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Date: 07.11.2024
Project No: GEO2024-6517
Project: Griffin Close, Frizington
Report Title: Summary on Geo-Environmental Investigations

Dear Troy,

Geo Environmental Engineering Ltd (GEO) have been commissioned by the Consultant, RG Parkins & Partners Ltd, on behalf of the Client to provide a report summarising all of the Geo-Environmental Reports for the site, the findings and the salient recommendations relating to the proposed residential development.

Previous Reports Summary

The following reports have been completed for the site:

- Phase 1: Desk Top Study, ref: 2022-6436, dated: 17.08.2022.
- Phase 2: Ground Investigation Report, ref: 2023-5496, dated: 03.02.2023.
- Supplementary Mining Investigation Report, ref: 2024-6310, dated: 06.08.2024.
- Soil Infiltration Test Report, ref: 2024-6310, dated: 06.08.2024.
- Ground Gas Protection System Verification Plan by GeoEnginSeer Ltd, ref: 1711, dated: 23.10.2024.

A brief summary of the findings is included below; however, it is recommended that the DTS is read in conjunction with this report.

Desk Top Study

Historical records showed that the site was undeveloped until 1981 when the former care home was constructed. It is understood that the care home was demolished around c.2012. GEO has not been able to identify a specific reason why the care home was demolished.

Made ground was anticipated associated with the former development, however, geological data did not indicate any significant made ground on site or within 250m. Drift deposits were recorded as glacial till overlying solid strata of Pennine Middle Coal Measures.

The report indicated a potential for shallow mining in the Bannock Coal seam which is indicated to sub-crop across the north east of the site and dip to the south west. Intrusive mining investigations were recommended. The report also noted a recorded a mine shaft in the northern part of the site. Two other shafts are recorded beyond the site boundary to the north of the site. The report recommended intrusive investigations to locate the mine shaft.

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The report indicated a high to very high geotechnical risk associated with redevelopment. The main concern was associated with historical coal mining geohazards such as the potential for shallow unrecorded coal mine workings and the presence of a shaft within the site boundary.

The report indicated a very low risk to human health from potential ground contamination as no significant sources of contamination were identified. A negligible risk was deemed appropriate with regards to controlled waters and a moderate risk was deemed appropriate with regards to possible ground gas (associated with possible shallow mining and on-site mine shafts).

Radon protection measures were not deemed necessary.

Ground Investigation Report

The ground investigation comprised mini-percussive boreholes, mechanically excavated trial pitting, trenching and rotary borehole drilling. Ground gas monitoring wells were installed, and gas monitoring was completed on 6 No. occasions between September and December 2022.

Made ground was typically between 0.40m and 2.70m deep and comprised topsoil with occasional fragments of clinker, coal, slag and brick overlying sandy clay fill with occasional of clinker, coal, sandstone, brick and dolomite. Pockets of topsoil/peat, wood fragments and silt were also noted within the fill.

Localised deeper 'made ground' was recorded in the north eastern part of the site associated with an area of geotechnically very poor ground and an underlying loosely infilled void between 3.50m and 5.00m bgl with occasional coal, clinker and brick gravel.

Trenches were excavated across the northern part of the site in order to locate the mine shaft. No evidence of the shaft was encountered.

The underlaying drift typically comprised firm to stiff or stiff sandy gravelly clay with occasional lenses of gravelly sand. Possible heavily weathered mudstone bedrock was encountered from c.0.90m and c.3.60m bgl. Solid mudstone strata were confirmed in the rotary boreholes between c.2.70m and c.3.60m bgl (excluding the areas of deeper 'made ground').

Samples of topsoil, made ground and natural strata were screened for a range of potential contaminants including metals, cyanide, PAH and asbestos. The results were assessed against GAC for a residential development with private gardens. All of the test results came back low with no exceedances. The report indicated that although the existing soils do not pose a risk to human health, they are considered unsuitable for re-use at the surface and an allowance should be made for importing clean soils within the proposed private gardens.

Gas monitoring did not identify any elevated concentrations of carbon dioxide or menthane. However, as a precaution given the potential for shallow mining, gas protection measures were recommended regardless.

Supplementary investigations were recommended to determine the location of the mine shaft and the determine the risk of shallow unrecorded coal mining beneath the northern part of the site. The report concluded that the rock cover across the central and southern parts of the site is sufficient to mitigate significant structural risks.

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Conventional strip foundations in the firm to stiff / stiff natural clay or weathered bedrock were considered suitable across the central and southern parts of the site. However, given the geotechnically poor ground in the north eastern parts of the site, piled foundations were recommended in this area.

Supplementary Mining Investigation Report

A geophysical Survey (Electromagnetic and Ground Conductivity) was completed in May 2024 in an attempt to identify the mine shaft and any mine working artefacts. The investigation identified several anomalies which could be representative of mining relicts or geological structures. Intrusive investigations were recommended at these locations to provide further information.

Dynamic probing was completed in two lines at right angles across the northern part of the site where the previous investigation had identified deep, geotechnically poor ground which was described as 'made ground'. The probes encountered variable ground conditions with very soft/loose ground in the north eastern part of the site to a maximum depth of c.7m bgl. The probe was occasionally falling under its own weight which is generally representative of extremely loose/soft ground or possible voids.

Trial trenching was completed across the north eastern part of the site in July 2024 in order to locate the mine shaft. The trenches encountered a shallow sub-cropping coal seam in the extreme north east which appeared to dip to the south. Weathered mudstone bedrock was typically encountered from depths of between c.1.10m and c.1.50m bgl in this area.

Trench TT03 was located over and targeting the former borehole WS02 which encountered deep 'made ground' and void. The trench encountered a band of coal from c.3.10m and an open void between c.3.40m and c.5.00m bgl. A pillar of coal was also noted along the edge of the void. This confirmed the presence of significant mining beneath the site. Although no made ground was encountered, the weathered bedrock was noted as occasionally loose, possibly due to localised collapse of the underlying workings (void migration).

Evidence of a suspected mine shaft was encountered in trench TT06. This comprised a column of soft / soft to firm brown clay with pockets of gravel which appeared reworked. The trench was excavated to a depth of c.3.60m bgl and the column of soft clay was noted to continue below this depth. Light grey weathered bedrock was recorded either side of this feature. The suspected shaft was surveyed following completion of the investigation

- Suspected Mine Shaft Location: 303377.806, 517407.38.

The rotary boreholes encountered solid bedrock at depths of between c.2.80m and c.5.20m bgl. The boreholes encountered up to three coal seams which varied between 0.15m and 1.55m thick. The thickest seam was encountered within the northern part of the site at depths of 5.50m and 7.60m bgl and corresponds with the workings encountered in the trench.

Evidence of workings was encountered in one of the rotary boreholes (RBH-E) located to the north east of the car park and recorded loss of flush and soft ground from c.11.10m and no returns (complete loss of flush) and broken ground from 12.30m bgl. Solid ground was recorded from c.13.80m bgl.

The report concluded that the Bannock Coal Seam has been worked beneath the site from depths of between 3.20m to over 11m bgl. The seam appears to be between 1.35m and 1.55m thick where

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it has been worked. Although workings were only encountered across the northern parts of the site, workings elsewhere on site (further south) could not be ruled out.

The report recommended remediation of the workings and mine shaft and re-design of the site layout, as discussed in the 'Coal Mining Remediation' Section below.

Due to the geotechnically poor ground encountered across the north eastern parts of the site, conventional strip foundations in this area were not considered suitable and alternative solutions such as a raft or piles were recommended. Strip foundations were considered suitable elsewhere.

In view of the workings, ground gas protection measures were recommended within 50m of the mine shaft and within all properties located above remediated mine workings.

Soil Infiltration Test Report

Two soakaway tests were completed on the 30th July 2024. This comprised two trial pits to depths of between 2.00m and c.2.20m bgl. The trial pits encountered made ground to depths of between c.1.00m and c.1.70m bgl which comprised clayey gravel and reworked gravelly clay overlying natural drift deposits of stiff gravelly clay.

The pits were filled with water from a mobile bowser and the water level checked regularly over a period of 5 hours. During this time, the water level dropped between 1cm and 4cm. The results suggested that the ground is practically impermeable and not suitable for soakaway drainage. The report concluded that an alternative drainage solution should be sought.

Ground Gas Protection System Verification Plan

Gas protection measures have been recommended within 50m of the mine shaft and overlying areas that have been stabilised (grouted).

The report states that 3.5 points are required for this type of building (Type A). The installation of an appropriate gas barrier membrane and subsequent independent verification testing provides 2.0 points. The inclusion of a passive dispersal layer of very good ventilation standard provides 1.5 points

The report indicates that the gas protection measures should be professionally designed by a Structural Engineer and should demonstrate sealing around penetrations, depth of ventilation sub floor void (minimum 150mm sub floor void for very good performance) and duct work connecting the subfloor void or passive ventilation layer to the outside air.

The report indicates that verification (100% inspections and 25% seams and seals) is required for all installation events prior to covering. Other items for inspection will include the sub-grade quality, depth of the void, installation of insulation over the membrane. Confirmation of appropriate products used will be conducted on each and every verification event.

A final Gas Protection Verification Report for the Griffin Close project will be supplied to summarise and document all the above testing, materials deployed and as built effectiveness of the passive ventilation system. Any damage, repairs and variations necessary, if any, to this plan will be documented.

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Radon and Gas

The Desk Top Study was completed in August 2022, prior to revision of the UK radon map in December 2022. GEO have acquired a Ground Sure Report which includes a detailed site specific radon report for the site.

The GSR indicates that the development site is located within a Radon Affected Area as defined by the British Geological Survey and UK Health Security Agency, as between 1% and 3% of properties are above the action level. However, in accordance with the British Geological Survey and UK Health Security Agency, radon protection measures are not necessary.

Radon risks are re-assessed periodically by the British Geological Survey and UK Health Security Agency, therefore, a re-assessment is recommended if the development does not commence within 12 months of issue of this report.

A copy of the Ground Sure Report is attached to this document.

As indicated previously, the ground gas concentrations were low throughout the monitoring period. However, GEO have recommended basic gas protection measures within 50m of the suspected mine shaft and overlying areas that have been stabilised (grouted) as a precaution and industry best practice.

Contamination Remediation

As indicated within the Ground Investigation Report, made ground was encountered across the site to varying depths associated with the previous care home. The made ground typically comprised topsoil and reworked clays and sands with fragments of clinker, ash, coal, slag and brick. Although some of the made ground did not appear visually acceptable for use at the surface, chemical testing confirmed that it does not pose a significant risk to human health. Therefore, ground contamination remediation was not deemed necessary.

In order to provide a suitable growing medium for plants and turf, GEO recommended that clean soils are imported to the site for placement within the proposed gardens.

GEO recommended that any imported materials should be screened prior to placement on site to ensure contaminated materials are not being imported and that they are suitable for use within a residential setting.

If topsoil is brought on to site, the materials should be as specified in BS 3882:2015 as ‘suitable for the intended purpose’. BS3882:2015 relates to nutrient content of topsoil and phytotoxic contamination and does not consider contaminants that pose a risk specifically to human health. Soils should be tested for contaminants that are considered to pose a risk to human health in addition to BS3882:2015 to ensure that they are suitable for their intended use. All materials brought on to site that are to be used as part of soft landscaped areas should be assessed with regards to human health criteria.

Coal Mining Remediation

GEO have confirmed the presence of shallow coal mining and a suspected mine shaft in the northern part of the site during supplementary ground investigations. The report recommended remediation

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of the shallow coal mine workings and the suspected mine shaft to stabilise the ground and mitigate the risks to the proposed development and end users.

GEO are currently acquiring quotations from specialist grouting contractors including Groundshire, Van-Elle and Soil Engineering. The successful contractor will provide a site-specific Method Statement and risk assessment for the proposed works.

The Supplementary Investigation report recommended that rotary probing is undertaken to delineate the areas that have been worked and to ascertain areas where sufficient rock cover is present to mitigate the structural risks. Remediation by pressure injection grouting using a PFA and cement mix was recommended to stabilise the ground where there is insufficient rock cover.

With regards to the suspected mine shaft, the report recommended rotary probing to confirm if the column of soft clay is a mine shaft and to determine the depth and fill type if it is. Grouting by appropriate contractor and under permit from The Coal Authority was recommended to stabilise any voids and fill within the shaft.

Supplementary stabilisation by an appropriately designed geotextile or concrete cap was also recommended in accordance with current standards.

The report recommended that the housing layout is redesigned to accommodate the mine shaft with no houses constructed within the zone of influence.

It is likely that the concrete cap could be designed by the Structural Engineer. However, the use of a geotextile would require specialist design. The Designer would require sufficient experience and knowledge to ensure that the system can adequately mitigate any residual risks to the end user should settlement or collapse of the mine shaft infill occur. The geotextile would require sufficient space around the shaft to ensure that it can be anchored beyond the zone of influence. As such, this system may not be suitable for the proposed development.

General Comments and Limitations

Consideration must be made for variations to occur in the ground conditions between the exploratory hole locations for which GEO holds no responsibility. It is therefore recommended that a “watching brief” be applied to ensure that if ground conditions vary from those identified during this investigation then advice should be sought from a suitably qualified and experienced Geo-Environmental Engineer.

The recommendations and opinions expressed in this report are based on the ground conditions observed. Consequently, GEO takes no responsibility for conditions that have not been revealed or which occur between them.

The conclusions and recommendations presented within this report are considered reasonable based on the available information. However, these cannot be guaranteed to gain regulatory approval. Therefore, the report should be passed to the appropriate regulatory authorities and/ or other key stakeholders, including warranty providers in order to seek their approval of the findings prior to undertaking any site works or development on site.

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If there are any queries, please do not hesitate to contact Geo-Environmental Engineering Ltd.

Yours Faithfully

.....
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