Ashfield
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KE/DN/46924-004

29 July 2022

For the attention of Mr Lewis Hickman

Dear Lewis,

Newark Road, Sutton-in-Ashfield

Hydrogeological Review and Groundwater Piling Assessment

A residential development is proposed for the approximate 21.4 hectare site located south of Newark Road and west of Coxmoor Road in Sutton-in-Ashfield.

Rodgers Leask Environmental (RLE) previously completed a '*Phase 1 Desk Study*' for the site, dated 26 January 2017, on behalf of others. RLE subsequently issued two further Technical Notes (dated 13 September 2017 and 18 May 2018) which summarise the findings of their intrusive investigation and gas monitoring programme.

Eastwood Consulting Engineers (ECE) completed a '*Phase 2 Geotechnical and Geo-Environmental Site Investigation*' for the site, referenced KE/ACR/46924-002 and dated 24 May 2022.

We write to provide a review of the hydrogeological conditions expected below the site, and potential impact of the development (and in particular where piled foundations are utilised) on aquifers, groundwater and controlled waters. This review should be read in conjunction with the above reports.

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Review of Desk Based Information

Site Description & History

The majority of the site comprises agricultural fields with a small area of woodland located in the south east corner (<5% of the total site area).

The site roughly lies between 149 m above Ordnance Datum (AOD) in the west and 177 m AOD in the south east, and generally slopes down to the west or north west at an average gradient of around 1 in 16, and locally up to around 1 in 8 in the south east corner.

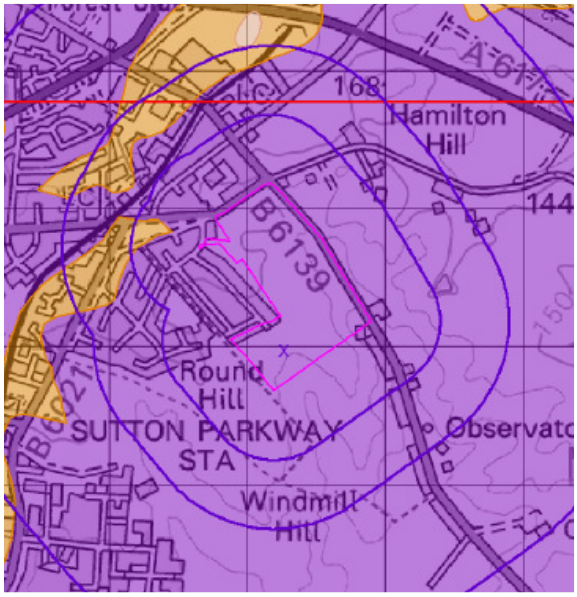
Historically, multiple sand pits (which eventually merged into a single large pit) were located across the northern 20% of the site since at least the late 19th Century. These sand pits are recorded as a Historical Landfill Site which permitted the disposal of inert waste (excavated natural materials, hardcore and rubble) between March 1980 and November 1983. A smaller sand pit was also undertaken in the site's south eastern corner, and part of the escarpment is still visible today. No development or other extractive activities have taken place across the remainder of the site.

Geology, Hydrogeology and Hydrology

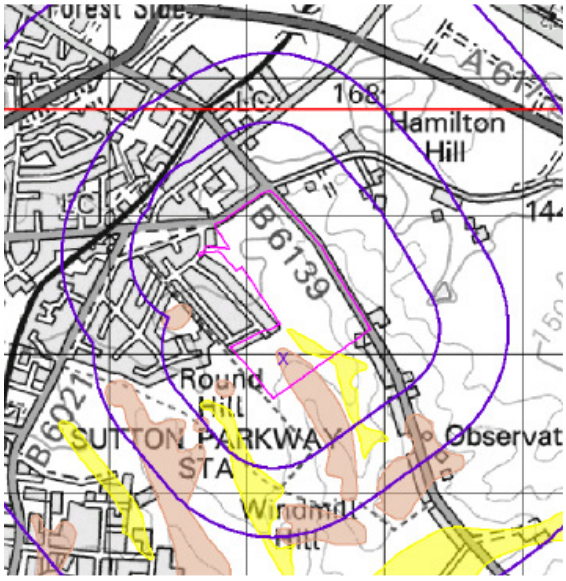
The solid geology below the site comprises the Lenton Sandstone Formation (sandstone with subordinate mudstone and siltstone). Two elongate bands of superficial deposits (glaciofluvial deposits and superficial Head) are shown to extend into the south of the site. A fault is inferred to cross the north west corner of the site.

The solid bedrock is classified as a Principal Aquifer. The superficial glaciofluvial deposits are classified as a Secondary A Aquifer. The superficial Head deposits are classified as a Secondary Undifferentiated Aquifer.

The below extracts are taken from the Envirocheck obtained for ECE's site investigation. The site is outlined in pink and the 250 and 500 m buffer radii are shown in purple:



Extract showing the solid geology Principal aquifer below the site and below the surrounding area within 500 m of the site.



Extract showing the superficial deposits (where present) Secondary A aquifer (brown) and Secondary Undifferentiated aquifer (yellow) below the site and below wider surrounding area.

The site lies within a Total Catchment – Zone 3 Groundwater Source Protection Zone, and there are no groundwater abstractions recorded by the Envirocheck to lie within 250 m of the site. The closest potable groundwater abstraction point is located approximately 8.75 km to the south east of the site at Papplewick Pumping Station.

The nearest surface water feature is an unnamed stream located 140 m to the south west of the site. The River Maun is the closest named surface water feature, located 422 m to the north west of the site. A culvert (a land drain installed by farmer) also crosses below the south of the site trending roughly north west to south east, although this has silted up.

The site is not at risk of flooding from rivers. Roughly 60% of the site (generally covering eastern and southern areas) is recorded as having limited potential for groundwater flooding to occur. Around 40% of the site (in the west / north west) is recorded as having potential for groundwater flooding of property situated below ground level. A small portion of the site (<5% by area) adjacent to the culvert is shown as being at low (1000-year return) risk of flooding form surface water.

The BGS Online Viewer has been consulted; a borehole was previously drilled below the works to the north of Newark Road around 30 m to the north of the site (referencedSK55NW135). The resting level of water in the borehole was recorded at 42 ft (12.8 m); the surface level of the borehole is approximately 155 m AOD, therefore the groundwater table is expected to lie at around 143 m AOD near the northern boundary.

Summary of Ground Investigations

Ground Conditions

Both RLE and ECE have completed intrusive investigations on the site. The locations of the exploratory holes are shown on the attached Exploratory Hole Location Plan (drawing 46924/003).

Topsoil was encountered across the site to between 0.1 and 0.5 m bgl (average 0.3 m).

Made ground was encountered across the northern 20% of the site within the infilled sand pit to depths of between 0.8 and 13.0 m bgl (and typically at least 5.0 m). The made ground generally comprising dark grey brown silty sandy gravel and/or gravelly sand, with scrap metal, plastics, wood and gravel of shale, mudstone, brick, sandstone, concrete, glass, wood and ceramics.

Reworked natural ground, comprising red-cream-brown slightly clayey, often slightly gravelly sand, was found to overlie the made ground in the former sand pit area to depths of between 0.5 and 1.2 m.

The shallow natural ground comprises red brown fine to medium sand, typically becoming gravelly with depth, considered to comprise residual / weathered Lenton Sandstone. Superficial deposits comprising sand and gravel were encountered in one exploratory hole (TT01) in the south of the site to at least 2.4 m bgl. Sandstone bedrock was encountered across the site at depths of between 1.9 and 4.2 m, and below the base of the made ground in the sand pit area.

Groundwater ingresses / running sand were recorded in the residual natural sand in TP32 (2.2 m) and TP33 (2.1 m). The pits were excavated either side of the culverted land drain and are located in one of the lower points of the site. The equivalent level of the ingresses is around 150.7 m AOD and 151.0 m AOD. A water ingress was also recorded in the made ground in TP9 at 2.8 m bgl (149.2 m AOD).

In the cable percussive boreholes, “wet pockets” were recorded in CP02 below 6.0 m bgl (151.4 m AOD) and also in CP03 between 4.8 and 5.0 m bgl (154.9 to 154.7 m AOD). However, no significant ingresses were recorded, which terminated in the sandstone bedrock up to 11.62 m bgl.

Chemical Testing

Olfactory evidence of contamination was identified in the made ground within the sand pit area in six different exploratory holes; hydrocarbon odours were noted in TP12, TP13 and TP17, and solvent or volatile odours were noted in TP15, CP02 and CP03. In addition, organic odours were noted in the made ground in a further six trial pits. No visual evidence of contamination (e.g. free product) was encountered.

Twenty-five samples of topsoil, sixteen samples of made ground, three samples of reworked ground and nine samples of natural ground were submitted for testing for a range of chemical suites (e.g. heavy metals, polycyclic aromatic hydrocarbons (PAHs), total petroleum hydrocarbon (TPHs), volatile organic compounds (VOCs) and asbestos). Results have been compared against assessment values for a residential with home-grown produce end use.

Six samples of topsoil recorded elevated concentrations of four different PAH compounds in varying combinations. Modified means have been calculated across the samples of topsoil for each of these PAHs, and all fall below their respective assessment criteria. The topsoil is therefore considered to be chemically suitable for re-use.

In total, ten samples of made ground, ranging in depth from 0.8 to 6.8 m, recorded elevated concentrations of contaminants. One sample recorded elevated concentrations of metals (cadmium and lead), nine samples recorded up to five elevated PAH compounds, and three samples recorded elevated hydrocarbon fractions (aromatic TPH >C16-C21 and >C21-C35). In addition, four samples of ‘deep’ made ground (i.e. below 5 m bgl) recorded concentrations above the limit of detection for three VOCs for which no standardised assessment values are available. No asbestos was detected in any of the samples.

None of the samples of natural ground (including reworked natural ground) recorded any elevated contaminants; this includes two samples collected from below the made ground in the sand pit area (TP3 2.8 m and TP21 2.1 m).

Gas Monitoring

RLE installed ten gas monitoring wells within the former sand pit area and completed six rounds of gas monitoring between April and July 2017. A summary of the results is given below.

- Methane was detected in four of the monitoring wells (CPBH01, CPBH02, WS04 and WS05) with a maximum concentration of 3.4%. Generally, the peak methane concentrations coincided with visits completed during times of low or falling atmospheric pressure;
- Carbon dioxide was detected in all eight of the monitoring wells, recording a maximum concentration of 13.9%;
- Limited concentrations (<1 ppm) of carbon monoxide during every monitoring visit;
- A peak positive gas flow of 0.1%.

RLE installed a further nine wells in 2018 along the eastern boundary to target the offsite landfill. Six rounds of monitoring were undertaken between February and May 2018 of both the new and 2017 sets of wells; only CPBH02 recorded elevated methane concentrations (<2.2%) whilst the highest carbon dioxide concentration was 8.4%.

Most wells remained dry throughout the monitoring period. The exceptions were CP01 which recorded water on one occasion at 3.4 m which would lie within the natural ground below the sand pit backfill, and in RO01 at 9.3 m on one occasion, again within the sandstone. The well installed in WS03 often recorded water within the made ground at around 2.4 m.

Given the elevated TPH fractions and other volatiles recorded in the made ground within the former sand pit area, ECE recommended Amber 2 gas precautions for plots located within the footprint of this area, and Amber 1 precautions for plots located within 30 m of the sand pit boundary. Amber 1 precautions are also recommended for plots located within 30 m of the off-site landfill to the east.

Construction

The site will be developed with low-rise housing of conventional construction.

Across the southern 80% of the site, traditional strip or trench fill foundations constructed within the shallow natural sand are considered to be appropriate.

For plots in the former sand pit area in the northern 20% of the site, piled foundations are expected to be utilised, extending through the made ground into competent sandstone bedrock.

The Environment Agency document, 'Piling and Penetrative Ground Improvement Methods on Land Affected by Contamination: Guidance on Pollution Prevention' (dated May 2001, reference NC/99/73) identified six situations where piling or penetrative ground improvement could potentially cause pollution. The situations described by the document are shown below with our associated comments:

1. **Creation of preferential pathways, through a low permeability layer (an aquitard), to allow potential contamination of an underlying aquifer.**

   Due to the presence of obstructions within the made ground, pre-bored piles may be required. Should pre-drilled piles be utilised, this will temporarily create an opening in the underlying Principal aquifer (i.e. sandstone bedrock). However, once the pile has been cast, the pathway into the aquifer will be sealed.

   Where driven piles are to be used, these will displace the soil outwards, generally densifying it around the piles. The made ground being piled through is therefore expected to seal itself around the piles, which will restrict the passage of water along the pile length into the underlying aquifer.

   The piles are therefore not expected to create a pathway into the underlying aquifer.

2. **Creation of preferential pathways, through a low permeability surface layer, to allow upward migration of landfill gas, soil gas or contaminant vapours to the surface;**

   A gas monitoring programme was previously carried out on the site by RLE. Elevated concentrations of methane and carbon dioxide have been recorded in the wells installed in the sand pit area. In addition, elevated concentrations of hydrocarbon fractions and VOCs were recorded in the made ground during the investigation by ECE, which could present a vapour risk to the proposed development.

Amber 2 gas precautions are recommended for plots overlying the former sand pit area, with Amber 1 measures recommended for plots located within 30 m of the sand pit and for plots located within 30 m of the off-site landfill to the east of the site.

The made ground is expected to seal up around the piles post pile installation. A pathway for upward migration of gases or vapours is therefore not expected to be created by the piling. The piling is consequently not expected to increase the gas risk to this development.

3. **Direct contact of site workers and others with contaminated soil arisings which have been brought to the surface;**

   Elevated concentrations of metals (cadmium and lead), PAHs, TPH fractions and VOCs have been recorded in the made ground within the sand pit area compared to their respective residential assessment criteria.

   Should pre-bored piles be utilised (a displacement piling technique), the displaced made ground will be brought to the surface. Care should be taken to ensure the impacted arisings are not spread across the uncontaminated part of the site.

   Groundworkers should be made aware that elevated concentrations of contaminants are present in the made ground. Normal site procedures, such as the wearing of gloves when handling soils and the washing of hands prior to eating, should be implemented at all times.

4. **Direct contact of the piles or engineered structures with contaminated soil or leachate causing degradation of pile materials (where the secondary effects are to increase the potential for contaminant migration);**

   Sub-surface concrete in contact with made ground should contain DS-3 AC-3 precautions. It is anticipated that piles will be steel, and any concrete used for infilling will contain this level of sulphate measures as a minimum.

5. **The driving of solid contaminants down into an aquifer during pile driving;**

   The piles are only expected to extend around 2 to 3 m into the sandstone bedrock. Only a small amount of made ground, if any, would be expected to be pushed down to the sandstone, which is typically expected from a depth of 5 to 13 m below existing ground level within the sand pit area.

   Olfactory evidence of contamination (including hydrocarbon, solvent and volatile odours) was noted in six exploratory holes completed in the sand pit area. No visual evidence of

contamination (e.g. free product) was encountered, however. No evidence of contamination was noted in the natural ground, including where encountered below the made ground.

Elevated concentrations of metals (cadmium and lead), PAHs, TPH fractions and VOCs have been recorded in the made ground collected from the sand pit area. However, of these contaminants, only TPHs and VOCs are considered to be particularly leachable. Only three samples of made ground (collected from TP14 and CP02) recorded elevated TPH fractions when compared against human health assessment criteria, as summarised below:

TPH Fraction	Assessment Value (mg/kg)	Elevated Concentration (mg/kg)		
		TP14 2.1 m	CP02 5.75 m	CP02 6.8 m
Aromatic TPH >C16-C21	930	-	1,100	970
Aromatic TPH >C21-C35	1,700	2,000	2,600	3,300

The elevated concentrations do not significantly exceed their respective assessment criteria for a residential end-use. Furthermore, according to the LQM/CIEH S4UL Handbook, these fractions have a very low solubility potential in water of 6.53 x 10^5 g/l and 6.61 x 10^3 g/l respectively (at 10℃) compared to other lighter hydrocarbon fractions.

In addition, four samples of 'deep' made ground collected from CP02 and CP03 recorded concentrations of three VOCs (for which no assessment criteria are available) above the limit of detection. These results are summarised in the table below.

Determinant	Recorded Concentration (mg/kg)			
	CP02 5.75 m	CP02 6.25-6.7 m	CP02 6.8 m	CP03 6.1-6.35 m
2-Methylnaphthalene	3.6	1.9	1.1	6.5
Dibenzofuran	13	7.5	6.2	1.4
Carbazole	11	4.4	3.8	0.8

Significant concentrations of VOCs were not recorded; dibenzofuran was recorded with a maximum concentration of 13 mg/kg in sample CP02 5.75 m.

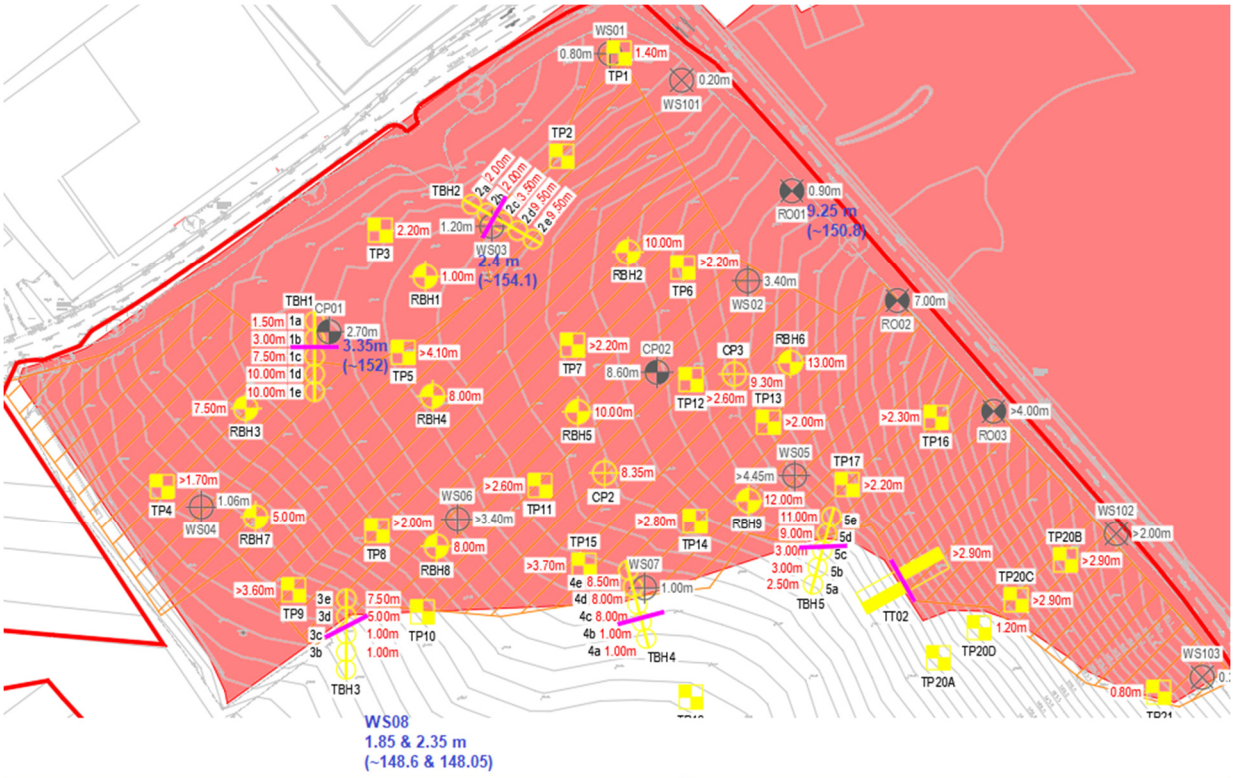
Two samples of natural ground collected from below the made ground were submitted for chemical testing (TP3 2.8 m and TP21 2.1 m). Neither of these samples recorded any

elevated contaminants. A sample of made ground was tested from TP3, although no contaminants at significant risk of leaching were recorded in elevated concentrations.

No evidence of the leaching of contamination from the made ground in the underlying natural ground has been recorded on the site.

Significantly elevated concentrations of potentially leachable contaminants were not recorded in the made ground, and no evidence of contamination leaching into the natural ground was recorded. Furthermore, the piled foundations are not likely to extend a significant depth into the Principal aquifer.

Only on rare occasions was groundwater noted within the sandstone below the sand pit area; within the RLE investigation, three monitoring wells recorded water (although no strikes were recorded during well installation). These ingresses are noted below in blue:



WS03 recorded water at around 2.4 m in most monitoring rounds; the well depth was however only 2.5 m deep so it is difficult to determine if this ingress is representative of a persistent water table. CP01's well was around 8.5 m deep and only on one occasion was water noted (at 3.35 m depth, just below the base of the made ground). During this same round, RO01's well (10 m deep) recorded water at 9.25 m. Around 50 m south of the sand pit, WS08's well recorded water on two occasions only.

There is therefore not likely to be a persistent water table directly below the backfilled sand pit area.

It is considered that there is a very low risk of contaminants being driven down into the underlying aquifer. Should any contaminants be dragged down during piling, concentrations are expected to be negligible and are not considered to present a significant risk to either groundwater or potable water abstractions, the closest of which lies over 8 km from the site.

6. **Contamination of groundwater and, subsequently, surface waters by concrete, cement paste or grout.**

If driven piles are utilised, it is likely these will comprise steel tubes infilled with concrete. These materials are therefore not expected to pose a significant risk to controlled waters.

The construction of the proposed development should not produce solid or liquid contaminants which can migrate through the underlying soil. Construction processes are therefore not considered to pose a significant risk to controlled waters.

It is considered that soakaway drainage is not viable for this site, and surface water from the proposed development will be directed into a suitable piped system. The proposed drainage strategy is not therefore exposed to pose a risk to controlled waters.

We trust the above is satisfactory. Please let us know if you have any queries.

Yours sincerely

Kate Edwards

Kate Edwards

Enc Exploratory Hole Location Plan, drawing 46924/003A

INFORMATION WITHIN THIS DRAWING IS NOT NECESSARILY PRODUCED TO SCALE.
ALWAYS USE FIGURED DIMENSIONS AND CO-ORDINATES - IF IN DOUBT, ASK.

Key:

- Approximate location of trial pit excavated by Eastwood & Partners between 16.03.22 & 28.03.22.
- Approximate location of rotary borehole drilled by Eastwood & Partners on 25.03.22.
- Approximate location of cable percussive borehole drilled by Eastwood & Partners on 28.03.22 & 30.03.22.
- Approximate location of rotary borehole transect (across highwall) drilled by Eastwood & Partners on 24.03.22.
- Approximate location of buried culvert taken from Harron Homes, Constraints Plan.
- Approximate location of water main taken from Harron Homes, Constraints Plan.
- 2.20m / 2.20m — Depth to base of made ground (m).
- Approximate extent of former sand pit, taken from the 1958 historical maps.
- Approximate location and reference of trial pit soakaway test excavated by RLE.
- Approximate location and reference of historic cable percussive borehole excavated by RLE.
- Approximate location and reference of historic window sample borehole excavated by RLE.
- Approximate location and reference of window sample borehole.
- Approximate location and reference of rotary borehole.
- Approximate position of highwall found.
- Approximate extent of landfill, taken from Envirocheck.

1. This drawing is to be read in conjunction with all relevant Eastwood & Partners drawings prefixed 46924 and Architect's drawings.

Note: Other services may be present on site; consult service plans for more information.

A	First Issue.

HARRON HOMES

NEWARK ROAD, SUTTON-IN-ASHFIELD, NOTTINGHAMSHIRE

EXPLORATORY HOLE LOCATION PLAN

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SCALE WHEN PLOTTED AT A1	DRAWING STATUS
1:1250	INFORMATION

DRAWN	CHECKED	DATE	DRAWING NUMBER	REV
JL	ACR/KE	06.05.22	46924/003	A