater. A piling risk assessment has been completed and is presented in *Technical Appendix A*. The report finds that the risk of the piles impacting on groundwater and receptors thereof is low due to the absence of significant ground contamination, the removal of groundwater by dewatering and the close bond between the concrete and the shaft wall. Site works will be carried out in accordance with Environment Agency guidance note on piling and penetrative ground improvement methods on land affected by contamination (Ref. 7-45).

7.6.1.3 Alteration of Groundwater Flow

The natural groundwater flow on the Hydrus Development Site will be diverted around the impermeable cofferdam. The Fish Ponds and associated surface water features will remain the ultimate receptor for groundwater, and groundwater flow paths will therefore converge on the features. The groundwater level up-gradient (i.e. west) of the cofferdam will be increased. In contrast, groundwater levels and the hydraulic gradient down-gradient of the cofferdam will be decreased. Immediately north and south of the cofferdam groundwater flow paths will be deflected to the north and south, with a small increase in hydraulic gradients expected.

The results of the detailed QRA (*Technical Appendix A*) suggest that the temporary alteration to groundwater flow paths will not result in an increased risk to groundwater quality beneath the Hydrus Development Site and at the site boundary. The severing of the link between groundwater within the cofferdam and down gradient groundwater, in addition to reduced hydraulic gradients may result in minor improvement in groundwater quality. Reduced flow down gradient of the cofferdam may result in a short-term reduction in groundwater discharge to the Fish Ponds, although this is unlikely to be discernable from natural seasonal variability considering the duration of the impact and their distance from the area of dewatering.

The Piling Report (*Technical Appendix A*) indicates that groundwater flow will not be disrupted by the presence of the piles, because although they are permanent structures they will not form a continuous cut-off wall through the Silchester Gravel aquifer.

7.6.1.4 Storage of Potentially Contaminating Materials and Accidental Spillage

During construction there is potential for the accidental spillage or leakage of potentially contaminating substances to ground. Accidental emissions may relate to vehicles and construction materials used on Hydrus Development Site, or the leakage or spillage of chemicals, oils or fuels stored on-site during operation. This has the potential to cause localised deterioration of soil and groundwater quality at the point of spillage. Contamination may be transported via groundwater towards the Hydrus Development Site boundary depending on the severity, longevity and location of the accidental emission. The risk of contamination is most acute in areas of excavation where soils are removed and the length of pathway to groundwater reduced.

Although the risk to soils and groundwater is considered low, it shall be minimised through a variety of mitigation measures to be included in SSoW produced for the works and implemented through the CEMP. This shall include storage within bunded areas to contain chemical spillages during construction and the availability of emergency spill-kits for the duration of construction works on the Hydrus Development Site. These issues are covered in AWE's *Code of Construction Practice* (CoCP) (Ref. 7-46). It is proposed that standard duties of care are employed within the Application Site with regards to delivery, use and storage of potentially contaminating materials and liquids (bunded storage platforms, control of substances hazardous to health (COSHH) assessments and safety inductions etc).

7.6.1.5 Disturbance of Dust and Silt

Dust and silt resulting from disturbance during construction activities may arise as a result of the movement of soil by construction machinery. This could result in the silting up of surface waters (see *Chapter 8: Water Resources*) or may have adverse effects on the health of construction workers and the general public. The impacts from disturbance would be further increased if the dust and silt is contaminated.

The site investigation has identified that the potential presence and extent of contaminated soil is limited, thus dust generation is unlikely to impact human health during construction works. However, any potentially adverse affects from dust impacts shall be minimised by covering or damping down of dusty surfaces during dry weather and wheel washing of vehicles exiting the site. It is also prudent to note that any temporary storage of materials will incorporate appropriate risk control measures (e.g. stockpiles will be appropriately fenced off in designated areas and covered or damped down if likely to generate dust). These mitigations are discussed in further detail within *Chapter 10: Air Quality.*

7.6.1.6 Buried Unexploded Ordnance and Explosive Residues

In light of the history of the Hydrus Development Site there is considered to be a low possibility of encountering explosive residue or ordnance. As a consequence the risk of such an impact is considered low. Notwithstanding, prior to undertaking any excavation works SSoW will be implemented which includes briefings regarding unexploded ordnance and visual inspection of arisings by an Explosive Ordnance Detection expert.

7.6.2 Operational Phase

Following completion of the construction of foundations, dewatering shall cease and sections of the cofferdam removed to allow groundwater levels to recover beneath the facility and the pre-construction groundwater flow pattern to generally be re-established. Hard-standing (including buildings and structures) will cover much of the Hydrus Development Site. The primary concerns associated with the operation of the Proposed Development are detailed below.

7.6.2.1 Soil Contamination

Based on available information and following the proposed excavation and remediation works (*Technical Appendix A*), the low level of soil contamination (both radiological and non radiological) that will remain in-situ following redevelopment is unlikely to pose a significant risk to the health of future site users.

Certain contaminants have the potential to adversely impact the integrity or performance of some building materials. Elevated sulphate and pH are typical examples of factors that must be considered in foundation design, particularly with respect to use of concrete and steel whilst, under some conditions, plastic water pipes and electrical cable insulation may be vulnerable to certain organic contaminants. Based on the generally low levels of contaminant concentrations recorded in soils and shallow groundwater, the impact magnitude is considered to be negligible to low in relation to impacts on materials.

7.6.2.2 Soil Gas

The migration of soil gas into buildings may have an adverse impact on the Proposed Development. Elevated methane can present an explosive risk and carbon dioxide an asphyxiant under some conditions. Soil gas data available indicates a low to moderate potential impact magnitude.

Based on current monitoring data as a precautionary measure, to mitigate these potential risks simple gas protection measures appropriate for Characteristic Situation 2 (CS2) shall be included in development design. Protective measures for the proposed development will comprise:

- Reinforced concrete cast in situ floor slab; and
- A gas proof membrane (at least 1200 g DPM2) fixed between the concrete and the soil where soil and the concrete substructure are in contact.

Ground gas is considered likely to have negligible impact on off-site receptors and undeveloped parts of the Hydrus Development Site, thus implying negligible significance.

7.6.2.3 Alteration of Groundwater Flow

The removal of sections of the cofferdam following constructions is expected to enable the pre-construction flow pattern on the Hydrus Development Site to be largely re-established. A minor change to groundwater levels and flow directions may persist, principally:

- Deep foundations in the centre of the Operations Building will represent a small physical barrier to groundwater flow;
- Elevated groundwater levels immediately up-gradient of sections of cofferdam remaining in the groundwater flow field;
- Possible small reduction in levels and throughflow beneath the Hydrus Facility as a result of reduced infiltration to the aquifer owing to increased hard-standing across the site; and
- Alteration to distribution of recharge across the development area owing to new SuDS design for Hydrus Development Site.

The concrete raft foundations of the Operations Building are not anticipated to intercept recovered groundwater underlying the Hydrus Development Site and will not therefore affect groundwater flow paths on the site.

The small impact anticipated on groundwater flow paths and groundwater fluxes across the Hydrus Development Site is unlikely to have any measurable impact on flows and water quality in down gradient groundwater receptors (principally Fish Pond) .

The developments may reduce infiltration and recharge of shallow groundwater. As these areas will already be connected to a receiving watercourse via the existing drainage network the runoff would, if not attenuated, lead to a significant increase in the surface water flow rates in the receiving systems. The significance of an increased surface water runoff during the operational phase is considered in *Chapter 8: Water Resources* of this DEEA. The overall impact is considered to be medium to low.

7.6.2.4 Groundwater Contamination

A conservative assessment of impacts suggests that the construction of the Hydrus Facility is likely to have a neutral impact on groundwater quality. However a possible improvement in groundwater quality may result in long term considering the following:

- Removal of potential sources of shallow soil contamination across much of the site;
- Removal of potentially contaminated groundwater contamination from within the cofferdam during construction; and
- Severed linkage with source areas beneath structures on the site.

7.6.2.5 Storage and Use of Potentially Contaminating Materials

Ancillary structures within the Proposed Development include a waste store and electricity substation. These structures have the potential for causing ongoing land and/or groundwater contamination during their use, the latter being a potential source of PCB contamination. The risk of contamination resulting from use of these structures will be minimised by adherence to appropriate construction guidance (Ref. 7-47 and Ref. 7-48) and the development of a long term management plan for the safe use of the facilities as part of the Environmental Permitting regime for the site. The potential impact on groundwater quality and groundwater dependent features is therefore considered low.

There is a potential for spillage of oil, diesel or petrol from vehicles associated with the Proposed Development. Land and groundwater could be contaminated via surface water runoff from areas of hardstanding including roads and the operational vehicle waiting area. The potential magnitude of such short term impacts is considered to be low. This risk shall be mitigated by a system that intercepts potential contaminated run-off from the access roads and hardstanding areas around the building before entering a surface water receptor or alternative discharge point. This is described in detail in *Chapter 8: Water Resources* of this DEEA.

Chemicals, oils or fuels stored on-site during operation could leak or be spilled and enter the sub-surface. The potential magnitude of impact is considered to be low. Where chemicals or fuels are stored on-site, drip trays and double-skinned bunded tanks on bunded impermeable surfaces will be used in accordance with regulatory guidance i.e. Environment Agency Pollution Prevention Guidelines, AWE's CoCP and The Control of Pollution (Oil Storage) (England) Regulations (Ref. 7-49).

7.6.2.6 Buried Unexploded Ordnance

The impact magnitude posed form buried ordnance is considered negligible to the operation of the Proposed Development.

7.7 Residual Impact Assessment

A summary of all potential impacts, mitigation measures and residual impact is provided in Table 7-8 (Construction Phase) and Table 7-9 (Operational Phase).

Table 7-8: Summary of Residual Impacts (Construction Phase)

Potential Impact / Known Receptor	**Potential Magnitude of Impact (pre mitigation)**	**Mitigation Measures**	**Scale**	**Residual Impact Significance (post mitigation)**
Mobilisation of existing soil contamination (chemical or radiological) during construction activities impacting on construction workers by ingestion, inhalation or dermal contact.	Negligible to Minor	Adherence of construction workers to safe working including provision of SSoW and CDM 2007 and AWE protocol. Completion of all works specified in the Remediation Statement. Use of current soil sample information as well as confirmatory sampling and analysis on soils proposed to be excavated to ensure excavated soils are reused / disposed of in accordance with current legislation and best practice (either pre-sentencing or post excavation).	Local	**Negligible to Minor Adverse**
Exposure of construction workers to contaminated groundwater during construction, by ingestion, inhalation or dermal contact.	Negligible to Minor	Adherence of construction workers to safe working including provision of SSoW and CDM 2007 and AWE protocol. Completion of all works specified in the Remediation Statement.	Local	**Negligible**
Presence of existing contamination in soils impacting on controlled waters, principally groundwater at site boundary.	Moderate	Excavation and appropriate disposal of shallow soils in north-east of the Proposed Development area, as described in Remediation Statement (*Technical Appendix A*). These works will have to be documented and validated during the construction process.	Local / District	**Negligible to Minor Adverse**
Presence of existing contamination in groundwater impacting on controlled waters, principally off-site groundwater in shallow aquifer.	Minor	Additional monitoring of speciated PAHs in boreholes within the Proposed Development area in final monitoring rounds to confirm absence of these contaminants at concentrations that may represent a risk to controlled waters.	Local	**Negligible to Minor Adverse**
Presence of existing contamination in groundwater impacting on controlled waters/groundwater in chalk aquifer (New water supply borehole within the Proposed Development boundary).	Negligible	Assumes competent well construction and implementation of good housekeeping measures as outlined in the CEMP in the vicinity of the new borehole during the Construction Phase	District	**Negligible**
Short-term, localised reduction in groundwater levels within the cofferdam by dewatering required for construction of Hydrus Facility.	Moderate	-	Local	**Minor Adverse**
Severing potential pollutant linkage down-gradient of cofferdam.	Negligible	-	Local	**Negligible to Minor Beneficial**
Short-term reduction in groundwater through flow down gradient of cofferdam.	Minor	-	Local	**Negligible to Minor Adverse**
Creation of new pathways by construction of piled foundations for eight lightning masts associated with the Operations Building.	Negligible	-	Local	**Negligible**
Presence of explosives and unexploded buried ordnance in shallow soils impacting upon construction	Minor	Adherence of construction workers to safe working including provision of SSoW and working under CDM 2007 AWE protocol	Local	**Negligible to Minor Adverse**
Accidental spillage of contaminants (fuels or chemicals) from vehicles / building materials and/or substances stored on site impacting construction workers, soils and/or controlled waters (principally groundwater underlying the site)	Minor	Adherence of construction workers to safe working including provision of SSoW and working under CDM 2007 and AWE protocol. Storage of fuels and chemicals in appropriately bunded areas with impermeable bases. Storage and use will be undertaken in accordance with site-specific method statements and in line with Environment Agency guidelines. Availability of emergency spill kits.	Local	**Negligible to Minor Adverse**
Disturbance of contaminated dust and silt and impacts on human health and controlled waters	Minor	Provision of wheel washing facilities. Damping down of soil surface in accordance with method statement and a geotextile membrane/ DPM sheet will be used, on which any soil waste arisings will be placed to prevent cross contamination. Implement SSoW to protect the health of workers from known and unknown contamination, including adherence to CDM 2007and AWE CoCP.	Local	**Negligible to Minor Adverse**
Mobilisation of contaminants due to changes in infiltration rates	Low to negligible	-	-	**-**
Installation of piled foundations	Moderate	Correct installation of piled foundations. Dewatering of Silchester Gravel aquifer. Profiling the ground around the piles to ensure there is no ponding at the surface.	Local	**Negligible**

Table 7-9: Summary of Residual Impacts (Operational Phase)

Potential Impact / Known Receptor	Potential magnitude of Impact (pre mitigation)	Mitigation Measures	Scale	Residual Impact Significance (post mitigation)
Presence of existing contamination (both chemical and radiological) in soils and groundwater impacting human health.	Negligible to Minor	-	Local	**Negligible**
Impacts of existing contamination in soil and groundwater on development – fabric of structures/ services etc	Negligible to Minor	Use of appropriate concrete and materials	Local	**Negligible**
Localised change in groundwater flow paths as a result of deep foundations associated with the Proposed Development.	Minor	-	Local / District	**Negligible**
Changes to groundwater quality following the recovery of groundwater levels beneath the Hydrus Facility, following removal of sections of the cofferdam.	Minor	-	Local	**Negligible to Minor Beneficial**
Impacts on soils and groundwater from vehicle spillage and runoff	Minor	Good housekeeping, including minimisation of storage of fuels / chemicals at the proposed development	Local	**Negligible**
Storage and use of chemicals / fuels	Minor	Where chemicals and fuels are stored on site, drip trays and double skinned bunded tanks on bunded impermeable surfaces will be used.	Local	**Negligible**
Soil gas migration impacting the Proposed Development	Minor to Moderate	Design and Installation of gas protective measures based on current understanding	Local	**Negligible**
Impacts from buried unexploded ordnance	Negligible	Future excavations to adopt a SSoW in line with AWE protocol.	Local	**Negligible**
Mobilisation of contaminants due to changes in infiltration rates	Negligible to Minor	-	Local / District	**Negligible to Minor Adverse**

7.8 Conclusions

An assessment of the baseline ground conditions has been undertaken for the Proposed Development. The assessment involved reviewing the history, geology and hydrogeology of the Application Site as well as available site investigation information including soil and analytical data, and soil gas monitoring data.

The Hydrus Development Site is considered to exhibit forms and general levels of contamination that are broadly typical of sites that have been involved in 'industrial' type land use. The underlying ground conditions and observed levels of contamination have been shown not to present any significant health and environmental risks requiring additional mitigation measures other than the excavation of soils in the north-east corner of the Hydrus Development Site. It is therefore considered that the Proposed Development can be implemented without unacceptable, significant, adverse impacts. As the Proposed Development offers the opportunity to better understand ground conditions and to deal with any individual cases of contamination there are beneficial impacts for the ground at the Hydrus Development Site.

However, it is recognised that provision must be made for unforeseen situations and the fact that the inevitable disturbance of land associated with construction can lead to changes that may affect the way in which contaminants interact with the environment. Appropriate Safe Systems of Work (SSoW) will be in place to mitigate the risks of encountering previously unidentified contamination such as unexploded ordnance, gross soil contamination and asbestos contaminated soils. All remedial works shall be completed on the site prior to construction. These works are described in the Remediation Statement and shall be implemented through the CEMP. These works include:

- Implementation of gas protection measures based on current understanding of soil gas regime and risk (conservative assumptions);
- Surface water controls (See *Chapter 8: Water Resources*);
- Implementation of Safe Systems of Works (SSoW) for encountering, and managing unexpected and unidentified contamination (including asbestos, explosive residue and ordnance) during construction, including minimising risks to construction workers; and
- Production of a Groundwater Management Plan (GWMP) for deep excavation on the site, including water disposal.

7.9 Cumulative Impact Assessment

The assessment of the cumulative impacts for the Proposed Development is based on information contained within the Site Development Context Plan 2008 (SDCP08) (Ref. 7-50) and also considers the potential combined impacts from on and offsite developments. Details of the cumulative impacts assessment are described in *Chapter 17: Cumulative Impacts* of this DEEA.

As schemes come forward for development, then the land planned for development and any new and unanticipated soil contamination will undergo assessment to evaluate risks and the significance of impacts posed by the development. Following this assessment, any identified requirement for remediation will be completed prior to the start of, or as a justified part of, the construction phase.

The principal cumulative impacts that relate to ground conditions include:

- Cumulative deterioration in groundwater as a result of construction and operation on the Hydrus Development Site, which may impact sensitive down-gradient receptors;
- Significant alteration to groundwater levels, flow volumes and flow directions resulting from change in land-use, which may impact groundwater underlying the site and sensitive down-gradient receptors.

As no impact is anticipated on groundwater underlying the Hydrus development Site, no additional deterioration to baseline water quality is predicted.

Although an increase in the hard-standing is anticipated within the Hydrus Development Site, the overall change in land use currently proposed over the entire AWE Aldermaston site will not substantially change the recharge quantity and distribution over the site. The cumulative significance of the impact on groundwater levels and flows is therefore considered **negligible** relative to baseline conditions.

Off-site developments i.e. outside of the AWE Aldermaston site boundary includes residential (housing and apartments) and commercial (business premises, new railway station, bus interchange, car parks, hotels) developments.

Assuming the land proposed for on and off-site development is adequately assessed, remediated and mitigated, it is considered that cumulative impacts posed to the Proposed Development will be of **negligible** significance overall.

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