geotechnical and environmental consultants

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# Review of Geotechnical Design Report

Angels Sandpit, Storrington, West Sussex

On behalf of Horsham District Council

| Report Reference: GWPR6236/Review/December 2024 | | | Status: Final |
|---|---|---|---|
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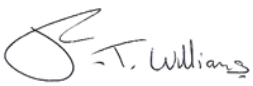
| V1.02 |  |  |  |
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| Review of Geotechnical Design Report | |
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| **PROJECT SCOPE** | Ground and Water were instructed by Horsham District Council to review and audit the Geotechnical Design Report, produced by Ground Conditions Consultants, for the site at Angels Sandpit, Storrington. The Geotechnical Design Report, referenced J20-002-R06, should be read in conjunction with this report. Ground and Water Limited cannot be held accountable for any shortcomings within the report.<br><br>**It should be noted that this Review of the Geotechnical Design Report does not review contamination aspects of the project.**<br><br>The conditions and limitations of this review can be viewed within Appendix A. A technical glossary has also been provided within Appendix B.<br><br>Comments from the Auditor from Ground and Water Limited have been provided with red. |
| **SITE DETAILS** | The site is an irregularly shaped ~1.27Ha parcel of land located to the north of Washington Road and the west of Water Lane in Storrington, West Sussex. The land was noted to be sloping from north-west to the east and south-east and was noted to be heavily vegetated with bramble and clusters of semi mature trees, shrubs and bushes to the north, west and southwest margins at the time of the site walkover. A site location plan can be viewed within Figure 1.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **PROPOSED DEVELOPEMNT** | The site is proposed to be redeveloped for residential housing with gardens.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **HISTORICAL MAPPING** | Site History Historic mapping from 1875 has shown that the site remained generally undeveloped as open field with trees and furze until 1947-48 where an aerial photo indicated that a sand pit had been developed on site. A works building was shown to have been built in the entrance path to the south of the site in 1971-73. In 1993 it was indicated that the sides of the quarry were quite steep as they were mapped as a cliff edge. The centre of the sand pit was shown to have been covered in grass in 1999 (aerial photo). It is understood that the sand pit was infilled as an inert waste landfill between 2000 and 2006 with restoration works continuing into 2008. In 2017 the sand/sand pit were no longer labelled.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **ANTICIPATED GEOLOGY AND HYDROGEOLOGY** | The British Geological Survey (BGS) maps and DEFRA online maps for the area suggest that the site was located on Infilled Ground. Substantial quantities of Made Ground, up to approximately 40m, are known to be present due to the infilling of the former sandpit on the site. Underlying the Made Ground is the Folkestone Formation (sandstone), which is classified as a Principal Aquifer.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **PREVIOUS REPORTING** | Information considered pertinent to this Review of the Geotechnical Design Report has been summarised below. |

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| Review of Geotechnical Design Report | |
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| Full information can be found within the GCC Geotechnical Design Report, which should be read in conjunction with this report. | *Hemsley Consulting (Oct 2008 Draft & Dec 2008 Final), Angell's Sand Pit, Storrington , West Sussex, Residential Area (Ref: HC3815)*<br>5No. Super Heavy Dynamic Probes were undertaken in the former landfill area to the south of the site, where a housing development has been constructed. The specification of the filling and monitoring of the compaction was undertaken by Hemsley Consulting. Fill material was spread and compacted with a sheepsfoot roller in ~300mm thick layers. It was reported that the fill comprised various soils, including clays, sands, chalk and gravel, with bricks, concrete and stone. The material was selected in order to exclude wet material and large blocks of brick and concrete. All rejected material was disposed of in the main area of the landfill site, indicating that the infilling of the main landfill was not engineered in the same way. The landfill was reported not lined.<br><br>*WYG Environment (Nov 2009), Sampling to support Closure of Angels Sandpit (Ref: A057957/SJS/pg-1))*<br>3No. Hollow Stem Auger Boreholes were drilled to 6.00 – 31.00m bgl within the main landfill (current study site). The borehole logs provided in the report contained limited descriptions of the material encountered and it was generally not clear which material are fill and which are natural soils.<br><br>*WYG Environment (Nov 2010), Ground Condition Assessment Report (Ref: A064537 V2)*<br>3No. Cable Percussion Boreholes were drilled to a maximum depth of 14.50m bgl in the former landfill area to the south of the site, where a housing development has been constructed. Additionally, four trial pits were excavated to a maximum depth of 3.10m bgl. No information pertinent to the review of the Geotechnical Design Report was noted.<br><br>*WYG Environment (Jun 2011), Angell's Sandpit Closure Report Update (Ref: A059751)*<br>No information pertinent to the review of the Geotechnical Design Report was noted.<br><br>*Geo-Environmental Services Limited (Dec 2017), Desk Study Report (Ref: GE16049-DSR-DEC17)*<br>Upon a review of the previous WYG documents produced, Geo-Environmental Services Limited stated that "foundations within areas of deeper Made Ground/Infilled Ground are likely to require a deeper or piled foundation solution, although this is subject to confirmation following intrusive investigation.<br><br>*Ground Condition Consultants Ltd (Apr 2020), Ground Condition Assessment Report (Ref: J20-002-R02 V3)*<br>This comprised a desk top study as well as both geotechnical and contamination assessments of the site, utilising the available data from the previous site investigations as well as data gathered from an additional 11No. Dynamic (Windowless) Sampler Boreholes across the site. The SI information has shown the upper 5.00m bgl of Inert Waste to comprise a mixture of fine- and coarse-grained soils, with no voids or geotechnically deleterious material being recognised within the 11No. boreholes. SPTs indicates that these soils have been well compacted, with a mean $N^{SPT}$ of 15.<br><br>If this were a greenfield site, a shallow foundation would be appropriate and to demonstrate this the ULS bearing resistance of the material has been calculated and returned a ULS bearing resistance of 130kN/m$^2$. The use of raft foundations may be the best option as it allows any soft spots/weaker soils (if present) to be spanned. |

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| | Settlement due to structural loading is unlikely to preclude the use of shallow foundations based on the results of this ground investigation, although it would be worthwhile to carry further investigation focussed on the actual development plots.<br><br>The most significant risk to the safe development of the site is the ongoing consolidation settlement of the Inert Waste Material as a result of its placement. A simple assessment of the time for 90% of the consolidation settlement predicts several years will be required due largely to the length of the drainage paths. This can only be considered as a rough guide as no details of the materials at lower level in the waste body were available.<br><br>*Hemsley Consulting (Nov 2022), Site Investigation Report (Ref: HC6085)*<br>Hemsley Consulting were involved with some of the placement of landfill waste at the site and noted that the fill was known to comprise inert material arising from construction sites. The material was likely to include clay, chalk, gravel, brick and concrete. The method of operation of the landfill is not known; however, plant available on the site included a large bulldozer and a heavy sheep's foot roller. Incoming material would be spread in layers and at least compacted by the passage of the bulldozer; however, large masses of concrete or brickwork are likely to be included in the fill.<br><br>6no Cable Percussion Boreholes were drilled, with two of these boreholes (BH1 and BH5) proving the sands of the Folkstone Beds at a depth of 40.0m bgl or at 31.0 – 34.0m AOD. BH3 was obstructed at a depth of 31.50m bgl. BH2, BH4 and BH6 were drilled to a depth of 25.00m bgl to assess the uniformity of the fill.<br><br>The fill mainly comprised grey brown silty clay with a variable content of sand and gravel or fine concrete. Some zones of chalk and concrete brick fill were encountered and there were frequent obstructions of large masses of concrete. Traces of wood, metal and plastic were also noted.<br><br>The underlying Folkstone Beds comprised yellow or pinkish brown medium sand in a dense state of compaction. The report concluded that development of the site will require intensive ground improvement. In view of the great depth of the fill, the following would both be viable options:<br><br>1. Stone columns to reinforce the upper weaker level of fill.<br>2. Pre-loading the footprint of each house to induce settlement of the fill prior to construction.<br><br>The proposed houses should be founded on reinforced concrete rafts. The fill may be liable to further compaction should the material become saturated, hence it is proposed any soakaways are located at least 10m from the nearest foundation and preferably in the sand at the edge of the filed area.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **REGULATOR CONSULTATION**<br><br>Full information can be found within the GCC Geotechnical Design | *Horsham District Council*<br>Prior to Phase 1 of the GCC SI, the EHO at Horsham District Council was contacted to determine if the Council held any additional documentation about the site, to determine what specific concerns the Council had regarding development of the site and to present an initial strategy for the investigation and ground gas monitoring for the site. |

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| Report, which should be read in conjunction with this report. | The EHO highlighted that significant previous monitoring classified the site as NHBC Amber 2 gas regime; therefore, GCC proposed to install and monitor more standpipes, as well as monitoring the previous standpipes, as part of their Phase 1 SI (summarised within the next section of this report).<br><br>The EHO was also keen to ensure that construction activities would not facilitate re-activation of the landfill emissions; therefore, piling into the body of the landfill was not considered acceptable.<br><br>*Environment Agency*<br>On the recommendation of the Horsham District Council EHO, GCC contacted the Environment Agency to ascertain the concerns they had regarding the site. No information pertinent to the review of the Geotechnical Design Report was noted.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **GCC SI: SITE WORKS**<br><br>Full information can be found within the GCC Geotechnical Design Report, which should be read in conjunction with this report. | Phase 1 Site Works were undertaken by GCC in February 2020 and comprised the drilling of 11No. Dynamic (Windowless) Sampler Boreholes (WS101 – WS111) to a maximum depth of 5.00m bgl. These were positioned to provide sitewide coverage and investigate the distribution of contamination across the site and provide preliminary geotechnical data.<br><br>Phase 2 Site Works were undertaken by Hemsley Consulting in September 2022 and comprised the drilling of 6No Cable Percussion Boreholes (BH1 – BH6) to a maximum depth of 41.50m bgl. These were positioned at each of the proposed building plots to assess the uniformity and quality of the fill material.<br><br>Phase 3 Site Works were undertaken by GCC in July 2023 and comprised the drilling of 18No. Dynamic (Windowless) Sampler Boreholes (WS101 – WS111) to a maximum depth of 5.00m bgl. These were positioned so that three boreholes were at the development plot, to provide more detailed geotechnical data. The development plots were cut to the formation level prior to the investigation to allow the investigation to progress from consistent levels and to allow the inspection of the formation level for deleterious material. WS102, WS103, WS106 and WS111 were all terminated before the target depth due to encountering solid obstructions within the fill material.<br><br>Soil samples were also taken from various depths in the GCC windowless sample boreholes for geotechnical testing purposes. No laboratory geotechnical testing was undertaken as part of the Hemsley investigation.<br><br>A trial hole location plan for all three phases of site works can be viewed within Figure 2.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **GCC SI: ENCOUNTERED GROUND CONDITIONS**<br><br>Full information can be found within the GCC Geotechnical Design Report, which should | **Geology**<br>Ground conditions were broadly in agreement with previous investigations. Made Ground was noted to the base of all boreholes, other than BH1 and BH5 where the natural Folkestone Formation was proven at 40.00m bgl.<br><br>Made Ground within the GCC Dynamic (Windowless) Sampler Boreholes comprised reworked natural soils of clay and sand, with variable gravel content and anthropogenic inclusions, such as brick, ash and |

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| be read in conjunction with this report. | concrete. Made Ground within the Cable Percussion Boreholes undertaken by Hemsley Consulting was generally similar, with additional traces of wood, metal and plastic, with periodic brick and concrete obstructions. This has been termed as Inert Waste Material (IWM) throughout the report and will be used within this report for consistency.<br><br>The Folkestone Formation within BH1 and BH5 comprised a yellowish brown/pinkish brown medium grained sand.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **GCC SI: ENCOUNTERED GROUNWDATER CONDITIONS**<br><br>Full information can be found within the GCC Geotechnical Design Report, which should be read in conjunction with this report. | Groundwater was not noted during the drilling of any of the windowless sample boreholes; however, groundwater was monitored during the initial monitoring rounds in the GCC wells and BH1 at between 0.60 – 6.73m bgl, with some wells dry to up to 4.87m bgl. Considerable fluctuation was recorded in BH1, with groundwater at 3.59m bgl in round 1 and 6.73m bgl in round 2.<br><br>As the majority of the fill material encountered was of a clay matrix with pockets of sand, groundwater is considered likely to be present in discrete pockets of granular fill at various depths throughout the former landfill material. A consistent groundwater body within the fill material that correlates with groundwater levels in the surrounding natural soils is considered unlikely.<br><br>It is understood that de-watering operations are on-going as part of the mineral extraction works to the east of the site, which are likely to be supressing groundwater levels in the natural soil in the vicinity of the site. It is anticipated that when these operations cease, locally supressed groundwater levels will recover to their natural levels.<br><br>While seasonal fluctuation of groundwater is likely and there may be some influence on groundwater from the mineral extraction works to the south of the site, groundwater in the Folkstone Formation appears to be below or at least towards the base of the landfill material. However, as the investigations to date have identified that the vast majority of the former inert waste landfill material on the site comprises a clay matrix with only small pockets of granular fill, it is not likely that the recovered natural groundwater table will readily extend through the landfill material beneath the site and if it does, groundwater migration rates through the fill material are likely to be very low, much lower than through the natural surrounding soil, with preferential groundwater migration pathways likely to be around the low permeability fill material. The primary interaction between the groundwater in the natural material and the landfill material is likely to be around the perimeter and based of the landfill material.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **GCC SI: IN-SITU AND LABORATORIAL GEOTECHNICAL TESTING** | **In-Situ Strength Testing**<br>A summary of the in-situ strength testing (SPTs) conducted within all boreholes has been summarised in the following table. |

| Interpretation of In-situ Geotechnical Testing Results | | | | |
|---|---|---|---|---|
| **Borehole** | **Approximate Depth (m bgl)** | **SPT "N" Value** | **Equivalent Undrained Shear Strength (Cu)** | **Soil Type (Cu for Cohesive, Density for Granular)** |

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Full information can be found within the GCC Geotechnical Design Report, which should be read in conjunction with this report.

| | | | | |
|---|---|---|---|---|
| **WS101** | 1.00 – 5.45 | 9 – 27 | 45 – 135 | Medium to High Cu |
| **WS102** | 1.00 – 1.45 | 50 | 250 | Very High Cu |
| **WS103** | 1.00 – 1.95 | 21 – 50 | 105 – 250 | High to Very High Cu |
| **WS104** | 1.00 – 1.45 | 20 | 100 | High Cu |
| | 2.00 – 2.45 | 26 | | Dense |
| **WS105** | 1.00 – 5.45 | 7 – 37 | 35 – 185 | Low to Very High Cu |
| **WS106** | 1.00 – 1.45 | 20 | 100 | High Cu |
| | 1.90 – 2.35 | 50 | | Very Dense |
| **WS107** | 1.00 – 2.45 | 10 – 50 | | Medium to Very Dense |
| | 3.00 – 5.45 | 10 – 50 | 50 – 250 | Medium to Very High Cu |
| **WS109** | 1.00 – 5.45 | 3 – 18 | 15 – 90 | Very Low to Medium Cu |
| **WS110** | 1.00 – 5.45 | 10 – 16 | 50 – 80 | Medium to High Cu |
| **WS111** | 1.00 – 3.45 | 10 – 50 | 50 – 250 | Medium to Very High Cu |
| **BH1** | 2.00 – 37.45 | 12 – 68 | ND | ND |
| **BH2** | 1.80 – 25.95 | 10 – 47 | ND | ND |
| **BH3** | 0.60 – 25.45 | 14 – >50 | ND | ND |
| **BH4** | 1.80 – 25.95 | 8 – 64 | ND | ND |
| **BH5** | 1.80 – 39.45 | 4 - | ND | ND |
| **BH6** | 1.50 – 25.95 | 7 – 38 | ND | ND |
| **WS201** | 1.00 – 5.45 | 6 – 20 | 30 – 100 | Low to High Cu |
| **WS202** | 1.00 –3.45 | 5 – 16 | 25 – 80 | Low to High Cu |
| **WS203** | 1.00 – 5.45 | 6 – 19 | 30 – 95 | Low to High Cu |
| **WS204** | 1.00 – 5.45 | 5 – 36 | 25 – 180 | Low to Very High Cu |
| **WS205** | 1.00 – 4.45 | 8 – 15 | 40 – 75 | Medium Cu |
| **WS206** | 1.00 – 5.45 | 6 – 10 | 30 – 50 | Low to Medium Cu |
| **WS207** | 1.00 – 5.45 | 14 – 34 | 70 – 170 | Medium to Very High |
| **WS208** | 1.00 – 5.45 | 8 – 15 | 40 – 75 | Medium Cu |
| **WS209** | 1.00 – 5.45 | 10 – 25 | 50 – 125 | Medium to High Cu |
| **WS210** | 1.00 – 5.45 | 9 – 15 | 45 – 75 | Medium to High Cu |
| **WS211** | 1.00 – 5.45 | 4 – 16 | 20 – 80 | Low to High Cu |
| **WS212** | 1.00 – 5.45 | 8 – 20 | 40 – 100 | Medium to High Cu |
| **WS213** | 1.00 – 5.45 | 5 – 12 | 25 – 60 | Low to Medium Cu |
| **WS214** | 1.00 – 5.45 | 7 – 34 | 35 – 170 | Low to Very High Cu |
| **WS215** | 1.00 – 5.45 | 8 – 20 | 40 – 100 | Medium to High Cu |
| **WS216** | 1.00 – 5.45 | 7 – 28 | 35 – 140 | Low to High Cu |
| **WS217** | 1.00 – 5.45 | 4 – 19 | 20 – 95 | Low to High Cu |
| **WS218** | 1.00 – 5.45 | 6 – 19 | 30 – 95 | Low to High Cu |

**Volume Change Potential Testing**

Across all phases of site investigation, 32No. soil samples underwent atterberg testing, with their results summarised in the following table.

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| Atterberg Limit Tests Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| Stratum | Moisture Content (%) | Modified PI (%) | Soil Class | Consistency Index (Ic) | Volume Change Potential | |
| | | | | | BRE | NHBC |
| Inert Waste Material (IWM) | 10 – 36 | 4 – 22 | MI, CI, ML, CL, MH, CH | Stiff to Very Stiff | Low to Medium | No to Medium |
| Sample WS111 1.00 – 1.80m bgl* | 17 | 41 | MV | Very Stiff | High | High |

***Sample WS111 at 1.00 – 1.80m bgl was noted to have organic material and therefore is not considered representative of the**

- **NP – Non-plastic**
- **BRE Volume Change Potential refers to BRE Digest 240 (based on Atterberg results)**
- **Soil Classification based on British Soil Classification System.**
- **Consistency Index (Ic) based on BS EN ISO 14688-2:2018.**

Across all phases of site investigation, 5No. soil samples underwent particle size distribution analysis, using the wet sieve method, with their results summarised in the following table.

| Particle Size Distribution Tests Results Summary | | | |
|---|---|---|---|
| Stratum | Range Passing 63µm Sieve (%) | Volume Change Potential | |
| | | BRE | NHBC |
| Inert Waste Material (IWM) | 5 – 58 | No – Yes | No – Yes |

- **Volume Change Potential refers to BRE Digest 240 (based on Grading test results).**
- **Shrinkability refers to NHBC Standards Chapter 4.2 (based on Grading test results).**
- **BRE 240 states that a soil has a volume change potential when the clay fraction exceeds 15%. Only the silt and clay combined fraction are determined by sieving therefore the volume change potential is estimated from the percentage passing the 63µm sieve.**
- **NHBC Standards Chapter 4.2 states that a soil is shrinkable if the percentage of silt and clay passing the 63µm sieve is greater than 35% and the Plasticity Index is greater than 10%.**

Given the very limited thickness of the coarse-grained IWM it is recommended that the entirety of the IWM is treated as a fine-grained material, and having low to medium volume change potential.

**UU Triaxial Compression Testing (Undrained Shear Strength Testing)**

Across all phases of site investigation, 4No. soil samples underwent unconsolidated undrained triaxial compression testing, with their results summarised in the following table.

| UU Triaxial Compression Tests Results Summary | | | | | | |
|---|---|---|---|---|---|---|
| Stratum | Moisture Content (%) | Bulk Density ($Mg/m^3$) | Dry Density ($Mg/m^3$) | Mode of Failure | Shear Strength (kPa) | Classification |
| Inert Waste Material (IWM) | 15 – 22 | 1.99 – 2.11 | 1.64 – 1.83 | Compound | 36 – 70 | Low to Medium Cu |

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**Drained (Effective) Shear Strength**

The widely accepted relationship between drained shear strength and plasticity index for remoulded clays has been used to determine the effective shear strength parameters. In terms of effective stress, the shear strength of a fine-grained soil can be considered as frictional, such that c'k = 0kN/m$^2$. Taking the characteristic plasticity index of 20% will give a characteristic effective angle of shearing resistance (Ø'k) of 26°.

**Modulus of Deformation**

Bjerrum (1975) suggests a minimum Euk / cuk ratio of 500 for normally consolidated clays giving an undrained modulus of deformation of 18MN/m$^2$. CIRIA R 143 states the drained modulus should be taken as 0.75 x Euk. Therefore, a drained modulus of 14MN/m$^2$ is considered appropriate for the IWM.

**Modulus of Volume Compressibility**

The modulus of volume compressibility (mv) has been determined from the empirical relationship with the plasticity index (IP) and published data for similar materials giving an mvk of 0.25m$^2$/MN, which is indicative of a material of medium compressibility.

**Aggressive Soil Chemistry**

Across all phases of site investigation, 21No. soil samples underwent chemical testing in accordance with Box C10 within BRE Special Digest 1, with their results summarised in the following table.

| BRE Special Digest 1 Tests Results | | | | | | |
|---|---|---|---|---|---|---|
| **Stratum** | **pH** | **Soluble Sulphate (g/l)** | **Total Sulphate AS** | **Total Sulphur (%)** | **Total Potential Sulphate TPS (%)** | **Oxidisable (Sulphate) (%)** |
| Inert Waste Material (IWM) | 8.0 – 12.4 | 0.0039 – 0.425 | 0.02 – 0.393 | 0.023 – 0.197 | 0.069 – 0.591 | 0.027 – 0.225 |

Based on the maximum determined water soluble and total potential sulphate contents Table C2 of BRE SD1 gives a Design Sulphate Classification of DS-2 and an Aggressive Chemical Environment for Concrete (ACEC) Class of AC-1s assuming static groundwater conditions in the largely fine-grained IWM.

No further comments from the Auditor from Ground and Water Limited.

**GCC SI: CHARACTERISTIC GEOTECHNICAL PARAMETERS**

Full information can be found within the GCC Geotechnical Design Report, which should

In the determination of the material parameters, the IWM has been treated as an engineering soil not as inert waste. This is considered appropriate given the very limited variation noted within all the boreholes undertaken within the site. The characteristic geotechnical values presented in the following table are considered appropriately conservative to mitigate the degree of risk perceived in the development on the Inert Waste Material.

| Characteristic Geotechnical Parameters | | | |
|---|---|---|---|
| **Stratum** | **Geotechnical Parameter** | **Characteristic Value** | **Notes** |
| IWM | Unit Weight (γ) | 19kN/m$^3$ | Lab UUT |

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be read in conjunction with this report.

| | | | |
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| | Undrained Shear Strength ($c_{uk}$) | 35kN/m$^2$ in the upper 5.00m, increasing thereafter | Lab UUT and SPT Correlation |
| | Undrained Shear Strength ($Ø_{uk}$) | 0° | Lab UUT and SPT Correlation |
| | Drained Shear Strength ($c'_k$) | 0kN/m$^2$ | BS8004 |
| | Drained Shear Strength ($Ø'_k$) | 26° | BS8004 |
| | Undrained Deformation Modulus ($E_{uk}$) | 18MN/m$^2$ | Correlation with SPT N |
| | Drained Deformation Modulus ($E'_k$) | 14MN/m$^2$ | 0.75 x $E_{uk}$ |
| | Modulus of Compressibility | 0.30m$^2$/MN | Correlation with SPT N |

No further comments from the Auditor from Ground and Water Limited.

**GCC SI: FOUNDATION AND GROUND RECOMMENDATIONS**

Full information can be found within the GCC Geotechnical Design Report, which should be read in conjunction with this report.

**Important Points to Consider**

The following points were pertinent to the GCC's interpretation of the ground model, which aided their foundation proposals:

- No voiding or very low strength horizons were identified in any of the boreholes undertaken and the material encountered was reasonably uniform throughout, generally comprising sandy gravelly Clay.
- SPTS undertaken within all boreholes showed an increase in SPT N value beyond 5.00m bgl where the placed material has undergone compression (compaction and consolidation) under its self-weight. The higher N values at the base of the IWM (>50) are consistent with the results that would be expected from a natural in-situ engineering soil. Therefore, given the ~15years since completion of IWM placement and the current geotechnical condition of the IWM, it is likely that waste mass settlement is largely complete. Whilst the auditor agrees with the logic, how can the compaction of the IWM be guaranteed, as well as the consistency of the material.
- Based on the ground conditions recorded in the IWM, in particular its lack of variability, it is considered appropriate to treat the IWM as an founding stratum for shallow foundation construction.
- The IWM should be classified as having medium volume change potential.

**Foundation Depth**

NHBC guidance recommended a minimum foundation depth of 0.90m bgl with no tree planning within a zone of influence dependent on the tree species. This would be as high as 1.25 x mature tree height for high water demand species, to as little as 0.50 x mature tree height for low water demand species. If foundations are deepened to 1.25m bgl, restricted tree planting is permitted within the zone of influence. This would be as high as 1.00 x mature tree height for high water demand species, to as little as 0.20 x mature tree height for low water demand species. It should be noted that this depth is measured from the existing ground surface.

**ULS Bearing Capacity**

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| | ULS Bearing Resistance Analysis was undertaken, in accordance with Eurocode 7, with a foundation depth of 0.90m used, representing the worst case as deeper foundations will offer higher bearing resistances.<br><br>The most critical case amounted to a ULS bearing resistance of 171kN/$m^2$.<br><br>**ULS Settlement Analysis**<br>SLS Settlement Analysis was undertaken, in accordance with Eurocode 7, on a 10 x 25m raft foundation at 0.90m bgl with varying evenly distributed unfactored loads. A limiting value of settlement (sCd) of 40mm is considered appropriate for the raft foundation construction under consideration.<br><br>The results of the SLS settlement analyses indicate that settlements will be less than 40mm for a uniformly applied load of 60kN/$m^2$; or, based on a serviceability limit of 40mm, the allowable bearing resistance is 60kN/$m^2$, which should be sufficient for the development under consideration.<br><br>Although it is possible that settlement of the IWM is occurring independently under its self-weight, there is sufficient evidence to suggest that this is largely complete, such as the increasing SPT N values with depth indicating increased densification with depth to a maximum value of N>50. The range of N-values returned within the IWM is similar to those that would be expected from an in-situ fine grained soil with the highest values at the base of the material being consistent with a very stiff material of high strength.<br><br>**Auditor Comments**<br>The Hemsley Report was commissioned outside the GCC assessment process, did not take account of the available data from previous investigations and has been superseded. As the findings of the subsequent GDR have determined that ground improvement is not required, a discussion would be superfluous.<br><br>As there was no direct evidence to support the compaction/consolidation of the in-situ IWM can be presented, it was proposed that, in line with good engineering practice, all foundation bases will be inspected by a qualified engineer prior to the placement of foundation concrete. If necessary, further in-situ testing will be carried out to ensure the condition of the IWM at founding level.<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **GCC SI: SLOPE STABILITY**<br><br>Full information can be found within the GCC Geotechnical Design Report, which should be read in conjunction with this report. | A preconstruction analysis of the finished landform of the placed inert waste material was carried out and presented in the facility "close out-report". At the time of issue (approximately 15years ago) the site was determined as being stable. Given the post placement densification of the IWM the stability will have increased as evidenced by recent site walkovers, which have not revealed any geomorphological evidence of ground movements.<br><br>A further slope stability assessment will be carried out and the results issued under separate cover. The stability assessment will determine both the global stability of the Inert Waste Material and each of the individual development plots with particular attention being paid to any cut faces and additional structural loads. |

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| | A slope stability assessment was issued under separate cover (dated October 2023).<br><br>No further comments from the Auditor from Ground and Water Limited. |
| **GCC SI: ACCESSWAYS**<br><br>Full information can be found within the GCC Geotechnical Design Report, which should be read in conjunction with this report. | Once the final route of the access is known a full design of the road construction will be required. It is possible given the sloping topography of the site that accessways may require low height earthworks to support the roads.<br><br>Based on the undrained shear strength a preliminary design CBR of <2% should be used. Further CBR testing is recommended once the final access route and level is finalised. It is recommended that the access way design is issued as a separate report .<br><br>It was understood that these CBR tests will be undertaken in due course as part of the detailed road design.<br><br>No further comments from the Auditor from Ground and Water Limited. |

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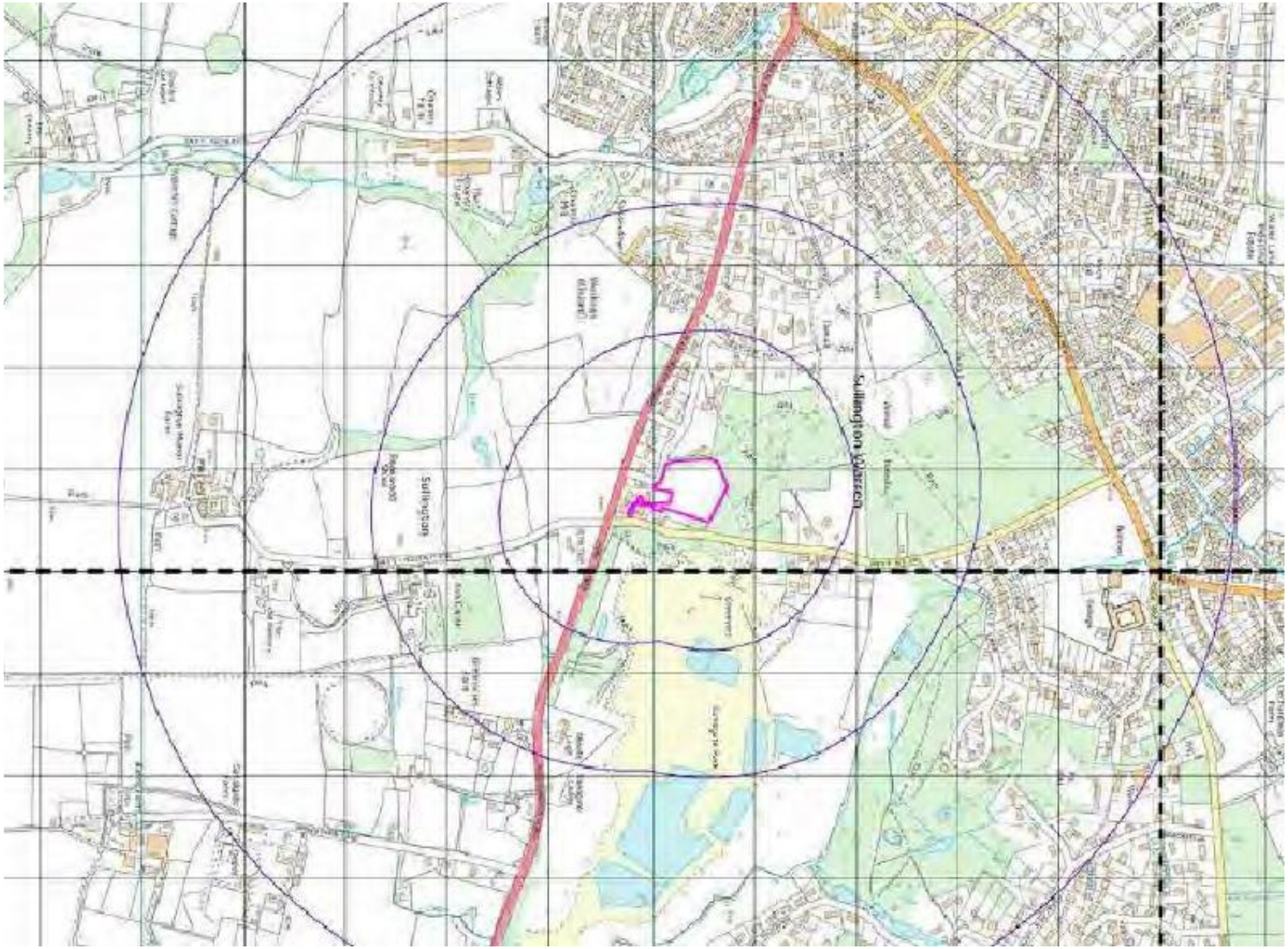
# FIGURES




Not to Scale

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|---|---|
| **Angels Sandpit, Storrington, West Sussex** | |
| **Horsham District Council** | **October 2024** |
| **Figure 1: Site Location Plan** | **GWPR6236** |

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Not to Scale

| | |
|---|---|
| **Angels Sandpit, Storrington, West Sussex** | |
| **Horsham District Council** | **October 2024** |
| **Figure 2: Trial Hole Location Plan** | **GWPR6236** |

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# APPENDIX A: Conditions and Limitations

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The ground is a product of continuing natural and artificial processes. As a result, the ground will exhibit a variety of characteristics that vary from place to place across a site, and also with time. Whilst a ground investigation will mitigate to a greater or lesser degree against the resulting risk from variation, the risks cannot be eliminated.

The report has been prepared on the basis of information, data and materials which were available at the time of writing. Accordingly any conclusions, opinions or judgements made in the report should not be regarded as definitive or relied upon to the exclusion of other information, opinions and judgements.

The investigation, interpretations, and recommendations given in this report were prepared for the sole benefit of the client in accordance with their brief; as such these do not necessarily address all aspects of ground behaviour at the site. No liability is accepted for any reliance placed on it by others unless specifically agreed in writing.

Any decisions made by you, or by any organisation, agency or person who has read, received or been provided with information contained in the report ("you" or "the Recipient") are decisions of the Recipient and we will not make, or be deemed to make, any decisions on behalf of any Recipient. We will not be liable for the consequences of any such decisions.

Current regulations and good practice were used in the preparation of this report. An appropriately qualified person must review the recommendations given in this report at the time of preparation of the scheme design to ensure that any recommendations given remain valid in light of changes in regulation and practice, or additional information obtained regarding the site.

Any Recipient must take into account any other factors apart from the Report of which they and their experts and advisers are or should be aware. The information, data, conclusions, opinions and judgements set out in the report may relate to certain contexts and may not be suitable in other contexts. It is your responsibility to ensure that you do not use the information we provide in the wrong context.

This report is based on readily available geological records, the recorded physical investigation, the strata observed in the works, together with the results of completed site and laboratory tests. Whilst skill and care has been taken to interpret these conditions likely between or below investigation points, the possibility of other characteristics not revealed cannot be discounted, for which no liability can be accepted. The impact of our assessment on other aspects of the development required evaluation by other involved parties.

The opinions expressed cannot be absolute due to the limitations of time and resources within the context of the agreed brief and the possibility of unrecorded previous in ground activities. The ground conditions have been sampled or monitored in recorded locations and tests for some of the more common chemicals generally expected. Other concentrations of types of chemicals may exist. It was not part of the scope of this report to comment on environment/contaminated land considerations.

The conclusions and recommendations relate to Angels Sandpit, Storrington, West Sussex.

Trial hole is a generic term used to describe a method of direct investigation. The term trial pit, borehole or window sampler borehole implies the specific technique used to produce a trial hole.

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The depth to roots and/or of desiccation may vary from that found during the investigation. The client is responsible for establishing the depth to roots and/or of desiccation on a plot-by-plot basis prior to the construction of foundations. Where trees are mentioned in the text this means existing trees, recently removed trees (approximately 15 years to full recovery on cohesive soils) and those planned as part of the site landscaping.

Ownership of copyright of all printed material including reports, laboratory test results, trial pit and borehole log sheets, including drillers log sheets, remain with Ground and Water Limited. Licence is for the sole use of the client and may not be assigned, transferred or given to a third party.

Only our client may rely on this report and should this report or any information contained in it be provided to any third party we accept no responsibility to the third party for the contents of this report save to the extent expressly outlined by us in writing in a reliance letter addressed from us to the third party.

Recipients are not permitted to publish this report outside of their organisation without our express written consent.

The aim of the investigation was understood to be to supply the client and their designers with information regarding the ground conditions underlying the site to assist them in preparing an appropriate scheme for development.

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# APPENDIX B: Technical Glossary

# TECHNICAL GLOSSARY

The list of possible definitions within the report may be seen below. Please note that some definitions may not be relevant to this report.

**HYDROGEOLOGY:**

A **Principal Aquifer** is a layer of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

**Secondary (A) Aquifers** consist of deposits with permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as Minor Aquifers.

**Secondary (B) Aquifers** consist of deposits with predominantly lower permeability layers with may stoke and yield limited amounts of groundwater due to localised features such as fissures, think permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers.

**Secondary Aquifers (Undifferentiated)** are assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both a minor aquifer and non-aquifer in different locations due to the variable characteristics of the rock type.

**Unproductive Strata** are rock layers with low permeability that have negligible significance for water supply or river base flow. These were formerly classified as non-aquifers.

**FLOOD ZONES:**

**Environment Agency Flood Zone 2**, defined as; land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding.

**Environment Agency Flood Zone 3** shows the extent of a river flood with a 1 in 100 (1%0 or greater chance of occurring in any year or a sea flood with a 1 in 200 (0.5%) or greater chance of occurring in any year.

**Environment Agency Flood Zone 3 area that benefits from flood defences**, defined as; land and property in this flood zone would have a high probability of flooding without the local flood defences. These protect the area against a river flood with a 1% chance of happening each year, or a flood from the sea with a 0.5% chance of happening each year.

**GROUNDWATER SOURCE PROTECTION ZONES (SPZS):**

**Inner Zone (SPZ1):** This zone is 50 day travel time of pollutant to source with a 50 metres default minimum radius.

**Outer Zone (SPZ2):** This zone is 400 day travel time of pollutant to source. This has a 250 or 500 metres minimum radius around the source depending on the amount of water taken.

**Total Catchment (SPZ3):** This is the area around a supply source within which all the groundwater ends up at the abstraction point. This is the point from where the water is taken. This could extend some distance from the source point.

**Zone of Special Interest (SPZ4):** This zone is where local conditions require additional protection.

**IN-SITU STRENGTH GEOTECHNICAL TESTING:**

**Windowless Sample and/or Cable Percussion and/or Rotary Boreholes** provide samples of the ground for assessment but they do not give any engineering data. The standard penetration test (SPT) is an in-situ dynamic penetration test designed to provide information on the geotechnical engineering properties of soil. The test uses a thick-walled sample tube, with an outside diameter of 50mm and an inside diameter of 35mm, and a length of around 650mm. This is driven into the ground at the bottom of a borehole by blows from a slide hammer with a weight of 63.5kg falling through a distance of 760mm. The sample tube is driven 150mm into the ground and then the number of blows needed for the tube to penetrate each 75mm up to a depth of 450mm is recorded. The sum of the number of blows is termed the "standard penetration resistance" or the "N-value".

**Dynamic Probing** involves the driving of a metal cone into the ground via a series of steel rods. These rods are driven from the surface by a hammer system that lifts and drops a 63.5kg (SHDP) hammer onto the top of the rods through a set height, thus ensuring a consistent energy input. The number of hammer blows that are required to drive the cone down by each 100mm increment are recorded. These blow counts then provide a comparative assessment from which correlations have been published, based on dynamic energy, which permits engineering parameters to be generated. (The Dynamic Probe 'Super Heavy' (SHDP) Tests were conducted in accordance with BS 1377; 1990; Part 9, Clause 3.2).