



Report
Title:

Remediation Verification Report

Project
Name:

Armour Road, Tilehurst, Reading



Report Reference: **BRD210736-OR3-A**

Date: **January 2018**



REPORT CONTROL SHEET

REPORT TITLE	REDMEDIATION VERIFICATION REPORT
PROJECT	ARMOUR ROAD, TILEHURST, READING
CLIENT	IRONGATE PROPERTY ASSET MANAGEMENT LTD

REPORT REFERENCE	ISSUE DETAIL	DATE	PREPARED BY	CHECKED BY
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REPORT LAYOUT

This report is divided into the following three sections: Technical Report, Supporting Information and Appendices.

TECHNICAL REPORT

The main report section is intended to provide the technical detail of the investigation and is intended to provide the level of information required by current guidance documents and practice. The Technical Report is written in a language that, in part, assumes knowledge of subject matter so that it can be written in as concise a form as possible. Its intended audience is peers, regulators and other professionals in related disciplines.

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This section of the report provides background details of a generic nature together with specific technical approaches adopted by BRD and details of the guidance documents that are commonly referenced in the report. The section also includes explanations of technical terms to assist non-specialist readers in understanding the Technical Report. It should be noted that not all the information within this section is necessarily applicable to this specific report.		

APPENDICES

The final section of the report presents the factual data collected and employed as part of the investigation.

APPENDIX 1 SITE PLANS

Site Location Plan.	Ref. BRD210736-OP1-A
Exploratory Point Plan	Ref. BRD210736-OD1-B
Remediation Photographs	Ref. BRD210736-OP6-A
Remediation Excavation Plan.	Ref. BRD210736-OD3-A
Verification Plan	Ref. BRD210736-OP4-A
Updated Conceptual Site Model.	Ref. BRD210736-OP5-A
Proposed Development Layout	The Keen Partnership Drawing ref. 'BR & Condition 02' ref. 8307-BR-11 dated 06- 10-14.

APPENDIX 2 EXPLORATORY HOLE LOGS

Logs of trial pits	Ref. TP05 to TP10 (inclusive)
Trial pit photographs	Ref. BRD210736-OP3-A

APPENDIX 3 CHEMICAL TEST RESULTS

16-51660, 17-64599, 17-64600	21 x A4 pages
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APPENDIX 4 SUPPORTING INFORMATION

Waste Haulage Tickets	8 x A4 pages
Imported Soil Tickets	5 x A4 pages
Water Supply Pipe Invoice	1 x A4 page

1. INTRODUCTION TO TECHNICAL REPORT

1.1. CONTRACT DETAILS

CLIENT	Irongate Property Asset Management Ltd.
SITE	14-16 Armour Road, Tilehurst, Reading.
CLIENT'S ADVISORS	BRD Environmental Limited (BRD) has been commissioned by The KEEN Partnership on behalf of the Client.
REPORT CONTEXT	The demolition of the existing industrial building is now complete and the construction of the proposed 3No. one bedroom houses and 1No. two bedroom house with small private gardens and amenity spaces is in the final stages of development.
REPORT TYPE	Remediation Verification Report.
REPORT OBJECTIVES	The site has been the subject of a previous combined desk study and site investigation by BRD in 2007 as well as an updated contamination assessment and remediation strategy by BRD in 2016, referenced as follows: • 'Site Investigation - Armour Road, Tilehurst, Reading', BRD Environmental Report Ref. 210736-OR1-A dated June 2007. • 'Updated Contamination Assessment and Remediation Strategy - Armour Road, Tilehurst, Reading', BRD Environmental Report Ref. 210736-OR3-A dated July 2016. The purpose of this report is to provide details of the completed remediation and subsequent verification works and to confirm that the site is now suitable for the intended residential land use and subsequently meets the requirements of condition 7 of the planning permission issued by Reading Borough Council ref. 12/00921/FUL.

1.2. REPORT LIMITATIONS

Any site boundary lines depicted on plans included within this report are approximate only and do not imply legal ownership of land. Any observations of tree species, asbestos containing materials within structures or invasive weeds, such as Japanese Knotweed, does not constitute a formal survey of such features. The identification of such features is therefore tentative only.

The recommendations, interpretations and conclusions of this report are based solely on the ground conditions found at the exploratory holes during previous site investigation. Due to the variability in the nature of ground, conditions between exploratory holes can only be interpreted and not defined. The description of the site and the ground conditions is accurate only for the dates of the previous field works. In particular, groundwater levels can vary due to seasonal and other effects. It should also be noted that due to the age of the previous investigation data, conditions at the site could have changed, in particular from off-site influences. Analytical methods may have also improved since this time. Therefore, the previous report should not be relied upon.

The assessment and interpretation of contamination risks is based on the scope of works agreed with the Client together with the budgetary and programme constraints imposed. Further investigation, analysis and assessment of contamination may be required by regulators or other third parties with an interest in the site. An ecological risk assessment of contaminated soils is beyond the scope of this report. This report is concerned with assessing those contamination risks which apply to the future use of the site through the proposed development as part of the planning regime. The assessment does not consider the risk to current site users or continued future use of the site in its current state. If development of the site should occur that differs from that proposed, then the findings of the contamination assessment would need to be re-evaluated.

This report is restricted to a contamination assessment only and does not include any form of geotechnical advice.

2. SITE CHARACTERISTICS

2.1. SITE SETTING

SITE ADDRESS AND POST CODE	The site is situated at 14-16 Armour Road, Tilehurst, Reading, Berkshire. The site postcode is RG31 6HN.
NATIONAL GRID REFERENCE	466940E 174170N

2.2. SITE SUMMARY

SUBJECT	COMMENTS
SITE DESCRIPTION	The site approximates to a rectangle in shape and measures around 15m wide and 50m long covering an area of approximately 0.08 hectares. Access to the site is from a large gateway on the south west boundary of the site from Armour Road. <u>Pre-Demolition</u> The site consisted of an old warehouse facility which covered the majority of the area with associated offices being located at the rear of the warehouse along the eastern boundary. The site was most recently used for servicing fork lift trucks. The warehouse and offices are constructed of brick walls with a cement asbestos roof. Located in the south west corner of the warehouse building was an old electricity substation. The majority of the site was covered by concrete hardstanding and other features including a possible underground tank identified within the floor slab of the warehouse and an underground waste oil tank, approximately 3.0m long x 3.0m wide and 1.5m deep was located in the western corner adjacent to the entrance gate to the site. The waste oil tank was previously noted to contain approximately 1m of oily water upon lifting the manhole cover. <u>Construction Phase</u> Due to the small size of the site, the remediation works were undertaken once the majority of the construction works were completed with only the landscaping and car parking areas yet to be finished. However, inspection visits were undertaken during various phases of site demolition.
SURROUNDING LAND USE	The site is set in an area of mainly residential land use. To the immediate east, west and north of the site are residential properties and to the south of the site is a church.
PROPOSED DEVELOPMENT	The proposed development consists of three adjoining one bedroom houses together with an adjoining two bedroom house at the north eastern corner. The larger property has an enclosed garden and the three smaller properties will have small courtyard front gardens. A parking area will form the south western section of the site, as well as a new electricity substation and bin and cycle store.

HISTORICAL SUMMARY	From between 1879 to 1912 the site was shown to be managed fields and by the map edition from 1912 some development had occurred along the eastern boundary of the site. Continued development occurred on site and by 1961 the site was shown as a works. By the map edition from 1968 the building was shown to be of similar size and shape to the current site layout. Anecdotal information would suggest that the site had most recently been used as a fork lift truck servicing yard, but was also historically used as a timber yard.
PUBLISHED GEOLOGY	The site is shown to be underlain by superficial deposits comprising the River Terrace Deposits of the Winter Hill Gravel. Beneath, the bedrock geology of the Lambeth Group (mottled silts and clays) are present.
RADON	The site is not located in an area where radon protection measures are required.
HYDROGEOLOGY	Both the superficial and bedrock deposits are classified as Secondary A Aquifers. The site is not within a groundwater source protection zone.
HYDROLOGY	The closest surface water feature to the site is a stream approximately 750m to the south east of the site, however, the River Thames is located around 1.2km to the north east and based on the topography of the site and surrounding area, it is anticipated that groundwater flow would likely be in this direction. The site is not located in an area indicated to be at risk of flooding.

3. SUMMARY OF REMEDIATION STRATEGY

The overall aim of remediation strategy was to design the remediation works necessary to mitigate the unacceptable risks identified through the previous phases of investigation.

A summary of the remediation strategy is provided below, however, for full details reference should be made to the following previous report:

- 'Updated Contamination Assessment and Remediation Strategy – Armour Road, Tilehurst, Reading', BRD Environmental Report Ref. 210736-OR3-A dated July 2016.

3.1. CONCEPTUAL MODEL

3.1.1. Source Characterisation

The contamination risks identified were associated with the following sources:

- Surface site wide Made Ground soils contaminated with lead and PAHs.
- Localised total petroleum hydrocarbon (TPH) contamination extending to a depth of around 2m bgl surrounding an underground waste oil tank in the south western corner of the site.
- Potential for further localised contamination in the potential location of an additional underground fuel tank in the centre of the site, as well as beneath an electricity substation at the southern corner of the former building.

3.2. RISK ASSESSMENT

The contamination risk assessment is presented below.

POTENTIAL SOURCES AND CONTAMINANTS	PATHWAYS (REFERENCE FROM MODEL)	RECEPTORS	POTENTIAL RISK
Contamination associated with shallow underground waste oil tank in SW corner.	Direct contact. Ingestion. Inhalation of vapours. (1)	Future residents	Negligible
	Migration through permeable strata. (2)	Groundwater / Surface Water	Low
	Direct contact. (3)	Building Materials and Services	Moderate
General surface Made Ground contaminated with lead and PAH	Direct contact. Ingestion. (4)	Future residents	Moderate
	Migration through permeable strata.	Groundwater / Surface Water	Negligible
	Direct contact. (5)	Building Materials and Services	Low
Contamination from	Direct contact.	Future residents	Negligible*

POTENTIAL SOURCES AND CONTAMINANTS	PATHWAYS (REFERENCE FROM MODEL)	RECEPTORS	POTENTIAL RISK
potential underground fuel tanks in centre of site.	Ingestion.		Negligible*
	Inhalation of vapours. (1)		
	Migration through permeable strata. (2)	Groundwater / Surface Water	Negligible*
	Direct contact. (3)	Building Materials and Services	Negligible*
Potential localised contamination from electrical substation in southern corner of building.	Direct contact.	Future residents	Low*
	Ingestion. (6)		
	Inhalation of dust/vapours.		
	Migration through permeable strata. (7)	Groundwater / Surface Water	Low*
	Direct contact. (8)	Building Materials and Services	Low*

Notes: *subject to further confirmatory investigation.

3.3. PROPOSED REMEDIATION AND ADDITIONAL INVESTIGATION WORKS

3.3.1. Confirmatory Investigation Works

Immediately following the demolition, inspection beneath the building floor slabs is required in order to confirm the ground conditions are consistent with the remainder of the site. In particular, the location of the former electrical substation will be targeted to confirm that no oils have leaked.

3.3.2. Proposed Remediation Works

During the demolition works excavation and removal of the waste oil tank and surrounding contaminated soils located in the eastern corner of the site is required.

In addition to this, if present, removal of any additional fuel tanks beneath the garage building will also be required.

3.3.3. Construction Phase Remediation Works

The construction phase remediation works requires the placement of a 600mm clean soil capping layer or removal of the Made Ground soils in their entirety within proposed garden and landscaping areas. If there are any areas where the contaminated soils extend beyond 600mm and they are not completely removed, then a geotextile layer will be required at the base of the capping to act as a marker layer.

In addition to this installation of hydrocarbon resistant protective water supply pipes is also required.

3.3.4. Remediation Verification

- Following the removal of the waste oil tank, surrounding contaminated soils and any additional fuel tanks a series of verification samples will be taken with at least one from

each face and one from the base of the excavation. A photoionization detector PID will also be used to verify the excavation.

- The verification of the clean soil layers at the site is twofold including verification of the removal of the Made Ground soils to ensure that the required placement depth has been met across all the garden areas and secondly, the thickness and quality of the imported soils will then be verified through the digging of hand dug pits once it has been placed.
- All imported soils will have to comply with the assessment criteria outlined in the table in Section 4.8.5 of the strategy report.
- The provision of the water supply pipes will be confirmed by the local water supply company and by the use of the prescribed pipework.

4. ADDITIONAL INVESTIGATION WORKS

4.1. INVESTIGATION DESIGN

METHODOLOGY	Following the removal of the building floor slab the recommended investigation was undertaken to confirm that no additional contamination sources were present. In addition to this further investigation was also completed in the location of the underground waste oil tank to determine the vertical and lateral extent of the previously identified contamination. Trial pits were selected as the most appropriate investigation method as they expose more soils which enabled a more reliable record of the ground conditions encountered.	
DATES OF SITE WORKS	Trial pits TP05 and TP06 undertaken beneath the building floor slab were completed on 26th August 2016. Trial pits TP07 to TP10 (inclusive) were completed on 10th November 2016. Hand dug pit HD04 was undertaken in the location of the former substation on the 20th September 2017.	
CONSTRAINTS TO EXPLORATORY HOLE LAYOUT	All potential contamination sources were investigated as part of these works resulting in no constraints to the exploratory hole layout.	
EXPLORATORY HOLE SPACING	The exploratory holes were positioned to target potential contamination sources.	
LAYOUT RATIONALE	SOURCE / FEATURE	EXPLORATORY HOLE
CONTAMINATION SOURCES TARGETED	Investigation beneath the former floor slab.	TP05 and TP06.
	Potential additional fuel tank.	TP06.
	Delineation of contamination associated with the waste oil tank.	TP07 to TP10 (inclusive).
	Testing beneath the waste oil tank.	TB01.
	Former electrical substation.	HD04.
CONTAMINATION SAMPLING PLAN	Based on the proposed end use, the sampling and analysis plan is more positively biased towards near surface samples as these represent the soils most likely to be available to future site users particularly in future garden areas. The analytical frequency has also been increased for samples around the waste oil tank in order to delineate the extent of the identified contamination.	
ANALYSIS PLAN	Given the site's history and identified contamination sources BRD has	

	scheduled a targeted suite of contaminants which included the following: • Polycyclic aromatic hydrocarbons (PAHs) • Total petroleum hydrocarbons (TPH) • Benzene, toluene, ethylbenzene and xylene (BTEX) compounds. In addition the samples have been analysed for methyl tertiary butyl ether (MTBE). • Polychlorinated biphenyls (PCBs)
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4.2. BRD FIELDWORK

TRIAL PITS	
REFERENCES	TP05 to TP10 (inclusive)
DEPTH RANGE	From 1.0m to 2.7m.
EXCAVATOR	360° Excavator.
BACKFILL	All the trial pits were backfilled with arisings upon completion and compacted with rams of the excavator bucket.

HAND DUG INSPECTION PITS	
REFERENCES	HD04
DEPTH RANGE	0.4m.
BACKFILL	The inspection pit was backfilled with arisings upon completion.

4.3. LABORATORY TESTING

SOIL CHEMICAL TESTING	
The soil samples for contamination and/or chemical geotechnical testing were forwarded to the laboratory of QTS Environmental Ltd and the testing suite is detailed below. The UKAS or MCERTS accreditation of the individual test methods is shown on the laboratory test report included in the Appendices.	
SOIL TESTS	NUMBER OF SAMPLES TESTED
Speciated Polycyclic Aromatic Hydrocarbons (PAH)	5
Total Petroleum Hydrocarbons (TPH) with full carbon banding and aliphatic/aromatic split	5
Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) plus Methyl Tert Butyl Ether (MTBE)	5

Polychlorinated biphenyls (PCBs)	1
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4.4. SUMMARY OF GROUND CONDITIONS

The ground conditions were in keeping those encountered during the previous phase of investigation works with Made Ground being encountered to depths of up to 0.8m bgl overlying silty gravelly sands of the Winter Hill Gravel Formation proven to depths of 2.7m bgl.

As previously identified, near surface ashy soils were again encountered beneath the building footprint in the location of TP05 and addition to this further hydrocarbon contamination was also encountered is the soils around the waste oil tank and associated pipework.

Groundwater was not encountered during the additional investigation works.

4.4.1. Made Ground Soils

In trial pit TP05 at the rear of the site the near surface Made Ground was encountered to a depth of 0.5m bgl and was typically described as 'Loose, black gravelly, ashy sand. Gravel of medium to coarse, subangular to angular brick, clinker, ceramic and glass with occasional metal'.

In the trial pits TP07 to TP08 at the site around the waste oil tank the Made Ground was proven to a maximum depth of 0.8m bgl and was typically described as 'Loose to medium dense, slightly clayey, sandy gravel. Gravel is medium to coarse with cobbles, subangular to subrounded flint, concrete, brick with half and whole bricks'.

4.4.2. Winter Hill Gravel

The Winter Hill Gravel formation was proven to a maximum depth of 2.7m bgl and was typically described as 'Medium dense, orange brown, slightly gravelly, silty SAND. Gravel of fine to coarse, subangular to subrounded flint'.

4.4.3. Groundwater

Groundwater was not encountered during the additional investigation works.

4.4.4. Contamination Observations

The presence of the ash and clinker in the near surface soils in trial pit TP05 is similar to previous soils encountered beneath the building floor slab known to contain elevated concentrations of both Lead and polycyclic aromatic hydrocarbons (PAHs).

In trial pits TP07 and TP08 hydrocarbon staining and odours were encountered at depths ranging from 0.6m bgl to 2.5m bgl. The presence of contamination from 0.6m bgl suggests that the cause of the leak was faulty pipe work rather than from the base of the underground tank. No contamination was identified in trial pit TP09 and TP10 confirming the hydrocarbon contamination to be isolated to the south western corner of the site.

4.4.5. Waste Oil Tank

The underground waste oil tank located in the south west corner of the site was removed by the groundworker prior to the BRD's visit to site to undertake the additional investigation works. It was reported that the tank was housed in a concrete structure with walls up to 150mm thick and due to its proximity to the adjacent public footpath there would be

potential difficulties in removing the structure without resulting in subsidence of the adjacent footpath.

This structure was then inspected by BRD during the additional investigation works and this inspection confirmed the potential difficulties in its removal. As a result, the following actions were completed at this time under the supervision of BRD:

- The internal walls of structure were thoroughly cleaned, removing all evidence of oil staining.
- The base of the structure was broken out using a hydraulic breaker to allow for the infiltration of water.
- A hand dug pit was then excavated below the base of the structure followed by confirmatory sampling of the soils to determine if any contamination present.

No evidence of contamination was encountered in the soils excavated from the beneath the structure and the result of the confirmatory testing is summarised in the table below along with the findings from the additional investigation works.

4.4.6. Former Substation

Hand dug pit HD04 was undertaken in the landscaping at the front of Plot 1 which was also the location of the former substation. The soils encountered were described as 'Firm orange brown very gravelly clay. Gravel is fine to coarse subangular to subrounded flint and brick' and no visual evidence of contamination was observed within these soils.

4.5. CHEMICAL TEST RESULTS - SOILS

CONTAMINANT	UNITS	NUMBER OF TESTS	MAXIMUM CONCENTRATION	GAC	NUMBER EXCEEDING GAC
Naphthalene	mg/kg	5	<0.1	2.3	0
Acenaphthylene	mg/kg	5	<0.1	170	0
Acenaphthene	mg/kg	5	<0.1	210	0
Fluorene	mg/kg	5	0.13	170	0
Phenanthrene	mg/kg	5	0.33	95	0
Anthracene	mg/kg	5	<0.1	2,400	0
Fluoranthene	mg/kg	5	<0.1	280	0
Pyrene	mg/kg	5	<0.1	620	0
Benzo(a)anthracene	mg/kg	5	<0.1	7.2	0
Chrysene	mg/kg	5	<0.1	15	0
Benzo(b)fluoranthene	mg/kg	5	<0.1	2.6	0
Benzo(k)fluoranthene	mg/kg	5	<0.1	77	0
Benzo(a)pyrene	mg/kg	5	<0.1	2.2	0
Indeno(1,2,3-cd)pyrene	mg/kg	5	<0.1	27	0
Dibenzo(a,h)anthracene	mg/kg	5	<0.1	0.24	0
Benzo(ghi)perylene	mg/kg	5	<0.1	320	0
TPH Aliphatic C5-C6	mg/kg	5	<0.01	42	0
TPH Aliphatic C6-C8	mg/kg	5	<0.05	100	0

CONTAMINANT	UNITS	NUMBER OF TESTS	MAXIMUM CONCENTRATION	GAC	NUMBER EXCEEDING GAC
TPH Aliphatic C8-C10	mg/kg	5	57	27	1
TPH Aliphatic C10-C12	mg/kg	5	97	130	1
TPH Aliphatic C12-C16	mg/kg	5	277	1,100	0
TPH Aliphatic C16-C35	mg/kg	5	2000	65,000	0
TPH Aliphatic C35-C44	mg/kg	5	575	65,000	0
TPH Aromatic C5-C7	mg/kg	5	< 0.01	70	0
TPH Aromatic C7-C8	mg/kg	5	< 0.05	130	0
TPH Aromatic C8-C10	mg/kg	5	35	34	1
TPH Aromatic C10-C12	mg/kg	5	48	74	0
TPH Aromatic C12-C16	mg/kg	5	94	140	0
TPH Aromatic C16-C21	mg/kg	5	116	260	0
TPH Aromatic C21-C35	mg/kg	5	693	1,100	0
TPH Aromatic C35-C44	mg/kg	5	< 10	1,100	0
Benzene	mg/kg	5	<0.002	0.87	0
Toluene	mg/kg	5	<0.005	130	0
Ethylbenzene	mg/kg	5	<0.002	47	0
Xylene (total of all types)	mg/kg	5	<0.002	56	0
Methyl Tert Butyl Ether (MTBE)	mg/kg	5	<0.005	49	0
Hydrocarbon Vapour (PID)	ppm	8	0.0	185.6	3
Polychlorinated biphenyls	mg/kg	1	<0.008	LOD*	0
Notes: *Limit of detection: Given the large amount of compounds in this group, coupled with the lack of GAC for certain compounds, any concentrations above the limit of detection will be highlighted in the first instance.					

4.5.1. Discussion

4.5.1.1. Soils Beneath Tank Structure

The analysis of the soils from beneath the concrete tank structure recorded no concentrations of fuel contaminants above detection limits. This confirms the observations made during the excavation of the hand dug pit beneath this structure.

4.5.1.2. TPH Contaminated Soils

Trial pits TP07 and TP08 have confirmed the findings of trial pit TP04, encountering elevated concentrations of TPH with total concentrations ranging from 2772mg/kg in TP07 at 1.2m bgl to 3057mg/kg in TP08 at 0.6m bgl. This is in keeping with the total TPH concentration recorded in TP04 of 1735mg/kg at 1.2m bgl.

Trial pits TP09 and TP10 recorded no elevated concentrations of contaminants confirming that fuel contamination was isolated to the south west corner of the site.

4.5.1.3. Former Substation

Hand dug pit HD04 was undertaken in the landscaping at the front of Plot 1 which was also the location of the former substation.

A sample of the near surface soils from this pit was analysed for PCBs and recorded no elevated concentrations above detection limits.

4.6. IMPLICATIONS FOR REMEDIATION

As no contamination has been identified beneath the tank structure and due to the complications in removing it, it is considered that sufficient investigation has been completed to justify it remaining in place beneath the proposed new car park.

However, as further hydrocarbon contamination has been identified in the soils to the north east of the former tank structure, it is considered that in order to remove the associated risks, to future residents, the groundwater aquifer (albeit at depth) and water supply pipes that the soils surrounding the concrete structure will be required to be excavated and removed from site as originally proposed.

The additional investigation has also confirmed the findings of the previous investigation works in that the soils have been classified as hazardous waste.

5. REMEDIATION WORKS

The main remedial excavation works associated with the hydrocarbon contamination were conducted under the full time supervision and guidance of an Environmental Consultant from BRD. The construction phase remediation elements i.e capping layers and protective water pipe installation were completed by the Client's groundworker and subsequently verified by BRD.

A selection of photographs taken throughout the remedial works is included in Appendix 1.

The main remedial excavation works were undertaken on the 18th and 20th September 2017.

5.1. REMEDIATION ACTIVITIES

The extent of all remedial excavations as well as PID and verification sampling locations are shown on the Remediation Excavation Plan provided in Appendix 1.

5.1.1. Remediation Excavation

EXCAVATION WORKS	The contamination had been identified as a distinct layer of hydrocarbon stained soils at a depth ranging from 0.6m to >2.7m bgl in trial pits TP04, TP07 and TP08. The surrounding exploratory holes encountered no contamination. The excavation and removal works were completed using both visual identification of contaminated soils as well as the use of a PID. Due to limited space for stockpiling and the proximity of the adjacent boundary wall, the excavation works were completed over two days. <u>Day 1 – 18.9.2017</u> On the first day of works, soils adjacent to the boundary wall were excavated to a depth of approximately 2.0m bgl and until the soils displayed no evidence of contamination both visually and through the use of the PID. These contaminated soils were then stockpiled and removed from site by a grab lorry. This section of the excavation was then backfilled with lean mix concrete so as to prevent collapse of the adjacent boundary wall, which was then left to harden over the next 24 hours before the remainder of the contaminated soils could be removed. <u>Day 2 – 20.9.2017</u> On the second day of works the remainder of the contaminated soils were excavated and removed from site with excavation continuing to a maximum depth of 2.9m bgl. These contaminated soils were also then stockpiled and removed from site by a grab lorry.
EXCAVATION SIZE	Approximately square in shape and approximately 6.5m (L) x 5m (W). The depth of excavation varied from 2.0m bgl to a maximum depth of 2.9m bgl.

VERIFICATION SAMPLING	A total of 7No. samples were taken from this excavation and referenced as 'B1' and 'F1' with 'B' representing samples from the base and 'F' from the face. A PID was also used to confirm the vapour generation potential of the remaining soils.
OBSERVATIONS	During the excavation works the most significant hydrocarbon staining and odours were located surrounding underground pipework in the location of Trial Pit TP08, with only limited staining and odours adjacent to the tank structure. It is considered that a leak from the pipework was the most likely cause of the soil contamination.

5.1.2. Capping Layers in Proposed Landscaping Areas

The excavation of the soils from the proposed landscaping areas and installation of the clean capping layers were undertaken by the groundworker. Confirmation of these works are discussed further in the verification section of this report.

The imported soils tickets used for the capping layers are enclosed in Appendix 4.

5.1.3. Water Supply Pipes

Protective barrier water supply pipes have been installed throughout the development.

5.2. WASTE DISPOSAL

A total of 7No. loads of contaminated soils were removed from site as Hazardous waste and transported to the HWM Ltd treatment facility at Otterbourne Farm, Kiln Lane, Otterbourne, Hampshire, SO21 2EN.

Copies of the consignment notes are included in Appendix 4 of this report.

6. REMEDIATION VERIFICATION

6.1. OVERVIEW

The verification works included sampling of the remedial excavation in the south west corner of the site, verification of capping layer thickness and suitability of the imported capping layer soils and finally confirming the use of the protective barrier water supply pipes.

A Remediation Excavation Plan, Remediation Verification Plan and photographs taken during the works are included in Appendix 1, along the verification test results in Appendix 3.

6.1.1. Remediation Excavation

In order to confirm the removal of the identified contaminated soils, verification sampling on the base and faces of the remedial excavation was completed along with the use of PID spike tests.

6.1.2. Verification Laboratory Analysis

SOIL CHEMICAL TESTING - REMEDIATION EXCAVATION	
The soil samples for contamination and/or chemical geotechnical testing were forwarded to the laboratory of QTS Environmental Ltd and the testing suite is detailed below. The UKAS or MCERTS accreditation of the individual test methods is shown on the laboratory test report included in the Appendices.	
SOIL TESTS	NUMBER OF SAMPLES TESTED
Speciated Polycyclic Aromatic Hydrocarbons (PAH)	6
Total Petroleum Hydrocarbons (TPH)	6
Benzene, Toluene, Ethylbenzene and Xylenes (BTEX) plus Methyl Tert Butyl Ether (MTBE)	6

6.2. VERIFICATION TEST RESULTS - SOILS

In the first instance the soil results summarised in the table below have been compared to the assessment criteria set out in the remediation strategy.

CONTAMINANT	UNITS	NUMBER OF TESTS	MAXIMUM CONCENTRATION	GAC	NUMBER EXCEEDING GAC
Naphthalene	mg/kg	6	<0.1	2.3	0
Acenaphthylene	mg/kg	6	<0.1	170	0
Acenaphthene	mg/kg	6	<0.1	210	0
Fluorene	mg/kg	6	<0.1	170	0
Phenanthrene	mg/kg	6	<0.1	95	0
Anthracene	mg/kg	6	<0.1	2,400	0
Fluoranthene	mg/kg	6	<0.1	280	0
Pyrene	mg/kg	6	<0.1	620	0
Benzo(a)anthracene	mg/kg	6	<0.1	7.2	0

CONTAMINANT	UNITS	NUMBER OF TESTS	MAXIMUM CONCENTRATION	GAC	NUMBER EXCEEDING GAC
Chrysene	mg/kg	6	<0.1	15	0
Benzo(b)fluoranthene	mg/kg	6	<0.1	2.6	0
Benzo(k)fluoranthene	mg/kg	6	<0.1	77	0
Benzo(a)pyrene	mg/kg	6	<0.1	2.2	0
Indeno(1,2,3-cd)pyrene	mg/kg	6	<0.1	27	0
Dibenzo(a,h)anthracene	mg/kg	6	<0.1	0.24	0
Benzo(ghi)perylene	mg/kg	6	<0.1	320	0
Total PAH	mg/kg	6	<0.1	100	0
TPH Aliphatic C5-C6	mg/kg	6	<0.01	42	0
TPH Aliphatic C6-C8	mg/kg	6	<0.05	100	0
TPH Aliphatic C8-C10	mg/kg	6	<2	97.3	0
TPH Aliphatic C10-C12	mg/kg	6	<2	653	0
TPH Aliphatic C12-C16	mg/kg	6	<3	12,600	0
TPH Aliphatic C16-C35	mg/kg	6	131	26,400	0
TPH Aliphatic C35-C44	mg/kg	6	<10	65,000	0
TPH Aromatic C5-C7	mg/kg	6	<0.01	70	0
TPH Aromatic C7-C8	mg/kg	6	<0.05	130	0
TPH Aromatic C8-C10	mg/kg	6	<2	34	0
TPH Aromatic C10-C12	mg/kg	6	<2	74	0
TPH Aromatic C12-C16	mg/kg	6	<2	140	0
TPH Aromatic C16-C21	mg/kg	6	<3	260	0
TPH Aromatic C21-C35	mg/kg	6	40	1,100	0
TPH Aromatic C35-C44	mg/kg	6	<10	1,100	0
Total TPH	mg/kg	6	<60	500	0
Benzene	mg/kg	6	<0.002	0.87	0
Toluene	mg/kg	6	<0.005	130	0
Ethylbenzene	mg/kg	6	<0.002	47	0
Xylene (total of all types)	mg/kg	6	<0.002	56	0
Methyl Tert Butyl Ether (MTBE)	mg/kg	6	<0.005	49	0
Hydrocarbon Vapour (PID)	ppm	16	12.6	50	0

Notes: *Limit of detection: Given the large amount of compounds in this group, coupled with the lack of GAC for certain compounds, any concentrations above the limit of detection will be highlighted in the first instance.

6.2.1. Discussion of Results

6.2.1.1. Soils

No elevated concentrations above the assessment criteria have been recorded in any of the verification samples, with the majority of the results being below detection limits. In addition to this, the PID spike tests have recorded no notable vapour concentrations on the soils remaining in the excavation.

It is therefore considered that the verification sampling has confirmed the successful removal of the hydrocarbon contaminated soils.

6.3. CAPPING LAYER VERIFICATION

6.3.1. Capping Layer Thickness

6.3.1.1. *Plot 4*

Hand dug pits HD01 and HD02 were excavated in the rear garden of Plot 4 and confirmed 0.3m bgl of topsoil overlying imported screened soil to a depth of 0.6m bgl. At the base of the hand dug pits natural soils described as a 'Medium dense yellow / brown clayey SAND' were recorded.

6.3.1.2. *Plots 1 - 3 (Inclusive)*

The remaining landscaping on site included small areas at the front of Plots 1-3 (inclusive) where 300mm of the original surface soils had been removed. During the inspection visits, the ash and clinker soils previously recorded in the garden of Plot 4 were not present within Plots 1-3.

As a result, a further three hand dug pits HD03, HD04 and HD05 were completed to confirm the exposed soils were suitable for use and would allow for a reduced depth of capping layer to be installed. The hand dug pits proved a mixture of reworked natural gravelly clay soils in HD04 to 0.4m below the existing ground level and Made Ground soils consisting of gravelly clays to 0.3m below the existing ground level in HD03 and HD05.

The results of the confirmatory testing are summarised in the table below and a copy of the test results are provided in Appendix 3.

6.3.2. Capping Layer Soils

A combination of screened subsoil and topsoil have been imported to form the capping layers at the site and representative samples of both soil types were tested to confirm their suitability for use within the development. The samples from HD01 and HD02 at depths of 0.1m and 0.2m bgl respectively were taken of the imported topsoil, whilst the sample from HD01 at 0.5m bgl was taken from the imported subsoil.

In addition to this the near surface soils in Plots 1-3 (inclusive) were also analysed to determine if a shallower capping layer could be installed. In these areas the sample from HD03 at 0.2m bgl was taken from the exposed soils located in the front landscaping areas of Plots 2 and 3, whilst HD04 at 0.1m bgl was taken from the exposed soils in landscaping at the front of Plot 4.

Topsoil from the same stockpile as that tested from Plot 4 (HD01 and HD02) was then used to form the capping layers in Plots 1-3 (inclusive).

6.3.2.1. *Laboratory Analysis*

SOIL CHEMICAL TESTING

The soil samples for contamination testing were forwarded to the laboratory of QTS Environmental Ltd and the testing suite is detailed below. The UKAS or MCERTS accreditation of the individual test methods is shown on the laboratory test report included in the Appendices.

SOIL TESTS	NUMBER OF SAMPLES TESTED
Arsenic, Cadmium, Chromium, Chromium VI, Copper, Lead, Mercury, Nickel, Selenium, Zinc	5
Speciated Polycyclic Aromatic Hydrocarbons (PAH)	5
Organic Matter	5
Asbestos Quantification	1

6.3.2.2. Chemical Test Results

The results of the verification testing have been assessed against the assessment criteria for human health with plant uptake as detailed in section 4.8.5 of the Remediation strategy ref. BRD210736-OR2-A and are summarised in the table below. In addition to this a sample of the exposed near surface soils in the front landscaping areas of Plots 1-3 was also analysed for Asbestos to confirm it was not present.

CONTAMINANT	UNITS	NUMBER OF TESTS	MAXIMUM CONCENTRATION	GAC	NUMBER EXCEEDING GAC
Arsenic	mg/kg	5	10	37	0
Cadmium	mg/kg	5	0.4	22	0
Chromium (hexavalent)	mg/kg	5	<2	21	0
Chromium (total)	mg/kg	5	19	910	0
Copper	mg/kg	5	27	2,400	0
Lead	mg/kg	5	78	200	0
Mercury	mg/kg	5	<1	11	0
Nickel	mg/kg	5	14	180	0
Selenium	mg/kg	5	<3	250	0
Zinc	mg/kg	5	123	3,700	0
pH	Units	5	8.4	<5-10>	0
Naphthalene	mg/kg	5	<0.1	2.3	0
Acenaphthylene	mg/kg	5	<0.1	170	0
Acenaphthene	mg/kg	5	<0.1	210	0
Fluorene	mg/kg	5	<0.1	170	0
Phenanthrene	mg/kg	5	1.25	95	0
Anthracene	mg/kg	5	0.28	2,400	0
Fluoranthene	mg/kg	5	1.79	280	0

CONTAMINANT	UNITS	NUMBER OF TESTS	MAXIMUM CONCENTRATION	GAC	NUMBER EXCEEDING GAC
Pyrene	mg/kg	5	1.49	620	0
Benzo(a)anthracene	mg/kg	5	0.73	7.2	0
Chrysene	mg/kg	5	0.85	15	0
Benzo(b)fluoranthene	mg/kg	5	1.01	2.6	0
Benzo(k)fluoranthene	mg/kg	5	0.39	77	0
Benzo(a)pyrene	mg/kg	5	0.76	2.2	0
Indeno(1,2,3-cd)pyrene	mg/kg	5	0.48	27	0
Dibenzo(a,h)anthracene	mg/kg	5	<0.1	0.24	0
Benzo(ghi)perylene	mg/kg	5	0.45	320	0
Asbestos	Presence	1	Not identified	Fibres Present	0
Notes: *Limit of detection: Given the large amount of compounds in this group, coupled with the lack of GAC for certain compounds, any concentrations above the limit of detection will be highlighted in the first instance.					

6.3.3. Discussion of Results

6.3.3.1. Capping Layer Thickness - Plots 1-3

The samples of the exposed soils in the landscaping areas of Plots 1-3 (inclusive) have not recorded any elevated concentrations of contaminants. It is therefore concluded that the shallower capping layer of 300mm of imported topsoil is acceptable as the underlying soils are uncontaminated. It should also be noted that these areas will be typically used for decorative purposes only given their small size and unlikely to be used for growing vegetables. The potential for any direct contact with the underlying soils below the 300mm imported topsoil is therefore significantly reduced.

6.3.3.2. Capping Layer Soils

When compared to the imported soils verification criteria none of the samples analysed recorded any elevated concentrations and therefore the imported soils including both subsoil and Topsoil can be considered suitable for intended use.

6.4. INSTALLATION OF PROTECTIVE WATER SUPPLY PIPES

The Client has confirmed that protective barrier water supply pipes have been installed on the site and a copy of the invoice confirming purchase of the pipe is included in Appendix 4.

7. REVISED CONCEPTUAL MODEL

7.1. CHANGES TO MODEL

The conceptual model described in Section 3.1 of this report, has changed by virtue that the pollutant linkages have been broken as a result of the verified remediation works undertaken at the site.

7.2. UPDATED RISK ASSESSMENT

The pollutant linkages identified in the revised conceptual site model can be re-evaluated.

POTENTIAL SOURCES AND CONTAMINANTS	PATHWAYS (REFERENCE FROM MODEL)	RECEPTORS	POTENTIAL RISK
Contamination associated with shallow underground waste oil tank in SW corner.	Direct contact Ingestion Inhalation of vapours (1)	Future residents	Negligible – Contamination source removed
	Migration through permeable strata (2)	Groundwater / Surface Water	
	Direct contact (3)	Building Materials and Services	
General surface Made Ground contaminated with lead and PAH	Direct contact Ingestion (4)	Future residents	Negligible – Capping layers installed
	Migration through permeable strata	Groundwater / Surface Water	Negligible – Non leachable contaminants
	Direct contact (5)	Building Materials and Services	Negligible – Barrier pipes installed
Contamination from potential underground fuel tanks in centre of site	Direct contact Ingestion Inhalation of vapours (1)	Future residents	Negligible – No tank identified
	Migration through permeable strata (2)	Groundwater / Surface Water	
	Direct contact (3)	Building Materials and Services	
Potential localised contamination from electrical substation in southern corner of building	Direct contact Ingestion Inhalation of dust/vapours (6)	Future residents	Negligible – No contamination identified
	Migration through permeable strata (7)	Groundwater / Surface Water	

POTENTIAL SOURCES AND CONTAMINANTS	PATHWAYS (REFERENCE FROM MODEL)	RECEPTORS	POTENTIAL RISK
	Direct contact (8)	Building Materials and Services	

RISK TO HUMAN HEALTH

The remediation works have included the excavation and complete removal of the hydrocarbon contaminated soil surrounding the former waste oil tank as verified by the chemical testing and PID spike tests. The verification has also confirmed the required soil capping layers in the garden areas. The associated risks from the migration of vapours and direct contact with the contaminated soils is therefore considered to be negligible.

The additional investigation works have also confirmed no contamination to be present beneath the former electrical substation or there to have been an additional fuel tank beneath the former building footprint. The associated risks from these potential sources are also considered to be negligible as no contamination sources was identified.

RISK TO WATER ENVIRONMENT

The identified hydrocarbon contamination presented a potential risk to the groundwater aquifer (albeit at depth) resulting from the migration through the underlying permeable soils on site. However, following the successful excavation and removal of this contamination source it its entirety the associated risk is now considered to be negligible.

As previously discussed within the remediation strategy, in regards to the site wide Made Ground, the contaminants are considered most likely to be associated to clinker fragments within the soils and are therefore not thought to be in any soluble form. The heavy PAHs recorded are not particularly soluble in any case and therefore the associated risk to the aquifer at depth remains as negligible.

RISK TO BUILDING MATERIALS AND SERVICES

The risks associated with direct contact with organic contaminants within the soils have been mitigated by the installation of protective barrier water supply pipe.

8. CONCLUSION

8.1. SUMMARY OF WORKS UNDERTAKEN

The following remedial measures have been completed and verified at the site.

- Excavation and disposal of all hydrocarbon contaminated soils associated with the former waste oil tank in the south west corner of the site have been successfully completed.
- Installation of a 600mm capping layer in the garden of Plot 4 along with a reduced capping layer of 300mm in the front gardens of Plots 1-3 (inclusive).
- Verification of all imported subsoil and Topsoil used within the garden areas.
- The installation of protective water supply pipes.

8.2. CONCLUDING DISCUSSION

The remediation of the site has been completed in accordance with the proposed remediation strategy and all of the identified pollutant linkages have been broken. It is concluded that the site is now suitable for the intended residential use in respect of land contamination issues.

This report should be submitted to Reading Borough Council to demonstrate that the required remediation works have been successfully completed and to allow for the discharge of the relevant planning conditions prior to occupation.

REPORT SPECIFIC REFERENCES

- 'Site Investigation – Armour Road, Tilehurst, Reading', BRD Environmental Report Ref. BRD210736/OR1-A, June 2007.
- British Geological Survey sheet 268 "Reading" Solid and Drift edition (1:50,000) published 1999.
- 'Updated Contamination Assessment and Remediation Strategy – Armour Road, Tilehurst, Reading', BRD Environmental Report Ref. 210736-OR3-A dated July 2016.

SUPPORTING INFORMATION

GROUND INVESTIGATION

Exploratory holes are logged by an experienced Geo-Environmental Consultant in general accordance with 'Code of practice for site investigations' BS5930:1999 +A2:2010, BSi, August 2010. Soil samples for chemical and geotechnical analysis are taken from the exploratory holes at intervals dictated by the nature of the soils and the objectives of the investigation.

Where stated on the logs of inspection pits, trial pits or boreholes (where insitu testing has not been undertaken), the relative density of coarse (sand and gravel) soils is tentative only. Such assessments of density are on the basis of visual inspection only taking into consideration such factors as drilling rates, stability of pit side walls, appearance and behaviour under excavation.

Where Chalk strata is encountered it is logged and graded in general accordance with CIRIA guidance 'C574 - Engineering in Chalk'. It should be recognised that where percussive drilling methods are employed, the structure of the Chalk is destroyed and therefore the grading stated on such logs is either tentative or absent where it is not possible to assess the grade.

Hand Dug Inspection Pits

Hand tools are used to forward shallow inspection pits as a cost effective method of describing and sampling near surface soils. The technique is also used where exposure of existing footings is required. The depth reached by such techniques is a function of the nature of the ground and generally does not exceed 1.5m

Trial Pits

Mechanically excavated trial pits allow detailed inspection of near surface ground due to the large volume of soil exposed. A wheeled backhoe loader is the usual machine for digging trial pits that are typically 3 to 4.5m deep, 0.5m wide and 3m long.

Windowless Sampling Boreholes

This type of borehole is formed by a small tracked dynamic percussion drilling rig with samples retrieved in thin plastic liners within the narrow diameter steel sampling tubes. Borehole depths of up to 5m are typical, but in exceptional circumstances up to 15m depth can be achieved. This is the smallest type of rig that is capable of undertaking Standard Penetration Tests (SPTs).

Hand Held Window Sampling

Hand held window sampling is a useful method of drilling narrow diameter boreholes particularly where access is difficult. Hand held mechanical percussive hammers are used to drive the sampling tube into the ground. The soil samples are collected within the hollow metal sampling tubes and inspected via the open window along one side. Window sampling boreholes can be forwarded to depths of 3m to 6m depending upon ground conditions.

Cable Percussive Boreholes

This form of drilling involves repetitive dropping of a tube into the soil under its own weight from a tripod support. The sample is obtained from the clay cutter head in fine soils or a bailer for wet granular soils. As the borehole progresses SPTs can be undertaken and relatively undisturbed samples can be obtained. Typically these boreholes are 15 to 25m

deep, but depths of double that can be achieved in soils, but only thin weak rock layers can be penetrated.

Rotary Boreholes

Where competent rock is required to be drilled then rotary drilling techniques are required. The drilling rigs can vary in size from small tracked units to larger units mounted on four wheel drive trucks. Rotary open hole drilling techniques break the rock into small fragments and so recovery of any samples is limited. In contrast, rotary coring retrieves excellent samples. Some rigs also allow windowless sampling to be undertaken through soil layers. There are no practical limits to the depths that this drilling method can achieve.

Dynamic Probing

Dynamic probing comprises a sectional rod with a sacrificial cone at the base of slightly larger diameter than the rod. The rod is driven into the ground by a constant mass falling through a set distance. The number of blows required to forward the rod per 100mm is then recorded and presented in a graph of N_{10} values. The standard applicable to dynamic probing is "BS EN ISO 22476-2:2005 Incorporating corrigendum no. 1, Geotechnical investigation and testing — Field testing — Part 2: Dynamic probing" BSi, February 2007.

Dynamic Penetrometer

The Transport Research Laboratory Dynamic Cone Penetrometer (TRL DCP) uses an 8 kg hammer dropping through a height of 575mm to drive a 60° cone of 20mm maximum diameter into the ground. The depth driven either per blow or per several blows is recorded. The strength of each of the soil layer encountered is then calculated by converting the penetration rate (mm per blow) into an approximate California Bearing Ratio (CBR) value employing the correlation proposed by TRL.

Gas Monitoring

Gas monitoring is undertaken with a portable gas monitor for oxygen, Methane, Carbon Dioxide, Hydrogen Sulphide and Carbon Monoxide together with recording of atmospheric pressure and any flow rate.

Vapour Monitoring

Headspace tests and monitoring for Volatile Organic Compounds (VOC) or Semi Volatile Organic Compounds (SVOC) is undertaken using a Photo Ionisation Detector (PID). The MiniRAE models used have a 10.6 eV lamp calibrated for isobutylene. The PID is useful tool to indicate the presence of a wide range of volatile compounds, but only provides semi-quantitative data as different compounds provide a different response and thus the reading is not a true reflection of the actual concentration present.

Low PID readings can be recorded in natural uncontaminated organic soils or even as a result of atmospheric pollution. It is generally accepted by consultants and regulators that recorded values in excess 50 parts per million (ppm) represents the presence of organic compound pollutants and in excess of 100 ppm such contamination may be significant.

The headspace test procedure involves the collection of a sample of suspected contaminated soils and placing within a sample bag. A tight seal to the bag is formed with a similar volume of air trapped to that of the soil and the sample is left for fifteen minutes to allow volatilisation of any contaminants. The bag is then pierced by, and sealed around, the sample probe of the PID and a reading taken.

Borehole well monitoring is undertaken by connecting the PID directly to the gas tap on the monitoring well installation.

Groundwater Level Monitoring

Groundwater levels are recorded with an electronic dip meter that has a detector end that is lowered into the borehole well. An audible signal is made when water is reached and the depth recorded from the graduated tape used to lower the detector. Where there is potential for a separate Light Non Aqueous Phase Liquid (LNAPL) to be present floating on the groundwater an oil/water interface meter is used in preference to a conventional dip meter so that any such floating product can be detected.

Contamination Sampling

BRD schedule contamination testing as appropriate to the ground conditions, available budget, potential contaminants and the proposed development. Samples are collected in single use laboratory supplied containers.

Soil samples are retrieved in plastic containers and/or amber glass jars with a lined plastic cap. Contamination samples are indicated by a 'J' on exploratory hole logs.

Water samples are collected in plastic bottles and/or amber glass jars with a lined plastic cap then placed in cool boxes together with freezer packs. Water samples are indicated by a 'W' on exploratory hole records, but generally such samples are not tested as testing from dedicated monitoring wells is preferred for sample quality reasons.

Samples retrieved from the exploratory holes are dispatched to the laboratory by overnight courier. Where samples cannot be transported directly from site they are temporarily stored in the BRD dedicated sample storage facility which includes refrigeration where necessary. The individual accreditation of the test methods is detailed in the laboratory test report.

CONTAMINATION ASSESSMENT METHODOLOGY

UK Policy

The UK Government's policy in relation to land affected by historic contamination is based on a 'suitable for use' approach. The approach recognises that the risks presented by any given level of contamination will vary greatly according to the use of the land and a wide range of other factors, such as the underlying geology of the site. Contamination risks therefore need to be assessed on a site-by-site basis. The 'suitable for use' approach limits requirements for remediation to the work necessary to prevent unacceptable risks to human health or the environment in relation to either the current use or future use of the land.

The three main drivers for contamination assessment and remediation are:

- *Voluntary action.*
- *Development as part of the planning regime.*
- *Regulatory action to mitigate unacceptable risks e.g. Part 2A of the Environmental Protection Act 1990.*

Pollutant Linkages

For a contamination risk to exist there must be a 'pollutant linkage' from the contaminant (source) via a pathway (the route from contaminant to receptor) to a receptor (the entity that could be harmed). The absence of a contaminant, pathway or receptor breaks the pollutant linkage and therefore no contamination risk exists.

Contamination is typically present at a site (in the ground and/or in the underlying groundwater) as a result of a historic or current industrial use, usually as a result of leaks, spills or disposal of residues, wastes and excess raw materials from the industrial processes. Contamination may also be present due to:

- *The deliberate application of chemicals e.g. the spraying of herbicide/pesticide.*
- *Migration of pollutants from adjacent land.*

Naturally occurring processes e.g. elevated concentrations of particular heavy metals associated with specific geological strata.

Conceptual Site Model

The conceptual site model can be defined as a textual or graphical representation of the identified pollutant linkages for a given site. The model forms the basis for designing the investigation as the aim will be to target all of the potential pollutant linkages to determine, through the subsequent phases of risk assessment, whether or not they pose an actual risk.

It is important that the conceptual site model is updated with new information as the various investigation, risk assessment and remediation works are completed.

Technical Guidance

The technical and legal framework for contamination assessment is complex. The process adopted through this report for assessing contamination risks is in general accordance with the following guidance, as listed below:

- 'Investigation of Potentially Contaminated Sites - Code of Practice - BS 10175: 2011', BSi, 2011.
- 'Model Procedures for the management of Land Contamination - CLR Document No. 11', Environment Agency, 2004.
- 'Guidance for the safe development of housing on land affected by contamination - R&D66: 2008', NHBC/Environment Agency, 2008.

Risk Assessment Methodology

In line with the technical guidance, the contamination risk assessment follows a series of phased stages for each particular site:

PHASE	DESCRIPTION	RISK ASSESSMENT STAGE
PHASE1	Generally limited to desk based research and a site walkover survey to develop an initial conceptual site model and identify what risks, if any, are likely to be presented by the site.	Hazard Identification and Assessment A preliminary stage of risk assessment concerned with identifying and characterising the hazards that may be associated with a particular site and identifying potential pollutant linkages.
PHASE 2	This phase is concerned with establishing whether contamination is present, usually through intrusive ground investigation, and then evaluating the degree and magnitude of the associated risks.	Risk Estimation A stage concerned with estimating the likelihood that receptors will suffer adverse effects if they come into contact with, or are otherwise affected by, a hazardous substance or agent under defined conditions. Risk Evaluation A stage of risk assessment concerned with evaluating the acceptability of estimated risks, taking into account the nature and scale of the risk estimates, any uncertainties associated with the assessment and the broad costs and benefits of taking action to mitigate risks.
PHASE 3	The appraisal and selection of remediation techniques, their implementation and verification.	Risk Management The process whereby decisions are made to accept a known or assessed risk and/or the implementation of action to reduce the consequences or probabilities of occurrence.

Risk Classification

The objective of risk assessment is to identify the nature and magnitude of the potential risks and should be based on a consideration of both:

- The likelihood/probability of an event [taking into account both the presence of the hazard and receptor and the integrity of the pathway].
- The severity of the potential consequence [taking into account both the potential severity of the hazard and the sensitivity of the receptor].

There is a need for a logical, transparent and repeatable system in defining the categories of severity of consequence and likelihood as well as for the risk itself and therefore the following risk rating matrix is employed:

		SEVERITY OF CONSEQUENCE			
		SEVERE	MEDIUM	MILD	MINOR
PROBABILITY	HIGH LIKELIHOOD	Very High Risk	High Risk	Moderate Risk	Moderate/Low Risk
	LIKELY	High Risk	Moderate Risk	Moderate/Low Risk	Low Risk
	LOW LIKELIHOOD	Moderate Risk	Moderate/Low Risk	Low Risk	Negligible Risk
	UNLIKELY	Moderate/Low Risk	Low Risk	Negligible Risk	Negligible Risk

These risk classifications are defined as follows:

- **Very High Risk** - There is a high probability that severe harm could arise to a designated receptor from an identified hazard at the site without appropriate remediation action.
- **High Risk** - Harm is likely to arise to a designated receptor from an identified hazard at the site without appropriate remediation action.
- **Moderate Risk** - It is possible that without appropriate remediation action harm could arise to a designated receptor. It is relatively unlikely that any such harm would be severe, and if any harm were to occur it is more likely that such harm would be relatively mild.
- **Low Risk** - It is possible that harm could arise to a designated receptor from an identified hazard. It is likely that, at worst if any harm was realised any effects would be mild.
- **Negligible Risk** - The presence of an identified hazard does not give rise to the potential to cause harm to a designated receptor.

This risk assessment matrix and classification system is based on guidance produced by Department for Environment, Food and Rural Affairs (Defra) and the Environment Agency in connection with contaminated land assessment.

RISK ESTIMATION - SOILS

Introduction to Soil Human Health Generic Assessment Criteria (GAC)

The Environment Agency (EA) and Department of Environment Food and Rural Affairs (DEFRA) had previously issued revised guidance following the consultation about the DEFRA publication "Assessing risks from land contamination - a proportionate approach. Soil Guideline Values: the Way Forward". This resulted in a revised version of the Contaminated Land Exposure Model (CLEA) model (version 1.06) and a few of the previously published Soil Guideline Values (SGVs) were revised.

The main legislative driver for dealing with historical land affected by contamination is Part 2A of the Environmental Protection Act 1990. Revised Statutory Guidance to support Part 2A was published in April 2012. This Guidance introduced a new four-category system for classifying land under Part 2A for cases of a Significant Possibility of Significant Harm to human health,¹ where Category 1 includes land where the level of risk is clearly unacceptable and Category 4 includes land where the level of risk posed is acceptably low. The impact assessment for the new Statutory Guidance stated "The new statutory guidance will bring about a situation where the current SGVs/GACs are replaced with more pragmatic (but still strongly precautionary) Category 4 screening levels (C4SLs) which will provide a higher simple test for deciding that land is suitable for use and definitely not contaminated land". The C4SLs are still derived using the CLEA model, but adopt a slightly different approach to toxicological assessment and exposure modelling.

In March 2014, the outcome of "SP1010 - Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination - Final Project Report" (CL:AIRE) was published. Due to slightly ambiguous wording within this report, Lord de Mauley, Parliamentary Under Secretary, DEFRA wrote to all local authorities on 3 September 2014 to confirm that the published C4SLs were final and that they can be used in risk assessment undertaken under the planning regime.

Whilst there are proposals for the industry to develop C4SLs for other contaminants, these have yet to produce any new values. BRD do not believe that C4SLs could be developed by a single organisation with sufficient confidence. BRD has therefore employed other, more conservative guidance based on the CLEA model (detailed below) within this assessment for compounds where C4SLs are not available. However, it should be noted that the results of this investigation may need to be reinterpreted as new C4SLs become available.

Due to the limited number of published C4SL values at this time, the Chartered Institute of Environmental health (CIEH) and Land Quality Management Ltd (LQM) have produced Generic Assessment Criteria (GAC) known as Suitable for Use Levels (S4ULs), for use in contaminated land human health risk assessment. These S4ULs (2014) have been derived for a large number of substances using the current CLEA model and are therefore consistent with current guidance. They also incorporate the revised exposure parameters as adopted by the C4SL programme, but have not adopted the revised toxicological approach adopted by the C4SLs and so remain a more conservative assessment criteria. The substances for which SGVs were previously published have also been revised as new S4ULs in light of the new exposure parameters proposed by the C4SL programme, and therefore effectively replace the existing SGVs.

In addition, in December 2009, other GAC for less common substances were produced by the Environmental Industries Commission (EIC), The Association of Geotechnical and Geoenvironmental Specialists (AGS) and Contaminated Land: Applications in Real Environments (CL:AIRE) using the CLEA model. These are referred to as the EIC/AGS/CLAIRE GAC.

In summary, C4SLs have been used where these are available. For those substances where C4SLs have yet to be issued, then the S4ULs have been adopted or in some cases, the EIC/AGS/CLAIRE GAC. All of the previously produced SGVs have now either been withdrawn, or superseded by the respective C4SLs or S4ULs.

The only exception to this approach is the PAH compound benzo(a)pyrene (BaP) where a C4SL guideline value has been produced, whereas BRD has adopted the S4UL value. The C4SL for BaP relates to its use as a surrogate marker compound representing all of the genotoxic PAH compounds as a mixture, rather than this individual compound. BRD has therefore adopted the compound specific S4UL value as the initial screening value, for consistency with the other PAH compounds before then employing the C4SL is necessary.

It should be noted that unless otherwise stated, all the assessment criteria adopted within this report have been derived based on a sandy loam soil at pH 7 and the values quoted are for a conservative soil organic matter content of 1% where applicable (i.e. organic contaminants).

Human Health - Soil Generic Assessment Criteria

The results of the soils analysis have been compared to generic assessment criteria for the default exposure scenarios comprising either residential land with plant uptake, residential land without plant uptake, or commercial/industrial land use. The criteria values selected are listed in the table below and full details on the source are referred to above. Where applicable, the results have also been assessed with reference to the required statistical tests presented within CLAIRE document "Guidance on comparing soil contamination data with a critical concentration".

ANALYSIS	GENERIC ASSESSMENT CRITERIA (mg/kg unless stated)			SOURCE
	RESIDENTIAL WITH PLANT UPTAKE	RESIDENTIAL WITHOUT PLANT UPTAKE	COMMERCIAL / INDUSTRIAL	
Arsenic	37	40	640	C4SL
Cadmium	22	150	410	
Chromium (total) ^s	910	910	8,600	S4UL
Chromium VI	21	21	49	C4SL
Lead	200	310	2,330	
Mercury*	11	15	320	S4UL
Selenium	250	430	12,000	
Nickel	180	180	980	
Copper	2400	7,100	68,000	
Zinc	3,700	40,000	730,000	
pH	<5 - 10> units			Professional judgement
Naphthalene	2.3	2.3	190	S4UL
Acenaphthylene	170	2,900	83,000	
Acenaphthene	210	3,000	84,000	
Fluorene	170	2,800	63,000	
Phenanthrene	95	1,300	22,000	
Anthracene	2,400	31,000	520,000	
Fluoranthene	280	1,500	23,000	
Pyrene	620	3,700	54,000	
Benzo(a)anthracene	7.2	11	170	
Chrysene	15	30	350	
Benzo(b)fluoranthene	2.6	3.9	44	
Benzo(k)fluoranthene	77	110	1,200	
Benzo(a)pyrene	2.2	3.2	35	
Indeno(1,2,3-cd)pyrene	27	45	500	

ANALYSIS	GENERIC ASSESSMENT CRITERIA (mg/kg unless stated)			SOURCE
	RESIDENTIAL WITH PLANT UPTAKE	RESIDENTIAL WITHOUT PLANT UPTAKE	COMMERCIAL / INDUSTRIAL	
Dibenzo(a,h)anthracene	0.24	0.31	3.5	S4UL
Benzo(ghi)perylene	320	360	3,900	
TPH Aliphatic C5-C6	42	42	3,200	
TPH Aliphatic C6-C8	100	100	7,800	
TPH Aliphatic C8-C10	27	27	2,000	
TPH Aliphatic C10-C12	130	130	9,700	
TPH Aliphatic C12-C16	1,100	1,100	59,000	
TPH Aliphatic C16-C35	65,000	65,000	1,600,000	
TPH Aliphatic C35-C44	65,000	65,000	1,600,000	
TPH Aromatic C5-C7	70	370	26,000	
TPH Aromatic C7-C8	130	860	56,000	
TPH Aromatic C8-C10	34	47	3,500	
TPH Aromatic C10-C12	74	250	16,000	
TPH Aromatic C12-C16	140	1,800	36,000	
TPH Aromatic C16-C21	260	1,900	28,000	
TPH Aromatic C21-C35	1,100	1,900	28,000	
TPH Aromatic C35-C44	1,100	1,900	28,000	
Benzene	0.87	3.3	98	C4SL
Toluene	130	880	56,000	S4UL
Ethylbenzene	47	83	5,700	
Xylene^	56	79	5,900	EIC/AGS/CL:AIRE GAC
MTBE	49	73	7,900	

Notes:

* The S4UL for methyl mercury has been adopted as the worst case mercury compound as generally there is no desk study evidence to suggest the potential for elemental mercury on the majority of sites.

^ The lowest S4UL of either p-xylene, o-xylene or m-xylene has been adopted for each land use as a conservative measure.

§ S4UL for Chromium III adopted, as in the absence of Chromium VI it is likely that all of the chromium will be in this form as these are the two most common and stable forms of chromium in the soil environment.

Where no GAC is available, any concentrations exceeding the laboratory limit of detection are identified and discussed in more detail.

Water Environment - Soil Generic Assessment Criteria

There are no UK published Generic Assessment Criteria for soil test results in respect of the risk to the water environment and therefore risk estimation is on the basis of the professional judgement and experience of BRD to employ values that are a reasonable concentration above which concern for water resources is valid.

The Total PAH GAC employed is the sum of the 16No. priority PAH compounds regularly tested for in contaminated land analysis (i.e. US EPA 16PAHs). BRD employ a soil screening based upon the total PAH limit for 'inert waste' of 100mg/kg. The rationale is based on PAHs are recognised to be generally of low solubility and the risk to the water environment is correspondingly low.

In respect of Total Petroleum Hydrocarbons, BRD employ a value of 500 mg/kg as a screening value in comparison to the sum of the component aliphatic and aromatic TPH carbon bands. The employed soil screening value is based upon:

- In common with some other consultants, the professional judgement and experience of BRD suggests that this value is a reasonable concentration above which concern for water resources is valid. The rationale is based on the fact that lower concentrations of fuel based contaminants are more likely to naturally degrade than migrate any great distance.*
- BRD is aware of regional Environment Agency groundwater and contaminated land teams that employ 500 mg/kg as a screening value for considering whether or not TPH could represent a risk to water resources.*
- The value mirrors the mineral oil Waste Acceptance Criteria limits for what is considered 'inert waste'.*

Should elevated contaminants that pose a potential risk to the water environment be identified then site specific assessment criteria should be developed.

Building Materials and Services – Soil Generic Assessment Criteria

Some hydrocarbon compounds are known to both attack and permeate through certain plastic pipe materials, with the primary concern being the degradation and tainting of water supplies. The UK Water Industry Research (UKWIR) has therefore produced a document 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites' (ref. 10/WM/03/21) that specifies threshold criteria for the adoption of 'standard' polythene (PE) or PVC pipes, protective barrier pipe and ductile iron/steel/copper pipes.

The UKWIR threshold assessment criteria from Table 3.1 of this document for standard PE pipes have been employed. It should be noted that the approach taken by UKWIR is very conservative, and both the document and research are flawed. However, it is these values that are being using to specify water pipe materials and therefore it is appropriate to consider them.

The UKWIR guidance is particularly flawed in respect of the chemical analysis it expects as it seeks a limit of detection that is generally below limits that are reasonable or commonly employed in contaminated land assessment. The UKWIR seeks that where a substance is below the limit of detection it should be taken as being present at half this concentration. For the larger suite of chemicals where the limit is against a sum of compounds, this approach would mean that a sample of virgin sub-soil from a greenfield site with absolutely no contamination would actually fail the criteria for using standard PE pipes. To avoid this situation, BRD have adopted the approach of summing only those compounds detected above their respective limits of detection.

In terms of building materials, the primary concern is in respect of concrete as certain commonly occurring natural ground conditions can adversely impact on buried concrete as discussed in 'Special digest 1:2005 Concrete in aggressive ground', BRE, 2005.

ANALYSIS	GENERIC ASSESSMENT CRITERIA	SOURCE
pH	<5.5	BRE Special Digest 1:2005
Sulphate (w/s)	500 mg/l	BRE Special Digest 1:2005
Sum of any VOC above detection limits	0.5 mg/kg	Relevant compounds adapted from UKWIR Table 3.1
Sum of SVOC + Aliphatic TPH >C5-C10 + Aromatic TPH >C5-C10 above detection limits	2 mg/kg	
Sum of Aliphatic TPH >C10-C21 + Aromatic TPH >C10-C21 above detection limits	10 mg/kg	
Sum of Aliphatic TPH >C21-C34 + Aromatic TPH >C10-C35 above detection limits	500 mg/kg	
Sum of BTEX + MTBE above detection limits	0.1 mg/kg	
Phenols	2 mg/kg	
Cresols and chlorinated phenols	2 mg/kg	
Naphthalene	0.5 mg/kg	
Benzo(a)pyrene	0.5 mg/kg	

RISK ESTIMATION - GROUNDWATER

The initial assessment of the contamination risk to groundwater is by comparing dissolved groundwater concentrations with screening values that are protective of groundwater resources.

The reference source for the target concentrations is generally the EA's Environmental Quality Standards (EQS), the Water Supply (Water Quality) Regulations (WSR) 1989 / 2000 and the DW1/DW2 criteria from the Surface Water (Abstraction for drinking water)(classification) Regulations 1996. The target concentrations are outlined in the table overleaf.

ANALYSIS	GENERIC ASSESSMENT CRITERIA	SOURCE
Arsenic	50 µg/l	EQS
Cadmium	5 µg/l	EQS
Chromium (total)	50 µg/l	DW2
Copper	50 µg/l	DW2
Nickel	20 µg/l	WSR
Lead	50 µg/l	DW2
Mercury	1 µg/l	EQS
Selenium	10 µg/l	WSR
Zinc	5 mg/l	DW2
Cyanide	50 µg/l	WSR
pH	6 to 9 units	EQS
Benzene	30 µg/l	EQS
Toluene	50 µg/l	EQS
Ethylbenzene	30 µg/l	EQS for benzene as a guide
Xylene	30 µg/l	EQS for benzene as a guide
Naphthalene	2.4 µg/l	EQS
Benzo(a)pyrene	0.05 µg/l	EQS
Total PAH	0.2 µg/l	DW1
TPH (dissolved or emulsified hydrocarbons)	50 µg/l	DW1

There are no available generic assessment criteria for some of the analytical parameters which have been scheduled, for example hexavalent chromium, and individual TPH and PAH and some VOC compounds. These parameters will be assessed based on professional judgement should they exceed the limit of detection.

RISK ESTIMATION - GROUND GAS

Introduction

A variety of potentially hazardous gases occur in naturally in the ground environment. Microbial decay of organic matter under anaerobic conditions and geological processes can lead to the generation of Methane and Carbon Dioxide, but can also include traces gases such as Hydrogen sulphide and Carbon monoxide.

Methane is a colourless and odourless gas that has the hazardous properties of being flammable and, at certain air/Methane mixtures, explosive. Methane has a low toxicity, but can be a simple asphyxiant due to the displacement of oxygen.

Carbon Dioxide is a colourless, odourless and non-combustible gas that has the hazardous property of being a highly toxic chemical. At concentrations of 3% by volume, shortness of breath and headaches will occur becoming acute by 6%. At levels of above 10% by volume headache, visual distortion, tremors and rapid loss of consciousness occur. Concentrations of Carbon Dioxide above 22% by volume are likely to be fatal. The effects of Carbon Dioxide poisoning are made more severe if there is accompanying reduction in oxygen concentrations.

Hydrogen sulphide is a colourless and flammable gas that has an odour of rotten eggs. It is important to that the sense of smell is over powered at higher concentrations. The gas is toxic and can be an asphyxiant.

Carbon monoxide is a colourless, odourless and explosive gas in air mixtures that has the hazardous property of being a highly toxic chemical.

Radon is a naturally occurring colourless and odourless gas that is radioactive. It is formed by the radioactive decay of radium which in turn is derived from the radioactive decay of uranium, both of which are minerals that can be found in many soil types. Whilst it is recognised that the air inside every house contains radon, some houses built in certain defined areas of the country might have unacceptably high concentrations and require special precautions to be taken. The maps contained within BRE211:2007 'Radon: guidance on protective measures for new buildings' identify areas where no radon protection measures are necessary or where higher concentrations are present that either basic or full radon protection measures are required to be fitted to all new dwellings.

Basis of Gas Assessment

In order to classify the level of risk and need, if any, for gas protection measures at a site with the potential for a gas problem, consideration of each of the following is necessary:

- The source of the gas.*
- The generation potential of the gas.*
- The location of the source and the geological setting.*
- Boreholes flow rate and estimated surface emission rate.*

- The nature of the proposed development.
- Confidence in the knowledge of the gas regime.

The gas assessment is made with reference to 'C665 - Assessing risks posed by hazardous ground gases to buildings', Construction Industry Research and Information Association (CIRIA), 2007.

Gas Screening Value

The method within CIRIA C665 uses both the gas concentrations and borehole flow rates to define a characteristic situation for a site based on the limiting borehole gas volume flow for Methane and Carbon Dioxide. This limiting borehole gas volume flow is called the Gas Screening Value (GSV) and is expressed below:

$$\text{Gas Screening Value (l/hr)} = \text{borehole flow rate (l/hr)} \times \text{gas concentration (fraction)}$$

The calculation of GSV is completed for both Methane and Carbon Dioxide and then the 'worse case' maximum values are used in the assessment. The assessment is to determine the gas regime at the site is dependent upon the nature of the development.

Situation A - All development types except low rise housing with gardens.

The characteristic situation for many sites is determined from evaluation of the Gas Screening Value derived against the criteria in the following table.

Characteristic situation	Risk classification	Gas Screening Value (CH ₄ or CO ₂ l/hr)	Additional factors	Typical sources of generation
1	Very low risk	<0.07	Typically Methane ≤1% and/or Carbon Dioxide ≤5%. Otherwise consider an increase to characteristic situation 2.	Natural soils with low organic matter content and 'typical' made ground.
2	Low risk	<0.7	Borehole air flow rate not to exceed 70 l/hr. Otherwise consider an increase to characteristic situation 3.	Natural soil with high organic peat/organic content and 'typical' made ground.
3	Moderate risk	<3.5		Old landfill, inert waste and flooded mine working.
4	Moderate to high risk	<15	Quantitative risk assessment required to evaluate scope of protection measures.	Mine working susceptible to flooding and landfill completed to WMP 26B criteria.
5	High risk	<70		Mine working unflooded inactive with shallow workings near surface.
6	Very high risk	>70		Recent landfill site.

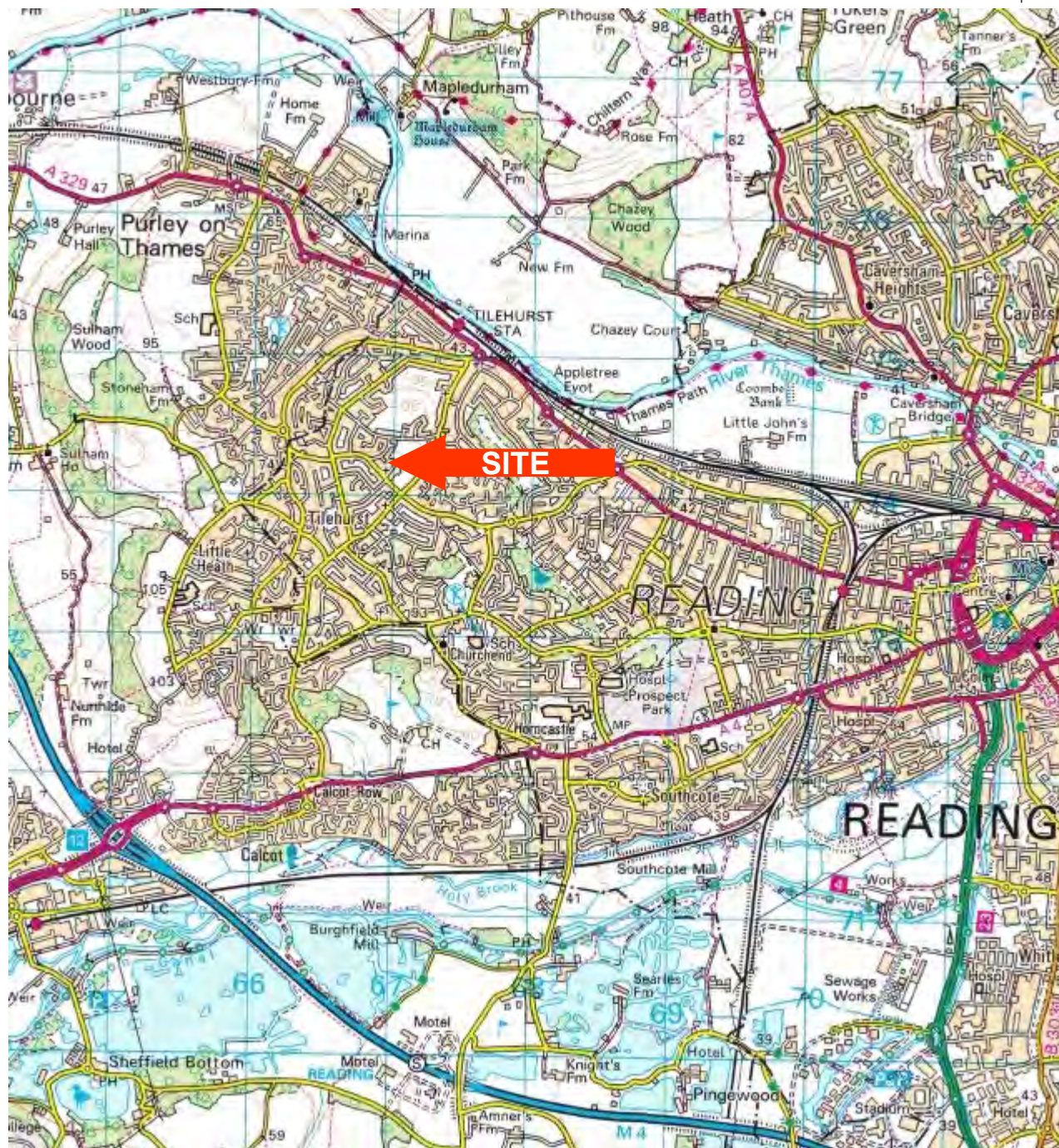
Situation B – Low rise housing with gardens – NHBC ‘Traffic Lights’

The NHBC model for low rise housing development considered a typical residential house with a ground floor area of 64m², suspended floor and ventilated sub-floor void of height 150mm. Where the proposed development of a site is consistent with this model, the NHBC traffic light situation of the site is determined from evaluation of the Gas Screening Value against the criteria in the following table.

Traffic Lights	Methane		Carbon Dioxide	
	Typical maximum concentrations (%)	Gas Screening Value (l/hr)	Typical maximum concentrations (%)	Gas Screening Value (l/hr)
Green	≤1	≤0.16	≤5	≤0.78
Amber 1	1 > to ≤5	>0.16 to ≤0.63	>5 to ≤10	>0.78 to ≤1.56
Amber 2	5 > to ≤20	>0.63 to ≤1.56	>10 to ≤30	>1.56 to ≤3.13
Red	>20	>1.56	>30	>3.13

APPENDIX 1

Site Location Plan

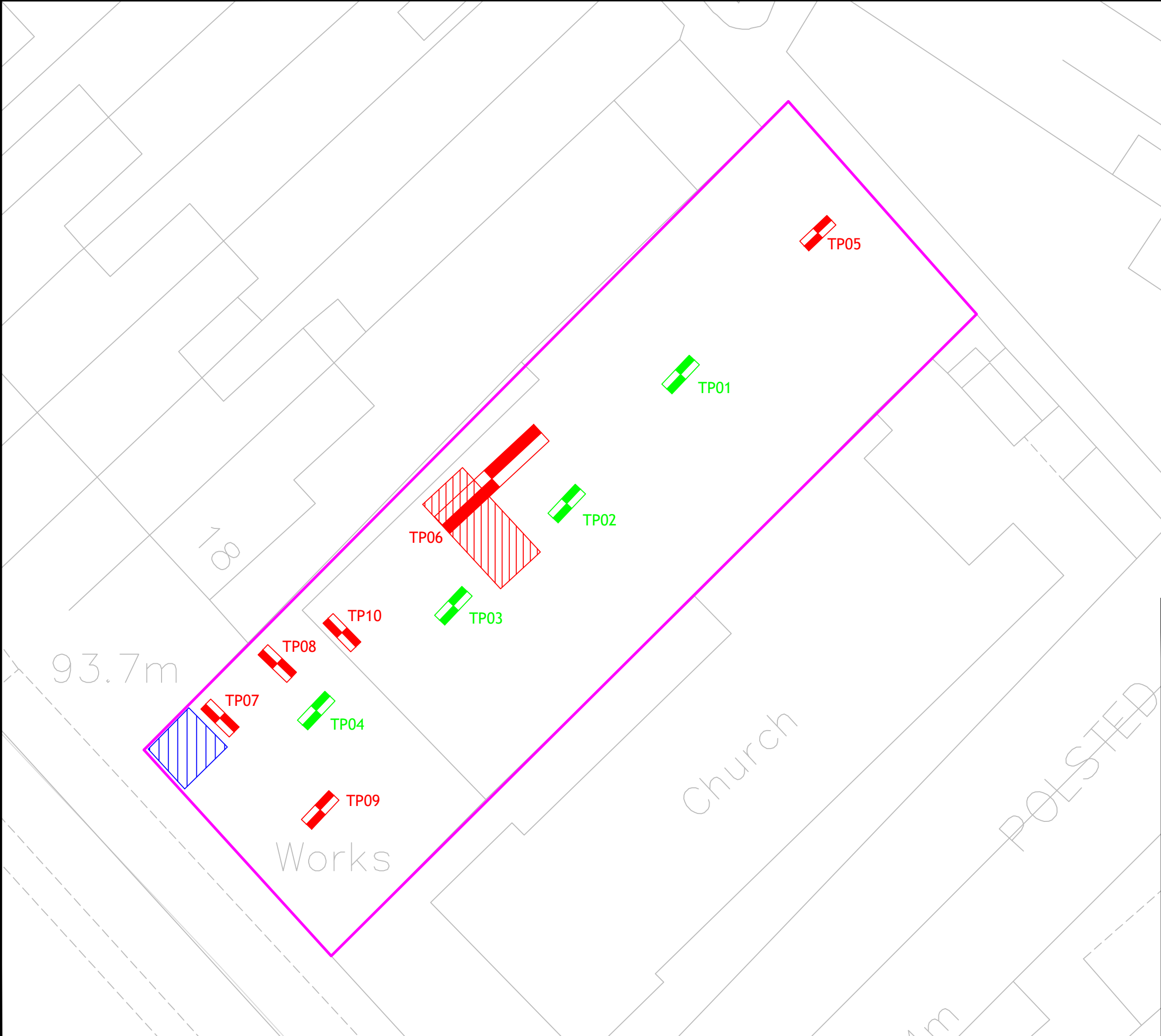


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Not to scale.

Project Title: Armour Road, Tilehurst, Reading
Client: Irongate Property Asset Management Ltd
BRD Reference: BRD210736-OP1-A
Date Issued: July 2016



- Key:
- BRD Trial Pit Location 2007 (Approximate Position)
 - BRD Additional Trial Pit Location (Approximate Position)
 - Site Boundary
 - Waste Oil Tank (Approximate Position)
 - Potential Underground Fuel Tank (Approximate Position)

Notes:

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B	15.1.18	Second Issue: Additional Trial Pits	HKA	BD
A	26.6.07	First Issue	IH	BD
Revision	Date	Description	Drawn	Approved

Drawing title			
EXPLORATORY POINT PLAN			
Project title			
ARMOUR ROAD, READING			
Client			
IRONGATE PROPERTY ASSET MANAGEMENT			
Scale	Original drg. size/colour	Date	
1:200	A3 / C	15.01.2018	
Drawn	Checked	Approved	
HKA	IH	BD	
Drawing Number			Rev
BRD210736-OD1			B



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Remediation Photographs



Plate 1: Waste oil tank concrete chamber following removal of tank. Concrete base broken out and underlying soils exposed.



Plate 2: Photograph showing proximity of concrete chamber to site boundary and public footpath.

Remediation Photographs



Plate 3: Excavation of contaminated soils adjacent to boundary wall looking north east.



Plate 4: Photograph of completed excavation looking south west.

Project Title: Armour Road, Tilehurst, Reading
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BRD Reference: BRD210736-OP6-A
Date Issued: January 2018

Remediation Photographs



Plate 5: Photograph of excavation - Face (F3)



Plate 6: Photograph of excavation looking north east

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Client: Irongate Property Asset Management Ltd
BRD Reference: BRD210736-OP6-A
Date Issued: January 2018

Remediation Photographs



Plate 7: Hand dug pit HD01 confirming placement of 600mm of capping in Plot 4.



Plate 8: Hand dug pit HD02 confirming placement of 600mm of capping in Plot 4

Remediation Photographs



Plate 9: Hand dug pit HD03 undertaken in Plot 2 / 3, confirming 300mm of capping.



Plate 10: Hand dug pit HD04 undertaken in Plot 1, confirming 300mm of capping

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BRD Reference: BRD210736-OP6-A
Date Issued: January 2018

Remediation Photographs



Plate 11: Hand dug pit HD05 undertaken in Plot 3, confirming 300mm of capping.



Plate 12: view of the finished garden Plot 4.

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Client: Irongate Property Asset Management Ltd
BRD Reference: BRD210736-OP6-A
Date Issued: January 2018

Remediation Photographs



Plate 13: Front garden of Plot 3.



Plate 14: Photograph showing garden areas of Plots 1-3 (inclusive).

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BRD Reference: BRD210736-OP6-A
Date Issued: January 2018

Key:

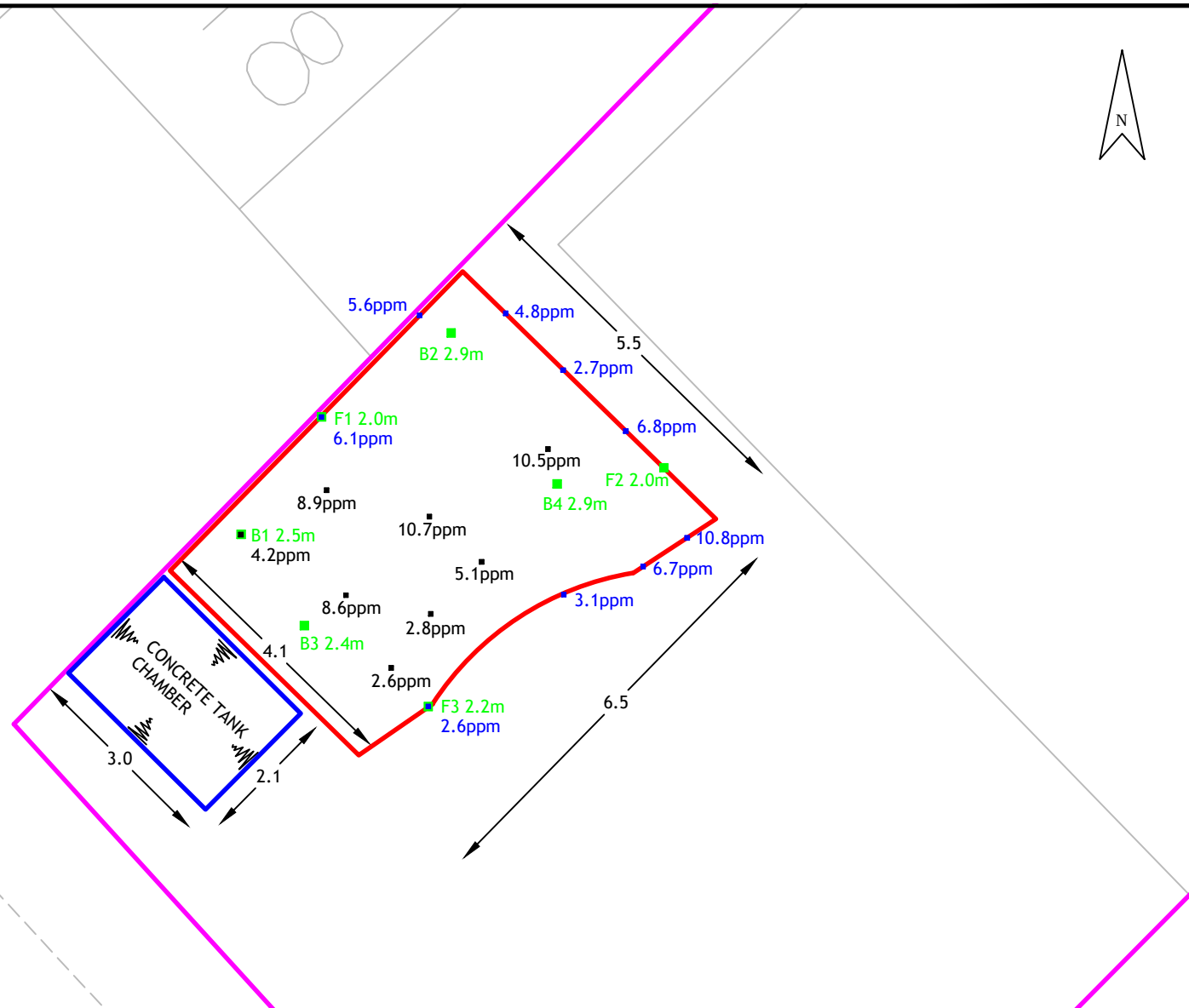
- Contamination Excavation
- F1 2.2m Verification Sample Location
- 0.0ppm PID at the Base of Excavation
- 0.0ppm PID at the Face of Excavation
- Site Boundary

Notes:

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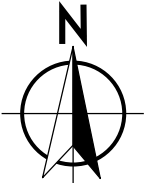
The location of the contamination excavation and concrete chamber have been positioned by tape measurement.

The location of the verification samples and PID measurements are approximate.

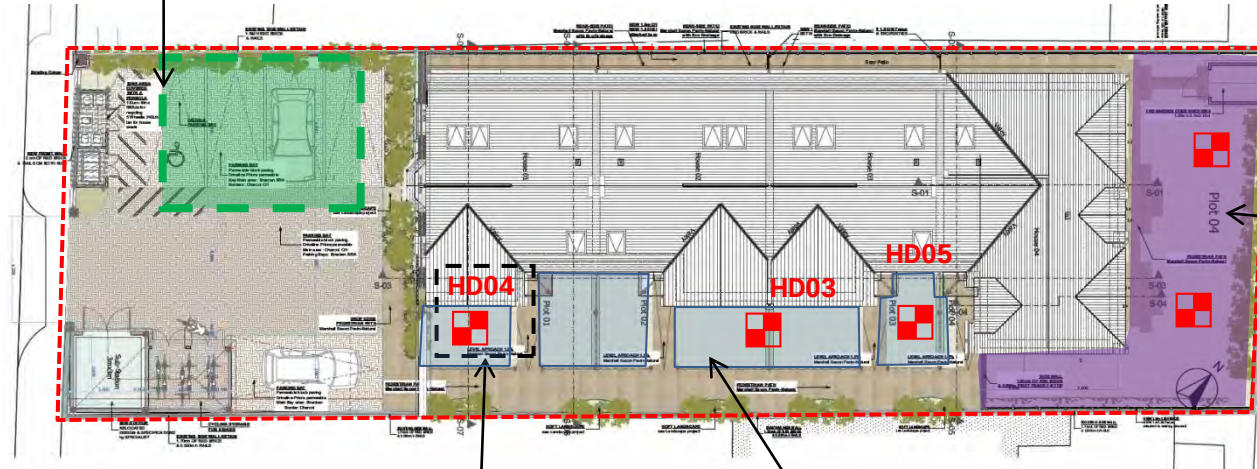


Project title ARMOUR ROAD, READING			Drawing title REMEDIATION EXCAVATION PLAN		
Client IRONGATE PROPERTY ASSET MANAGEMENT					
Scale 1:100	Original drg. size/colour A4 / C	Date 16/01/2018	Drawing Number BRD210736-OD3		
Drawn HKA	Checked IH	Approved BD			
			Rev A		

Remediation Verification Plan



Location of
excavated
hydrocarbon
contamination



HD01

Plot 4 - 600mm
capping applied

HD02

HD05

HD03

HD04

Location of
former sub-
station

Plots 1-3 - Additional investigation
confirmed no contamination.
300mm capping applied regardless

Key:

HD Hand Dug Pit

Site Boundary

Drawing based on The Keen Partnership Drawing ref.

'BR & Condition 02' ref. 8307-BR-11 dated 06-10-14.

Not to scale.

All positions illustrative only

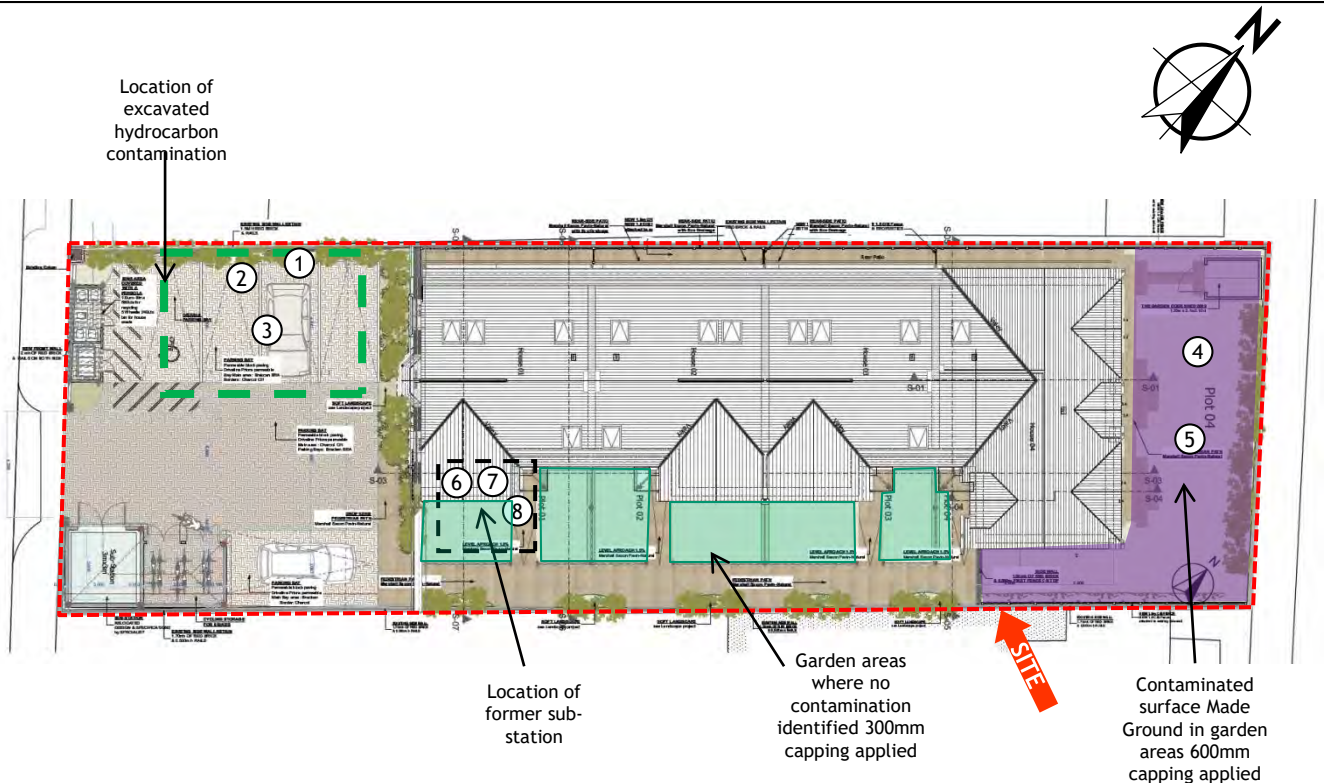
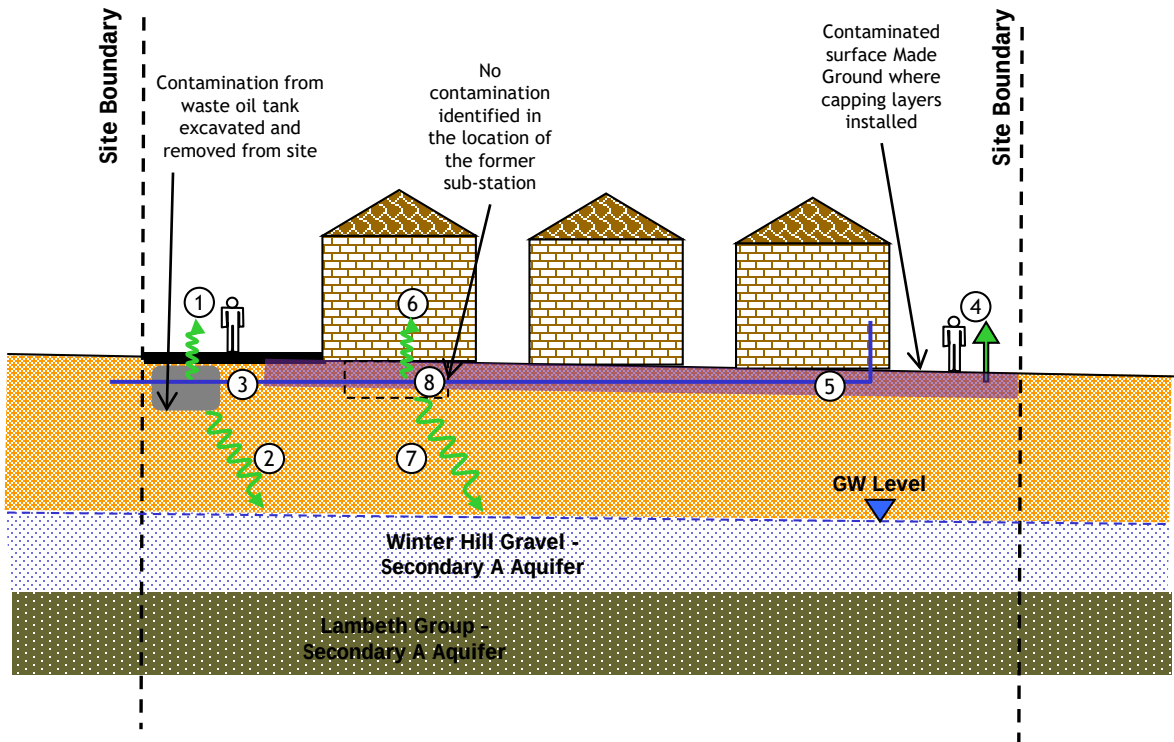
Project Title: Armour Road, Tilehurst, Reading
Client: Irongate Property Asset Management Ltd
BRD Reference: BRD210736-OP4-A
Date Issued: January 2017



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Updated Conceptual Site Model

Proposed Development



Project Title: Armour Road, Tilehurst, Reading
 Client: Irongate Property Asset Management Ltd
 BRD Reference: BRD210736-OP5-A
 Date Issued: January 2017