Contaminated Land
Air Quality
Environmental Audit

SMITH GRANT Environmental Consultancy LLP

Partnership No: OC 300776

New Settlement Area, Heyford Park Oxfordshire

Dorchester Phase 1b: Area 1 Remediation Earthworks Completion Report

For: Urban Regen Ltd.

November 2014

Report Ref: R1742-R07-v1

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DOCUMENT CONTROL SHEET

Report Title: New Settlement Area, Heyford Park: Dorchester Phase 1b: Area 1 Remediation Earthworks Completion Report

Client: Urban Regen Ltd

Report Reference Number: R1742-R07

Report Status: Final

Version: v2

Report Date: 27th November 2014

Signed For Smith Grant LLP:

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Document Revision Record:

Version	Report Status	Date	Details of Revision
v1	Draft	03.11.14	Draft issued to client for comment
v2	Final	27.11.14	Minor edits; issue final version to all parties

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1. Introduction

1.1. Planning permission for the redevelopment of the former RAF/USAF Upper Heyford airbase was granted by Cherwell District Council (CDC) on the 2nd November 2012, reference 10/01642/OUT. The site, converted to commercial and residential uses is known as Heyford Park, and is divided between the Flying Field Area (FFA) and New Settlement Area (NSA). Urban Regen Ltd. (URL) was instructed by the consortium of Dorchester Heyford Park Group Ltd and Bovis Homes to carry out demolition, remediation and preparatory earthworks across the NSA to prepare various zones for residential development. Dorchester Group and Bovis have divided the site into a number of development phases, and the URL works are referenced to these various phases.

1.2. The above planning consent contains the following conditions relating to contamination remediation:

24	*No operational development approved by this planning permission shall take place (or such other date or stage in development as may be agreed in writing with the Local Planning Authority), until the following components of a scheme to deal with the risks associated with contamination of the site shall each be submitted to and approved, in writing, by the local planning authority:*
a.	*A preliminary risk assessment which has identified:*
(i)	*- all previous uses.*
(ii)	*- potential contaminants associated with those uses.*
b.	*A conceptual model of the site indicating sources, pathways and receptors.*
c.	*Potentially unacceptable risks arising from contamination at the site.*
d.	*A site investigation scheme, based on (1) to provide information for a detailed assessment of the risk to all receptors that may be affected, including those off site.*
e.	*The site investigation results and the detailed risk assessment (2) and, based on these, an options appraisal and remediation strategy giving full details of the remediation measures required and how they are to be undertaken.*
f.	*A verification plan providing details of the data that will be collected in order to demonstrate that the works set out in (3) are complete and identifying any requirements for longer-term monitoring of pollutant linkages, maintenance and arrangements for contingency action.* *Any changes to these components require the express consent of the local planning authority. The scheme shall be implemented as approved.*
25	*Prior to occupation of any new build dwellings, a verification report demonstrating completion of the works set out in the approved remediation strategy and the effectiveness of the remediation shall be submitted to and approved, in writing, by the local planning authority. The report shall include results of sampling and monitoring carried out in accordance with the approved verification plan to demonstrate that the site remediation criteria have been met. It shall also include any plan (a "long-term monitoring and maintenance plan") for longer-term monitoring of pollutant linkages,*

	maintenance and arrangements for contingency action, as identified in the verification plan, and for the reporting of this to the local planning authority.
26	*If during development contamination not previously identified is found to be present at the site then no further development within 20m of the contamination shall be carried out until the developer has submitted to and obtained written approval from the local planning authority for an addendum to the method statement. This addendum to the method statement shall detail how this unsuspected contamination will be remediated (if necessary) and thereafter this will be carried out as approved before any development within 20m recommences. Following completion of any such additional remediation, a verification report shall be submitted within 3 months of the completion of the works for the approval of the Local Planning Authority in writing.*

1.3. A Remediation Strategy (ref: EED10658-109_S_12.2.3_FA, September 2012) prepared by Waterman Energy, Environment and Design Ltd. (Waterman) on behalf of Dorchester Group, together with a Demolition and Remediation Method Statement produced by Vertase F.L.I Ltd. were submitted to the Local Planning Authority (Cherwell District Council). The Council subsequently approved the discharge of Condition 24 on 2/11/12. Whilst the role of Waterman has changed within the remediation scheme, and Vertase FLI is no longer involved in the site, the principles of the remediation strategy remain the same, and have been adopted by URL in their role as Principal Contractor to Dorchester Group and Bovis.

1.4. For clarity, SGP re-submitted an updated Remediation Strategy (R1742-R01-v3) in April 2014 that reflects the changed contractual circumstances with respect to contamination remediation. Approval of the revised Strategy was received from the EHO in October 2014; however the completed works as detailed within this report were completed in accordance with that of the Waterman Strategy.

1.5. Smith Grant LLP (SGP) has been instructed by URL to advise upon the implementation of the remediation works and to carry out all necessary inspections and monitoring of the works and to prepare all necessary verification reports as the preparatory earthworks in each phase are completed by URL. This verification reporting is intended to assist in the discharge of Condition 25 (although some aspects can only be completed by the developers). SGP also assesses whether the requirements of Condition 26 relating to previously unidentified contamination need to be invoked.

1.6. This report deals with the completion of remediation by URL for Dorchester Group (the Developer) across Dorchester Phase D1b: Area 1. The site location is shown below and the site boundary that makes up the wider Dorchester Phase 1b area (D1B) and the sub-phase area (referred to by the Developer as Phase 3) of intended handover is marked on Drawing D02. A separate Completion Report will be completed for the remainder of the D1b phase upon completion in due course.

1.7. A development layout plan has not been provided however it is anticipated that the development will consist of a variety of detached, semi-detached and terraced housing with private gardens and associated infrastructure.

Figure 1.1 Approximate boundary of Phase D1B: Area 1

1.8. SGP has regularly inspected the URL preparatory earthworks carried out to date, and has collected samples of the stripped or replaced soil surfaces and aggregate for determination of compliance with the agreed quality standards. This report describes the works carried out, drawing conclusions and making recommendations concerning the further works required by Dorchester in order to fully discharge Planning Conditions 25 and 26.

2. Remediation Strategy

2.1. Expected Contamination

2.1.1. The wider development comprises an area of the former Upper Heyford Airbase, latterly developed and used by the United States Airforce, which has been decommissioned and is used in part for civilian purposes, including commercial and residential uses as part of Heyford Park. Identified known or potential contamination sources determined from the historical uses of the site and site investigations were generally found to be minor, consisting of low-level but pervasive contamination by metals / metalloids and PAHs, with localised hydrocarbons associated with bulk fuel storage tanks and the potential for asbestos in pipe laggings and gaskets, insulation board and cement-bound products, or as dispersed fibre in

made ground. The key identified contamination hot-spots in the wider site were associated with bulk underground fuel storage tanks (USTs).

2.1.2. Natural background contamination may be present in the bedrock and soils. The site lies within or adjacent to the "ironstone domain" as described in DEFRA Technical Guidance Sheet TGS01 "Arsenic", July 2012; the site lies within 1km of mapped outcrops of ironstones within the Jurassic sedimentary rocks. Within the ironstone domain, the normal background concentration (NBC) of arsenic is reported to be 220 mg/kg; the NBC is defined as the upper 95% confidence limit of the 95th percentile of topsoil concentrations. The normal background concentration of vanadium within the ironstone domain is reported by BGS to be >128 mg/kg. Both values substantially exceed the Remediation Strategy Table B1 criteria for cover soils.

2.2. Remediation Objectives and Approach

2.2.1. The key contamination remediation objectives are to:

- create a significant betterment of the groundwater environment thereby protecting groundwater quality at and beyond the site boundary;
- remove/remediate significant pollution sources such as hydrocarbon hot-spots, if present, that pose a risk to man and the environment, to the extent feasible;
- break significant or potentially significant future pollutant linkages resulting from the change of landuse, in particular related to shallow garden soils and human exposure;
- carry out further soil investigations/inspections to complete gaps in the existing investigation coverage;
- respond appropriately to contingencies in particular the discovery of previously undisclosed contamination;
- remove development constraints and prepare the site physically to enable residential development;
- manage all emissions to air and water to protect surface waters and groundwater and the atmosphere during the remediation works;
- provide appropriate additional protection measures where necessary, to be implemented during construction, including building gas barriers, water mains protection, and garden / open space soil quality and thickness.

2.2.2. The general requirements for garden and landscaped soils taken from the approved Remediation Strategy are as follows:

- provision of 600mm of clean soil cover over made ground materials within garden and landscaped areas;
- materials to be used as the garden/landscape soils must be suitable for use and validated, to comply with contamination targets set out in the Remediation Strategy at a rate of 1 sample per 500m^3;

- imported soils used for cover purposes to comply with contamination targets set out in the approved Remediation Strategy at a rate of 1 sample per 250m^3 with a minimum of 3 samples per source;
- in areas where natural uncontaminated soils are present following the site re-grade, clean topsoil may be required as a growing medium but there will be no requirement for a full 600mm of placed soil cover;

2.2.3. It is confirmed that the Dorchester D1B phase may be classed as "Green" under the NHBC classification scheme with no special measures required to address risks posed by ground gas.

2.3. Site Characterisation

Area 1 of the wider Dorchester Phase 1b area extends to about 2.2 ha and was previously occupied by 11 buildings, roads and grassed areas. Buildings formerly located within the D1B-Area1 are detailed in the table below:

Table 2.1 Buildings formerly located within the D1B-Area1

Building Number	Building Use	Date of Construction
440, 480, 489	Barracks	1925, 1925, 1926
440b	Boiler Room	unknown
476	Substation	1950
443	Store	1971
444	Unknown	1982
474	Dining Room/Cook House	1925
475	Ration Store	1925
486	Offices	1976
484	Disused	1940/1977

2.3.1. 1 underground storage tank (UG-NSA-04) was present within the site, located adjacent to the north-east corner of building 440b. Ground adjacent was previously investigated by trial-pit TP-NSA205 by Jomas in 2011. No significant hydrocarbon contamination was reported with screening of soils with a PID reporting a reading of <0.1 ppm. The UST was inspected by SGP on 20th November, 2013 and was found to contain water with sludge present at the base. The tank was of steel construction and estimated volume of 4,900 (US) gallons, or 18,550 litres based on gauge maximum contents. A PID reading for VOCs within the tank headspace measured 115ppm.

2.3.2. Elsewhere, and outside service trenches, the site was found to generally have a thin veneer of made ground or natural topsoil to around 0.3m depth over sandy clayey gravel derived from the weathered limestone at around 1m depth.

2.4. Phase-specific Strategy

2.4.1. It was concluded that the Dorchester Phase 1B handover Area 1 posed a minor risk of contamination associated with the former underground fuel tank (UG-NSA-04), sub-station, and former buildings.

2.4.2. The site-wide strategy of ensuring clean cover soils to 600mm depth is considered to be appropriate approach. No requirement for hydrocarbon remediation of soils or groundwater was identified pending additional inspection / investigation of the former UST location adjacent to building 440b after emptying and removal of the tank. The verification measures specific to dealing with USTs as set down in the approved Remediation Strategy were to be invoked with regard to the UG-NSA-04 location.

3. Description of Works

3.1. General Approach

3.1.1. Preparatory works within Phase 1B: Area 1 included:

- soft strip and vegetation clearance;
- asbestos survey and strip in accessible buildings and structures;
- segregation of waste materials including wood, metal and plastic for recovery / disposal;
- demolition of all above ground structures.

3.1.2. Remediation earthworks within Phase 1b: Area 1 included:

- grubbing out of relict ground floor slabs, foundations, roadways and services down to natural strata;
- removal / treatment of underground storage tank in accordance with the Remediation Strategy
- trim site surfaces to approximately -250mm below pre-existing ground levels
- crushing on-site of suitable hard materials (masonry, concrete and brick) to recover aggregate for reuse.

3.1.3. The works within the Phase D1b: Area 1, including site preparatory works, were carried out over the period from April 2014 and were completed by October 2014 with the exception of finalising development levels which SGP understands is to be completed by the developer.

3.1.4. The existing buildings were demolished following an asbestos survey carried out by a specialist sub-contractor. Removal of any asbestos containing material (ACM) from the buildings was carried out prior to demolition; copies of the asbestos survey reports and removal of ACM certificates are retained by URL and are available on request.

3.1.5. Shallow natural deposits of weathered limestone were present at surface levels following breaking out and removal of hard-standing. Bedrock of limestone underlies the weathered natural deposits and was encountered at a minimal depth of approximately 0.5m bgl.

3.1.6. Oversized materials (classed as those which may present an obstacle to sub-surface infrastructure and foundation construction), voids and relict structures such as foundations, drains and redundant infrastructure were removed. Recoverable materials such as concrete, brick and masonry were segregated before crushing to produce aggregate to be used by the developer as bulk fill or construction platform/sub-base under building footprints, roads and private gardens. Waste timbers were removed to a processing area in the north of the remaining Phase 1b area to undergo chipping prior to off-site removal. Scrap metal was sent for recycling.

3.1.7. An estimated 4,000m^3 of site-generated aggregate has been placed in a temporary stockpile (referred to as Agg-D1B-NE) which is intended to be handed over to the developer for use within the Ph1b: Area 1.

3.2 Contamination Hot-Spots

3.2.1 One area within the Phase D1b: Area 1 was determined as a potential contamination hotspot due to the presence of an underground fuel tank (UG-NSA-04), the location of which is indicated on Drawing D01. Previous intrusive investigations around the UST failed to identify any residual contamination within the surrounding shallow ground, however there was potential for contamination to be present.

3.2.2 The tank was subject to emptying, purging and removal, followed by validation testing as described in Section 4 and 5. Contamination indicators encountered were considered indicative of a small quantity of potentially unacceptable contamination consisting of black hydrocarbon impacted gravel. Contaminated arisings were removed and placed on an impermeable membrane in a temporary quarantine area within the wider Phase D1b area with along with arisings generated from other UST remediation within the wider site.

3.2.3 Validation testing on the base and sidewalls of the excavation following tank and contaminated arisings removal was carried out by SGP in accordance with the Remediation Strategy.

3.3 Validation of Formation Level Strata

3.3.1 It is a requirement under the Remediation Strategy that a 600mm cover of clean soils over made ground is placed in garden areas, however due to the requirement to trim development areas by -200mm below existing ground levels, made ground was largely absent due to the

shallowness of natural strata. This meant that a 400mm depth of subsoil will be left which could form part of the full 600mm of garden soil cover after replacement of garden topsoil.

3.3.2 In-situ sampling of the formation level strata was carried out by sampling of the top 400mm at a test frequency of 1 sample per 500m^3, the residual depth 400mm depth equating to 1 sample per 1250m^2 plan area of development. Eighteen in-situ samples were collected from the exposed formation level with depth validation photos showing the extent of the 0-400mm depth range. Samples were analysed for a suite of contaminants as specified within the Remediation Strategy.

3.3.3 Multiple or significantly elevated concentration exceedances within the in-situ sampling resulted in the collection of further validation samples to delineate areas around the exceedance. Following the assessment and delineation, the non-conforming soil was removed to a nominal 400mm depth under the guidance of SGP.

3.4 Site Waste Management

3.4.1 As described, waste materials removed from the Phase D1b: Area 1 included timber, scrap metal, ACM and hydrocarbon impacted soils. Recovered wastes of metal and wood were temporarily stockpiled in the wider Phase D1b area before off-site removal of further treatment and assessment.

3.4.2 Timber associated with beams, flooring and roof-trusses was recovered following demolition and were temporarily stockpiled in the north of Phase D1b with recovered timber waste from the wider phase area. A specialist sub-contractor chipper the timber which is currently awaiting off-site disposal.

3.4.3 ACM removed prior to demolition works was disposed off-site by a specialist sub-contractor.

3.4.4 Hydrocarbon impacted arisings were temporarily stored on an area of hard-standing in the centre of the wider Phase D1b site together with impacted arisings generated from other UST remediation in the wider development area. The stockpile was frequently turned and mixed by a mechanical excavator to allow aeration of the soils before further sampling and assessment was carried out. The results of the further assessment will be provided in the wider Phase D1b Completion Report.

3.5 Constraints and Limitations

3.5.1 Remediation earthworks within the Phase 1B:Area 1 were constrained due to the presence of a live electricity cable which enters the site off the eastern boundary before entering a sub-station and crossing the southern half of the handover area. A stand-off corridor was adopted in the location of the electricity cable during remediation earthworks. SGP understand that

the cable is to be diverted at a later date during which the sub-station will be decommissioned and relocated.

3.6 Unforeseen Contamination

3.6.1 No unforeseen contamination was identified or encountered during the remediation earthworks.

4. Inspections and Testing

4.1. SGP attended the site on nine occasions during and following the remediation earthworks. The dates and activities carried out in the Phase D1B: Area 1 during SGP attendance, cross referenced to the site inspection photographic record (Appendix A), formation level validation photo record (Appendix B) and Analysis Results (Appendix C) are summarised in the table below.

Table 4.1 SGP Inspection Summary

Date	SGP Activities	Record
30/04/2014	Site inspection during demolition of buildings and soft landscaping strip	Appendix A - Photos: 1-7
05/06/2014	Site inspection; supervision of underground storage tank UG-NSA-04 removal and collection of validation samples	A detailed photographic record; validation samples and laboratory certificates are provided within R1742-R06-UST Remediation Verification Report
09/06/2014	Inspection of backfilled void following removal of UG-NSA-04	See R1742-R06- UST Remediation Verification Report
18/08/2014	In-situ sampling of formation level (SS1-4,6,8-14)	Appendix B - Photos 1-12 Appendix C - Lab Ref: 14/08441 & 14/9392
19/08/2014	Site Inspection; Sample Aggregate Stockpile 'Agg-NE '	Appendix A - Photos: 8-10 Appendix C - Lab Ref: 14/08436 & 14/9392
10/09/2014	Site Inspection; Re-sample in-situ SS4 and SS6 following exceedances of assessment criteria	Appendix B – Photos 13-23 Appendix C – Lab Ref: 14/09783
24/09/2014	Site Inspection; In-situ sampling of formation level (SS36, 38-40)	Appendix A - Photos: 11-12 Appendix B – Photos 24-27 Appendix C – Lab Ref: 14/11667 & 14/10872
07/10/2014	Site Inspection; Re-sampling in-situ of formation level (SS4F-K) following additional failure and supervision of formation level strip following delineation of exceedances at SS6	Appendix A – Photos 13-16 Appendix B – Photos 28-37 Appendix C – Lab Ref: 14/11756

Date	SGP Activities	Record
22/10/2014	Site Inspection; Re-sampling in-situ of formation level (SS38A-D) following exceedance of assessment criteria and supervision of formation level strip following delineation of exceedances at SS4	Appendix A – Photos 17-19 Appendix B – Photos 38-44 Appendix C – Lab Ref: 14/12802

4.2. Validation of UST (UG-NSA-4) Removal

4.2.1. SGP attended site on 05.06.14 during the removal of UG-NSA-4 to carry out the required inspection and validation procedure as outlined within the Remediation Strategy. Information detailing the screening of excavated arisings, the collection of validation samples and interpretation of the chemical results are discussed in detail within the UST Remediation Verification Report (R1742-R06). Validation works within the report are supplemented with a detailed photographic record.

4.2.2. Validation samples (8 no.) collected from the sides of the excavation all contained hydrocarbon concentrations below the validation criteria. The sides and base (in bedrock) of the excavation were reported to be free from oil-staining, sheen or odour.

4.3. Validation of Formation Level Soils

4.3.1. Sampling and analysis was carried out to determine the suitability of formation level soils to form part of the 600mm soil cover system. Development levels for the site are yet to be confirmed by the developer; however in-situ sampling of the formation level will determine whether a reduced 200mm topsoil cover can be placed within garden areas providing the 400mm of natural strata is chemically suitable for retention.

4.3.2. A total of 18 samples (excluding re-samples) were taken from the stripped or replaced soil surfaces within the Phase D1B: Area 1 and within sampling cells which straddle both areas of the site. On the worst case assumption of the soils forming the lower 400mm of the garden / landscaping cover layer and a total site area of ~22,000m^2, the volume of validated soil is effectively 8,800m^3 and the test rate is equivalent to 1 sample per 488m^3, achieving the specified rate of 1 sample per 500m^3.

4.3.3. All samples were collected by SGP geo-environmental consultants and were placed in appropriate laboratory-provided containers and stored in cooled boxes. Samples submitted for chemical analysis were delivered to Jones Environmental Ltd (JEL) within 24 hours of collection and samples for asbestos screen were sent to Chemtest within 48 hours of collection. SGP retains chain of custody documentation.

4.3.4. Chemical laboratory certificates (14/9392, 14/10359, 14/10872, 14/12802) and asbestos laboratory certificates (14/08441, 14/11756, 14/09783, 14/08441, 14/1167) are included within

Appendix C. Results are summarised in the table below and are compared to assessment criteria for garden cover soils.

Table 4.2 Analysis Summary for 0-400mm Formation Level Soils

Contaminant	Samples	Range of Concentrations (mg/kg unless stated)	Residential Use	
			Screening criteria* (mg/kg unless stated)	Exceedences
SOM	21	<0.2-22.8	-	
pH	18	8.07-10.07	WRAS <5>8	**(18) All**
asbestos fibre*	30	NFD-Fibres Detected	<0.001%	**(1) SS6**
antimony	18	<0.1-7	550	**None**
arsenic	22	14-86.40	32	**(3) SS3, SS12, SS38**
barium	18	25-500	1300	None
beryllium	18	0.5-2	51	None
cadmium	18	<0.1-1.1	10	None
chromium	18	14.9-69.3	3000	None
chromium IV	18	<0.3-0.6	4.3	None
cobalt	18	4.60-13.20	240	None
copper	18	<1-17	300	None
lead	24	5-2035	450	**(1) SS6**
mercury	18	<0.1-0.8	1	None
molybdenum	18	0.5-5.2	670	None
nickel	18	11-39.1	130	None
selenium	18	<1-1	350	None
vanadium	18	41-144	75	**(7) SS2, SS3,SS6,SS7,SS8,SS12,SS38**
water soluble boron	18	0.6-4.2	291	None
zinc	18	29-172	300	None
naphthalene	26	<0.04-0.16	1.5	None
acenaphthylene	26	<0.03-0.82	210	None
acenaphthene	26	<0.06-0.71	170	None
fluorene	26	<0.04-0.60	160	None
phenanthrene	26	<0.03-10.19	92	None
anthracene	26	<0.04-3.71	2300	None
fluoranthene	26	<0.03-19.90	260	None
pyrene	26	<0.03-17.90	560	None
benzo(a)anthracene	26	<0.06-9.79	3.1	**(2) SS4, SS4E**
chrysene	26	<0.02-10.24	6	**(1) SS4**
benzo(bk)fluoranthene	26	<0.07-17.64	-	**-**
benzo(a)pyrene	26	<0.04-10.97	0.83	**(5) SS2,SS4,S4E,SS9,SS38, SS38B, SS38C**
indeno(123cd)pyrene	26	<0.04-6.49	3.2	**(1) SS4**
dibenzo(ah)anthracene	26	<0.04-1.05	0.76	**(1) SS4**
benzo(ghi)perylene	26	<0.04-6.01	44	None
aliphatic C5-C6	18	<0.1	30	None
aliphatic C6-C8	18	<0.1	73	None
aliphatic C8-C10	18	<0.1	19	None

Contaminant	Samples	Range of Concentrations (mg/kg unless stated)	Residential Use	
			Screening criteria* (mg/kg unless stated)	Exceedences
aliphatic C10-C12	18	<0.2	93	None
aliphatic C12-C16	18	<4	740	None
aliphatic C16-C21	18	<7	1000	None
aliphatic C21-C35	18	<7-121	1000	None
aromatic C6-C7	18	<0.1	30	None
aromatic C7-C8	18	<0.1	120	None
aromatic C8-C10	18	<0.1	27	None
aromatic C10-C12	18	<0.2	69	None
aromatic C12-C16	18	<4	140	None
aromatic C16-C21	18	<7-70	250	None
aromatic C21-C35	18	<7-358	890	None
benzene	18	<0.005	0.08	None
toluene	18	<0.005	120	None
ethylbenzene	18	<0.005	65	None
o-xylene	18	<0.005	45	None
m-xylene	18	<0.005	44	None
p-xylene	18	<0.005	42	None
methyl tert butyl ether	18	<0.005	49	None

* not included in approved Waterman's Remedial Strategy but proposed in SGP revised Strategy, R1742-R01 Table 6.2

4.4. Validation of Formation Level Soils – Vanadium and Arsenic Exceedances

4.4.1. Three samples (D1B-SS3, D1B-SS12 and D1B-SS38) were found to exceed the 32 mg/kg screening criteria for arsenic, at 48.6 mg/kg, 86.4 mg/kg and 40.7 mg/kg respectively. Exceedances of vanadium were also recorded in 7 samples (D1B-SS2, D1B-SS3, D1B-SS6, D1B-SS7, D1B-SS8, D1B-SS12, D1B-SS38), exceeding the 75 mg/kg screening criterion with a maximum concentration of 144 mg/kg. All samples comprised natural soils of weathered bedrock. In the absence of any identified anthropogenic material it was determined that a statistical estimate should be carried out of the sample mean within the Phase 1B: Area 1 as a single averaging area. Locations of vanadium and arsenic exceedances are reproduced in Drawings D02 and D03 respective. The statistical analysis results are tabulated in the table below:

Table 4.3 Statistical Analysis of Arsenic and Vanadium Concentrations

statistic	arsenic (mg/kg)	vanadium (mg/kg)
criterion	32.0	75.0
no. of samples	18	18
Grubbs outlier test for highest value (P0.05)	D1B-SS12 (max value 86.4 mg/kg) is an outlier	No Outliers
arithmetic mean, including outlier	26.5	77.1
upper confidence limit (UCL 0.95) including outlier	44.57 (fail)	112.1 (fail)

arithmetic mean, excluding D1B-SS12 outlier	23.0	As above (no outlier) - Fail
upper confidence limit (UCL 0.95) excluding D1B-SS12 outlier	33.05 (fail)	As above (no outlier) - Fail

4.4.2. The statistical analysis including the exceedances of arsenic show a marginal exceedance with a UCL (0.95) of 33.05 mg/kg when the statistical outlier of D1B-SS12 is excluded. This results in a marginal exceedance of the assessment criteria of 32 mg/kg, but is below the Category 4 Screening Level (C4SL) for arsenic of 37 mg/kg which DEFRA has stated indicates suitability for residential use. Exceedances of vanadium concentrations were generally located in the north of the Phase 1B: Area1 with concentrations recorded within the natural background concentrations for the ironstone domain.

4.4.3. Further in-situ sampling was carried out within the location of D1B-SS38 due to chemical exceedances, discussed below. Four samples (denoted SS38- A, B, C and D) were collected to delineate the extent of arsenic contamination (Lab Ref: 14/12802). Re-test samples confirmed concentrations below the assessment criteria with a range of concentrations between 13.9 -21.9 mg/kg.

4.4.4. Soil sampled was of natural appearance from an area of the site remote from identified historical contaminative activities, identical in appearance to other soils around the phase, and mineralisation is therefore likely to be of natural origin. Typically the bio-accessibility of naturally occurring arsenic associated with ironstones (normally present in the form of arsenopyrite) will be low, and the risk to future residential use is therefore considered also likely to be low.

4.4.5. Research into the bioaccessibility of arsenic was published by Wragg *et al.* (2014)[1] for natural ironstone soils sampled from the Cherwell District, including a sample from Upper Heyford. The paper concluded that total concentrations of arsenic are locally elevated due to the soil parent material, and that bioaccessibility testing, which mimics the human gastrointestinal system, shows only a small proportion of the total concentration is available for absorption into the human body. The samples obtained from Upper Heyford contained an average bioaccessible arsenic fraction of about 15% of the total arsenic content.

4.4.6. The basis of the low bio-availability for naturally-occurring arsenic is its strong retention within low solubility iron compounds, together with absorption onto clay minerals and organic matter. Similar conditions apply to naturally occurring vanadium which is also present in excess of the screening criterion. This element also forms very insoluble compounds with iron as demonstrated by analysis of naturally elevated concentrations in soils formed on Jurassic

[1] J Wragg, M Cave, S Gregory., "The Solid Phase Distribution and Bioaccessibility of Arsenic, Chromium, and Nickel in Natural Ironstone Solids in the UK", Applied and Environmental Soil Science, vol. 2014, no. 924891, 2014

ironstone rocks in the elsewhere in the UK[2]. The GAC screening criterion is published by LQM/CIEH based on a tolerable daily intake (oral) of 3 µg per kg bodyweight per day of vanadium in the form of sodium metavanadate, a highly soluble compound (water solubility 211 g/l). The GAC is therefore highly conservative and is unrealistic for exposure to naturally occurring vanadium in soil. It is concluded that vanadium within the site and within future garden soils poses no significant risk to human health.

4.5. Validation of Formation Level Soils – Lead Exceedance

4.5.1. A single exceedance of lead was reported within sample D1B-SS6 with a concentration of 2,035 mg/kg (lab ref: 14-9392). Following other substance exceedances within D1B-SS6 (asbestos fibre identification as discussed in Section 4.6) SGP attended site to collect a further 6 in-situ samples (D1B-SS6B-G) to delineate the area of exceedance. Re-test concentrations were significantly reduced and below the assessment criteria with a lead concentration range of 5-20 mg/kg. Following review of the re-test results, URL under the supervision of SGP removed a 400mm depth strip of the formation level strata where the original lead exceedance had been determined.

4.5.2. The exceedance location of lead is reproduced in Drawing D04 together with the approximate extent of the remedial strip. The contaminated arisings have been temporarily stored in a stockpile within the remaining Phase D1b area pending re-use as fill below the cover elsewhere.

4.6. Validation of Formation Level Soils – Asbestos Fibre Exceedances

4.6.1. Asbestos fibres were identified within two samples, D1B-SS6 (lab ref: 14-08441) and re-test sample D1B-SS4E (lab ref: 14/10359). Following fibre identification within D1B-SS6, six re-test samples (D1B-SS6B-G) were collected to delineate the area of fibre impacted soil. Re-test samples (lab ref: 14-09783) failed to identify the presence of any asbestos fibres following which URL under the supervision of SGP removed a 400mm depth strip of the D1B-SS6 source material.

4.6.2. During the re-test of samples from D1B-SS4 due to exceedances of PAHs, the laboratory notified SGP that asbestos fibres had been identified during the preparation of sample D1B-SS4E. SGP attended site on 07/10/14 to collect a further 6 in-situ samples (lab ref: 14-11756) around the location where the fibre had been identified to delineate the extent of fibre impacted soils. No fibres were identified during the re-test samples (D1B-SS4F-K); SGP supervised a 400mm depth strip to remove the impacted strata from within the D1B-SS4 location.

[2] N Breward, BGS "Arsenic and presumed resistate trace element geochemistry of the Lincolnshire (UK) sedimentary ironstones, as revealed by a regional geochemical survey using soil, water and stream sediment sampling". Applied Geochemistry 22 (2007) 1970-1993

4.6.3. Locations of fibre identification are reproduced in Drawing D05 with the approximate extent of remedial strip.

4.7. Validation of Formation Level Soils – PAH Exceedances

4.7.1. Four sampling locations (D1B-SS2, D1B-SS4, D1B-SS9, D1B-SS38) reported elevated concentrations of PAHs, these were generally limited to the PAH benzo(a)pyrene (BaP) however sample D1B-SS4 contained widespread PAH exceedances of benzo(a)anthracene, chrysene, benzo(a)pyrene, dibenzo(ah)anthracene and benzo(b)fluoranthene. Exceedances of BaP ranged between 0.84 mg/kg in D1B-SS9 (a marginal exceedance of 0.01 mg/kg) to a maximum concentration of 10.97 mg/kg in D1B-SS4.

4.7.2. Following exceedances of multiple PAHs within D1B-SS4, and where the maximum BaP concentration was reported, four further in-situ samples were collected (D1B-SS4B-E) to delineate the area of impacted soils (lab ref: 14/10359). Re-test samples confirmed that multiple PAH exceedances were limited to the single location of D1B-SS4, however exceedances of BaP at a concentration of 3.87 mg/kg and a marginal exceedance of benzo(a)anthracene at 3.36 mg/kg were identified in sample D1B-SS4E. Following review of the results, URL under SGP supervision removed a 400mm depth strip of formation level soils from the areas of D1B-SS4 and D1B-SS4E.

4.7.3. It was anticipated that delineation of BaP impacted soils as per the previous methodology would be implemented within the location of D1B-SS38, however following the collection of four further in-situ samples (D1B-SS38A - D1B-SS38D) exceedances of 1.08 mg/kg (D1B-SS38B) and 1.96 mg/kg (D1B-SS38B) were reported.

4.7.4. Concentrations of BaP within sampling locations where a 400mm depth soil strip has not been carried out (D1B-SS2, D1B-SS9, D1B-SS38, D1B-SS38B, D1B-SS38C) ranged between 0.85 mg/kg to 1.96 mg/kg, exceeding the assessment criteria of 0.83mg/kg.

4.7.5. The exceedance locations of PAH are reproduced in Drawing D06.

4.7.6. PAH ratio analysis to determine the source of the PAHs on the five samples where exceedances in retained soils remained confirms a coal source whilst the signature of sample D1B-SS38B suggests a coal tar signature; a copy of the plot is included within Appendix D. It is likely that inclusions of relatively small proportions of coal/clinker/tarmac may be mixed up within the formation level soils following removal of hard-standing and the -200mm trim. Source identification confirms a probable low bio-availability due to the sequestration of PAHs within a carbon or vitrified matrix with BaP concentrations significantly below the DEFRA C4SL criteria of 5 mg/kg for garden soils, and BaP is therefore unlikely to represent an unacceptable risk to human health.

4.8. Validation of Formation Level Soils – pH Exceedances

4.8.1. Soil pH values ranged from 8.07 within D1B-SS9 to alkaline at 10.07 within D1B-SS2 with all samples (18) exceeding the former WRAS trigger pH value of >8. Elevated concentrations of pH in the majority of samples are likely to be attributed the ubiquitous presence of carbonate limestone identified across the NSA, although the highest pH values are probably also indicative of concrete fragments; the hydroxides in freshly exposed concrete will undergo carbonation over a period of days, with an accompanying reduction in pH.

4.9. Validation of Site Generated Crushed Aggregate

4.9.1. Sampling analysis was carried out to determine the suitability of crushed recovered aggregate for potential reuse during the development phase.

4.9.2. It is proposed that a stockpile currently located just off the north-west corner of the Phase 1B: Area 1 boundary is handed over to the developer for use during construction. The stockpile of processed aggregate is approximately 4,000m^3 and is denoted as 'D1B-NE-Agg'. SGP has carried out sampling of the stockpile with eight samples being submitted for an asbestos screen at Chemtest laboratories achieving the required sampling frequency of 1 per 500m^3. Results are provided in laboratory certificates 14-08436 (Appendix C) and are summarised in the table below:

Table 4.6 Asbestos Screening Summary for Aggregate Stockpile D1B-NE-Agg

Contaminant	Samples	Range of Concentrations (mg/kg unless stated)	Screening criteria* (mg/kg unless stated)	Albion Water Pipeline Screening Criteria (mg/kg unless stated)	Exceedances
SOM	3	<0.2-0.3	-	-	-
pH	3	8.25-9.64	WRAS <5>8	-	**(3) D1B-NE-AGG1; D1B-NE-AGG2; D1B-NE-AGG3**
asbestos fibre*	8	NFD	<0.001%	-	None
antimony	3	<1-1	550	-	None
arsenic	3	16.8-27.2	32	-	**None**
barium	3	64-144	1300	-	None
beryllium	3	0.5-1.1	51	-	None
cadmium	3	<0.1-0.1	10	-	None
chromium	3	18.-26.3	3000	-	None
chromium IV	3	<0.3	4.3	-	None
cobalt	3	4.7-7.5	240	-	None
copper	3	6-13	300	-	None
lead	3	6-48	450	-	None
mercury	3	<0.1-0.5	1	-	None
molybdenum	3	1-1.5	670	-	None
nickel	3	12.8-18.7	130	-	None
selenium	3	<1-1	350	-	None

Contaminant	Samples	Range of Concentrations (mg/kg unless stated)	Screening criteria* (mg/kg unless stated)	Albion Water Pipeline Screening Criteria (mg/kg unless stated)	Exceedances
vanadium	3	31-54	75	-	None
water soluble boron	3	1.9-3.7	291	-	None
zinc	3	41-205	300	-	None
naphthalene	3	<0.04-0.82	1.5	-	None
acenaphthylene	3	0.06-0.19	210	-	None
acenaphthene	3	0.09-1.02	170	-	None
fluorene	3	0.04-0.79	160	-	None
phenanthrene	3	0.94-7.77	92	-	None
anthracene	3	0.29-2.26	2300	-	None
fluoranthene	3	2.58-8.44	260	-	None
pyrene	3	2.18-7.01	560	-	None
benzo(a)anthracene	3	1.01-3.63	3.1	-	**(1) D1B-NE-AGG3**
chrysene	3	0.92-3.28	6	-	None
benzo(bk)fluoranthene	3	1.4-5.18	-	-	**-**
benzo(a)pyrene	3	0.91-3.41	0.83	-	**(3) D1B-NE-AGG1; D1B-NE-AGG2; D1B-NE-AGG3**
indeno(123cd)pyrene	3	0.56-1.77	3.2	-	None
dibenzo(ah)anthracene	3	0.07-0.37	0.76	-	None
benzo(ghi)perylene	3	0.46-1.64	44	-	None
aliphatic C5-C6	3	<0.1	30	10	None
aliphatic C6-C8	3	<0.1	73	10	None
aliphatic C8-C10	3	<0.1	19	10	None
aliphatic C10-C12	3	<0.2	93	10	None
aliphatic C12-C16	3	<4	740	10	None
aliphatic C16-C21	3	<7	1000	10	None
aliphatic C21-C35	3	<7-46	1000	500	None
aromatic C6-C7	3	<0.1	30	10	None
aromatic C7-C8	3	<0.1	12	10	None
aromatic C8-C10	3	<0.1	27	10	None
aromatic C10-C12	3	<0.2	69	10	None
aromatic C12-C16	3	<4-10	140	10	None
aromatic C16-C21	3	16-67	250	10	**(3) D1B-NE-AGG1; D1B-NE-AGG2; D1B-NE-AGG3**
aromatic C21-C35	3	76-163	890	500	None
benzene	3	<0.005	0.08	0.1	None
toluene	18	<0.005	120	0.1	None
ethylbenzene	18	<0.005	65	0.1	None
o-xylene	18	<0.005	45	0.1	None
m-xylene	18	<0.005	44	0.1	None
p-xylene	18	<0.005	42	0.1	None
methyl tert butyl ether	18	<0.005	49	0.1	None

* not included in approved Remedial Strategy but proposed in SGP revised Strategy, R1742-R01 Table 6.2

4.2.1 All samples collected from D1B-NE-AGG stockpile were reported as containing 'no fibres present', however exceedances of the PAH benzo(a)anthracene (D1B-NE-AGG3) and

benzo(a)pyrene (D1B-NE-AGG1, D1B-NE-AGG2, D1B-NE-AGG3) were above the assessment criteria for material within the capping / garden cover system.

4.2.2 Heavy end aromatic fractions (C16-C21) exceeded the Albion Water Pipeline Screening Criteria (10mg/kg) in all three samples submitted for chemical testing with a maximum concentration of 67 mg/kg (D1B-NE-AGG3).

4.2.3 It is anticipated that the PAH and aromatic hydrocarbon exceedances are attributed to the minor presence of tarmac fragments which have been processed with the concrete hard-standing during crushing.

4.2.4 The stockpile was sampled for grading analysis, with 2 samples delivered to Testconsult Ltd. (Ref: DOR Crush 3-4 and DOR Crush 14-4). The laboratory certificate of analysis is provided in Appendix C; both samples met the grading requirements for class 6F2 material.

4.3 Unknown Contamination

4.3.1 No previously unknown contamination was encountered within the Dorchester Phase 1b: Area 1, with the exceptions of the elevated natural concentrations of arsenic and vanadium within the formation level strata. Exceedances of the PAHs, primarily benzo(a)pyrene within the formation level and the occurrence of asbestos fibres have been identified and appropriate remedial action implemented in order to mitigate the potential risk.

5. Conclusions and Recommendations

5.1. Verification of Remediation

5.1.1. The site formation level surfaces and generated aggregate materials have been inspected and sampled by SGP in accordance with the approved Remediation Strategy. The types of materials encountered during the additional assessment and remediation works carried out in Phase 1B: Area 1 area was consistent with those described in the site characterisation.

5.1.2. On the basis that URL has stripped the overall area to -200mm existing ground levels (development levels are yet to be confirmed), SGP has validated and sampled the formation level surfaces to an average depth of 400mm (see validation photos in Appendix B). A sampling frequency of 1 per 500m^3 of potential cover soil material has therefore been achieved.

5.1.3. In-situ locations where asbestos fibres (D1B-SS4E and D1B-SS6) and where multiple chemical exceedances (D1B-SS4 and D1B-SS6) were identified, further validation sampling was carried out to delineate impacted soils which were subsequently removed to -400mm.

Removed soils have been temporarily stockpiled on the wider Phase D1B area for placement at depth below the capping layer.

5.1.4. Three exceedances of the arsenic screening criterion were identified and 6 initial vanadium exceedances, however this was reduced to 5 exceedances following the removal of impacted soils in D1B-SS6. The arsenic and vanadium levels are considered to represent normal background concentrations in the area arising from the bedrock, and evidence is available to suggest their low bio-availability, and consequent minimal significance for human health.

5.1.5. Statistical analysis conducted on samples where arsenic exceedances were reported confirmed that sample D1B-SS12 (86.4 mg/kg) was a statistical outlier to the dataset and when the outlier was removed, the upper confidence limit (UCL 0.95) reduced to 33.05 mg/kg. Whilst this remains a marginal exceedance of the assessment criteria of 32 mg/kg it is below the DEFRA C4SL value of 37 mg/kg. On the basis of the statistical analysis, failure to exceed the C4SL value and review of the bio-accessibility of arsenic in local soils, SGP conclude that there is a minimal risk to future site occupants on the basis of arsenic concentrations within the capping layer soils. Similar considerations apply to vanadium where the form of vanadium present is likely to be highly insoluble and unavailable to human uptake.

5.1.6. Development levels are not finalised, and whilst in-situ validation sampling has been carried out to confirm the suitability of a reduced cover system in garden areas (i.e. 200mm of topsoil placed on top of validated formation level strata) it is possible that the final levels will require more than 200mm additional topsoil cover. SGP considers that the occurrences of elevated arsenic and vanadium in some validation samples represent normal background concentrations and are very unlikely to pose a risk to human health for future site residents, due to low bioavailability of these elements. However the concentrations do exceed the approved Remedial Strategy criteria and therefore represent a departure from the Strategy which should be agreed with CDC.

5.1.7. Exceedances of the soil cover screening criterion for benzo(a)pyrene were found in a total of 7 sampling locations (including a re-test sample in D1B-SS4 and two re-test samples within D1B-SS38). However after the stripping and removal of impacted soils in D1B-SS4 this was reduced to 6 locations. Residual exceedances were significantly below the DEFRA C4SL for garden soils of 5 mg/kg and a source identification ratio plot confirmed the likely source to be coal with only D1B-SS38B producing a coal tar signature. The identified sources are likely to be of low significance in terms of solubility and bioavailability due to the sequestration within coal / coal ash or bitumen, and in light of concentrations below the C4SL value SGP considers that the risk associated to future site occupants to concentrations within the capping layer to be minimal. Both DCLG and NHBC have confirmed that they consider C4SLs as useful in assessing the suitability of soils for planned residential land uses. Again, the

concentrations do exceed the approved Remedial Strategy criteria and therefore represent a departure from the Strategy which should be agreed with CDC.

5.1.8. One underground fuel storage tank was located within the site, UG-NSA-4, alongside building 440B. The tank contents were removed for specialist treatment and the tank and surrounds were removed in accordance with the Remediation Strategy requirements, together with a small volume of oil-impacted soil / gravel. The tank surrounds were validated in accordance with the Strategy, and no significant hydrocarbon contamination was found; accordingly, no further remediation was required.

5.2. Recovered Materials

5.2.1. Approximately 4000m^3 recovered aggregate was generated on site. A total of 8 samples were collected from this stockpile for asbestos screening achieving the 1 per 500m^3 frequency and 4 samples for chemical analysis. No asbestos fibres were detected within the samples, however exceedances of PAHs, benzo(a)pyrene and benzo(a)anthracene mean that the recovered aggregate cannot form part of the garden capping layer, and should not be used for water main pipe bedding or trench backfill.

5.3. Ground Gas / Vapour Hazards

5.3.1. No significant sources of hydrocarbon vapours were identified on or adjacent to the site. The former underground storage tank (UG-NSA-4) location was not significantly contaminated following remediation.

5.3.2. Significant amounts of degradable organic materials were not reported during the site turnover and there is no evidence to revise the classification of the site in respect to risks to development from hazardous ground gas.

5.4. Water Main Risk Assessment

5.4.1. No significant risks have been identified with respect to the laying of water mains; however the requirements of the water services provider, including risk assessment, should be followed.

5.4.2. Further assessment should be carried out when the pipeline routes are confirmed, and following the completion of groundworks / prior to trench excavation.

5.5. Sulphates and Concrete

5.5.1. No specific testing has been undertaken for potentially aggressive conditions to concrete. Reference should be made to the preceding site investigation reports.

5.6. Further Requirements

5.6.1. In order to secure completion of remediation in Dorchester Phase D1B: Area 1 in accordance with the Remediation Strategy, the Developer is required to complete the agreed garden / landscaping cover system. This will entail a minimum further 200mm of clean, validated soils in all garden and landscaped areas and up to 600mm in gardens / 300mm in landscaping areas depending on development levels and acceptance by CDC of the risk assessments conclusions that the occasional residual minor exceedances of generic risk assessment criteria for arsenic, vanadium and benzo(a)pyrene do not pose an unacceptable risk to human health.

5.6.2. With the adoption of the above normal practices for Brownfield development, and on the information available to it, SGP concludes that the preparatory remedial works have been completed in accordance with the agreed strategy. In the event that any previously undisclosed contamination or suspect materials are identified then this should be assessed by an appropriately qualified and experienced person.

5.7. Long-term Management and Monitoring

5.7.1. No specific requirements for long-term monitoring or management have been identified within the site. Residual contamination has been found to be of low significance, low mobility and stable, and is unlikely to become a pollution source in the future.

5.8. Limitations

5.8.1. SGP reserves the right to alter any of the foregoing information in the event of new information being disclosed or provided and in the light of changes to legislation, guidelines and responses by the statutory and regulatory authorities.

5.9. This report has been prepared by Smith Grant LLP, for the sole and exclusive use of Urban Regen Ltd. and Dorchester Group, and the benefit of this report may not be assigned to any third party without the prior agreement in writing of Smith Grant LLP.

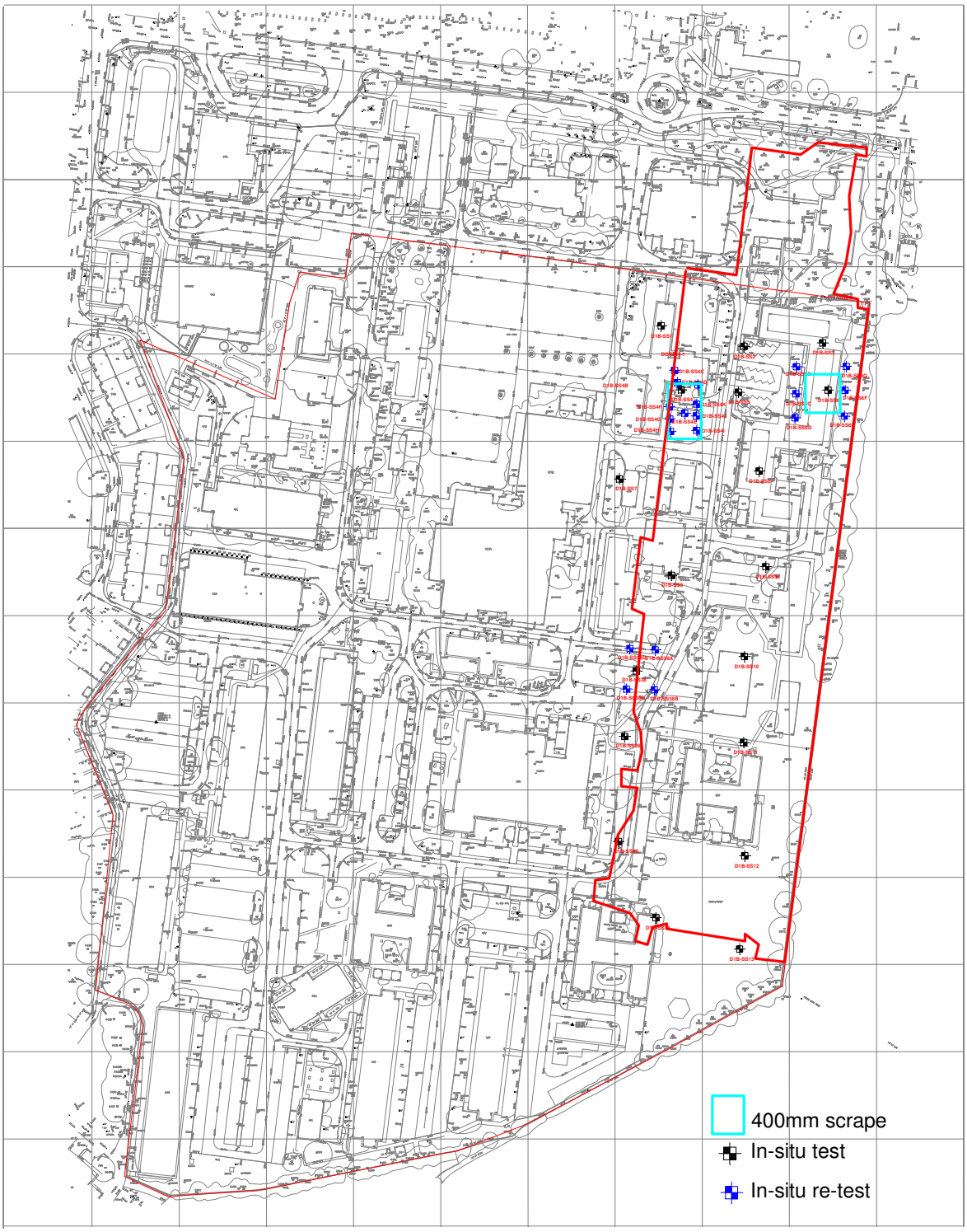
5.10. Reasonable skill, care and diligence have been exercised within the timescale and budget available, and in accordance with the technical requirements of the brief. Notwithstanding the efforts made by the professional team in undertaking the assessment and preparing this report, it is possible that other ground conditions and contamination as yet undetected may exist. Reliance on the findings of this report must therefore be limited accordingly. Such reliance must be based on the whole report and not on extracts which may lead to incomplete or incorrect conclusions when taken out of context. This report reviews and relies upon site investigations largely conducted by others. If errors or omissions in previous work have been noted then these have been duly noted, however SGP accepts no responsibility for advice given on the basis of incorrect factual information provided to it.

DRAWINGS

N

Phase
D1B Boundary

Phase Boundary
D1B:Area-1



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Project: Upper Heyford: Ph1b Dorchester		Drawn: DW	Checked: AFS
		Date: 28.10.14	Scale: 1:2,500
Drawing: Soil Validation Location Plan		Job No: R1742B	Drg No: D01

Vanadium

Phase D1B Boundary

Phase Boundary D1B:Area-1

N

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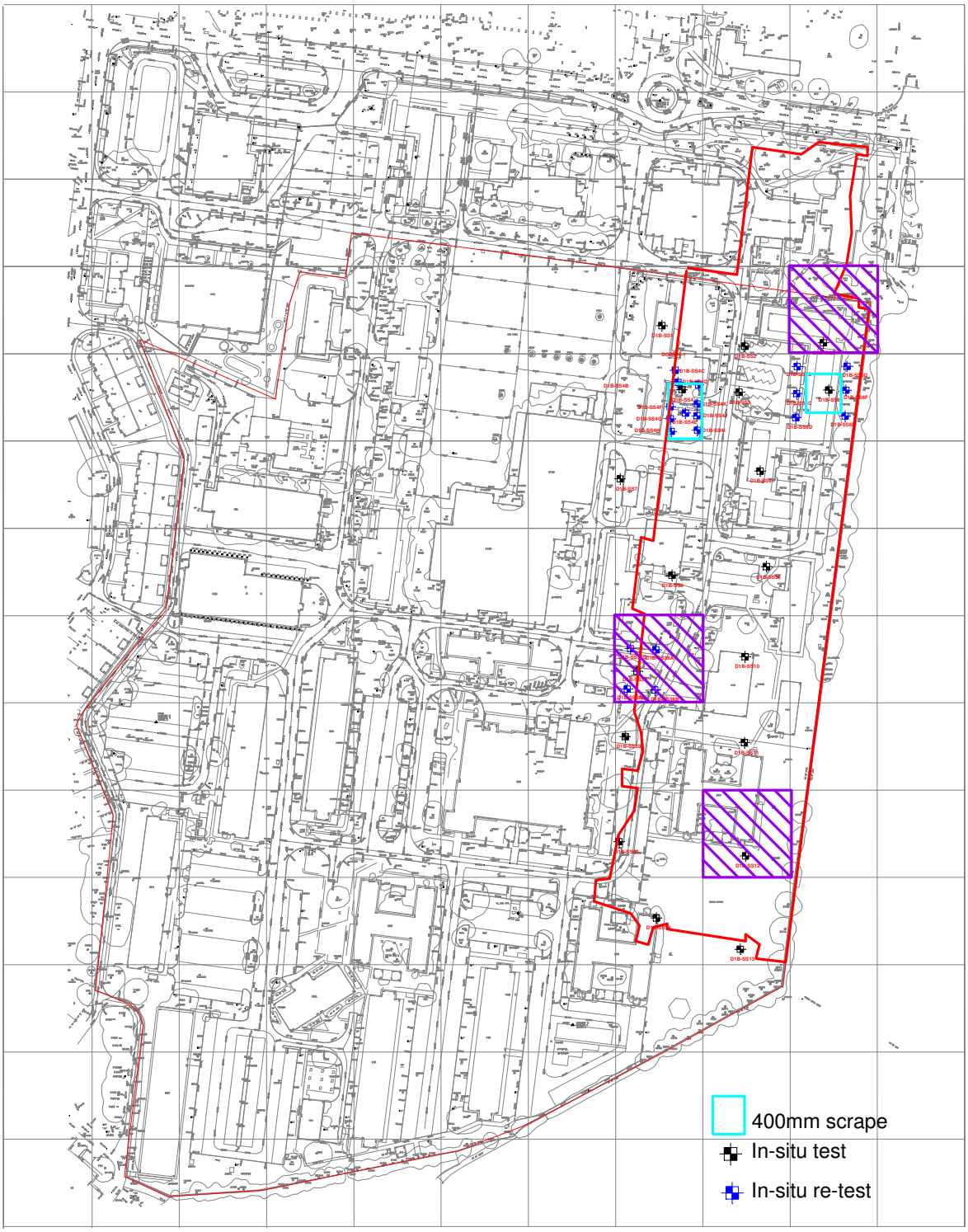
Project: Upper Heyford: Ph1b Dorchester		Drawn: DW	Checked: AFS
		Date: 28.10.14	Scale: 1:2,500
Drawing: In-Situ Exceedance - Vanadium		Job No: R1742B	Drg No: D02

Arsenic

Phase D1B Boundary

Phase Boundary D1B:Area-1

N



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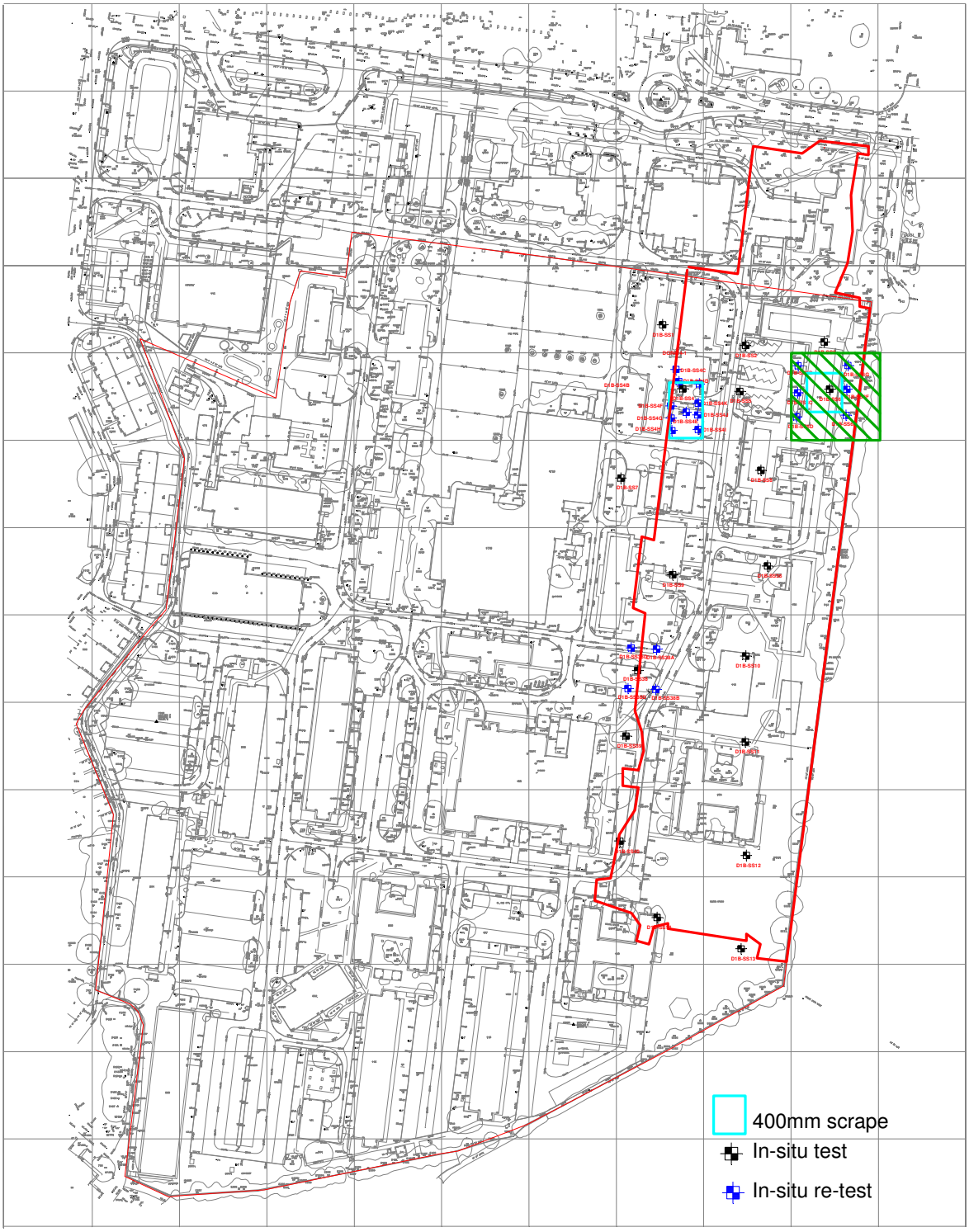
Project: Upper Heyford: Ph1b Dorchester		Drawn: DW	Checked: AFS
Drawing: In-Situ Exceedance - Arsenic		Date: 28.10.14	Scale: 1:2,500
		Job No: R1742B	Drg No: D03

Lead

Phase
D1B Boundary

Phase Boundary
D1B:Area-1

N



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Project: Upper Heyford: Ph1b Dorchester		Drawn: DW	Checked: AFS
Drawing: In-Situ Exceedance - Lead		Date: 28.10.14	Scale: 1:2,500
		Job No: R1742B	Drg No: D04

Asbestos Fibres

Phase D1B Boundary

Phase Boundary D1B:Area-1

N

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Project: Upper Heyford: Ph1b Dorchester		Drawn: DW	Checked: AFS
Drawing: In-Situ Exceedance - Asbestos		Date: 28.10.14	Scale: 1:2,500
		Job No: R1742B	Drg No: D05