

Foundation Works Risk Assessment

Weldale Street,
Reading

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CONTENTS

1	INTRODUCTION	3
1.1	General	3
1.2	Scope and Objectives	3
1.3	Proposed Development	3
1.4	Sources of Information	4
1.5	Limitations	4
2	SITE OVERVIEW	6
2.1	General	6
2.2	Site Description	6
2.3	Ground Conditions Encountered	6
2.4	Groundwater	8
2.5	Hydrological Setting	9
2.6	Contamination	9
2.7	Conceptual Site Model	11
3	FOUNDATIONS	13
3.1	Foundation Solution	13
3.2	Basis of Assessment	13
3.3	Characteristics of Piling Method	13
3.4	Potential Foundation Risks	13
4	CONCLUSIONS AND RECOMMENDATIONS	17

FIGURES

- Figure 1. Site Location Plan
Figure 2. Exploratory Hole Location Plan

APPENDICES

- APPENDIX A Combined General Arrangements
APPENDIX B Piling Layout of Block A1 and Block A2

1 INTRODUCTION

1.1 General

Fairhurst have been appointed by Ropemaker Properties Ltd. (The Client) to undertake a Foundation Works Risk Assessment for the proposed development of a site, located at Weldale Street, Reading, at approximate postcode RG1 7BZ. A site location plan is provided as Figure 1 and development plans provided in Appendix A.

1.2 Scope and Objectives

The development is subject to Reading Borough Council Planning Permission ref: 170326, dated 15th March 2018 and is subject to a number of planning conditions pertaining to contaminated land and groundworks piling.

Condition 36 - Piling or any other foundation designs using penetrative methods shall not be permitted other than with the express written consent of the LPA, which may be given for the part of the site that there is no resultant unacceptable risk to groundwater. The development shall be carried out in accordance with the approved details.

A number of investigations and assessments (see Section 1.4) were carried out at the site, the findings of which were summarised in a Geotechnical and Geo-Environmental Ground Investigation Report (112990/R5, June 2019), with the aim to support discharge of contaminated land conditions 21, 22, 23.

A Remediation Option Appraisal & Strategy was prepared by Fairhurst and submitted in August 2019 to the Local Authorities in order to discharge Conditions 18.

With reference to the Reading Borough Council Planning Portal, the aforementioned reports have all been approved, as detailed in planning condition discharge notice 191011, dated August 2019.

This Foundation Works Risk Assessment has been prepared for submission to and approval by the Local Planning Authority to support discharge of Condition 36.

This report therefore provides an assessment of the potential risk of penetrative foundations forming viable preferential pathways to Controlled Water receptors, potentially resulting in 'unacceptable risks to groundwater'. Where unacceptable risks are determined, recommendations for mitigation measures are to be provided. It includes outline of proposed piling methods and recommendations for groundwater monitoring prior and during the piling operations.

This report includes the following information:

- A brief summary review of the findings of the geo-environmental quantitative risk assessment, reported under separate cover (Fairhurst report references 112990/R4 and 112990/R5) for the site and proposed development;
- A review of the proposed foundation solutions and the characteristics of piled foundations in the context of the site conditions and potential risk to Controlled Waters;
- Conclusions and recommendations, including appropriate mitigation measures for the construction of foundations at the site.

1.3 Proposed Development

Development proposals for the site comprises the demolition of all existing buildings (including 3 retail units) and structures and the erection of new buildings ranging between lower ground & 4 storeys to lower ground & 11 storeys in height. The proposed development is understood to provide 427 (233x1, 182x2 & 12x3-bed) residential units (Class C3) and 1 flexible ground floor retail shop (Class A1) or

restaurant and cafe (Class A3) unit, together with new public realm, landscaping, accesses, parking and associated works.

Foundation solutions are considered to include piling, with continuous flight auger (CFA) likely to be the most suitable piling technique for this site. Soft landscaping is proposed, concentrated in central, eastern and southern sections of the site. Proposed development plan is presented in Appendix A.

It is understood that only the western portion of the site (Block A1 and Block A2 within Appendix A) is currently subject to development. The remaining eastern portion of the site may be developed at a later date.

Notwithstanding this, this risk assessment has been prepared for the construction of piled foundations all phases of development. Should a piling technique alternative from CFA be adopted during the development phases, a revised Piling Risk Assessment will be submitted.

1.4 Sources of Information

The following existing information and documents have been reviewed and form the basis of the assessment:

- Reading Borough Council Planning Portal (April 2019, Ref: 170326);
- Phase II Geo-Environmental Ground Investigation Report by Fairhurst (January 2017 Ref. 112990/R4);
- Geotechnical and Geo-Environmental Ground Investigation Report by Fairhurst (June 2019 Ref. 112990/R5).
- Remediation Options Appraisal & Strategy, Weldale Street, Reading. Prepared by Fairhurst in August 2019.

In addition to the ground investigation and risk assessment reports mentioned above, the following site specific reports and industry guidance has been utilised in the preparation of this report.

This report has been prepared utilising the following site specific reports and industry guidance:

- Environment Agency, National Groundwater and Contaminated Land Centre, *Piling into contaminated sites*, February 2002;
- Environment Agency, National Groundwater and Contaminated Land Centre, *Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention*, May 2001, Reference NC/99/73;
- Groundwater Protection Collection (previously covered by GP3), available: <https://www.gov.uk/government/collections/groundwater-protection>;

1.5 Limitations

As detailed above, Fairhurst have prepared a Geotechnical and Geo-Environmental Ground Investigation Report (112990/R5, June 2019) and submitted it to the Local Planning Authority (Reading Borough Council) in support of discharge of planning condition 21, 22 and 23. A Remediation Options Appraisal & Strategy Remediation was also submitted with the aim to discharge planning conditions 18.

It should be noted that this report has been prepared based on the findings and conclusions of the geo-environmental risk assessments contained in the aforementioned reports. If any revisions are made to risk assessments, or proposed piling methods, either during the planning condition consultation process or at a later stage due to alterations in design and/or due to unexpected ground conditions, this foundation risk assessment should be reviewed and amended as necessary.

The risk assessment has been prepared based on information regarding piling type and methods provided by others available at the time of writing. If any other piling or penetrative foundation methods are proposed, e.g. for retaining structures, this risk assessment should be reviewed and, if necessary, updated.

2 SITE OVERVIEW

2.1 General

The following sections provide a brief summary of the previous reporting findings for ease of reference. However, the Geotechnical and Geo-Environmental Ground Investigation Report (112990/R5) and the reports referred to therein (detailed in Section 1.4) should be referred to for full details.

2.2 Site Description

The site is centred on National Grid Reference 471020 173610 and comprises a relatively level and roughly rectangular parcel of land of area of approximately 1 hectare. Situated off the south of Weldale Street, Reading RG1 7BZ, the site is accessible via a gate located on Weldale Street, which bounds the site to the north. The site boundary is provided on Figures 1.

The site is currently occupied by a vacant Iceland supermarket warehouse and associated delivery yard (central northern and north-eastern portion of the site respectively), a vacant single storey warehouse (central southern and south-eastern portions of the site), car parking in the western third of the site with a dual storey parking present in the far western portion.

Chatham Street runs east to west to the south of the site and is bisected from the site by an area of soft landscaping and a public footpath. To the west, the site is bounded by residential dwellings and to the east a parade of vacant shops, beyond which is the A329, which runs south to north at this location.

The existing site layout within the exploratory hole locations is included as Figure 2.

Based on the findings of the Geotechnical and Geo-Environmental Preliminary Risk Assessment, the site is understood to have initially comprised residential housing (1879-1862), later commercial units including a garage and a bus depot (1957-1988) on the eastern boundary and in the central - northern portion of the site respectively. The site layout has been altered between 1986 and 1993 to include other commercial buildings and car park areas with no apparent further changes in the latest years. The site has included an electricity sub-station.

2.3 Ground Conditions Encountered

Ground conditions encountered during the historical ground investigations and as part of the recent Fairhurst GIR (112990/R5, 2019) were found to be in keeping with the anticipated published geology, as summarised below.

Made Ground

All exploratory holes on-site encountered hardstanding as concrete/rebar/tarmacadam/block paving/red brick to proven depths of 42.92 – 39.79mAOD with an average thickness of approximately 0.22m across the site.

Made Ground was encountered below the hardstanding principally as gravelly sand/occasional sandy gravel with inclusions of flint, concrete, brick fragments, tile, chalk, sandstone and steel.

Cohesive Made Ground was noted within TP102, BH4B, WS4, WS5, WS8, WS9, BHD1, WSF & TTA and was principally encountered as 0.30 – 1.21m thick bands between the granular Made Ground, with the exception of WS9, where a thickness of 2.50m is recorded. The cohesive Made Ground was typically recorded as sandy gravelly clay with inclusions of flint, concrete, brick fragments, tile, and chalk.

The Made Ground encountered across the three site investigations was encountered to proven depths of 42.00 – 38.04mAOD and was typically between 0.20 – 1.30m in thickness, with limited difference in spatial distribution and no particular trend across the site.

Taplow Gravel Member

The Taplow Gravel Member was encountered locally within the north-western (BH1, BH102A, WS103B, WSG, WSIC, TP103 & WS104A, north-eastern (BH4B & TP102) and south-eastern (WS5 & WS8) areas of the site to proven depths of 36.00 – 41.70mAOD. Elsewhere, where obstructions were not encountered, this strata was found to be absent and the Made Ground was underlain by the White Chalk Subgroup.

Overall, the Taplow Gravel Member is shown to comprise both cohesive and granular material in varying proportions/thickness throughout the site.

White Chalk Subgroup

The White Chalk Subgroup was encountered in all exploratory hole locations where they could be advanced to a sufficient depth. Within the cable percussive/windowless sampling boreholes, this strata was principally logged as off white chalk, recovered as sandy/gravelly clay or silt, with the exceptions of BHB, BHC, BHE & BHF where the strata was recovered as silty sandy fine to coarse gravel from depths of 5.00 – 12.50m bgl. There is no clear pattern shown relating to the locations of Grade Dm and Grace Dc structureless chalk across the site.

Structureless chalk was generally recorded at depths of between 36m AOD to 41.70m AOD across the site with structured chalk below these levels to the full depths of drilling (between 11.07m to 1.27m AOD).

In BHB a 1.45m thick band of Grade Dc structureless chalk was encountered at depths of between 26.84 – 25.39mAOD interbedded within the structured chalk. Rotary core loss occurred in BHA between 39.36 – 36.26mAOD and within BHC from 24.65 – 22.65mAOD and 15.65 – 14.65mAOD. This was also attributed to the presence of more weathered structureless chalk at these locations and the result of flint becoming stuck in the rotary drill bits. No other apparent voids were encountered within the boreholes. Overall, findings from the ground investigation show levels of the top of the chalk and the thickness of structureless chalk to be variable across the site.

A summary of the ground conditions encountered during the CBRE and Fairhurst Ground Investigation works is provided below.

Table 1: Summary of Ground Conditions Encountered

Lithology	Proven Base of Lithology Range (m bgl)	Proven Base of Lithology Range (m AOD)	Proven Thickness (m)
Hardstanding (concrete, tarmacadam, block paving, red brick, ceramic tile, grout)	0.07 – 0.40	39.79 – 42.92	0.07 – 0.40
Made Ground	0.40 – 3.10	38.04 – 42.00	0.20 – 2.50
Taplow Gravel Member	0.80 – 4.70	36.00 – 41.70	0.10 – 4.10
White Chalk Subgroup (Structureless)*	4.70 – 13.40	27.87 – 36.37	3.10 – 11.90
White Chalk Subgroup (Structured)*	30 - 40	1.27 – 11.97	25.30 - 28.70

*Structured chalk was only obtained using core recovery during rotary drilling. It is possible that structured chalk may be present at shallower depths, however any structure would be destroyed from the cable percussive and windowless sampling drilling technique, and the recovered description would not be considered representative of in-situ conditions.

**Base of White Chalk Subgroup (structured) not proven in any exploratory hole. Proven to depth and elevation presented in table above.

Exploratory holes are presented within the site investigation plan provided as Figure 2.

2.4 Groundwater

During the three phases of ground investigation, groundwater was encountered within fifteen of the forty nine exploratory holes undertaken (BH1, BH2, BH4B, WS1, WS2A, WS4, BH101, BH102A, WS101, WS103, WS03B, BHC, BHDA, BHE & BHF) with no trends in the locations of the strikes noted. Groundwater strikes were encountered between 4.30m bgl (BHD1) and 6.50m bgl (BH101) and elevations of 34.53mOD (BH101) and 36.40mAOD (WS4) within the White Chalk Subgroup.

During the CBRE ground investigation (2015), groundwater was encountered in exploratory hole locations between 2 and 6m bgl during the drilling processes. Subsequent monitoring undertaken between 8th October and 16th November 2015 encountered resting groundwater levels between 4.43 and 5.43m bgl (approximate elevation range between 36.41 and 36.14m AOD), within the Chalk deposits.

During the 2017 Fairhurst Ground Investigation, groundwater was struck within the White Chalk Subgroup, at depths of 4.70 – 6.50m bgl (encountered elevation range between 36.28 – 34.53m AOD). Four subsequent rounds of groundwater level monitoring were undertaken between the 6th September and 28th September 2016. Serviceable monitoring wells installed during the CBRE ground investigation were also monitored during this period. The groundwater levels recorded indicates a relatively stable groundwater table between 35.89 and 36.404m AOD (4.28 – 5.34m bgl) within the White Chalk Subgroup bedrock. Groundwater was encountered at the base of the Taplow Gravel within BH102 (strata base at 36m AOD), where this strata was encountered at its greatest thickness. It is considered that this formation is in hydraulic connectivity with the underlying chalk.

It was considered in the CBRE ground investigation that groundwater is flowing in a north-easterly direction. This largely corroborated with results of groundwater monitoring undertaken by Dunelm in the 2017 Ground Investigation, which encountered highest groundwater elevations BH101, BH2 and WS9

in the south-western portion of the site and lowest is WS6 in the north-east as presented in Drawing ref. 112990/9003 within the Phase II Geo-Environmental Ground Investigation Report by Fairhurst (January 2017 Ref. 112990/R4).

2.5 Hydrological Setting

The Environment Agency defines the underlying Taplow Gravel Member and White Chalk Subgroup as Secondary A and Principal Aquifers respectively.

The nearest records of licensed abstractions located within 500m relate to an abstraction for retail (drinking, cooking, sanitary and washing) located approximately 140m south east and commercial/industrial (drinking, cooking, sanitary and washing) located approximately 465m north.

There are three named surface water features within 1km of the site including Holy Brook (550m south-east of the site) and the Kennet and Avon Canal (680m south-east of the site), both flowing in a north-easterly direction towards the River Thames (located 750m north-east of the site), flowing in an easterly direction at this location. The nearest surface water feature is an un-named stream positioned approximately 260m north of the site.

A Detailed Quantitative Risk Assessment was undertaken in relation to Controlled Water Receptors within the GIR, as discussed further in Section 2.6.

2.6 Contamination

Based on the review of the information available to date, this section summarises the available data.

Contaminants in the Made Ground

No soil contamination has been previously identified within the Made Ground in concentrations deemed to pose unacceptable risk for human health, with a few exceptions. Localised PAH, lead and VOCs concentrations exceeding their respective human health assessment criteria for residential without homegrown end use were recorded across the site, the majority of which in the north western portion of the site.

The risks posed by these exceedances will be addressed by either a barrier to users via the hardstanding of the development or via the provision of clean cover system (future site users) and by the use of appropriate PPE, good working practices and good hygiene practices (site workers) during the development itself.

A single fragment of asbestos tile was recorded within an exploratory hole undertaken as part of the 2016 Fairhurst investigation (within BH101). Analysis on samples from this position and also TP123 (from the same investigation) identified the presence of fibres, however when quantitatively analysed, these were identified to be below the limit of detection (<0.001%). On the basis of this, it was considered that risks to construction workers were likely to be low.

It was discussed within the 2019 Fairhurst Ground Investigation Report that no contamination had been identified within the Made Ground which would pose a risk to drinking water supply pipework. It would however be prudent to consult the water supplier prior to installation. No contamination in soils was encountered deemed to pose unacceptable risk to controlled waters.

Ground Gas & Vapour

Based on the findings of the monitoring undertaken at the site, the risk of bulk ground gases and generation of vapours harmful to human health and built development was considered to be 'low'.

Contaminants in Groundwater

Groundwater contaminant data and observations have revealed elevated concentrations of petroleum hydrocarbons in groundwater. Due to the extent to which concentrations have been found to exceed the respective WQS, the highest risk posing potential has been associated with petroleum hydrocarbon falling into the 'aromatic EC12-EC16' band, recorded in the highest concentrations and characterised by a 'moderate' mobility in groundwater.

Outline R&D P20 modelling detailed within the GIR suggest concentrations of the TPH CWG aromatic EC12-EC16 fraction have the potential to result in exceedances of the respective 90 µg/l 'WHO guideline value for drinking water quality' over a 100 - 200 meters distance from the site.

Whilst this would be in excess of the 50 metres default compliance point distance for hazardous substances in accordance with the 'land contamination groundwater compliance points for quantitative risk assessments guidance', constituents of potential concern (CoPC) for respective TPH CWG fractions (i.e. 2-methylnaphthalene, acenaphthylene, acenaphthene) have been assessed to be relatively low.

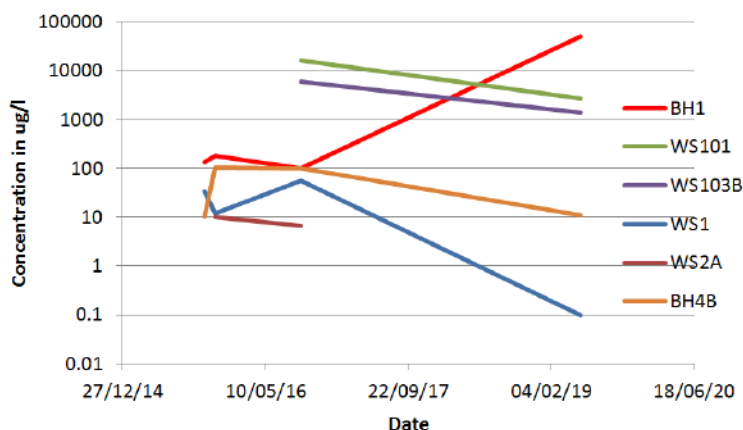
Data and information obtained from approximately thirty exploratory holes advanced as part of three phases of ground investigations did not identify any entry point of the contaminant within the groundwater. It is noted that the groundwater level is below rockhead.

The spatial distribution and variability of maximum concentrations indicates the source term to potentially be present at diffuse locations across the site, with preferential pathways and complex migratory patterns being associated with the groundwater flow direction but also the locations and orientation of fractures within the Chalk Principal aquifer underneath the site.

The composition of the petroleum hydrocarbons contamination with easily degradable petroleum hydrocarbon fractions largely being absent would suggest the source that was identified as 'diesel' to be historic and possibly a result of on or off-site free product release that probably occurred several decades ago. While the concentrations may be conducive to the presence of free phase product (i.e. above the aqueous phase limit for individual bands) and visual sheens were identified during sampling, it is noted that a detectable free phase product was not identified by the interface probe.

Concentrations recorded over the three site investigation phases, including the 'aromatic EC12-EC16' fraction results have been extremely variable. In general as illustrated in Figure 1, concentrations of the 'aromatic EC12-EC16' fraction decreased. This is with the exception of concentration found in a sample from BH1. Here, the levels increased from a concentration (135 µg/l in Oct 2015) near the WQS for this hydrocarbon fraction (90 µg/l) to the aforementioned value of 50,000 µg/l (May 2019).

Figure 1: Aromatic EC12-EC16' fraction results over three phases of site investigations



It is also possible that the maximum concentrations and their variation is caused by hydrocarbon contamination with a free phase source element in the areas of BH1, WS101 and WS103B and possibly also BHE. The latter is a monitoring point that was installed as part of the recent (2019) site investigation. Here, the second highest concentration of the 'aromatic EC12-EC16' fraction (4,300 µg/l) was found.

Data and information obtained from approximately thirty exploratory holes advanced as part of three phases of ground investigations did not reveal petroleum hydrocarbon contamination to be present at shallow depths (<4.5 m bgl).

2.7 Conceptual Site Model

The Controlled Waters risk assessment, reported within the Remediation Strategy, was conducted in accordance with the principles of EA 'Remedial Targets Methodology: Hydrogeological Risk Assessment for Land Contamination' 2006 (RTM) and on the 'prevent and limit' approach of the Water Framework Directive (2000/60/EC).

The Controlled Water receptors identified in the conceptual site model are:

- Secondary A (on and offsite) within the Taplow Gravel Member;
- Principal Aquifer (on and offsite) within the White Chalk Subgroup.

As such, in the first instance, contaminant concentrations found in groundwater were compared against UK Drinking Water Standards.

In the absence of UK Drinking Water Standards, World Health Organisation (WHO) guidelines values and [e.g. Water Framework Directive (WFD)] environmental quality standards were adopted.

The Controlled Waters risk assessment was undertaken soil-leachate analysis and groundwater samples throughout the three phases of ground investigation (112990/R5). Testing was undertaken in current and historic serviceable boreholes based on a lateral site spread and within a range of geologies.

Leachate analyses undertaken during ground investigation did not identify evidence for potential leachable contaminants within the soil. Groundwater samples taken from depth did provide contaminant data which noted the presence of elevated concentrations of hydrocarbons of moderate mobility.

Despite the high concentrations, given the absence of a clearly identified primary source of contamination, the fact that the site does not lie within an Environment Agency designated Source Protection Zone (SPZ) and the fact that the nearest licensed abstractions the Primark groundwater abstraction is situated up gradient approximately 140 meters to the southeast (Primark groundwater abstraction), the completion of a formal remediation strategy and validation report was not considered warranted.

However a groundwater monitoring programme was recommended as part of the foundation works risk assessment scope of works.

The ground investigation and associated risk assessments have therefore determined that contamination is already present within the groundwater. This is present in groundwater within the Chalk, i.e. not as a result of direct contact of groundwater with Made Ground deposits or point-source identifiable sources of contamination.

This foundation works risk assessment therefore needs to consider whether the piling works would cause any further deterioration of the groundwater via the introduction of new pathways.

While the DQRA has confirmed a relatively low risk in relation to dissolved phase contamination, the potential for migration of free phase contamination during piling works needs to be considered.

In keeping with the GIR, and to support the implementation of the foundation works risk assessment, it is recommended a further 2 no. rounds of groundwater monitoring, sampling and analysis are undertaken prior to piling commencing. This monitoring should aid in the determination of a baseline environmental condition, where possible, given the high variation in contaminant concentration identified to date. The following controls should be in place:

- Low flow sampling techniques to allow for the groundwater properties to stabilise/reach equilibrium;
- Filtering of the water samples to remove sediment which may contain adsorbed contamination resulting in 'artificially' elevated TPH concentrations within groundwater;
- Free Phase observations including interface probe for DNAPL and LNAPL, and visual observations of colour, turbidity, odour etc., during groundwater sampling.

3 FOUNDATIONS

3.1 Foundation Solution

The proposed piling contractor for the development, Colets piling Ltd, has provided the details of the proposed piling operations for the superstructure at the site. The following salient points are reported:

- The proposed piling method is Continuous Flight Auger (cast in-situ);
- The piling rig used will be a Casagrande B125 XP and Soil Mec SR20 (CFA Version);
- Piles will be bored to c. 7.5-17.3mbgl (i.e. into the White Chalk Subgroup) and 350mm and 600mm in diameter;
- Piles may be terminated at shallower depth on refusal, subject to appropriate design validation.

As such, the piles are to be bored through the Made Ground, Taplow Gravel Member (where present) and White Chalk Subgroup, will be cast in situ below the groundwater table.

3.2 Basis of Assessment

This assessment has been carried out in conjunction with the guidance and information provided in the following documents:

- Piling into Contaminated Sites. Environment Agency National Groundwater and Contaminated Land Centre (February 2002); and,
- Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention. Environment Agency (May 2001).

3.3 Characteristics of Piling Method

CFA piles are 'non-displacement' methods and based on the information presented within relevant EA guidance their main features are as follows:

- Potentially contaminated soils are removed and stockpiled at surface;
- There is minimum displacement and thus the density and permeability of the surrounding soils are not increased; and
- There is negligible downward vertical movement of soil either beneath the toe of the pile or due to drag down along the sides of the pile shaft.

3.4 Potential Foundation Risks

As stated within the EA guidance, the main potential risks associated with constructing foundations in ground with known areas of contamination is that pathways will be created between the contaminants and sensitive receptors i.e. the groundwater and/or surface water receptors on, and / or adjacent to the site or new pathways in relation to ground gas or risks to site personnel during the piling activities associated with contaminated arisings. Table 2 below presents a summary of the six potential pollution scenarios where the EA is concerned that piling or penetrative ground improvement operations have the potential to cause pollution, along with a site specific assessment as to whether these pollutant linkages are likely to be realised:

Table 2: Potential Hazards Associated with Proposed Piled Foundations

Potential Hazard	Site Specific Comment
Creation of preferential pathways, through a low permeability layer (an aquitard) to allow potential contamination of an underlying aquifer	The groundwater levels recorded indicate a relatively stable groundwater table between 35.89 and 36.52mAOD within the structureless White Chalk Subgroup bedrock. Groundwater contaminant data and observations have revealed elevated concentrations of petroleum hydrocarbons in groundwater, predominantly in the north western and north central portions of the site. The variability and spatial distribution of maximum concentrations would indicate the source terms to be present at diffuse locations across the site with preferential pathways and migratory patterns being associated with the groundwater flow direction but also the locations and orientation of fractures within the Chalk Principal aquifer underneath the site. However, as a result of the adopted piling technique and the designed depth of the piles, the removal of saturated potentially contaminated arisings in areas where the highest concentrations of TPH were recorded, may allow an improvement of the groundwater conditions (e.g. near BH1) where contaminated materials are removed from site. Additionally, with this technique there is no open bore at any time and the potential for groundwater to flow down the auger is very limited by the continuous upward movement of soil and the advance of the rising concrete which prevent the creation of preferential pathways or downward transportation of contaminants. It is noted that there is the potential for free phase product to be present on site, and although the risk of downward migration of contaminated water is considered low, there is a potential risk of migration of free phase product via groundwater laterally along fractures and bedding within the bedrock. For this reason, it is recommended that a watching brief is maintained in respect to grossly contaminated soil or free phase product in groundwater, in addition to precautionary water sampling during the piling works. It is considered that, given the non – displacement method of piling, any disturbance to the ground is minimal and there should be no formation of preferential pathways, as the concrete is cast in intimate contact with the surrounding soil. The contamination encountered on site has been compared to the pile layout and suggests that while WS103B seems to fall within the piled area, the majority of the locations where the contamination was encountered in groundwater fall outside the piled area (WS101, BHE and – although very close to – BH1).
Creation of preferential pathways, through a low permeability surface layer, to allow upward migration of landfill gas, soil gas or contaminant vapours to the surface.	No volatile vapour or ground gas sources have been identified. No new pathway for ground gas migration is considered to be generated via the installation of piles with regard to the site ground model.

Direct contact of site workers and other contaminated soil arisings which have been brought to surface.	Localised Human health exceedances of Lead, limited PAH and VOCs have been identified in the shallow Made Ground in the north western portion of the site (with regard to residential without plant uptake). No gross contamination in soil or groundwater has been identified in the previous ground investigation works. There are no appropriate assessment criteria in respect to construction worker exposure pathways, however there is a potential risk in relation to handling of pile arisings, which should be appropriately managed including as follows: - Construction workers will need to adopt appropriate management procedures to mitigate risks from potentially contaminated soils, including use of PPE and hygiene practices appropriate for a brownfield site; and - Correct characterisation and disposal of the soils will be required, with appropriate materials management and good working practices (e.g. dust suppression of stockpiles/materials in dry weather).
Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials (where the secondary effects are to increase the potential for contaminant migration).	Soil and groundwater testing, detailed within the Fairhurst GIR (Ref. 112990/R5, 2019) confirms the risk of this pathway is low and confirmed concrete classification DS2 AC2 in Made Ground and DS1 AC1 in natural material (BRE, SD1, 2005) is adequate for buried concrete proposed, such as the CFA piles proposed.
The driving of solid contaminants down into an aquifer during pile driving.	The proposed piling methods (CFA Piles) are non-displacement methods that result in generation of arisings i.e. any contaminated soils in the path of the emplaced pile will be excavated to the surface. As such there is minimal potential to drive down a plug of contaminant into the Secondary A or Principal Aquifers beneath the site.
Contamination of groundwater and, subsequently, surface waters by concrete, cement paste or grout.	The EA guidance indicates that loss of wet concrete, cement paste or grout may occur in fast-flowing groundwater, probably associated with fractured or jointed rocks such as limestones and the Chalk or permeable gravel formations. Migration may occur until setting of the concrete, cement paste or grout occurs; this would generally occur on a timescale of a few minutes. Use of retarder additives could extend this timescale to a few hours, although their effectiveness would be reduced by dilution. In most circumstances, therefore, the impact, if any, is likely to be localised. The groundwater table has been recorded between 35.89 and 36.52m AOD within the White Chalk Subgroup and it is considered that this is fully saturated, and fast flowing groundwater is not considered likely to be present. No viable surface water receptors have been identified in close proximity, with the nearest down hydraulic gradient surface water feature and un named stream positioned approximately 260m north of the site. A flow meter should be utilised when adding the concrete to monitor any excessive losses. The risk of this pathway being realised is considered low.
Works are close to surface water bodies and run-off from arisings could pollute these waters.	There are no nearby surface water receptors. Furthermore, appropriate measures for control of surface water generation and runoff during site construction practices should be addressed and managed as part of the Principal Contractors Risk Assessment and Method Statements.

The above assessment of hazards confirms that there are no viable source-pathway-receptor pollutant linkages in relation to the proposed CFA piled foundations, with exception of:

- Direct contact of site workers and other potentially contaminated soil arisings which have been brought to surface;

This pathway can be addressed via the following mitigation measures:

- Construction workers will need to adopt appropriate management procedures to mitigate risks from potentially contaminated soils, including use of PPE and hygiene practices appropriate for a brownfield site; and
- Correct characterisation and disposal of the soils will be required, with appropriate materials management and good working practices (e.g. dust suppression of stockpiles/materials in dry weather).

As noted above, pathways to groundwater from sources of groundwater already exist, as is evident from the hydrocarbon impact in groundwater. DQRA has indicated that the risk to Controlled Water Receptors associated with the dissolved phase contaminants is likely to be low.

To avoid significant deterioration of the groundwater it is recommended the following is undertaken:

- Baseline groundwater monitoring and sampling pre-piling (using the techniques and analysis outlined below);
- a watching brief for gross contamination and free phase product is maintained during piling works;
- weekly groundwater monitoring during the piling to confirm the absence of significant increases attributable to the piling works, which could pose a risk to receptors. The water samples should be collected via low flow sampling techniques, filtered and subject to analysis for dissolved oxygen and TPH CWG, pH and sulphate, to help support further risk assessment if it was deemed to be required.

The results should be assessed by a Fairhurst Geo-Environmental Engineer. Where gross levels of contamination are identified either visually or as a result of monitoring, work should cease to allow consideration of appropriate mitigation measures, such as sacrificial casing.

4 CONCLUSIONS AND RECOMMENDATIONS

The proposed method of non-displacement, cast in-situ, continuous flight auger piles have been considered in context of the site sensitivity and GIR findings. The method of CFA piling is generally considered appropriate and poses a low risk to Controlled Waters, including the Principal Aquifer beneath the site.

There is the potential for piling to generate contaminated soil arisings, originating from Made Ground beneath the site, which may pose a risk to site workers via ingestion/inhalation/direct contact. However, this pathway can be addressed via appropriate PPE, good working and hygiene practices and appropriate materials management in accordance with the requirements of developing a brownfield site and waste regulations.

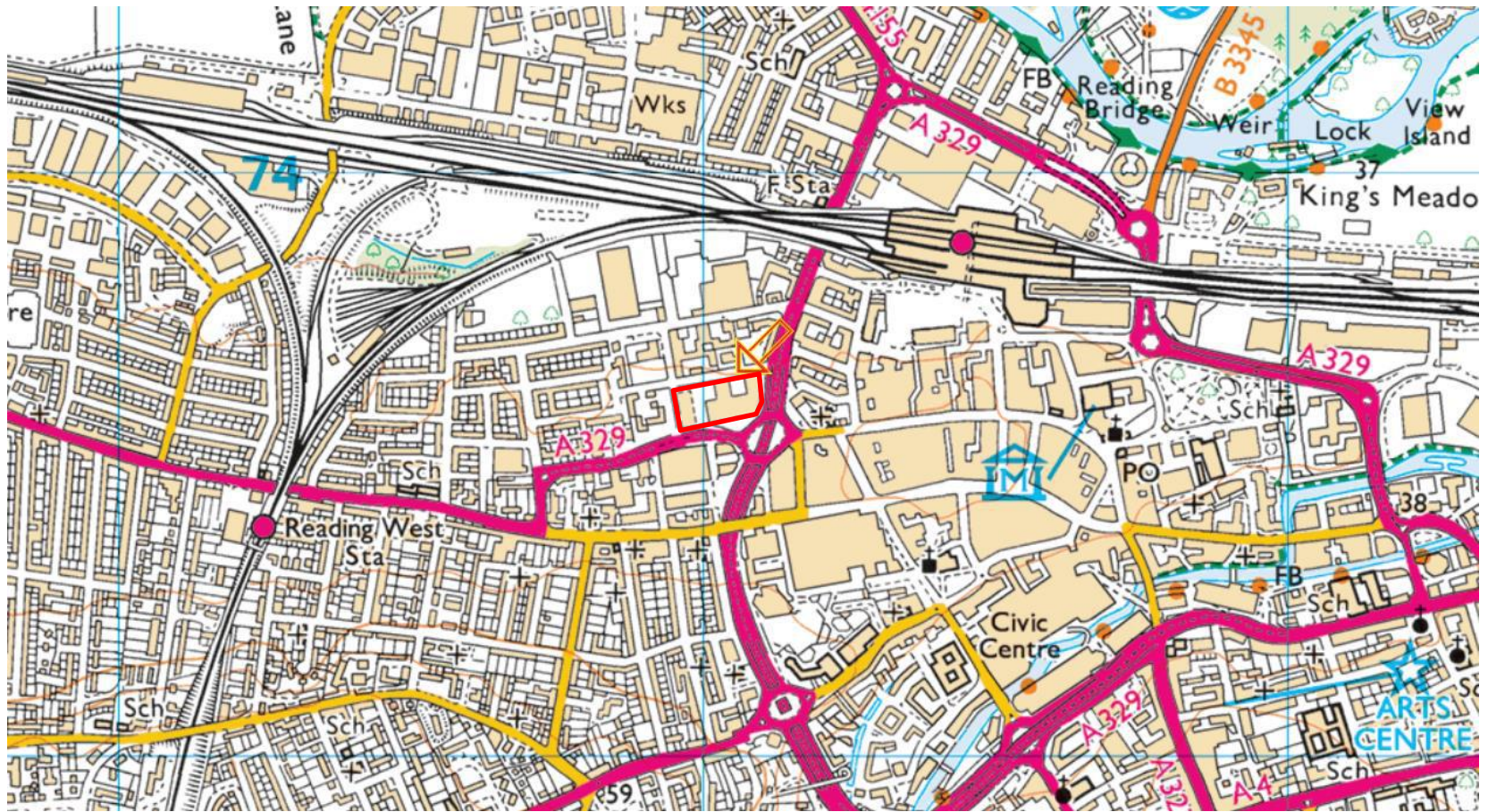
It is also recommended that spoils are immediately removed from the auger.

It is recommended, given the presence of free phase product cannot be discounted, that the following precautionary measures are implemented to avoid significant deterioration of the groundwater:

- Baseline groundwater monitoring and sampling pre-piling (using the techniques and analysis outlined previously and below);
- a watching brief for gross contamination and free phase product is maintained during piling works;
- weekly groundwater monitoring during the piling to confirm the absence of significant increases attributable to the piling works, which could pose a risk to receptors. The water samples should be collected via low flow sampling techniques, filtered and subject to analysis for dissolved oxygen and TPH CWG, pH and sulphate, to help support further risk assessment if it was deemed to be required.

It is recommended that the specialist Piling Contractor is provided with a copy of this risk assessment, in addition to the aforementioned GIR and Remediation Strategy. If any assumptions made within this report in respect to foundation methods are amended, or unexpected contamination is identified during construction, a Fairhurst Geo-Environmental Engineer should be consulted and this risk assessment updated as necessary.

FIGURES

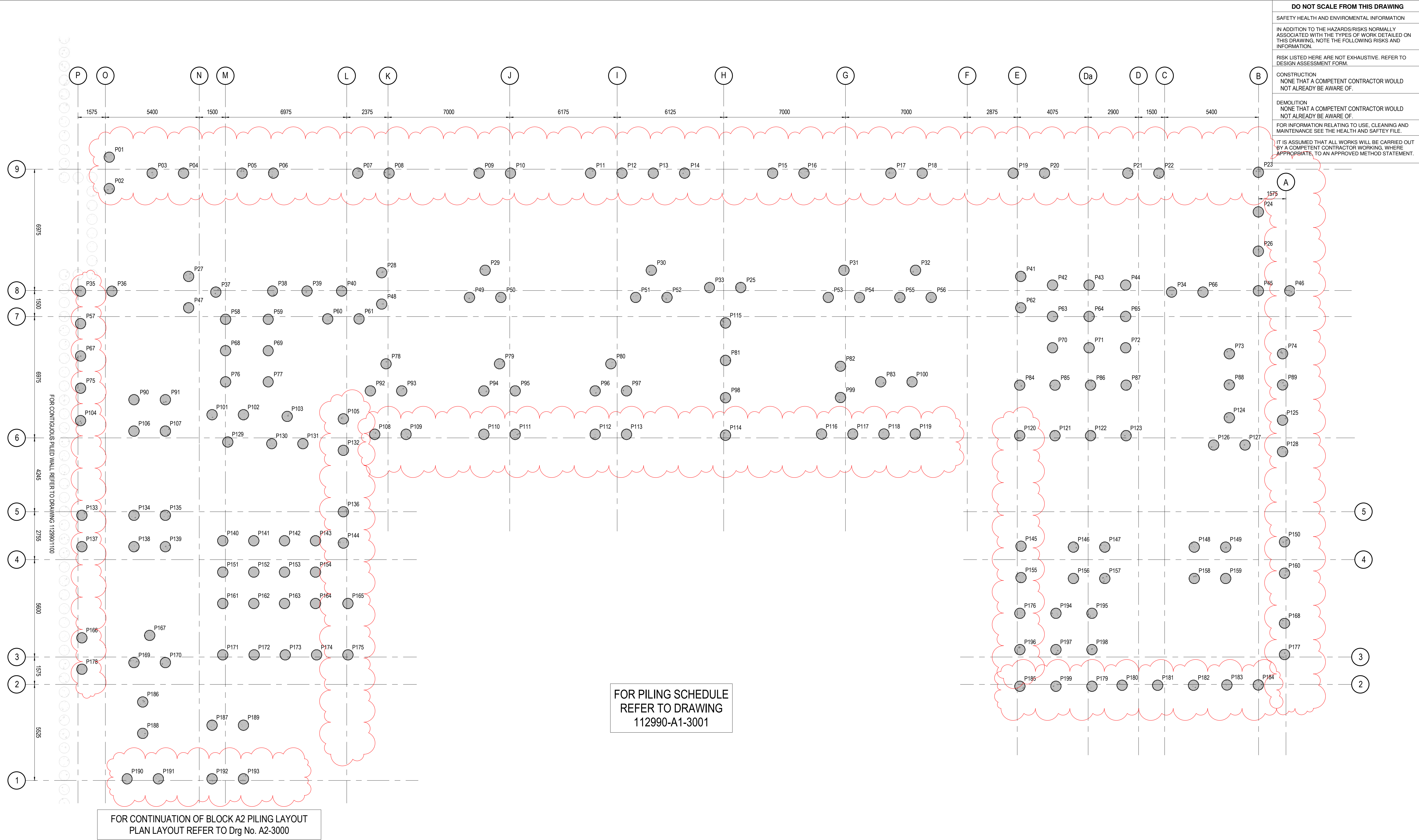


— Approximate Site Boundary

FAIRHURST Weldale Street Reading	Site Location Plan (Not to Scale)		
	Ground Investigation Report		
Date: 26/04/19	Initials: HB	Figure: 1	

APPENDIX A

APPENDIX B

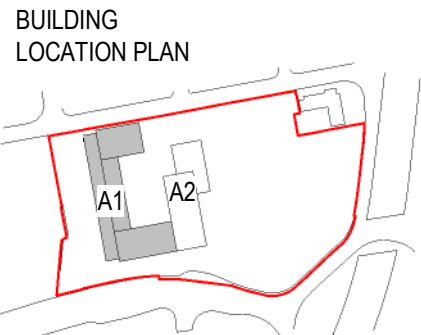


C	01/10/19	PILE POSITION REVISED TO SUIT SLAB EDGE. TO ARCHITECT'S DETAILS.	JIM/LT
B	04/09/19	PILE LAYOUT AMENDED TO SUIT REPOSITIONED SHEAR WALLS. TRANSFORMER BASE PILE LAYOUT ADDED.	JIM/LT
A	12/06/19	PILES P01 & P02 AMENDED TO AVOID CONTIG PILED WALL. PILES UNDER SERVICE RISER AMENDED AND PILES TO COLUMNS C1 POSITIONS REVISED AT ARCHITECT'S REQUEST.	PMJ/LT
-	09/05/19	FIRST DRAWING ISSUE.	PMJ/LT
Rev	Date	Description	Drm/Chkd/Appd.

GENERAL NOTES

- DO NOT SCALE THIS DRAWING. WORK TO FIGURED DIMENSIONS ONLY. ALL DIMENSIONS ARE IN MILLIMETRES (mm). ALL LEVELS IN METRES (m).
- SETTING OUT TO ARCHITECT'S DRAWINGS.
- THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT ARCHITECTS, ENGINEERS & SPECIALISTS DRAWINGS & SPECIFICATIONS.
- FOR ALL STRUCTURAL NOTES REFER TO DRG No. 112990 A1/A2-0.
- ALL F.F.L & S.S.L LEVELS T.B.C BY ARCHITECT.

THIS DRAWING IS INTENDED TO INDICATE THE SCOPE OF STRUCTURAL WORKS REQUIRED BASED ON THE CURRENT ARCHITECTURAL, SERVICES & M&E DESIGN. FURTHER DESIGN DEVELOPMENT IS ANTICIPATED TO BE REQUIRED, WHICH MAY REQUIRE ADDITIONS, DELETIONS AND ALTERATIONS TO THE SCOPE & DETAIL OF THE STRUCTURAL WORKS INDICATED ON THIS DRAWING.



Client	Project Title		RESIDENTIAL DEVELOPMENT, WELDALE STREET, READING		FAIRHURST	
	Drawing Title					
	BLOCK A1 PILING LAYOUT GENERAL ARRANGEMENT					
	Scale @ A1 As indicated		Purpose of issue PRELIMINARY		Clifton Heights, Triangle West, Clifton Bristol, BS8 1EJ Tel: 0117 925 0259 Fax: 0844 381 4412	
	Drawn PMJ		Checked LT		Approved	
Drawn Date 17/04/19		Checked Date 10/05/19		Approved Date		
Drawing Number. 112990 - A1-3000				Rev C		



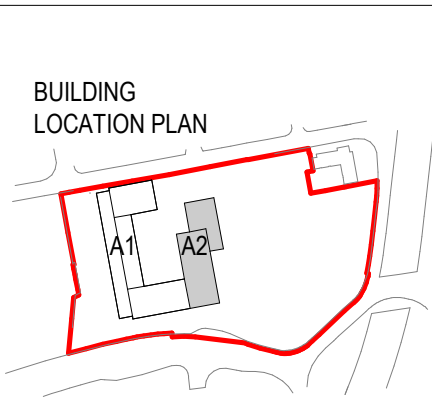
DO NOT SCALE FROM THIS DRAWING
SAFETY HEALTH AND ENVIROMENTAL INFORMATION
IN ADDITION TO THE HAZARDS/RISKS NORMALLY ASSOCIATED WITH THE TYPES OF WORK DETAILED ON THIS DRAWING, NOTE THE FOLLOWING RISKS AND INFORMATION.
RISK LISTED HERE ARE NOT EXHAUSTIVE. REFER TO DESIGN ASSESSMENT FORM.
CONSTRUCTION NONE THAT A COMPETENT CONTRACTOR WOULD NOT ALREADY BE AWARE OF.
DEMOLITION NONE THAT A COMPETENT CONTRACTOR WOULD NOT ALREADY BE AWARE OF.
FOR INFORMATION RELATING TO USE, CLEANING AND MAINTENANCE SEE THE HEALTH AND SAFETY FILE.
IT IS ASSUMED THAT ALL WORKS WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROVED METHOD STATEMENT.

B	04/09/19	PILE LAYOUT AMENDED TO SUIT REPOSITIONED SHEAR WALLS.		JJMLT
A	12/06/19	UPDATED TO SUIT LATEST ARCHITECTS LAYOUT AND COMMENTS.		PMJLT
-	08/05/19	FIRST DRAWING ISSUE.		PMJLT
Rev	Date	Description		Drm/Chkd/Appd.

GENERAL NOTES

- DO NOT SCALE THIS DRAWING. WORK TO FIGURED DIMENSIONS ONLY. ALL DIMENSIONS ARE IN MILLIMETERS (mm). ALL LEVELS IN METERS (m).
- SETTING OUT TO ARCHITECT'S DRAWINGS.
- THIS DRAWING IS TO BE READ IN CONJUNCTION WITH ALL OTHER RELEVANT ARCHITECTS, ENGINEERS & SPECIALISTS DRAWINGS & SPECIFICATIONS.
- FOR ALL STRUCTURAL NOTES REFER TO DRG No. 112990 A2-0.
- ALL F.F.L & S.S.L LEVELS T.B.C BY ARCHITECT.

THIS DRAWING IS INTENDED TO INDICATE THE SCOPE OF STRUCTURAL WORKS REQUIRED BASED ON THE CURRENT ARCHITECTURAL, SERVICES & M&E DESIGN. FURTHER DESIGN DEVELOPMENT IS ANTICIPATED TO BE REQUIRED, WHICH MAY REQUIRE ADDITIONS, DELETIONS AND ALTERATIONS TO THE SCOPE & DETAIL OF THE STRUCTURAL WORKS INDICATED ON THIS DRAWING.



Client

ROPEMAKER PROPERTIES LTD

Project Title

RESIDENTIAL DEVELOPMENT, WELDALE STREET, READING

Drawing Title

BLOCK A2 PILING LAYOUT GENERAL ARRANGEMENT

Scale @ A1
As Indicated

Purpose of Issue
PRELIMINARY

Drawn PMJ	Checked LT	Approved
Drawn Date 17/04/19	Checked Date 10/05/19	Approved Date

Drawing Number.
112990 - A2-3000

Rev
B

FAIRHURST

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APPENDIX A

APPENDIX B

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