DEFENCE ESTATES

RAF BICESTER ESA

PHASE TWO
LAND QUALITY ASSESSMENT

TECHNICAL NOTE

FINAL

PROJECT NO: 12074

Technical Note
February 2003

Defence Estates
Copthorne Barracks
Copthorne Road
Shrewsbury
SY3 7LT

Prepared by Carl Bro Group Limited
for the Defence Estates under
Commission DE11/4470

REPORT RELEASE SHEET

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Carl Bro Group

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1.0 INTRODUCTION

This Technical Note on the status of land quality at RAF Bicester former Explosive Storage Area (ESA) has been prepared by Carl Bro Group Limited (Carl Bro) on behalf of Defence Estates in accordance with Term Commission DE11/4470.

1.1 Terms of Reference

The project was undertaken in accordance with the LQA Directive issued by Defence Estates, presented in **Appendix A**.

The purpose of the Land Quality Assessment (LQA) has been to undertake a site investigation to determine the environmental quality of the ground conditions at RAF Bicester ESA and to assess the potential for any health and environmental risks at the site. The review also assesses the potential for future contamination that may occur as a result of demolition of existing buildings.

This Technical Note presents a summary the findings of the LQA and recommendations for options, where appropriate, to manage any risk associated with the status of land quality at the study site. The Note should be read in conjunction with the LQA Report for the study site which describes the assessment methodology. The recommendations included in this Note are based upon the information and qualitative environmental risk assessment as set out in the LQA Report.

1.2 Report Structure

The Technical Note is structured as follows:

Chapter 2
- a summary of the Land Quality Statement (LQS) and qualitative environmental risk assessment for the site.

Chapter 3
- provides data on relevant environmental legislation relating to the historical contamination issues identified at the site.

Chapter 4
- includes an options study which summarises potential management alternatives for dealing with land quality issues at the site.

Chapter 5
- gives details of the financial risk analysis for the management options.

Chapter 6
- presents the overall land quality of the site, and comments on the suitability for redevelopment.

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2.0 SUMMARY OF LAND QUALITY STATEMENT FOR RAF BICESTER ESA

2.1 Location

The RAF Bicester site is located approximately 1.5km north of the centre of Bicester at grid reference SP 591 244. The former ESA site occupies an area of approximately 6 hectares and is located at the eastern side of the RAF Bicester airfield, which is in an area of mixed residential, commercial and agricultural land use.

The location of RAF Bicester ESA is shown in **Figure 1**.

2.2 Operations and Site History

The current RAF Bicester site is believed to have had a 'greenfield' land use prior to being occupied by the Royal Flying Corps in 1920, and the RAF in 1928. RAF Bicester was used as a logistical centre and a training centre for aircrew during the war. Following the war the station became a transit centre for equipment, an assembly point for vehicles and a Command centre for aircraft repair and salvage. RAF Bicester ceased being an active station in 1976, but was reopened under the USAF in 1978. A contingency hospital was established at the main site by the USAF in 1984 and remained until RAF Bicester was closed in 1994. The airfield portion of the site is currently used by the RAF Gliding and Soaring Club for flying and maintaining gliders. The ESA was used for the storage of explosives during the active operation of RAF Bicester as a military base.

The existing site layout is shown in **Figure 2**.

2.3 Explosive Ordnance

The ESA was historically the storage area for explosives used at RAF Bicester. Consequently, the Armament Support Unit, (ASU) was commissioned to carry out an explosive ordnance disposal (EOD) exercise. This was carried out prior to the intrusive investigation in the ESA, greatly reducing the risk of encountering explosive ordnance.

2.4 Radiological Materials

As part of the overall RAF Bicester LQA, Dstl Radiological Protection Service (DRPS) was contacted to provide any relevant information regarding use of radiological materials. DRPS indicated that a potential existed for radioactive contamination to be present at the RAF Bicester site. Radium luminised items have historically been used in aircraft and are currently used in gliders. Given the historical use of the site in aircraft repair and salvage operations and the current use of the site for flying and maintenance of gliders, DRPS believe that there exists a potential for 'low level radioactive contamination' in the areas of the Old Dump and scrap metal yard, although DRPS did not specify risks of encountering radiological materials in the ESA.

No radioactivity above background elevations was encountered throughout the investigation of the ESA.

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2.5 Environmental Setting

The shallow subsurface geology underlying the site is comprised of made ground and topsoil overlying the Cornbrash Formation at shallow depths. The Cornbrash Formation is made up of highly weathered rubbly limestone and is immediately underlain by inter-bedded clay and limestone of the Forest Marble Formation. The Forest Marble is underlain by the White Limestone Formation, a major aquifer from which groundwater is extracted for domestic, agricultural and industrial use.

Although not confirmed within the ESA, due to the lack of groundwater in excavations, groundwater flow in the Cornbrash is known from the LQA of the remainder of the RAF Bicester site to be unconfined, and flowing in a southeasterly direction. Groundwater in the White Limestone is confined by the clay layers in the upper strata of the formation, which may afford some protection to the underlying aquifer. The piezometric surface in the White Limestone is higher than that in the Cornbrash.

Available information indicates that three surface water bodies are located with one kilometre of the site; these include - Langford Brook, which flows in a south-westerly direction 450m south-east of the site; Audley Brook, a tributary of the Langford Brook, which flows in a south-easterly direction, 650m north-east of the site; and a spring immediately south-east of the site that drains to the north-east and south-west. No evidence of the spring was identified during the site investigation. Langford Brook is located immediately down-gradient of groundwater flow direction.

The sensitivity of the site with respect to groundwater and surface waters is considered to be moderate to low. Ecological sensitivity has been assessed as low.

2.6 Environmental Risk Assessment

2.6.1 Risk Assessment Methodology

A qualitative risk assessment has been undertaken based upon the information collated for the LQA. The level of risk relating to the contamination identified during the site investigation has been evaluated in accordance with published best practice and Government Guidance.

In the context of this study, hazards relate to sources or potential sources of contamination capable of causing harm (frequently termed ‘contaminant’, ‘source’ or ‘pollutant’). Receptors are the entity which may be at risk of adverse effects from the hazard and include human health, surface waters, groundwater, buildings and services. In order for a hazard to present a risk to a receptor they must be linked by an exposure pathway. Environmental risk assessment is based upon the ‘source-pathway-receptor’ model and is adopted for the purposes of this assessment. The estimation of the significance of any risk to identified receptors is based upon consideration of the severity of the potential consequence of a hazard and the likelihood of the hazardous event occurring.

2.6.2 Potential Sources of Contamination

The following potential sources of contamination have been identified at RAF Bicester ESA as a result of historical/ current activities either on-site or within the immediate surrounding area (listed in decreasing order of significance):

- Arsenic in soils.

- Asbestos in soils around footprint of former buildings.

The locations of contaminated soils are shown on **Figure 3**.

2.4.3 Potential Risks Identified

The most significant potential environmental risks identified based upon current site conditions are summarised below.

Potential Source	Potential Receptor	Potential Risk
Asbestos in soils in footprint of former buildings	• Humans (current and future site users) • Humans (redevelopment workers)	Low Moderate*
Arsenic in soils	• Humans (current and future industrial site users, construction/ demolition workers) • Humans (future residential site users)	Low Moderate

* Risk is reduced with appropriate expert supervision and health & safety precautions during excavations

An evaluation of environmental risk and potential significance of liability associated with the identified risks are presented in **Table 2.1**. Details of the definition and terms used in this assessment are contained within Annex B of the Consultants Directive contained in Appendix A of this report.

During any redevelopment of RAF Bicester ESA, site workers may be exposed to elevated risks, in particular due to the potential for asbestos materials to be present in soils in the footprint of former buildings. However, these risks could be effectively mitigated through appropriate Health and Safety controls and procedures.

2.7 Land Quality

The results of the non-targeted intrusive investigation indicated that current and historic activities at RAF Bicester ESA have not resulted in widespread ground contamination of the site.

The land quality of the site is suitable for current use as a result of no significant pollutant linkages having been identified. However, should the site be considered for redevelopment, then there may be risks associated with elevated concentrations of arsenic in made ground soils. Statistical analysis of the data suggests that there would be a possibility of significant harm resulting to human receptors under a residential without plant uptake land use.

The ESA is unlikely to be classified as contaminated land under the provisions of Part IIA. However, due to the variable made ground deposits it is possible that further contamination could exist in these areas.

2.8 Suitability for Redevelopment

The site is considered to be suitable for redevelopment for commercial or industrial purposes. The site is unlikely to be suitable for a residential land use in its current state, owing to elevated concentrations of arsenic in made ground soils.

There remains some potential for undetected hotspots of contamination to be present at locations not investigated in this LQA. These include areas currently occupied by building footprints.

If a redevelopment for housing is considered, then additional quantitative risk assessment may be required to confirm the extent of risk from arsenic contamination.

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TABLE 2.1: Environmental Risk Assessment Summary Table for RAF Bicester ESA

Area/ Building	Potential Pollutant [Hazard]	Potential Receptor	Potential Pathway to Receptor	Associated Hazard	Potential Consequence of Pollutant linkage	Likelihood of Pollutant linkage [Probability]	Potential Significance Risk Classification	Potential Significance Liability Classification
Made Ground Soils	Arsenic	Humans (Current and Future Commercial /Industrial Users, Trespassers)	Direct contact, ingestion inhalation	Health Risks	Moderate to Severe	Unlikely Given the current land use of the site and the extent of contamination is likely to be limited, exposure to contaminants is likely to be negligible.	Low Risk	E (Minor significance, no remediation required)
		Humans (Future Residential Users)	Direct contact, ingestion inhalation	Health Risks	Moderate to Severe	Possible Potentially significant contamination above SGV for this use.	Moderate Risk	D (Minor remediation liability)
		Groundwater (Cornbrash Aquifer)	Leaching and subsequent migration via unsaturated zone.	Contamination of major aquifer	Mild	Unlikely Groundwater impacts to the upper aquifer are unlikely given the absence of groundwater identified in the investigation.	Negligible Risk	E (Minor significance, no remediation required)
		Groundwater (White Limestone Aquifer)	Leaching and subsequent migration via unsaturated zone.	Contamination of Major Aquifer supporting Public Water Supply	Moderate	Unlikely Contamination of the deeper aquifer would be small-scale and mitigated by the thick upper clay and unfractured rock between upper aquifer and major aquifer.	Low Risk	E (Minor significance, no remediation required)
		Surface Water	Migration via shallow groundwater	Contamination of Surface Water	Mild	Unlikely Lack of groundwater to transport any contaminants to surface water and lack of contaminants.	Negligible Risk	E (Minor significance, no remediation required)
		Fauna and Vegetation	Uptake via plant roots	Phytotoxic effects	Mild	Unlikely The vegetation in the vicinity is fairly widespread and no phytotoxic contaminants were identified.	Negligible Risk	E (Minor significance, no remediation required)

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Asbestos in soils around building footprint	Asbestos	Humans (Current and Future Site Users, Trespassers)	Direct contact, ingestion, inhalation	Health Risks	Severe	Unlikely No asbestos encountered during investigation. If present, asbestos likely to be in limited quantities around former building footprints.	Low Risk	E (Minor significance, no remediation required)
		Humans (Redevelopment Workers)	Direct contact, ingestion, inhalation	Health Risks	Severe	Low Asbestos register completed for the site, but not reviewed at time of LQA. Potential presence of asbestos in footprint of former building structures.	Low to Moderate Risk	D/E (Minor remediation liability or Minor significance, no remediation)

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3.0 LIABILITY ASSESSMENT

3.1 Introduction

The presence of environmental risks as outlined in the preceding section indicates that, although most of the site is not contaminated, there is some potential for harm or pollution to occur due to the potential presence of some contaminants associated with parts of RAF Bicester ESA.

In general terms, an operator of a site or land which contains contamination may be exposed to potential liability, including:

- Criminal liability for non compliance with environmental statutes;
- Civil liability for any damage caused to third parties;
- Financial costs associated with regulatory action to determine, verify or prevent pollution; and
- Financial costs associated with enforced clean-up of contamination.

The principal environmental legislation associated with MoD property includes the following:

- Part IIA of the Environmental Protection Act 1990, Contaminated Land;
- Water Resources Act 1991
- Control of Asbestos at Work Regulations 2001
- Health and Safety at Work Act
- Radioactive Substances Act 1993 & Ionising Radiation Regulations 1999

It is MoD policy to comply with the existing environmental legislation (although Crown Immunity can be invoked in certain circumstances) and to concord with Government environmental strategy and sustainability principles.

A discussion of the above legislation and their significance for RAF Bicester ESA is provided below.

3.2 Part IIA of the Environmental Protection Act 1990, Contaminated Land.

The Contaminated Land Regulations 2000, enacted by Part IIA of the Environmental Protection Act 1990, sets out a new regime for identifying and dealing with Contaminated Land in the UK. The Act, Regulations and associated guidance (particularly DETR Circular 02/2000) describe the regulatory functions and actions aimed at identifying contaminated land and define the persons liable for voluntary or enforced remediation.

Contaminated land is defined under the Act on the basis of the potential for harm to human health or pollution of controlled waters. Detailed tests of these definitions are included in DETR Circular 02/2000.

For a site to constitute 'Contaminated Land', as defined in Part IIA of the Environmental Protection Act, a significant pollutant linkage must be identified between the source and a sensitive receptor via an appropriate environmental pathway. The degree of significance of a pollutant linkage depends on a number of factors including the hazardous nature of the *source*, the type of *pathway* (such as direct contact with contaminants) and the sensitivity of the *receptor*.

Where a site is designated as Contaminated Land, the enforcing authority (Local Authority/ Environment Agency) will identify the **'appropriate person or persons'** to bear responsibility for the remediation and associated costs. Part IIA follows a **'polluter pays'** principle and there are two classes (Class A / Class B) of appropriate person.

Class A persons are those *'who have caused or knowingly permitted the pollutant in question to be in, on or under the land'*. If no Class A persons can be found and the significant pollutant linkage relates solely to the pollution of controlled waters, rather than to any significant harm, there will be no liability group and the site should be treated as an "orphan" site.

In any other case where no Class A persons can be found, the current owners or occupiers of the contaminated land (Class B persons) shall be liable.

The MoD, as owner and former operators of the site, would be liable under the Act as a Class A person.

In this assessment of RAF Bicester ESA, the site contains elevated concentrations of contaminants but does not constitute 'Contaminated Land' under the present use of the site.

3.3 Water Resources Act 1991

The Water Resources Act defines 'controlled waters' and Section 85 of the Act introduces the offence:

'to cause or knowingly permit any poisonous, noxious or polluting matter or any solid waste matter to enter any controlled water'.

The legislation is applied by means of specific regulations, the most important being:

- The Anti-Pollution Works Regulations 1999;
- The Groundwater Regulations 1998.

These regulations allow the Environment Agency to serve 'Works Notices' on persons causing or knowingly permitting pollution of controlled waters. If the Works Notice is not complied with the EA may undertake the works directly and recover costs as well as fining the polluter for non-compliance.

In general, where water pollution is caused by historical contamination, the EA has indicated that regulatory action would be pursued through Part IIA of Environmental Protection Act provisions rather than the Water Resources Act. It is therefore unlikely that MoD would be served with a Works Notice since the processes which could have led to groundwater contamination are no longer operational. Furthermore, groundwater contamination has not been identified on this site.

3.4 Management of Health and Safety at Work Regulations 1992

These regulations and the associated Health and Safety at Work Acts place a general duty on employers to carry out suitable and sufficient risk assessments of all risks to the Health and Safety of employees and the identification of necessary preventative and protective measures to prevent injury.

The site is no longer in active use although the LQA has identified the potential for localised ground contamination with a potential to affect the health of individuals involved in future excavation or site redevelopment works. Where potential health risks from contamination are identified, there is a need for these potential risks to be established with greater certainty and for these to be controlled in a manner that provides appropriate protection under Health and Safety legislation.

3.5 Control of Asbestos at Work Regulations 2002

These regulations require operators of facilities to ensure that appropriate information is obtained and maintained on the presence of asbestos in order to ensure that asbestos can be managed effectively.

At RAF Bicester ESA there is the potential for isolated pockets of asbestos containing materials (ACMs) to be present within soils in the footprint of former buildings. It should be noted that during EOD clearance of the site, asbestos was identified and disposed of to an appropriate facility off-site. However, no ACMs were identified during soil sampling and analysis undertaken during the LQA .

Although it is understood that an asbestos register has now been completed for the RAF Bicester site, this has not yet been reviewed or incorporated into the LQA. It is possible that the asbestos register may require amendments to include reference to the assessment of risks from asbestos stated in this report.

Until such time that the management of potential ACMs is included in the asbestos register, there is a potential for the site to contravene the Asbestos Regulations.

3.6 Radioactive Substances Act 1993 and Ionising Radiation Regulations 1999

There are a large number of controls on the keeping, management and disposal of radioactive materials under the above legislation.

The LQA has confirmed the absence of radiological materials at investigation points at the site data to suggest that contamination. On this basis the site does not contravene legislation associated with radioactive materials.

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4.0 MANAGEMENT STUDY

4.1 Introduction

For the purposes of this options appraisal it has been assumed that existing use of the sites constitutes a vacant, disused site, with occasional visits from MoD staff and trespassers.

It is understood that in the future the MoD may decommission the site and release it for sale. The Client Representative has indicated that it is possible that this site may be used for residential development, but specific plans for development have not been provided. Currently, the site falls into the commercial/ industrial use classification but may be suitable for residential redevelopment after undergoing additonal assessment or remediation.

The LQA has identified that the most significant potential risks and liabilities associated with the site relate to the presence of arsenic in made ground soils and to the potential presence of asbestos containing materials.

A number options for addressing the land quality and environmental issues at the site and their consequences have been evaluated as summarised in the following table:

Option	Action	Consequences
1	Do nothing	• No cost. • No improvement in land quality of the site. • Potential contravention of asbestos regulations.
2	Do minimum (Review and amend asbestos register)	• Minor cost. • Documented risk management procedure for potential presence of asbestos. • No improvement in land quality of the site.
3	Detailed QRA for arsenic for residential land use	• Additional cost. • Improvement in understanding of risk, possibly leading to reduction in assessed liability and increase in sale value.
4	Removal of arsenic contaminated made ground soils	• Large additional cost. • Sale of site with remediation of all known contamination allowing increased value of the site. • Removes the potential liability of future contamination or action under Part IIA by the Environment Agency. • Likely to make the site suitable for most sensitive development scenarios including residential development. • Removal may not be necessary for all development scenarios.

Undertaking remediation of the contamination encountered at the site will require the development of a remedial strategy and production of accompanying contract documentation to tender the work to a specialist contractor. Validation testing would be required to demonstrate that remediation had been undertaken to a satisfactory standard and the results of the testing presented in a validation report. The process of contract procurement, undertaking remedial works, validation testing and reporting is likely to take several months to complete. A Quantitative Risk Assessment (QRA) could be completed within a number of weeks.

4.2 Option 1 – Do Nothing

Option 1 involves taking no further action. This option would incur no further costs although the MoD could be in breach of current legislation relating to the potential presence of asbestos containing materials (ACMs).

A number of buildings on site were constructed between 1950 and 1980 when the use of asbestos in construction materials was ubiquitous. Although it is understood that an asbestos register is now complete, and may be available for review, by taking no action (i.e. not updating the register with information from this report) the MoD could be in breach of The Control of Asbestos at Work Act and (as amended) and the Control of Asbestos at Work Regulations 2002.

The LQA has concluded that under current use, there is no significant possibility of significant harm due to the contaminants identified. Should the site be considered for re-sale, then it is likely that patterns of use of the land could change, leading to different conclusions concerning risks to human health.

Current site investigation information could be provided to a potential purchaser with the opportunity of transferring the potential liability to the future owner upon sale of the land, i.e. the land be sold with information.

4.3 Option 2 – Do Minimum

Option 2 involves no change to current site use, but concentrates on management of known risks. This option includes the review (and if appropriate, amendment) of the asbestos register for the site, which is understood to have recently been completed.

Remedial works may still be required to make the site suitable for redevelopment for residential land use, should any additional asbestos material be encountered during redevelopment works.

4.4 Option 3 – QRA for Arsenic

Completion of a quantitative risk assessment to better characterise risk to human health for a residential land use would also be undertaken for this option. This option does not improve the land quality of the site, but an increase in sale value could be achieved provided the QRA identified that minimal remedial measures for future uses could be justified as suitable for protecting human health or pollution of water resources.

This option aims to present a pragmatic solution to the known contaminants, with an emphasis on avoiding excavation and disposal of waste material where possible. Prior to the completion of the QRA, some additional soil sample analysis would be carried out to assess the bioavailability of the arsenic in the soils. Such an option would be most usefully undertaken with a specific redevelopment proposal so the study characetrises risks arising from the actual planned use.

Option 3 would incur some additional cost to the MoD but could reduce the liability associated with contamination at the site. This option could allow higher sensitvity development of the site and may increase the sale value.

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4.5 Option 4 – Remediation

In the unlikely event of subsequent studies concluding that arsenic concentrations do present a risk to future residential site users, then some form of remediation may be necessary (if residential development were to occur). It is possible that this could take the form of an innovative ground treatment rather than excavation and disposal. Innovative remediation technologies could offer considerable savings over traditional excavation and disposal methods. However, estimating the costs of such activities is more complicated, and would be best carried out upon completion of toxicity/ bioavailability studies.

Therefore, as a worst case, this option allows for excavation and disposal to an appropriately licensed landfill of all known sources of contamination (arsenic in made ground soils). The volumes of material to be excavated have been estimated based on the ground conditions and analytical data obtained during the site investigation.

Location	Area (m^2)	Thickness (m)	Volume (m^3)
Whole ESA site (Made Ground)	57,500	0.7	19,263*

*Assumes that only 50% of the arsenic impacted soils would require removal, to allow for hardstanding/foundation areas to appropriately cover part of any development.

Option 4 would incur additional cost to the MoD. However, it will allow the sale of the site with removal of potentially liability associated with known elevated concentrations of arsenic encountered during the site investigation. The extensive remediation of the site should increase the sale value of the site, although a cost-benefit analysis may prove this option to be inappropriate.

5.0 FINANCIAL RISK ANALYSIS

A financial risk assessment has been undertaken for the remedial options outlined in Chapter 4.0. The risk analysis has been undertaken in accordance with the Ministry of Defence Technical Bulletin 99/21 Estimating Using Risk Analysis. The following options have been considered in the analysis:

- Option 1- Do nothing.
- Option 2- Do Minimum (review and amend asbestos register).
- Option 3- QRA for Arsenic.
- Option 4- Remediation of Arsenic contaminated made ground.

The detailed order of costs, risk register and full calculations are included in **Appendix B**.

A summary of the order of cost estimates relating to these options are presented below:

Option	Base Cost	Average Risk Allowance	Average Risk Estimate (ARE)	Maximum Risk Allowance	Maximum Likely Risk Estimate (MLRE)
1 Do Nothing	**0**	0	**0**	0	**0**
2 Do Minimum (review and amend asbestos register)	**3,500**	700	**4,200**	1,050	**4,550**
3 QRA for Arsenic	**12,400**	2,690	**15,090**	3,974	**16,374**
4 Remediation	**2,930,093**	1,115,597	**4,045,690**	1,731,933	**4,662,027**

The above table indicates that to complete any remediation of the site involving excavation and disposal of soils would be prohibitively expensive and that Option 2 offers the lowest cost solution (apart from doing nothing at all).

Note that Option 2 includes the review (and if appropriate, amendment)of the asbestos register. There may also be cost implications from that study, concerning the safe management of asbestos containing materials, or their disposal.

6.0 OVERALL LAND QUALITY AND SUITABILITY FOR REDEVELOPMENT

A site investigation has been undertaken at RAF Bicester ESA to clarify the nature and extent of potential sources of contamination identified in the Phase One LQA. The land quality of the site is suitable for current use as a result of no significant pollutant linkages having been identified. Should the site be considered for redevelopment, then there may be risks associated with elevated concentrations of arsenic in made ground soils. Statistical analysis of the data suggests that there would be a possibility of significant harm resulting to human receptors under a residential without plant uptake land use.

The risks to current site users from potential ground contamination have been assessed as low, though this would increase to moderate for future residential users.

Risks to current site users from asbestos are low. Although asbestos containing materials (ACMs) may have been present within former buildings on site, ACM was not encountered during the investigation. The buildings were of an age and type where ACMs may be present and it should be noted that asbestos was identified and removed during the EOD clearance of the site. Therefore there remains a limited potential for isolated pockets of ACM to exist in soils around the footprint of former buildings.

There is a low to moderate risk that site redevelopment workers may come into contact with and be exposed to ACMs. Potential risks can be controlled with the implementation of appropriate site clearance procedures, including the provision of suitable Personal Protective Equipment for site personnel.

Risks to site users from the potential presence of unexploded ordnance are considered to be low, as the site has been subject to an extensive EOD exercise.

Potential risks to groundwater are negligible with regard to the Cornbrash Major Aquifer, and low with regard to the White Limestone Major Aquifer. The lack of groundwater encountered in the investigation and the generally low concentrations of contaminants limits risk to the aquifers. Furthermore, the uppermost aquifer is unlikely to be used as a groundwater resource due to its limited extent. The sequence of clay and consolidated rock between the upper and low aquifers is also likely to prevent the vertical migration of any contaminants.

Given the general lack of shallow groundwater, there is minimal potential for shallow groundwater to impact on surface water bodies at the site. The risk to surface water is therefore considered to be negligible due to the distance to the nearest surface water body.

Risks to future users of the site will depend upon the nature of that use. However, it is considered that the ESA part of RAF Bicester will be suitable for a non-sensitive end-use (commercial or light industrial). The ESA site may also be suitable for a more sensitive (residential) end-use.

A number of options for dealing with the identified contamination have been outlined. These range from a taking no action to an option involving removal of all known contaminated soils.

Recommendation of management options has been based upon two scenarios:

- Continuation of existing use (unoccupied).
- Decommissioning and release for sale and redevelopment for commercial or residential end-use.

6.1 Existing Use: Option 2 – Do Minimum

If RAF Bicester were to be retained by the MoD for its existing use then Option 2 is recommended. This would confirm the current risk management procedures to address the potential extent of asbestos materials present within buildings.

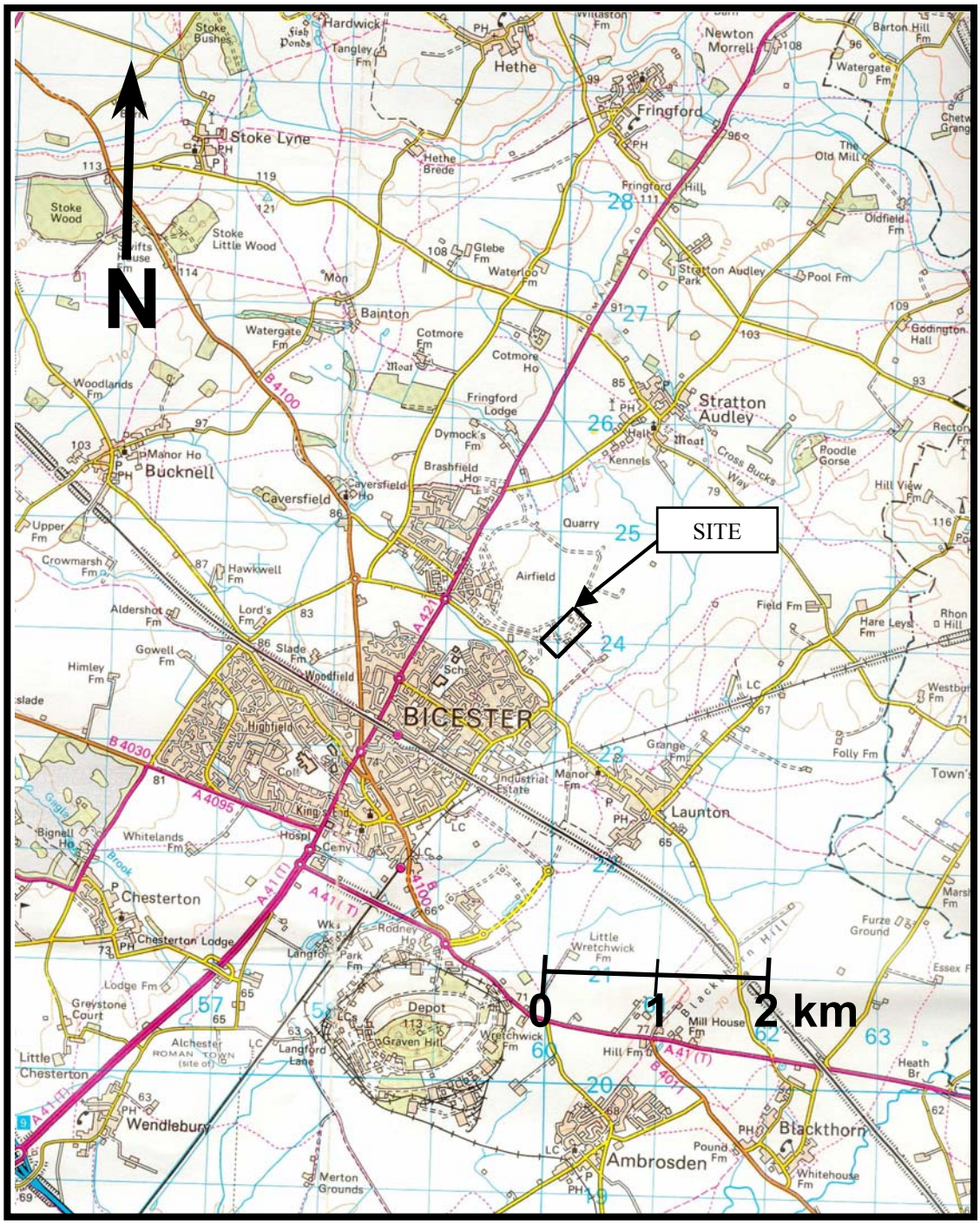
This option does not address any potential environmental liability associated with the contamination but will allow for appropriate management of the site to control the identified environmental risks characterised in the exploratory site investigation.

6.2 Decommissioning and Release for Sale: Option 3 – QRA for Arsenic

This option is recommended should the MoD wish to release the site for sale for non-sensitive end-use. Elevated concentrations of arsenic have been identified in made ground soils, which may represent unacceptable risks to some forms of development. This could lead to a requirement for some form of remediation dependent on the type and layout of further use. However, the need for remediation might be significantly reduced by studies of arsenic bioavailability and site specific quantitative analysis of risks to an agreed form of development.

This option could reduce the liability associated with the contamination and may increase the sale value of the site.

FIGURES



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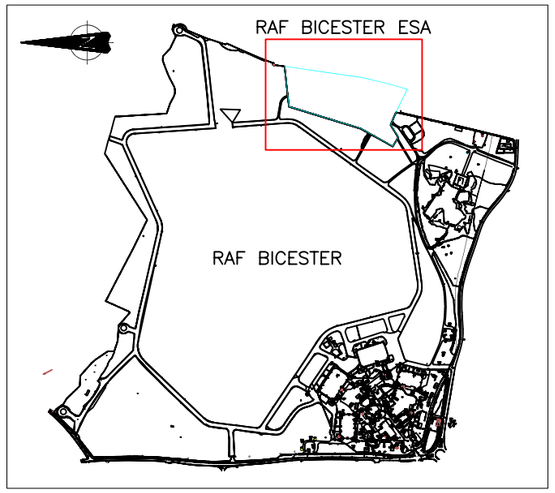
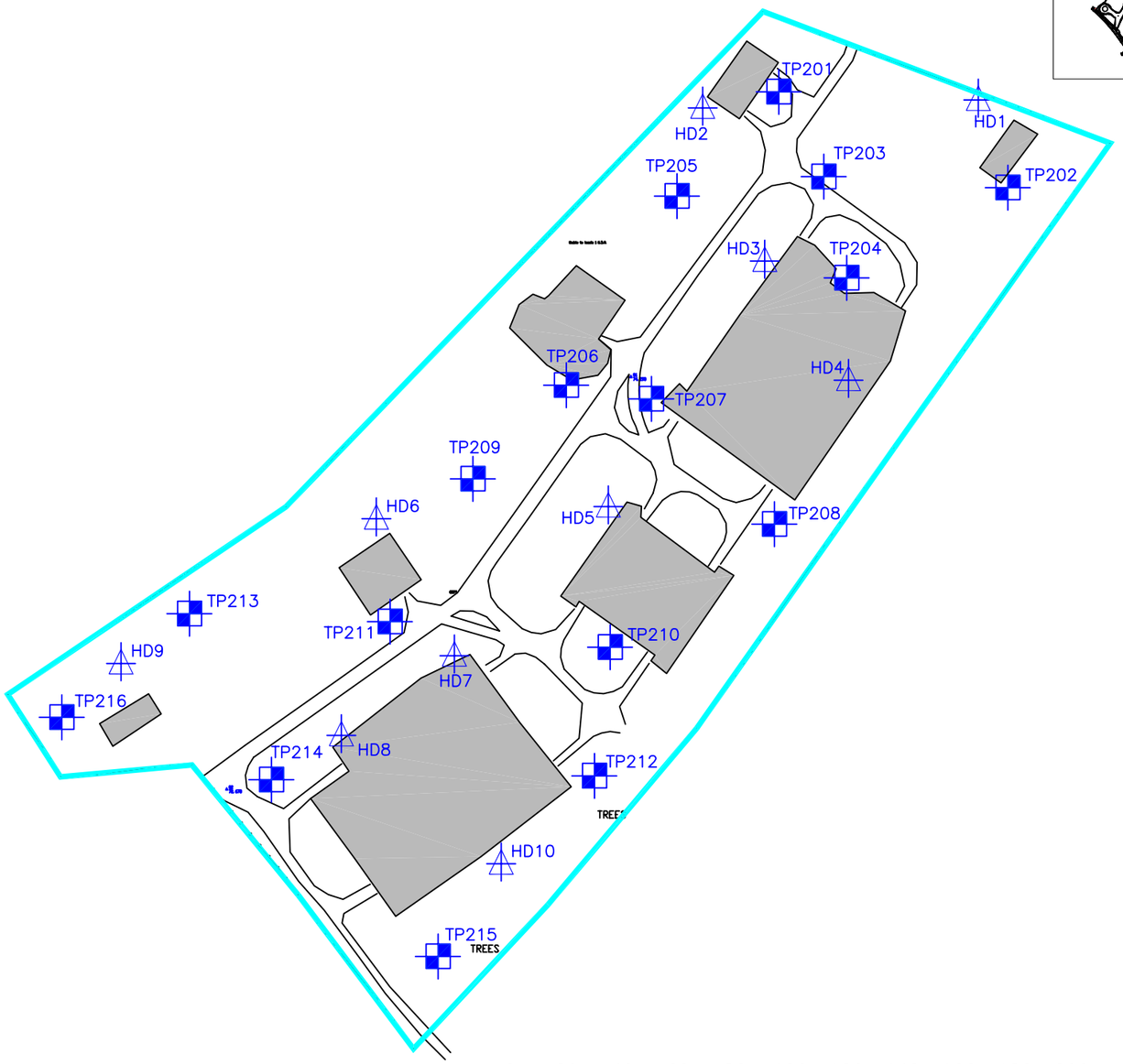
PROJECT: RAF Bicester ESA Phase 2 LQA	CLIENT: Defence Estates	
SCALE: AS SHOWN	GRID REFERENCE: 460150 224200	
JOB NUMBER: 73.1247.03	TITLE: Site Location Map	FIGURE 1





NOTES

KEY

- SITE BOUNDARY
- TRIAL PIT LOCATION
- HAND DIG PIT LOCATION
- BUILDINGS AND INFRASTRUCTURE

REV	AMENDMENTS	BY	CHKD	APR'D	DATE
0	FIRST ISSUE				

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CLIENT

DEFENCE ESTATES

PROJECT

RAF BICESTER ESA PHASE 2 LQA

TITLE

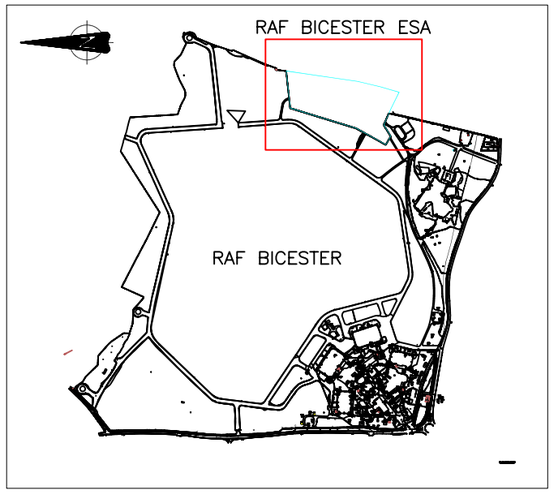
FIGURE 2 – SITE LAYOUT AND EXPLORATORY HOLE LOCATIONS

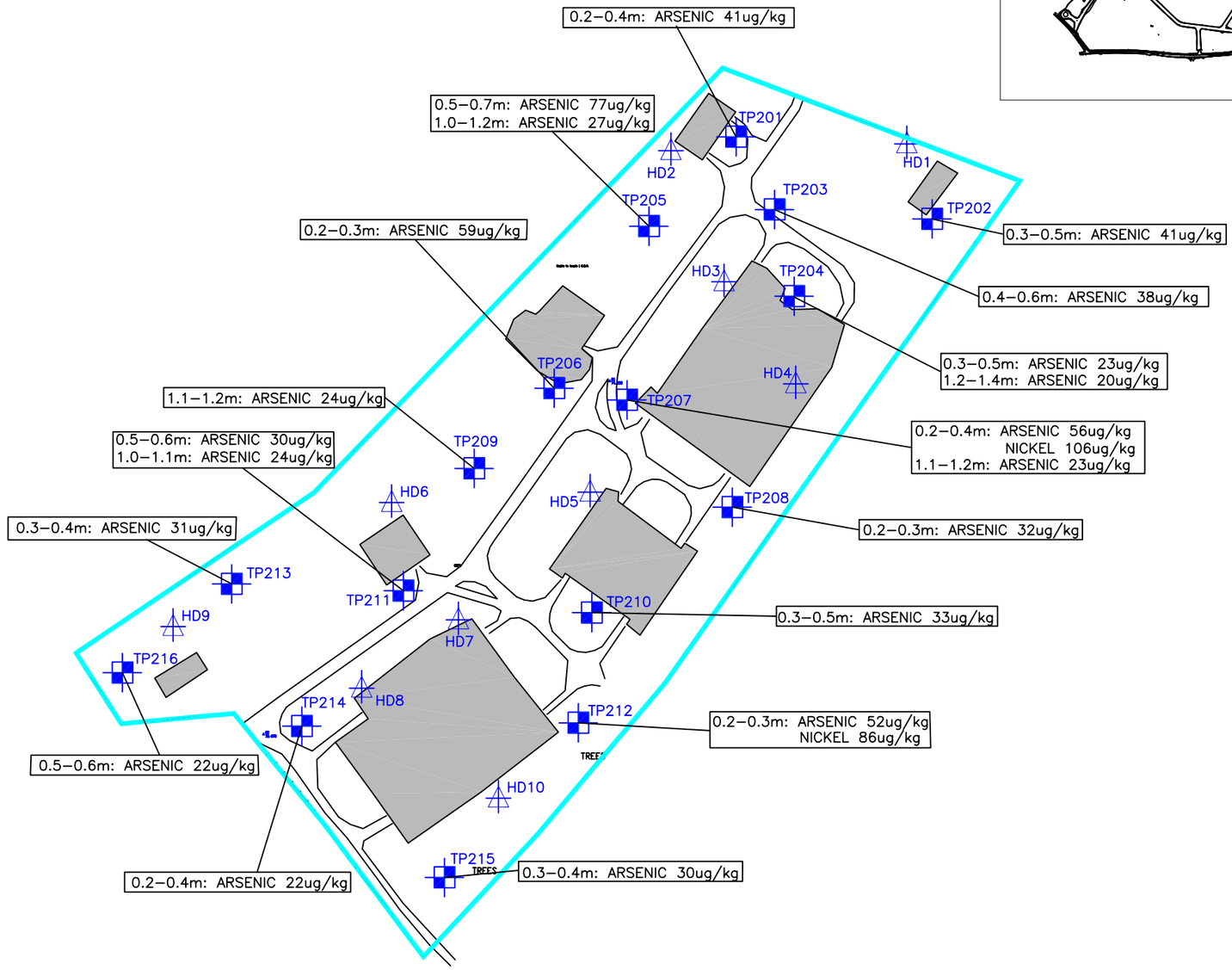
DRAWING STATUS

FINAL

DRAWN	CHECKED	APPROVED
TM		
DATE	DATE	DATE
20.02.03		
SCALE	ORIGINAL DRAWING SIZE	
1:2000	297 x 420 - A3	

DRAWING No 73.1247.03–FIG2 REV. 0





NOTES

KEY

- SITE BOUNDARY
- TRIAL PIT LOCATION
- HAND DIG PIT LOCATION
- BUILDINGS AND INFRASTRUCTURE
- 0.2–0.4m: ARSENIC — EXCEEDS TIER 1 SGV FOR RESIDENTIAL WITHOUT PLANT UPTAKE

REV	AMENDMENTS	BY	CHKD	APR'D	DATE
0	FIRST ISSUE				

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DEFENCE ESTATES

PROJECT

RAF BICESTER ESA PHASE 2 LQA

TITLE

FIGURE 3 – AREAS OF SOIL CONTAMINATION

DRAWING STATUS

FINAL

DRAWN	CHECKED	APPROVED
TM		
DATE	DATE	DATE
20.2.03		
SCALE	ORIGINAL DRAWING SIZE	
1:2000	297 x 420 - A3	
DRAWING No		REV.
73.1247.03–FIG3		0

APPENDIX A

DE LQA DIRECTIVE

APPENDIX B

FINANCIAL RISK ESTIMATE CALCULATIONS

REMEDIATION COST ESTIMATE

RAF Bicester ESA

BASE COST ESTIMATES

Area of contaminated material		m^2	Source	
Average depth		m	Source	
Volume of contaminated material		m^3		

Item	Amount	Unit	Unit rate, £	Cost,£
Base Construction Cost				**£0**

Review Asbestos Survey	Allow	2000	
Completion reporting	sum	1500	
Base Resource Cost			**£3,500**

Total Base Cost	**£3,500**

RISK ELEMENT CALCULATION

Risk Element	Average Risk (%increase)	Maximum Risk (%increase)	Type	Average Risk: Base Value of Risk Element	Average Risk: Probability Factor (F) or Confidence Limit (V)	Average Risk: Value	Maximum Risk: Probability Factor (F) or Confidence Limit (V)	Maximum Risk: Value	Maximum Risk: Deviation from the Average (h)	Maximum Risk: Square of the Deviation (h^2)
CONSTRUCTION RISKS										
Increased excavation	30	50	F	0	50%	0	90%	0	0	0.00E+00
Increased disposal to landfill	30	50	F	0	50%	0	90%	0	0	0.00E+00
Dealing with increased groundwater	5	10	F	0	50%	0	90%	0	0	0.00E+00
Tender price increases	10	20	V	0	50%	0	90%	0	0	0.00E+00
Additional Item (OVERTYPE)						0		0	0	0.00E+00
RESOURCE RISKS										
Increased resource costs	20	30	V	3,500	50%	700	90%	1,050	350	1.23E+05
Regulatory Approvals			V	2,000	50%	0	90%	0	0	0.00E+00
Additional Item (OVERTYPE)						0		0	0	0.00E+00
Additional Item (OVERTYPE)						0		0	0	0.00E+00

Construction Average Risk Allowance:	**0**
Resource Average Risk Allowance:	**700**

Sum of $(h)^2$:	0.00E+00
Square root of sum of $(h)^2$:	0
Add Average Risk Allowance:	0
Construction Maximum Risk Allowance:	**0**

Sum of $(h)^2$:	1.23E+05
Square root of sum of $(h)^2$:	350
Add Average Risk Allowance:	700
Resource Maximum Risk Allowance:	**1,050**

RISK ADDITION

	BASE COSTS		RISK ALLOWANCES		SUM OF BASE + RISK		**TOTAL RISK ESTIMATE**
	Construction	Resource	Construction	Resource	Construction	Resource	
Average Risk Estimate	0	3500	0	700	0	4200	**4200**
Maximum Risk Estimate	0	3500	0	1050	0	4550	**4550**

Assumptions
Density approximation : 1.7 tonne = $1m^3$
Bulking Factor of 1.3

REMEDIATION COST ESTIMATE

RAF Bicester ESA

BASE COST ESTIMATES

Area of contaminated material		m^2	Source	
Average depth		m	Source	
Volume of contaminated material		m^3		

Item	Amount	Unit	Unit rate, £	Cost,£
Trial Pitting	2	day	200	400
PBET Analysis	20	each	100	2000
Base Construction Cost				**£2,400**

Consultations and negotiations with Regulators	sum	1500	
QRA study	Allow	4500	
Completion reporting	sum	4000	
Base Resource Cost			**£10,000**

Total Base Cost	**£12,400**

RISK ELEMENT CALCULATION

Risk Element	Average Risk (%increase)	Maximum Risk (%increase)	Type	Average Risk: Base Value of Risk Element	Average Risk: Probability Factor (F) or Confidence Limit (V)	Average Risk: Value	Maximum Risk: Probability Factor (F) or Confidence Limit (V)	Maximum Risk: Value	Deviation from the Average (h)	Square of the Deviation (h^2)
CONSTRUCTION RISKS										
			F		50%	0	90%	0	0	0.00E+00
			F		50%	0	90%	0	0	0.00E+00
			F		50%	0	90%	0	0	0.00E+00
Tender price increases	10	20	V	2,400	50%	240	90%	480	240	5.76E+04
Additional Item (OVERTYPE)						0		0	0	0.00E+00
RESOURCE RISKS										
Increased resource costs	20	30	V	10,000	50%	2,000	90%	3,000	1,000	1.00E+06
Regulatory Approvals	30	50	V	1,500	50%	450	90%	750	300	9.00E+04
Additional Item (OVERTYPE)						0		0	0	0.00E+00
Additional Item (OVERTYPE)						0		0	0	0.00E+00

Construction Average Risk Allowance:	**240**
Resource Average Risk Allowance:	**2,450**

Sum of $(h)^{2:}$	5.76E+04
Square root of sum of $(h)^2$:	240
Add Average Risk Allowance:	240
Construction Maximum Risk Allowance:	**480**

Sum of $(h)^{2:}$	1.09E+06
Square root of sum of $(h)^2$:	1,044
Add Average Risk Allowance:	2,450
Resource Maximum Risk Allowance:	**3,494**

RISK ADDITION

	BASE COSTS		RISK ALLOWANCES		SUM OF BASE + RISK		**TOTAL RISK ESTIMATE**
	Construction	Resource	Construction	Resource	Construction	Resource	
Average Risk Estimate	2400	10000	240	2450	2640	12450	**15090**
Maximum Risk Estimate	2400	10000	480	3494	2880	13494	**16374**

Assumptions

Density approximation : 1.7 tonne = 1m^3
Bulking Factor of 1.3

REMEDIATION COST ESTIMATE

RAF Bicester ESA

BASE COST ESTIMATES

Area of contaminated material	57500	m^2	Source	Site Topo Survey
Average depth	0.7	m	Source	Calculation based on Fig 3.
Volume of contaminated material	38525	m^3		

Item	Amount	Unit	Unit rate, £	Cost,£	
Excavation	19263	m^3	1.50	28894	assumes only 50% of made ground requires disposa
Disposal to licensed landfill	31783	tonne	75.00	2383734	
Backfill void with imported clean fill	31783	tonne	10.00	317831	
Dealing with groundwater			Allow	2000	
Mobilisation, prelims, temp facilities		Percentage	4	109298	
Insurance		Percentage	2	56835	
Base Construction Cost					**£2,898,593**

Consultations and negotiations with Regulators	sum	2000	
Detailed design and project management	Allow	8500	
Contract docs and tendering	sum	3000	
Site supervision, validation sampling and testing	sum	10000	
Contract Negotiations	sum	2000	
Completion reporting	sum	6000	
Base Resource Cost			**£31,500**

Total Base Cost	**£2,930,093**

RISK ELEMENT CALCULATION

Risk Element	Average Risk (%increase)	Maximum Risk (%increase)	Type	Average Risk: Base Value of Risk Element	Average Risk: Probability Factor (F) or Confidence Limit (V)	Average Risk: Value	Maximum Risk: Probability Factor (F) or Confidence Limit (V)	Maximum Risk: Value	Maximum Risk: Deviation from the Average (h)	Maximum Risk: Square of the Deviation (h^2)
CONSTRUCTION RISKS										
Increased excavation	30	50	F	28,894	50%	8,668	90%	14,447	5,779	3.34E+07
Increased disposal to landfill	30	50	F	2,701,566	50%	810,470	90%	1,350,783	540,313	2.92E+11
Dealing with increased groundwater	5	10	F	2,000	50%	100	90%	200	100	1.00E+04
Tender price increases	10	20	V	2,898,593	50%	289,859	90%	579,719	289,859	8.40E+10
Additional Item (OVERTYPE)						0		0	0	0.00E+00
RESOURCE RISKS										
Increased resource costs	20	30	V	31,500	50%	6,300	90%	9,450	3,150	9.92E+06
Regulatory Approvals	10	20	V	2,000	50%	200	90%	400	200	4.00E+04
Additional Item (OVERTYPE)						0		0	0	0.00E+00
Additional Item (OVERTYPE)						0		0	0	0.00E+00

Construction Average Risk Allowance:	**1,109,097**
Resource Average Risk Allowance:	**6,500**

Sum of $(h)^2$:	3.76E+11
Square root of sum of $(h)^2$:	613,180
Add Average Risk Allowance:	1,109,097
Construction Maximum Risk Allowance:	**1,722,277**

Sum of $(h)^2$:	9.96E+06
Square root of sum of $(h)^2$:	3,156
Add Average Risk Allowance:	6,500
Resource Maximum Risk Allowance:	**9,656**

RISK ADDITION

	BASE COSTS		RISK ALLOWANCES		SUM OF BASE + RISK		**TOTAL RISK ESTIMATE**
	Construction	Resource	Construction	Resource	Construction	Resource	
Average Risk Estimate	2898593	31500	1109097	6500	4007690	38000	**4045690**
Maximum Risk Estimate	2898593	31500	1722277	9656	4620870	41156	**4662027**

Assumptions

Density approximation : 1.65 tonne = 1m^3

Bulking Factor of 1.3

RISK REGISTER

Reference	Description	Dependencies	Effect Time/Cost	Allowance Average	Allowance Maximum	Status Current	Status Previous	Response Status/ Action Required
Co.001 /Opt2	Increased Resource Costs		C	2700	4050	A	I	Current
T.001 /Opt2	Regulatory Approvals		T,C	150	300	A	I	Current

Risk Reference Categories	
Cl.	Client Risks
Co.	Consultant Risks
T.	Third Party Risks
O.	Other Risks

Effect Categories	
T	Time
C	Cost

Status Categories	
A	Assessed and allowed
M	Managed out
D	Designed out
S	Shared
I	Ignored

RISK REGISTER

Comments

RISK REGISTER

Reference	Description	Dependencies	Effect Time/Cost	Allowance Average	Allowance Maximum	Status Current	Status Previous	Response Status/ Action Required	Comments
D.001 /Opt3	Increased capping volume		T,C	21400	64200	A	I	Hold	
D.002 /Opt3	Dealing with increased groundwater		T,C	75	150	A	I	Hold	
T.001 /Opt3	Tender price increases		C	24205	48410	A	I	Hold	
Co.001 /Opt3	Increased resources costs		C	10700	16050	A	I	Hold	
T.002 /Opt3	Regulatory approvals		T,C	1200	2000	A	I	Hold	

Risk Reference Categories	
Cl.	Client Risks
Co.	Consultant Risks
D.	Design Risks
T.	Third Party Risks
O.	Other Risks

Effect Categories	
T	Time
C	Cost

Status Categories	
A	Assessed and allowed
M	Managed out
D	Designed out
S	Shared
I	Ignored

Appendix B - Risk Register Option 4 -Extensive Remediation

RISK REGISTER

Reference	Description	Dependencies	Effect Time/Cost	Allowance Average (£)	Allowance Maximum (£)	Status Current	Status Previous	Response Status/ Action Required
D.001 /opt4	Increased excavation		T,C	11241	18735	A	I	Hold
D.002 /opt4	Increased disposal to landfill	D.001	T,C	1082883	1804805	A	I	Hold
D.003 /opt4	Dealing with increased groundwater		T,C	100	200	A	I	Hold
T.001 /opt4	Tender price increases		C	402275	804549	A	I	Hold
Co.001 /opt4	Increased resource costs		C	11300	16950	A	I	Hold
T.002 /opt4	Regulatory Approvals		T,C	150	300	A	I	Hold

Risk Reference Categories	
Cl.	Client Risks
Co.	Consultant Risks
D.	Design Risks
T.	Third Party Risks
O.	Other Risks

Effect Categories	
T	Time
C	Cost

Status Categories	
A	Assessed and allowed
M	Managed out
D	Designed out
S	Shared
I	Ignored

RISK REGISTER

Comments

APPENDIX C

SUMMARY OF LQA FINDINGS

Carl Bro Group

APPENDIX C : Summary of LQA Findings for RAF Bicester ESA

Site DPR #	Site Name	Area (Ha)	Grid reference	LQA Priority	Current LQA Phase	Start Date	Finish Date	Total Spend to Date	Overall Land Quality
	RAF Bicester (ESA Site) Buckingham Road Caversfield Bicester Oxon	6 H	SP 601 242	1 See Note 1	2 See Note 2	September 2002	February 2003	£17,072.39	2 See Note 3

Pollutant Source (Area / Building)	Pollutant	Key Receptor	Approx. Area of Site Affected (m^2)	Liability Class
1. Made Ground Soils	Arsenic	Humans		[D: Minor remediation liability to C : Large remediation liability][A]
2. Made Ground Soils where buildings have been demolished	Asbestos	Humans		[D: Minor remediation liability][B]

Comments :

- Total Spend to Date can be completed for Final Report.

Note 1:

1	Land identified for disposal or subject to rationalisation or where significant change in land use is envisaged.
2a	Land in sensitive area and with known or suspected contamination.
2b	Known threat; site sensitive area such as major aquifer.
2c	Strongly suspected threat or possible threat from e.g. radioactive substances, dioxins, CW materials.
2d	No known evidence of threat.

Note 2:

0	Prioritisation
1	Desk Study
2	Site Investigation
3	Assessing need for remediation

Note 3:

1	No known or potential sources of contamination.
2	Majority of site is unlikely to be contaminated. A number of localised sources of contamination are or may be evident.
3	Majority of site is likely to be contaminated.

[A] Liability relates to future change in use, and may be reduced by detailed QRA
[B] Liability classification allocated without benefit of review of asbestos register