




**REPORT ON  
GROUND INVESTIGATION  
AT  
CATALYST BICESTER,  
WENDLEBURY ROAD**



**REPORT STATUS SHEET**

<b>Client:</b>	Albion Land Ltd
<b>Report Title:</b>	Report on Ground Investigation at Catalyst Bicester, Wendlebury Road
<b>Report Number:</b>	AG2875A-20-AK72
<b>Report Status:</b>	Validated Issue 1
<b>Date:</b>	September 2020



		<b>Date</b>	<b>Signed for and on behalf of Applied Geology Limited</b>
<b>Co Author</b>	K McGeoch BSc (Hons) MSc Project Geologist	24/9/2020	
<b>Co Author and Checked</b>	F Hadley-Jones BSc (Hons) MSc FGS Lead Project Engineer	24/9/2020	
<b>Checked and Authorised</b>	G P Wiggin BSc (Hons) MSc, FGS Associate Director	24/9/2020	

## CONTENTS

<b>1.0</b>	<b>INTRODUCTION.....</b>	<b>1</b>
1.1	Objectives and Scope of Investigation .....	1
1.2	Report Layout .....	1
<b>2.0</b>	<b>SITE DESCRIPTION AND PROPOSALS.....</b>	<b>2</b>
2.1	Site Description.....	2
2.2	Site Proposals.....	3
<b>3.0</b>	<b>DESK STUDY INFORMATION – SUMMARY.....</b>	<b>4</b>
<b>4.0</b>	<b>GROUND INVESTIGATION WORKS.....</b>	<b>5</b>
4.1	Fieldwork .....	5
4.2	Instrumentation and Monitoring .....	6
4.3	Laboratory Testing.....	7
<b>5.0</b>	<b>GROUND CONDITIONS.....</b>	<b>8</b>
5.1	Strata Summary .....	8
5.2	Topsoil, Subsoil and Made Ground .....	9
5.3	Alluvium .....	9
5.4	River Terrace Deposits.....	9
5.5	Kellaways Formation .....	10
5.6	Cornbrash Formation.....	11
5.7	Groundwater .....	12
5.8	Contamination.....	14
5.9	Soil Gas .....	14
<b>6.0</b>	<b>GEOENVIRONMENTAL ASSESSMENT.....</b>	<b>14</b>
6.1	Human Health Risk Assessment.....	14
6.2	Controlled Waters Risk Assessment .....	15
6.3	Disposal of Soil Arisings .....	15
6.4	Conclusions and Recommendations.....	16
<b>7.0</b>	<b>GEOTECHNICAL ASSESSMENT.....</b>	<b>17</b>
7.1	General .....	17
7.2	Earthworks.....	17
7.3	Foundation Design .....	18
7.4	Floor Slab and Gas Protection .....	19
7.5	Excavations .....	19
7.6	Attenuation Basins.....	20
7.7	Buried Concrete and Services.....	20
7.8	Conclusions and Recommendations.....	21

## GENERAL NOTES

## APPENDICES

<b>APPENDIX A</b>	<b>DRAWINGS &amp; FIGURES</b>
	<ul style="list-style-type: none"><li>• Site Location Plan, Dwg AG2875A-20-01</li><li>• Exploratory Hole Location Plan, Dwg No AG2875A-20-02 Rev 1</li><li>• Proposed Development Drawings (Drawing No's. S1358-Ext-09A, 10A, 30A, 34B, 37, 46B, 48A and 49)</li><li>• Topographical Survey, Dwg 25646R1</li><li>• SPT N value v depth</li></ul>
<b>APPENDIX B</b>	<b>EXPLORATORY HOLE LOGS</b>
<b>APPENDIX C</b>	<b>TRIAL PIT PHOTOGRAPHS</b>
<b>APPENDIX D</b>	<b>FIELD MONITORING RESULTS</b>
<b>APPENDIX E</b>	<b>LABORATORY TEST RESULTS &amp; DATA SHEETS</b>
<b>APPENDIX F</b>	<b>STANDARD FIELDWORK AND ASSESSMENT PROCEDURES</b>

**EXECUTIVE SUMMARY**

<b>Investigation Objective</b>	Supplementary ground investigation – comprising trial pitting and boreholes to fully assess the ground conditions at the site and also now including in the former chicken farm, which was previously inaccessible during the 2018 investigation.
<b>Site Description</b>	Promised Land Farm, located off Wendlebury Road, approximately 1.5km southwest of Bicester town centre. Site covers an area of approximately 17.28ha and comprises three undeveloped fields, with the former chicken farm and associated infrastructure in the southwest. Langford Brook bounds the site to the east, fields to the south, Wendlebury Road to the west and an access road leading on to the Thames Water Sewage works to the north.
<b>Site History</b>	The site comprised undeveloped fields since the earliest historical map (1885). The chicken farm and associated building in the southwest were constructed between 1970 and 1983 and remained unchanged to the present day.
<b>Anticipated Geology</b>	Published information indicates that the majority of the site is initially underlain by Alluvium. The Alluvium is absent in the northwest and southwest of the site, where River Terrace Deposits are shown. Solid geology of the Kellaways Formation is anticipated below, comprising interbedded sandstone and siltstone of the Kellaways Sand Member, underlain in turn by predominantly mudstone of the Kellaways Clay Member. Kellaways Sand is shown to be absent in the north of the site. The Kellaways Formation is anticipated to be underlain by limestone of the Cornbrash Formation.
<b>Other Pertinent Desk Study Data</b>	<p>No current or historical records of landfills sites within 250m of the site.</p> <p>One recorded pollution incident within 250m of the site located 160m north east associated with microbiological pollutant (2002).</p> <p>No recorded petrol/fuel sites identified within 250m.</p> <p>Five current industrial land uses, relating to electricity substations and the Sewage Works. One commercial land use associated with the former Promised Land chicken farm located in the southwest of the site.</p> <p>Superficial Deposits and Kellaways Sand Member are designated as Secondary A Aquifers. Kellaways Clay Member is designated as Unproductive strata. The underlying Cornbrash Formation is a Principal Aquifer.</p> <p>The site is within a Zone 3 Floodplain, where probability of annual flooding estimated as 1 in 100. No ecologically sensitive areas within 1000m of the site.</p>
<b>Scope of Investigation</b>	Sixteen Cable Percussion boreholes, four Driven Continuous Sampling boreholes, eleven machine excavated trial pits together with a programme of ground gas and ground water monitoring and laboratory testing of soils.
<b>Ground Conditions</b>	<p>Surface topsoil/subsoil was underlain by Superficial Deposits comprising Alluvium and River Terrace Deposits. The Superficial Deposits were underlain by the Kellaways Formation, predominantly comprising clay, with initial horizons of sand in the southeast of the site. The Cornbrash Formation was encountered at the base of the boreholes.</p> <p>Groundwater was recorded in the majority of the exploratory holes during drilling and excavation, predominantly in the River Terrace Deposits, from depths of between 1.10m and 2.10m bgl. A second groundwater strike was also recorded at the base of the boreholes within the Cornbrash Formation, which was noted to be predominantly under sub-artesian conditions with one borehole recording artesian groundwater.</p>
<b>Geo-environmental Assessment</b>	Contamination related risks to Human Health and Controlled Waters are negligible.
<b>Geotechnical Overview</b>	<p>Widened reinforced foundations placed within the River Terrace Deposits may adopt safe net design bearing pressures up to 120kN/m<sup>2</sup>. It is recommended that foundations are maintained as shallow as possible within the upper horizons of the River Terrace Deposits to prevent significant groundwater ingress into the foundation excavations.</p> <p>Where the River Terrace Deposits are absent in the northwest of the site, foundations may be placed in the cohesive Kellaways Formation where a similar allowable bearing pressure is considered achievable.</p> <p>Ground bearing floor slabs may be adopted following removal/replacement of any localised desiccated, soft or organic material identified at exposed formation level and successful completion of earthworks to a suitable specification.</p> <p>Gas and radon protection measures are not considered necessary.</p> <p>No special concrete design measures are required for shallow foundations placed within the River Terrace Deposits. Deeper foundations placed in the underlying Kellaways Formation, will require sulphate resisting concrete appropriate to DS-4/AC-4.</p>

---

## 1.0 INTRODUCTION

### 1.1 Objectives and Scope of Investigation

A plot of land at Promised Land Farm located off Wendlebury Road, Bicester (the site) is being considered for development by Albion Land Ltd (the Client). The site comprises three unoccupied tree-lined fields, together with a rectangular shaped plot of land in the southeast, previously used as a chicken farm.

A Phase I desk study and preliminary pre-acquisition Phase II investigation was previously undertaken on the site by Applied Geology Ltd on behalf of the Client in July 2018 and reported in November 2018 (ref AG2875-18-AF37). The investigation was undertaken to provide preliminary information to inform development feasibility and potential liabilities relating to the ownership of the site. At the time of the previous investigation, access was not available to the chicken farm area. The investigation concluded that based on the testing undertaken, contamination related risks were negligible. Following the purchase of the site and once all areas were available, it was recommended that further site investigation should be undertaken to provide sufficient information for design and to support discharge of Planning Conditions. Planning Permission for the site has now been granted and a number of Conditions relating to the investigation of potentially contaminated land were imposed.

Applied Geology was appointed by the Client to undertake a supplementary ground investigation in order to:

- assess the potential for hazardous substances or conditions to exist at the site that might warrant mitigation or remediation appropriate to the intended end use proposed by the Client.
- establish geological conditions and geotechnical parameters to assist in the safe and economic engineering design of the proposed development.
- Support discharge of conditions associated with planning application referenced 19/01740/HYBRID and 19/01746/OUT.

The terms of reference/brief for the supplementary works were mutually developed between Bailey Johnson Hayes (Engineer to the Client) and Applied Geology in accordance with Applied Geology's proposal and estimate (ref AG2875A-20let002, dated 2<sup>nd</sup> April 2020).

The scope of supplementary investigation works comprised trial pitting, cable percussion boreholes and driven continuous sampling boreholes together with sampling, in situ testing and both chemical and geotechnical laboratory testing.

The findings of the both phases of investigation (preliminary and supplementary) are presented and evaluated in this report.

### 1.2 Report Layout

This report presents a brief description of the site, a summary of the previous desk study report and the factual results of the intrusive investigations carried out. An interpretation of the ground conditions and a discussion/assessment of the findings

is presented in the later report text sections. The report should be read in conjunction with the general procedures detailed in Appendix F and General Notes given at the end of the main text, which provide details of investigation techniques, assessment methodology, standards, health & safety and limitations and exceptions of the report. Drawings and factual data including exploratory hole records, laboratory testing results and desk study records are presented in the other Appendices.

## **2.0 SITE DESCRIPTION AND PROPOSALS**

### **2.1 Site Description**

The site is located off Wendlebury Road, approximately 1.5km to the southwest of Bicester town centre. The Ordnance Survey grid reference for the centre of the site is 457226 220693 as shown on the Site Location Plan in Appendix A. Access to the site was gained through two separate gateways off Wendlebury Road

The site is approximately rectangular in plan shape, with approximate dimensions of 360m from east to west, and 480m from north to south. The site covers an approximate area of 17.28ha and reference to the topographic survey drawing in Appendix A, shows the site to slope gently from an elevation of c. 66m AOD in the northwest to c. 63m AOD in the southeast.

At the time of the walkover undertaken during the current investigation, the site comprised three undeveloped grassed fields and a former chicken farm, which occupied an area of approximately 200m by 150m in the southwest corner of the site. The fields were in use for grazing cattle, (although the farmer subsequently relocated the cattle for the duration of the investigation works). Except for the northern boundary of the site and the boundary with the chicken farm in the south, the fields were all lined with hedgerows and semi-mature and mature trees. Electricity pylons with associated overhead cables orientated north-south were located along the west of the site with two sets also located in the east.

Access to the former chicken farm was not available directly from the fields, hence a separate padlocked gate off Wendlebury Road was used. At the time of the walkover, the farm was no longer in use. Eight chicken sheds (wooden structures with suspected asbestos sheet roofing), each measuring approximately 60m by 20m occupied the eastern half of the farm area, either side of a concrete access road which bisected the farm from east to west. The chicken sheds were largely vacant, aside from the pipework previously used for feeding. A 2-storey brick-built residential property was located in the southwest of the farm. A circular pond, approximately 50m in diameter, was located in the northeast. An above ground diesel tank resting on a concrete pad was located adjacent to the chicken sheds. Six propane gas cylinders were located between the residential property and the chicken sheds, again constructed on a concrete pad. No visual or olfactory evidence of contamination was noted around the diesel tank, gas cylinders or elsewhere across the site and it appeared, in general, that the farm had been previously well managed with a good level of housekeeping. Aside from the access road, the ground surface comprised overgrown grass. A number of semi-mature and mature trees were located around the pond and residential property in the west.





Above ground diesel tank in the west of the former chicken farm, view facing north.



Propane gas cylinders in the west of the former chicken farm, view facing southwest.



View facing south between two former chicken sheds



View in the north of the former chicken farm, facing northeast towards the fields.

The site as a whole was bound to the north by an access road to the neighbouring Thames Water STW, which was segregated by a post and rail fence line, to the east by Langford Brook, to the south by further fields belonging to the Promised Land Farm and to the west by Wendlebury Road.

## 2.2 Site Proposals

The proposals for the site comprise the construction of 13 No industrial units with office space, a sports and leisure facility, associated infrastructure accessed via a new roundabout on Wendlebury Road. The eastern margin of the site in the lower lying areas nearer to Langford Brook are given to attenuation basins and a wetland area comprising shallow wet areas, reed beds and shrubs.

Earthworks will be required to create level plateaus for the buildings and to raise levels to provide flood protection. Finished Floor Levels (FFL) of around 64.75m AOD are proposed. It is understood that the thickness of engineered fill required to raise the floor slabs to proposed levels following the removal of the existing topsoil/subsoil at the site is generally less than around 1m. Existing levels are to be reduced by a small amount to accommodate the development levels in the northwest of the site.

The proposals are shown on a series of drawings by Bailey Johnson Hayes (Drawing No's. S1358-Ext-09A, 10A, 30A, 34B, 37, 46B, 48A and 49), copies of which are included in Appendix A.

### 3.0 DESK STUDY INFORMATION – SUMMARY

A Phase 1 Geoenvironmental Risk Assessment was undertaken as part of the previous 2018 investigation (Ref: AG2875-18-AF37). Reference should be made to this report for full details of the desk study; however, a summary of the findings is provided below.

- **Site History:** The site has comprised undeveloped fields since the earliest historical map (1885). The chicken farm and associated buildings in the southwest were constructed prior to the 1983 Ordnance Survey map edition and these appear to have remained essentially unchanged to the present day.
- **Geology:** Published British Geological Society Mapping shows the majority of the site to be initially underlain by Alluvium, which in turn is underlain by River Terrace Deposits. The Alluvium is absent in the northwest and southwest of the site. Solid geology of the Kellaways Formation is anticipated below, comprising interbedded sandstone and siltstone of the Kellaways Sand Member and mudstone of the Kellaways Clay Member. The Kellaways Sand Member is shown to be absent in the north of the site. The Kellaways Formation is anticipated to be underlain by limestone of the Cornbrash Formation. The site does not lie within a radon affected area, with less than 1% of homes above the action level. The site is not indicated to be within an area of mining activity.
- **Hydrogeology:** The Superficial Deposits and Kellaways Sand Member are classified as Secondary A Aquifers, with the Kellaways Clay Member listed as unproductive strata. The Cornbrash Formation is classified as a Principal Aquifer. According to the Groundsure report dated 7<sup>th</sup> June 2018, the nearest groundwater abstraction was located within the chicken farm. The license was still active at the time of the Groundsure report and used for general farming and domestic uses (this will need to be formally re-commissioned or decommissioned as part of the future development).
- **Hydrology:** The nearest surface watercourse is Langford Brook, which flows along the eastern boundary of the site. The site is shown to lie within a Zone 2 and Zone 3 floodplain and within a Nitrate Vulnerable Zone. There are no surface water abstractions within 500m of the site. The nearest licensed discharge is located 45m to the southeast of the site and associated with sewage discharges into Langford Brook. This license was revoked on 01/11/1989.
- **Other Environmental Data:** No historical or current landfills or licensed waste sites are noted within 250m of the site. Five potentially contaminative industries are located within 250m of the site, relating to electricity substations (26m and 169m northeast) and the Sewage Works (175m east). One commercial land use was noted within 250m of the site associated with the former Promised Land chicken farm located in the southwest corner of the site. The Groundsure report undertaken for the previous phase of works, identified the operator as Faccenda Foods Limited with the process indicated as 'intensive farming, > 40,000 poultry'. The farm was licensed



under permit number: MP3935RW which remained effective as of 1<sup>st</sup> March 2018 (the date of the GroundSure Report).

The Conceptual Site Model derived from the desk study data is reproduced below:

Source	Pathway	Receptor	Risk*
Potential contaminants within Made Ground or resulting from site development (chicken farm)	Inhalation, ingestion, dermal contact.	End users, adjacent residents	Low
	Migration and Leaching	Superficial Deposits and Kellaways Sand Member (Secondary A Aquifers) Cornbrash Formation (Principal Aquifer)	Low
Soil gas from Made Ground – both on site and off site sources (methane, carbon dioxide, VOCs)	Migration into buildings, service ducts etc.	End users	Low
Elevated sulphates in Made ground or natural soils	Direct contact, leaching and contact with groundwater	Buried concrete	Low-Medium
Hydrocarbon contaminants from vehicle/plant leaks and leaks from tanks at the chicken farm	Inhalation, ingestion, dermal contact	End users	Low
	Migration/leaching	Superficial Deposits and Kellaways Sand Member (Secondary A Aquifers) Cornbrash Formation (Principal Aquifer)	Low-Medium
	Direct contact	Water Supply Services	Low

**\* Definition of Risk Categories**

Negligible - Contaminants that might have unacceptable impact on key receptors, are unlikely to be present, or, no pathway is envisaged.

Low Risk: Contaminants may be present but are unlikely to be at levels to have unacceptable impact on key receptors, or pathways are likely to be minimal.

Medium Risk: Contaminants are probably present and might have an unacceptable impact on key receptors. Pathways may also be present therefore remedial measures may be necessary to reduce the risks.

High Risk – Contaminants probably or certainly present and pathways are probably also present. Therefore, contaminants are likely to have an unacceptable impact on key receptors and remedial measures are likely to be necessary to reduce the risks to acceptable levels.

## 4.0 GROUND INVESTIGATION WORKS

### 4.1 Fieldwork

Underground service plans for the site were obtained by Applied Geology on 5<sup>th</sup> June 2020. A topographic survey (Drawing No. 25646R1, by MK Surveys, dated June 2018) was provided by the Engineer.

The fieldwork undertaken during the preliminary 2018 investigation comprised 18 machine excavated trial pits (designated TP1 to TP18) taken to depths of between 2.35m and 4.1m below ground level (bgl).

The fieldwork for the supplementary 2020 investigation comprised the following:

- 16 cable percussion boreholes (designated BH1 to BH15A) taken to depths of between 2.0m and 5.5m bgl (BH15A was drilled adjacent to BH15 to facilitate the installation of a shallow standpipe);
- 4 driven continuous sampling boreholes (designated DCS1 to DCS4) taken to depths of between 4.3m and 5.0m bgl;
- 11 machine excavated trial pits (designated TP101 to TP111) taken to depths of between 1.9m and 2.8m bgl;
- 1 hand excavated trial pit (designated HDP1) to a depth of 1.20m bgl (undertaken to obtain a shallow soil sample adjacent to the gas cylinders).

The borehole and trial pit records are included in Appendix B together with Standard penetration Test (SPT) calibration certificates and an SPT summary sheet. Trial Pit photographs are presented in Appendix C.

The locations of the exploratory holes were selected generally in accordance with a proposed borehole location plan provided by the Engineer and set out on site by Applied Geology. A number of the positions were constrained by the presence of a sewer, the electricity pylons/overhead cables and other infrastructure within the chicken farm area. The cable percussion boreholes were positioned within the footprints of the proposed buildings for geotechnical purposes and to install standpipes for subsequent ground gas and groundwater monitoring. The trial pits were positioned to gain general site coverage to assess the shallow groundwater conditions and obtain samples for subsequent contamination analysis. The driven continuous sampling boreholes were positioned to obtain further site coverage in areas within the chicken farm not accessible by the cable percussion drilling rig. HDP1 and DCS2 were located specifically to target the gas cylinders and diesel tank respectively within the chicken farm.

The positions of the exploratory holes are approximated in relation to field boundaries and identifiable features on the topographical survey provided by the Engineer. Ground levels have been extrapolated from the topographical survey and presented on the exploratory hole logs. The locations are presented on Drawing No. AG2875A-20-02 Rev 1 (Appendix A).

## 4.2 Instrumentation and Monitoring

On completion of boring, 50mm diameter standpipes were installed in selected boreholes. Full details of these installations are provided on the relevant borehole records in Appendix B. A summary of the standpipes outlining the depths of the response zone and the strata targeted is provided in the following table:

Exploratory Hole	Response Zone (m bgl)	Strata
BH1	0.9 to 2.9	Alluvium / Kellaways Formation
BH2	2.1 to 2.8	Kellaways Formation / Cornbrash Formation
BH3	1.0 to 2.0	Alluvium
BH4	2.1 to 2.9	Kellaways Formation / Cornbrash Formation
BH6	2.6 to 3.6	Kellaways Formation / Cornbrash Formation

Exploratory Hole	Response Zone (m bgl)	Strata
BH7	1.0 to 2.0	River Terrace Deposits / Kellaways Formation
BH8	1.0 to 2.0	River Terrace Deposits / Kellaways Formation
BH9	1.0 to 2.0	River Terrace Deposits / Kellaways Formation
BH10	2.4 to 3.4	Kellaways Formation / Cornbrash Formation
BH11	0.8 to 2.7	River Terrace Deposits / Kellaways Formation
BH12	1.0 to 4.0	Alluvium / River Terrace Deposits
BH14	1.0 to 3.0	River Terrace Deposits / Kellaways Formation
BH15A	1.0 to 2.0	River Terrace Deposits / Kellaways Formation
DCS1	1.0 to 2.0	River Terrace Deposits
DCS2	1.0 to 3.0	River Terrace Deposits
DCS3	1.0 to 3.0	River Terrace Deposits / Kellaways Formation
DCS4	1.0 to 3.0	River Terrace Deposits / Kellaways Formation

Washed silica gravel (2-6mm) was used as the filter medium and each standpipe was fitted with a push-in bung with gas tap and was finished with a flush metal cover concreted in place. The standpipe within BH6 was installed approximately 0.5m above ground level to allow for the monitoring of potential artesian groundwater conditions. As a result, the standpipe was finished with a raised lockable metal cover concreted in place.

Ground gas and groundwater monitoring visits were undertaken on four occasions between the 3<sup>rd</sup> and 24<sup>th</sup> July 2020 including during one period of falling atmospheric pressure. Each monitoring well was monitored for concentrations of carbon dioxide, methane, oxygen, flow rates and differential pressures and water level. The monitoring results are included in Appendix D.

### 4.3 Laboratory Testing

Geotechnical laboratory testing was undertaken on selected samples during the both preliminary and supplementary investigations and comprised the following:

- 20 natural moisture content tests;
- 20 Atterberg limit tests;
- 11 particle size distribution tests;
- 16 BRE SD1 suite (9 with pyrite) tests;
- 13 BRE SD1 with pyrite suite tests;
- 16 Undrained Single Stage Triaxial Tests;
- 6 One Dimensional Consolidation Tests.

Chemical testing was undertaken based upon the desk study, walkover and site observations during the fieldwork. Selected samples were analysed for the following suite of contaminants:

- Selected metals suite [arsenic, beryllium, boron, cadmium, chromium (total), copper, mercury, nickel, lead, zinc, selenium, vanadium] (24 samples);
- Chromium hexavalent and trivalent (4 samples);

- Speciated (16 US EPA) Polycyclic Aromatic Hydrocarbons (PAH) (24 samples);
- Total Petroleum Hydrocarbons Criteria Working Group (TPH CWG) (15 samples);
- Phenols (total) (4 samples);
- pH (24 samples);
- Soluble sulphate (24 samples);
- Organic matter (24 samples);
- Asbestos Containing Material (ACM) (17 samples);
- Pesticides (5 samples);
- Inert Waste Acceptance Criteria [WAC] (4 samples).

This testing included samples from HDP1 and DCS2, which were located specifically to target the gas cylinders and diesel tank respectively within the chicken farm. These samples were tested for the full list of determinands (except pesticides and WAC).

All laboratory test results from both phases of investigation are included in Appendix E.

## 5.0 GROUND CONDITIONS

### 5.1 Strata Summary

Shallow Made Ground was encountered in the chicken farm area. Elsewhere, surface materials comprised natural/agricultural topsoil and subsoil. These were underlain by Superficial Alluvium and River Terrace Deposits, which in turn were found to rest on the solid geology of the Kellaways Formation, predominantly comprising clay, with initial horizons of sand in the southeast of the site. The Cornbrash Formation was encountered at the base of the cable percussion boreholes. Full details of the strata encountered are given on the borehole records presented in Appendix B. A generalised ground profile is presented below:

Stratum	Depth to Top of Strata (m bgl)	Thickness (range) (m)	Comments
Topsoil/subsoil	GL	0.15 – 0.70	
Made Ground	GL / 0.3	0.40 - 0.70	Only encountered within the chicken farm area (TP105, DCS2 & DCS3)
Alluvium	0.15 / 0.7	0.20 – 1.60	Not encountered in TP1, TP2, TP7, TP14, BH6 & BH8
River Terrace Deposits	0.4 / 1.65	0.15 - 1.95	Not encountered in TP3, TP11, TP12, TP111, BH1, BH3 & BH5 located in the northwest and eastern field
Kellaways Formation – Clay Member	0.6 / 3.8	0.20 – 2.75	Not encountered in TP106 & HDP1. Top of stratum generally deepening southwards
Kellaways Formation – Sand Member	0.6 / 2.1	0.60 – 2.00	Only encountered in TP11, TP13, TP14, TP15, TP17, TP18 TP102, TP106 & TP107 all located in the

Stratum	Depth to Top of Strata (m bgl)	Thickness (range) (m)	Comments
			southeast of the site
Cornbrash Formation	2.7 / 5.4	0.05 – 0.10	Encountered near base of BH1 to BH15. Top of stratum generally deepening southwards. Base not proven.

## 5.2 Topsoil, Subsoil and Made Ground

Topsoil was encountered from surface to depths of between 0.15m and 0.35m bgl and generally comprised firm dark brown slightly sandy friable clay with rootlets and occasional shell fragments. Underlying subsoil was encountered at several locations to depth of between 0.35m and 0.70m bgl comprising stiff brown friable clay, with occasional gravel and rootlets.

Made Ground was recorded in the chicken farm area at TP105, DCS2 and DCS3 only, where it was proven to depths of between 0.40m and 0.70m bgl. The Made Ground generally comprised soft to firm brown and greyish brown slightly gravelly clay occasional concrete and brick fragments.

## 5.3 Alluvium

Strata considered to represent Alluvium were encountered in the majority of the exploratory holes, beneath the Topsoil, Subsoil or Made Ground extending down to variable depths of between 0.40m and 1.80m bgl. The Alluvium was found to be variable in nature typically comprising soft to firm or firm orangish-brown and light greyish brown mottled variably sandy variably gravelly silty clay, with gravel comprising quartzite. On rare occasions, darker coloured materials were present sometimes accompanied by relict rootlets, shell fragments and an organic odour (e.g. DCS2).

The results of six Atterberg limit tests undertaken in the Alluvium have indicated corrected plasticity index values of between 16% and 51% (corrected to 17% and 49%) and liquid limits of between 32% and 73%, indicating variable shrinkability and plasticity, ranging from low to high. Moisture contents of between 17% and 26% were also recorded.

Four Standard Penetration tests, all undertaken at a depth of 1.2m bgl, recorded variable SPT 'N' values of between 6 and 21. Applying the empirical relationship between SPT 'N' values and mass shear strength (after Stroud et al), these suggest variable undrained shear strengths between around 30 to 100kN/m<sup>2</sup> (low to high strength).

## 5.4 River Terrace Deposits

Beneath the Alluvium, River Terrace Deposits were encountered at all locations with the exception of BH1, BH3, BH5, TP3 & TP111 (located in the northwest) and TP11 & TP12 (in the east). These deposits extended to depths of between 0.60m and 2.85m with the stratum typically deepening towards the south of the site. The

River Terrace Deposits generally comprised orangish-brown silty sand and gravel, with the gravel comprising fine to coarse subangular to subrounded quartzite and occasional limestone.

Seven Particle Size Distribution tests were undertaken on samples of the River Terrace Deposits at depths of between 0.6m and 1.6m. The results are summarised in the table below:

Location	Depth (m bgl)	Sample Proportion (%)			
		Fines (Clay and Silt)	Sand	Gravel	Cobbles
TP2	0.6	16	30	54	0
TP9	1.20	13	40	47	0
TP101	1.40-1.50	32.3	39.4	28.3	0
TP104	1.60-1.80	3.9	35.3	60.8	0
TP105	1.40-1.60	4.6	25.9	69.5	0
BH4	1.65	20.4	54.5	25.1	0
BH7	1.20	16.8	39.5	43.7	0

Twenty-one SPTs were undertaken in the River Terrace Deposits indicated SPT 'N' values of generally between 10 and 29 indicating medium dense conditions. Lower 'N' values of between 4 and 13 were recorded within the driven continuous sampling boreholes, which is considered possibly a result of sample disturbance or water imbalance and not necessarily indicative of loose conditions.

## 5.5 Kellaways Formation

Strata considered to represent the Kellaways Formation were encountered beneath the Superficial Deposits (Alluvium or River Terrace Deposits) and were proven to depths of between 2.7 and 5.4m bgl, generally becoming deeper towards the south of the site. The strata were typically described as firm becoming stiff bluish grey silty clay, occasionally with thin indistinct laminations, occasional fine to coarse subrounded to subangular limestone gravel and with rare fossil shell fragments. Occasional gypsum crystals were noted.

In the south and southeast of the site, the Formation often initially comprised a granular layer, generally comprising bluish grey slightly clayey silty gravelly fine to coarse sand (silt in TP13), with the gravel comprising fine to coarse subangular to subrounded limestone. This granular layer was encountered directly beneath the Superficial Deposits, extending down to depths of between 1.75m and 3.8m bgl and usually underlain by further cohesive deposits of the Kellaways Formation, although TP106 terminated within the sand at 1.9m bgl.

Four Particle Size Distribution tests were undertaken on samples of the granular layer at depths of between 0.8m and 2.3m bgl. The results are summarised in the table below:

Location	Depth (m bgl)	Sample Proportion (%)			
		Fines (Clay and Silt)	Sand	Gravel	Cobbles
TP11	0.8	21	35	44	0
TP13	2.2	39	50	11	0
TP15	2.3	27	60	13	0
TP107	1.30-1.50	30.9	68.8	0.3	0

The results of twelve Atterberg limit tests undertaken on the cohesive Kellaways Formation have indicated plasticity index values of between 15% and 51% (corrected to between 13.5% and 51%) and liquid limits of between 28% and 73% indicating variably low to high shrinkability and plasticity. Moisture contents of between 15% and 38% were also recorded.

Twenty-four Standard Penetration tests undertaken in the cohesive Kellaways Formation recorded 'N' values generally between 15 and 23, indicating the materials to be of medium to high strength with approximate undrained shear strength ranging between around 65 and 100kN/m<sup>2</sup>, (using standard correlations). As with the River Terrace Deposits, lower SPT 'N' values of between 6 and 14 were recorded within the driven continuous sampling boreholes. The SPT N value against depth plot (Appendix A) indicates the strength of the material to be relatively uniform with depth.

Sixteen quick undrained triaxial tests were undertaken on cohesive samples of the Kellaways Formation from depths of between 2.0 and 5.15m bgl. The results indicate variable undrained shear strengths of between 33kN/m<sup>2</sup> and 112kN/m<sup>2</sup> (soft to stiff) which are predominantly lower than the values suggested by SPT correlation and visual descriptions.

Six oedometer consolidation tests were undertaken on undisturbed samples of the cohesive Kellaways Formation between depths of 2.0 and 4.55m bgl. The results of these tests indicated  $m_v$  values of between 0.077 and 0.286m<sup>2</sup>/MN for the stage corresponding to overburden pressure ( $p_0'$ ) + 100 kN/m<sup>2</sup>, suggesting low to medium compressibility. Applying standard correlations using SPT 'N' values and plasticity,  $m_v$  values of between 0.09 and 0.15m<sup>2</sup>/MN are indicated, which broadly concurs with the laboratory data.

## 5.6 Cornbrash Formation

Strata considered to represent the Cornbrash Formation were encountered at the base of the cable percussion boreholes at depths of between 2.7m bgl in the north and 5.4m bgl in the south of the site. The strength of the materials prevented any significant penetration of the stratum using the cable tool techniques. The strata comprised weak grey limestone recovered as coarse limestone gravel.



SPTs carried out within the limestone 'refused' with penetrations of between 0 and 10mm for 50 blows.

## 5.7 Groundwater

During the 2018 preliminary investigation, groundwater was recorded in all trial pits (except TP12) within the River Terrace Deposits at depths of between 0.5 and 1.3m bgl, with the shallowest groundwater generally recorded in the east of the site closest to the Langford Brook. The groundwater generally occurred as seepages although fast inflows were noted in TP4 (from 0.8m bgl) and TP5 (from 1.2m bgl). Seepages were also noted within the Kellaways Formation in TP3 (from 1.3m bgl) and TP15 (from 1.9m bgl).

Similar groundwater conditions were encountered during the 2020 supplementary investigation. Details of the groundwater occurrences and behaviour during the 2020 investigation are presented in the table below:

Location	Strata	Groundwater occurrence/behaviour
<b>Northern Field</b>		
BH1	Cornbrash Formation	Groundwater encountered at 2.85m and rose to 1.20m bgl after 20 minutes.
BH2	River Terrace Deposits	Groundwater encountered at 1.50m bgl with no rise recorded.
	Cornbrash Formation	Groundwater encountered at 2.85m and rose to 1.40m bgl after 20 minutes.
BH4	River Terrace Deposits	Groundwater encountered at 1.50m bgl with no rise recorded.
	Cornbrash Formation	Groundwater encountered at 2.90m and rose to 1.90m bgl after 20 minutes.
TP110	River Terrace Deposits	Trial pit excavated to 2.40m bgl. Seepages were noted at 1.50m and 1.80m bgl. On completion, standing water rose from 1.80m to 1.60m bgl after 10 minutes.
TP111	Kellaways Formation	Trial pit excavated to 2.40m bgl. Slight seepage encountered at 1.70m bgl. On completion, standing water level rose from 2.35m to 2.18m bgl after 10 minutes.
<b>Centre Field</b>		
BH6	Cornbrash Formation	Groundwater encountered at 3.55m bgl and rose to 0.20m above ground level after 2 minutes. Groundwater was monitored for a further 20 minutes with no further rise recorded.
BH7	River Terrace Deposits	Groundwater encountered at 1.60m bgl with no rise recorded.
BH8	River Terrace Deposits	Groundwater encountered at 1.60m bgl with no rise recorded.
BH9	River Terrace Deposits	Groundwater encountered at 1.65m and rose to 1.60m bgl after 20 minutes.
BH10	Cornbrash Formation	Groundwater encountered at 3.30m and rose to 2.60m bgl after 20 minutes.
BH15	Alluvium	Groundwater encountered at 1.30m bgl with no rise recorded.
	Cornbrash Formation	Groundwater encountered at 4.60m and rose to 2.00m bgl after 20 minutes. Groundwater continued to rise and reached ground level after 60 minutes. Groundwater was monitored for a further 30 minutes and no further rise was recorded.
BH15A	River Terrace Deposits	Groundwater encountered at 1.60m bgl with no rise recorded.
TP106	River Terrace Deposits	Trial pit excavated to 1.20m bgl. Seepage recorded at 1.0m and standing water level rose to 0.85m bgl after 10 minutes.

Location	Strata	Groundwater occurrence/behaviour
		Trial pit excavated to 1.90m bgl. Standing water level rose from 1.90m to 1.30m bgl after 10 minutes with no further rise recorded thereafter.
TP107	River Terrace Deposits	Trial pit excavated to 2.60m bgl. Groundwater seepage encountered at 1.15m bgl. On completion, standing water level rose from 1.50m to 1.35m bgl after 10 minutes.
TP108	River Terrace Deposits	Trial pit excavated to 2.70m bgl. Groundwater seepage encountered at 1.20m. On completion, standing water level rose from 1.35m to 1.25m bgl after 10 minutes.
TP109	River Terrace Deposits	Trial pit excavated to 2.30m bgl. Groundwater seepages were noted at 1.10m and 1.50m bgl. On completion, standing water level rose from 1.80m to 1.60m bgl after 10 minutes.
<b>Chicken Farm</b>		
BH11	River Terrace Deposits	Groundwater encountered at 1.80m and rose to 1.60m bgl after 20 minutes.
BH12	River Terrace Deposits	Groundwater encountered at 2.10m and rose to 1.60m bgl after 20 minutes.
BH13	River Terrace Deposits	Groundwater encountered at 2.00m bgl with no rise recorded.
	Cornbrash Formation	Groundwater encountered at 5.40m and rose to 0.20m bgl after 20 minutes.
BH14	River Terrace Deposits	Groundwater encountered at 1.80m and rose to 1.60m after 20 minutes.
TP101	River Terrace Deposits	Trial pit excavated to 2.40m bgl. Groundwater seepage encountered at 1.40m bgl. On completion, standing water level rose from 1.85m to 1.70m bgl.
TP102	River Terrace Deposits	Trial pit excavated to 1.80m bgl. Groundwater seepage encountered at 1.50m. Standing water rose from 1.70m to 1.55m bgl after 10 minutes.
		Trial pit excavated to 2.80m bgl. On completion, standing water rose from 2.00m to 1.90m bgl after 10 minutes.
TP103	River Terrace Deposits	Trial pit excavated to 2.80m bgl. Groundwater seepage encountered at 1.20m bgl. On completion, standing water level rose from 1.50m to 1.33m bgl after 10 minutes.
TP104	River Terrace Deposits	Trial pit excavated to 1.80m bgl. Groundwater seepages recorded at 1.30m and 1.70m bgl. Standing water level rose from 1.70m to 1.40m bgl after 10 minutes.
		Trial pit excavated to 2.80m bgl. Standing water level rose from 2.20m to 1.70m bgl after 20 minutes.
TP105	River Terrace Deposits	Trial pit excavated to 1.60m bgl. Groundwater seepage encountered at 1.15m bgl. Standing water level rose from 1.60m to 1.35m after 10 minutes.
		Trial pit excavated to 2.40m bgl. Standing water level rose from 2.20m to 1.60m bgl after 10 minutes.
DCS1	River Terrace Deposits	Groundwater encountered at 1.10m bgl with no rise recorded.
DCS2	River Terrace Deposits	Groundwater encountered at 1.10m bgl with no rise recorded.
DCS3	River Terrace Deposits	Groundwater encountered at 1.40m bgl with no rise recorded.
DCS4	Alluvium	Groundwater seepage encountered at 0.30m bgl.
HDP1	River Terrace Deposits	Hand dug pit excavated to 1.20m bgl. Groundwater seepage was recorded at 1.00m bgl with no rise recorded.

In summary, groundwater was recorded in the majority of the exploratory holes during drilling and excavation, generally in the River Terrace Deposits, from relatively shallow depths of between 1.1 and 2.1m bgl. Groundwater strikes were

also recorded at the base of the cable percussion boreholes upon encounter with the Cornbrash Formation at depths of between 2.85 and 5.4m bgl. The groundwater within the Cornbrash Formation was noted to be under sub-artesian conditions and rose (following the initial strikes) to shallow depths, sometimes approaching existing ground levels (e.g. BH15). Artesian conditions were recorded within BH6, where a water strike at the top of the Cornbrash (3.55m bgl) rose to a level of 0.2m above the existing ground level over a 2-minute period.

Groundwater levels in borehole installations were recorded during the four subsequent monitoring visits undertaken between the 3<sup>rd</sup> July 2020 and 24<sup>th</sup> July 2020. Water levels were generally recorded at between 0.63m and 1.98m bgl. During the monitoring of BH6, groundwater was noted to be between 0.27 and 0.30m above ground level.

Applied Geology also briefly attended the site in February 2019 during an archaeological dig to inspect shallow groundwater within the excavated trenches. The trenches were excavated to shallow depths into the Alluvium. Standing water was present in all of the trenches and water entry was at a depth of circa 0.1m from within the Topsoil. The site had experienced heavy rainfall prior to the visit and the ground surface had subsequently become saturated. It was, therefore, concluded that this shallow water did not represent the true groundwater table but perched water within the Topsoil.

## **5.8 Contamination**

No visual or olfactory evidence of contamination was observed in any of the exploratory holes.

## **5.9 Soil Gas**

The results of the ground gas monitoring undertaken have indicated methane concentrations below the limit of detection (<0.1%) together with carbon dioxide concentrations of between <0.1% and 3.3% (highest concentration in BH12). Oxygen concentrations were recorded at between 14.4% and 21.1% and a maximum average flow rate of 1.1l/hr (BH12).

Based on the highest recorded steady carbon dioxide and methane concentrations and the highest average flow rate from the four visits, gas screening values have been calculated in accordance with CIRIA C665 of 0.0363l/hr (carbon dioxide) and 0.0011l/hr (methane).

## **6.0 GEOENVIRONMENTAL ASSESSMENT**

### **6.1 Human Health Risk Assessment**

During the walkover survey, no visual or olfactory evidence of contamination was noted and the chicken farm itself appeared to have been well managed and demonstrated generally a very good level of housekeeping. The chicken farm has operated under license, effective up to at least March 2018, under which the farm would have been required to demonstrate that operations were in accordance with relevant standards. It is understood that the farm was utilised for raising, feeding and heating poultry. The protocol was to remove all waste from site.

The results of the chemical testing on soils from both the 2018 and 2020 investigations have been subjected to human health risk assessment as described in Appendix F, with specific details as follows:

- Proposed end-use – industrial units, with leisure centre and landscaping;
- Screening criteria – Public Open Space (Parks) (conservative given limited landscaping), assuming 6% SOM;
- Assuming a single dataset based on the site's history, current land-use and proposed developments.

Spreadsheets summarising the laboratory results and relevant screening values are presented in Appendix E. These illustrate that none of the results exceed the Screening Criteria.

Total Petroleum Hydrocarbons (TPH) concentrations were recorded below the laboratory detection limits in all samples tested, including in DCS2, which was undertaken adjacent to the above ground diesel tank and HDP1, which was undertaken adjacent to the gas cylinders within the former chicken farm.

The Asbestos screening tests did not detect the presence of any ACM in any samples, including those tested adjacent to the chicken sheds.

The pesticides/herbicides screening tests did not detect the presence of any pesticides.

The results of the soil testing have indicated concentrations well below the conservative Human Health screening criteria (Public Open Space - Parks).

Based on the above assessments, it is considered that the risks to human health at the site are negligible.

## **6.2 Controlled Waters Risk Assessment**

The results of the chemical testing on soils has not identified any concentrations within the Made Ground or natural soils elevated above those considered to be at general background levels.

Based on the context of the site, the proposed development, and the absence of any identified pollution sources on site, the risk to Controlled Waters is considered to be negligible.

## **6.3 Disposal of Soil Arisings**

General comments regarding the procedures for the assessment of waste soil for off-site disposal purposes is included in Appendix F. As requested, waste acceptance criteria (WAC) tests were undertaken on four samples of natural ground, including one sample of Alluvium, two samples of River Terrace Deposits and one sample of Kellaways Formation (clay).

The WAC testing generally indicated results below the limits for inert landfills. One exceedance of sulphate was recorded in the Kellaways Formation taken from TP109 at 2.0 to 2.2m bgl. The sulphate was recorded at a concentration of

1900mg/kg, which is considered marginal when compared to the inert WAC threshold of 1000mg/kg.

The results of the testing, therefore, demonstrates compliance with the WAC limits for inert landfills for the Superficial Deposits (Alluvium and River Terrace Deposits). Although marginal, the exceedance of sulphate in the Kellaways Clay may push this material into the non-hazardous landfill category. It is recommended that this report is provided to the chosen landfill for confirmation.

#### 6.4 Conclusions and Recommendations

Following the ground investigation, laboratory testing and monitoring the Conceptual Site Model has been reviewed and the risk ratings revised in light of the findings:

Source	Pathway	Receptor	Notes from Investigation	Updated Risk*
Potential contaminants within Made Ground or resulting from adjacent site development.	Inhalation, ingestion, dermal contact.	End users, adjacent residents	Minimal Made Ground encountered within the former chicken farm. Low concentrations of contaminants identified in near surface soils	Negligible
	Migration and Leaching	Superficial Deposits and Kellaways Sand Member (Secondary A Aquifers)	Minimal Made Ground encountered within the former chicken farm. Low concentrations of contaminants identified in near surface soils	Negligible
Soil gas from Made Ground – both on site and off site sources (methane, carbon dioxide)	Migration into buildings, service ducts etc.	End users	Ground gas monitoring is ongoing. Initial results recorded no elevated concentrations of gases	Low
Elevated sulphates in Made ground or natural soils	Direct contact, leaching and contact with groundwater	Buried concrete	River Terrace Deposits	Low
			Kellaways Formation – Granular	Low
			Kellaways Formation - Cohesive	Low <sup>*see note</sup>
Hydrocarbon contaminants from vehicle/plant leaks	Inhalation, ingestion, dermal contact.	End users	Low/trace concentrations of contaminants identified	Negligible
	Migration/leaching	Superficial Deposits and Kellaways Sand Member (Secondary A Aquifers)	Low/trace concentrations of contaminants identified	Negligible
	Direct contact	Water supply services	Low/trace concentrations of contaminants identified	Negligible

Note:

\*: Sulphate risks when founding in Kellaways Formation are fully mitigated by use of recommended measures as detailed in Section 7.7, therefore a low risk is assigned.

On the basis of the investigation, the site is considered essentially 'clean'. The above risk assessments have established negligible risks to Human Health and Controlled Water receptors. It is therefore considered that remediation or any further assessment is not required for this development.

Issues with respect to ground gas and potential effects of contaminants on buried concrete and water supply pipework are included in Section 7.0.

## **7.0 GEOTECHNICAL ASSESSMENT**

### **7.1 General**

The development proposal comprises the construction of 13 No industrial units with office space, a Sports and Leisure facility, associated access roads and car parking, together with attenuation basins. A wetland area is proposed in the east of the site, comprising a number of shallow wet areas, reed beds and shrubs. Some earthworks are proposed to create level plateaus for the buildings and to raise finished floor levels to offer flood protection. Following removal of the topsoil/subsoil, it is understood that the thickness of engineered fill required to achieve the finished levels will generally be less than 1m. In the northwest of the site some minor reductions in level will be required.

The ground investigations have identified Topsoil from surface underlain by Superficial Deposits comprising Alluvium and River Terrace Deposits, which in turn were found to be underlain by the Kellaways Formation, predominantly comprising clay, with initial horizons of sand in the southeast of the site. The Cornbrash Formation was encountered at the base of the boreholes from depths of between 2.7m and 5.4m bgl (deepest in the south of the site). Groundwater levels were recorded between 1.10m and 2.10m bgl, predominantly within the Superficial Deposits during the drilling and excavation. A deeper sub-artesian/artesian groundwater regime is present within the Cornbrash Formation. During subsequent groundwater monitoring, levels were generally recorded between 0.63 and 1.98m bgl within the Drift deposits, although the standpipe in BH6, which was installed with a response zone extending into the Cornbrash, was consistently found to be 0.30m above ground level.

### **7.2 Earthworks**

Material used for raising site levels will be derived mainly from 'imported' material, although small amounts of suitable 'site won' material may also be used. It is understood that, following the site strip, the topsoil/subsoil will be removed off site and approximately 30,000m<sup>3</sup> of suitable inert material will be imported to use as fill.

It will be necessary to produce a detailed specification for the earthworks detailing methods, controls and verification testing with target end performance criteria. This could initially be based upon the guidance in the Manual of Contract Documents for Highway Works, Specification for Highway Works: Volume 1: 2009 [SHW] and BS 6031:2009. It is recommended that validation of the earthworks is carried out by an independent party. Based on the classification testing undertaken, the Alluvium is likely to be classified as Class 2A 'Wet Cohesive Material', whilst the River Terrace Deposits is likely to be classified as Class 1A 'Well Graded Granular' or Class 2C 'Stoney Cohesive Material'.

Prior to any filling, the site should be stripped of topsoil/subsoil and the formation should be carefully inspected. Any localised organic, soft or desiccated material should be removed and replaced with compacted stone.

It is understood the re-use of materials on site is to be undertaken using CL: AIRE practise and guidance.

### 7.3 Foundation Design

The Made Ground encountered at the site is not considered a suitable founding stratum owing to its inherent variable and generally low strength.

The Alluvium is variable in nature and shrinkability and may locally contain some organic material. Hence this is not recommended as a bearing stratum for foundations. The Alluvium appears generally to be between 0.5 and 1.0m in thickness and is generally above the groundwater table. Hence, extending foundations below is unlikely to be problematic or pose severe construction difficulties. Deeper Alluvium appears to be present only in the northwest corner of the site (up to 1.6m in thickness) and again, groundwater was absent within the strata at test locations in this area.

The medium dense granular River Terrace Deposits, directly underlying the Alluvium, are generally suitable as founding strata and it is understood that widened reinforced foundations are proposed. A minimum founding depth of 0.75m will apply, although the exploratory hole data suggests it may be necessary to increase excavation depths locally up to around 1.2m below existing levels to ensure that the foundations are taken beneath the Alluvium. The occurrence of shallow groundwater in the Drift deposits is of concern and hence, notwithstanding the above requirements, it would be prudent to keep founding depths as high as possible, within the River Terrace Deposits, to reduce construction difficulties.

Foundations (up to 1.5m wide) competently designed to the above criteria may adopt safe net design bearing pressures up to 120kN/m<sup>2</sup>. This is estimated using traditional methods of bearing capacity calculations e.g. as set out in Tomlinson 7<sup>th</sup> Edition with a factor of safety of 3 against bearing capacity failure whilst limiting total settlement to 25mm.

Where the River Terrace Deposits are absent in the northwest of the site deepening of foundations into the underlying firm to stiff clay of the Kellaways Formation will be required. Based on the proposed layout, it would appear that this is likely to relate only to the sports and leisure facility. A minimum founding depth of 1.0m will apply to foundations placed in the Kellaways Formation to cater for seasonal variations, however, the exploratory hole data suggests that founding depths of between 1.8m and 2.2m below existing levels may be required to deepen beneath the Alluvium. Further deepening of foundations may be required with respect to existing, recently felled or proposed trees in line with current guidance such as NHBC standards for soils of high shrinkage potential. Any foundations deeper than 1.5m will require anti-heave precautions according to location and in line with guidance.

Foundations (up to 1.5m wide) competently designed to the above requirements and placed within the firm (or better) clay of the Kellaways Formation may adopt safe net design bearing pressures up to 120kN/m<sup>2</sup>. This is again based on traditional methods adopting a lower bound undrained shear strength.



It is noted that the proposed footprint of Unit 12 conflicts with the existing pond located in the former chicken farm in the southwest of the site. The nearest exploratory hole undertaken, (DCS1) encountered Alluvium to a depth of 0.7m, underlain by River Terrace Deposits to 2.0m, which in turn was underlain by the Kellaways Clay to the base of the borehole (4.3m bgl). It should be noted that conditions beneath the pond may vary and excavations should be extended to suitable founding strata.

If, during the construction groundworks, conditions significantly at variance to those described herein are encountered, further geotechnical advice should be sought to make appropriate assessment and recommendations.

#### **7.4 Floor Slab and Gas Protection**

It is understood that ground bearing floor slabs will be required.

As mentioned in Section 7.2, following the site strip and prior to any engineered filling, the exposed formation should be carefully inspected. Any localised organic, soft or desiccated material should be removed and replaced with compacted stone.

Subsequent to successful completion the earthworks, the floor slab should be constructed on a compacted granular mattress of appropriately designed thickness.

Based on the conceptual model, the ground conditions encountered and the calculated GSVs the site can be characterised as Situation 1 (CIRIA C665) for which no special ground gas measures are required. The desk study also indicates that radon protection measures are not required.

#### **7.5 Excavations**

Excavations for the foundations and service trenches are expected to be in a combination of Alluvium, River Terrace Deposits and locally Kellaways Formation. The River Terrace Deposits were found to be unstable during excavation of the trial pits and subject to depths, the foundation excavations and service trenches are likely to be prone to short term instability and spalling, especially related to groundwater occurrence. Excavations may, therefore, need to be graded back to a stable angle or trench support should be provided. Trench support or the angle of batter should be designed by an appropriately qualified party to suit the required depth and the ground and groundwater conditions.

Shallow groundwater is present within the River Terrace Deposits across the site, it is anticipated that foundations will generally be placed above this groundwater table, however conflict could arise locally if it is necessary to deepen foundations. Some construction difficulty should therefore be expected locally and it will be necessary to make good provisions for ground water control and excavation support.

If deeper excavations are planned for services or drainage infra-structure, these should be very carefully planned should there be a risk of conflict with the deeper artesian groundwater regime in the Cornbrash Formation. Should this be the case, a more detailed localised assessment may be required based on the detailed proposals.

## 7.6 Attenuation Basins

Given the high groundwater table and subsequent low capacity for soakaway drainage, 3 No linked dry attenuation basins are proposed to control surface water drainage. These will in turn discharge water into Langford Brook, via existing ditches that bound the site, controlled by hydrobrakes. In order to offer flood protection, the perimeter of the basins will be mounded by between c.0.3m and c. 0.8m above existing ground levels. The following table summarises the ground conditions encountered in the vicinity of each proposed basin:

Basin	Location	Invert Level	Groundwater Level (m bgl)	Ground Conditions
1	Along the southern margin of the site	63.20m AOD (1.0m below existing ground level)	1.4m to 2.0m during excavation and drilling 1.0m during monitoring	Alluvium over granular River Terrace Deposits. The River Terrace Deposits were encountered from a depth of between 0.7m and 1.5m bgl and proven to a depth of between 2.2m and 2.8m bgl where the Kellaways Clay was encountered.
2	Along the eastern margin of the centre field	63.00m AOD (between 0.7m and 1.0m below existing ground level)	1.15m to 1.3m during excavation and drilling Between 1.17m and 1.24m during monitoring	Alluvium to between 0.95m and 1.65m underlain by River Terrace Deposits to between 1.25m and 1.8m. The underlying Kellaways Formation was recorded as clayey sand to a depth of 2.0m where it was in turn underlain by the Kellaways Clay.
3	Upgrading of the existing pond in the southeast	-	0.9m (TP13)	TP13 was excavated adjacent to the existing pond and encountered Alluvium to 0.7m bgl underlain by River Terrace Deposits to 1.35m. The Kellaways Formation was encountered from 1.35m but was recorded as sandy silt to 2.6m bgl.

In summary, the groundwater table is anticipated to be beneath the design invert level. The base of Basin 1 is anticipated to be within a combination of Alluvium and River Terrace Deposits, whilst the base of Basin 2 is anticipated to be solely within Alluvium.

## 7.7 Buried Concrete and Services

The results of the testing in the various strata on site indicate characteristic values as following:

Stratum	Water Soluble Sulphate (g/l) <sup>1</sup>	Total Potential Sulphate (%)	pH	Potentially Pyritic	Design Sulphate Class	ACEC <sup>2</sup>
Alluvium	0.1	-	7.6	-	DS-1	AC-1
River Terrace Deposits	0.2	-	8.3	-	DS-1	AC-1
Kellaways Formation –	0.8	2.1	7.6	Yes (2 of 2)	DS-4	AC-4

Stratum	Water Soluble Sulphate (g/l) <sup>*1</sup>	Total Potential Sulphate (%)	pH	Potentially Pyritic	Design Sulphate Class	ACEC <sup>*2</sup>
Sand Member				samples)		
Kellaways Formation – Clay Member	0.9	10.3	7.6	Yes (11 of 13 samples)	DS-4	AC-4

Notes:

\*1: Characteristic values are rounded to the nearest 0.1g/l.

\*2: Assumes mobile groundwater.

The results of the sulphate tests undertaken in the Alluvium and River Terrace Deposits have identified the Design Sulphate Class to be DS-1 with the Aggressive Chemical Environment for Concrete (ACEC) being AC-1 as defined by the BRE Special Digest 1, Concrete Aggressive Ground, 2005 for a greenfield site and mobile groundwater regime. Sulphate resisting concrete is therefore not required for foundations placed solely in these strata.

Thirteen of the fifteen samples tested from the Kellaways Formation (clay and sand combined) were found to be potentially pyritic and the Design Sulphate class has therefore been based on the total potential sulphate for this stratum. The results of the sulphate tests carried out on the Kellaways Formation have identified a sulphate class of DS-5 and ACEC being AC-5. However, as the water-soluble sulphate results are commensurate with DS-3 or less, the classification may be limited to DS-4, AC-4.

In summary, no special measures relating to buried concrete are therefore required for foundations placed in the River Terrace Deposits, however, foundations placed in the Kellaways Formation will require sulphate resisting concrete appropriate to DS-4/AC-4 conditions.

Further reference may be made to BRE Special Digest 1 for requirements in respect of types of cement and aggregate to be used and variations in type of concrete construction.

Chemical testing has not identified significant petroleum hydrocarbons or any detectable phenols that may affect buried water supply pipes or buried concrete. Therefore, no special precautions are envisaged with regards to water supply pipes. However, it should be noted that the full suite of testing required by the UKWIR guidance has not been undertaken as part of this investigation and such testing could be required by the Water Authority once the pipeline routes are known.

## 7.8 Conclusions and Recommendations

Foundations bearing within the River Terrace Deposits (or Kellaways Clay Formation in the northeast of the site) designed in accordance with the recommendations outlined in Section 7.2, may be designed with an allowable bearing capacity of up to 120kN/m<sup>2</sup>. Given the shallow groundwater table, it is recommended that foundations are maintained as shallow as possible within the upper horizons of the River Terrace Deposits to avoid significant groundwater ingress into foundation excavations.

Some earthworking is proposed to raise finished floor levels. This will involve inspections, following the site strip, to deal with any localised areas of desiccated, soft or organic materials, followed by placement of both site-won and imported suitable materials in accordance with a specification. The site will then be suitable for ground bearing floor slabs constructed on an appropriate granular mattress.

Ground gas or radon protection measures are not considered necessary for the proposed development.

Special measures relating to buried concrete are not required for foundations placed in the River Terrace Deposits, although foundations placed in the Kellaways Formation will require sulphate resisting concrete appropriate to DS-4/AC-4 conditions.

**Applied Geology Limited  
Unit 23  
Abbey Park  
Stareton  
Kenilworth  
Warwickshire  
CV8 2LY**

**Tel: 02476 511822**

## **GENERAL NOTES**

- a) The Client has requested that a Desk Study and combined geotechnical and geoenvironmental ground investigation ("The investigation") be performed in order to provide guidelines for safe site development and long term usage.
- b) The "investigation" was conducted and this report has been prepared for the sole internal use and reliance of the Client. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Applied Geology Limited. If any unauthorised third party comes into possession of this report they rely on it at their peril and the authors owe them no duty of care and skill.
- c) The findings and opinions conveyed via this "investigation" report are based on information obtained from a variety of sources as detailed within this report, (eg desk study data, service plans, proposal layouts etc) and which Applied Geology Limited believes are reliable. Whilst Applied Geology Limited has used all reasonable care in obtaining and using this data, it does not guarantee its reliability.
- d) The report represents the findings and opinions of experienced geoenvironmental consultants. Applied Geology Limited does not provide legal advice and the advice of lawyers may also be required.
- e) The opinions presented in this report are based on findings derived from a site inspection and walkover and offsite surveys, a review of records and historical sources, comments made by interviewees (if relevant), and the findings of the physical investigation. The assumed subsurface geological profiles and other plots are generalised by necessity and have been based on the information found at the locations of the exploratory holes and depths sampled and tested. Other Conditions could exist between exploratory hole locations which have not been identified and therefore have not been taken into account in assessments. Applied Geology Limited has not found indicators that suggest that hazardous substances exist at the site at levels likely to warrant mitigation or consideration appropriate to the end use stated by the Client.