GRAVEN HILL, BICESTER

Remediation Options Appraisal and Remediation Strategy Report Land Transfer Area 1

January 2016

Waterman Infrastructure & Environment Limited

Merchants House, Wapping Road, Bristol, BS1 4RW
www.watermangroup.com

GRAVEN HILL, BICESTER

Land Transfer Area 1

Client Name: Graven Hill Village Development Company Limited
Document Reference: WIB13983-104-R-2-2-3-MA-MACF
Project Number: WIB13983-104

Quality Assurance – Approval Status

This document has been prepared and checked in accordance with Waterman Group's IMS (BS EN ISO 9001: 2008, BS EN ISO 14001: 2004 and BS OHSAS 18001:2007)

Issue	Date	Prepared by	Checked and Approved by	Approved by
First Issue	October 2015	Mark Amos Senior Consultant		Richard Stockwell Regional Director
Comments				
Second Issue	January 2016	Mark Amos Senior Consultant		Richard Stockwell Regional Director
Comments		Updated to reflect changes to scheme design		

Our Markets

Property & Buildings

Transport & Infrastructure

Energy & Utilities

Environment

Disclaimer

This report has been prepared for the sole and exclusive use of **Graven Hill Village Development Company Limited,** the Client, from whom it was commissioned and has been prepared in response to their particular requirements and brief.

This report has been prepared by **Waterman Infrastructure & Environment Limited** with reasonable skill and care in accordance with the agreed; brief, scope of works, fee proposal, contract, subsequent agreed instructions and requirements of the Client, taking into account the available timescale and resources devoted to it, all as agreed with the Client.

We disclaim any responsibility to the Client and others in respect of any matters outside the scope of this report.

This report is not intended for and should not be relied on by any third party and no responsibility is undertaken to any third party.

This report is confidential to the Client and we accept no responsibility of whatsoever nature to third parties to whom this report, or any part thereof, is made known. Any such party relies on the report at its own risk.

The Contracts (Rights of Third Parties) Act 1999 shall not apply to this report and the provisions of the said Act are expressly excluded from this report.

This report may not be used for any purpose other than that for which it was commissioned.

This report may not be reproduced and/or made public by print, photocopy, microfilm or any other means without the prior written permission of Waterman.

Some of the information, conclusions and recommendations presented in this report are based on information provided by others. None of that information has been checked nor independently verified by Waterman.

The information, conclusions and recommendations presented in this report are not necessarily indicative of future conditions, or operating practices; at, beneath or adjacent to the Site.

It is possible that other ground conditions, contamination or geo-environmental conditions may exist and consequently reliance on the findings of this report must be limited accordingly.

Contents

Tables

Appendices

Executive Summary

1. This report will assist in discharging Planning Condition 77 "Contamination".
2. This Executive Summary must not be read in isolation. It must be read in conjunction with the remainder of this report.
3. This report should be read in conjunction with Waterman's report entitled "Graven Hill, Bicester, Environmental Interpretative Report for Land Transfer Area 1, September 2015, Document Reference: WIB13983-104-R-1-1-7-GH, Project Number: WIB13983-104".
4. This report refers to Land Transfer Area (LTA) 1. Refer to Figure A2 Appendix A.
5. At the Client's request some areas of LTA 1 are not covered by this report. In particular, this report does not cover the new proposed school site.
6. Very little ground, or groundwater, contamination has been encountered during the March 2015 Intrusive Ground Investigation.
7. However, isolated contaminated hot spots, not yet identified, cannot be discounted.
8. Reference to elevated concentrations refer to "elevated" with respect to a "residential end use".
9. **Heavy Metals:** Only limited, very slightly elevated concentrations of heavy metals were encountered, but only at localised hot spots or within drainage channels open ditches/swales. Refer to locations in Figure A4A 'Proposed Master Plan showing Soil Exceedance Locations' and Figure A4B 'Existing Topography showing Soil Exceedance Locations' is contained within Appendix A.
10. **Poly-aromatic Hydrocarbons:** Only limited, very slightly elevated concentrations of poly-aromatic hydrocarbons (PAH) were encountered, but only at localised hot spots associated with areas of tarmac and within drainage channels open ditches/swales. Refer to locations in Figure A4A 'Proposed Master Plan showing Soil Exceedance Locations' and Figure A4B 'Existing Topography showing Soil Exceedance Locations' is contained within Appendix A.
11. **Hydrocarbons:** Elevated total petroleum hydrocarbons have also been encountered, but only at one isolated location near Rodney House, refer to locations in Figure A4A 'Proposed Master Plan showing Soil Exceedance Locations' and Figure A4B 'Existing Topography showing Soil Exceedance Locations' is contained within Appendix A. .
12. **Asbestos:** No visible asbestos containing materials (ACMs) have been encountered. However, Amicus Environmental Ltd has identified localised areas of asbestos containing materials (ACMs) associated with the now disused above ground MOD district heating pipes. Therefore, the presence of asbestos containing materials (ACMs) cannot be discounted.
13. **Contaminated Soils :** Such slightly contaminated soils are mostly associated with:
    a. shallow sediments in existing ditches and swales;
    b. Made Ground;
    c. natural soils, but only at shallow depths.
14. The slightly elevated contaminants in the:
    a. ditches and swales comprise beryllium, lead, zinc, and poly-aromatic hydrocarbons;
    b. Made Ground comprise beryllium, lead, zinc, benzo(b)fluoranthene, di-benzo(a.h.)anthracene, benzo(a)pyrene;
    c. natural soils comprise beryllium and lead (very few locations).

15. Following further Generic Quantitative Risk Assessment the risk of minor elevated contaminated soils at the site is considered low and soils at the locations as illustrated in Figure A4A 'Proposed Master Plan showing Soil Exceedance Locations' and Figure A4B 'Existing Topography showing Soil Exceedance Locations' is contained within Appendix A, present a low risk to future site occupiers and therefore no remediation of these soils is considered necessary.
16. Further Generic Quantitative Risk Assessment assessed the soils against the following revised assessment criteria:
17. **Public Open Space:** In areas designated as future Public Open Space, the existing shallow soils should not present a risk to human health, and therefore no remediation at these locations is considered necessary.
18. **Commercial:** In areas designated as future Commercial (Employment), the existing shallow soils should not present a risk to human health, and therefore no remediation at these locations is considered necessary.
19. **Residential:** In areas designated as future Residential, the existing shallow soils had only minor exceedances that are not considered a significant risk to human health, and therefore no remediation at these locations is considered necessary.
20. **Ditches and Swales:** Sediment from ditches and swales exceeds the residential assessment criteria, i.e. are considered contaminated.
21. Sediment from surface water drainage (including interceptors), ditches and swales has been found to exceed the residential assessment criteria in all instances. Therefore, should these features form part of a residential setting, or be intended for removal as part of the development works, then these sediments should be deemed to be contaminated material and excavated to a minimum depth of 250mm and stockpiled.
22. Sediment within surface water drainage (including interceptors) should be removed in their entirety prior to drains being broken out and removed, or re-used as part of the new development drainage system.
23. Where sediments are stockpiled they:
    a) may be temporarily stockpiled on Site, but without causing or spreading pollution;
    b) but, shall not form part of the permeant Works without treatment (including clean cover system);
    c) shall be removed from the Site; OR
    d) may be used below new buildings, hardstanding or roads, if geotechnically suitable; OR
    e) may be buried at depth beneath landscape areas (Public Open Space), with a coloured geotextile base marker layer and a 1.0m thick clean cover layer.
24. **Groundwater:** No significant leachable contaminants were encountered.
25. Minor exceedances of sulphate were encountered in leachate samples (considered to be natural background concentrations).
26. Minor exceedances of copper, vanadium, sulphate were encountered in the groundwater, at such low concentrations no significant risk to groundwater is perceived and no remediation is required.
27. Such slightly contaminated soils are mostly above perched water and therefore not likely to be in hydraulic conductivity with any deeper groundwater bodies.
28. **Ground Gases:** No significant ground gases have been encountered. **Characteristic Situation 1** is appropriate, requiring no ground gas protection measures.

29. The Site does not lie in a radon protection area. Nevertheless, radon protection measures should be agreed with the Building Control Officer.
30. **Potable Water Pipes:** Very minor elevated concentrations of arsenic and selenium were encountered. Polyethylene potable water pipes are not recommended. Potable water pipe specifications should be agreed with Thames Water.

Specification Requirements

31. All site won soils to be used as fill shall be tested for the list of determinants in Appendix B at a rate of 1 test per 250m^3.
32. Imported soils to be used as fill shall be tested for the list of determinants in Appendix B at a rate of 1 test per 500m^3.

Options Appraisal

33. **Re-Use on Site:** The most cost effective solution is likely to re-use such slightly contaminated soils on-site by:
    a. breaking the "pollutant linkage", i.e. clean cover layer;
    b. burying beneath new buildings, roads or hard standings;
    c. burying at depth beneath landscape areas with a coloured geotextile base marker layer and a 1.0m thick clean cover layer;
    d. provided that are geotechnically acceptable.
34. **"Dig & Dump":** Alternatively, excavate and remove off-site, "Dig & Dump", to an appropriate landfill.
35. But, off-site landfill disposal would likely require pre-treatment as a result of the high sulphate content.
36. Sediments from ditches and swales, if disposed of off-site to landfill, may be classified as Hazardous Waste due to elevated metals and hydrocarbons, which would add significantly to any disposal costs.
37. **On-Site Treatment:** Due to the limited volume of slightly contaminated soils, on site treatment is unlikely to be cost effective.

1. Introduction

1.1 Project Brief

Waterman Infrastructure & Environment Limited ("Waterman") was instructed by EC Harris (now Arcadis) on behalf of the Graven Hill Village Development Company Limited to undertake a Remediation Options Appraisal and Remediation Strategy within Land Transfer Area 1 (LTA1). It is recommended that consideration is given to further environmental assessment within the remaining Graven Hill Master Plan areas and Land Transfer Area 2 (LTA2), at a later date, to support the proposed redevelopment of Graven Hill, Bicester, Oxfordshire. The requirement for further environmental assessment, amongst other things, may depend on the actual findings on Site during the Construction Phase 1a infrastructure works.

Following completion of Waterman's Environmental Interpretative Report for ground conditions with LTA1, entitled "Graven Hill, Bicester, Environmental Interpretative Report for Land Transfer Area 1, September 2015, Document Reference: WIB13983-104-R-1-1-7-GH" the purpose of this report is to set out the further qualitative risk assessment, the remediation options appraisal and the preferred remediation solution/s, where found appropriate, to satisfy the requirements of the "Model Procedures for the Management of Land Contamination, Contaminated Land Report 11, Environment Agency, September 2004".

This report also includes an outline of the overall strategy that will be used to manage and minimise the environmental impact of the remediation works, which also relate to the initial enabling works. The main objectives of this report are to:

- further develop the Conceptual Site Model in respect of the identified ground conditions based on the March 2015 Ground Investigation, entitled "Graven Hill New Urban Community, Bicester, Factual Report on Ground Investigation, Prepared for Graven Hill Village Development Company, Report Ref: 30378, Volume 1 of Version 1 - B Final, dated 27/11/15", by Geotechnical Engineering Ltd, Centurion House, Olympus Park, Quedgeley, Gloucester. GL2 4NF;
- assist in discharging Planning Condition 77 "Contamination" (ref: 11/01494/OUT) relating to the investigation and remediation of contaminated land.

Condition 77 "Contamination" states:

> *"Prior to the commencement of the development on any phase hereby permitted on Graven Hill, a comprehensive intrusive investigation in order to characterise the type, nature and extent of contamination present, the risks to receptors and to inform the remediation strategy proposals shall be documented as a report undertaken by a competent person and in accordance with DEFRA and the Environment Agency's 'Model Procedures for the Management of Land Contamination, CLR 11' and submitted to and approved in writing by the Local Planning Authority. The report shall identify clearly the phase to which it relates and the relationship to remediation of phases already completed and to those remaining to be undertaken. No development shall take place unless the Local Planning Authority has given its written approval that it is satisfied that the risk from contamination has been adequately characterised as required by this condition.*
>
> *Reason - To ensure that risks from land contamination to the future users of the land and neighbouring land are minimised, together with those to controlled waters, property and ecological systems, and to ensure that the development can be carried out safely without unacceptable risks to workers, neighbours and other offsite receptors in accordance with Policy ENV12 of the adopted Cherwell Local Plan and Government guidance contained within the National Planning Policy Framework."*

The information contained within this report is based upon the Waterman 'Environmental Interpretative Report for Land Transfer Area 1' report (Ref: WIB13983-104-R-1-1-7-GH), dated September 2015 which should be read in conjunction with this report.

It is recommended that this report, together with Waterman's Environmental Interpretive Report will be used as supporting documentation to the planning process.

1.2 The Proposed Development

The proposed development is located at the Graven Hill MOD Site, located south of Bicester, Oxfordshire, as shown in Figure A1, Appendix A.

This report pertains only to the area of Site outlined as Land Transfer Area (LTA) 1, highlighted in Figure A2 Appendix A.

The proposed development layout (Site wide Master Plan) of the Graven Hill Village Site is illustrated in Figure A3 in Appendix A. This figure includes development within LTA 1 and LTA 2 comprising the redevelopment of former MOD Site, including demolition of existing buildings, development of approximately 1,700 self build homes; local centre to include a two form entry primary school, a community hall, five local shops or facilities, a pub / restaurant / hotel and parking areas; B1, B2 and B8 employment, the creation of public open space and improvement of site infrastructure.

1.3 Limitations

This assessment has been undertaken in general accordance with the Model Procedures for the Management of Land Contamination (Contaminated Land Report 11 – Environment Agency, September 2004) and forms a decision record in relation to the assessment of the Site.

The ground conditions reported relate only to the point of excavation and do not necessarily guarantee a continuation of the ground conditions throughout the non-inspected area of the Site. Whilst such exploratory holes would usually provide a reasonable indication as to the general ground conditions, these cannot be determined with complete certainty.

Waterman has endeavoured to assess all information provided to them during this assessment, but makes no guarantees or warranties as to the accuracy or completeness of this information.

Whilst the scope of the March 2015 ground investigation provided coverage of the majority of LTA1 several areas within the LTA1 Site boundary, at the request of the Client were not targeted during this phase of ground investigation works. Areas that have not been targeted thus far are as follows:

- Area to the far east of LTA1;
- Area to the west of MOD Building E3 (proposed school site);
- Areas in and around Graven Hill Woodland (not subject to development); and
- Any areas below existing buildings.

Figure A2 within Appendix A illustrates the areas of the March 2015 ground investigation

The scope of the March 2015 ground investigation includes an assessment of the presence of asbestos containing materials in the ground at the Site, but not within buildings or structures or below ground structures (basements, buried service ducts and the like).

The Client has commissioned Amicus Environmental Ltd to carry out Refurbishment / Demolition Asbestos Surveys. To date, asbestos surveys have been completed in MOD Building E3, the Former Garrison Theatre, the Romney Huts and Associated Brick Buildings and at Rodney House Social Club Out Buildings.

The Amicus Environmental Ltd Report for MOD Building E3 completed in September 2015 identified partially buried asbestos cement fragments directly below the former raised district heating pipe that runs adjacent and south of MOD Building E3. Waterman's ground investigation was undertaken in March 2015 and therefore undertaken without the benefit of this report. Whilst ground investigation trial pits were undertaken within this general area, there were limitations owing to the presence of underground services. No asbestos was noted at the surface or within shallow soils during the ground investigation in this area and whilst soil samples tested were screened for asbestos, no asbestos was identified.

Based on the findings of the Amicus Report it is advised that during demolition of MOD Building E3, further works are undertaken to remove shallow buried asbestos in this area.

The conclusions resulting from this study are not necessarily indicative of future conditions or operating practices at or adjacent to the Site.

2. Environmental Setting

The full environmental setting and Conceptual Site Model are reported in Waterman's Environmental Interpretive Report (Ref. WIB13983-104-1-1-7-GH) and a summary of the key points is given below.

2.1 Site Setting and Description

Land within LTA1 includes a derelict building (Rodney House) in the north of the Site, while buildings currently in use by the MOD are located in the north and east of the Site. Large amounts of LTA1 include soft landscaping, fields (used by a tenant farmer) and the Graven Hill Woodland at the south of the Site, which is not subject to any future development.

2.2 History

Earliest mapping indicates the entire Site to comprise agricultural land, with Graven Hill Woodland within the south of the Site and a railway line and sidings located at the north western boundary.

A rifle range was present from the early 1900s at the centre of the Site.

From the 1940s DSDC Bicester was constructed as a military equipment distribution and logistics centre. Military equipment and vehicles were stored on Site prior to the European invasion during WWII.

After WWII the Site was used for the processing of returned stores from WWII and the Korean War. During the 1950s the entire site was re-designed as a Base Ordnance Depot with the adjacent St. David's Barracks constructed by 1956.

By 1961 the Site had been re-organised as MOD Bicester, the main UK depot for military clothing and general stores.

Several above ground fuel tanks were recorded within the north of Site.

By 1992 the Site was known as Defence Storage and Distribution Centre, Bicester, and remains as such to this day.

2.3 Geology

The strata encountered in the March 2015 ground investigation (and as reported in Waterman's Environmental Interpretive Report (Ref. WIB13983-104-R-1-1-7-GH)) was generally consistent with the geology identified in the Graven Hill: Land Quality Assessments – Phase 1 and Phase 2 (Ref: BIC/OPA/DOC/21), dated September 2011, prepared by Entec UK and as detailed within BGS records.

A summary of the geological strata encountered at the Site is also given in Waterman's combined Ground Investigation Report (GIR) and Geotechnical Design Report (GDR) entitled: "Land Transfer Area 1, Ground Investigation & Geotechnical Design Report, January 2016, Document Reference: CIV15119/GT/GIR-GDR/A02, Project Number: CIV15119".

Detailed geological logs are illustrated within Appendix B of Waterman's Environmental Interpretive Report (Ref. WIB13983-104-1-1-7-GH).

3. Conceptual Site Model

The Conceptual Site Model has been developed during the desk-based and ground investigation (March 2015) phases of the Site environmental assessment and is summarised below.

3.1 Ground Conditions

3.1.1 Soil

The Site geology comprises Topsoil in areas of soft landscaping, currently used as agricultural land comprising of silty fine to coarse sand and sandy gravelly clay. Where encountered Topsoil was found to be between 0.2m and 0.5m in thickness.

Made Ground was encountered elsewhere up to 1.0m bgl, consisting of gravelly silty clay and sand with brick, flint, sandstone and glass. In areas of hardstanding Made Ground consisted of tarmacadam and sub-angular to sub-rounded gravels and cobbles.

Natural ground comprised soft, firm and stiff silty gravelly clays of the Peterborough Oxford Clay Formation across the entire site, but only proved up to 8m in thickness.

In order to assess the potential risk to human health the soil chemical laboratory data has been assessed against residential with plant uptake Generic Assessment Criteria (GAC) as the most conservative of assessment criteria for the proposed future development.

Limited elevated contamination (lead, beryllium, zinc, poly-aromatic hydrocarbons (PAH) and TPH) was identified across the Site.

3.2 Pollution Linkages

The pollutant linkages identified and evaluated are detailed within Waterman's Environmental Interpretive Report (Ref. WIB13983-104-R-1-1-7-GH) Table 16, Section 8.1. The following actions were recommended to address the potentially unacceptable risks that remained following the initial risk assessment:

- **Further Risk Assessments:** Further risk assessment is undertaken to refine the generic risk assessment and to give a more accurate evaluation of the potential risks at the Site, based on Site specific parameters and final proposed end use;
- **Implement Remediation Options:** The remediation options or other adequate methods should be implemented to ensure the future potential risk to human health in a residential setting is minimised. This should be agreed with the Local Authority prior to works commencing;
- **Cleaning of Drains:** The surface water drains and open swales/ditches at the Site are cleaned in advance of being broken out and the materials undergo appropriate waste assessment testing to determine the waste classification;
- **Asbestos:** Although no Asbestos Containing Materials (ACMs) were identified within the soils, any previously unidentified asbestos containing materials encountered during the ground works should be segregated and disposed of as hazardous waste at a licensed facility. Any buildings that are due to be demolished and are known to contain asbestos should be demolished in a manner that prevents soils being cross contaminated by asbestos containing materials;
- **Surplus Excavated Soils:** Wherever possible and practical the earthworks cut and fill should ideally be designed to balance, however this may not always be possible, and soils reused in accordance with the principles of the CL:AIRE Code of Practice, or where soil arisings from ground works are deemed surplus to requirements they should be subject to appropriate waste assessment testing to determine the correct waste classification;
- **Radon:** The requirements for radon protection measures below residential buildings should be discussed with the local Building Control Officer; and

- **UXO:** Although un-exploded ordnance (UXO) was not encountered during the investigation, based on the findings of the Entec assessment, future construction workers should undergo toolbox talks to be made aware of the potential risk of buried UXO at the Site. The potential pollutant linkages described above can be managed by design of appropriate mitigation measures during the redevelopment of the site.

4. Further Generic Quantitative Risk Assessment

Soil samples obtained during our March 2015 intrusive ground investigation were scheduled for analysis where potential sources of contamination were encountered, such as Made Ground and known areas of historic contamination. Additional soil samples were also collected and tested to obtain appropriate site coverage. Exceedances against the residential with plant uptake Generic Assessment Criteria (GAC) are presented in Tables 9 to Table 14 within Waterman's Environmental Interpretive Report (Ref. WIB13983-104-R-1-1-7-GH).

In order to better conceptualise the overall spread of shallow soil contamination across the Site, where shallow soils are shown to exceed residential assessment criteria, the locations have been plotted onto the Proposed Graven Hill Master Plan and onto the existing topographical plan, so that the intended end use at the exceedance location can be more accurately assessed. This output is illustrated in Figure A4A 'Proposed Master Plan showing Soil Exceedance Locations' and Figure A4B 'Existing Topography showing Soil Exceedance Locations' is contained within Appendix A.

Soil exceedances noted within road cored locations along Site roads have not been considered further in this assessment. As it is recognised that slightly elevated concentrations of poly-aromatic hydrocarbons observed within the shallow Made Ground soils are likely as a result of the tarmac layer found directly above them and not as a result of direct contamination in these areas.

Poly-aromatic hydrocarbons identified in the Made Ground soils did show concentrations typically found in tarmac with one sample from core CC419 showing high concentrations more typical of a tarmac containing coal tar. Chemical testing from natural soils at greater depths did not identify further contamination or exceedances of the assessment criteria.

Exceedances noted from sediment samples obtained from surface drains, open drainage ditches and swales around the Site have also not been considered further in this assessment. But, it is recommended that the near surface soils from these existing open drainage ditches and swales are dredged and any sediments removed from inspection chambers, as part of the future remediation/ groundworks at the Site. Based on the low concentrations of contaminants encountered, it is envisaged these sediments can be stockpiled on Site and be used beneath areas of public open space or below roads or buildings if found to be geotechnically suitable.

4.1 Generic Assessment Criteria (Public Open Space - Residential)

Waterman has further assessed the residential soil exceedances against a more accurate end use assessment criteria, in order to establish the residual risk of shallow soil contamination across the Site.

Results are illustrated in Tables 1 to 3 below.

The Graven Hill Proposed Master Plan identifies the following sample locations as being within areas designed as Public Open Space, therefore the Waterman Generic Assessment Criteria (GAC) for Public Open Space (POS) within a residential scheme has been selected as the most appropriate assessment criteria.

A summary of the revised assessment is presented in Table 1 below.

Table 1: Summary of previous identified soil exceedances compared to a revised public open space GAC

Final Development End Use	Contaminant	Location	Conc. (mg/kg)	Number of Exceedances	Generic Assessment Criteria (mg/kg)
Public Open Space (Residential)	Beryllium	CP111 (0.25m);	1.80 – 1.90	0	2.20
	Beryllium	TP541 (0.35m);	1.90	0	2.20
	Beryllium	HP703 (0.5m)	2.0	0	2.20
	Benzo(b)fluoranthene	TP549 (0.3m); TP552 (0.2m); TP528 (0.4m)	3.3 – 4.7	0	7.2
	Benzo(a)pyrene	TP528 (0.4m)	3.2	0	5.70
	Lead	HP703 (0.5m)	290	0	630

When compared against Waterman's Generic Assessment Criteria (GAC) for Public Open Space (POS) within a residential scheme, **the shallow soils at the above locations do not present a risk to human health.**

4.2 Generic Assessment Criteria (Commercial)

The Graven Hill Proposed Master Plan identifies the following sample locations as being within areas designed as commercial (employment) development, therefore the Waterman Generic Assessment Criteria for commercial end use has been selected as the most appropriate assessment criteria.

A summary of the revised assessment is presented in Table 2 below.

Table 2: Summary of previous identified soil exceedances compared to a revised commercial GAC

Final Development End Use	Contaminant	Location	Conc. (mg/kg)	Number of Exceedances	Generic Assessment Criteria (mg/kg)
Commercial (Employment)	Beryllium	CP115 (1.50m); TP554 (0.2m);	1.8 - 2.0	0	12
	Aromatic EC16 – EC21 TPH	CP115 (1.0m)	1,200	0	28,000
	Aromatic EC35 – EC44 TPH	CP115 (1.0m)	1,900	0	28,000

When compared against Waterman Generic Assessment Criteria for commercial end use, **the shallow soils at the above locations do not present a risk to human health.**

4.3 Generic Assessment Criteria (Residential with Plant Uptake)

The Graven Hill Proposed Master Plan identifies the following sample locations as being within areas designed as residential development, therefore the existing assessment criteria is still valid, however Table 3 below has been updated following the revised risk assessment.

Table 3: Summary of previous identified soil exceedances compared to a residential with plant uptake GAC

Final Development End Use	Contaminant	Location	Conc. (mg/kg)	Number of Exceedances	Generic Assessment Criteria (mg/kg)
Residential	Beryllium	TP518 (0.25m); TP520 (0.25); RC304 (0.3m); HP704 (0.20m and 0.40m)	1.80 – 2.1	5	1.70
	Benzo(a)anthracene	TP529 (0.5m)	13	1	11
	Benzo(b)fluoranthene	TP529 (0.5m);	14.0	1	3.30
	Benzo(a)pyrene	TP529 (0.5m);	11.0	1	2.70
	Di-benzo(a.h)anthracene	TP529 (0.5m);	1.7	1	0.28

Beryllium: Where exceedances of beryllium still exist at four locations (however note that location hand pit HP704 recorded two exceedances) within the intended residential development area, the concentrations of beryllium within the soils at these locations are very low and only of a very minor exceedance to the assessment criteria.

Based on such minor exceedances shallow soils within these areas are not considered a significant risk to human health, and therefore no remediation of soils at these locations is considered necessary.

PAH: The shallow and slightly elevated concentrations of poly-aromatic hydrocarbons (PAH) at location trial pit TP529 can likely be linked to the presence of an asphalt layer above the shallow soils. The area currently comprises a car park therefore the asphalt layer and any underlying granular sub-base will be removed as part of the future residential development. It is recommended that any impacted soils below the asphalt layer should be removed and stockpiled on Site for use below buildings or beneath landscaped areas. Further chemical testing on deeper soils within this area did not identify any elevated contaminants. Based on the low concentrations of benzo (a) pyrene observed in the shallow Made Ground Soils, the asphalt is unlikely to contain coal tar, however further chemical testing is recommended on the asphalt and underlying Made Ground soils to ensure the material was suitable for re-use or alternative disposal off Site.

Statistical Analysis: To provide further assurance on our assessment that the results in Table 3 do not pose an unacceptable environmental risk, statistical analysis was undertaken on the chemical data to determine the confidence level of the concentrations of contaminants and this is reported in Section 5 of this report.

Figure A5 in Appendix A illustrates the remaining locations with shallow soil exceedances following the revised generic quantitative assessment.

4.4 Cut and Fill Enabling Works

Based on the latest Cut and Fill calculations to determine finished site levels, the majority of the Site will be subject to a minor increase in levels.

Therefore as long as the fill materials used are chemically (and geotechnically) suitable, the risk of future site users coming into contact with historic impacted soils within future residential areas will be substantially reduced.

Figure A6 Proposed Cut and Fill is illustrated in Appendix A.

However, as more detailed design is carried out this Cut and Fill will most likely change.

4.5 Statistical Analysis - Using CL:AIRE Guidance on Comparing Soil Contamination Data with a Critical Concentration

The guidance note: Guidance on Comparing Soil Contamination Data with a Critical Concentration published by CL:AIRE and CIEH May 2008 has been referred to within this statistical assessment.

The analytical data for the entire Site was reviewed in respect of the contaminants showing elevated concentrations when compared to the Residential with plant uptake Generic Assessment Criteria (GAC).

The sampling and testing was carried out by suitably qualified professionals.

The data was found to meet the data quality criteria described in the above guidance.

4.6 Beryllium

Hypothesis

The following has been set up to determine if there is sufficient evidence that the true mean concentration of Beryllium is less than the critical concentration of 1.7mg/kg (Residential with plant uptake GAC).

Null Hypothesis (H0) = the true mean is equal to, or greater than, the critical concentration

Alternative Hypothesis (H1) = the true mean is less than the critical concentration.

Non- detects, Outliers and Distribution (Normality)

There are no non-detects within the data range (value less than the laboratory method of detection limit).

In all cases, outlying data should be assumed to be genuine and reflective of the full range of soil concentrations to which receptors may be exposed.

Outliers can only be excluded where strong justification is given.

In this case we can justify removal of the data sets relating to the road cored boreholes (CC) undertaken along the on-site roads as this data can be proven to not be reflective of wider Site ground conditions.

The concentrations of contaminants within Made Ground below the site roads can be proven to be elevated based on the type of materials used in its construction and not as a direct result of contamination in this area.

Mean and Standard Deviation

Using descriptive statistic application on Microsoft Excel the mean and standard deviation was calculated:

Mean = 1.38 (2 dp)

Standard deviation = 0.43 (2 dp)

Therefore the mean is less than the critical value.

i.e. 1.38<1.70

The dataset is not normally distributed and therefore a Chebychev Theorem Test has to be undertaken in accordance with CL:AIRE guidance. The working has been detailed below:

Number in sample = 62

$$K_0 = \frac{1.38 - 1.70}{0.05}$$

= -6.4

$K_{0.005}$ = 4.36

$UCL_{0.95}$ = 1.38 + (4.36 x 0.05) = 1.598

K_{crit} = 4.36

K_0 is less than K_{crit}

Therefore the H0 can be rejected and it can be concluded that the true mean is not significantly greater than the critical concentration at a confidence level of 95%.

This can be confirmed by the following conservative estimate or worst case scenario

K_1 = 6.4

A = 0.02%

p_1 = 98%

Therefore a conservative estimate of the evidence against H_0 being true is 98%.

The evidence suggests that true mean concentration of beryllium present at the Site is not significantly greater than the critical concentration (1.7mg/kg Residential with plant uptake GAC).

Therefore, the area of land being assessed can be considered suitable for use.

4.7 Benzo(a)anthracene

Hypothesis

The following has been set up to determine if there is sufficient evidence that the true mean concentration of Benzo(a)anthracene is less than the critical concentration of 11mg/kg (Residential with plant uptake GAC).

Null Hypothesis (H0) = the true mean is equal to, or greater than, the critical concentration

Alternative Hypothesis (H1) = the true mean is less than the critical concentration.

Non- detects, Outliers and Distribution (Normality)

The non-detects in the sample have been included as 0.1, to reflect the worst case scenario, as accepted in the guidance.

The limit of detection is not near the critical concentration therefore a sensitivity test is not required.

In all cases, outlying data should be assumed to be genuine and reflective of the full range of soil concentrations to which receptors may be exposed.

Outliers can only be excluded where strong justification is given.

In this case we can justify removal of the data sets relating to the road cored boreholes (CC) undertaken along the on-site roads as this data can be proven to not be reflective of wider Site ground conditions.

The concentrations of contaminants within Made Ground below the site roads can be proven to be elevated based on the type of materials used in its construction and not as a direct result of contamination in this area.

Mean and Standard Deviation

Using descriptive statistic application on Microsoft Excel the mean and standard deviation was calculated:

Mean = 0.79 (2dp)

Standard deviation = 1.87 (2 dp)

Therefore the mean is less than the critical value

i.e. 1.38<11.00

The dataset is not normally distributed and therefore a Chebychev Theorem Test has to be undertaken in accordance with CL:AIRE guidance.

Number in sample = 62

$$K0 = \frac{0.79 - 11}{0.24}$$

$$= -42.54$$

K0.005 = 4.36

$UCL_{0.95}$ = 0.79 + (4.36 x 0.24)= 1.8364

Kcrit = 4.36

K0 is less than Kcrit

Therefore the H0 can be rejected and it can be concluded that the true mean is not greater than the critical concentration at a confidence level of 95%.

This can be confirmed by the following conservative estimate or worst case scenario.

K1 = 42.54

a = 0.01%

p1 = 99%

Therefore a conservative estimate of the evidence against H0 being true is 99%.

The evidence suggests that the true mean concentration is not greater than the critical concentration.

Therefore, the area of land being assessed can be considered suitable for use.

4.8 Benzo(b)flourathene

Hypothesis

The following has been set up to determine if there is sufficient evidence that the true mean concentration of Benzo(b)flourathene is less than the critical concentration of 3.3mg/kg (Residential with plant uptake GAC).

Null Hypothesis (H0) = the true mean is equal to, or greater than, the critical concentration

Alternative Hypothesis (H1) = the true mean is less than the critical concentration.

Non- detects, Outliers and Distribution (Normality)

The non-detects in the sample have been included as 0.1, to reflect the worst case scenario, as accepted in the guidance.

The limit of detection is not near the critical concentration therefore a sensitivity test is not required.

In all cases, outlying data should be assumed to be genuine and reflective of the full range of soil concentrations to which receptors may be exposed.

Outliers can only be excluded where strong justification is given.

In this case we can justify removal of the data sets relating to the road cored boreholes (CC) undertaken along the on-site roads as this data can be proven to not be reflective of wider Site ground conditions.

The concentrations of contaminants within Made Ground below the site roads can be proven to be elevated based on the type of materials used in its construction and not as a direct result of contamination in this area.

Mean and Standard Deviation

Using descriptive statistic application on Microsoft Excel the mean and standard deviation was calculated:

Mean = 1 (2dp)

Standard deviation = 2.22 (2 dp)

Therefore the mean is less than the critical value

i.e. 1<3.30

The dataset is not normally distributed and therefore a Chebychev Theorem Test has to be undertaken in accordance with CL:AIRE guidance.

Number in sample = 62

$$K0 = \frac{1 - 3.30}{0.28}$$

$$= -8.21$$

K0.005 = 4.36

$UCL_{0.95}$ = 1 + (4.36 x 0.28) = 2.22

Kcrit = 4.36

K0 is less than Kcrit

Therefore the H0 can be rejected and it can be concluded that the true mean is not greater than the critical concentration at a confidence level of 95%.

This can be confirmed by the following conservative estimate or worst case scenario.

K1 = 8.21

a = 0.02%

p1 = 98%

Therefore a conservative estimate of the evidence against H0 being true is 98%.

The evidence suggests that the true mean concentration is not greater than the critical concentration.

Therefore, the area of land being assessed can be considered suitable for use.

4.9 Benzo(a)pyrene

Hypothesis

The following has been set up to determine if there is sufficient evidence that the true mean concentration of Benzo(a)pyrene is less than the critical concentration of 2.7mg/kg (Residential with plant uptake GAC).

Null Hypothesis (H0) = the true mean is equal to, or greater than, the critical concentration

Alternative Hypothesis (H1) = the true mean is less than the critical concentration.

Non- detects, Outliers and Distribution (Normality)

The non-detects in the sample have been included as 0.1, to reflect the worst case scenario, as accepted in the guidance.

The limit of detection is not near the critical concentration therefore a sensitivity test is not required.

In all cases, outlying data should be assumed to be genuine and reflective of the full range of soil concentrations to which receptors may be exposed.

Outliers can only be excluded where strong justification is given.

In this case we can justify removal of the data sets relating to the road cored boreholes (CC) undertaken along the on-site roads as this data can be proven to not be reflective of wider Site ground conditions.

The concentrations of contaminants within Made Ground below the site roads can be proven to be elevated based on the type of materials used in its construction and not as a direct result of contamination in this area.

Mean and Standard Deviation

Using descriptive statistic application on Microsoft Excel the mean and standard deviation was calculated:

Mean = 0.83 (2dp)

Standard deviation = 1.79 (2 dp)

Therefore the mean is less than the critical value.

i.e. 0.83<2.70

The dataset is not normally distributed and therefore a Chebychev Theorem Test has to be undertaken in accordance with CL:AIRE guidance.

Number in sample = 62

$$K0 = \frac{0.83 - 2.70}{0.22}$$

$$= -8.5$$

K0.005 = 4.36

$UCL_{0.95}$ = 0.83 + (4.36 x 0.22) = 1.79

Kcrit = 4.36

K0 is less than Kcrit

Therefore the H0 can be rejected and it can be concluded that the true mean is not greater than the critical concentration at a confidence level of 95%.

This can be confirmed by the following conservative estimate or worst case scenario.

K1 = 8.5

a = 0.02%

p1 = 98%

Therefore a conservative estimate of the evidence against H0 being true is 98%.

The evidence suggests that the true mean concentration is not greater than the critical concentration.

Therefore, the area of land being assessed can be considered suitable for use.

4.10 Di-benzo(a,h)anthracene

Hypothesis

The following has been set up to determine if there is sufficient evidence that the true mean concentration of Di-benzo(a,h)anthracene is less than the critical concentration of 0.28mg/kg (Residential with plant uptake GAC).

Null Hypothesis (H0) = the true mean is equal to, or greater than, the critical concentration.

Alternative Hypothesis (H1) = the true mean is less than the critical concentration.

Non-detects, Outliers and Distribution (Normality)

The non-detects in the sample have been included as 0.1, to reflect the worst case scenario, as accepted in the guidance. The limit of detection is not near the critical concentration therefore a sensitivity test is not required.

In all cases, outlying data should be assumed to be genuine and reflective of the full range of soil concentrations to which receptors may be exposed.

Outliers can only be excluded where strong justification is given.

In this case we can justify removal of the data sets relating to the road cored boreholes (CC) undertaken along the on-site roads as this data can be proven to not be reflective of wider Site ground conditions.

The concentrations of contaminants within Made Ground below the site roads can be proven to be elevated based on the type of materials used in its construction and not as a direct result of contamination in this area.

Mean and Standard Deviation

Using descriptive statistic application on Microsoft Excel the mean and standard deviation was calculated:

Mean = 0.14 (2dp)

Standard deviation = 0.21(2 dp)

Therefore the mean is equal to the critical value

i.e. 0.14<0.28

The dataset is not normally distributed and therefore a Chebychev Theorem Test has to be undertaken in accordance with CL:AIRE guidance.

Number in sample = 62

$$K0 = \frac{0.14-0.28}{0.02}$$

$$= -7$$

K0.005 = 4.36

$UCL_{0.95}$ = 0.14 + (4.36 x 0.02) = 0.23

Kcrit = 4.36

K0 is less than Kcrit

Therefore the H0 can be rejected and it can be concluded that the true mean is not greater than the critical concentration at a confidence level of 95%.

This can be confirmed by the following conservative estimate or worst case scenario.

K1 = 7

a = 0.02%

p1 = 98%

Therefore a conservative estimate of the evidence against H0 being true is 98%.

The evidence suggests that the true mean concentration is not greater than the critical concentration.

Therefore, the area of land being assessed can be considered suitable for use.

4.11 Conclusions

For all exceedances of contaminants when compared to a residential assessment criteria, it is considered based on this analysis that the concentrations present within trial pit locations TP518, TP520, RC304 and TP529 on the Site are not considered significantly elevated and therefore not considered to be contaminated with respect to the wider Site ground conditions.

5. Clean Cover System

5.1 Sediments within Surface Drains and Open Swales/Ditches

Sediments previously identified as within surface drainage inspection chambers and at the base of open swales and ditches within the Site have been chemically tested and found to contain contaminants at concentrations that exceed the residential assessment criteria.

A summary of the assessment is presented in Table 4 below.

Table 4: Assessment of re-use of surface drain and open swale sediments on site

Stratum / Source / Zone	Contaminant	Location	Conc. (mg/kg)	Number of Exceedances	Residential Assessment Criteria (mg/kg)
Surface Drains	Beryllium	SD05	1.90	1	1.7
	Lead	SD07	320	1	200
	Zinc	SD07	6,800	1	3,700
	Benzo(b)fluoranthene	SD01; SD02; SD03	5.1 – 6.5	3	3.30
	Di-benzo(a.h.)anthracene	SD01 and SD02	0.32 – 0.41	2	0.28
	Benzo(a)pyrene	SD01; SD02; SD03	4.4 – 5.6	2	2.70

The majority of sediment samples analysed exceed the residential assessment criteria and therefore would need to be removed as part of future remediation works at the Site.

However, once excavated the surface drain sediments could be used below areas of hardstanding or roads, if deemed geotechnically suitable.

Alternatively, the material could be used at depth within landscaping areas (Public Open Space), providing a clean cover layer (comprising a minimum of 500mm of acceptable soil as stipulated by the BRE) is present overlying the made ground.

It is recommended a basal membrane is used below the clean cover system to avoid mixing with the contaminated soils.

The thickness of capping required was determined using the calculations within the BRE cover systems document: Cover Systems for Land Regeneration: Thickness of Cover Systems for Contaminated Land (BR 465) March 2004, using the calculation below:

$$X = M(Cg-1)/(Cg-Cc)$$

Where:

- X is the cover system thickness;
- M is the mixing layer thickness (in this case 500mm, as no mixing will be possible as a result of the basal membrane);
- Cg is the concentration of contaminants within the sediments (the maximum recorded concentrations of contaminants as illustrated in Table 4) i.e. zinc 6,800mg/kg; and

- Cc the concentration of contaminants within the cover system (based on a concentration less than residential assessment criteria – assumed 0.5 x criteria) i.e. zinc 1,850mg/kg.

Using this equation, the cover system thickness calculated was 0.7m for zinc and 1.0m for lead.

As such, a 1.0m thick chemically suitable cover system with base marker layer is sufficient for use above the sediment soils.

It is recommended that, in areas where deeper excavations are proposed (such as for trees), that the thickness of the cover system is increased to ensure that the risks associated with the excavation are minimised.

5.2 Chemical Acceptance Criteria

Chemical acceptance criteria for the Site have been derived based on the requirements for re-use of site won soils within the development areas.

Two sets of criteria have been formulated based on the sensitivity of the end use:

- one set of criteria is to be adopted for soils intended for re-use in landscaped or residential areas (private gardens) and
- the other is to be adopted for soils to be used under buildings or areas of hardstanding or in commercial areas.

The full set of Chemical Acceptance Criteria can be found in Appendix B.

6. Anticipated Cut and Fill

Figure A6 'Proposed Cut and Fill Earthworks' illustrates the current proposed cut and fill for the development enabling earthworks. However, as more detailed design is carried out this Cut and Fill will most likely change.

As some soils are to be moved around the Site to achieve the required construction formation levels, it is recognised that soils have currently been assessed against the intended end-use of their current location.

It is therefore recommended that 'fill' soils are chemically tested to demonstrate compliance with the end-use of the final destination of the material.

Further details on testing frequency and specification are given in subsequent sections, however, the chemical acceptance criteria that should be used to assess the re-use of soils are included in Appendix B.

These concentrations are the same as the GACs used to initially assess contaminant soil concentrations.

All material used within areas of hardstanding or within areas of landscaping or residential areas (private gardens) should comply with the chemical criteria as presented in Appendix B.

7. Remedial Options Appraisal and Strategy

The March 2015 ground investigation indicated that in general very little ground contamination has been encountered and that much of the Site comprises shallow Made Ground overlying natural uncontaminated clay geology.

The subsequent revised risk assessment presented above indicates that, while a few potential pollutant linkages have been identified at the Site, these pollutant linkages can be broken, through the use of standard mitigation measures.

The potential pollutant linkages can be summarised as follows:

- The risk to future site users within areas of landscaping as a result of direct contact, ingestion and inhalation of the limited contaminated soils present at shallow depth within the site boundary;
- The risk to construction personnel associated with direct contact, ingestion and inhalation of contaminated soils;
- The risk to buried water supply pipes associated with direct contact with made ground containing elevated concentrations of potentially degrading substances; and
- The risk to vegetation within landscaped areas as a result of contact with potentially contaminated soils.

7.1 Remedial Options

The limited elevated concentrations of contaminants identified at the Site are considered to be representative of the wider area, which has had a long history of military occupation.

It is recommended that the remedial measures undertaken at the Site should take into account the potential for contamination within the wider Masterplan area and the measures adopted should ensure that no significant environmental risks associated with sources of contamination are likely to impact on the Site on completion of the development.

The remedial options considered viable for this development are discussed below.

7.1.1 Source Removal

Removal of sources of ground contamination at the Site would remove the immediate risks to future site users, services and structures. Source removal could be considered as a suitable option, although it is noted that any materials disposed of off-site would likely require pre-treatment before landfilling as a result of the high sulphate content of the soils.

It is also possible that some impacted soils and sediments found within the Site could potentially need to be disposed of as hazardous waste owing to the elevated metal and hydrocarbon concentrations, which would add significantly to any disposal costs.

In addition, site levels will need to be adjusted to create the proposed development platform, and as such, there is a need for the material on site and therefore there is a definite financial and sustainable benefit to retaining material on site.

7.1.2 On-site Treatment of Contaminated Soils

Only limited elevated concentrations of metals and poly-aromatic hydrocarbons (PAH) have been identified at the Site. For this reason, the relatively high costs associated with the mobilisation and treatment of any contaminated soils by immobilisation or chemical treatment methods is considered to be uneconomical in scale.

7.1.3 Break of Pollutant Linkages

The proposed raising of site levels in much of the Site and the introduction of hardstanding (car parking, access roads and structures) to be constructed at the Site will act as a barrier to prevent future site users

from coming into contact with underlying contaminated soils and also from any additional contaminants migrating onto the Site.

Similarly, the use of a clean cover system, incorporating a base marker layer within areas of landscaping and residential (private gardens) would act as a barrier to end users.

Soils tested were generally not found to contain leachable fractions of potential contaminants.

Soils found to contain elevated results of contaminants were on the majority located within the Made Ground and where found within natural soils were present at shallow depths, above perched water and therefore not likely to be in hydraulic conductivity with any deeper groundwater bodies.

The bedrock geology across the majority of the Site of Oxford Clay is classified as an unproductive aquifer and therefore not a sensitive environmental receptor.

Should soils containing elevated contaminants be present below a clean cover system as part of the final remediation works then the location of such soils should be noted within the Sites Health and Safety Plan to notify future ground-workers in the event deeper excavations are required in these areas. This will ensure appropriate risk assessment and mitigation in the form of standard PPE could be adopted.

It is considered that this represents a cost effective and sustainable method of handling potentially contaminated soils and minimises the need for material to be exported and imported onto Site.

In addition, the use of barrier or wrapped ductile iron pipes will protect buried potable water supply pipes. However, it is recommended that this standard practice should be confirmed with the utility supplier.

7.2 Remedial Methodology

7.2.1 Clean Cover System

Should removed/dredged surface drainage sediments be required to be used within soft landscaping areas (Public Open Space) the use of a clean cover system within such areas would protect future site users and vegetation.

The cover system should comprise chemically suitable material, with a suitable marker layer (such as coloured geotextile or netting) placed at the base.

The thickness of the cover system at the Site has been assessed using the method specified within the BRE cover systems document and is outlined in detail within Section 6 of this report.

The clean cover material should be subject to laboratory analysis to demonstrate that it is suitable for use within landscaped areas.

The assessment criteria to be used to assess the suitability of this material are included in Appendix B of this report. These have been selected to minimise the risk to both human health and vegetation. In addition, all material utilised within the cover system should be visually acceptable and no made ground material should be present at the surface. It is recommended that testing of re-used (site won) soils should be undertaken at a rate of 1 sample per 250m^3 of soil. However this should be agreed with the Regulator.

Local thickening of the cover system should be undertaken in areas of deeper excavations (such as for tree pits or swales) to meet the requirements of the landscape architect. It should be noted that current discussions with the landscape architect have indicated that this depth should be 1.0m.

Whilst the majority of soils at the Site have been chemically proven to be suitable for use with landscaped and residential (private gardens) confirmation of required chemical criteria and thickness of topsoil within should be sought from the landscape architect.

At this stage it is envisaged that topsoil in landscaped and or residential private garden areas should conform to British Standards BS 3882:2015 and be a minimum of 150mm thickness.

Subsoil (below topsoil) should conform to BS 8601:2013 and be a minimum of 450mm thickness.

7.2.2 Water Supply Pipes

The Site has been identified as a brownfield site and, as such, elevated concentrations of potentially degrading substances may be present within the made ground.

Based on the UKWIR guidance, it is recommended that barrier pipes should be used for all potable water supply pipes.

This is now considered standard practice by Water Companies and should not be considered a development abnormal.

7.2.3 Re-use of Site Won Material

Site won material is proposed for use across the Site to raise founding levels and to be laid beneath structures, areas of hardstanding and to create new landscaped areas.

This material is considered to be chemically suitable for re-use provided it is deposited in a managed fashion and that suitable remedial measures, such as the use of a capping layer, are utilised to break the identified pollutant linkage.

The use of a Materials Management Plan is recommended, detailing the nature of the materials used, together with a record of material origin, movement and deposition, should be adopted during the construction works.

All material reuse should be undertaken in line with the CL:AIRE Code of Practice. Definition of Waste: Development Industry Code of Practice Version 2 March 2011. CL:AIRE.

The material proposed for re-use at the Site does meet all of these criteria, providing it is managed in accordance with the recommendations given above i.e. deposited beneath hardstanding or a suitable clean cover system.

This approach should be agreed with the Local Authority, however.

7.2.4 Verification of Remedial Measures

It will be necessary to demonstrate that the recommended remedial measures have been undertaken correctly.

This verification report should be prepared by a suitably qualified environmental consultant and submitted to the local authority in support of the planning application for redevelopment.

The verification report should confirm:

- The composition, nature and thickness of any clean cover layer installed within landscaped areas. Laboratory test results for the re-used and any imported material and photographic evidence confirming the thickness of the material should be supplied;
- The type of potable water supply pipes used; and
- Details of all material movements both on-site and off-site.

A copy of the verification report should be retained on site as part of the Health and Safety File for the completed development.

7.3 Environmental Recommendations

The following further actions are recommended:

- A copy of this report should be provided to the Local Authority for review and agreement in support of the development planning process and prior to site works commencing;
- The sediments within on-site surface drains, open swales and ditches should be removed/dredged and stockpiled on Site for further testing and potential future re-use on Site. Surrounding soils within the

area of the open swales/ditches should be suitably validated to confirm no residual contamination remains;

- All soils retained on Site for re-use should be validated as 'suitable for use', whereby appropriate geotechnical and or chemical testing is undertaken;
- Soil results indicate that Site soils are chemically suitable for reuse at the site either beneath buildings and other areas of hardstanding or within landscaped and residential (private gardens). It is recommended, however, that in order to re-use drainage sediment soils within landscaping (Public Open Space) areas, a 'clean' capping with a base marker layer is provided with a minimum depth of 0.9m. Where reuse is required, it is recommended that the CL:AIRE Waste Protocol is followed and a Materials Management Plan should be prepared for the Site;
- In accordance with the CL:AIRE Code of Practice, a Materials Management Plan should be prepared for the site demonstrating how excavated materials will be reused and providing a detailed record of material movement around the Site and, if necessary, off-site. This should be reviewed by an appropriate CL:AIRE Qualified Person and a declaration sent to the Environment Agency in advance of earthworks starting;
- The scope of protection measures for buried potable water supply pipes should be confirmed with the utilities provider;
- Whilst the March 2015 ground investigation locations and chemical testing has not recorded asbestos containing materials in the ground, particular attention must be taken during the demolition and site clearance of site structures known to contain asbestos materials, such as above ground pipes around MOD Building E3 (as identified in the September 2015 Amicus Report). This is to ensure that surrounding soils are not cross contaminated; and
- A copy of the future verification report should also be provided to the local authority to demonstrate successful implementation of all of the identified remedial measures.

8. Main Remediation Activities

8.1 Material Management

Material management will be a significant aspect during the project during the groundworks. The following section details the processes that should be followed with respect to materials generated during the work.

It is recommended that materials management will be governed under the CL:AIRE Code of Practice depending on the type of material encountered. Materials expected to be encountered during the works are listed below:

- Asphalt/Bitumen – recovered from Site roads and paved areas;
- All recycled aggregate – brick and concrete recovered from demolition of buildings paved areas and buried structures;
- Soil including Made Ground and granular sub-base – recovered during re-levelling of the Site.

8.1.1 Asphalt

Areas of asphalt may be planed and crushed.

Asphalt will be stockpiled separately.

Once chemically tested and confirmed to contain no coal tar it can be re-used on Site in accordance with Environment Agency Waste exemption: U1 use of waste in construction.

Where deemed suitable for reuse such that is does not pose a risk to the wider environment it can be placed, subject to correct geotechnical properties, as granular sub base under areas of paving, roads and car parks (up to a limit of 1,000 tonnes).

Up to 50,000 tonnes of asphalt can be used (if found to contain no coal tar) in building roads.

The road should be constructed to a specific engineering standard and have a sealed surface in order to qualify for this larger limit.

8.1.2 Concrete

Concrete will likely be crushed to 6F2, or to other specification, as required and feasible from this original material.

The resulting recycled aggregate will be subject to visual and olfactory testing only and will be reused as backfill in excavations, sub-base under roads, paving and hardstanding and as capping over remediated material placed in exactions.

Recycled aggregates not reused at this point in the redevelopment can be temporarily stockpiled and used in later phases of the redevelopment, subject to waste management regulations that relate to volumes and timescales of storage. Environment Agency Waste exemption: S2 storing waste in a secure place stipulates road planing's can be stored up to 500 tonnes for a period of up to 12 months.

8.1.3 Clearance of Sediments from Surface Water Drains and Ditches/ Swales

Sediment from surface water drainage (including interceptors), ditches and swales has been found to exceed the residential assessment criteria in all instances. Therefore should these features form part of a residential setting, or be intended for removal as part of the development works then these sediments should be deemed to be contaminated material and excavated to a minimum depth of 250mm and stockpiled.

Sediment within surface water drainage (including interceptors) should be removed in their entirety prior to drains being broken out and removed, or re-used as part of the new development drainage system.

Where sediments are stockpiled they:

- may be temporarily stockpiled on Site, but without causing or spreading pollution;
- but shall not form part of the permeant Works without treatment (including clean cover system);
- shall be removed from the Site; OR
- may be used below new buildings, hardstanding or roads, if geotechnically suitable; OR
- may be buried at depth beneath landscape areas (Public Open Space), with a coloured geotextile base marker layer and a 1.0m thick clean cover layer.

8.1.4 Potentially Contaminated Soils (within areas not previously investigated)

Soils within areas not previously investigated will be subject to visual and olfactory assessment by a competent person at the point of excavation.

As a minimum where current buildings and hardstanding are removed, underlying soils shall be tested on a 30m grid with a minimum of three soil validation samples per building and the results compared to the assessment criteria contained in Appendix B. Based on this assessment further chemical and geotechnical testing may be required.

Site won soils to be reused on site should be tested at the rate of 1 sample per 250m^3 and compared to chemical criteria included in Appendix B.

Geotechnical testing criteria is addressed in a separate document. Subject to the results of the testing it will fall into the one of the following categories:

- suitable for reuse within areas of hardstanding or below buildings; and /or
- suitable for reuse within areas of landscaping and private gardens, below a clean cover system.

8.1.5 Topsoil recovered from areas of soft landscaping

Topsoil recovered from the Site will be stockpiled separately and, subject to chemical testing at the rate of one test per 250m^3 and any further requirements of the Landscape Architect, will be reused as topsoil cover in the proposed development.

Reuse of topsoil and sub-soils will be covered by the CL:AIRE Code of Practice.

8.1.6 Stockpiling

Any soils that are stockpiled on Site shall be appropriately managed to prevent impact to the surrounding environment.

Mitigation measures should be employed to minimise wind whip from stockpiled materials.

Stockpiles of contaminated or suspected contaminated material should be placed on an impermeable membrane incorporating a surrounding bund wall to prevent contaminated water runoff or leachate impacting underlying soil and/or groundwater.

Stockpiles containing confirmed uncontaminated material can be placed on areas of hardstanding. However drainage in areas close to stockpiles should be protected from receiving runoff from the stockpiles.

Different material types should be segregated and clearly labelled with a unique identifier to avoid cross contamination.

A stockpile tracking register as detailed in the CL:AIRE Material Management Plan should be maintained during the works this shall include but not be limited to the following:

- A unique identification number for each stockpile from the creation to the end of the stockpile;

- Details relating to the date of creation, material type, contamination status, volume, proposed endues/destination and information of chemical and/or geotechnical testing;
- A schematic diagram showing the location, size, movement and ultimate destination of each stockpile, to be updated as required, daily if necessary; and
- Number of samples taken per stockpile and results of analysis.

Each stockpile should be clearly labelled to allow plant drivers and other Site staff and operatives to easily identify them.

8.1.7 Off Site Disposal

Where off-site licensed disposal is required, appropriate waste classification testing should be undertaken to allow an accurate disposal route to be determined.

A record of the quantities of materials disposed off-Site should be kept, along with consignment notes for the materials.

8.1.8 Imported Materials

All materials imported onto Site need to be suitable for the proposed use in accordance with the relevant legislation and subject to agreement with regulators.

Imported material shall be from a known source and shall be validated to ensure physical and chemical suitability.

It is recommended that imported topsoil shall be a natural 'as dug' material and not from a recycled source. This shall be completed by provision of appropriate physical or chemical certification from the supplier or by on site testing.

As a minimum imported material shall be tested at the rate of one sample per 500m^3 (minimum 3 recent representative sample results per source) to meet the requirements of chemical criteria within Appendix B.

Imported topsoil and subsoil will also be required to meet the relevant British Standards as detailed in Section 8.2.1.

Geotechnical performance specifications of imported material will be specified in other documents.

Duty of Care certification shall be provided for all imported materials.

8.1.9 Unforeseen Contamination

Whilst there has been a significant amount of ground contamination investigation, which has not identified widespread ground contamination, there is potential for previously un-investigated areas of contaminated ground to be encountered across the Site during the progression of the ground works.

Should suspected contaminated material be encountered, either visually or olfactory, the following procedures should be implemented:

- Localised groundworks should be halted and the material identified to site workers to prevent potential cross contamination/ material dispersion;
- The Environmental Consultant shall be contacted to inspect the area of concern;
- Photographs of the area should be taken and appropriate plans and method statements for dealing with the issue shall be drafted by the Contractor and forwarded to the Environmental Consultant;
- If necessary, an Addendum Remediation Method Statement shall be prepared by the Contractor and evaluated by the Environmental Consultant prior to being issued to the Statutory Authorities for approval and subsequent implementation.

9. Reporting

9.1 Validation Reporting

On completion of the remediation works the Contractor will provide a factual Validation Report detailing the works carried out.

The Validation Report will include, amongst other items, 'as-built' scale drawings showing areas of the Site cut and fill earthworks and all other excavations, updated Materials Management Plan to record any variations of soil movement; all validation chemical test results at the appropriate test frequency (together with sample locations and depths), the appropriate chain of custody and proof of disposal records for materials disposed off-Site and similar details of imported materials.

The Environmental Consultant will also provide a Completion Statement independently confirming that the works carried out by the Contractor have met the objectives and requirements of the agreed remediation strategy.

The Statement will record the update environmental risk rating associated with Site ground conditions.

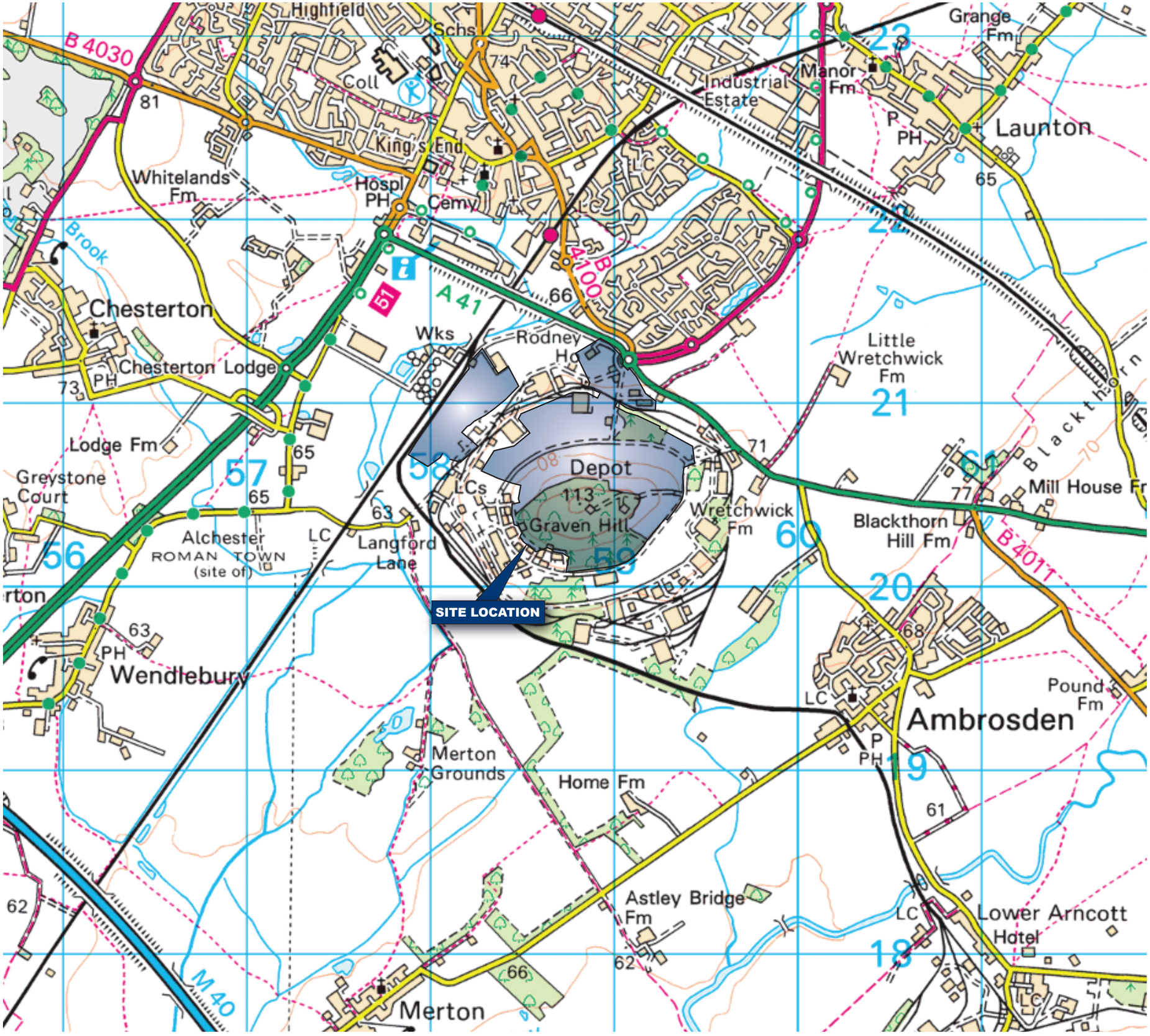
The Completion Statement will be based on a review of the Contractors as built information, together with on-site evidence gathered from site attendance during the groundworks.

Both the Validation Report and the Completion Statement will be submitted to the Regulatory Authorities (Environmental Health Officer and Environment Agency) for approval in order to allow construction to commence.

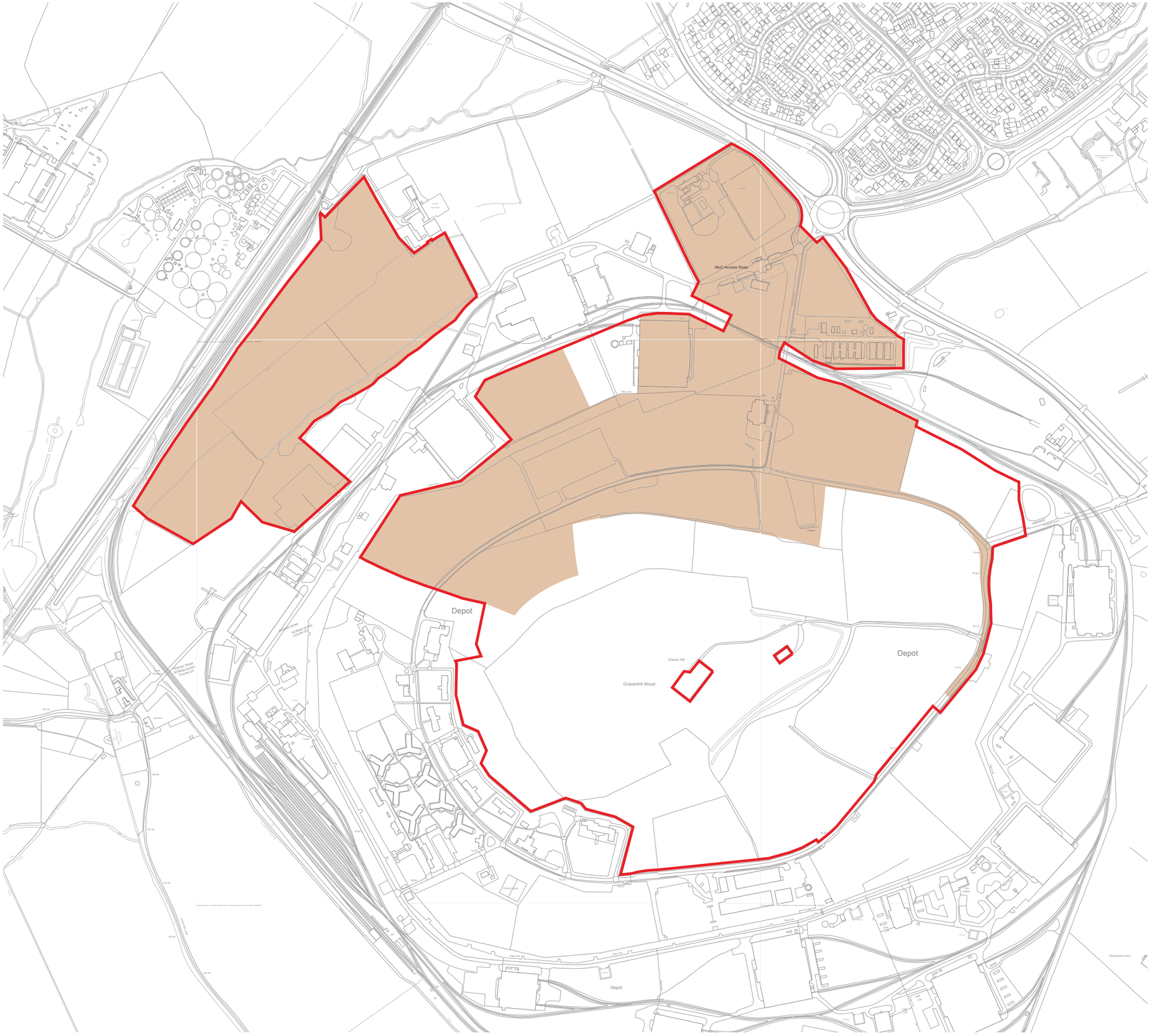
The approved reports will be added to the Site Health and Safety File for future use.

Appendix A Site Plans

- **Site Location Plan (Fig. A1)**
- **Site Plan (Fig. A2)**
- **Site Master Plan (Fig. A3)**
- **Proposed Master Plan showing Soil Exceedance Locations (Fig. A4A)**
- **Existing Topography showing Soil Exceedance Locations (Fig. A4B)**
- **Soil Exceedance Locations based on Master Plan End Use (Fig. A5)**
- **Proposed Cut and Fill (Fig. A6)**



Project Details	WIB13983-104: MOD Graven Hill, Bicester
Figure Title	Figure A1: Site Location
Figure Ref	WIB13983-104_GR_RO_A1A
Date	February 2016
File Location	\\s-lncs\wiel\projects\wib13983\104\graphics\ro\issued figures



waterman

Phase 1 Land Transfer Area

Extent of Ground Investigation

N

Project Details	WIB13983-104: MOD Graven Hill, Bicester
Figure Title	Figure A2: Site Plan
Figure Ref	WIB13983-104_GR_RO_A2A
Date	February 2016
File Location	\\s-lncs\wiel\projects\wib13983\104\graphics\ro\issued figures

www.watermangroup.com