



Report type	Phase 2 Intrusive Site Investigation
Date	13 October 2021
Client	PAG Developments Limited
Site address	Judy Cross Barn, Water Gate, Quadring, Spalding, PE11 4PY
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Supervised by	Mr Joseph Turner

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1. Introduction

The following document details a Phase 2 Intrusive Site Investigation carried out by Oakshire Environmental, commissioned by PAG Developments Limited. It includes a description of the site location, previous investigations carried out on the site, details of sampling methodology and results of laboratory testing. This information has been used to update the initial conceptual site model of potential sources, pathways and receptors of contamination. A brief overview of the proposed development is also included below.

1.1 Project Overview

The client's proposed project involves the conversion of a barn into residential dwelling and associated works at Judy Cross Barn, Water Gate, Quadring, Spalding, PE11 4PY. A Phase 1 Preliminary Risk Assessment has been carried out by Oakshire Environmental (August 2021). This assessment recommended that an intrusive site investigation should be carried out. Oakshire Environmental have carried out a Phase 2 Intrusive Site Investigation, as described below.

1.2 Purpose of Investigation

The objectives of the Phase 2 Intrusive Site Investigation were to:

- Identify and assess the nature and extent of contamination risk at the site.
- Assess the requirement for further investigations, remediation or mitigation measures, based on the identified contamination risk.

1.3 Scope of Work

- In order to identify the nature and extent of contamination, 4 x samples were taken by the client, from a depth of 0.3m and analysed for Metals (As, Be, Cd, Co, Cu, Fe, Hg, Pb, Ni, Mn, Se, V, Zn), Chromium (III & VI), Cyanide, Phenols, PAHs, BTEX & MTBE, TPH CWG (Aliphatic/ Aromatic), pH and Organic Matter in a UKAS accredited laboratory.
- Borehole logs were produced as part of the sampling process to assess ground conditions encountered at the site, this information has been used to inform recommendations and conclusions.
- Results of laboratory testing have been assessed with reference to suitable screening values, including LQM/CIEH Suitable 4 Use Levels (S4ULs), CL:AIRE Category 4 Screening Levels (C4SLs) and Generic Assessment Criteria (GAC), to assess the risk to human health and the environment, taking into account the site's proposed residential use.
- Results have been used to update the Conceptual Site Model, produced as part of the Phase 1 Preliminary Risk Assessment, to identify potential pollutant linkages at the site, in order to determine the need for remediation or further investigation.
- Supporting appendix includes photographs of the site, sampling locations and depths and maps of the site.
- Sample locations and depths have been chosen to allow identification of spatial variability on the site and provide adequate sampling of proposed use areas, taking into account proposed development at the site.
- Site investigations have been carried out, by professional Environmental Consultants with BSc (Hons) in Environmental Science or above, in accordance with the Environment Agency's Land Contamination: Risk Management (LCRM) guidelines as updated from Environment Agency's Model Procedures for the Management of Land Contamination (CLR11) framework.

1.4 Limitations

Quantum Intelligent Trading Ltd is previously and hereafter referred to as “Oakshire Environmental” or “the company”. Oakshire Environmental has exercised such professional skill, care and diligence as may reasonably be expected of a properly qualified and competent consultant when undertaking works of this nature. This report is only valid when used in its entirety and any information or advice contained within the report should not be relied upon until considered in the context of the whole report. Oakshire Environmental disclaims any responsibility to the client and others in respect of any matters outside the scope of this work. Any comments made on the basis of information obtained from the client or other third parties are given in good faith on the assumption that the information is accurate. This report has been prepared solely for the benefit of the client and any other party using or placing reliance upon any information contained in this report does so at their own risk. Oakshire Environmental accepts no responsibility or liability for the contents of this report being used for any purpose or project for which it was not commissioned. Oakshire Environmental accepts no liability whatsoever for any loss or damage arising from the interpretation or use of the information contained within this report. Furthermore, Oakshire Environmental does not accept any liability for the consequences of any legislative changes or the release of subsequent guidance documentation and following delivery of the report has no obligation to advise the client or any other party of such changes or their repercussions.

This report excludes consideration of potential hazards arising from any activities at the site other than normal use and occupancy for the intended land uses. Hazards associated with any other activities have not been assessed and must be subject to a specific risk assessment by the parties responsible for those activities. Oakshire Environmental does not warrant or guarantee that the site is free of hazardous or potentially hazardous materials or conditions. It should be noted that this report has been produced for environmental purposes only.

Oakshire Environmental cannot be held responsible for incorrect analysis of samples as the laboratory analysis presented in this report was carried out by Chemtech Environmental Ltd. The information and conclusions provided in this report are limited to, and representative of, the samples taken and cannot be extended to apply to the whole site, in addition, Oakshire Environmental cannot guarantee the accuracy of analysis for samples not taken at the source by the company or those which deviate due to exceedance of holding time or inappropriate sampling practises. The findings and/or recommendations of this report do not take into account any conditions that may be present but have hitherto not been encountered and as such further investigation and/or a reconsideration of the findings of this report should be undertaken if such conditions are subsequently encountered or an alternative development plan or land use is subsequently proposed.

2. Site Description

The site is located on the corner of Water Gate and Green Lane to the north east of the village of Quadring in South Holland and is approximately 1,350m². There is a brick barn building at the south of the site with a pile of crushed limestone to the west of this building and a concrete base with some wooden pallets to the north. The barn building is unused and contains some old wood and metal products, broken concrete and brick rubble. Adjacent to the building is a water tank and some concrete blocks. The remainder of the site is covered by grass and shrubs.

The site is bordered by an agricultural field to the north and east, Water Gate to the south and Green Lane to the west. A land drain curtails the south and west boundaries of the site. The surrounding area is predominantly agricultural with some residential dwellings in the vicinity, including just south of Water Gate and 150m east of the site. There are no woodlands, ancient monuments or archaeological sites within 500m of the site.

National Grid Reference: 523345 333676

3. Previous Investigations

A Phase 1 Preliminary Assessment has been carried out by Oakshire Environmental in August 2021. This assessment considered there to be a low to moderate risk to human health from contamination potentially present at the site due to its past use as a corn mill. The assessment recommended further investigation in the form of a Phase 2 Intrusive Site Investigation to include sampling of shallow soil for a suite of contaminants including heavy metals and hydrocarbons.

Based on the findings of the Phase 1 Preliminary Risk Assessment, sampling of shallow soil at the site has been carried out and tested for a comprehensive suite of contaminants including Metals (As, Be, Cd, Co, Cu, Fe, Hg, Pb, Ni, Mn, Se, V, Zn), Chromium (III & VI), pH, Cyanide, Phenols, Organic Matter, Polycyclic Aromatic Hydrocarbons (PAH), BTEX and Total Petroleum Hydrocarbons (TPH).

4. Methodology

4.1 Sampling Work

Boreholes were dug at the locations shown on plans in the appendix, to a depth of 0.3m. Soil conditions were noted through the process in order to produce borehole logs.

Soil samples were collected using a trowel and soil was then placed into sample containers. Samples collected for VOC analysis were filled as much as possible to minimise air spaces, as volatile compounds can be lost into these spaces. Sampling equipment was wiped clean between sample locations to minimise cross contamination.

4.2 Sampling Strategy

Four samples were considered to be a sufficient sample size, based on the size of the site and the levels of contamination expected. Locations were chosen to focus on the area of concern outlined in the previous investigation while providing coverage of the whole site.

The sample depth of 0.3m has been chosen as this depth will represent the depth that is most likely to impact site users through inhalation, ingestion and dermal contact pathways while avoiding distorted results that may arise from sampling the soil surface.

4.3 Health & Safety

When collecting soil samples on a potentially contaminated site it must be assumed that the soil is contaminated in order to protect the health of the assessor. Protective rubber gloves were worn at all times as well as substantial footwear. Equipment was washed thoroughly before and after use and kept in a container when transported to avoid the spread of any possible contamination. Sample containers were packed with biodegradable fill for protection and placed in a sealed plastic container for transportation to the laboratory.

5. Ground Conditions

The following table summarises the ground conditions observed during sampling work. Groundwater was not encountered.

Table 1: Ground conditions encountered at sample locations

Depth	PD01	PD02	PD03	PD04
0.1m	Clayey Loam with	Clayey Loam with brick fragments and roots	Clayey Loam with Gravel, brick fragments and roots	Loam with roots
0.2m				
0.3m	Clayey Loam with Gravel and roots	Clayey Loam with Gravel	Clayey Loam with roots	Clayey Loam with roots

6. Evaluation of Results

6.1 Screening Levels

Results of laboratory testing of soil samples were analysed by comparing them to industry standard screening levels used for risk assessments. Screening levels used include the DEFRA Category 4 Screening Levels (C4SLs) based on Low Level of Toxicological Risk and the LQM/CIEH S4ULs for Human Health Risk Assessment. These levels cover multiple Soil Organic Matter (SOM) contents (1%, 2% and 6%) and assume a pH of 8. The 'residential with plant uptake' screening values were used to assess results. This land use considers direct soil and indoor dust ingestion and inhalation, skin contact with soils and dust, inhalation of vapours and ingestion of homegrown produce as exposure pathways. These levels take a conservative approach to assessing potential risk and concentrations below these screening values can be considered to represent 'uncontaminated conditions' which pose 'LOW' risk to human health based on the proposed land use.

It is important to note that exceedance of a relevant screening value does not necessarily constitute evidence of either a 'significant possibility of significant harm' or the need for remediation under the UK's planning regimes. Rather such exceedance should usually trigger a further detailed quantitative risk assessment, where site-specific parameters are used to derive site-specific assessment criteria. Common sense tells us, and a robust risk evaluation reveals, that a gross exceedance is a good indicator that an unacceptable risk is present.

6.2 Results

Table 2: Results of chemical testing for samples taken on 26th September 2021

Sample ID			PD01	PD02	PD03	PD04
Depth (m)			0.3	0.3	0.3	0.3
Test	Method	Units				
Arsenic (total)	CE127 ^M	mg/kg As	41	26	13	12
Beryllium (total)	CE127 ^U	mg/kg Be	1.2	1.1	2.0	<1
Cadmium (total)	CE127 ^M	mg/kg Cd	0.2	<0.2	<0.2	<0.2
Chromium (total)	CE127 ^M	mg/kg Cr	48	69	49	56
Chromium (III)	CE208	mg/kg CrIII	48	69	49	56
Chromium (VI)	CE146	mg/kg CrVI	<1	<1	<1	<1
Cobalt (total)	CE127 ^M	mg/kg Co	8.8	10	9.1	10
Copper (total)	CE127 ^M	mg/kg Cu	47	33	30	11
Iron (total)	CE127	mg/kg Fe	26233	30466	25697	25767
Lead (total)	CE127 ^M	mg/kg Pb	394	186	73	30
Manganese (total)	CE127	mg/kg Mn	420	760	573	729
Mercury (total)	CE127 ^M	mg/kg Hg	<0.5	<0.5	<0.5	<0.5
Nickel (total)	CE127 ^M	mg/kg Ni	22	29	22	24
Selenium (total)	CE127 ^M	mg/kg Se	1.3	1.3	1.5	1.1
Vanadium (total)	CE127 ^M	mg/kg V	46	52	49	50
Zinc (total)	CE127 ^M	mg/kg Zn	95	121	65	52
pH	CE004 ^M	units	7.6	8.0	7.8	8.2
Cyanide (free)	CE077	mg/kg CN	<1	<1	<1	<1

Phenols (total)	CE078	mg/kg PhOH	<0.5	<0.5	<0.5	<0.5
Total Organic Carbon	CE072 ^M	% w/w	3.8	2.0	2.4	0.9
PAH						
Naphthalene	CE087 ^M	mg/kg	0.08	0.02	0.03	<0.02
Acenaphthylene	CE087 ^M	mg/kg	0.44	0.07	0.04	<0.02
Acenaphthene	CE087 ^M	mg/kg	0.11	0.03	<0.02	<0.02
Fluorene	CE087 ^U	mg/kg	0.39	0.05	<0.02	<0.02
Phenanthrene	CE087 ^M	mg/kg	4.50	0.83	0.22	<0.02
Anthracene	CE087 ^U	mg/kg	0.72	0.18	0.04	<0.02
Fluoranthene	CE087 ^M	mg/kg	5.88	1.72	0.46	<0.02
Pyrene	CE087 ^M	mg/kg	4.94	1.50	0.40	<0.02
Benzo(a)anthracene	CE087 ^U	mg/kg	2.33	0.75	0.24	<0.02
Chrysene	CE087 ^M	mg/kg	2.60	0.89	0.33	<0.03
Benzo(b)fluoranthene	CE087 ^M	mg/kg	2.80	1.09	0.39	<0.02
Benzo(k)fluoranthene	CE087 ^M	mg/kg	1.02	0.39	0.14	<0.03
Benzo(a)pyrene	CE087 ^U	mg/kg	2.16	0.82	0.28	<0.02
Indeno(123cd)pyrene	CE087 ^M	mg/kg	1.65	0.67	0.23	<0.02
Dibenz(ah)anthracene	CE087 ^M	mg/kg	0.33	0.13	0.06	<0.02
Benzo(ghi)perylene	CE087 ^M	mg/kg	1.47	0.58	0.24	<0.02
PAH (total of USEPA 16)	CE087	mg/kg	31.4	9.74	3.09	<0.34
BTEX & TPH						
Benzene	CE192 ^U	mg/kg	<0.01	<0.01	<0.01	<0.01
Toluene	CE192 ^U	mg/kg	<0.01	<0.01	<0.01	<0.01
Ethylbenzene	CE192 ^U	mg/kg	<0.01	<0.01	<0.01	<0.01
m & p-Xylene	CE192 ^U	mg/kg	<0.02	<0.02	<0.02	<0.02
o-Xylene	CE192 ^U	mg/kg	<0.01	<0.01	<0.01	<0.01
VPH Aromatic (>EC5-EC7)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01
VPH Aromatic (>EC7-EC8)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01
VPH Aromatic (>EC8-EC10)	CE067	mg/kg	<0.01	<0.01	<0.01	<0.01
EPH Aromatic (>EC10-EC12)	CE068	mg/kg	<1	<1	<1	<1
EPH Aromatic (>EC12-EC16)	CE068	mg/kg	<1	<1	<1	<1
EPH Aromatic (>EC16-EC21)	CE068	mg/kg	17	5	2	<1
EPH Aromatic (>EC21-EC35)	CE068	mg/kg	14	6	3	<1
EPH Aromatic (>EC35-EC44)	CE068	mg/kg	2	<1	<1	<1
VPH Aliphatic (>C5-C6)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1
VPH Aliphatic (>C6-C8)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1
VPH Aliphatic (>C8-C10)	CE067	mg/kg	<0.1	<0.1	<0.1	<0.1

EPH Aliphatic (>C10-C12)	CE068	mg/kg	<4	<4	<4	<4
EPH Aliphatic (>C12-C16)	CE068	mg/kg	<4	<4	<4	<4
EPH Aliphatic (>C16-C35)	CE068	mg/kg	69	13	<4	<4
EPH Aliphatic (>C35-C44)	CE068	mg/kg	<10	<10	<10	<10

6.3 Summary of Results

- Arsenic and Lead concentrations exceeded the residential screening values in sample PD01
- Beryllium concentration exceeded the residential screening values in sample PD03
- pH is slightly alkaline in all four samples
- Cyanide (free) and Phenols (total) concentrations are all below the laboratory limit of detection suggesting they may not be present at all
- Total Organic Carbon values were low in all samples, particularly sample PD04
 - Soils with higher organic matter content will limit the leaching of hydrocarbons through the soil as these organic contaminants will adsorb to organic matter particles
- One PAH (*Dibenz(ah)anthracene*) exceeded the residential screening values in sample PD01
 - PAHs are often present in made ground deposits and they are also the by-products of exhaust emissions from vehicles and can, therefore, build up to high concentrations near roads.
- There were no exceedances of the screening values for BTEX and TPHs and most of the more volatile fractions were below the laboratory limit of detection
 - These substances are used in various oil and fuel products such as petrol, diesel and lubricant oils
 - These contaminants often impact soils where fuel and oils are stored such as garages and agricultural sites

6.4 Risk Assessment Methodology

The potential level of risk posed by a particular source is determined by assessing the severity of the impact of the contaminant linkage on the receptor, if it is assumed to be present, and the probability of the contaminant linkage being present.

Severities are categorised from Minor to Severe and probabilities are categorised from Unlikely to High Likelihood to give a potential level of risk output.

Table 4: Risk Matrix

Probability	Severity of Consequence			
	Severe	Medium	Mild	Minor
High Likelihood	Very High Risk	High Risk	Moderate Risk	Low / Moderate Risk
Likely	High Risk	Moderate Risk	Low / Moderate Risk	Low Risk
Low Likelihood	Moderate Risk	Low / Moderate Risk	Low Risk	Very Low Risk
Unlikely	Low / Moderate Risk	Low Risk	Very Low Risk	Very Low Risk

Very High Risk

There is a high probability that severe harm could arise to a designated receptor from an identified source; or there is evidence that severe harm to a designated receptor is currently happening.

High Risk

Harm is likely to arise to a designated receptor from an identified source.

Moderate Risk

It is possible that harm could arise to a designated receptor from an identified source. It is relatively unlikely that any such harm would be severe or if any harm were to occur it is more likely that the harm would be relatively mild.

Low Risk

It is possible that harm could arise to a designated receptor from an identified source, however, it is likely that this harm, if realised, would normally be mild.

Very Low Risk

There is a low possibility that harm could arise to a receptor. In the event of such harm being realised it is not likely to be severe.

6.5 Conceptual Site Model

Laboratory testing of soil samples at the site identified elevated concentrations of heavy metals and PAHs at the west of the site. A Conceptual Site Model has been produced to reflect these findings.

Table 5: Conceptual site model

Sources	Pathways	Receptors	Severity	Probability	Potential Level of Risk	
Heavy metals and PAHs at the west of the site	Ingestion/inhalation of contaminated soil dust Dermal contact with contaminated soil Ingestion of homegrown produce Permeation into drinking water pipes	Residential end users	Medium	Likely	Moderate	Concentrations of heavy metals and PAHs at the west of the site were identified above the residential screening values, suggesting that these soils are not suitable for a residential site and pose an unacceptable risk to human health. There are multiple pathways that will exist between contaminants in the soil and residential end users in soft landscaped areas at the west of the site. Contamination is likely to be due to elevated concentrations of contaminants in made ground.
	Leaching through soil Surface runoff	Controlled waters	Mild	Low Likelihood	Low	Leaching of contaminants through soil is unlikely and the underlying geology is unproductive so the risk to groundwater is considered to be low. Contamination of surface waters in the nearby land drains may be caused by surface runoff from contaminated soil on the site, however, this is not likely to pose a significant risk to human health or the environment.

6.6 Recommendations

Based on laboratory testing of soil samples from the site and the updated Conceptual Site Model, soft landscaping areas at the west of the site are not considered suitable for residential use, based on the currently proposed development. It is expected that contamination is largely limited to made ground material, however, remediation should be implemented to mitigate the risk to residential end users.

In order to identify and assess suitable remediation options, a Phase 3 Remediation Options Appraisal and Strategy should be carried out, to include analysis of suitable remediation options.

It should also be noted that in order to ensure regulatory compliance, Waste Classification & WAC testing of excavated material from the site, produced as part the remediation work or construction process, may be required prior to off-site disposal.

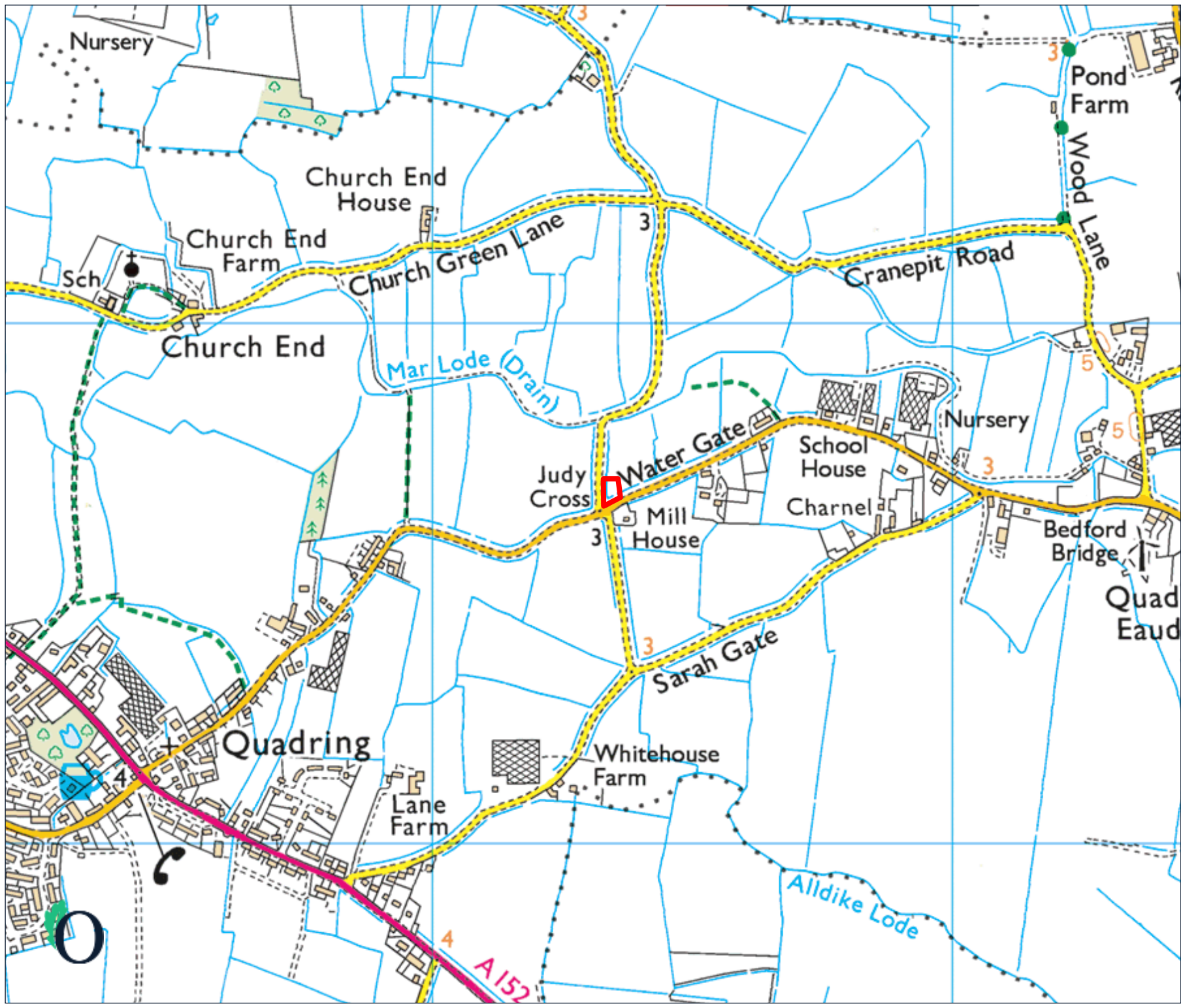
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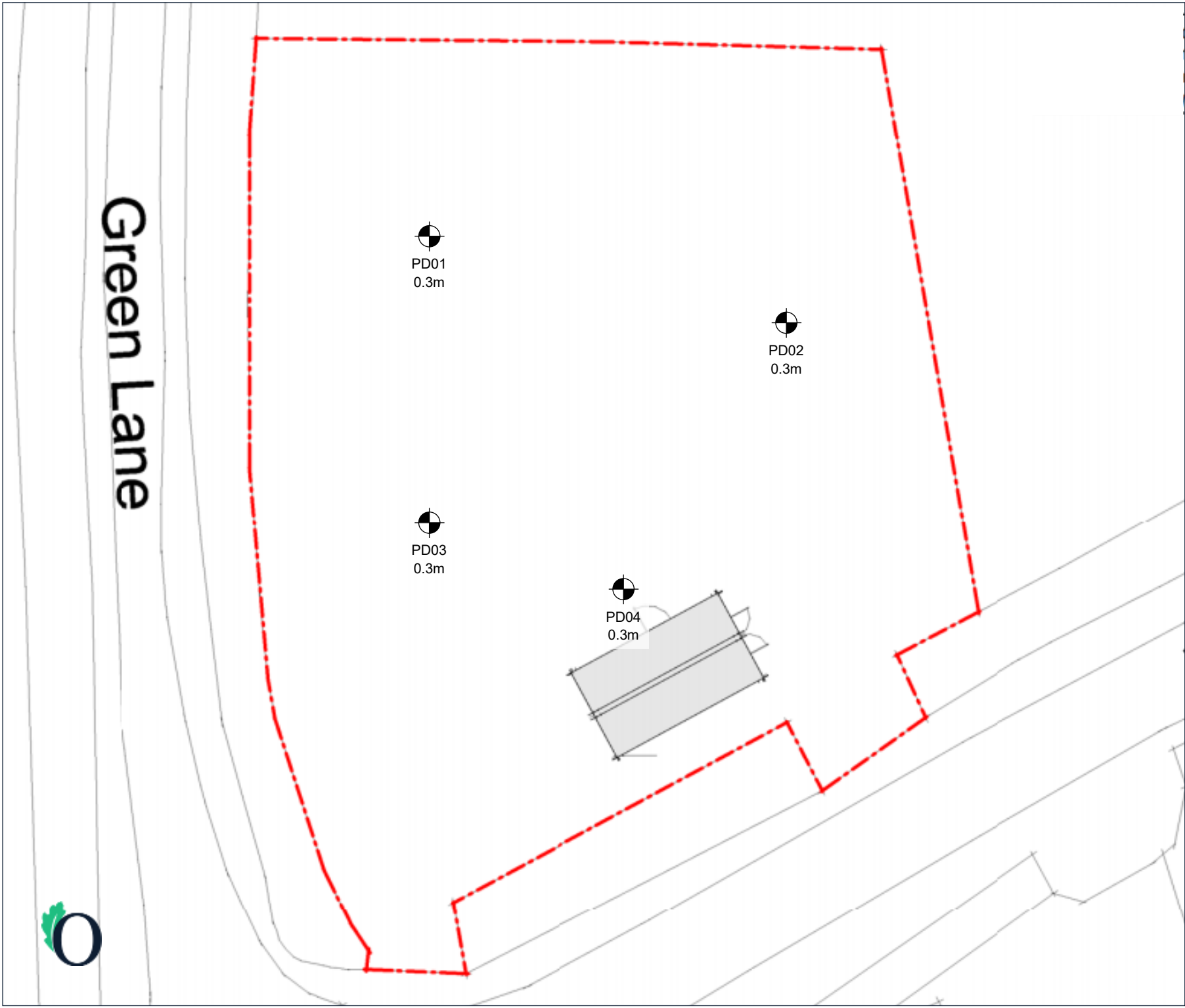
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Appendix A - Site Maps & Plans	
Description	
OS location plan	
Sources	
Contains OS data © Crown copyright and database rights 2021	
Key	
	Site boundary
Name	Figure 1





Appendix A - Site Maps & Plans	
Description	
Existing block plan	
Sources	
Remway Design Ltd	
Key	
	Site boundary
	Sample location
Name	Figure 2





Appendix A - Site Maps & Plans	
Description	
Proposed block plan	
Sources	
Remway Design Ltd	
Key	
	Site boundary
	Sample location
Name	Figure 3





Description

Sources

Key

[illegible]

Figure 4



Appendix B - Site Photos

Description

Photo of borehole for sample PD01

Sources

Key

Name

Figure 5



Appendix B - Site Photos

Description

Photo of location of sample PD02

Sources

Key

Name

Figure 6



Appendix B - Site Photos

Description

Photo of borehole for sample PD02

Sources

Key

Name

Figure 7



Appendix B - Site Photos

Description

Photo of location of sample PD03

Sources

Key

Name

Figure 8



Appendix B - Site Photos		
Description		
Photo of borehole for sample PD03		
Sources		
Key		
Name		Figure 9



Appendix B - Site Photos

Description

Photo of location of sample PD04

Sources

Key

Name

Figure 10



Appendix B - Site Photos

Description

Photo of borehole for sample PD04

Sources

Key

Name

Figure 11