

8.0 CONCLUSIONS & RECOMMENDATIONS

8.1 Site Summary

The site comprises a long irregularly shaped parcel of land located between the A17 trunk road and a road known as Low Lane, Holbeach, Lincolnshire. The majority of the site comprised a sensibly level area of long grass and weeds; near the western end of the site what appeared to be footings for a pair of semi-detached houses were present. Overhead power lines and a transformer were present near the eastern end of the site and a culvert was identified crossing from north to south near the centre.

Residential dwellings were present to the south of the site, off Low Lane and a water pumping station was present to the west of the site. The land to the north of the A17 appeared to be predominantly in agricultural use.

8.2 Site History

Historically the site appears to have originally formed parts of several fields and become a single plot following the construction of the A17 trunk road. Anecdotal evidence from residents indicates that it had been used for the cultivation of cabbages in the relatively recent past.

8.3 Site Geology

The site is indicated to be initially underlain by Tidal Flat Deposits, underlain at depth by the Ampthill Clay and West Walton Formation. The Ampthill Clay is indicated to be typically around 10m in thickness and the West Walton Formation is indicated to be typically around 15m in thickness, below which the Oxford Clay Formation is indicated.

8.4 Ground Conditions

Topsoil was encountered across the site to depths of between approximately 0.10m and 0.35m begl.

The underlying Natural Strata comprised soft to firm SILT/CLAY, to depths of between approximately 0.40m and 1.60m begl, underlain by firm, rapidly becoming soft, moist sandy SILT to depths of between approximately 1.90m and 5.00m begl. At depth medium dense wet very silty SAND was encountered until termination of the boreholes at depths of up to 15.25m.

8.5 Foundation Design

The natural Silt soils underlying the site appear suitable to support a nett allowable ground bearing pressure of up to 40kN/m². Foundations for the proposed development may therefore comprise traditional strip/trench fill (where these can be designed on the basis of this bearing pressure), or alternatively may comprise a raft foundation. The use of piles may also be considered where excessive loads from buildings are present and shallow foundations are not stable.

Based on the results of the geotechnical laboratory analysis, the Silt/Clay has been found to exhibit both non-plastic and medium volume change potential characteristics. On this basis, it is recommended that strip/trench fill foundations should be advanced to a minimum founding depth of 0.90m and founded within undisturbed suitably competent natural soils.

Should any Made Ground or soft spots be encountered at founding depth, foundations will require further deepening to encounter underlying undisturbed suitably competent natural soils. However, we would note that the soils became damp/moist below depths of around 1.10m begl, with water ingress observed at depths of below 2.00m to 2.50m begl; softening of the soils was also locally observed at these depths. On the basis of the foregoing, it is important to ensure that all foundation excavations are kept as shallow as possible due to the decrease in soil strength and risk of water ingress affecting foundation construction. During the exploratory works, peat deposits were not encountered at shallow depth beneath the site.

Should shallow strip/raft foundations be proposed for adoption, we would recommend that seeks formal approval from the NHBC (or similar body) regarding the use of rafts at the site, prior to the Structural Engineer commencing design. Where piles are to be adopted, the advice of a specialist piling contractor should be sought to confirm the depths of the piles and the most feasible and cost efficient type of pile to be used at the site.

It is recommended that all organic soils (i.e. Topsoil) are removed from beneath foundations and replaced with compacted stone where necessary.

A further consideration as an alternative to strips/rafts and piles may be the use of ground improvement by vibro stone columns. However, the very soft cohesive nature and the excessive depth of the soft soils may preclude the use of this technique. Advice from a specialist contractor should be sought to confirm the feasibility of ground improvement at the site, if necessary.

The founding solution adopted should take account of the presence of a culvert crossing beneath the site and appropriate mitigation measures adopted to prevent damage to the feature(s), where they are to remain as part of the development. It may be necessary to undertake a CCTV survey of the culvert(s) prior to the commencement of enabling works at the site.

8.6 Ground Gas Precautions & Floor Slab Design

Based on the programme of ground gas monitoring undertake the site may be classified as Characteristic Situation 'CS2' in accordance with BS 8485:2015 and Amber 1 bordering on Amber 2 in accordance with NHBC guidance. On the basis of the foregoing and the development proposals for the site, the following ground gas precautions may be adopted within proposed dwellings.

- Suspended floors with a clear ventilated void (i.e. beam and block).
- Provision of periscopic air-brick ventilation on two sides of each dwelling. The recommended minimum area of ventilation for a sub-floor void is 1500mm² per metre run of wall or 500mm² per square metre of floor area, whichever gives the greater area of opening.
- Low-permeability well installed proprietary gas membrane. The membrane should be suitably lapped and taped and should be extended across wall cavities and lapped with cavity trays to effectively exclude ground gases from the footprint of the proposed buildings. Service penetrations through the membrane should be kept to a minimum and should be suitably sealed to the membrane. The membrane should be inspected by third party in accordance with the requirements of CIRIA C735 '*Good practice on the testing and verification of protection systems for buildings against hazardous ground gas*' (2014). The membrane must be suitably robust to withstand the construction process and should be suitably protected following installation and inspection to minimise damage during construction.

The foregoing precautions would score 4.5 points in accordance with BS 8485:2015 and are therefore considered appropriate for the site, based on the requirements for a minimum of protection level of 3.5 points. Alternative floor slab and ground gas protection measures (e.g. cast in-situ reinforced suspended slab on a granular/ventilation layer) that give a minimum protection score of 3.5 may be adopted at the site, to suit the requirements of the Client.

Where the proposed dwellings are to benefit from a buildmark warranty (i.e. NHBC, or similar) we would recommend that the Structural Engineer liaises with the warranty provider with respect to the floor slab design and ground gas protection measures to ensure that the proposals fully satisfy their requirements.

8.7 Building Near Trees

The geotechnical laboratory test results have revealed that cohesive soils of medium volume change potential should be assumed for design purposes. Foundation designs will need to be adjusted in full accordance with NHBC Standards Chapter 4.2 '*Building near trees*' where building near existing, proposed or recently removed trees.

We would recommend that an arborist survey is undertaken to identify the species and heights of the existing trees and hedgerows at, and within influencing distance of, the site to enable a foundation schedule to be produced (as required).

8.8 Water

During the monitoring programme, water was encountered at depths of between 1.76m to 2.17m bgl within the monitoring installations. These depths generally correspond to the water strikes noted during the course of the intrusive investigation works, and are therefore likely to be representative of shallow groundwater conditions at the site.

On the basis of the foregoing, it is anticipated that excavations in excess of around 1m deep may require some dewatering. This may involve sump pumping techniques, in the first instance, particularly where excavations are left open for a significant period of time. For deeper excavations (such as for sewers construction) alternative methods of dewatering may become necessary (such as wellpoints or eductors etc.) subject to the prevailing ground conditions at the time of excavation.

Excavations may also be susceptible to standing water following periods of wet weather. It should be noted that groundwater levels may vary due to seasonal or other effects.

8.9 Radon

No radon precautions are required at the site.

8.10 Excavations and stability

The sides the trial pits generally remained stable where the soil was dry or slightly moist but were observed to become unstable where wet soils were encountered (typically 1.5m to 2.0m), collapsing from the base and undermining the overlying strata.

During advancement, the borehole sides were cased to prevent collapse. On the basis of the exploratory works, shallow excavations are unlikely to require trench support, other than for health and safety reasons. However, trench support may be required within deeper excavations (approximately 1.5m or greater) where wet soils are encountered. The assessment of excavations and provision of support will be the responsibility of the contractor on site. We would note that there is a risk of increased instability if excavations are left open for long periods.

The natural soils are likely to be subject to deterioration and softening if excavations are left open and exposed to wet weather. Any softened soils should be removed from excavations prior to the pouring of concrete and foundation construction.

8.11 Sulphate Classification

In accordance with BRE Special Digest 1 (2005), the site falls into Design Sulphate Class DS-1 and an Aggressive Chemical Environment for Concrete (ACEC) classification of AC-1. Therefore, an appropriate concrete mix should be adopted in accordance with BRE Special Digest 1 for all buried concrete in contact with the ground.

8.12 Coal Mining

No coal mining precautions or associated investigation works are required at the site.

8.13 California Bearing Ratios (CBRs)

CBR values of ranging between <2% and 3% may be anticipated within the shallow Natural Strata, subject to confirmation by in-situ testing.

8.14 Surface Water Drainage

The testing undertaken has revealed soil infiltration rates ranging between 3.50×10^{-6} (fastest) and 1.19×10^{-6} (slowest) within the near surface soils, with the results indicating that the site may not be widely suitable for the use of soakaways. We would advise that alternative methods of surface water drainage are therefore investigated at this stage.

8.15 Contamination Assessment

Contamination testing was carried out on selected samples of the topsoil and the underlying Natural Strata. It was considered appropriate to base our sampling and investigation strategy on the potential contamination issues identified within our land use assessment taking into account the proposed end-use and the historical and existing use of the site.

On the basis of the chemical contamination assessment undertaken, the soils may be considered to be uncontaminated for the proposed residential with plant uptake end-use (i.e. in relation to human health).

We would additionally note that no visual or olfactory evidence of significant contamination was identified during the course of the exploratory investigation works.

Given the low contaminant concentrations revealed by the testing, together with the low groundwater sensitivity of the area, there are considered to be no specific risks posed to Controlled Waters or other surface waters by the findings of the laboratory analysis undertaken to date.

8.16 Remediation Proposals

8.16.1 Proposed Garden Areas

It is considered that taking account of the current setting of the site and development proposals, human health is the principle driver for any remediation works based on the proposed residential end-use of the site.

However, the chemical analysis undertaken to date has revealed the site to be uncontaminated with respect to the determinands tested, based on a residential with plant uptake end-use. Therefore, no remediation works will be required other than the provision of topsoil in proposed gardens to provide a suitable growing media for plants.

8.16.2 Proposed Areas of Hard Standing

Specific remedial measures are considered not necessary within areas of proposed hard standing at the site (i.e. external hard standing areas and beneath the floor slabs to the proposed dwellings).

8.16.3 Re-use of Existing Topsoil and Natural Strata

The existing topsoil is considered suitable for re-use within the proposed development. We would recommend that the existing topsoil is stripped and appropriately stockpiled prior to commencement of the development.

Furthermore, where there is an excess volume of topsoil, consideration should be given to re-use on other developments (subject to regulatory approval) rather than off-site disposal. Similarly, the Natural Strata may be regarded as suitable for re-use within proposed gardens as subsoil (to raise levels, as appropriate) or for landscaping/capping on alternative developments (subject to regulatory approval) where surplus arisings are generated from the site. Please note that further sampling and analysis may be required in due course where these options are to be investigated and a Materials Management Plan (MMP) prepared accordingly.

8.17 Off Site Disposal & Waste Acceptance Criteria Testing

If off-site disposal is required the chemical testing regime can be different to the chemical testing required to assess the suitability of the soils for retention on site and the risks to human health. Therefore, a new contamination assessment may be required to include bespoke leachate analysis (i.e. Waste Acceptance Criteria [WAC] testing) to classify the soils for off-site disposal with testing criteria to assess whether the soil is hazardous, non-hazardous or inert waste. However, the existing chemical test data will assist this process.

If disposal is necessary then the environmental laboratory test results (included within Appendix VII) should be provided to several landfill operators for consideration and cost provision in the first instance, prior to the material being removed from the site.

8.18 Flood Risk

The Landmark Envirocheck report has revealed the site to lie within an area identified as being at risk of flooding. It is recommended that advice be sought from a Drainage Consultant with respect to this matter.

8.19 Construction Workers

No contamination has been identified that requires specific PPE. However, it is recommended that construction personnel involved with direct contact with the soils at the site use appropriate PPE equipment (i.e. boots, gloves and overalls) together with hygiene facilities in accordance with general health and safety guidelines.

A copy of this report should be included in the site health and safety file, and site workers should be made fully aware of the sites setting.

8.20 Utilities

Prior to development of the site, we would recommend that a copy of this report, including the Anglian Water Suite laboratory analysis certificates included in Appendix VII, are supplied to the appropriate utility companies, and that their recommendations relating to appropriate supply pipes are adhered to.

8.21 Unforeseen Circumstances

Should any areas of potentially contaminated soil be encountered during site construction works we would recommend consultation with GeoDyne Limited to ensure that our recommendations continue to apply. Any potentially contaminated soils should be left in-situ and subjected to further assessment, to potentially include further chemical testing and risk assessment.

The following procedure should be adhered to if any areas of previously unidentified suspected contamination are encountered during the development of the site:

- i. Suspected contaminated material will remain in-situ.
- ii. GeoDyne Limited to be notified. We will then undertake a visual assessment of the possible contamination, followed by appropriate sampling/testing (as necessary).
- iii. If necessary, an appropriate strategy to remove/remediate the contamination will be submitted to the Local Authority.

8.22 Licences, Permits, Registrations, Plans & Approvals

The Contractor/Developer is responsible for, and must ensure that, all necessary licenses, permits, plans, registrations and approvals are in place prior to commencing with the earthworks at the site. These will include any Mobile Treatment Licenses (MTLs), Materials Management Plans (MMPs), Site Waste Management Plans (SWMPs) and/or Environmental Permits as necessary to enable the completion of the proposed works.