Phase III Geotechnical Site Investigation Report

at Twyford Bridge Farm, Reading, RG10 9PP

for Croudace Homes Ltd

Report Reference: LP3408

Report Date: 15th August 2023

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EXECUTIVE SUMMARY

The site is located at the Twyford Bridge Farm, Reading, RG10 9PP and comprises an approximately 12Ha irregularly shaped plot of land. It is situated to the east of the River Loddon and west of the Henley to Twyford Railway Line. The majority of the site comprises open agricultural fields used for grazing livestock except for a small area in the centre which is occupied by hardstanding and barns.

It is proposed to redevelop the north and east of the site with 200 No. residential properties with private gardens including associated access roads and small areas of open green space. The southwest of the site is proposed as an area of public open space including two attenuation basins.

The site is mapped as being underlain by Alluvium in the southwest and Kempton Park Gravel elsewhere over the Seaford and Newhaven Chalk Formation. Ground conditions encountered during LEAP's previous investigation in May 2023 (LP3302) generally comprised topsoil over interbedded sands, gravels and clays of Kempton Park Gravel to between 0.8m and 4.0m bgl, over highly weathered chalk to the full depth of investigation (5.0m bgl). The depth of the chalk was irregular across the site and showed a general deepening towards the north of the site. The ground conditions in the south west of the site comprised of very soft to firm clays and loose sands considered to represent the Alluvium, over the chalk at depth. Investigation within the two gravel pits (TP106 and TP111) encountered made ground to between 1.5m and 2.3m bgl. Several of the trial pits were noted to be unstable with minor side collapses occurring during the investigation works.

Groundwater seepages were encountered between 1.0m and 3.0m bgl and were more prevalent towards the south and west of the site. Groundwater monitoring recorded groundwater levels between 1.28m and 1.94m bgl in the south of the site, but groundwater was not encountered in the upper 3.0m of the ground in the north of the site.

The probing results generally indicate that soft/ loose zones are present on site. These zones are generally present in the shallower soils, however deeper zones are noted in several locations across the site down to depths of ~8m to 9m bgl, especially within the eastern half of the site. These loose zones likely represent deep weathering of the upper portion of the chalk at depth as well as loose soils overlying the chalk..

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Date:	15 August 2023
Revision:	Issue 1

A INTRODUCTION

1 Authority

Leap Environmental, trading name of RSK Environment Ltd (hereafter referred to as LEAP) has been appointed by Croudace Homes Ltd to undertake an additional Geotechnical Investigation of a site referred to as the Twyford Bridge Farm, Reading, RG10 9PP (Figure 1). The instruction was given in an email dated 20th June 2023 and signed by Matthew Houson of Croudace Homes Ltd.

2 Proposed Development

LEAP understands that the site is currently owned by a local resident and Croudace is in the process of purchasing the site to redevelop the northern and eastern areas with 200 No. residential properties with private gardens including associated access roads and small areas of open green space. The southwest of the site is proposed as an area of public open space including two attenuation basins as per the attached layout in Figure 1b, Appendix B.

The proposed development is currently at a final design phase and has been assessed in accordance with BS EN 1997[1], as being a Geotechnical Category 2 structure.

3 Background & Objectives

LEAP has undertaken a previous intrusive investigation on site. The previous investigation noted highly variable depths to chalk across the site and where encountered the chalk was observed to be highly weathered. Furthermore, WS104 in the central east of the site encountered chalk below which a layer of loose sand was encountered overlying chalk at depth. This stratigraphy was considered to be indicative of a potential infilled solution feature at a depth of 2.0m in this area. Furthermore, a desk study for the site completed by Stantec noted the potential for solution features to be present on site.

During the previous investigation the landowner indicated that the gravel pit situated in the southeastern field was actually a "bomb hole" from the second world war which had since been infilled.

The previous Stantec Desk Study indicated the site was situated in an area where 1% to 3% of the properties were above the radon action level. However, following the December 2022

[1] BS EN 1997-1(2004)+A1:2013 Eurocode 7:Geotechnical Design: General Rules

update to the freely available Radon maps (www.ukradon.org), the site is now situated in an area where 5% to 10% of properties are above the action level.

Based on the information summarised above the objectives of this investigation were as follows:

- Undertake one Super Heavy Dynamic Probe (DPSH) within the footprint of each plot located in the northwestern, northeastern and southeastern sections of the site to provide a preliminary assessment of the potential solution feature risk.
- Provide a preliminary UXO risk assessment of the site, to assess the UXO risk to the site investigation and construction works.
- Source the updated small scale Radon Risk mapping for the site to confirm the Radon Risk attributed to the site.

4 Previous Studies

The site has been the subject of previous investigations by LEAP and others. The following site investigation reports have been supplied by the Client and the reader is referred to these earlier reports which should be read in conjunction with this report.

- Geophysical Survey Report, Bridge Farm Twyford by Magnitude Surveys dated July 2020 (Ref: MSSU700).
- BRE 365 Soakage Testing Letter Report, Bridge Farm Twyford by LEAP dated April 2021 (Ref: LP2497/ST/1).
- Phase I Ground Condition Assessment, Bridge Farm Twyford by Stantec Ltd dated August 2021 (Ref: 332510718/3501).
- Phase 11 Phase II investigation Report, by LEAP dated 24th May 2023 (Ref: LP3302).

5 Scope of Works

This report describes a process whereby the site is investigated and risks are assessed. The terms geotechnical is referred to throughout the report.

Geotechnical refers to all other aspects of the ground conditions and the impact they may have on the physical construction of existing or future development, principally foundations, slope stability, drainage, pavement and road design and groundwater control.

5.1 Intrusive Investigation Scope

The Phase III work comprises an intrusive investigation. The results of this and previous investigation reports are used to validate and/or update the initial site conceptual ground model. This phase of site investigation comprised the following tasks:

- 175 No. 6.0-10.0m deep Super Heavy Dynamic Probes (DPSH) tests undertaken with a tracked rig.

The intrusive works were completed by contractors who have been scrutinised and are on LEAP's approved contractor list. The DPSH tests were carried out by Oakland Site Investigation Ltd. The probing locations were positioned using a global positioning system (GPS) device and a site boundary clearance using ground penetrating radar (GPR) was undertaken by Land Utility Group UK. The individual positions were cleared using cable avoidance tools (CAT) carried out by LEAP. All works were supervised by LEAP.

6 Limitations

This report has been prepared by Leap Environmental on the basis of information received from a variety of sources which Leap Environmental believes to be accurate. Nevertheless, Leap Environmental cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Leap Environmental has used all reasonable skill, care and diligence in the design and execution of this report, taking into account the manpower and resources devoted to it in agreement with the Client. Although every reasonable effort has been made to obtain all relevant information, all potential contamination, environmental constraints or liabilities associated with the site may not necessarily have been revealed.

The conclusions reached in this report are necessarily restricted to those which can be determined from the information consulted and may be subject to amendment in the light of additional information becoming available. These conclusions may not be appropriate for alternative schemes.

This report is confidential to the Client and Leap Environmental accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Leap Environmental beforehand. Any such party relies upon the report at their own risk.

Full details of the limitations are provided in Appendix A.

B SUMMARY OF BACKGROUND INFORMATION

7 Environmental Setting

7.1 Site Location and Description

The site is located to the northwest of the village of Twyford, Berkshire, to the south of the New Bath Road, the east of the River Loddon and west of the Henley to Twyford railway line as shown in Figure 1, Appendix B.

The approximate National Grid Reference of the site is SU783766. The site slopes gently towards the south and southwest from its highest point along its northern boundary (~39m AOD) to its lowest near the boundary with the river (~35m AOD).

7.1.1 General Description and Boundaries

A walkover survey was carried out as part of the Phase II investigation on the 11th of April 2023. At the time of the Phase III investigation the agricultural fields in the northeast and east of the site had been mown. Access was not possible to the land to the west of the barns and agricultural buildings due to overgrown vegetation.

The majority of the site comprises open fields used for grazing livestock (cattle). The centre of the site is occupied by several cattle barns and concrete hardstanding and just to the north of this is a private house which is not within the development land.

The site is divided into four separate fields. The largest in the east of the site is separated from the others by a fence and Bridge Farm Road along with the cattle barns. The next largest, located in the northwest of the site is separated from those to its south by a row of mature deciduous trees. Mature trees were also present along the south section of Bridge Farm Road. The two largest fields were at the time of the investigation capped with cropped grass and despite recent rains were relatively firm underfoot. These fields were relatively level except for in the southeast of the site adjacent to the trainline where a small area was notably lower compared to the surrounding field. Discussion with the landowner indicated that this was a "bomb hole" from WWII that was subsequently backfilled by the landowners father.

The two smaller fields in the south and southeast of the site (adjacent to the stream) were soft underfoot and the ground was uneven. Furthermore, plants indicative of wet conditions were present in this area.

The central area comprised concrete hardstanding and several farm buildings and was still in use at the time of the investigation with the barns occupied by cattle. The area was capped with concrete hardstanding and vehicles including a tractor, lorry and a caravan were being stored in this area. The existing structures were relatively dilapidated and included some corrugated cement sheeting which may potentially contain asbestos. Two large silos are

present in this area and a small generator as well as some oil/fuel drums were noted adjacent to one of the structures.

Several services were noted to be present on site. Two sewers are present in the southern fields of the site following a southeast-northwest alignment before doglegging in the south and exiting the site through its eastern boundary. BT and high voltage electrical cables are present following the alignment of Bridge Farm Road, through the centre of the site. Discussions with the landowner indicated that a private water pipe also runs along the alignment of this road and that a sewer (the exact location of which is not known) runs from the house near the centre of the site westwards.

The site is bounded by New Bath Road to the north, the Henley to Twyford rail line to the East, fields woodland and a children's nursery to the south and the River Loddon to the West.

7.2 Geology

The geology of the site has been ascertained by reference to the BGS website (www.bgs.ac.uk). The site is mapped as being underlain by the Kempton Park Gravel Member over the Undifferentiated Seaford and Newhaven Chalk Formations of the White Chalk Subgroup. Alluvium is mapped extending onto the far southwest of the site only.

7.2.1 Alluvium

Alluvium is a recent deposit laid down by rivers. In the Thames Valley it forms a flat surface in the Valley floor and generally it lies unconformable on river terrace gravel.

Alluvium consists largely of silty clay and clayey silt with locally developed beds of fine to coarse grained sand mainly less than 1m thick. Alluvium can present several problems for construction. Rapid lateral transitions in soil type are to be expected. Running sands are common. The clays and silts in particular are weak and highly compressible.

7.2.2 Kempton Park Gravels

Kempton Park Gravels are part of the former Flood Plain Gravel which is the youngest of the three River Terrace Gravels that were laid down by the Thames. The river terrace deposits consist of variable proportions of sand and gravel. They were deposited in a braided river system, an estimated 5km wide. Gravel dominated beds, generally less than 2m thick are cut through by broad shallow channels which are in-filled with tabular cross bedded gravelly sand in fining upward sequences. There are also impersistent beds of clayey and silty fine sand which are generally less than 1m thick.

7.2.3 White Chalk Subgroup

The White Chalk Subgroup (Seaford and Newhaven Chalk Formations) is a very fine grained white limestone consisting predominantly of the disaggregated skeletal remains of tiny planktonic algae, and is composed of almost pure calcium carbonate. Layers of flint are common within the White Chalk Subgroup. Flint is composed of silica derived from the dissolved skeletons of siliceous sponges and microfossils.

Chalk is particularly affected by weathering and the effects of dissolution. The top surface of the chalk is usually irregular and may be include deep drift filled solution pipes for example. Chalk is also susceptible to frost action.

7.2.4 BGS Boreholes

The online BGS Geoindex (http://www.bgs.ac.uk/geoindex/) has been reviewed for detailed local geological and hydrogeological information. Nine boreholes have been identified within 150m of the site boundary. Eight of these are located to the north of the site (beyond New Bath Road) the other is located to the immediate south of the site in the area of the childrens nursery. The following historical borehole logs have been reviewed.:

- SU77NE91 located 50m to the north.
- SU77NE92 located 40m to the north.
- SU77NE93 located 75m to the north.
- SU77NE94 located 100m to the north.
- SU77NE95 located 85m to the north.
- SU77NE106 located 140m to the northwest.
- SU77NE109 located 60m to the northwest.
- SU77NE170 located 70m to the south.

The logs generally indicate that the ground conditions comprise sands and gravels with variable proportions of clay to between 1.6m and 5.6m bgl over chalk which is indicated to have been recovered as "clay". The logs generally report that the boreholes were dry although one notes that soils encountered were damp at 3.0m bgl.

7.2.5 Solution Features

Solution features generally occur where preferential weathering of the chalk occurs along discontinuities or joints. They are more common along geological boundaries, where surface water runoff from impermeable soils meets the more permeable underlying chalk. They are generally infilled with loose/soft soils and can be visible at ground level due to surface depressions, although this may be masked by overlying superficial deposits. They may lie dormant for many years, and are generally reactivated by the introduction of water from, for example, a leaking drain, soakaway etc. The top surface of the chalk is usually irregular and may be include deep drift filled solution pipes for example.

The Stantec Natural Cavity database was noted to not include any records of natural cavities on the site or in close proximity. The nearest solution features were recorded in geology of Lambeth Group over Chalk or River Terrace Deposit over Chalk. Both are recorded 850m to the south east and 650m to the east. The Stantec report notes that on the site the Lambeth Group was removed by fluvial erosion and the chalk surface etched before the River Terrace Deposits placed lying 1.0m to 2.0m above the modern flood plain.

During LEAP's Phase II investigation a potential solution feature was identified during LEAP's previous investigation in WS104, located in the central east of the site, where a layer of loose sand was encountered from 2.0m to 2.9m bgl, between two layers of intact chalk.

7.3 Hydrogeology

The hydrogeology of the site has been ascertained from the Groundsure.IO and Defra.Magic websites. The source of the data is reported to be the Environment Agency groundwater vulnerability mapping.

The superficial Alluvium and Kempton Park Gravel deposits which are mapped beneath the site are classified as a Secondary A aquifer whilst the underlying Chalk is classed as a Principal Aquifer.

The site is situated within an outer (Zone 2) of a Groundwater Source Protection Zone (SPZ).

The River Loddon bounds the site's west and south western boundary.

According to 1:100,000 scale Hydrological map of the South West Chilterns and the Berkshire and Marlborough Downs – Sheet 7 (BGS, 1978) the ground water level is the chalk is recorded between 30m to 35m AOD (August 1976), with ground water flow in the chalk in a south easterly direction.

7.4 Flooding

According to the Environment Agency sections of the site are located with a flood risk zone. Flood Zones 2 and 3 extend across much of the south and south western sections of the site close to the river.

A zone 2 floodplain estimates the annual probability of flooding as one in one thousand (0.1%) or greater from rivers and the sea but less than 1% from rivers or 0.5% from the sea.

A zone 3 floodplain estimates the annual probability of flooding as one in one hundred (1%) or greater from rivers and a one in two hundred (0.5%) or greater from the sea.

8 Previous Investigations

The site has been the subject of a number of reports undertaken by LEAP and others the findings of which are summarised below, where relevant to this investigation. All previous investigations are summarised within the Phase II report (LP3302).

8.1.1 BRE 365 Soakage Testing Letter Report, Bridge Farm Twyford by LEAP dated April 2021 (Ref: LP2497/ST/1).

The investigation comprised of 5 No. up to 3.0m excavated trial pits where BRE365 soakage tests were carried out. The ground conditions were noted as topsoil to 0.2m/0.3m over clay to 0.55m/1.80m over sand from 0.25m/1.80m to 2.0m/3.10m over gravel from 1.35m to 3.0m over chalk from 1.60m/2.30m to the full depth of investigation. The chalk is logged as highly weathered recovered as Grade Dm in TP03, TP04 and TP05. Fast flowing water seepages

were noted on the western side of the site at depth of 2.0m to 2.2m and 2.8m in the eastern side. The results of the soakage test results ranged from 1.03 x10-5m/s to 2.5 x10-4m/s.

8.1.2 Stantec Phase I Ground Condition Assessment, dated August 2021, Ref. 332510718/3501

The Stantec report assessed there to be a moderate risk of subvertical or subhorizontal dissolution features within the chalk. This was due to the site being located adjacent to the River Loddon valley floor as it flows north towards the River Thames, therefore the chalk may have well developed flow pathways following bedding planes and fissures. Over time these can result in minor dissolution cavities.

The risk of vertical solution features was considered to be low due to the proximity to the river meaning it's unlikely that significant portions of the chalk would be unsaturated. As such it was considered that significant downward peculation of surface water through the chalk which could produce vertical dissolution feature was unlikely.

The reports notes that there is no record of natural cavities present onsite or in close proximity recorded on the Stantec Natural Cavities Database.

8.1.3 LEAP Phase II Site Investigation Report, dated 24th May 2023, Ref. LP3302

The Phase II investigation comprised 15 No. 1.8m to 3.2m deep machine excavated trial pits and 6 No. 4.0m to 5.0m deep windowless boreholes to 3.0m deep with groundwater monitoring wells installed within 4 boreholes. The ground conditions encountered varied across the site. Generally the development area was underlain by gravel and the public open space by alluvium. The development area ground conditions comprised topsoil over sand, gravels & clays (Kempton Park Gravel) over silt (Chalk Head) over Chalk. The public open space area ground conditions comprised of topsoil over alluvium over chalk. Two areas of infilled pits were encountered in the eastern field at TP106 and TP111 with ground conditions comprising of reworked topsoil over made ground over gravel over clay.

The upper surface of the chalk was noted to be irregular and highly weathered across the site. The ground conditions in WS104 where chalk was encountered overlying loose sands which themselves were underlain by chalk were considered to be indicative of a potential solution feature within this area.

The Chalk was encountered, deepening towards the north, at a depth of 1.2m to 2.8m bgl and 33.07m AOD to 36.08m AOD. The chalk returned intact dry densities of 1.47Mg/m^3 to 1.57Mg/m^3 indicating low to medium density Grade Dm and occasional Dc. Two further samples from WS101 and WS105 were scheduled for testing but were unsuitable due to their highly weathered nature.

SPT 'N_{60}' values ranged from N=3 to N=42. Low N values of <10 were recorded in seven of the 13 No. tests undertaken within the chalk. The low blow counts are indicative of

structureless chalk. It was noted that N values of less than 10 were recorded below 3.0m in all boreholes where chalk was encountered. It was concluded that the lower blow counts likely related to the softening of the chalk around the water table due to seasonable variations in groundwater level however the potential for solution features could not be entirely discounted.

As such a preliminary assessment across the site for solution features was recommended.

C ADDITIONAL DESK STUDY INFORMATION

9 Radon

The Stantec Desk Study, dated 2021, indicated the site was situated in a Radon area where 1% to 3% of the properties were above the actionable level. However, in December 2022 the UK Radon maps were up updated and upon review of the freely available mapping the site was situated in an area of 5% to 10% of properties are above the action level. In England basic pretention measures are required above 3%.

As such a BGS radon report was commissioned for the site. The report indicates that the majority of the site is situated within at area where less than 1% of properties are above the action level. A small area in the farm west of the site is mapped within a 1 – 3% area. The radon risk mapping overlaid on the proposed development layout is presented in Figure 6 Appendix B.

Based on the BGS Radon Report radon protection measures are not deemed to be required on site. It is the clients responsibility to confirm whether radon protection is required and it is recommended that the above guidance is confirmed with the warrantor prior to construction commencing.

10 Unexploded Ordnance (UXO)

The Zetica UXO Risk mapping for the site indicates the site is within a low-risk area for unexploded ordnance. However, during the previous intrusive works the landowner indicated that the south gravel pit was actually an infilled "bomb hole". As such it was recommended that a UXO risk assessment to be undertaken for the site prior to any further investigation or construction works.

A preliminary UXO risk assessment has been undertaken by Brimstone Site Investigation Ltd which concludes there was no evidence for Allied activity or German bombing of the site. As such the assessment concluded that a Stage 2 Detailed Risk Assessment would not be considered necessary prior to works commencing and recommended a UXO Safety Awareness Briefing to all personnel conducting ground works be undertaken as part of site inductions.

D INTRUSIVE INVESTIGATION

11 Investigation Rationale

The key objective of the intrusive investigation was to aid the design and construction of the proposed development plan (Figure 1b, Appendix B) and to determine any constraints associated with foundation design with particular reference to potential solution features.

To achieve the investigation rationale, the scope of works comprised a total of 175 investigation locations across the site comprising of DPSH (Dynamic Probe Super Heavy) to a depth of 6.0m to 10m. An additional 25 locations were scheduled for the buildings planned in the area of the farm buildings and barns. These were not possible due to the farm buildings, barns and hardstanding all currently in use.

The investigation was targeted with one probe location for each plot in the northwestern, northeastern and southeaster fields to assess any soft / loose soils indicative of an infilled solution feature are present on site.

The site investigation locations are provided in Figure 2 Appendix B and Table 1 provides a summary of the rationale, proposed scope and what was achieved in the field:

Table 1: Rationale and Scope for Investigation Locations

Trial Hole/Test Location	Rationale	Proposed Depth (m bgl)	Achieved Depth (m bgl)	Additional Comments
DP001 – DP175	Located in proposed pile locations to provide information on the quality of the ground with particular reference potential solution features.	6.0 – 10.0	6.0 - 10.0	All DPSH tests reached 6.0m bgl, with further testing of up to 10.0m if 0 or 1 encountered in the final metre.

12 Site Work

12.1 Date and Weather Conditions

The intrusive investigations were undertaken between 3rd July 2023 and 12th July 2023. At the time of the investigations, the weather was sunny and overcast with occasional showers.

The Met Office Climate Summaries[2] have been reviewed for July 2023, which indicate that rainfall was generally 170% of the average rainfall across England.

12.2 Site Work Methods

12.2.1 Dynamic Probing

175 No. dynamic probe (super heavy) tests were undertaken across the site, in accordance with BS EN ISO 22476-2:2005 +A1;2011. The results are attached in Appendix E.

13 Ground Conditions

The ground conditions encountered in the Phase II investigation are described in detail in the logs attached in Appendix D. In summary, the ground conditions encountered during LEAP's previous investigation (Ref. LP3302) are provided in the table below.

The ground conditions encountered across the site varied between the areas mapped as being underlain by the gravels (the development area) and those underlain by Alluvium (the public open space). As such the ground conditions encountered in these two areas are summarised separately below. The ground conditions encountered within the two infilled pits are also summarised separately for clarity.

13.1 Development Area

Table 2: Summary of soils encountered across the development area (excluding the gravel pits).

Depth From (m)	Depth To (m)	Soil Type	Description
0.0	0.20 / 0.40	**TOPSOIL**	Brown slightly gravelly silty sandy TOPSOIL with abundant rootlets. Gravel is medium to coarse subrounded to rounded occasionally angular flint. (Appeared reworked in TP102 and WS106 only)
0.20 / 0.30	0.45 / 0.90	**SUBSOIL**	Brown to orange brown slightly gravelly sandy clay and clayey sand SUBSOIL. Gravel is medium to coarse occasionally cobble sized sub-rounded to rounded flint. (Appeared reworked in TP102 only)
0.45 / 0.90	0.80 / 4.00*	**SAND, GRAVEL & CLAY**	Interbedded: Medium dense orange brown to light brown occasionally mottled off white slightly clayey slightly sandy GRAVEL.

[2] [2]Climate summaries - Met Office

			Gravel is medium to coarse occasionally cobble sized subrounded flint. AND Medium dense locally loose brown to orange brown slightly gravelly occasionally slightly clayey silty fine SAND. Gravel is fine to coarse occasionally cobble sized flint. AND Soft to firm occasionally stiff brown to orange brown occasionally thinly laminated slightly sandy to sandy slightly gravelly CLAY. Gravel is fine to coarse subrounded flint and occasional fine chalk.
0.80 / 2.90	1.60 / 4.0*	**SILT (Chalk Head)**	White to off white mottled brown gravelly SILT with pockets of brown sandy clay. gravel is medium to coarse subrounded flint and fine to medium chalk. (Encountered in TP108, TP112 and WS104 only).
1.2 / 2.0**	1.8* / 5.0*	**CHALK**	Off white highly weathered variably grade Dc and Dm CHALK with occasional medium to cobble sized flint recovered as silty gravel. (Encountered in WS101, WS103, WS104 WS105, WS106 TP03, TP110, TP112, TP113, TP114)

*full depth of investigation

**where encountered

The majority of the development area of the site is underlain by silty sandy topsoil of between 0.2m and 0.4m thick over clayey sand and sandy clay subsoils to between 0.45m and 0.9m bgl. The topsoil was noted to appear reworked in TP102 and WS106 including fine fragments of brick, tile and concrete. This was underlain by interbedded medium dense to dense occasionally loose sandy gravels, silty sands and firm occasionally stiff gravelly clays representing the Kempton Park Gravels Member, which were underlain in 9 No. of the 21 No. trial holes completed by highly weathered Chalk. In three locations the chalk was overlain by a layer of gravelly silt chalk head deposits representing the entirely weathered former upper surface of the Chalk.

The Kempton Park soils were variable and showed little consistent variation other than a slight increase in the proportion of sand towards the north of the site and a reduction in clay content with depth. The thickness of the superficial deposits showed a general deepening towards the northeast of the site. Occasionally pockets of off white gravelly silt were encountered within the superficial deposits which were considered to represent weathered chalk fragments within the superficial soils.

The depth to chalk was highly variable ranging from 1.2m to >4.0m bgl across the site and showed a general deepening towards the northeast. The upper surface of the chalk encountered within the trial pits was noted to be irregular and varied in depth significantly from one end of the pit to the other. The chalk encountered was highly weathered. WS104

situated in the central east of the site encountered a layer of chalk from 1.7m to 2.0m bgl which was underlain by loose sand to 2.9m below which chalk head was encountered. This chalk band may represent a chalk boulder deposited within the superficial soils, alternatively this may be indicative of an infilled dissolution feature within chalk in this area.

13.2 Public Open Space Area

Table 3: Summary of soils encountered across the POS area (TP04, TP05, TP115 & TP116).

Depth From (m)	Depth To (m)	Soil Type	Description
0.0	0.25 / 0.30	**TOPSOIL**	Dark brown sandy gravelly silty TOPSOIL with abundant rootlets. Gravel is fine to coarse flint.
0.25 / 0.30	2.0 / 2.8*	**CLAY and SAND (Alluvium).**	Interbedded: Loose to medium dense orange brown very clayey silty fine to medium SAND with occasional medium rounded flint gravel and pockets of off white silt gravelly chalk head. AND Soft to firm orangish brown silty very sandy gravelly CLAY. Gravel is fine to coarse occasionally cobble sized rounded flint.
2.0 / 2.8	2.40* / 3.20*	**CHALK**	Off white completed weathered structureless variably grade Dm and Dc CHALK with occasional subrounded to rounded flint cobbles. Not encountered in (TP116)

*full depth of investigation

The public open space portion of the site was underlain by topsoil over interbedded soft to firm sandy gravelly clays and loose to medium dense clayey sands to between 2.0 and 2.8m bgl over highly weathered chalk to the full depth of investigation. The chalk was not encountered in TP116 which was terminated at 2.4m bgl due to pit sides being unstable.

13.3 Infilled Pits

Table 4: Summary of soils encountered across the POS area (TP106 and TP111).

Depth From (m)	Depth To (m)	Soil Type	Description
0.0	0.20 / 0.30	**Reworked TOPSOIL**	Brown gravelly sandy silty reworked TOPSOIL. Gravel is fine to coarse flint, brick, plastic, blacktop and concrete.
0.20 / 0.30	1.50 / 2.0	**MADE GROUND**	MADE GROUND comprising brown to orange brown mottled off white and brick red slightly clayey gravelly sand and sandy gravel. Gravel comprised chalk and flint in TP106 and brick, plastic, wood, metal and electronics in TP111.

2.0	2.3	**MADE GROUND**	Dark brown mottled black green and white gravelly sandy clay MADE GROUND. Gravel is fine to coarse subrounded to rounded flint, fine chalk, metal, wood metal wire, and cannisters, tar and rubber. (TP106 only)
1.5	2.3	**GRAVEL**	Orange to orange brown slightly clayey sandy GRAVEL or fine to coarse occasionally cobble sized sub-angular to rounded flint (TP111 only)
2.3	3.15	**CLAY**	Firm brown mottled dark brown silty sandy CLAY. (TP106 Only)

*full depth of investigation

The two infilled pits were topped with a layer of reworked topsoil overlying made ground (infill). Within TP106 the made ground generally comprised silty gravelly sand to 2.0m bgl with fragments of chalk and flint below which was a dark brown mottled green layer of made ground including fragments of metal, wite, plastic, tar, glass and metal cannisters. The made ground extended to 2.3m in TP106, below which firm natural clays were encountered.

TP111 comprised made ground underlying the topsoil to 1.5m bgl. The made ground was sand gravelly clays with household and general waste including, bric, metal, plastic, fabric and electronic household appliances. This was underlain by clayey sandy flint gravel to depth.

13.3.1 Groundwater

Groundwater strikes were recorded in the following trial holes:-

Table 5: Groundwater Strikes

Trial Hole	Date of water strike	Depth to Groundwater strike (mbGL)	Depth to Groundwater strike (m AOD)	Comments
TP101	12/04/23	2.3	35.95	Soil recovered damp at 2.3m bgl.
TP110	11/04/23	2.9	33.87	Groundwater seepage at 2.9m bgl
TP111	11/04/23	1.8	34.81	Soil recovered damp to the touch at 1.8m bgl
TP112	11/04/23	1.6	33.89	Groundwater seepage at 1.6m bgl.
TP114	11/04/23	1.0	36.58	Groundwater seepage at 1.0m bgl
TP115	11/04/23	2.8	33.07	Groundwater seepage at 2.8m bgl
TP116	11/04/23	1.0	33.79	Groundwater seepage at 1.0m bgl
WS105	12/04/23	3.0	32.92	Groundwater seepage at 3.0m bgl
TP3	22/03/23	2.8	-	Groundwater seepage at 2.8m bgl rising to 2.5m after 10 minutes
TP4	22/03/23	2.2	-	Groundwater seepage at 2.2m bgl
TP5	22/03/23	2.0	-	Groundwater seepage at 2.0m bgl

Groundwater monitoring results are summarised as follows:-

Table 6: Groundwater Monitoring Results

Monitoring well	Depth to groundwater (mbgl) [m AOD]		
	18/04/23	24/04/23	04/05/23
WS101	Dry [<34.74]	Dry [<34.74]	Dry [<34.74]
WS103	Dry [<35.02]	Dry [<35.02]	Dry [<35.02]
WS105	1.78 [34.14]	1.86 [34.06]	1.94 [33.98]
WS106	1.28 [34.11]	1.41 [33.98]	1.49 [33.90]

The full monitoring results are provided in the Phase II Investigation (Ref: LP3302). It should be noted that groundwater monitoring was undertaken in the spring months following an unusually dry February and as such shallower groundwater levels should be anticipated during the winter months.

13.3.2 Visual and Olfactory Evidence of Contamination

Visual and olfactory evidence of contamination noted during the investigation works is summarised in the following table.

Table 7: Visual and Olfactory Evidence of Contamination

Location	Depth (m bgl)	Olfactory Evidence	Visual Evidence
TP102	0.60	-	Reworked slightly gravelly sandy clayey subsoils encountered with concrete and brick.
TP106	2.0 – 2.3	-	Made ground encountered including fragments of wood, metal, rubble and tar.
TP111	0.0 – 1.5	-	Made ground encountered including metal, plastic, wood, fabric and brick.

Deep made ground was encountered in trial pits TP106 and TP111 situated within the areas of the former gravel pits. The made ground included fragments of wood, metal, brick and in the case of TP111 large metal objects.

E GEOTECHNICAL INFORMATION

For simplicity the following section represents a re-reporting the geotechnical findings of the Phase II investigation (Ref: LP3302).

14 Strata Encountered

14.1 Made Ground

The site is generally underlain by topsoil, however made ground to depths of between 1.5m and 2.3m, was encountered in in TP106 and TP111 in the area of the former gravel pits.

Made ground or fill is by nature highly variable in both composition and bearing capacity, and can be subject to large differential settlements when loaded. It is therefore generally unsuitable for use as a bearing stratum. In addition, made ground may contain contaminated and/or putrescible material. It can therefore be potential source of contamination and landfill gas.

14.2 Alluvium

In the public open space area of the site the topsoil was underlain by interbedded clayey sand and sandy clay alluvium deposits.

14.2.1 Clay and Sand

The results of limited geotechnical testing undertaken on the alluvial soils are summarised in 13 below.

Table 8: Summary of Geotechnical Test Results for Clay

Test	Range
Perth penetrometer blow counts	(5 – 16)
Undrained shear strength (kN/m^2)	16 - 69

Parentheses indicates testing completed during previous investigation.

Limited insitu testing has been undertaken in the POS area. Shear vane tests undertaken in the cohesive soils ranged from 16kPa to 69kPa indicating very soft to firm deposits. Perth penetrometer tests undertaken during the previous soakage testing return blow counts of 5 to 16 within the sands and 15 within the clays indicating loose to medium dense and firm deposits respectively.

14.3 Kempton Park Gravels

Across the developable area of the site the topsoil and where present made ground were underlain by interbedded sandy clays, fine sands and sandy gravels of the Kempton Park Gravel.

14.3.1 Clay

The results of the geotechnical testing undertaken on the clays are summarised in 14 below.

Table 9: Summary of Geotechnical Test Results for Clay

Test	Range
SPT 'N value'	8 -14
SPT 'N_{60} value'	10 - 18
Perth penetrometer blow counts	(16)
Moisture Content (%)	13.1 – 14.9
Liquid Limit (%)	24 – 31
Plastic Limit (%)	13 – 14
Plasticity Index (%)	11 - 17
Undrained shear strength (kN/m^2)	88
Water Soluble Sulphate Content (g/l)	<0.010
Acid Soluble Sulphate	0.013 - 0.030
Total Sulphur (%)	0.010 – 0.020
pH	7.6 – 8.5

The results of limited Atterberg limit testing undertaken on the cohesive soils indicate they comprise low plasticity clay. An A line plot of the plasticity testing results is presented in Figure 4 Appendix B.

Due to the high sandy and gravel content of the clays it was generally not possible to undertake insitu shear vane testing. The results of one shear vane test completed returned an undrained shear strength of 88kPa indicative of firm to stiff clays. This is in general accordance with field observations and the results of Standard Penetration testing. SPT N_{60} values of N=10 to N=18 indicative of firm to stiff clays were encountered within the windowless sampler boreholes.

14.3.2 Sands & Gravels

The results of the geotechnical testing undertaken on the granular soils are summarised in Table 15 and Table below.

Table 10: Summary of Particle Size Distribution tests for Sand/Gravel

Location	Depth (m)	Clay (%)	Silt (%)	Sand (%)	Gravel (%)	Cobbles (%)
TP101	1.10	16.4		39.8	43.8	0.0
TP102	1.20	11.3	12.6	75.6	0.5	0.0
TP109	1.10	8.0		26.3	60.5	5.2
TP113	1.50	10.9	16.5	27.6	45	0.0

The results of particle size distribution (PSD) testing indicate that the soils comprise slightly

clayey slightly silty sandy gravels and gravelly sands with occasional cobbles. The co-efficient of uniformity and curvature indicate that the sands and gravels vary from well graded to gap graded.

Table 11: Summary of Geotechnical Test Results for Sand and Gravel

Test	Range
SPT 'N value'	7 - 31
SPT 'N_{60} value'	9 - 40
Water Soluble Sulphate Content (g/l)	<0.010
pH	7.8 - 7.9

Standard penetration tests undertaken in the granular soils return N_{60} values of N=9 to N=40 indicating loose to very dense sands and gravels. N values indicative of loose soils were only encountered in WS101 and WS104 at 1.0m bgl and 2.0m bgl respectively.

14.4 Chalk – White Chalk Subgroup

The interbedded soils of the Kempton Park Gravels were underlain by Chalk of the White Chalk Subgroup. The results of the geotechnical laboratory testing completed on the chalk are summarised in Table below.

Table 12: Summary of Geotechnical Test Results for Chalk

Test	Range
SPT 'N' value	2 - 33
SPT 'N_{60}' value	3 - 42
Dry Density (Mg/m^3)	1.47 – 1.57
Saturated Moisture Content (%)	27 - 31

The chalk has been characterised in accordance with CIRIA C574[3] from a visual assessment of the chalk excavated from the trial pits and the saturated moisture contents. Classification of the chalk encountered in the windowless sampler boreholes was not possible due to disturbed nature of the samples recovered. The chalk returned intact dry densities of 1.47 to 1.57Mg/m^3 indicating the chalk encountered is low to medium density. In addition two further samples of the chalk taken from WS101 and WS105 were scheduled for testing but the chalk was so highly weathered the samples recovered were not suitable for testing. On this basis the chalk is classified as low occasionally medium density Grade Dm occasional Dc chalk.

[3] CIRIA C574 Engineering in Chalk (2002)

Standard Penetration Tests undertaken in the chalk returned SPT N_{60} values of N=3 to N=42. Low N values of <10 were recorded in seven of the 13 No. tests undertaken within the chalk. The low blow counts recorded are indicative of structureless chalk while the high values often coincide with where flint gravel is logged within the chalk. Furthermore, it is noted that N values generally decreased with depth with N values of less than 10 recorded below 3.0m in all boreholes where chalk was encountered. It is considered that these lower blow counts likely relate to softening of the chalk around the water table due to seasonable variations in groundwater level on site. A plot of the SPT result vs depth is presented in Figure 5.

The ground conditions encountered in WS104 where chalk was encountered overlying loose sands which were themselves underlain by chalk may indicate that a potential solution feature is present in this area of the site and that there is the potential for other such features to be present elsewhere on site.

F FIELD TESTING ANALYSIS

This section refers to the probing results completed in July 2023 in addition to information provided by LEAPs Phase II investigation in May 2023. This is to aid in the analysis of potential solution features and/ or soft spots within the chalk to assess the suitability of pile design.

For a full geotechnical appraisal of the site, please refer to the previous investigation report by LEAP (Ref. LP3302, dated May 2023).

15 Probe Results

A total of 175 No. DPSH tests ranging in depth from 6.0m to 10.0m bgl were undertaken across the site with one probe within the footprint of each proposed plot to assess whether soft / loose soils were present. The probing results have been used in conjunction with the previous 6 No. windowless and 15 No. machine excavated trial pits that were undertaken across the site during May 2023 to create a ground model for the site. Low blow counts considered to be indicative of a potential solution feature are classified as consecutive 0s or 1s where these are present at levels within the chalk strata. Or where 0s and 1s are encountered in sequence within superficial soils extending into the underlying chalk.

In order to effectively analyse the probing and windowless borehole results, the site has been split into three areas: Northwestern Field (DP001- DP040), North of Eastern Field (DP041-103, DP131–DP158) and south of Eastern Field (DP104 – DP130, DP159-175) areas, as shown in Figure 3, Appendix B.

15.1 Northwestern Field (DP1 – DP40)

This area refers to the field, approximately 1.57 Ha, located in the northwest adjacent to the Old Bath Road and to the north of the farm buildings. Boreholes located in the vicinity of these probing locations are WS101, WS102, TP101, TP102 and TP114 as shown in Figure 5a, Appendix B.

The logs note the ground conditions as topsoil to 0.3m/0.4m over interbedded clay, sands and gravels to 2.1m/4.0m+ over chalk to full investigation depth of 3.0m to 5.0m. Chalk was only encountered in WS101 and TP114 in the far west of the field at 2.1m to 2.6m.

DP002, DP007, DP026, DP028 and DP038 recorded multiple low blow counts of consecutive 1s. Low blow counts were encountered between 1.0m and 2.0m in DP002, DP007, DP026 and DP038, which is likely attributed to a loose pockets or soft clays within the interbedded gravels, silts, sands and clay. In DP028 the low blow counts are recorded at a greater depth between 1.9m -2.6m, this is also likely attributed to a localised loose / soft soils in this area rather than a solution feature at depth.

DP012, DP021, DP027 all recorded multiple consecutive low blow counts below 2.0m. DP012 recorded 2 sequences of 1s between 1.0m and 5.5m, DP021 recorded 4 sequences of 1s between 5.3m and 8.0m and DP027 recorded both 1s and 0s between 3.6m – 4.7m. At this stage it is considered this deeper low blow counts represent a combination of the weathered upper surface of the chalk (DP012 & DP027) localised deeper weathering of the chalk at depth (DP021) rather than a solution feature.

Probe depths were extended greater than 6.0m due to soft zones encountered in DP012 and DP021 with all recording higher blow counts indicative of less weathered chalk underlying these zones. DP021 was noted to indicate less weathered chalk from 8.0m.

A majority of probes show a softer layer around 2.0m, which may be indicative of groundwater levels. This is further supported by the Stantec report where the River Terrace Deposits on top of the chalk are referenced as 1.0m to 2.0m above the modern flood plain level. As well as within the soakage tests TP4 and TP5, located in the western fields closest to the River Loddon, carried out in April 2021 noted groundwater strikes between 2.0m and 2.2m. Water monitoring results carried out in the Phase II Investigation showed WS101 recording dry wells and indicating groundwater at 3.0m+. It should be noted that these were carried out in March and May 2023 and are not representative of winter groundwater levels.

Table 13: Summary of Geotechnical Probe Results

DPT	Low Blow Count Depth Range (mbGL)	Feature
DP002	1.2 – 1.5	Soft/ Loose pockets of clay/silt/sands/ gravels
DP007	1.4 – 1.8	Soft/ Loose pockets of clay/silt/sands/ gravels
DP012	1.0 -1.2 / 5.3 -5.5	Chalk Weathering
DP021	5.3–5.6 / 6.2-6.5 / 7.0-7.7 / 7.8-8.0	Chalk Weathering
DP026	1.2 -1.4 / 1.7 – 1.9	Soft/ Loose pockets of clay/silt/sands/ gravels
DP027	3.6 – 4.7	Chalk Weathering
DP028	1.9-2.6	Soft/ Loose pockets of clay/silt/sands/ gravels
DP038	1.0 – 1.3	Soft/ Loose pockets of clay/silt/sands/ gravels

15.2 North of Eastern Field (DP41-103, DP131-158)

This area refers to the northern part of the eastern field, approximately 2.35 Ha. Boreholes located in the vicinity of these probing locations are TP01, TP102, TP104, TP105, TP106 and WS103. Please refer to Figure 5b, Appendix B.

The logs noted topsoil to 0.2m/0.35m over interbedded clays, sand, silt and gravels to 2.8m/3.1m over chalk to the full depth of investigation of 2.8m to 4.0m. A gravel pit is mapped at TP106, where made ground of gravelly sand with gravels of flint and chalk are logged between 0.35m to 2.0m then underlain by clay. Chalk was only encountered in WS103 at 3.1m

and a gravelly silt / sandy clay was noted as Chalk head in TP108 at 1.7m. In the other locations the underlying chalk is at depths of 2.8m+ to 3.15m+.

Multiple low blow counts were recorded in DP084 between 4.7m and 6.0m and DP082 between 1.1m and 5.0m. It should be noted that both are located within the area mapped as a gravel pit with the made ground logged between 0.3m to 2.0m. The consecutive low blows are likely attributed to the gravel pit. Prior to construction the areas of the gravel pits will be required to be remediated .

Consecutive low blow counts of 1s were noted between 1.0m and 2.0m in 11 No. probe locations and 13 No. locations were associated with either a shallow depth of 1s and 0s or a dominance of 1s at depth. Based on the shallow occurrences, dominance of 1s and the ground condition encountered in previous site investigation these are likely attributed to loose / soft soils within the interbedded gravel, silt, sand and clays. Deeper consecutive low blows were recorded in DP066 at 5.5m to 5.8m and in DP092 at 2.4m to 2.7m. These are likely attributed to deeper weathering within the chalk or chalk head.

Low blow counts dominated by 0s in either a single longer sequence generally over 0.5m or multiple consecutive sequences varying in length from 0.3m up to 1.4m were recorded in DP052, DP062, DP080, DP088, DP103, DP150, DP151 and DP156. These are considered indicative of a potential solution feature, although may also be representative of deep weathering of the chalk. Please refer to Figure 5b, Appendix B.

DP093, DP094, DP096, DP097, DP139 and DP158 all recorded soft / loose zones ranging from 0.8m to 3.9m in length and 2.8m to 7.0m in depth. Given the depth and thickness of these soft / loose area these are considered to be a probable solution features within the chalk at depth. Please refer to Figure 5b, Appendix B.

Probe depths were extended greater than 6.0m due to soft/loose zones encountered in 8 positions. DP093 and DP139 were extended to 8.0m. DP066, DP084, DP097, DP154, DP157 and DP158 were extended to 7.0m.

Table 14: Summary of Geotechnical Probe Results

DPT	Low Blow Count Depth Range (mbGL)	Feature
DP052	5.5-6.0 / 6.1-6.8 / 7.4-8.1	Possible Solution Feature
DP062	2.6-3.6	Possible Solution Feature
DP080	3.1-3.7 / 4.5-4.7	Possible Solution Feature
DP088	2.1-3.1 / 3.8-4.1	Possible Solution Feature
DP093	2.4-2.7 / 4.1-4.9 / 5.2-5.7 / 5.8-6.3 / 6.6-6.8	Probable Solution Feature
DP094	4.4-5.0 / 5.2-6.0	Probable Solution Feature
DP096	3.1-4.5 / 5.0-5.4 / 5.6-5.9	Probable Solution Feature
DP097	2.4-4.1 / 4.5-4.8 / 5.4-5.7	Probable Solution Feature
DP103	4.8-5.1 / 5.2-6.3 / 6.8-7.1	Possible Solution Feature

DP139	5.1-6.0 / 6.3-7.0	Probable Solution Feature
DP150	4.5-4.9 / 5.3-5.7 / 5.8-6.4 / 6.5-6.7	Possible Solution Feature
DP151	1.9-2.6	Possible Solution Feature
DP156	2.2-2.7	Possible Solution Feature
DP158	3.4-5.1 / 5.4-6.0	Probable Solution Feature

15.3 South of Eastern Field (DP104-130, DP159-175)

This area refers to the southern part of the eastern field, approximately 2.35 Ha. Boreholes located in the vicinity of these probing locations are WS104, WS105, TP03, TP110, TP111, TP112 and TP113. Please refer to Figure 5c, Appendix B.

The logs note topsoil to 0.2m/0.4m over interbedded clays, sand, silt and gravels to 1.2m/2.3m+ over chalk to the full depth of investigation of 2.3m to 4.0m. Chalk was not encountered in TP111 where a gravel pit is mapped. In TP111 made ground is logged from ground level to 1.5m comprising a clayey gravel with gravels of brick, metal, plastic, wood and household electronics. Gravels were encountered beneath the made ground to the full depth of the trial pit to 2.3m. Chalk is logged below 1.2m to 2.7m in the other intrusive investigation locations. It should also be noted the presence of a possible solution feature in WS104 where chalk is logged from 1.7m to 2.0m then again at 2.9m to 4.0m with sand present in the space between from 2.0m to 2.9m.

Multiple low blow counts were recorded in DP169 between 2.0m and 2.9m and DP171 between 3.2m and 4.9m. It should be noted that both are located within the area mapped as a gravel pit with the made ground logged between GL to 1.50m, with gravel below to the full depth of excavations at 2.3m. The consecutive low blows are likely attributed to the gravel pit. Prior to construction the areas of the gravel pits will be required to be remediated .

Low blow counts between 1.0m and 2.0m were noted in 3 probes, lows blows associated with either a shallow depth or a dominance of 1s were recorded in 8 probe locations and multiple deeper sequences are recorded in 4 probe locations. These are likely attributed to loose ground or soft spots in the gravels, silts, sands and clay overlying the chalk or deeper weathered zones within the chalk.

Low blow counts dominated by 0s in either a single longer sequence generally over 0.5m or multiple consecutive sequences varying in length from 0.5m to 1.0m were recorded in DP113, DP128, DP129, DP159, DP160 and DP164. These show a possibility of solution features present, though there is also a possibility that they may be associated with a deeper weathering profile. Please refer to Figure 5c, Appendix B.

DP111, DP161, DP168 and DP172 all recorded low blow sequences 0 dominated ranging from 1.0m to 2.7m in length. 2 sequences were recorded in DP111 and DP168, with 3 or more in DP161 and DP172. Where multiple sequences occurred, the longer sequence were associated with others of low blow counts shorter in length. These are indicative of potential solution features. Please refer to Figure 5c, Appendix B.

Probe depths were extended greater than 6.0m due to soft/loose zones encountered in 13 positions. DP120 and DP161 were extended to 10.0m. DP113, DP128 and DP129 were extended to 9.0m. DP124, DP159 and DP172 were extended to 8.0m. DP108, DP112, DP115, DP173 and DP174 were extended to 7.0m. Higher blow counts indicative of less weathered chalk underlying these zones.

Table 15: Summary of Geotechnical Probe Results

DPT	Low Blow Count Depth Range (mbGL)	Feature
DP111	1.-3-3.2 / 3.3-4.0	Probable Solution Feature
DP113	3.1-4.0	Possible Solution Feature
DP128	1.3-2.7 / 3.5-3.7 / 4.2-6.8 / 6.9-7.9	Possible Solution Feature
DP129	4.3-4.5 / 4.6-4.9 / 5.1-6.4 / 6.6-7.4	Possible Solution Feature
DP159	3.6-3.8 / 5.3-5.6 / 6.3-7.0 / 7.2-7.4	Possible Solution Feature
DP160	3.9-4.9	Possible Solution Feature
DP161	4.1-4.6 / 5.4-5.8 / 5.9-6.1 / 6.3-7.5 / 7.6-8.2 / 9.0-9.2	Probable Solution Feature
DP164	4.3-4.8	Possible Solution Feature
DP168	1.9-3.6 / 3.8-4.3	Probable Solution Feature
DP172	4.2-4.4 / 4.6-4.9 / 5.2-7.3	Probable Solution Feature

G RECOMMENDATIONS

The probing results generally indicate ground conditions consistent with those encountered within LEAP's previous investigation in May 2023, and encountered soft/ loose zones within the superficial deposits on site. The majority of the loose soils were noted within the shallower soils, however deeper zones are noted in several locations across the site down to depths of up to 9m bgl. No significant evidence for potential solution features were noted in the northwest field section of the site. In the eastern field 14 No. probes flagged possible solution features and 10 flagged as a probable solution feature.

The shallower loose zone encountered are interpreted to represent loose pockets within the superficial deposits relating to their fluvial deposition and extensive weathering of the upper surface of the underlying chalk. This weathering of the chalk likely also represents softening associated with seasonal movements of the groundwater table.

Probe depths were extended beyond 6.0m bgl where evidence for loose / soft were encountered between 5.0 and 6.0m bgl until at least one metre without any loose zones present was recorded. As such probes in some locations were extended to a maximum depth of 10m bgl. In total 22 No. probes were extended below 6.0m bgl. The eastern field showed a greater occurrence of probe results indicating the potential for solution features.

Based on the findings of these additional works evidence for loose shallow soils have been encountered across the site. Furthermore, evidence for potential solution features within the chalk at depths of between 1.3m and 8.2m bgl were encountered in the eastern half of the site. Please refer to Figure 5b and 5c, Appendix B.

The soft/loose soils and potential solution features would be susceptible to settlement, where loaded. Given the extent of loose soils it is recommended that a presumed bearing resistance of 85kPa may be applicable where shallow foundations . At this stage the north western site area may be suitable for shallow footings, however, given the low blow counts encountered in some of the DPTs, additional windowless sampled boreholes should be undertaken to confirm this bearing capacity.

Given the evidence for potential solution features within the eastern area of the site in accordance with CIRIA C574, consideration may be given to the following treatment methods:

- Excavation and replacement with compacted suitable material
- Bridging
- Ground stabilisation by grouting
- Ground treatment by grouting
- Piling
- Control of drainage

Further assessment is required to assess the extent of potential solution features in the eastern half of the site. Probing at the corners and midpoints of plots would be required to assess the extent of any existing features identified and the potential for further features to

be present. Where potential solution features have been identified (Figure 5b and 5c) it is likely that deep foundations (piles) may be required.

Where the probing indicates shallow foundations may be appropriate, given the presence of potential solution features within the chalk underlying the superficial deposits the following remedial measures are recommended as part of the shallow foundation design.

- Cruciform shaped, reinforced foundations, designed to extend at least 1m beyond the proposed building corner in each direction and with a minimum span of 5m (as per CIRIA C574)

- Proposed footprints should be kept as square as possible. Long terraces and linked buildings should be avoided.

Completion of deep boreholes to between 20 and 25m bgl is also recommended to provide parameters for pile design.

APPENDIX A – Limitations

Limitations

LIMITATIONS

This report is confidential to the Client, and Leap Environmental Ltd accepts no responsibility whatsoever to third parties to whom this report, or any part thereof, is made known, unless formally agreed by Leap Environmental Ltd beforehand. Any such party relies upon the report at their own risk. Unless explicitly agreed otherwise in writing, this report has been prepared under LEAP's standard terms and conditions, as included in the quotation for this works.

This report has been prepared by Leap Environmental Ltd on the basis of information received from a variety of sources which Leap Environmental Ltd believes to be accurate. Nevertheless, Leap Environmental Ltd cannot and does not guarantee the authenticity or reliability of the information it has obtained from others.

Leap Environmental Ltd has used all reasonable skill, care and diligence in the design and execution of this report, taking into account the manpower and resources devoted to it in agreement with the Client. Although every reasonable effort has been made to obtain all relevant information, all potential contamination, environmental constraints or liabilities associated with the site may not necessarily have been revealed. LEAP cannot be held responsible for any disclosures or changes in regulation that are provided post production of this report, and will not automatically update the report.

The conclusions reached in this report are necessarily restricted to those which can be determined from the information consulted, and may be subject to amendment in the light of additional information becoming available. These conclusions may not be appropriate for alternative schemes.

The extent of the exploratory holes, laboratory testing and monitoring undertaken may have been restricted due to a number of factors including accessibility, the presence of buried or overhead services, current development and site usage, timescales or clients specification. The exploratory holes only assess a small proportion of the site area with respect to the site as a whole, and as such may only provide an overall assessment of ground conditions on site. The presence of hotspots of undisclosed contamination or exceptional and unforeseen ground conditions cannot be discounted.

Eurocode 7 gives guidance on the type of sampling, sample quality, number and spacing of intrusive investigations, and number of laboratory tests required. It is intended that the Geotechnical Information section of this report will fulfil the general requirements of the Ground Investigation Report as set out in section 6 of Eurocode7[4], although this is subject to the restrictions imposed on the investigation as listed above. For geotechnical design,

[4] BS EN 1997 Eurocode 7- Geotechnical Design - Part 1: General Rules (2004) and Part 2: Ground Investigation and Testing (2007)

Eurocode 7 requires the Geotechnical Design Report to address both the geotechnical and structural aspects of the geotechnical design for both the limit and serviceability states. The Geotechnical Appraisal section of this report will not meet the requirements of a Geotechnical Design Report (GDR), and should therefore be used for preliminary guidance only.

The presence of asbestos may be noted during the site walkover survey, intrusive investigations and/or from the results of contamination testing. However, this report does not constitute an asbestos survey. On this basis, the presence of asbestos on site cannot be discounted and a full asbestos survey should be undertaken.