Contaminated Land
Air Quality
Environmental Audit

Partnership No: OC 300776

Heyford Park
Dorchester Living: Phase 9
Development for Residential-led Uses
(Planning Consent 16/02446/F)

REMEDIATION STRATEGY

For: Dorchester Living

December 2020

R1742d-R03-v1

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Signed For Smith Grant LLP

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HEYFORD PARK, DORCHESTER PHASE 9

REMEDIATION STRATEGY

CONTENTS

DRAWINGS

1. Introduction

1.1. Planning Consent (ref. 16/02446/F) has been granted for residential-led redevelopment of the area referred to as Phase 9 within the former RAF/USAF Upper Heyford Airbase New Settlement Area (NSA). Dorchester Living (DL) intend to redevelop the site with the construction of 296 residential dwellings with associated infrastructure and areas of landscaping and public open space. DL has instructed Smith Grant LLP (SGP) to produce a revised Remediation Strategy for the preparatory works and construction-stage of the development.

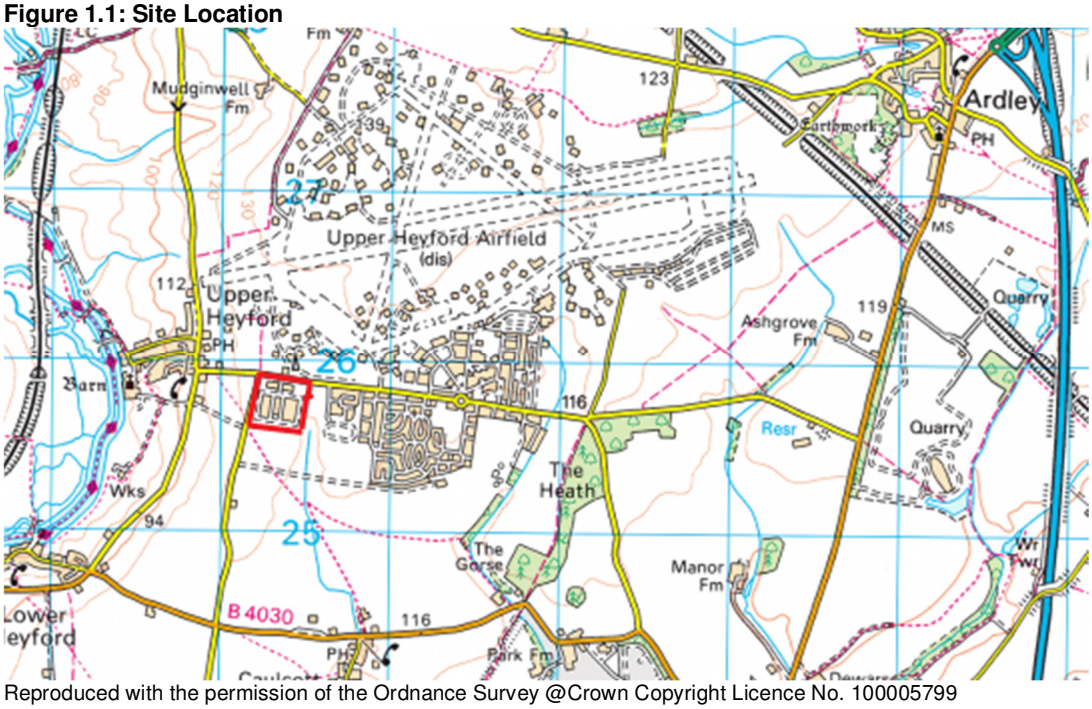
1.2. A Remediation Statement which covers Phase 9 and other development phases has been produced by Hydrock (ref. HPW-HYD-PX-REM-RP-GE-P1-S2; April 2017). However, it was decided that a revised Strategy should be produced to align remedial and verification works with the approved SGP Strategy which covered the neighbouring NSA area (R1742-R01-v1; May 2014) under Planning Consent 10/1642/OUT for consistency.

1.3. The site currently comprises of the southwestern portion of the former Upper Heyford Airbase, latterly developed and used by the United States Airforce. Phase 9 is located to the south of Camp Road which bisects the NSA and served as a school with associated buildings and a baseball pitch.

Table 1.1: Site details

Address	Upper Heyford, Camp Road, Oxfordshire
National Grid Reference	450358, 225742
Local Authority	Cherwell District Council
Site Area	11.5 Ha
Current Site Use	Derelict school with associated buildings and baseball pitch in the northeast
Proposed Use	296 residential dwellings with associated works including infrastructure, landscaping and public open space
Planning Consent	16/02446/F

Figure 1.1: Site Location



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1.4. Planning Consent has been granted by Cherwell Valley District Council (CVDC) for the construction of 296 dwellings with new and amended vehicular and pedestrian accesses, public open space, landscaping, utilities and infrastructure.

1.5. Condition 10 of the Consent relates to Contaminated Land and is worded as follows:

Table 1.2: Planning Condition relating to Contaminated Land

10	No development shall take place within a phase or sub-phase hereby approved until a Remediation Strategy that includes the following components to deal with the risks associated with contamination of that phase or sub-phase has been submitted to and approved, in writing, by the Local Planning Authority:
a).	A Preliminary Risk Assessment which has identified: • All previous uses • Potential contaminants associated with those uses • A conceptual model of the site indicating sources, pathways and receptors • Potentially unacceptable risks arisings from contamination affecting that phase or sub-phase
b).	A site investigation scheme, based on (a) to provide information for a detailed assessment of the risk to all receptors that may be affected, including those off-site.
c).	The results of the site investigation and detailed risk assessment referred to in (b) 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.
d).	A verification plan providing details of the data that will be collected in order to demonstrate that the works set out in the remediation strategy in (c) are complete and identifying any requirements for long-term monitoring of pollutant linkages, maintenance and arrangements for contingency action.

1.6. The assessment methodology in the production of this Remediation Strategy follows the framework described in the EA 'Land Contamination: Risk Management' (LCRM), comprising an Options

Appraisal to evaluate and identify feasible remediation options, specification of appropriate techniques, and an implementation programme and verification plan.

1.7. It is understood that Condition 10a has been approved following consultation between planning and the Local Authority Environmental Protection Officer (EPO) on 12.06.2018 where it is acknowledged that an intrusive investigation and remediation strategy is required. Comment provided by the Environment Agency (ref. WA/2016/123334/03-L01) also acknowledges that the Waterman Preliminary Environmental Risk Assessment (ref. WIB14371-100-R-3-3-2.EB) which supported Chapter 10 of the Environmental Statement satisfies Part 1 (Condition 10a).

1.8. Site investigation reporting (ref. HPW-HYD-MS-ZZ-RP-G-0001) and Remediation Method Statement (ref. HPW-HYD-PX-REM-RP-GE-3000-P1-S2) produced by Hydrock in February and April 2017 are understood to have been submitted to satisfy Condition 10b and 10c: for the purpose for producing a revised Strategy, it is assumed these documents have been approved.

1.9. SGP produced a Remediation Strategy which covered the wider NSA area to the east and was based on the findings and assessment of works undertaken by Waterman which covered part of the site and wider NSA, this included devising site-specific remedial targets for hydrocarbon hotspots. Based on the site (Ph9) PRA produced by Waterman, similar conditions and potential contamination sources have been identified, therefore it is considered appropriate to produce a revised Strategy so that remedial works are consistent with those of the wider NSA.

2. Information Sources

2.1. Previous reports

2.1.1. The principal sources of information consulted in the preparation of this report include:

Table 2.1: Information Sources

Report	Factual Information
Vertase POL System – Clean and Make Safe, Upper Heyford, Oxfordshire: De-commissioning Method Statement (August 2011) Ref. 1246DOR	Method statement for the decommissioning of the POL system which enters from the south of the site and extends north. Includes a plan showing the route of the POL.
Vertase POL System – Clean and Make Safe, Upper Heyford, Oxfordshire: Contract Completion Report (February 2012) Ref. 1246DOR	Completion information on the decommissioning of the POL system included the confirmed routes of the pipeline network (Appendix B) and detail on the infilling of tanks and pipework
Watermans Controlled Waters Detailed Quantitative Risk Assessment (July 2012) Ref. EED10658-14-1.7_FA	Assessment of groundwater contamination risks across NSA, remediation options, objectives and production and remedial target values.
Smith Grant LLP New Settlement Area – Remediation Strategy (May 2014) Ref. R1742-R01-v3	Revised remedial Strategy to cover NSA superseding the approved Watermans Strategy and adopted verification criteria.
Watermans Preliminary Environmental Risk Assessment (November 2016). Ref. WIB14371-100-R-3-3-2.EB	Desk Study comprising historical review, site setting, site description, geology, hydrogeology, hydrology, preliminary conceptual site model. Reference is made to an Aspinwall ground investigation report (1997) and the Waterman 2012 investigation which extended onto part of the site. Recommendations for a site investigation and production of a Remediation Strategy.
Hydrock Desk Study & Ground Investigation – Western Development, Phase 9, 10, 16 and 16A (February 2017)	Desk Study review comprising site setting and description, historical review, geology and hydrogeology & preliminary conceptual site model. Intrusive investigation consisting of 29 trial-pits to a max depth of 2.75m bgl, 4 cable percussion boreholes with groundwater/gas installations. Collection of 18 soil samples and 4 groundwater samples and 3 rounds of gas monitoring. Revised conceptual site model and outline remedial recommendations.
Hydrock Remediation Method Statement Phases 9, 10, 15, 16 & 16A (April 2017) Ref. HPW-HYD-PX-REM-RP-GE-3000-P1-S2	Remediation Strategy including demolition, enablement and construction phases with supervision, verification and reporting. Report includes areas of identified visual / olfactory contamination (potential hotspots) and reference to remedial criteria for hydrocarbon hotspot remediation.

Smith Grant LLP Phase 9 Baseball Pitch – Supplementary Site Investigation (August 2018) Ref. R1742b-L07	Supplementary investigation to sample site topsoil and underlying subsoils involving the excavation of 12 shallow trial-pits across baseball pitch. 9 topsoil samples and 12 formation samples collected and submitted for analysis based on SGP NSA Strategy criteria / validation requirements. Statistical assessment and recommendations for reuse.

2.2. Investigation Coverage

2.2.1. The total of the 45 entries across the site is roughly equivalent to an average of 1 entry per 2,565m^2 or an approximate 50m grid spacing across the site. An increased density of entries was achieved within the area of the former baseball pitch in the northeast of the site, although these were limited to shallow (0.5m trial-pits) to support a supplementary soil sampling assessment for soil reuse.

2.2.2. Hydrock report that the entries were on a nominal 50m spacing but that no formal grid pattern was adopted, entries were also targeted around fuel tanks in the centre of the site associated with the former boiler house. Boreholes were drilled in the corners of the site with BH03 located between an AST and interceptor.

2.2.3. The site investigations completed are considered to cumulatively provide an assessment of ground conditions at the site appropriate to its development history and anticipated ground conditions. On this basis, it is concluded that although localised sources could have been missed and some areas (under buildings, roads, and hardstanding) were not included, the investigation has been sufficient to develop an appropriate Remediation Strategy.

2.3. Use of Information in Strategy Development

2.4. The Site Characterisation and Risk Assessment outcomes from the available Information Sources are briefly summarised and used to define appropriate and proportionate Remediation Objectives to allow safe redevelopment for its intended use, remove risks of unacceptable pollution, manage residual risks where these exist and bring in line remedial works to that implemented within the wider NSA. An assessment of viable, and then feasible Remediation Options is provided, the preferred approaches selected and a decision of the techniques to be adopted is arrived at before Implementation and Verification Plans are provided.

3. Site Characterisation, Risk Assessment & Remediation Objectives

3.1. Historical Development and Potentially Contaminative Land Use

3.1.1. A review of the historical development of the site is made within the Watermans Preliminary Environmental Risk Assessment (ref. WIB14371-100-R-3-3-2.EB) The site was occupied by agricultural farmland (1884-1885) with a surface watercourse (Gallos Brook) in the east until 1966 when the site formed part of RAF Upper Heyford, with some roadways shown. By 1980-1982 the site has been developed as a school with a pipeline mapped in the southeast corner within the location of the Brook. It is assumed that this refers to the culvert of the watercourse as it does not follow the route of the POL (Petroleum Oil Lubricant, see 3.1.4) as reported previously by Vertase. Operations at the airbase closed in 1993 following which the buildings have remained disused.

3.1.2. Watermans report that the site was initially used as houses for families living on the airbase but once the airbase was extended, these buildings were converted into the 'Upper Heyford American High School' with playing field and boiler house.

3.1.3. Reference is made to a site investigation report by Aspinwall (1997) which reported that the boiler house in the centre of the site contained 3 Above Ground Storage Tanks (ASTs) and at least 1 Underground Storage Tank (UST). A second boiler house was referenced in the northeast of the site which previously housed an AST, however no further evidence to suggest this has been identified. A second AST is also referred to in the southwest although it is assumed this is in error and should refer to the southeast where an AST is present with pipeline and interceptor. The Groundsure Report within the Hydrock reporting identifies a former discharge consent from the interceptor into Gallos Brook for miscellaneous effluent. There is no evidence to suggest that this AST and interceptor was associated with fuel storage and has not been identified as such within the reviewed reporting. It is considered, given the former use of the site that this was most likely associated with settlement tanks or similar for foul water / site drainage.

3.1.4. The presence of a POL system is referred to by Watermans but is not discussed by Hydrock. The POL system was a supply pipe present on the Upper Heyford Flying Field and consisted of above and below ground infrastructure of pipework, pumps, valves and storage tanks to transport aviation fuel around the airbase. The POL system was previously connected to the National Fuel Pipeline (NFP) which is understood to be adjacent to the southern boundary.

3.1.5. The POL system has been disconnected from the NFP, emptied, foam filled and cut in several locations by Vertase as part of the decommissioning works but remains beneath the eastern portion of the site. Vertase produced a Method Statement (ref. 1246DOR) for the decommissioning of the POL in 2011 which confirmed the route of the pipeline. During decommissioning works by Vertase in 2012, a secondary POL pipeline route was encountered also in the east of the site. The

approximate routes are reproduced in Drawing D01 but both are shown to enter the site to the west of the interceptors before both extending north.

3.1.6. Vertase have confirmed the foam filling of the pipeline as well as excavation of trial-pits with pipe cut and filled (TP34A, TP34B, TP35, TP5-1 and TP5-2). Breaking of the pipe was undertaken to allow the removal of contaminated water by vacuum tanker before foam filling. Works were reportedly undertaken in accordance with the approved Method Statement.

3.1.7. Release of fuels and lubricant associated with the USTs and ASTs may have historically occurred, similarly the presence of the POL, a significant fuel source may result in significant contamination if pipeline failure occurred. The Groundsure Report obtained by Hydrock does not identify any pollution incidents within the boundary of the site.

3.1.8. The surrounding land is mixed agricultural to the south and west whilst the RAF Upper Heyford site extends to the north and to the east. Land to the east has recently underground redevelopment with Heyford Park free school with associated sports pitches / play areas whilst to the north beyond camp road the site remains vacant with fuel tanks associated with POL21 present although these are understood to have been decommissioned as part of the works undertaken by Vertase.

3.1.9. External sources with the potential to significantly impact the site are limited to the POL21 fuel tanks to the immediate north, however reporting by Hydrock who carried out site investigation works within this part of the site did not report any significant contamination present which could migrate onto the site. Similarly, an infilled quarry is shown off the southern boundary of the site and this area was systematically investigated by Hydrock who did not reported the presence of any made ground or infilled materials.

3.1.10. The various former buildings constructed on the site may have contained Asbestos Containing Materials (ACM) which would be typical to similar structures within the wider site. It is assumed that all structures will undergo a comprehensive asbestos survey and strip prior to demolition, but that asbestos impacted materials could be associated with any historical demolition arisings present on the site.

3.2. Present Land Condition

3.2.1. Descriptions are based on observations made within the reviewed reports and examination of more recent mapping and aerial photographs.

Table 3.1: Land Condition Summary

Site Description	The site currently comprises of two main areas, the former baseball pitch in the northeast which remains as an area of public open space with a path and the former school area which is occupied by numerous dilapidated buildings. The school area is served by various internal roads with a former boiler house located in the centre of the site and areas of soft landscaping. It is understood at least one UST associated with the boiler house remains. ASTs are noted in

	the south of the site with an adjacent interceptor, possibly associated with former foul treatment / drainage. The school site is currently being used as a material store area by the developer for the adjacent construction sites. Materials stored are limited to block / bricks and stockpiles of soil / arisings.
Access	The site is accessible off Camp Road to the north
Boundaries/Adjoining Land Uses	**North:** Chain-link fence and hedge to the north extending on to Camp road **East:** Fence / open boundary to the east onto playing fields **South:** Chain-link fence onto open fields **West:** Fence and mature hedgerow onto open fields
Services / Wayleaves	Service information has not been obtained as part of this report; however, reference is made within the Hydrock site investigation report that some entries were constrained due to the presence of live services. Numerous drains are anticipated across the site as well as other utilities which may include a fire hydrant system. Pipes / drains associated with the AST and interceptor in the southwest are likely to remain and are assumed to be associated with former foul drainage sewers. Two underground pipelines associated with the POL system are present in the east of the site although decommissioning works by Vertase confirms their disconnection from the National Fuel Pipeline and removal of any contaminated water and infilling with foam.
Surfaces / Vegetation / Structures	The surfaced areas of the site are mainly tarmac with some concrete. The ground between the surfaced areas is covered by overground vegetation associated with areas of former landscaping / verges. The baseball pitch in the northeast is covered by grass which is maintained.

3.2.2. There are no landfills or COMAH registered sites within 250m of the site. The site is not located within an area which could be impacted by Coal Mining Areas and is not within an area affected by Radon areas with the potential to impact the site. A former quarry is located to the immediate south of the site with the Groundsure Report stating this was associated with surface mineral working of limestone. This area has been investigated as part of works conducted by Hydrock and no made ground or infill material was encountered.

3.3. Geology

3.3.1. Ground conditions reported during the investigations were consistent with the mapped geology and developed history of the site, as summarised below.

Made Ground

3.3.2. Made ground was encountered within approximately half of the Hydrock entries with the remainder reporting topsoil overlaying natural strata. Beneath both the made ground and topsoil, sandy clay or gravel of limestone associated with the Great Oolite Group was encountered.

3.3.3. Made ground typically consisted of reworked natural soils with occasional inclusions of inert material such as glass fragments and brick. Rare incidences of ash (TP132 – 0.15-1.30m) and asphalt (TP08-0.2-0.9m) but were not widespread within the made ground and appeared limited to discreet locations.

3.3.4. Depths in which made ground extended were generally shallow to around 0.3-.04m bgl where encountered with deeper deposits recorded in the east (TP105-TP107, TP132 and TP133) to depth of 1.1-1.6m bgl.

3.3.5. The composition and depths in which made ground have been encountered on site are typical to those recorded within the wider NSA.

Topsoil

3.3.6. Topsoil was encountered within the remaining entries where made ground was not recorded and comprised of a clayey gravelly sand with limestone gravel to a nominal depth of 0.3m bgl. Natural deposits of the Great Oolite Group were present directly beneath the topsoil within all entries where encountered.

Natural Strata

3.3.7. Natural strata were encountered within all entries directly below made ground or topsoil consisting of a gravelly to sandy clay underlain by limestone bedrock.

3.3.8. The thickness of the gravelly sandy clay (assumed to be weathered bedrock) varied between 0.3m (TP04) to 2.45m (TP02). No weathered bedrock was encountered within entries TP103, TP106, TP132 and SA4 with made ground soils located directly above the limestone bedrock.

3.3.9. Penetration beyond the limestone bedrock within trial-pits was not possible and entries terminated in refusal in all instances with thy e exception of boreholes drilled by rotary means (BH01-BH04) which extended through the limestone to a maximum depth of 8m bgl. Clay was reported beneath the limestone within entries BH02 (7.6-8.0m bgl) and BH03 (7.5-8.0m bgl) located in the south of the site.

3.4. Hydrogeology and Hydrology

3.4.1. The Great Oolite Group is classed as a Principal Aquifer which is described as ‘geology with a high intergranular and/or fracture permeability, usually providing a high level of water storage and may support water supply/river baseflow on a strategic scale’. The site is not located within a Source Protection Zone.

3.4.2. Groundwater was not encountered during the intrusive investigation with the trial-pit entries with the borehole logs confirming that groundwater information as not recorded during drilling. Subsequent monitoring of the boreholes reported variable depths of groundwater ranging from 7.23-7.37m bgl in BH01 to 2.49-2.81m bgl in BH03.

3.4.3. Gallos Brook, a tertiary river is present within the east of the site. Historical mapping shows this as a surface watercourse, however more recent mapping shows the watercourse no longer present suggesting it may have been culverted beneath the site. Anecdotal evidence referred to by Hydrock confirms this is the case.

3.4.4. Groundwater movement beneath the site is likely to be significant with groundwater flow direction as confirmed by Watermans (ref. EED10658-109-R-14.1.7.FA) to the southeast. Waterman's, who undertook a detailed assessment on the site hydrogeology, report that the NSA can be described as a two-aquifer system separated by a mudstone/siltstone layer of significantly lower permeability although there is evidence of some leakage between the aquifers.

3.4.5. Site drainage is considered to be predominantly be infiltration and sub-surface flow within the bedrock aquifer within areas absent from hardstanding. Surface water run-off into the surface water drains present within the internal access roads is also considered likely. Waterman's report that the NSA is drained by Gallos Brook which ultimately discharges into the River Cherwell. Monitoring undertaken by Waterman in Gallos Brook (June 2011 – August 2011) recorded TPH concentrations between <0.01 and 0.03 mg/l.

3.5. Soil Contamination

3.5.1. Visual or olfactory evidence of contamination were reported within 3 entries by Hydrock, these are summarised as follows:

- TP101 (0.0-0.2m bgl) – Slight tar odour
- TP102 (0.3-0.5m bgl) – Black staining and tar odour
- TP104 (0.03-0.2m bgl MG & 0.2-0.8m bgl Natural) – Black staining and tar odour

3.5.2. The descriptions are associated with tars or similar materials at shallow depths and it is noted that the logs of TP104 suggest the black staining and tar odour is present on a below ground concrete slab.

3.5.3. Waste materials were occasionally encountered within the made ground where present but were generally limited to inert materials. Based on the descriptions, degradable organic matter is unlikely to constitute a significant proportion within the made ground and the materials described are not considered likely to generate hazardous amounts of ground gas.

3.5.4. A comprehensive testing suite has been completed on the soil present which is appropriate for the site characterisation; most samples did not contain elevated concentrations of contaminants that would be unacceptable in a residential land use scenario. Where exceedances of Generic Assessment Criteria (GACs) for a residential land use (with plant uptake), these were limited to hydrocarbons within two samples of made ground in TP102 and TP104 and occasional PAH exceedances with the made ground.

3.5.5. Elevated hydrocarbons were associated with the observation of black staining and a tar odour within entries TP102 and TP104 with further assessment by Hydrock concluding that these are localised hotspots which require further investigation / remediation and are not representative of the wider made ground soils.

3.5.6. The findings are consistent with those reported within the wider NSA to the east, particularly regarding the occasional minor elevated PAHs within made ground soils where anthropogenic inclusions appear absent. Such exceedances have previously been attributed to inclusions of the overlaying hardstanding resulting in some cross-contamination during sampling which has been confirmed using source-identification (ratio cross-plot) techniques. Given the heterogeneity in ground conditions between that of the site and wider NSA it is reasonable to assume this is also the case.

3.5.7. It is noted that entries around the fuel tanks associated with the boiler house were limited due to the presence of live services, however TP09, TP11 and TP103 were excavated around the boiler house down to depths of 1.5-2.6m bgl and into the natural strata. No contamination indicators were reported which would suggest significant contamination is absent although it can be reasonably considered that some localised impacted soils attributed to any historical leaks or spills could be present.

3.5.8. Whilst Hydrock did not intentionally target the POL system which crosses the site in the east, six entries (BH03-BH04, TP104-TP106, TP14 and TP132) were located within close proximity of one of the pipelines. Trial-pits extended down to bedrock and boreholes to a depth of 8m bgl, no contamination indicators were reported. Given the absence of any contamination indicators within the soils the presence of significantly impacted soils associated with the pipeline is unlikely, but it is acknowledged that localised impacted ground around the pipe could exist.

3.5.9. Borehole logs obtained from the British Geological Society and referenced within Hydrock's Groundsure Report identify two clusters of site investigation entries within the area of the POL system on the site. One is associated with an investigation in 1987 and second in 1989 both works completed prior to the decommissioning of the POL system. Whilst a plan is not available to confirm the entry locations and so reliance on the information should be used with some caution, their location would suggest they were in the general eastern area where the pipelines are present. A review of the logs confirms no visual or olfactory contamination indicators reported which further suggests the absence of any significantly impacted soils associated with the pipeline.

3.6. Groundwater Contamination

3.6.1. Groundwater samples were collected by Hydrock during a single round of monitoring. Minor exceedances of some PAHs (BH02 only) and heavy metals were reported; however, these were not considered indicative of any pollution risk.

3.6.2. Hydrocarbons were below detection limits in BH03 and BH04 whilst elevated concentrations were reported within BH01 and BH02 with maximum concentrations recorded in the aliphatic C12-C16 range with concentrations of 13,000 µg/l (BH01) and 83,000 µg/l (BH02). Hydrock assessed that the concentrations were lower than the maximum concentrations presented by Watermans within the wider NSA and that concentrations within downgradient boreholes (BH06-BH09) were below detection limits which is inline with the findings by Watermans that there are low to negligible hydrocarbon concentrations within the groundwater at the southern boundary of the site.

3.6.3. The sources of the elevated hydrocarbons has not been confirmed and remains uncertain, particularly for BH01 which is located in the northwest corner of the site. The presence of elevated concentrations in an upgradient borehole may suggest an off-site source.

3.6.4. Hydrock's assessment concluded that the recorded groundwater contamination does not represent a significant risk of pollution to the groundwater beneath the site but that existing fuel stores (tanks / pipelines) and impacted soils should be removed which again is consistent with the recommendations outlined by Watermans and the approved remedial approach adopted within the wider NSA.

3.7. Surface Water Samples

3.7.1. Surface water samples were collected from Gallos Brook with only a single exceedance reported for copper with this being attributed to the natural geology. Hydrock concluded that impact of the Brook is not occurring.

3.8. Ground Gas Contamination

3.8.1. No significant sources of hazardous ground gas have been identified on the site or surrounding area with no significant depths of made ground soils encountered. A historical quarry is present immediate off the site's southern boundary, however information within the Groundsure Report suggests this was for surface extraction of limestone. This area has also been subject to investigation by Hydrock with no evidence of made ground or backfill material encountered.

3.8.2. Hydrock carried out 3 initial rounds of ground gas monitoring and proposed a further 3, however it is uncertain whether this has been completed. In the absence of any identifiable ground gas sources a ground gas monitoring programme would not typically be required.

3.8.3. No elevated concentrations of methane or carbon dioxide were reported with the site being classed as CIRIA CS1 (no risk) / NHBC Green meaning that gas protection measures are not required.

3.9. Risk Assessment

3.9.1. The potential contamination sources identified during the investigations which could impose constraints on the proposed redevelopment of the site for residential uses are:

- Asbestos Containing Materials within the building fabric.

- Two localised hotspots (TP102 & TP104) where elevated hydrocarbons have been attributed to the presence of black staining / tar odours;
- Underground fuel tanks and pipework associated with the former boiler house in the centre of the site;
- Occasional PAH exceedances within the made ground soils;
- Decommissioned POL pipeline in the east where there is potential for residual hydrocarbon impacted soils associated with historical leaks and spills;
- ASTs identified in the southeast of unknown use (assumed to be associated with drainage interceptor but unconfirmed), and;
- Releases of pollutants to surface watercourse (Gallow Brook) during construction.

3.9.2. The potential risks identified will be managed to break potential pollution linkages and allow development of the site for residential use without harm to human health and the environment. Each of the potential contaminant linkages identified in the Waterman conceptual site model and risk assessment (ref. EED10658-R-109_14.1.7_FA, May 2012) and Preliminary Generic Quantitative Environmental Risk Assessment, (ref. EED10658-R-13.2.2_FA, May 2012) and Hydrock Desk Study and Ground Investigation, (ref. HPW-HYD-MS-ZZ-RP-G-0001, February 2017) will be addressed for the Remediation Strategy to be considered appropriate for the site and to allow construction to commence.

3.9.3. Concentrations of contaminants were compared to current assessment criteria derived for the protection of human health; initial screening levels were adopted from published generic assessment criteria for a residential land use. The exceedances of soils (outside identified hotspot areas) were limited to occasional PAHs within the made ground soil and it is noted that in approximately half of the entries made ground was absent. Given the main absence of anthropogenic inclusions within the made ground, retention as shallow garden soils may be acceptable providing further testing demonstrates compliance with residential soils and additional assessment of any PAH exceedances demonstrated no residual risks. This approach would be in line with that adopted under the approved Strategy for the NSA to the east where formation testing of soils has been carried out to determine compliance.

3.9.4. The other exposure pathway with the potential to affect human health is the volatilisation, migration and indoor inhalation of volatile hydrocarbons associated with historical fuel spills or leaks (if present) associated with USTs, ASTs, pipelines and identified hotspots. Additional assessments will be undertaken during tanks, pipeline and hotspot investigation/remediation to confirm whether this pathway requires source remediation and/or building vapour protection.

3.9.5. The risk from migration of other hazardous soil gasses (methane and carbon dioxide) appears to be low and there is no present evidence for significant on-site sources and made ground deposits are unlikely to generated significant volumes/flows. No potential off-site sources have been identified. Should deeper fills or significant quantities of degradable material be encountered during

site works the requirement for gas protection measures should be re-assessed, possibly supported by post-remediation gas monitoring from wells.

3.9.6. Off-site groundwater impacts are not considered to be significant on the monitoring evidence although the results from BH01 suggest some impact from an upgradient source. The presence of a UST associated with the boiler house could hold a significant volume or fuel and remains a significant potential primary pollution source. Similarly, any relict pipework associated with the tank could also contain residual fuels. As a priority, the works must not cause the release of any polluting substances to controlled waters, either via sub-surface or overland flows. The POL pipelines which cross the east of the site have been disconnected from the NFP, emptied and filled with foam as per an approved Method Statement and are unlikely to contain any residual fuels, however care should be taken during its removal to confirm this.

3.9.7. The Remediation Strategy assumes controlled demolition of all buildings preceded by appropriate asbestos surveys and stripping by specialist contractors. These works will be fully contained and monitored; thus, remediation works only need to consider the methods of handling and monitoring retained hard materials that are to be recovered for use as aggregates within the works.

3.9.8. The Remediation works will also physically prepare the site for the proposed redevelopment. This entails modifying ground levels, improvement of the engineering properties of the ground by removing obstructions to foundations and services, and removal or treatment of deleterious materials, provision of supporting structures and suitable founding surfaces for infrastructure.

3.9.9. An assessment of the ground conditions, to determine their potential to impact concrete has been carried out by Hydrock, who recommended a classification of Design Sulphate DS-1 and Aggressive Chemical Environments for Concrete of AC-1. The production of a water pipeline risk assessment was beyond the remit of Hydrock; however, they are reported that due to the presence of organic contamination (PAHs and hydrocarbons) that barrier pipe may be required.

3.10. Conceptual Site Model

3.10.1. The conceptual site model is summarised below:

Table 3.2: Summary of Pollutant Linkages under development and residential use

receptors	pathways	contaminant sources
Human health (future residents) (transient risks to construction workers addressed under HSWA 1974 / COSSH)	Consumption of contaminated vegetables	Occasional elevated hydrocarbons and PAHs within made ground soils. Potential for naturally elevated concentrations of arsenic and vanadium associated with bedrock deposits. Possible localised hydrocarbon contamination associated with underground fuel tank and decommissioned fuel pipeline.
	Soil and dust ingestion	
	Inhalation of dust	
	Dermal uptake	

	Vapour ingress into buildings from hydrocarbon hotspots	Localised hydrocarbon hotspots identified, potential for other hotspots associated with UST and redundant fuel pipeline.
Built development (and by extension future residents)	Contact with aggressive soil or groundwater	Recommendation for concrete classification has been made, potential requirement for the use of barrier pipe due to the reported presence of elevated organic contaminants which could permeate water supply pipes.
	Ingress of hazardous ground gas into poorly ventilated spaces and build up to harmful or flammable concentrations	No sources of ground gas have been identified. Three rounds of ground gas monitoring have been undertaken which classifies the site as CIRIA CS1 / NHBC Green (no gas protection measures required.
	Ingress of vapours into poorly ventilated spaces and build up to harmful or flammable concentrations	Localised hydrocarbon hotspots identified, potential for other hotspots associated with UST and redundant fuel pipeline.
Controlled waters	Migration via permeable stratum or preferential flow pathways to nearby surface watercourse. Underlying bedrock aquifer a Principal Aquifer although no groundwater abstractions reported within 1km.	Former USTs associated with the boiler house may contain fuel which could serve as an on-going source. Former fuel line has been infilled and decommissioned so unlikely to form a long-term source. Potential for localised impacted soils at both features.

3.11. Remediation Objectives

3.11.1. The key remediation objectives are to:

- Create a significant betterment of the groundwater environment by removing remaining primary pollutant sources thereby protecting groundwater quality at and beyond the site boundary;
- Remove / remediate significant secondary pollution sources such as soil hydrocarbon hotspots, 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 land use, in particular related to shallow garden soils and human exposure;
- Carry out further targeted soil investigations / inspections to complete gaps in the existing investigation coverage;
- Respond appropriately to contingencies in particularly the discovery of previously undisclosed contamination;
- Remove development constraints and prepare the site physically to enable residential development with associated infrastructure;
- 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.

3.11.2. The potential risks identified will be managed to break any potential pollution linkages and allow development of the site for its intended residential use without harm to human health, property and the environment. Each of the potential contaminant linkages identified in the Hydrock site conceptual model and risk assessment ('Desk Study and Ground Investigation, ref. C-04583-C) and Watermans conceptual site model (Waterman "Controlled Waters Detailed Quantitative Risk Assessment", ref: EED10658-R-109_14.1.7_FA, July 2012; and "Preliminary Generic Quantitative Environmental Risk Assessment", ref: EED10658-R-13.2.2_FA, May 2012) will be addressed for the Remediation Strategy to be considered appropriate for the site and to allow construction to commence.

3.11.3. During the remediation works various contaminated materials may be exposed. Therefore, mitigation to prevent exposure of site workers, and site visitors to harmful or nuisance substance is a requirement of the Remediation Strategy. Similarly, the works must not cause pollution of water by discharge of silt or other materials to the surface water or groundwater receptors linked to the site.

3.11.4. Risks to human health associated with potential contamination by asbestos, metals, PAHs and non-volatile hydrocarbons can be managed by isolation of affected soils from future residents and, to a lesser extent, maintenance workers (whose exposure is likely to be limited). It is assumed that these substances could be present in the made ground (where present) across the site. Natural undisturbed soils are likely to be exposed following the removal of surface hardstanding / structures; other areas will be covered by permanent hardstanding or buildings to provide physical isolation of any residual contamination. Specific measures to isolate human from direct exposure to such contaminated is only required in areas where gardens or soft landscaping is proposed and where significant levels of contamination are present.

3.11.5. The other exposure pathway with the potential to affect human health is the volatilisation migration and indoor inhalation of volatile hydrocarbons associated with historical fuel spills or leaks (if present); additional assessments will be undertaken during tank and pipeline removal to confirm whether this pathway requires source remediation and/or building vapour protection.

3.11.6. The risk from migration of other hazardous soil gasses (methane and carbon dioxide) appears to be negligible with no on or off-site sources with the potential to impact the site identified.

3.11.7. The potential for exposure of concrete to aggressive ground conditions and water supply pipes to damaging substances is considered to be low, however if areas of impacted ground associated with historical fuel leaks or spills are encountered then protective water supply pipes may be required and may be subject to further assessment during or following remediation works.

3.11.8. Off-site groundwater impacts are not considered to be significant on present monitoring evidence, however there is potential for a substantial volume of hydrocarbon-contaminated water or free product within any remaining USTs on the site. The presence of such materials within the existing tanks is unknown. The former POL pipeline in the east of the site has been subject to decommissioning works and infilling by Vertase and so is not considered to support a reservoir of fuel. As a priority, works associated with tank and pipework removal must not cause the release of any polluting substances to controlled waters, either via sub-surface or overland flows.

3.11.9. The Remediation Strategy assumes controlled demolition of all buildings preceded by appropriate asbestos surveys and stripping by specialist contractors. These workers will be full contained and monitored; thus, remediation works only need to consider the methods of handing and monitoring retained hard materials that are to be recovered for use as aggregate within the works.

3.11.10. The Remediation works will also prepare the site for the proposed redevelopment. These entails modifying ground levels, improvement of the engineering properties of the ground by removing obstructions to foundations and services, and removal or treatment of deleterious materials, provision of supporting structures and suitable founding surfaces for infrastructure.

3.11.11. A watching brief should be maintained during all the required preparatory earthworks and excavations for uncharacterised sources of contamination. However, there are specific requirements in relation to enquiries regarding existing USTs and fuel pipelines and scheduled inspections of local ground conditions to confirm the absence of associated contamination or deleterious conditions, and to delineate for removal if these are encountered.

3.12. Remediation Criteria

Shallow Soils & Site-Won Material

3.12.1. Remediation Criteria are site specific objectives and that have been determined through quantitative or qualitative risk assessment. The Risk Assessment completed by Hydrock has relied on the use of Generic Assessment Criteria (GACs) for residential land use to compare against concentrations of common industrial and urban contaminants. This is considered a reasonable a proportionate means of assessing the limited risks posed by ground contamination on the site.

3.12.2. The criteria selected are protective of human health when applied to shallow soils in a model residential garden, with sensitive (child) receptors and high exposure frequencies and durations assumed for a conservative approach. While exceedances of the GACs may indicate a significant risk, it is also acceptable to undertake further testing, statistical analysis of the results and / or more detailed risk assessment in this eventuality. If failures for the residential criteria occur, then the impacted materials could be utilised in less sensitive areas such as Public Open Space (POS).

3.12.3. The criteria will be applied to shallow soils, defined as those which will be in the upper 600mm of garden surfaces following completion of the development, with a shallower depth of 300mm suitable for managed POS areas and landscaping where penetration below the surface layer is less likely and can be controlled. They can be applied to other deeper soils but are unnecessarily conservative for these and would only be used as a screening criterion for this purpose

3.12.4. The Remediation criteria for the site are summarised in the tables below:

Table 3.3 Shallow (Garden) Soils Compliance Criteria

Contaminant	Residential Use Screening criteria (mg/kg unless stated)
Asbestos	**<0.001%** by mass (LOD)
Arsenic**	**37** LQM/CIEH S4UL
Cadmium	**11** LQM/CIEH S4UL
Chromium (total)	**910** LQM/CIEH S4UL
Hexavalent Chromium	**6** LQM/CIEH S4UL
Copper	**2,400** LQM/CIEH S4UL
Lead	**200** (C4SL)
Mercury	**40** LQM/CIEH S4UL
Nickel	**180** LQM/CIEH S4UL
Vanadium**	**410** LQM/CIEH S4UL
Zinc	**3,700** LQM/CIEH S4UL
Naphthalene	**2.3** LQM/CIEH S4UL
Acenaphthylene	**170** LQM/CIEH S4UL
Acenaphthene	**210** LQM/CIEH S4UL
Fluorene	**170** LQM/CIEH S4UL
Phenanthrene	**95** LQM/CIEH S4UL
Fluoranthene	**2400** LQM/CIEH S4UL
Anthracene	**280** LQM/CIEH S4UL
Pyrene	**620** LQM/CIEH S4UL
Benzo(a)anthracene	**7.2** LQM/CIEH S4UL
Chrysene	**15** LQM/CIEH S4UL
Benzo(b)fluoranthene	**2.6** LQM/CIEH S4UL
Benzo(k)fluoranthene	**77** LQM/CIEH S4UL
Benzo(a)pyrene	**2.2** LQM/CIEH S4UL
Indeno(123cd)pyrene	**27** LQM/CIEH S4UL
Dibenzo(ah)anthracene	**0.24** LQM/CIEH S4UL
Benzo(ghi)perylene	**320** LQM/CIEH S4UL
Aliphatic C5-C6	**42** LQM / CIEH S4UL
Aliphatic C6-C8	**100** LQM / CIEH S4UL
Aliphatic C8-C10	**27**LQM / CIEH S4UL
Aliphatic C10-C12	**130**LQM / CIEH S4UL
Aliphatic C12-C16	**1100** LQM / CIEH S4UL
Aliphatic C16-C21	**65,000** LQM / CIEH S4UL
Aliphatic C21-C35	**65,000** LQM / CIEH S4UL
Aromatic C5-C6	**70** LQM / CIEH S4UL
Aromatic C6-C8	**130** LQM / CIEH S4UL
Aromatic C8-C10	**34** LQM / CIEH S4UL
Aromatic C10-C12	**74** LQM / CIEH S4UL

Contaminant	Residential Use Screening criteria (mg/kg unless stated)
Aromatic C12-C16	**140** LQM / CIEH S4UL
Aromatic C16-C21	**260** LQM / CIEH S4UL
Aromatic C21-C35	**1100** LQM / CIEH S4UL
Benzene	**0.08** LQM / CIEH S4UL
Toluene	**130** LQM / CIEH S4UL
Ethyl-benzene	**47** LQM / CIEH S4UL
m/p-xylene	**56** LQM / CIEH S4UL
o-xylene	**60** LQM / CIEH S4UL

S4UL: Generic assessment criteria published by Chartered Institute of Environmental Health and Land Quality Management Ltd S4UL, residential land use scenario;
C4SL: Category 4 Screening Levels published by CL: AIRE 'residential land use with plant uptake'
** Naturally elevated concentrations may be present and could require further risk assessment

Hydrocarbon Hotspots

3.12.5. Site-specific remediation criteria for the verification of hydrocarbon contamination removal designed to be protective of controlled waters outside the site have been produced by Watermans ('Controlled Waters Detailed Quantitative Risk Assessment, ref. EED10658-14.1.7_FA). This criterion was adopted within remedial works within the main extent of the NSA and to be consistent with the remedial approach is to be adopted within Phase 9.

3.12.6. The criteria are organised in two tiers according to the distance of hotspots from the southern / south-eastern (downgradient) boundary of the site.

Table 3.4 Screening Criteria, Hydrocarbon hotspots dependent on distance from the southern / south-eastern site boundary (from Waterman Tables B2 and B3)

Petroleum Hydrocarbon Fraction	Target Concentration 0-250m (mg/kg)	Target Concentration >250m (mg/kg)
Aliphatic C8-C10	80	240
Aliphatic C10-C12	1000	1000
Aliphatic C12-C16	1000	1000
Aliphatic C16-C21	1000	1000
Aliphatic C21-C35	1000	1000
Aromatic C10-C12	7	23
Aromatic C12-C16	120	1000
Aromatic C16-C21	440	1000
Aromatic C21-C35	1000	1000

4. Options Appraisal

4.1. Options Appraisal Objectives

4.1.1. The objectives of the Options Appraisal are therefore to determine the most appropriate means of meeting the above Remediation Objectives and Criteria, taking into consideration project and site-specific considerations including:

- Physical site constraints (boundaries, groundwater levels, available space);
- Costs;
- Programme (Duration);
- Sustainability (use of resources);
- Environmental Impact (pollution, nuisance);
- Health and Safety requirements;
- Geotechnical Requirements & Development Design;
- Regulatory controls -Permitting and Waste;

4.1.2. Physical site clearance, demolition and earthworks will be carried out in accordance with the earthworks design specifications and are not considered further. However, the chosen remedial techniques must not impede the works to physically prepare the site or unduly compromise the stability of the ground in respect of the design of foundations, pavements, and infrastructure.

4.1.3. One of the main constraints in selecting an appropriate remediation technique can be programme duration. Lengthy post-remediation monitoring to demonstrate the adequacy of the remediation techniques to achieve the objectives is undesirable. Also, given an approximate earthworks balance (no net surplus or deficiency in fill materials), it is important that the volume of any excavated materials that cannot be returned to the earthwork's operation is minimised, and that as far as possible, excavated materials can ultimately be retained, subject to their contamination status and geotechnical suitability.

4.1.4. Several potential methods could be considered to meet the site remediation objectives and criteria; however, these will vary in their impacts and requirements as well as their effectiveness. The objective of the Options Appraisal is to assess what remedial techniques might be effective, then to balance the advantages and disadvantages of each and arrive at the most appropriate method or combination.

4.2. Viable Technical Approaches

4.2.1. The identified pollutant linkage that requires addressing as the primary objective of the task is limited to the sporadic and occasional exceedances of residential soil criteria in made ground and topsoil, and potential hydrocarbon hotspots. These materials have been identified on the site and new receptors will be introduced following development. There is therefore a viable pollutant

source, sensitive receptor, and linkages between these at the site. Remediation measures could be targeted to any of these three elements to reduce risk to acceptable levels.

4.2.2. Modification of receptor behaviour would not normally be considered for a new development. For example, the planned dwellings have private gardens and areas of adjoining open space for reasons of amenity and marketing. As the properties may be sold freehold with permitted development rights, it is considered that the preferred approach should protect the future residents from unacceptable exposure during whatever activities can be reasonably envisaged over the design life of the development.

4.2.3. Based on the above considerations, managing the sources and / or exposure pathways is confirmed as the most appropriate means of managing risks to the future residents in the long-term. Source reduction may be appropriate for some, specific circumstances, for example asbestos containing materials or hydrocarbon impacted soils if these are identified, and can be achieved through a number of means, the simplest is to remove the contamination from the site to be dealt with elsewhere. Other methods generally utilise chemical or biological processes which destroy the contaminants or achieve a reduction in the amount of effective contaminant mass through removal of mobile phase contaminants only or fixing these within the soil matrix.

4.2.4. However, for the most part, as impacted soils do not appear to present a pollution risk and the types and concentrations of contaminants anticipated are of low mobility in the environment, retaining the impacted materials on site and severing the exposure linkage by ensuring isolation from contact with the future residents would appear to provide a sure and robust means of reducing risks.

4.2.5. There is, however, potential for fuel contamination hotspots associated with former underground storage tanks and fuel pipelines on the site and so methods to deal with any such contamination (if encountered) are required to develop a robust Remediation Strategy.

4.3. Feasible Remediation Options & Feasibility Screening

4.3.1. Based on existing information gained from the intrusive investigations and risk assessment, a variety of techniques could be applied to manage the potential or confirmed sources. The general classifications of technique which could be considered viable in the context of the development and the requirement to manage the identified pollution linkage under consideration are listed below:

- Isolation of the materials through reduction of infiltration or in-ground barriers to achieve *Engineered Encapsulation*;
- *Excavation and Disposal* of contaminated soils off-site;
- Excavation and *Ex-Situ Treatment* by physical, chemical, or biological means to reduce concentrations, replacement once Remediation Criteria are achieved;

- Application of similar chemical, biological or physical process to the contaminant mass while still in the ground, or *In-Situ Treatment* to reduce concentrations sufficiently to achieve Remediation Criteria;
- Use of chemical / physical treatments to reduce the mobilisation of the contaminants from the impacted material matrix by *Solidification and Stabilisation* – may be achieved In-situ or Ex-situ.

4.3.2. Several different techniques could be used for the above methods giving a wide range of options, these are explored further below with the costs / benefits and advantages / disadvantages of each and a separate assessment of the possibility of combinations of options. Each of the various classes of remediation that could be applied to the potential or confirmed sources has relative advantages and disadvantages, some of which allow early exclusion from the feasibility.

Table 4.1: Feasibility Screening Assessment

Method Class	Advantages / Merits	Disadvantages / Limitations	Feasible?
Isolation / Encapsulation	Avoids generation of wastes, and large-scale earthworks / vehicle movements / import materials. Short term programme constructing engineered barriers. Allows for the retention of impacted bedrock if it cannot be readily excavated.	May require additional earthworks to achieve isolation by moving materials to less sensitive areas, Requirement to source clean cover materials, requirement to maintain barriers or design so would not be compromised during site operations.	Yes
Excavation and disposal	Fast and can be achieved using traditional plant to shallow water table / bedrock and verified simply with on-site monitoring equipment (PID) and comparison residual soil concentrations to Remediation Criteria ; Allows physical preparation of site through removal of structures to be completed at the same time.	Excessive cost if large volumes or hazardous waste classification. Large number of lorry movements and use of resources (landfill space and replacement fill). Possible release emissions and associate health / nuisance odour risks during disturbance. Not feasible to remove shallow impacted bedrock.	Yes (shallow soils only)
Excavation and Ex-Situ Treatment : Destructive Techniques	All advantages of excavation and disposal (above) without generation of excessive wastes. Wide range of techniques applicable.	Inorganic and recalcitrant organic contaminants less amenable to biodegradation. Different techniques have different costs and timescales: faster techniques generally more expensive. Possible emissions and associate health / nuisance odour risks during disturbance.	Yes (Hydrocarbons only)
In-Situ Treatment	Avoids generation of wastes, and large-scale earthworks. Wide range of techniques applicable.	Significant uncertainty in terms of programme length and cost. Long-term monitoring programme to demonstrate no	No

Method Class	Advantages / Merits	Disadvantages / Limitations	Feasible?
		rebound effect conflicts with programme constraints Currently distribution of contamination is uncertain and further investigation required to fix design parameters.	
Stabilisation / Solidification	All advantages of Excavation and Disposal without generation of excessive wastes. Fast; materials can be processed in short timescales and binder curing completed to allow fast recovery of fill. Cost effective depending on amount and type of binders used. Can produce geotechnically suitable fill materials which are of lowered permeability, giving treated materials intrinsic properties with some of the advantages of encapsulation.	Uncertainty with respect to leaching properties of contaminants under consideration; may require special binders/ additives increasing costs. Limited track record in UK context Possible release of emissions and associate health / nuisance odour risks during disturbance. Requirement of treatment trials to demonstrate remedial targets can be achieved. Limited success in reducing volatile compounds	No

4.3.3. The ground on the site locally contains concentrations of contaminants, that in the absence of mitigation, could pose a potentially unacceptable risk to the human health of future site users if present in garden soils and where residents may be exposed by inhalation of harmful vapours. The “do nothing’ option, containing no specific measures to remediation ground contamination or deal with further mobile substances, is therefore inappropriate and not acceptable.

4.3.4. A Strategy involving removal of all contaminated soils for off-site treatment or disposal has the benefit of remaining all potential contamination sources. However, much of the soils present on the site is unlikely to pose an unacceptable risk to human health or controlled waters. This option would require the use of significant resources in the form of replacement fill material and landfill space, and large additional lorry movement numbers, and is therefore regarded as unsustainable both economically and environmentally.

4.3.5. Risks to future site users from direct exposure to any residual contaminated soils can be managed by the use of a barrier system. Use of a suitable thickness of clean cover material over the site surface in areas where residual contaminants will remain and where human exposure could occur following remediation would provide physical isolation and break the relevant pollutant linkages. Minor risks to site users from tainting of water supplies could be managed by the use of high specification pollution resistant materials.

4.3.6. Hydrocarbon contamination in the areas where potential sources of these substances were identified has only been confirmed in a few locations, and the results of the additional inspection and validation works proposed will be used to confirm any contamination by these substances.

Depending on the volumes of impacted materials, off-site disposal may be considered a desirable option. However, if more significant volumes are encountered, ex-situ treatment through monitored natural attenuation, enhanced biodegradation or stabilisation may be considered to be more appropriate. This would require temporary relocation of impacted soils to a quarantine / soils treatment area, where risks of emissions to the environment can be managed, and adoption of well-established techniques to aerate the soils and allow indigenous biota to degrade substances such as oil and fuels. The efficiency of such works in determining the reuse of the treated soils on the site would be subject to achieving the remedial targets produced by Watermans and agreed with the Environment Agency (Table 3.4).

4.3.7. If significant amounts of asbestos containing materials are encountered, these can also be isolated but the locations and depth will require further consideration to avoid the exposure of future construction and maintenance workers during the construction and operational phases of the development.

4.4. Decision

4.4.1. Most materials can be left in-situ or relocated around the site to meet the earthworks requirements without constraint. Inspection and / or testing of soils to remain at shallow depth, i.e.at remediation formation level, and of topsoil to be used as a growing medium in gardens and soft landscaped areas, will provide surety that no unacceptable materials have been placed in these sensitive areas or advised where garden soil cover system may be required over formation soils.

4.4.2. Two identified hotspots where elevated hydrocarbons have been reported require further investigation / remediation. Similarly, the removal of a UST associated with the former boiler house in the centre of the site and removal of the decommissioned and infilled fuel pipeline in the east are also required. Hydrocarbon hotspots would be subject to verification testing in accordance with the approved criteria produced by Watermans to verify the efficiency of remedial works. Any hydrocarbon impacted soils would be removed down to bedrock with the preferred remedial technique dependent on the overall volume of removed materials.

4.4.3. If impacted bedrock is encountered and cannot be removed, further assessment will be required to establish whether a potential vapour source to future dwellings remains. Such an assessment would establish whether vapour barriers are required to be installed within dwellings, an approach which is consistent with the wider NSA.

4.4.4. Risks to human health would then be limited to exposure of construction and future maintenance workers. The reduced exposure durations and frequencies negate these for the most part, provided normal occupational hygiene and environmental management practices are adopted. The possible exception is asbestos for which special workplace exposure controls are required, however no asbestos residues have been encountered to date and all buildings will be subject to an asbestos survey and strip by specialist contractor prior to demolition.

4.4.5. For buildings and foundations, appropriate concrete classification should be specified, and advice sought regarding materials for water supply pipes. Given the apparent minimal risks from ground gas, gas protection measures are not required within the proposed dwellings, however the requirement for vapour protection measures (see 4.4.3) would be subject to the findings following remedial works and if necessary further assessment through post-remediation vapour monitoring.

5. Implementation Plan

5.1. Preferred Approach

5.1.1. Based on the above assessment it is envisaged that, following demolition works and vegetation clearance, a topsoil strip will initially be carried out prior to the commencement of earthworks. Stripped topsoil will be formed into a number of stockpiles for testing to demonstrate compliance. Topsoil should be segregated individually from the areas where it was recovered i.e., baseball pitch / soft landscaping etc. to avoid cross contamination before testing. If the material from these areas is not suitable for use in private gardens it may still be acceptable for use in Public Open Space or landscaping providing it is compliant with the appropriate assessment criteria for its intended use.

5.1.2. Excavations to recover materials and structures which are constraints to construction would form the next logical step, with removal or road surfacing and stockpiling separately to stone sub-base. Where concrete structures are present these can be broken out and crushed to form additional for recovered aggregates materials if volumes make this an economical alternative to disposal off-site. Resultant aggregate product will require testing for asbestos to demonstrate compliance with the required specifications for recovery.

5.1.3. The identified hydrocarbon hotspots (TP102 & TP104), removal of the UST associated with the boiler house and removal of the decommissioned fuel pipeline in the east should all be subject to further investigation. If required, unacceptably contaminated materials should be removed down to bedrock with verification samples collected from the base and sides of the remediation excavation to verify the efficiency of the remedial works. Removed arisings should be located within a temporary quarantine area pending either waste classification for disposal or ex-situ treatment.

5.1.4. These areas requiring dedicated investigation / remediation are indicated on Drawing D01. Outside of these areas, regrading of the site to achieve the planned remediation formation can be carried out without constraint. A watching brief should be maintained by operatives and supervisors in case any currently uncharacterised areas need addition to the prescribed list where inspections and remediation excavations are recommended. Areas of heterogenous fills, soils emitting odours or the presence of high proportions of wastes, staining, sheens, drunks, tanks or other containers, or suspected ACM will trigger inspection by a specialist in land contamination, sampling, analysis and assessment.

5.1.5. Inspection of formation level following preparatory earthworks to confirm whether the shallow soils are suitable for retention within garden areas should be carried out with formation sampling completed across the site.

5.1.6. The preferred option for managing soil contamination within the site therefore involves elements of all previously described techniques. This will entail:

- Decontamination and removal of bulk storage tanks and associated pipelines
- Limited trial trenching and inspection of identified contamination hotspot areas (TP102 & TP104);
- Trenching within area of former fuel pipeline route in east prior to removal to determine the presence of impacted soils;
- removal of un-treatable contaminated / deleterious materials (e.g. organic wastes, asbestos products or heavy hydrocarbon contamination) for off-site treatment / disposal;
- Soil / vegetation strip and recovery with testing to determine likely potential for reuse within the development as a growing medium to garden or landscape areas;
- Regrading of the site to appropriate design formation levels;
- In-situ formation testing across the site to assess the suitability for retention within garden areas or the requirement for 600mm clean cover soils for gardens and 300mm cover in landscape areas where exceedances present, and;
- no requirement has been ascertained at present for the provision of gas/vapour barriers to buildings; this will be reviewed following the further assessments and monitoring as appropriate.

5.2. General Approach: Preparatory Remediation Earthworks

5.2.1. The general approach to site preparatory / remediation works is described below:

Site security and supervision	The site will be securely fenced throughout the works and appropriate security provided; a full-time site manager representing the Principal Contractor will attend site during the works and welfare facilities for staff / visitors will be provided.
Access	Access will be formed off Camp Road to the north
Further investigations	Further investigations will be directed by the Environmental Consultant in the areas of identified contamination hotspots (TP102 & TP104) and areas of suspected contamination, most notably the former underground storage tanks associated with the boiler house and the decommissioned fuel pipeline in the east. These should be undertaken at an early stage of works. General inspections of ground conditions during site turnover and construction excavations by operatives and supervisors for heterogeneous or unusual conditions is required. Unless specific contamination indicators are encountered, the only further sampling and analysis will be on formation soils following the completion of preparatory works to determine the suitability for retention as shallow garden soils, testing of recovered or imported topsoil intended for use in a growing medium, and any additional recovered aggregates
Ecological clearance	SGP are not aware of a detailed ecological survey having taken place, a separate method statement will be required for management of any invasive or protected species.

Vegetation strip	The vegetation strip will entail tree-felling and chipping / flailing to remove any tall plants, grass and turf stripping to a nominal 50mm depth; stripped vegetation with be stockpiled pending removal for reuse or disposal.
Asbestos clearance	Any asbestos cement sheet or insulation board fragments / lagging / pipe gaskets will be removed by hand during systematic surveys by the specialist sub-contractor using suitably trained staff and in accordance with the contractor's method statements; asbestos will be double-bagged and placed in secure temporary storage (hazardous waste skips) pending off-site disposal; site staff will be trained in asbestos recognition and may hand pick further bonded asbestos where observed during the earthworks; in the event of significant unexpected deposits of asbestos containing materials being encountered then the specialist sub-contractor will revisit the site to carry out decontamination.
Demolition/Obstructions Breaking out paved surfaces, foundations, and sub-structures	Existing concrete slabs, tarmac roads, relict foundations, manholes and other sub-structures will be grubbed out by hydraulic excavator; all hard materials will be crushed and stockpiled for re-use by the contractor or developers; crushing and screening plant will be operated under a valid permit with appropriate controls over noise and dust, and will be located at least 100m from existing housing; hard materials stockpiles will be inspected for potential asbestos-containing materials before crushing, with any suspect materials being removed for disposal.
Soils stripping, handling and stockpiling	Soils will be carefully stripped by hydraulic excavator in panels to facilitate inspection of the exposed surfaces by the Site Engineer or Environmental Consultant; the Environmental Consultant will carry out appropriate further investigations / sampling in the event that suspect and unexpected contamination is discovered; stripping will progress down to the undisturbed natural subsoil surface or bedrock; internal site haulage will be by articulated dump truck; stockpiles will be placed in locations to be agreed with the developers, to be a maximum 5m in height and shaped to a smooth profile; stockpiles will be segregated to facilitate materials management and tracking.
Treatment of storage tanks and pipes, contents, and associated contamination	Tank contents will be sampled and, where liquids are present, will be drained to tanker for subsequent treatment and disposal; tanks will be degassed prior to removal; any linking pipework will be similarly drained with collection of any contents and stripped out; the Environmental Consultant will inspect the excavations and advise upon the removal of unacceptable contamination and collect validation samples from the stripped surfaces prior to controlled filling.
Earthworks completion	On completion of the remediation works, the site will be re-graded to -200mm from finished levels, with deep excavations for USTs / interceptors etc. backfilled with suitable material. Stockpiles of topsoil and recovered aggregate will be handed over to the respective developer. Further inspection and targeted sampling of the formation soils will allow the determination on whether the soils are suitable for retention within garden areas or whether garden formation levels should be reduced further (-600mm) to allow the placement of a clean cover system to isolate impacted materials from residents.

5.3. Identified Contamination Hotspots

5.3.1. Investigation of the contamination hotspots (TP102 & TP104) identified by Hydrock should be completed at an early stage by an appropriately qualified contaminated land specialist and comprise of excavations within each area to inspect for the presence of contamination and if encountered delineation and removal. If contamination indicators are encountered, soil samples of impacted materials will be collected and submitted for an appropriate suite of analysis. Hydrocarbon contamination would be subject to testing in accordance with the remedial criteria produced by Watermans (see Table 3.4).

5.4. Decommissioned Fuel Pipeline

5.4.1. Investigation along the decommissioned fuel pipeline in the east should also be undertaken at an early stage and prior to removal. The pipeline has been subject to decommissioning and reporting by Vertase which included the disconnection from the National Fuel Pipeline, draining of contaminated water/fuel, foam filling and trial-pitting through the pipe at several locations. Trial-pitting is recommended at 50m intervals along the pipeline to confirm its location and inspect the underlying and surrounding ground for contamination. If contamination indicators are encountered, soil samples of impacted materials will be collected and submitted for an appropriate suite of analysis.

5.4.2. If impacted ground surrounding the pipeline is encountered, the remediation contractor will notify the Environmental Consultant who will attend site. Delineation of the extent of the contamination will then be carried out and remediated and validated as per the Section 5.5 below.

5.5. Fuel Tanks and Pipelines

5.5.1. A sequential approach will be taken to dealing with tank and pipeline contents prior to physical removal of the structures and backfilling of UST voids. This will entail:

- Inspection and survey, including monitoring of VOCs using PID and sampling contents;
- Emptying contents using a vacuum tanker for free liquids; where possible, free product and contaminated water will be separated for treatment or recovery / disposal; sludges will be removed when safe access can be gained (probably following tank demolition);
- Following further vapour checks and venting, tanks will be removed or broken out using hydraulic breakers and metals shears as necessary, particular care will be taken to pump out any liquids retained in the tank surrounds to avoid release into the ground;
- Pipelines will be temporarily sealed pending draining / purging of any liquid contents;
- The Environmental Consultant will attend all UST removals and will advise on the requirements to remove residual contamination from the tank surrounds, and will observe

and record the works and collect validation samples to the extent possible, noting that entry to the voids will not be permitted on safety grounds, and that sampling from intact bedrock surfaces will not be undertaken;

- Following removal of the tank and its surrounds, samples of the surrounding soils (if any) will be obtained in order to visually assess the presence of hydrocarbon contamination; all significant hydrocarbon contamination in soils as determined by the Environmental Consultant on the basis of appearance or odour will be stripped back to a maximum vertical depth below ground level of 3m and laterally until the edges of the contaminated zone are judged to have been reached; validation samples will be taken from these surfaces as described in Section 6;

- In the event that validation samples from the extents of the excavation exceed the validation criteria (Table 3.4) then the results will be subject to further risk assessment and/or further excavation and validation will be undertaken, with the process repeated until the agreed completion criteria are achieved.

5.5.2. If hydrocarbon contamination is found in additional investigations or during tank / pipeline removals, specific measures to reduce or remove sources of contaminants will be implemented entailing the identification of impacted soils using a PID to determine removal and visual inspection up to either site boundaries, retained buildings, services or intact bedrock. Impacted soils will be removed to a secure stockpile placed in a bunded area on an impermeable membrane liner or suitable impermeable paved surface; the stockpile will be sheeted to minimise leachate generation. The volume of material to be treated and/or disposed of will be minimised by segregation of contaminated and non-contaminated materials where possible. The sidewalls and bases of excavations where contaminated materials are removed will be sampled to verify that contamination has been reduced as far as practicable or to acceptable concentrations.

5.5.3. The extent to which hydrocarbon-contaminated soil will be generated remains unknown at this time, and therefore details of any planned ex-situ treatment cannot be finalised. Where the volume of spoil is less than 1,000m^3 then the options to remove the spoil off-site, or treat the spoil on-site to achieve target concentrations meeting the Waterman's Criteria (Table 3.2) remain open. In the even that a greater volume of spoil is generated then a decision will be made as to an appropriate ex-situ treatment. Any such treatment works would be undertaken by a specialist sub-contractor with works carried out under an Environmental Permit with site-specific deployment details. If ex-situ treatment (e.g. bioremediation) is undertaken, then a detailed Method Statement will be issued for regulatory approval prior to commencement; this will detail the treatment location, methods of screening, mixing and handling the waste, containment and environmental protection measures, including runoff, leachate, dust and odour controls, and anticipated treatment programme and closure procedures for the treatment zone.

5.5.4. If asbestos fibre is detected in quantifiable amount (>0.001%) in fills, then this material will be excluded from use in soil cover and will be placed at depths over 1m below ground level within excavations (primarily with tank / pipeline backfill) subject to suitability. Locations of such fill will be agreed with the Developer, so as to avoid future disturbance during subsequent construction activities. The provision will not apply to hazardous levels of unbonded asbestos (>0.1%) which will be removed for disposal off-site.

5.5.5. The natural underlying deposits are unlikely to be contaminated by organic substances outside potential hydrocarbon hotspots, and in areas where the natural strata (including reworked natural strata) are exposed at the formation surface following level works, then the surfaces will be inspected for evidence of contamination. The Developer will be responsible for validating the natural soils and provided any additional topsoil needed as a growing medium for plants in gardens and landscaping.

5.5.6. It is noted that 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 natural mean background concentrations of arsenic is reported to be 220 mg/kg which exceeds the Table 3.3 for garden cover soils. Where natural mineralisation is present in the bedrock and rock-derived soils in excess of the criteria then further consideration and with assessment, possibly including bioavailability testing may be carried out to determine acceptability of the cover soils.

5.6. Materials Management

5.6.1. Assuming an earthworks balance can be achieved and that development levels do not necessitate significant regrading, and the recovery of soils or other materials which would otherwise be wastes is not intended, the proposed preparatory works would not require a Materials Management Plan (MMP) as set out under the Definition of Waste: The Development Industry Code of Practice (CoP) for use on the site of origin. If the contamination status of soils necessitates their relocation or treatment to manage risks is it likely an MMP will be required.

5.6.2. The site operations will be carried out to ensure that any contaminated materials / runoff or discharge do not affect clean areas of the site or surroundings. In particular, soils and materials from any hydrocarbon remediation excavations will be segregated and placed inside lined bunds where appropriate.

5.6.3. Contaminated water will be removed from tanks or other containments by vacuum tanker for off-site treatment. In the event that temporary dewatering of excavations is required then the necessary monitoring, risk assessment and regulatory permits will be obtained.

5.6.4. Most topsoil on the site is likely to be suitable for reuse in gardens subject to careful segregation, handing, quarantine and verification testing. If moderate exceedances of Remediation Criteria are noted these could still be used in less sensitive areas or be subject to further assessment. Topsoil

testing has been undertaken within the baseball area in the northeast of the site with results indicating its suitability for reuse, however such validated material will be subject to careful stripping, segregation and storage under the same controls. Verification testing of recovered topsoil will be required outside the baseball pitch area. Stockpiles of materials intended for re-use should be battered to prevent saturation.

5.6.5. In the event that surplus arisings requiring removal from the site comprising made ground are generated, or materials other than natural soils or recovered aggregate need to be removed, then these will be waste materials requiring disposal at a suitably permitted facility and retention of transfer documentation. Similarly, waste transfer notes for other materials removed from the site should be retained. Clean, uncontaminated soils could be transferred off the site within an MMP for the receiving site.

5.7. Unexpected Contamination

5.7.1. If previously uncharacterised materials or contamination sources (i.e. buried wastes) are identified during the works, then these will be investigated by the Environmental Consultant. The Local Authority Contaminated Land Officer will be notified immediately in writing following any such discovery and a decision as to whether the contamination can be remediated under the existing Strategy made. If necessary, an addendum or revised Strategy will be produced.

5.7.2. It is anticipated that immobile (low volatility / solubility) contaminants similar to the types described in the site characterisation would be retained below the proposed barrier system in garden areas and that other contaminants including asbestos hazardous waste, volatile or liquid hydrocarbons, drums, tanks or pipes will be excavated and removed from the site for waste treatment or disposal.

5.7.3. There is a very small potential for the presence of unexploded arms ordnance within the site, although nothing has been found during the current ground investigations. The Remediation Contractor is alerted to the potential for the presence of buried ordnance and will undertake all necessary health and safety measures and make contingency arrangements for quarantining areas where suspect items are disclosed pending attendance by the appropriate services.

5.8. Construction materials

5.8.1. On the basis of the information to date, the use of protected water mains is unlikely, however a final recommendation should be made following the completion of remediation earthworks including the remediation of any fuel tanks and pipelines. A water pipeline risk assessment may be required by the Utility Provider which should use post-remediation data where available. Requirements for concrete specification (DS1-AC1) are as specified within the Hydrock Ground Investigation report subject to any further testing which may be completed.

5.9. Construction Stage Mitigation Measures

5.9.1. The area requiring a clean soil cover system for garden areas is yet to be confirmed and is subject

to the formation testing across the site following regrade. A final recommendation of the requirement and locations for a soil cover system will be made within the forthcoming earthworks verification completion reports.

5.9.2. The standing recommendation for the provision of gas protection measures in accordance with CIRIA CS1 / NHBC Green classification within all plots and buildings is considered appropriate. The requirement for VOC protection measures within plots will be subject to the verification testing of retained soils within hotspot areas as part of the remediation works and the presence of any impacted bedrock which cannot be remediated. Should elevated fuel concentrations remain and cannot be otherwise remediated (i.e., impacted bedrock or contamination extends beyond the site boundary), a programme of post-remediation vapour monitoring will be undertaken to inform the requirement to install VOC protection measures.

5.10. Health and Safety Roles / Responsibilities

5.10.1. The Principal Contractor under the Construction Design and Management Regulations 2015 (CDM2015) will be responsible for managing health and safety during the remediation / preparation works and for producing any risk assessments and method statements required.

5.10.2. SGP's responsibilities as 'Designer' under CDM 2015 are to eliminate, reduce or control foreseeable risks that may arise during construction, maintenance or use and to provide information to other members of the project team to assist them in fulfilling their duties. The recommendations in this report should be therefore considered by the 'Client' and/or 'Principal Designer', and Principal Contractor, and included in the Health and Safety File for the site.

5.10.3. Protection of site workers, local residents and visitors during the remediation works can be achieved by the adoption of appropriate health and safety practices, environmental management, and site security. All site workers will be given a comprehensive health and safety induction and required to use appropriate personal protective equipment.

5.11. Environmental Management Issues

5.11.1. The scope of remediation works is unlikely to have a significant impact upon the nearby housing and environment provided that due care is taken to control dust, odour, noise, and vibration, and to prevent surface runoff onto roads, into drains and in particular the surface watercourse Gallos Brook. Noise emissions will be managed through the observation of approved working hours and use of appropriate plant.

5.11.2. Appropriate dust suppression measures will be deployed for crushing plant and earthworks during dry periods. Dust will be routinely monitored visually, and if unacceptable emissions beyond the site boundaries are noted then the element of the works contributing to this will be halted until appropriate mitigation (damping down, road sweeper, etc) can be deployed.

5.11.3. No discharges of dewatering or surface runoff to surface waters is permitted, however uncontaminated or marginally contaminated water may be discharged to foul sewer in agreement with the utility provider. Regular inspections of the Gallos Brook and drains which cross the site or are immediately adjacent must be undertaken to allow appropriate mitigation measures to deployed in the event that silt runoff or other pollutants enter the watercourses as a result of the works.

5.11.4. If on-site storage and treatment of hydrocarbon-impacted soils is carried out, it is expected that polluted leachate will be generated; this will be contained by means of impermeable liners to the treatment area and may either be recirculated to the soils under treatment as part of the process, or removed for separate treatment / disposal in accordance with the general requirements for contaminated liquids.

5.11.5. Plant fuel and lubricant storage will take place using suitable containers, bunds, and secured filling points. An oil spill kit and adsorbent materials to manage any accidental release of liquid pollutants will be provided. Suitable sealed skips and containers will be used for the temporary storage of small quantities of asbestos or other hazardous wastes, if encountered.

5.12. Programme and Phasing

5.12.1. The area consists of a single parcel of land with demolition and preparatory earthworks to be completed in advance of any construction activities. It is anticipated that remediation earthworks will be completed and reported on a phased basis, although this is subject to development proposals.

5.12.2. A separate, construction-stage verification report for the site is not anticipated to be required provided that all of the formation inspection measures and recovered soils verification is completed prior to occupation, and that only verified materials are used.

6. Inspection and Verification Plan

6.1. General Site Inspections

6.1.1. The remediation earthworks should be carried out under the supervision of an appropriately qualified and experienced site manager. If unexpected ground conditions and potential indicators of significant ground contamination are encountered, then works in that area should cease until specialist advice can be sought.

6.1.2. Fortnightly inspections of the site and exposed soils and made ground are to be undertaken by an independent consultant to assess whether currently uncharacterised contamination or pollution sources exist on the site and to carry out formation sampling / sample recovered soils to determine suitability for reuse.

6.1.3. Full-time attendance by the appointed consultant will be required during the remediation of the UST or any contamination hotspots encountered to allow the recording of remedial works and the collection of appropriate validation samples.

6.1.4. During construction, a full-time site manager will be required to supervise the implementation of the remaining mitigation measures and arrange verification testing and inspections by the independent consultant as required.

6.2. Targeted Additional Investigation

6.2.1. Additional investigation / assessment is required in a number of specific areas including:

- Hydrock Hotspots –TP102 & TP104
- USTs associated with the former boiler house
- Decommissioned Fuel Pipeline in the east

6.2.2. It is intended that these inspections and investigations will largely be carried out contemporaneously with the demolition and remediation works but that these investigations / assessments will be completed at an early stage.

6.3. Verification Testing

Hydrocarbon Hotspots

6.3.1. Stripped surfaces within any hydrocarbon hotspot area following removal of unacceptable contamination will be validated by visual inspection and PID screening to provide assessment of the efficiency of the works; additional soil samples will be collected for laboratory analysis. A minimum of 3 entries / samples will be taken where validation is required following any stripping of contaminated soils; for larger areas where more than 3 samples will be collected, the testing rate will be 1 composite sample per 15m^2 of exposed surface. Composite samples will comprise 5 representative sub-samples collected by the Environmental Consultant.

6.3.2. Screening criteria for hydrocarbon hotspots (see Table 3.4) will be adopted to determine any requirement for additional excavation or risk assessment, although intact rock surfaces where contamination is apparent will be assessed and recorded but not excavated. Where the screening criteria are exceeded then the specified depth of clean soil cover, post-remediation vapour monitoring or precautionary VOC protection measures will be deployed as appropriate following any additional source removal or remediation.

6.3.3. A record of descriptions, supplemented by photographic records, of the exposed strata in all areas where natural soils are present will be maintained by the Environmental Consultant. The national grid coordinates and level of all sampling points will be recorded.

Site-Won/Generated Aggregate

6.3.4. If any demolition arisings from the existing buildings, broken out hardstanding or removed oversized obstructions are intended to be crushed and recovered these should be stockpiled separately. The feedstock should be inspected by an appropriately trained operative and an asbestos screen on the final product at an appropriate frequency will be required. Depending on the volume generated, a sampling rate of 1 sample per 500m^3 is required with samples submitted for an asbestos screen, the chemical testing of aggregate is not required.

6.3.5. Any suspected Asbestos containing material will undergo sampling and bulk asbestos identification, the surrounding soil matrix will undergo soils asbestos identification and full quantification to provide information for assessing the type of work being undertaken in respect of the Control of Asbestos Regulations and determine where and how the material can be safely retained or whether disposal is required.

6.3.6. . Widely accepted threshold values are currently unavailable for asbestos in soils or reclaimed materials but incidences over the common quantification threshold of 0.001% will require further assessment to determine the suitability of processed materials for retention within the development.

Formation Soils

6.3.7. The remediation contractor is contracted to leave the general site surfaces within redevelopment zones stripped of topsoil, at 200mm below existing ground levels. For the purposes of validation of the general development zones, this means that a 400 mm depth of subsoil will be left which would form part of the full 600 mm of garden soil cover after replacement of garden topsoil; the 600m depth is assumed as the soil mixing zone for human health risk assessment under the residential land-use scenario. Taking a nominal soil screening test frequency of 1 sample per 500m^3, the residual 400mm depth equates to 1 sample per 1,250m^2 plan area of development, or an approximate 35m grid spacing of sample points which will be used for validation, with samples collected from the upper 400mm of the soil profile. Samples will be submitted for the garden cover soils test suite in Table 3.3.

Site-Won Topsoil

6.3.8. Topsoil recovered during the site strip will be tested for the same contamination suite to that of the formation soils (see Table 3.3) at an initial screening frequency of 1 sample per 500m^3. Samples will be submitted to a laboratory with MCERTS accreditation as available.

6.4. Remediation / Preparatory Earthworks Completion Reporting

6.4.1. A report detailing the works carried out and the results of the validation / verification testing will be prepared by an Independent Consultant and submitted to the Local Authority for approval upon completion of the relevant phase of works. The report will include a full description of the works carried out, findings of all validation and verification testing, any photographic records, and details of wastes removed, and any fills imported. The report will also confirm the construction – stage recommendations with respect to vapour protection and soil cover systems, specifically. whether these are still considered unsafe or whether conditions have been encountered during the works and inspections whereby these may be required.

6.5. Developer Stage Remediation Verification

Gas / Vapour Protection

6.5.1. On present information the site is classed as CIRIA CS1 / NHBC Green, meaning that no special precautions against ground gases are required.

6.5.2. It is expected that any hydrocarbon hotspots associated with USTs can be remediated to sufficient standard to negate the requirement for vapour protection measures, however, where it is not feasible to remediate any hydrocarbon contamination due to adsorption into bedrock etc. the developer will be required to undertake post-remediation vapour monitoring to assess whether vapour protection measures are required. In the absence of post-remediation monitoring where required, precautionary VOC protection measures including a venting sub-floor void, installation of an appropriate VOC membrane and verification in accordance with CIRIA C748[1] and C735[2] will be completed.

Garden and Landscaping Cover Soils

6.5.3. The developer is responsible for placing and validating the full thickness of cover soils as necessary to achieve finished levels which may incorporate the reduced level surfaces handed over by the remediation contractor following completion of their works. These finished levels will be subject to the Developer's respective engineering designs. The cover soils will either be obtained from stockpiled site-stripped soils, be generated during the process of the development, or will be imported from off-site sources by the Developer.

6.5.4. The Developer will be responsible for managing soil stockpiles and completed areas of soil cover so as to avoid cross-contamination of clean materials.

[1] Guidance on the use plastic membranes as VOC vapour barriers
[2] Good Practice on the testing and verification of protection systems for buildings against hazardous ground gases

6.5.5. The general Developer responsibilities will be as follows:

- in areas where natural uncontaminated soils are present following the site re-grade, clean topsoil may be required as a growing medium of nominal 150-200 mm depth, but there will be no requirement for a full 600mm of placed soil cover;

- provision of 600mm of clean soil cover within garden areas, with a reduced thickness of 300mm in landscape areas, where the underlying soil contains one or more concentrations of substances in excess of contamination targets set out in Table 3.3;

- site-won materials to be used as the garden/landscape clean soil cover must be suitable for use and validated to comply with contamination targets set out in Table 3.3 at the rate of 1 sample per 500m^3, and validated for depth on the basis of 1 entry per 3 plots for gardens, or the equivalent of a 50m grid in POS / landscaping areas;

- imported soils used for cover purposes are to comply with contamination targets set out in Table 3.3 validated at a rate of 1 sample per 250m^3 with a minimum of 3 samples per source;

- potential cross-contamination of clean natural soils or cover soils due to secondary excavations for foundations construction or trenching must be avoided, with appropriate replacement or disposal of arisings.

7. Conclusions and Recommendations

7.1. Conclusions

7.1.1. The site is generally of low to moderate risk from significant land contamination associated with the former military use of the site where bulk fuel stores and transport has historically taken place. Whilst significant contamination has not been encountered to date, it is recognised that there is potential for localised hotspots attributed to bulk fuel storage on the site.

7.1.2. Two identified hydrocarbon hotspots have been identified which require further investigation / remediation whilst a underground fuel tanks associated with a boiler house in the centre of the site requires removal. It is uncertain at present as to whether the tank contains any residual fuels, however these would be removed in any case as part of the proposed works.

7.1.3. A former fuel pipeline traverses the eastern half of the site, formerly connected to the National Fuel Pipeline and which provided aviation fuel to the network of POL tanks on the airfield. The pipeline was disconnected, emptied and infilled as part of decommissioning works undertaken by Vertase although the infilled pipe remains. Several intrusive entries have been excavated near to the pipeline with no contamination encountered.

7.1.4. SGP considers that most parts of the site have been adequately investigated for the purpose of devising a Remediation Strategy suitable to prepare the site for residential development and the likely key development constraints and requirements for remediation are understood. However, some inspections / investigations are proposed to be incorporated within the demolition and preparatory earthworks programme to give additional confidence in this.

7.1.5. The proposed management and programme for remediation and verification / validation testing regime will demonstrate that the proposed remedial works have been carried out and the site made suitable for the proposed development, subject to the execution of the additional requirements on the developers set out above.

7.1.6. Remedial works and their verification are consistent with those in the approved Strategy for the neighbouring NSA where similar ground conditions and contaminants were encountered.

7.2. Recommendations

7.2.1. The further recommended environmental investigation and verification measures to be adopted are summarised as follows:

Table 7.1 Summary of investigation / verification works

Remediation Stage 1 (Preparatory earthworks)	
1. further investigations	• Hydrock hotspot areas: TP102 & TP104 • USTs associated with former boiler house • Fuel Pipeline in the east All to be inspected during remediation excavations. Requirements for post-remediation vapour monitoring to be assessed following completion of investigation, remediation and verification.
2. stockpile testing	• recovered aggregate – testing for asbestos at 1/500m^3 • recovered topsoil – screening tests for soil contaminants (Table 3.3) at 1/500m^3
3. regular inspections and site attendance	Fortnightly site visits by Environmental Consultant during earthworks operations as required, and full-time attendance for tank removal / hotspot remediation and validation
4. response to unexpected conditions / occurrences	SGP available to attend site and investigate any occurrences at short notice; the Local Authority will be advised as soon as possible in event of discovery of new contamination
5. formation testing	In-situ formation testing of the top 400mm of natural or reworked natural soils on a nominal 35m grid spacing across the site with samples submitted for the test suite as per Table 3.3
6. reporting	SGP will produce phased earthworks remediation completion reports
Remediation Stage 2 (Development Phase)	
7.cover soil verification	Contamination testing will be carried out for placed site-won cover soils at rates of 1 sample / 500m^3 (site won) or 1 per 250m^3 (import). Depth of soil cover will be dependent on the results of formation sampling. Where a full 600mm garden (300m landscape) cover system is required this will be verified using test pits at 1 per 3 plots, or a 50m grid over POS; inspection and testing certification will be provided on plots as they are completed, copied to NHBC and the Local Authority; imported soils will be tested at 1 sample/ 250m^3, with a minimum 3 samples from each source
8.vapour protection inspection	If vapour protection measures are required, independent inspection in line with current guidance to inspect the installed membrane and provision of inspection certificates on a plot-by-plot basis will be completed and issued to NHBC and the Local Authority. If vapour protection measures are required these and the level of verification will be agreed with by the Local Authority in advance of installation.
9.water mains risk assessment	The developer will undertake a standard water supply pipe risk assessment for the utility provider as required, utilising post-remediation data where possible.

7.2.2. With the adoption of the above normal practices for Brownfield development, and on the information available to it, SGP considers that the site can be safely and economically redeveloped, and the existing environmental liabilities managed.

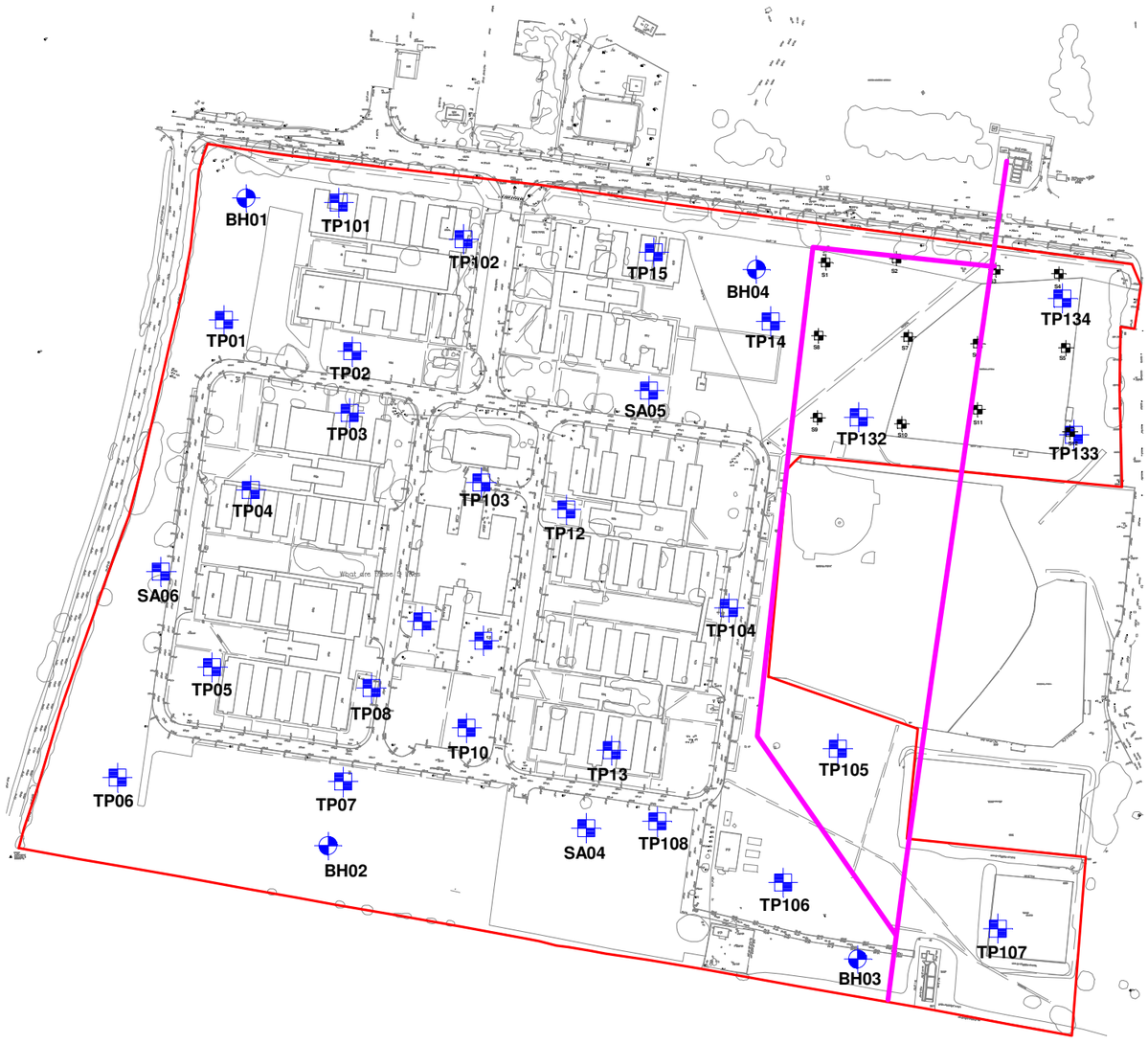
7.3. Limitations

7.3.1. This report has been prepared by SGP for the sole and exclusive use of Dorchester Living. All reasonable skill, care and diligence has been exercised within the 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.

7.3.2. The factual information and recommendations for foundations measures has been largely informed by information prepared by third parties and provided to SGP. The recommendations contained within this report have been made in good faith, based on the totality of the information provided to SGP, however SGP accepts no responsibility or liability for errors or omissions caused by information which has been withheld, or where errors or omissions within previous reporting have led to false or unreliable conclusions by others relating to the contamination status of the site

7.3.3. 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.

DRAWING



Approx Line of POL pipeline

Hydrock Trial-Pit

Hydrock Borehole

SGP Shallow Trial-Pit

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Project: Heyford Park: Phase 9

Drawing: Phase 9 Site Boundary & Previous SI Locations

Drawn:	Checked:
DW	BJT
Date: 17.12.20	Scale: 1:2,500 @ A3
Job No: R1742d	Drg No: D01

Approx Line of POL pipeline

Hydrock Trial-Pit

Hydrock Borehole

SGP Shallow Trial-Pit

Further Investigation / Remediation Required

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Project: Heyford Park: Phase 9	
Drawing: Remediation / Further Investigation Requirements	
Drawn: DW	Checked: BJT
Date: 17.12.20	Scale: 1:2,500 @ A3
Job No: R1742d	Drg No: D02