

Phase I and II Geoenvironmental Site Assessment

Site: Glen Dimplex, Prescott

Reference: 17-500-R1-2

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EXECUTIVE SUMMARY

Site Address	Glen Dimplex Home Appliances Ltd, Stoney Lane, Rainhill, Prescott, L35 2XW
Grid Reference	E 348017 N 391531
Site Area	5.96 Ha.
Proposed Development	At present, a proposed development plan has not been decided, however it is assumed the redevelopment will comprise residential dwellings with associated private gardens, roadways and associated infrastructure.
Current Site Use	The site is an irregularly shaped parcel of land situated to the south of Stoney Lane in Rainhill, Prescott. Presently, the site is occupied by the Glen Dimplex Home Appliances manufacturing factory, which predominantly comprises a large active factory structure with associated smaller buildings and infrastructure, including a gas governor to the north and two electricity substations to the west and south. Surrounding the main factory structure, a service road is present to the south and the west, connecting to Stoney Lane at the north. An associated area of hardstanding car parking is noted at the east of the site. Small areas of soft cover landscaping (managed grasses) are noted at the north and east of the structure, with sporadic semi-mature trees towards the northern boundary.
Site History	Following a review of pertinent Ordnance Survey mapping circa 1850, the site appears to be utilised as vacant agricultural land with a small dwelling situated at the centre of the southern boundary. A roadway leading to the dwelling is running parallel to the southern boundary. A well is noted adjacent to the dwelling at the southern boundary. Several segmenting tree-lined field boundaries are present, with the site comprising seven smaller fields. Two small ponds are recorded; one situated at the northern boundary towards the east, with another pond situated towards the centre of the southern boundary. Historical mapping was unavailable between 1907 and 1925. However, records held by Heritage Gateway indicates a factory had been developed on the site, and that it was being used as a Munitions Works during the First World War (1914-1918) and up until at least 1925 (likely for the manufacturing of military based explosives and propellants). Minor changes were noted in the mapping with significant changes noted in mapping circa 1925, where the site was completely redeveloped and now comprises an Iron Foundry with associated railway sidings across the site. The works structures consisted of two large structures segmented by a railway siding traversing east to west through the centre of the site. Multiple small outbuildings were noted along the western sector of the main factory structure and the outbuilding situated to the south of the main factory structure is assumed to be associated with the railway sidings. Subsequent mapping circa 1927 identified minor compositional changes to the main factory structure with a tank situated towards the south. Following mapping dated 1937, the site was renamed to Rainhill Stove works, with minor compositional changes to the structure noted. Records held by Heritage Gateway indicates the factory was repurposed as a Munitions Works during the Second World War (1939-1945), again likely for the manufacturing of military based explosives and propellants.



Site History
Continued...

Alterations continued to the main factory structure identified in mapping circa 1954 with the main factory structures now recorded as one large structure, with the former segmenting sidings removed. Additional outbuildings were constructed towards the northeast of the site, with an electricity substation noted at the northwest of the main factory structure and a small pond noted at the southern boundary adjacent to the sidings towards the east.

By 1978, all railway and tramway sidings were removed with a segmenting boundary noted at the eastern sector of the site, separating the area from the main works structure. It is assumed this is the construction of the car parking area.

Minor expansions of the main factory structure were noted in following mapping, but predominantly the present day composition was first noted in aerial imaging dated 2000.

ENVIRONMENTAL SETTING

Geology	Superficial Geology	Glacial Till (Majority of site) – CLAY, SAND, and GRAVEL Glaciofluvial Deposits (Southeast) – SAND and GRAVEL
	Bedrock Geology	Kinnerton Sandstone Formation (Majority of site) – SANDSTONE Chester Formation (East) - SANDSTONE
	Faults	The nearest geological fault is located on-site (Cronton Fault) traversing northwest to southeast through the eastern sector of the site, with a downthrow to the east.
Geomorphology		Based on the initial geological assessment, a review of available topographic data and pertinent mapping, E3P has undertaken a preliminary geomorphological evaluation of the landform and its possible mechanism for formation. Based upon a review of historical mapping and topographical contours, it would appear that the placement and upfilling of material will have formed the current site level plateau prior to the construction of the historical development. It is possible that the historical level raising has resulted in a greater thickness of Made Ground overlying the natural glacial till and glaciofluvial deposits, and potentially underwent earthworks to create a development platform for the main factory structure present.
Hydrogeology		A Secondary (undifferentiated) aquifer and Secondary A aquifer (East) has been recorded on-site in the superficial geology with a Principal aquifer in the bedrock geology. An active groundwater abstraction licence is recorded within 50m of the site located 16 m SE, pertaining to Elis UK Ltd and used for laundry purposes.
Hydrology		No surface water features are located within 100 m of the site boundary. Due to the local topography, it is unlikely that any shallow groundwater will be present. The site is located within Flood Zone 1 - no risk of flooding.



Utility Locations	A full ground penetrating radar (GPR) and utility survey has been undertaken by Geo UK Ltd in March 2024. The survey identified electricity cables surrounding the main factory structure and feeding into the two on-site electricity substations. Two gas governors and associated pipework were identified along the northern boundary and fed into a polystyrene manufacturing plant and the northwest corner of the main factory structure. Water and sewerage mains and telecommunication cables were also identified surrounding the main factory structure and feeding into the surrounding smaller structures.
Landfill Sites and Waste Sites	No landfill sites (current or historic) are located within 250 m of the site. The site has undergone significant historical development and ground working, the Made Ground associated with the landmark development may produce hazardous ground gases such as methane and carbon dioxide.
Radon	Radon Class 1 - less than 1% of homes are estimated to be at or above the Action Level. No radon protection measures required.
Unexploded Ordnance	Low risk UXO area - no further works required. Records held by Heritage Gateway indicates the site had previously been used as Munitions Works during the First World War (1914-1918), up until at least 1925; and again during the Second World War (1939-1945). Though the type of munitions manufactured at the site is currently unknown, given the operational years during the First and Second World Wars, it is likely that military based explosives and propellants were manufactured at the site.
Per- and Poly-Fluorinated Substances (PFAS) and Perfluorooctanoic Acid (PFOA)	Due to current and/or historical processes on the site, the site has been identified to be a potential risk of PFAS/PFOA and further risk assessment will be required.
Hazardous Installations	The following hazardous installations have been identified on-site which have the potential to affect the proposed development: Electricity substation, Gas and Governors.

E3P PRELIMINARY GROUND INVESTIGATION

Preliminary Ground Investigation Works	E3P has completed a preliminary intrusive ground investigation comprising: ✳ 10 x window sample boreholes, ✳ 2 x Cable Percussive Boreholes, ✳ Construction of environmental monitoring installations; ✳ 2 no. rounds of groundwater sampling; and ✳ 4 no. rounds of ground gas monitoring.
Ground Conditions	Made Ground – 0.00 m bgl to 3.50 m bgl Made Ground deposits were encountered within all exploratory hole locations to depths of between 0.00 m and in excess of 3.00 m bgl although, in general, Made Ground was encountered to a depth of less than 1.50 m bgl.



Ground Conditions
Continued...

Made Ground deposits were varied across the site, however all generally comprised concrete in the upper 300 mm in the majority of locations. The exception of this was WS104–WS106 which encountered asphalt within the upper 150 mm of the boreholes as they were situated in the car park.

Typically, the concrete or asphalt was underlain by a slightly clayey sandy gravel, with gravel of brick, concrete, mudstone, limestone, coal and slag with rare fragments of glass, plastic, and timber in some locations. These deposits were encountered from 0.15–0.80 m bgl, and were typically overlaying a reworked gravelly clay, with gravel of brick, sandstone, mudstone and in rare instances coal to a maximum proven depth of 3.00 m bgl (CP102).

Hydrocarbon odours were noted within six locations, situated across the site within the Made Ground deposits. The depths the hydrocarbon odour was encountered ranged from 0.50–1.90 m bgl (WS106) and was typically noted within a reworked very gravelly clay with gravel of sandstone, mudstone, concrete, ash, and slag.

Superficial Deposits – 3.50 m bgl to 4.44 m bgl

Superficial deposits were encountered within all exploratory locations, with the superficial deposits varying across the site. The most common stratum recorded was an orangish brown sandy gravelly CLAY with gravel of sandstone, mudstone, and instances of coal and quartz. Typically, the CLAY was locally interbedded with an orange very clayey fine to medium SAND from 0.70–4.44 m bgl.

In five locations, a very sandy CLAY with pockets of orange fine to medium SAND was noted, which was typically towards the east, with the exception of WS107 which recorded this stratum from 0.90–4.00 m bgl.

In CP102, a band of SAND and GRAVEL approximately 500 mm thick was recorded from 3.00–3.50 m bgl, with gravel of sandstone. This was in turn underlain by the orange-brown mottled sandy gravelly CLAY from 3.50–9.00 m bgl. A rare band of clayey fine to medium SAND with pockets of grey CLAY was noted in WS103, from 1.40–3.00 m bgl.

Bedrock – 4.00 m bgl to 9.37 m bgl

The bedrock geology was encountered between 4.00–9.37 m bgl during the preliminary ground investigation as highly weathered SANDSTONE recovered as a red very gravelly medium to coarse SAND.

Generally, bedrock was encountered at shallower depths (<5.00 m bgl) towards the north of the site, in WS107 and WS109, deepening to 9.00 m bgl towards the south of the site (CP101 and CP102).

Groundwater

Groundwater strikes were encountered as seepages in two locations at depths from 1.00–7.00 m bgl.

During the monitoring programme, groundwater was recorded at depths ranging from 0.60 m to 5.47 m bgl.



CONTAMINATED LAND ASSESSMENT

	Human Health
Initial Conceptual Site Model	Sources - Historical Iron Foundry (PL1, PL2, PL3, PL4, PL6, PL7, PL8) - Heavy Metals (Spent Oxides), Non-Volatile Polycyclic Aromatic Hydrocarbons (PAHs), Asbestos Containing Materials (ACM) (Former Structure), Total Petroleum Hydrocarbons (TPHs), Volatile Organic Compounds (VOCs), Semi Volatile Organic Compounds (SVOCs), Sulphates (slag, clinker, ashy deposits). - Historical Munitions Works (PL1, PL2, PL3, PL4, PL6, PL7, PL8, PL9) - Heavy Metals & Metal Compounds, Inorganic Compounds, Explosive Compounds and Propellants (inc. TNT, RDX, HMX, Tetryl, PETN, Nitroguanidine, Nitroglycerine and Picric Acid), Acids, Organic Solvents, TPHs and VOCs; Accidental Detonation of Explosive Compounds and Propellants. - Made Ground (PL1, PL2, PL3, PL4, PL6, PL7, PL8) - Heavy Metals, Non-Volatile PAHs, ACM, TPHs, VOCs, SVOCs, Sulphates (slag, clinker, ashy deposits). - Historical Railway/Tramway Sidings (PL1, PL2, PL3, PL6, PL8) - Heavy Metals, Non-Volatile PAHs, TPHs, VOCs (Degreasers, Oil lubricants), SVOCs, Sulphates (ashy deposits). - Historical & Current Oven Manufacturing Factory (PL1, PL2, PL3, PL4, PL6, PL7, PL8) - Heavy Metals, Non-Volatile PAHs, ACM (Fabric of Structures), TPHs, VOCs (Coatings, Solvents, Slurry Waste, Acids), SVOCs, PFAS/PFOA (Coatings). - Electricity Substations (Pre 1970) (PL1, PL2) - Polychlorinated biphenyl (PCBs). - Historical Infilled Ponds (centre south, southeast and northeast) (PL1, PL2, PL3, PL7) - Heavy Metals, Non-Volatile PAHs, ACM, Organic Compounds.
	Controlled Waters Sources - Historical Munitions Works (PL2, PL5) –Explosive Compounds and Propellants, Acids, Solvents, low end TPHs, VOCs. - Historical & Current Oven Manufacturing Factory (PL2, PL5) – low-end TPHs VOCs, SVOCs, PFAS/PFOA.
	Ground Gas Sources Substantial Made Ground associated with Historical Iron Foundry, Historical Railway/Tramway Sidings, Historical and Current Oven Manufacturing Factory, and Historical Infilled Ponds (PL4)– Methane, Carbon Dioxide.



Initial Conceptual Site Model
Continued...

- Receptors**
- ✳ Volatile Contaminants associated with Historical Iron Foundry, Historical Munitions Works, Made Ground deposits, Historical Railway/Tramway Sidings, and Historical and Current Oven Manufacturing Factory (PL4) - Volatile Vapours.
 - ✳ Groundworkers and Site Personnel
 - ✳ Future End Users
 - ✳ Underlying Secondary A Superficial Aquifer and Principal Bedrock Aquifer

Human Health

Inorganic Heavy Metals

- ✳ Three instances of exceedances of inorganic heavy metals (Arsenic, Lead and Nickel) were identified within the Made Ground deposits in the upper 1.30 m bgl of the ground, predominantly towards the north of the site.
- ✳ The identified elevated concentrations of heavy metalloid compounds have primary exposure pathways related to dermal contact and ingestion of soils (PL2), and consumption of homegrown vegetables (PL1).

Volatile Organic Compounds (VOCs)

- ✳ Localised areas of elevated Trichloroethene (TCE), Dichloroethene (cis 1,2-Dichloroethene, and Trans 1,2-Dichloroethene), and Vinyl Chloride have been identified within soils in three locations (WS101 to WS103) across the southern boundary of the site, directly to the south of the main factory structure. It is noted that WS102 and WS103 are located within the immediate vicinity of the enamel slurry waste storage area, located to the southeast of the main factory structure. As such, the enamel slurry waste storage area may be the potential source of these exceedances.
- ✳ These elevated compounds present a primary exposure pathway linked to the potential volatilisation to indoor air risk (PL4), in addition to exposure pathways of dermal contact and ingestion of soils (PL2) and consumption of homegrown vegetables (PL1) within impacted areas.
- ✳ Further investigation and subsequent testing is recommended in order to determine the spatial extent of the VOC contamination identified within the soils across the southern boundary of the site and to understand whether leaching had occurred into the underlying natural strata, particularly in WS101 and WS103 where exceedances were only recorded within Made Ground Deposits.
- ✳ If the enamel slurry waste storage area is deemed to be the source, removal of the impacted material is recommended to mitigate any further migration and degradation of TCE into further areas of the site. Subject to the findings of further phases of intrusive ground investigation, further assessment in the form of a Detailed Quantitative Risk Assessment (DQRA) may also be required.



Human Health *Continued...*

Asbestos

- ✳ No asbestos contamination was identified within any samples submitted for laboratory testing, however the fabric of the current main factory structure is known to contain asbestos throughout.
- ✳ Following demolition of the main factory structure, further investigation and subsequent testing is recommended in order to obtain representative soil samples of the underlying strata and determine whether the underlying soils are impacted with asbestos.
- ✳ If Asbestos fibres are encountered, a primary exposure pathway of inhalation of fibres (PL3) would be presented to site personnel and end users.
- ✳ Impacted soils should be managed according to the asbestos risk mitigation conceptual site model.

Controlled Waters

Sources

- ✳ Historically, the site has been subjected to extensive infilling and a number of industrial uses including an Iron Foundry and Oven Manufacturing Factory which, at the time of writing the report is still present and active.
- ✳ Chemical by-products of manufacturing processes and compounds within the Made Ground may have subsequently leached down into underlying ground and contaminated groundwater both within Made Ground and natural superficial deposits.
- ✳ Widespread Trichloroethene (TCE), Dichloroethene (cis 1,2-Dichloroethene, and Trans 1,2-Dichloroethene), and Vinyl Chloride contamination and localised heavy metal exceedances have been identified in the groundwater analysis at the site.
- ✳ It is noted that where there are exceedances of VOCs in soils, exceedances in groundwater were often recorded. Therefore, it is considered that there is a likely on-site source of contamination which may be leaching across the site.
- ✳ A plume of Trichloroethene (TCE), Dichloroethene variants, and Vinyl Chloride has been identified within groundwater monitoring data, extending from WS107 towards the northwestern entrance of the site, through to CP102 towards the southeast of the factory. It is noted that concentrations of VOCs were significantly higher in deeper groundwater monitoring wells, which suggests the plume is formed of DNAPL.

Pathways

- ✳ The site is underlain by a mixed geology, generally cohesive clay in the south of the site with discrete areas of interbedded cohesive and granular materials towards the north. The granular deposits will afford less protection to the underlying Principal aquifer in the bedrock in comparison to the remainder of the site, where generally clay deposits are anticipated to, or proven in excess of 5.00 m in areas.



Controlled Waters
Continued...

- ✳ Towards the northern sector of the site, bedrock was encountered at lesser depths (<5.00 m bgl), which further increases the risk of vertical migration of compounds towards the underlying bedrock aquifer as a result of cohesive material is not present within suitable quantities to afford protection to the underlying aquifer.

Receptor

- ✳ Principal Bedrock Aquifer and Source Protection Zone 3.
- ✳ Given the significantly elevated concentrations of the VOC impact within both shallow and the deeper groundwater wells in the south of the site, the principal aquifer is deemed to be at a high risk.
- ✳ No environmental monitoring wells have been advanced into the principal aquifer (bedrock) and so, it is not yet proven whether the source-pathway-receptor linkage is complete. Without samples of the principal aquifer, the extent, if any, of VOC impact cannot be proven.

Ground Gas

Sources

- ✳ Historically, the site has been subjected to extensive infilling and a number of industrial uses including an Iron Factory and Oven Manufacturing Factory which, at the time of writing the report is still present and active.
- ✳ Chemical by-products of manufacturing processes and compounds within the Made Ground may have subsequently leached down into underlying ground and contaminated both Made Ground and natural superficial deposits.
- ✳ Three historically infilled ponds were formerly present towards the centre south, southeast and northeast boundaries, which are potential sources of ground gases.
- ✳ Widespread VOC (Trichloroethene, Dichloroethene and Vinyl Chloride) contamination impact have been identified in the soil analysis towards the south.

Pathways

- ✳ The site is underlain predominantly by cohesive clay with discrete areas of interbedded cohesive and granular materials towards the north. The granular deposits will facilitate in the migration of ground gas across the site from on-site sources including MADE GROUND deposits, historically infilled ponds and known VOC impacts.

Assessment

- ✳ Based on the initial ground gas monitoring data, the site classifies in variable categories with the majority of site situated within Characteristic Situation 1 (CS1).



Ground Gas <i>Continued...</i>	✳ There are two noted areas falling within Characteristic Situation 2 (CS2), and a further two areas falling within Characteristic Situation 3 (CS3). ✳ As a precautionary measure, it is recommended that the whole site should be categorised within CS2, which will require basic gas protection measures, with any proposed plots within the area of CS3 classification potentially requiring further precautions. ✳ Further environmental monitoring wells are required within the footprint of the main factory structure in addition to further ground gas monitoring regimes under lower pressure conditions and further falling and rising pressure events due to elevated readings and known VOC impacted soils and groundwater. ✳ With regards to the elevated volatile contaminants identified within soils and groundwater across the southern boundary of the site, vapour resistant membranes may be required to be installed during the build phase for any proposed buildings situated within the immediate vicinity of the impacted soils. Radon ✳ A Radon Class 1 has been applied to the site, therefore no radon protective measures are required in the construction of residential dwellings.
Potable Infrastructure Water	Based upon chemical soil analysis and depth of Made Ground, it is considered likely a barrier pipe will be required. This will be confirmed following a UKWIR pipeline assessment as post remedial site condition may vary from the present.

GEOTECHNICAL ASSESSMENT

Underground Obstructions & Subterranean hazards	In the northern part of the site in WS108, a notable concrete obstruction was identified within the Made Ground. These findings suggest the presence of remnants from a previous platform associated with historical railway sidings. As part of the process of creating a suitable development platform, all subterranean obstructions will need to be excavated and removed beneath new structures and infrastructure. This will facilitate the construction of the proposed plots as intended.
Allowable Capacity Bearing	Based upon the ABC data, suitable materials for founding have been identified at 1.00 m bgl to 2.00 m bgl within the natural firm to very stiff CLAY in WS102, WS105, WS107 and WS109, with all other locations containing Made Ground exceeding 1.40 m bgl. The ABC ranges from 52 kN/m² –155 kN/m² from 1.00–1.45 m bgl within the aforementioned locations. Within three other locations, a suitable ABC was identified at 2.00 m bgl, in the firm to very stiff gravelly CLAY in WS104 and WS110, and in the dense clayey fine to medium SAND in WS106. The ABC ranges from 75 kN/m² –301 kN/m² from 2.00–2.45 m bgl within the aforementioned locations.



Allowable Capacity <i>Continued...</i>	Bearing	Towards the south of the site, the remaining four exploratory hole locations (WS101, WS103, CP101 and CP102), reached a material considered a suitable ABC at 3.00 m bgl, in either the firm to very stiff gravelly CLAY or the dense SAND & GRAVEL, with CP101 recorded at 4.00 m bgl due to extensive MADE GROUND. The ABC ranges from 170 kN/m ² – 435 kN/m ² from 3.00–4.45 m bgl within the aforementioned locations.
Foundation Options		Several foundation options should be considered for residential development on confirmed soil mechanics, cost, and construction feasibility. In this instance, it is thought that the following foundation options for low-rise housing: ✳ Shallow strip foundations bearing on the firm to very stiff gravelly clay at 1.45 m bgl; ✳ Reinforced trench fill to support reinforced strip foundations should be considered where the target bearing stratum is greater than 1.50 m below the proposed level and in areas of softer variable ground and/or potential tree influence ✳ Driven pile foundations within areas of extensive MADE GROUND (> 2.50 m bgl) or anomalies. Within the site, there are areas of variable ground conditions that will preclude the use of a shallow spread foundation. This includes the footprint of the main factory structure and outbuildings, where extensive Made Ground deposits are anticipated. Therefore, consideration should be given to the use of Ground Improvement by Vibro Stone Column to ensure the treatment achieves a suitable design ABC to support a doubly reinforced strip foundation or construction of piled foundations.
Foundations Trees	Near	Foundation depths within the conjectured influence of former, existing or proposed trees will need to be deepened to ensure that structural loading bears within the underlying target founding stratum, which cannot be subject to volumetric instability associated with fluctuation in moisture content.
Heave Near Trees	Precautions	Given that the underlying clay is of low volume change potential, heave precautions will not be required to the internal face of a foundation less than 1.50 m in depth. Heave precautions will be required to the underside of floor slabs (where there is no 200 mm void) and pile ground beams are required within the modelled influencing distance of trees.
Building Floor Slabs		Ground-bearing floor slabs are not considered viable given the anticipated depths of Made Ground > 600 mm and shallow cohesive soils.
Soakaway Drainage		The Made Ground and underlying granular soils are cohesive in nature and impacted by low-level inorganic and volatile organic compounds which would preclude the use of infiltration drainage systems.
Sulphate Assessment		Concrete classification will be DS1, AC-1s in accordance with soil chemical analysis of sulphate data. Concrete design should be completed in accordance with this classification. Further intrusive ground investigation required to confirm areas not investigated.
Highway Infrastructure Construction	&	Unsuitable materials are potentially present within areas of the infilled ponds. Where a proposed highway or infrastructure is to be constructed in these areas, remediation works will be required to ensure the site is engineered to a suitable geotechnical design specification. Further investigation is required to confirm underlying material within the vicinity of infilled ponds.



CBR Design %	Granular soils can be re-engineered to ensure 5% within the subgrade during favourable climatic conditions. Natural clay soils will provide a CBR in the order of 3–5% during drier climatic periods. However, if water is allowed to shed onto the formation, the CBR will reduce to < 2%, which will require specialist engineering of the subgrade.
Civil Engineering Excavations	Extensive obstructions are anticipated within the footprint of the main factory structure with known obstructions encountered within WS108 (north of the main factory structure).
Waste Characterisation	Any material that is to be disposed off-site should undergo assessment using Technical Guidance WM3: <i>Waste Classification – Guidance on the classification and assessment of waste</i> . This can be done upon request and in line with the Environment Agency sampling frequencies.

RECOMMENDATIONS

Based on the findings of the Geoenvironmental site assessment and the various conclusions drawn, the following additional works are recommended to be completed in due course:

- ✳ Further intrusive ground investigation, including delineation of VOC impacted soils and groundwater and determination of any potential PFAS/PFOA, Explosive Compounds and Propellant contamination;
- ✳ Further intrusive ground investigation of inaccessible areas (main factory structure and outbuildings);
- ✳ Human Health Detailed Quantitative Risk Assessment (DQRA) of VOC impacted soils (subject to findings of further phases of intrusive ground investigation);
- ✳ Controlled Waters DQRA of VOC DNAPL plume;
- ✳ Plot-specific foundation schedule (upon receipt of the final development levels);
- ✳ Geotechnical Design Report (GDR), including settlement analysis;
- ✳ Geotechnical Earthworks Specification (infrastructure);
- ✳ Remediation and enabling works strategy; and
- ✳ Specification for Mitigation of Hazardous Ground Gases & Verification Plan.



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17-500-010 – Human Health Conceptual Site Model	
17-500-012 – Depth to Bedrock Plan	
17-500-015 – Development Constraints Plan	
17-500-018 – Contamination Issues Plan (Groundwater)	
17-500-026 – Contamination Issues Plan (Human Health)	
17-500-027 – Controlled Waters Conceptual Site Model	
17-500-028 – Utility Survey Plan	
17-500-029 – Groundwater Flow Plan	



1. INTRODUCTION

1.1. BACKGROUND

Glen Dimplex Homes Appliances Ltd (the client) has commissioned E3P to undertake a Phase I and II Geoenvironmental Site Assessment at the Glen Dimplex Factory, Stoney Lane, Rainhill, Prescott, L35 2XW.

This report is required to determine potential contaminated land liabilities, remediation requirements and geotechnical engineering works that will be required as part of the proposed development for a low-rise residential development.

1.2. PROPOSED DEVELOPMENT

At present, a proposed development plan has not been decided, however it is assumed the redevelopment will comprise residential dwellings with associated private gardens, roadways and associated infrastructure.

At the time of writing this report, the proposed development is potentially subject to change and will be updated following significant changes.

1.3. OBJECTIVES AND SCOPE

The objectives of the geoenvironmental investigation are as follows:

- ✳ Review historical plans, geology, hydrogeology, site sensitivity, floodplain issues, mining records and any local authority information available to complete a desk study in line with Environment Agency (EA) document Land Contamination: Risk Management (LCRM) (updated June 2023).
- ✳ Undertake a phase of sampling and analysis to provide an overview of the environmental issues identified.
- ✳ Assess the implications of any potential environmental risks, liabilities and development constraints associated with the site concerning the site's future use and off-site receptors.
- ✳ Assess the geotechnical information and provide recommendations concerning foundations, pavement construction and floor slabs.
- ✳ Assess the coal mining-related information and provide recommendations regarding any future treatment; and,
- ✳ Provide recommendations regarding future works required.

1.4. SOURCES OF INFORMATION

Background information was sought from the following sources:

- ✳ Groundsure Enviro+Geo Insight Search Reference GS-APN-DM7-KX2-GEA;
- ✳ Historical mapping dated 1893 to 2017. A selection of historical maps is reproduced in APPENDIX VI;



- ✳ Online planning records held by Knowsley Metropolitan Borough Council and St Helens Metropolitan Borough Council;
- ✳ Consultations with representatives of Knowsley Metropolitan Borough Council and St Helens Metropolitan Borough Council;
- ✳ Consultations with representatives of the Coal Authority;
- ✳ Magic Map Groundwater Vulnerability Map;
- ✳ Radon: Guidance on protective measures for new buildings (BRE Document BR 211, 2007);
- ✳ British Geological Survey Map;
- ✳ Groundsure IO database;
- ✳ <https://zeticauxo.com/downloads-and-resources/risk-maps/>;
- ✳ <https://www.heritagegateway.org.uk>;
- ✳ <https://flood-map-for-planning.service.gov.uk>; and
- ✳ Environment Data - Catchment Data Explorer

1.5. SCOPE OF WORKS

The scope of works includes the elements included in Table 1.

Table 1 Scope of Works
PRELIMINARY REPORTING

- ✳ Phase 1 Geoenvironmental Assessment

PRELIMINARY GROUND INVESTIGATION

- ✳ Design of suitable preliminary ground investigation;
- ✳ Window sample probeholes with the construction of environmental monitoring installations;
- ✳ Deep cable percussive boreholes with the construction of groundwater monitoring installations; and
- ✳ Soil and groundwater sampling.

TESTING AND MONITORING

- ✳ In-situ geotechnical testing;
- ✳ Chemical and geotechnical analysis;
- ✳ Groundwater monitoring; and
- ✳ Ground gas monitoring.



ASSESSMENT AND REPORTING

- ✦ Factual and interpretative reporting;
- ✦ Contamination risk assessment and conceptual site model; and
- ✦ Geotechnical assessment and interpretation.

1.6. LIMITATIONS

The limitations of this report are presented in APPENDIX I.

1.7. RISK CLASSIFICATION

The description of risk classification and the likely action required as set out in CIRIA C552 are included in APPENDIX III.

1.8. CONFIDENTIALITY

E3P has prepared this report solely for the use of the client and those parties with whom a warranty agreement has been executed or with whom an assignment has been agreed. Should any third party wish to use or rely upon the report's contents, written approval must be sought from E3P; a charge may be levied against such consent.



2. SITE SETTING

2.1. SITE DETAILS

Table 2 Site Details	
Site Address	Glen Dimplex Home Appliances Ltd, Stoney Lane, Rainhill, Prescott, L35 2XW
National Reference	Grid E 348017 N 391531
Site Area	5.96 Ha.
Site Ownership	Glen Dimplex Home Appliances Ltd.

The Glossary presented in APPENDIX II defines all acronyms used within this report.

A site location map is presented as Drawing 17-500-001 in APPENDIX IV.

2.2. CURRENT SITE USE

A site walkover was completed by an E3P representative on 18th March 2024, with the full details included in Table 3. Site features are presented as Drawing 17-500-004 in APPENDIX IV, and site photographs are presented in APPENDIX V.

Page 20



FEATURE	DESCRIPTION	PHOTOGRAPHIC EVIDENCE
Retaining Structures	Small retaining structures were noted in the small area of landscaping towards the east of the main factory structure. Further retaining walls were noted along the northern boundary adjacent to Stoney Lane to the north of the structure.	
Access	Surrounding the main factory structure, a service road is present to the south and the west, connecting to Stoney Lane at the north. Access for both pedestrians and vehicles can be gained at the northwest off Stoney Lane in Prescott. The access is restricted with security adjacent at the northwest, which is manned 24 hours.	



FEATURE	DESCRIPTION	PHOTOGRAPHIC EVIDENCE
Slope	Minor slopes were identified particularly at the northern boundary and towards the west at the soft cover adjacent to the structure. A small retaining structure is noted at the southern face adjacent to the building.	
Vegetation/Ecology	No significant instances of vegetation/ecology were noted with the exception of small areas of soft cover landscaping (managed grasses) are noted at the north and east of the structure, with semi sporadic semi-mature trees towards the northern boundary.	



FEATURE	DESCRIPTION	PHOTOGRAPHIC EVIDENCE
Hazardous Material Storage	An enamel slurry waste storage area was recorded to the southeast of the main factory structure both in an above ground waste skip pictured to the right, and in a below ground storage tank. Two large above ground oil storage containers were noted to the west of the structure, with all containers identified in good condition with no sign of damage. Further instances of hazardous material storage is anticipated within the factory. However, this has not been confirmed at the time of the walkover as a full survey of the factory interior has not been completed.	



FEATURE	DESCRIPTION	PHOTOGRAPHIC EVIDENCE
Asbestos-Containing Material (ACM)	No evidence of ACM was noted across the majority of the site during the site walkover. Anecdotal information from site personnel indicated asbestos sheeting roof was present. Due to the age of the building, asbestos containing material is expected throughout the fabric of the building. A pre-demolition asbestos survey will be required within all existing buildings within the site boundary.	
Polychlorinated Biphenyls (PCBs)	Two electricity substation have been identified on-site towards the northwest and south, both of which were present prior to 1970. Therefore, it is considered likely PCBs are contained within the vicinity of these substations.	



FEATURE	DESCRIPTION	PHOTOGRAPHIC EVIDENCE
Volatile Organic Compounds (VOCs)	An active polystyrene manufacturing plant was noted with large imports of polystyrene recorded at the northern boundary adjacent to the structure. This presents a potential source of VOCs within the vicinity of the polystyrene manufacturing plant (northern boundary), however all instances of polystyrene were well stored with all surrounding areas covered in hardstanding. It is understood the polystyrene manufacturing plant was constructed in 2006, and that during the site walkover, no evidence of above or below ground storage tanks of VOCs were identified. However, as access to the plant was restricted due to its active nature, the presence of storage tanks within the plants interior cannot be fully discounted at this time.	
PFAS/PFOA	It is understood that the site has operated as a Stove Works and oven manufacturing factory since 1937. This presents a potential source of PFAS/PFOA within the vicinity of the main factory structure, as PFAS/PFOA based products may have been utilised in the manufacturing process (e.g. non-stick coatings). During the site walkover, no evidence of above or below ground storage tanks of PFAS/PFOA were identified. However, as access to the main factory structure was restricted due to its active nature, the presence of storage tanks within the factory's interior cannot be fully discounted at this time.	



FEATURE	DESCRIPTION	PHOTOGRAPHIC EVIDENCE
Waste Storage	Non-hazardous waste storage was present in large containers to the south of the main factory structure adjacent to the two small outbuildings. Some localised areas of fly tipped material was noted across the site however none appeared hazardous.	
Drainage & Utilities	During the site walkover, multiple instances of manholes and drainage covers were noted across the site within the roadways surrounding the main factory structure. Further instances of services are anticipated across the site due to the active nature including low–high voltage electricity cables, gas mains, clean water, and telecommunications cables connecting the structure to the adjacent roadways. A full GPR and utility survey has been undertaken by Geo UK Ltd in March 2024 and is presented as Drawing 17-500-028 in APPENDIX IV. The survey identified electricity cables surrounding the main factory structure and feeding into the two on-site electricity substations. Two gas governors and associated pipework were identified along the northern boundary and fed into the polystyrene manufacturing plant and northwest corner of the main factory structure. Water and sewerage mains and telecommunication cables were also identified surrounding the main factory structure and feeding into the surrounding smaller structures. Due to the site being an active oven manufacturing factory, the utility survey was not able to access the interior of the main factory structure or surrounding small structures.	



2.3. SURROUNDING AREA

The immediate surrounding area land uses are summarised in Table 4.

Table 4 **Surrounding Land Uses**

DIRECTION	LAND USE
North	Whiston Hospital, Whiston Ambulance Station, Residential units.
East	Elis (Laundry Service), Residential units.
South	Willis House Learning Disabilities, St Edmund Arrowsmith Catholic Academy
West	Residential units



3. SITE HISTORY

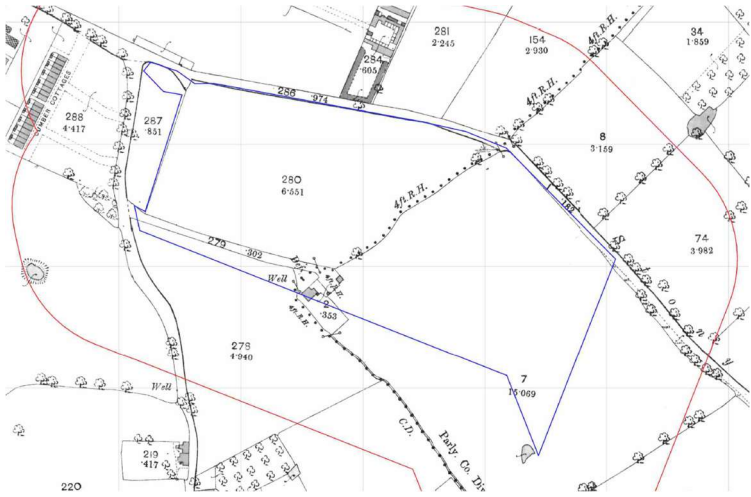
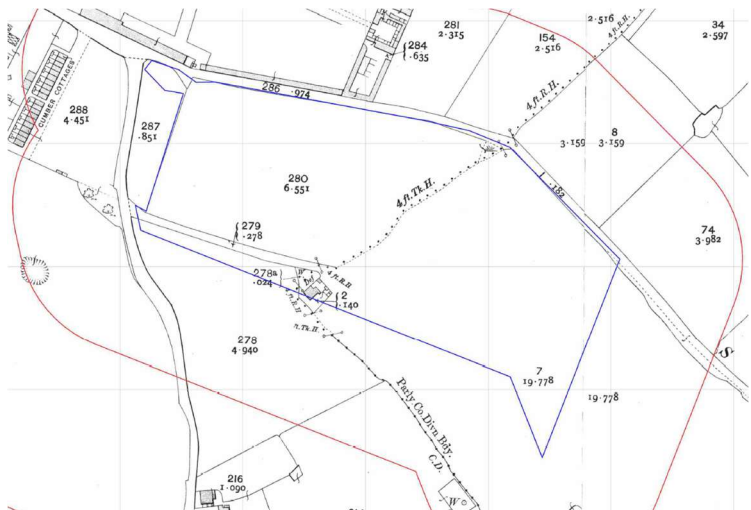
3.1. ON-SITE HISTORICAL DEVELOPMENT

A review of historical mapping and historical aerial imagery pertinent to the site is summarised in Table 5. In addition, historical site features are presented in Drawing No 17-500-003 in APPENDIX IV.

Table 5 **Historical Development**

MAP EDITION	HISTORICAL LAND USE	HISTORICAL MAP EXCERPT
1850 1:10,560	The site appears to be utilised as vacant agricultural land with a small dwelling situated at the centre of the southern boundary. A roadway leading to the dwelling is running parallel to the southern boundary. A well is noted adjacent to the dwelling at the southern boundary. Several segmenting tree-lined field boundaries are present, with the site comprising seven smaller fields. Two small ponds are recorded at the northern boundary towards the east, with another pond situated towards the centre of the southern boundary. A topographical gradient is noted towards the northeast of the site, suggesting natural geomorphology was variable.	



MAP EDITION	HISTORICAL LAND USE	HISTORICAL MAP EXCERPT
1892 1:2,500	The majority of the field boundaries have been removed. A small site boundary is noted at the north-western most point of the site, with a small portion noted entering at the centre of the northern boundary. The field boundary traversing through the centre of the site is now noted as a small hedge-lined road traversing from the south towards the northeast, continuing off-site. The two small ponds recorded at the northern boundary towards the east, and towards the centre of the southern boundary are no longer recorded. No other notable features have been identified.	
1907 1:2,500	One of the wells present towards the south has been removed. The hedge-lined road is now remarked as a Hedge Track. No other notable features have been identified.	

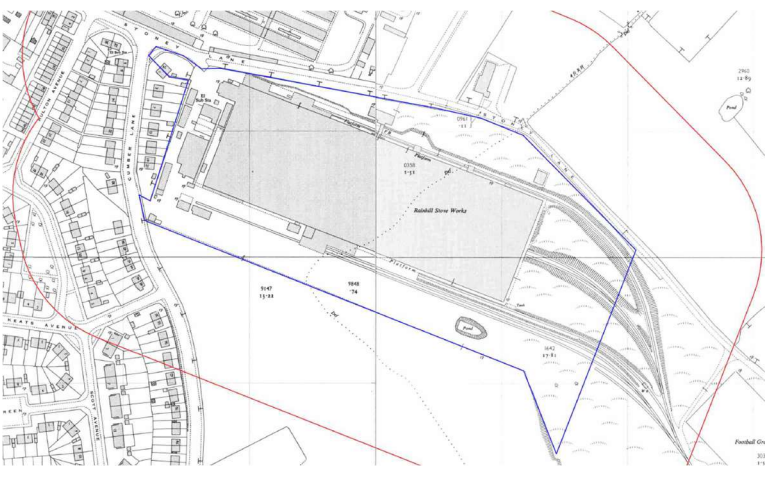
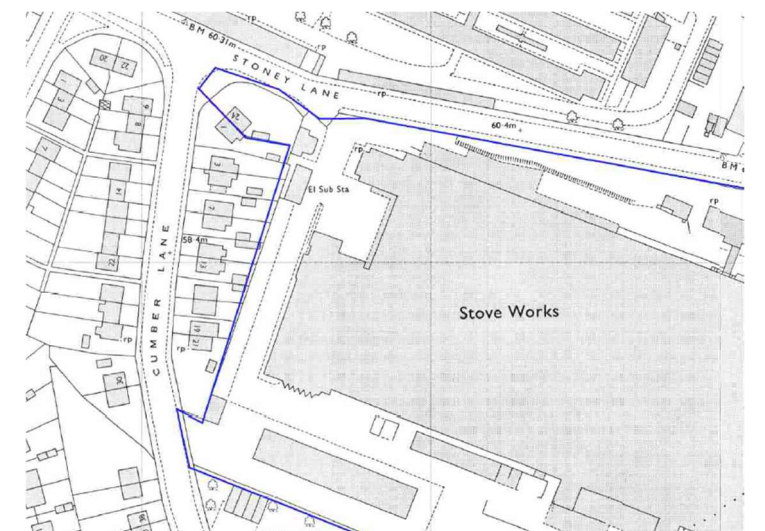


MAP EDITION	HISTORICAL LAND USE	HISTORICAL MAP EXCERPT
1914-1925	Historical mapping was unavailable between 1907 and 1925. However, records held by Heritage Gateway indicates a factory had been developed on the site, and that it was being used as a Munitions Works during the First World War (1914-1918) and up until at least 1925 (likely for the manufacturing of military based explosives and propellants).	
1925 1:10,560	The site has been completely redeveloped and comprises an Iron Foundry with associated railway sidings across the site. The Iron Foundry consists of two large structures separated by a railway siding traversing east to west through the centre of the site. Multiple small outbuildings are noted along the western sector of the main factory structures. The outbuilding situated to the south of the main factory structure is assumed to be associated with the railway sidings. Cuttings are noted at the northern boundary, north of the structure, with further cuttings noted adjacent to railway sidings towards the eastern and southern boundaries. Railway sidings are noted entering the site at the eastern boundary, branching off to the south, centre of, and north of the main foundry building.	

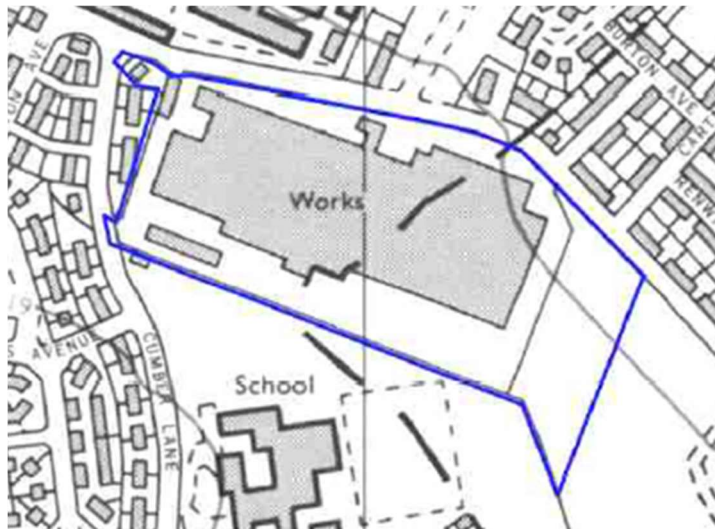
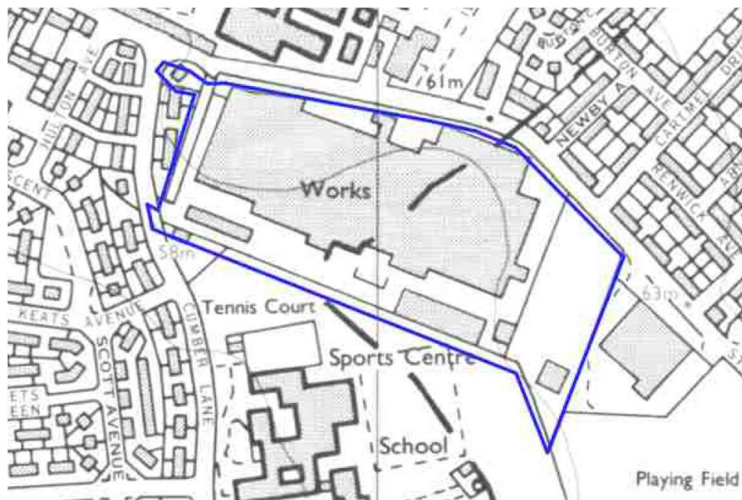


MAP EDITION	HISTORICAL LAND USE	HISTORICAL MAP EXCERPT
1927 1:2,500	A tank is noted at the southern boundary adjacent to the railway sidings to the south of the structure. No other significant changes have been identified.	
1937 1:2,500	The site is now named Rainhill Stove Works. A small extension to the structure at the northeast of the works structure is noted. Changes to the cutting at the centre of the northern works structure is noted now protruding further north than previous mapping. The sidings to the south are now noted as tramway sidings, with a small portion of the branch traversing southeast removed.	
1939-1945	Records held by Heritage Gateway indicates the factory was repurposed as a Munitions Works during the Second World War (1939-1945), again likely for the manufacturing of military based explosives and propellants.	



MAP EDITION	HISTORICAL LAND USE	HISTORICAL MAP EXCERPT
1954-1955 1:1,250	The site now comprises one large structure, with the sidings previously noted segmenting the two structures removed. Additional outbuildings have been constructed towards the northeast of the site with an electricity substation noted to the northwest of the main factory structure. A small pond is noted at the southern boundary adjacent to the sidings towards the east. The tank previously recorded at the southwestern boundary has been removed with a new tank recorded present at the southeastern corner of the main factory structure. Two platforms at the north and south of the main factory structure are noted.	
1972-1975 1:1,250	The separated outbuildings previously noted along the western boundary have either been removed or incorporated into the main factory structure. An additional connecting structure is noted at the central northern point of the main factory structure. The structure at the southwestern sector of the site is noted as extended. <i>Other sectors of the site are not available within historical mapping.</i>	



MAP EDITION	HISTORICAL LAND USE	HISTORICAL MAP EXCERPT
1978 1:10,000	All railway and tramway sidings present in previous mapping have now been removed. A County Parish boundary is noted segmenting the site through the centre of the site. A segmenting boundary is noted at the eastern sector of the site, separating the area from the main works structure. It is assumed this is the construction of the car parking area.	
1990 1:10,000	Small compositional changes to the main factory structure have been identified, with expansions noted towards the northern and southeastern sector of the main factory structure. Additional structures are noted at the southeastern and southern sectors of the site. Further boundaries segmenting the western sector of the site are noted.	



MAP EDITION	HISTORICAL LAND USE	HISTORICAL MAP EXCERPT
2000 Aerial Imaging	A roadway surrounding the main factory structure connecting to Stoney Lane to the north traversing south and west along the structure is noted. An associated car parking area to the east of the site is identified. Localised areas of soft standing landscaping are noted surrounding the main factory structure. No other significant changes have been identified.	
2024 Aerial Imaging	No significant changes from previous mapping have been identified. Present day site composition is displayed.	



3.2. SUMMARY OF ON-SITE HISTORICAL DEVELOPMENT

The following summary points have been highlighted after a detailed review of the historical mapping series.

3.2.1. POTENTIAL HISTORICAL CONTAMINATION ISSUES

- ✳ Iron Foundry – Heavy Metals, Non-volatile Polycyclic Aromatic Hydrocarbons (PAHs), Total Petroleum Hydrocarbons (TPHs), Sulphates (Slag, Ash, Dust).
- ✳ Munitions Works – Heavy Metals & Metal Compounds (Silver, Lead, Magnesium, Mercury Fulminate); Inorganic Compounds (Nitrite, Nitrate, Sulphate Ions, Ammonium Nitrate, Sodium/Potassium Nitrate, Sodium Sulphite, Sodium/Potassium/Ammonium Perchlorate); Primary Explosive Compounds (Silver Azide, Lead Azide, Lead Styphnate, Tetrazene); Secondary Explosive Compounds (TNT (2,4,6-Trinitrotoluene), RDX (Cyclotrimethylene Trinitramine), HMX (Cyclotetramethylene Tetranitramine), Tetryl (Trinitrophenylmethylnitramine), PETN (Pentaerythritol tetranitrate), Nitroguanidine, Nitroglycerine, Nitrocellulose, Picric acid (2,4,6-trinitrophenol) and Ammonium Picrate; Propellants (solid – single, double or triple base, and composite; or liquid); Acids (nitric, sulphuric and acetic), Organic Solvents (acetone, ether, ethanol, cyclohexanone, diethyl ether, ethyl carbonate, and triacetin), TPHs (including unsymmetrical dimethylhydrazine, polyisobutylene (PIB) and hydroxy-terminated polybutadiene (HPTB)), and Volatile Organic Compounds (VOCs) (including Hexamine, Toluene, Mononitrotoluene, Dinitrotoluene, Polymers, Glycerine, Phenol, Anilines, Aldehydes, Organic Esters, Acetic Anhydride, Guanidine Nitrate, Dicyanodiamide, diphenylamine, isopropyl nitrite and nitrate, ethyl centralite, and glycerine).
- ✳ Stove Works - Heavy Metals, Non-volatile PAHs, TPHs, Sulphates (Slag, Ash, Dust), PFAS/PFOA (Coatings).
- ✳ Historical Tanks – Volatile Compounds (TPHs, Volatile Organic Compounds - VOCs)
- ✳ Historical Electricity Sub Station – Polychlorinated Biphenyls (PCBs)
- ✳ Historical Railway/Tramway Sidings – Heavy Metals, Non-volatile PAHs, TPHs, Sulphates (Ashy deposits)
- ✳ Made Ground – Heavy Metals, Non-volatile PAHs, TPHs, Asbestos Containing Materials (ACM)
- ✳ Historical Infilled Ponds – Heavy Metals, Non-volatile PAHs, TPHs, Organic Compounds, ACM.

3.2.2. POTENTIAL HISTORICAL GEOTECHNICAL ISSUES

- ✳ Historical Development (Made Ground and Obstructions) – Significant (likely reinforced) concrete floor slabs in main factory structure footprint.
- ✳ Historical Railway/Tramway Sidings and associated platforms (Made Ground and Obstructions) – iron and concrete floors with deeper Made Ground fill expected in these areas.
- ✳ Historical Infilled Ponds (centre south, southeast and northeast) – Soft organic deposits with detritus materials.



3.3. OFF-SITE HISTORICAL DEVELOPMENT

A review of potentially contaminative uses identified on historical Ordnance Survey maps within a 100 m radius of the site is summarised in Table 6.

Table 6 Surrounding Historical Development

SURROUNDING FEATURE	DISTANCE	DATES	DIRECTION
Unspecified Workhouse Then: Poor Law Institution Then: Whiston County Hospital Then: Whiston Hospital	3 m	Pre 1891 – Pre 1906 Pre 1906 – Pre 1947 Pre 1947–Pre 1966 Pre 1966–Present	Northwest
Electricity Sub Station Then: No longer present	30 m	Pre 1955 – Pre 1964 Pre 1964 - Present	Northwest
Unspecified Tank Then: No longer present	35 m	Pre 1984 – Pre 1993 Pre 1993 - Present	Southeast
Unspecified Pit Then: No longer present	76 m	Pre 1906 – Pre 1955 Pre 1955 - Present	West
Electricity Sub Station Then: No longer present	81 m	Pre 1984 – Pre 1993 Pre 1993 - Present	Southeast
Electricity Sub Station Then: No longer present	93 m	Pre 1973 – Pre 1993 Pre 1993 - Present	Northeast

3.4. PLANNING HISTORY

E3P has reviewed online planning records held by Knowsley Metropolitan Borough Council and St Helens Metropolitan Borough Council, and environmentally pertinent information has been obtained for the site, outlined within Table 7 below.

Table 7 Planning History

PLANNING REFERENCE	PLANNING APPLICATION	PERTINENT DOCUMENTS
95/00211/APP	Installation of Tank for storage of liquid oxygen.	None Provided (1995)
97/00304/APP	Construction of vehicular access from Stoney Lane.	None Provided (1997)
02/00052/FUL	Erection of extension to south side of factory for storage facilities.	None Provided (2002)
06/00093/FUL	Erection of Industrial Building for manufacture of Polystyrene, erection of boiler house and associated water tower.	None Provided (2006)

3.5. ANECDOTAL INFORMATION

A web-based search of the subject site has recovered the following photographs, courtesy of Britain From Above:



Table 8 **Summary of Anecdotal Information**

**PLATE EPR000530 –
BRITAIN FROM
ABOVE 1935**



**PLATE EPR000532 –
BRITAIN FROM
ABOVE 1935**



3.6. PREVIOUS REPORTS

No previous reports have been submitted to E3P for review.



4. ENVIRONMENTAL SETTING

4.1. GEOLOGY

The British Geological Survey (BGS) map (Sheet 097) for the site (1:50,000, Solid and Drift editions) and online records indicate the area is underlain by the geological sequence presented in Table 9.

Table 9 Summary of Underlying Geology

GEOLOGICAL UNIT	CLASSIFICATION	DESCRIPTION	AQUIFER CLASSIFICATION
Superficial	Glacial Till (majority of site)	SAND, CLAY and GRAVEL	Secondary undifferentiated
	Glaciofluvial Deposits (Southeast)	SAND and GRAVEL	Secondary A Aquifer
Bedrock	Kinnerton Sandstone Formation (Majority)	SANDSTONE	Principal Aquifer
	Chester Formation (Eastern)	SANDSTONE	

E3P has reviewed the BGS database, which identified several boreholes in close proximity, from which to compare the published geology above.

The borehole logs are summarised in Table 10 below.

Table 10 Summary of BGS Borehole Records

LOCATION	DEPTH	MADE GROUND	SUPERFICIAL	BEDROCK
21 m SW	2.10 m	1.00 m	Firm to Stiff CLAY > 1.0 m	Not encountered
26 m W	6.00 m	1.20 m	Soft to Stiff CLAY > 1.20 m	Not encountered
70 m SE	10.97 m	0.38 m	Soft to Stiff CLAY >0.38 m	Not encountered

The BGS mapping also identifies the location of faults, as presented in Table 11.

Table 11 Faulting

LOCATION	DESCRIPTION
On-site (eastern sector – Cronton Fault)	Fault Inferred / Northwest to Southeast, downthrow to East
69 m NW	Fault Observed / Northwest to Southeast

4.2. HYDROGEOLOGY

The Groundsure report indicates that the site is located within a Groundwater Source Protection Zone 3. Furthermore, there is an active groundwater abstraction point located 16 m SE of the site, pertaining to Elis UK Ltd and used for laundry purposes.

Following a review of the site's historical and present-day mapping, a well was identified historically in the southern sector of the area adjacent to historical farm buildings (Drawing 17-500-004, APPENDIX IV).

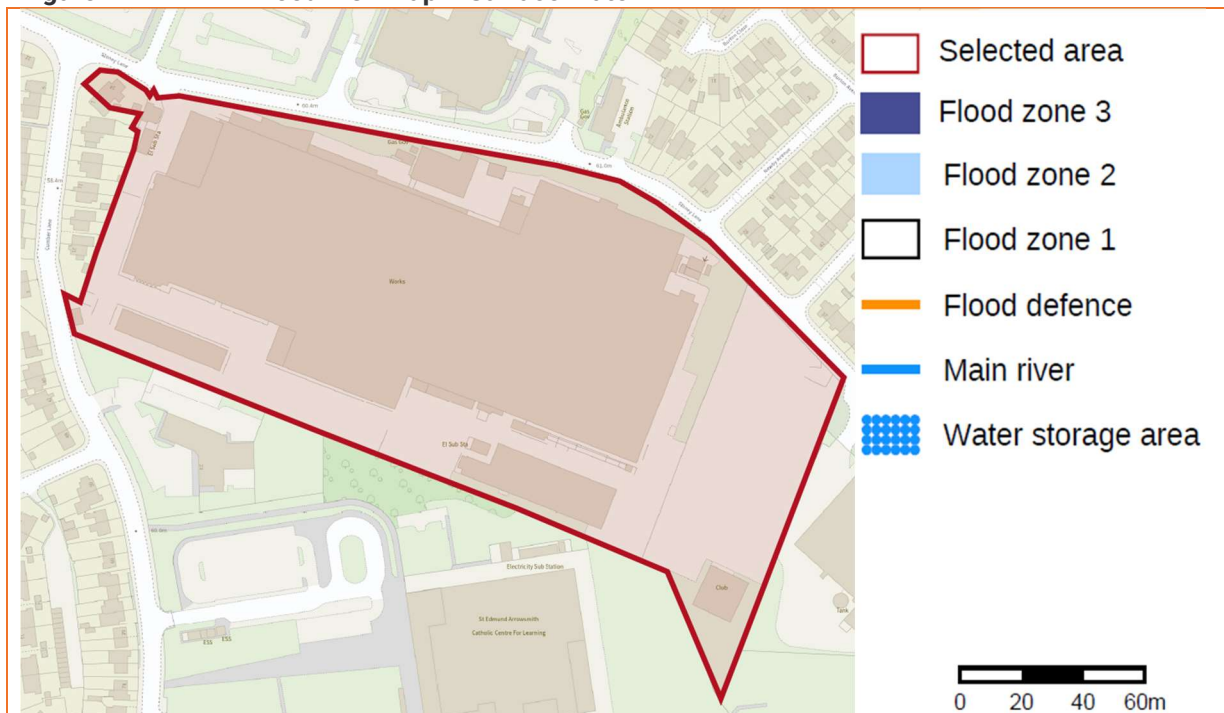


4.3. HYDROLOGY

No surface water features are located within 50 m of the site boundary. The closest surface water feature is an unnamed inland river situated 138 m south of site.

The site is predominantly located within a currently defined “Flood Risk Zone 1”, defined as land assessed as having less than 1 in 1,000 annual probability of river or sea flooding (< 0.1%) and, as such, is considered to be unaffected by river flooding. In addition, the Groundsure report states there is a limited potential for groundwater flooding at the majority of the site, with discrete areas at the southeast at a moderate risk. The Environment Agency (EA) Flood Risk Maps for the site is presented in Figure 1 and Groundsure Groundwater Flooding Map in Figure 2.

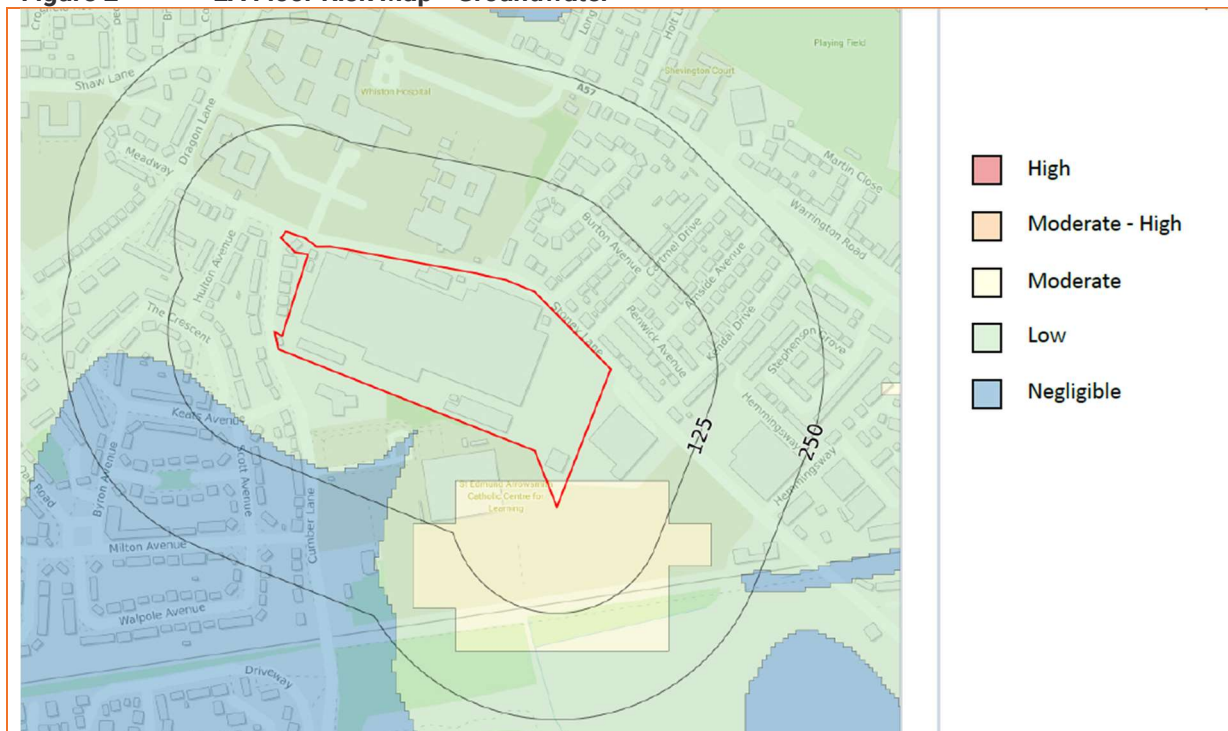
Figure 1 EA Flood Risk Map – Surface Water



Source - <https://flood-map-for-planning.service.gov.uk/>



Figure 2 EA Floor Risk Map - Groundwater



Source – Groundsure mapping

4.4. RADON RISK POTENTIAL

The Groundsure report indicates the site is situated in an area where less than 1% of homes are above the “Action Level” and that the BGS reports that radon protective measures are not necessary for the construction of new dwellings or extensions.

4.5. LANDFILL SITES

No active or historical landfill or waste sites have been recorded within 1 km of the site boundary.

4.6. WASTE MANAGEMENT LICENSES AND ENVIRONMENTAL PERMITS

No Waste Management Licenses or Environmental Permits have been identified in the environmental database for the site and surrounding area.

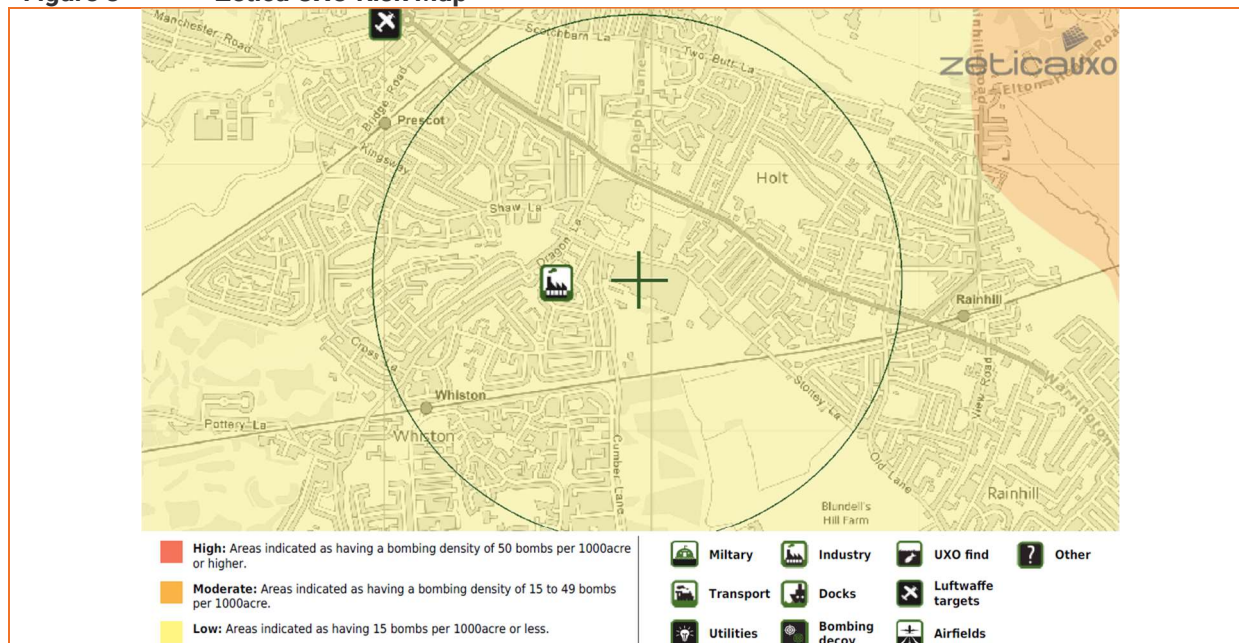
A singular waste exemption is recorded within 100 m of the site (42 m SE), categorised as storage of waste exemption, in a secure place, not on a farm.

4.7. UNEXPLODED ORDNANCE

The regional unexploded bomb risk map from Zetica (2014) indicates that the site is in an area at a low risk from possible unexploded ordnance (UXO) resulting from the Second World War. The Zetica UXO Risk Map is presented in Figure 3.



Figure 3 Zetica UXO Risk Map



Source - <https://zeticauxo.com/downloads-and-resources/risk-maps/>

Records held by Heritage Gateway indicates the site had previously been used as Munitions Works during the First World War (1914-1918) and up until at least 1925; and again during the Second World War (1939-1945). Though the type of munitions manufactured at the site is currently unknown, given the operational years during the First and Second World Wars, it is likely that military based explosives and propellants were manufactured at the site.

4.8. INDUSTRIAL LAND USES

The site is located within a predominantly industrial area; therefore several industrial land uses have been identified within a 100 m radius of the site, summarised in Table 12.

Table 12 Industrial Land Uses

INDUSTRIAL LAND USE	DISTANCE	DIRECTION	STATUS
Gas Governor	28 m	Northeast	Active
Electricity Substation	29 m	South	Active
Whiston Ambulance Station	32 m	Northeast	Active
Tank	40 m	Southeast	Active
Electricity Substation	82 m	Southeast	Active
Mabley Electrical Services	84 m	Southwest	Active
Electricity Substation	97 m	Northeast	Active

4.9. SITE SENSITIVITY ASSESSMENT

The site is assessed to be located within a "Moderate/High" sensitivity setting, as discussed in Table 13.



Table 13 Site Sensitivity Assessment

SENSITIVITY PROFILE	DISCUSSION	RATING
Groundwater Source Protection Zone or Drinking Water Safeguard Zone	The site is situated within a Groundwater Source Protection Zone 3 – Therefore is considered high sensitivity underlying aquifers.	High
Distance to the Closest Groundwater Abstraction Point	An active groundwater abstraction point is noted 16 m SE from the site, pertaining to Elis UK Ltd and used for laundry purposes.	High
Aquifer Classification in Superficial Deposits	The majority of the site is situated within a secondary undifferentiated superficial aquifer, with the eastern sector of the site underlain by a secondary A superficial aquifer.	Moderate
Aquifer Classification in Bedrock	The site is underlain by a principal bedrock aquifer.	High
Is the Site Underlain by Low-Permeability Superficial Deposits to Depths in Excess of 10 m?	Based upon nearby BGS boreholes the underlying superficial deposits are likely to comprise low permeability clay soils to depths in excess of 5 m, which may reduce the potential for mobile phase contaminants to migrate towards the bedrock aquifer. Towards the eastern sector of the site, high permeability granular deposits are anticipated which will afford less protection to the underlying bedrock aquifer.	Moderate
Is the Site Located Within 50 m of a Surface Watercourse?	The risk to surface water is negligible, given the absence of a viable receptor within influencing distance of the site.	Low
Sensitive Land Uses	The site is situated within an SSSI Impact Risk Zone however, the proposed development does not fall within the type of development requiring consultation.	Low
Sensitive Ecological Receptors	None Identified.	Low
OVERALL SITE ENVIRONMENTAL SENSITIVITY		Moderate/High

4.10. REGULATORY DATABASE

The information summarised in Table 14 has been obtained from a commercially available environmental database. The summary table only includes records from within 250 m of the subject site and is not otherwise detailed in the report.

Table 14 Summary of Environmental Data

RECORD	ENTRIES WITHIN 250 M	DETAILS
Contaminated Land Register Entries and Notices	0	None Identified
Authorised Industrial Processes (IPC/IPPC/LAPPC)	1	On-site - Glen Dimplex Home Appliances Ltd– Licensed Pollutant Release (Part B) – Current Permit (Coating Processes).
Fuel Stations Entries	0	None Identified
Licensed Radioactive Substances	1	92 m NW - St Helens and Knowsley Hospital Trust - Effective
Enforcements, Prohibitions or Prosecutions	0	None Identified
Discharge Consents	0	None Identified



RECORD	ENTRIES WITHIN 250 M	DETAILS
Pollution Incidents	0	None Identified
Consents Issued Under the Planning (Hazardous Substances) Act 1990	0	None Identified
Control of Major Accident Hazard (COMAH) Sites	0	None Identified



5. PRELIMINARY MINING ASSESSMENT

5.1. COAL MINING

The Coal Authority (CA) mapping and records indicate that the site is in an area that may be affected by coal mining.

A CA mining report was obtained (Ref: 51003408185001) dated February 2024.

The CA operates a risk-based approach to assessing potential instability issues associated with future land development located within the predefined CA consultation areas. This risk-based approach subdivides the potential risk into “low” and “high” risk categories.

The risk categories can be defined as:

Low-Risk Sites – Deemed to be land where coal mining has taken place, however, it was at such depth not to pose a risk to new development, and it, therefore, contains no known recorded risks and as such, no further assessment is required.

For low-risk sites, the CA categorically states:

If your proposed development is within the Development Low Risk Area, there is no need for you to submit any coal mining information with your planning application and The Coal Authority will not be consulted by the LPA. The LPA will include our Standing Advice as an informative note within the decision notice.

High-Risk Sites – Deemed to be landholdings located within an area known to contain legacy risks that include:

- ✳ Mine entries (shaft or adit);
- ✳ Shallow coal workings (recorded and probable);
- ✳ Workable coal seam outcrops;
- ✳ Mine gas sites and areas;
- ✳ Recorded coal-mining-related hazards;
- ✳ Geological features (fissures and break lines); and
- ✳ Former surface mining sites (sometimes using historical opencast extraction methods).

5.2. COAL MINING INFORMATION

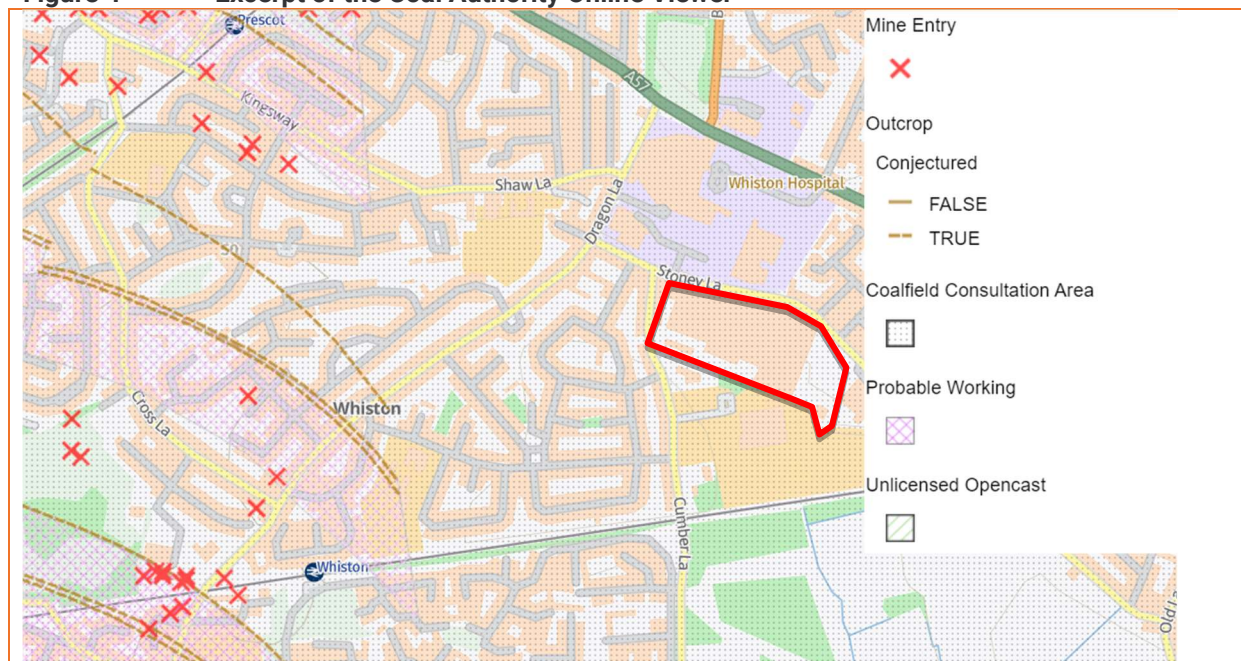
Prior to the enactment of the Coal Mines Regulation Act (1872), which came into force on the 1st of January 1883, there was no statutory requirement to record the extent of abandoned mine workings and as such the CA has no knowledge of extensive workings throughout the UK Coal Fields where shallow workings are present at a depth that could result in a subsidence event in the future (through successive cavitation) associated with failure of support mechanism.



Determining if a site may have unrecorded or recorded coal mine workings requires the consideration of a wide range of information, and E3P has completed a review of relevant information in relation to potential coal mining activities.

In the first instance, E3P has reviewed the Coal Authority Online Viewer, and an excerpt of this is presented in Figure 4. This map shows that the site does not lie within a high-risk development area. No recorded coal seams are present on-site; the closest worked coal seam is located approximately 530 m to the west, which dip down away from the site.

Figure 4 Excerpt of the Coal Authority Online Viewer



As the site is within an area affected by coal mining, E3P has obtained a Consultant Coal Mining Report for the site (ref: 51003408185001), which is presented in APPENDIX XIII.

Table 15 provides a summary of pertinent coal mining information within this report.

Table 15 Coal Mining Information

SOURCES OF INFORMATION	SUMMARY
Known Past Underground Mining	No past mining is recorded
Probable Unrecorded workings	No
Spine Roadways at Shallow Depth	No spine roadways recorded at shallow depths.
Mine Entries within 100 m of the Site	None recorded within 100 m of the site boundary.
Mine Abandonment plans	No
Known outcrops	No outcrops recorded
Faults / Fissures	Through the eastern sector of the site (Cronton Fault), traversing northwest to southeast, with a downthrow to the east.
Opencast mines	None recorded within 500 m of the site boundary.

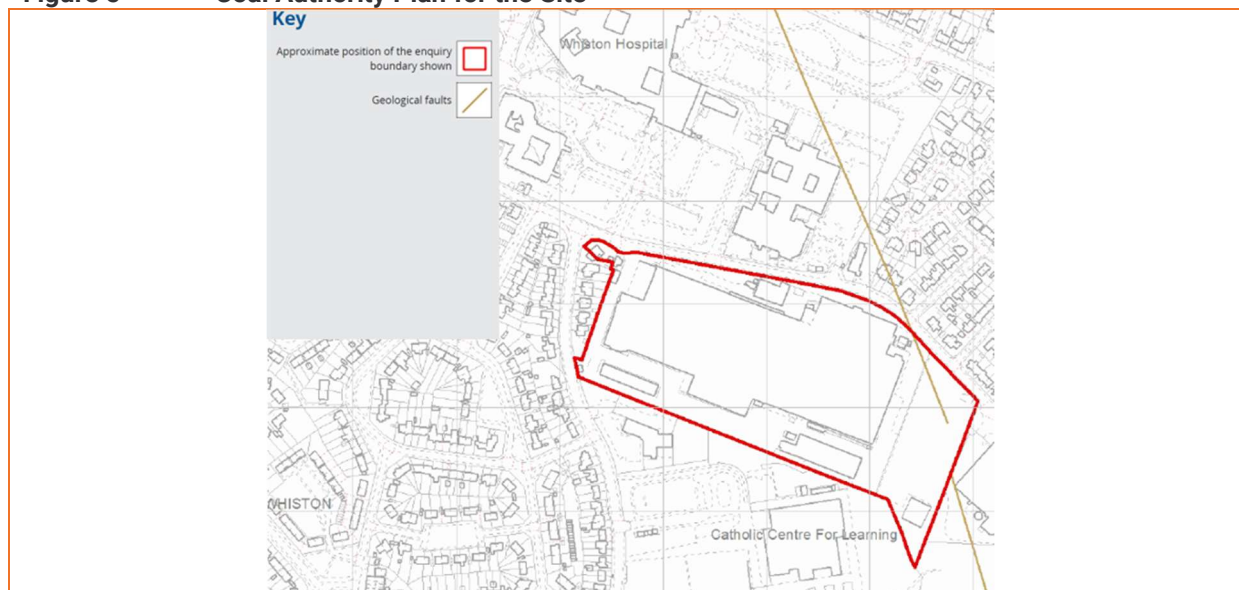


SOURCES OF INFORMATION	SUMMARY
Coal Authority Managed Tips	None recorded within 500 m of the site boundary.
Remediated Sites	None recorded within 50 m of the site boundary.
Coal Mining Subsidence	The Coal Authority has not received a damage notice or claim for the subject property, or any property within 50 metres of the enquiry boundary, since 31 October 1994. There is no current Stop Notice delaying the start of remedial works or repairs to the property. The Coal Authority is not aware of any request having been made to carry out preventive works before coal is worked under section 33 of the Coal Mining Subsidence Act 1991.
Mine Gas	None recorded within 500 m of the enquiry boundary.
Mine Water	None recorded within 500 m of the enquiry boundary.
Future Underground Mining	None recorded
British Geological Survey Mapping	A review of 1:10,000 geological mapping indicates no recorded coal seams are present on-site, with the closest worked coal seam located approximately 530 m to the west, which dips down away from the site.
Review of Coal Authority Archive	No CA archives/mine abandonment plans are made available.
Historical Ordnance Survey Mapping	A review of historical Ordnance Survey Mapping did not identify any coal mining associated features within 500 m of the site boundaries. As no recorded coal outcrops have been recorded within the boundary of, or in immediate proximity to the site, no further assessment is likely required.
Historical Ground Investigations	E3P has not been provided with any historical ground investigation reports.

5.3. COAL AUTHORITY PLAN

The Coal Authority plan referenced: MR-LARGE-PLOT-51003408185001-1709132950870 shows there are no hazardous mining associated features within the vicinity of the site as illustrated in Figure 5.

Figure 5 Coal Authority Plan for the Site





5.4. COAL MINING GEOLOGY

Figure 6 is a photograph of the 1:63,360 plan for the site, which shows a geological fault (Cronton Fault) traversing northwest to southeast through the eastern sector of the site, with a downthrow to the east.

No coal outcrops are recorded within an influencing distance to the site, with all known worked seams situated > 500 m to the west of the site within the Pennine Middle Coal Measures.

Figure 6 Photograph of the 1:63,360 Plan for the Site



5.5. MINE ABANDONMENT PLANS

Mine abandonment plans are not currently available for the site.

5.6. OPEN CAST MINING

There are no records of open-cast mining related to the site.

5.7. PRELIMINARY MINE GAS ASSESSMENT

If coal mining is present below the site, this may be a potential source of ground gas that could pose a risk to site end users. A preliminary mine gas assessment is provided in Table 16.

Table 16 Preliminary Mine Gas Assessment

SCENARIO	DISCUSSION	RATING
Are there known coal seams beneath the Site?	No – no known seams are recorded below the site.	Low
Are there coal seams within 150 m of the top of the bedrock?	No – no known seams are recorded below the site.	Low



SCENARIO	DISCUSSION	RATING
Are there any known workings below the Site?	No – no known seams are recorded below the site.	Low
Are the underlying superficial deposits impermeable?	Yes – the site is anticipated to be underlain by impermeable cohesive deposits. However, the eastern sector is anticipated to be underlain by granular deposits, and shallow bedrock deposits are anticipated to be present at depths ranging from 4.00–10.00 m bgl.	Moderate (High in eastern sector only)
Are there any mine entrances within the site boundary or within 50 m of the Site?	No – the closest mine entrance is situated greater than 150 m from site.	Low
Are there any faults below the Site or in close proximity?	Yes – there is a fault (Cronton Fault) traversing northwest to southeast through the eastern sector of the site, with a downthrow to the east.	High
Is there any records of mine gas emission on or within 50 m of the Site	No	Low
Is there any record of historical mine stabilisation works?.	No	High
Evidence of rising groundwater in flooded mine workings?	Not known	Moderate
OVERALL, MINE GAS RISK (IF MODERATE/ HIGH, THEN FURTHER ASSESSMENT IS REQUIRED)		Low to Moderate
Conclusions: The site is not underlain by any known coal seams or situated within immediate proximity of any coal workings at a shallow depth. Overall the potential source of ground gases are considered negligible. No further assessment is required.		

5.8. COAL MINING RISK ASSESSMENT

This risk assessment comprises a desk-based review of all available information on coal mining issues that are relevant to the application site deemed to be located within a high-risk area. This includes:

- ✳ Interpretation of information to identify and assess the risks to the proposed development from coal mining legacy, including the cumulative impact of issues;
- ✳ Setting out appropriate mitigation measures to address the coal mining legacy issues affecting the site, including any necessary remedial works and/or demonstrate how coal mining issues have influenced the proposed development; and
- ✳ Demonstrating to the local planning authority that the application site is, or can be made, safe and stable to meet the requirements of national planning policy with regard to development on unstable land.



The coal mining risk assessment is summarised in Table 17.

Table 17 Summary of Coal Mining Risk Assessment

COAL MINING RISK ASSESSMENT	YES/NO	RISK ASSESSMENT
Recorded Underground Coal Mining at Shallow Depth (< 30 m)	No	Low
Recorded Underground Coal Mining at Shallow Depth (> 30 m)	No	Low
Evidence of Unrecorded Surface Extraction of Coal Outcrop	No	Low
Unrecorded Underground Coal Mining at Shallow Depth (< 30 m)	No	Low
Mine Entries (Shaft/Adits)	No	Low
Coal Mining Geology – Fractures/Fissures	No	Low
Recorded Gas Emissions	No	Low
Recorded Mining Surface Hazard	No	Low
Surface Mining (Opencast)	No	Very Low/Low

Based on a continuation of the current site use and the redevelopment of the site for residential end use, there is considered to be a low risk associated coal mining activity.



6. PRELIMINARY GEOTECHNICAL ASSESSMENT

6.1. GEOTECHNICAL DATA

Geotechnical data presented within a commercially available environmental database is summarised in Table 18.

Table 18 Summary of Geotechnical Data

HAZARD	DESIGNATION
Shrink-Swell Clay	Very low risk
Landslides	Very low risk
Ground Dissolution	No hazard
Compressible Ground	No hazard
Collapsible Deposits	Very low risk
Running Sand	Very low risk

6.2. ARTIFICIAL LANDFORM AND GEOMORPHOLOGY

Based on the initial geological assessment, a review of available topographic data and pertinent mapping, E3P has undertaken a preliminary geomorphological evaluation of the landform and its possible mechanism for formation.

Based upon a review of historical mapping and topographical contours, it would appear that the placement and upfilling of material will have formed the current site level plateau prior to the construction of the historical development.

It is possible that the historical level raising has resulted in a greater thickness of Made Ground overlying the natural glacial till and glaciofluvial deposits, and potentially underwent earthworks to create a development platform for the factory present.

Figure 7 Surface Lidar Data





6.3. GROUND CAVITIES AND SINK HOLES

Information within the Groundsure Report states the site is within an area of no hazard to very low hazard from rock solubility. No sources indicative of geotechnical hazards including ground cavities and sink holes have been identified on-site, or within the immediate vicinity.

6.4. PRELIMINARY GEOTECHNICAL ASSESSMENT

Based on the desk-study information, the following geotechnical assessment has been made:

- ✿ Given the predominantly developed nature of the site, it is likely there will be substantial Made Ground fill deposits and obstructions. Existing buildings will require demolition, with all relict foundations grubbing out before the proposed development's construction.
- ✿ Three historically infilled ponds were formerly present towards the centre south, southeast and northeast boundaries, which are potential sources of alluvial deposits, silts and possible organic peat deposits, and localised greater depths of Made Ground. An investigation will be required to assess these and undertake in-situ geotechnical testing to determine the potential foundation solution for any proposed plots in these areas.
- ✿ The site contains no topographical variances due to the developed nature of the site. Therefore, significant earthworks are unlikely to be required for the proposed redevelopment.
- ✿ Nearby geology and BGS boreholes suggest that shallow bedrock may be present, potentially at depths ranging from 4.00–10.00 m bgl.
- ✿ A geological fault (Cronton Fault) is recorded traversing northwest to southeast through the eastern sector of the site, with a downthrow to the east, which potentially presents a geotechnical risk in these areas.



7. INITIAL CONCEPTUAL SITE MODEL

Under EA LCRM (updated June 2023) and BSI 10175 (Code of Practice for Investigation of Potentially Contaminated Land), and BS EN ISO 21365:2021 (Soil Quality – Conceptual models for potentially contaminated sites), E3P has developed a Tier 1 risk assessment comprising an initial conceptual site model (CSM) to identify potential contamination sources, migration pathways and receptors within the study area. An initial screening of the on and potential off-site sources of contamination has been undertaken in Table 19, with the more detailed initial CSM included overleaf as Table 20.

Table 19 Initial Contaminant Source Screening

SOURCE	SOIL	GROUNDWATER	GROUND GAS
ON-SITE			
Historical Iron Foundry (inc. Tanks)	Heavy Metals (Spent Oxides), Non-Volatile PAHs, ACM, TPHs, VOCs, SVOCs, Sulphates (slag, clinker, ashy deposits)	TPHs, VOCs	Volatile vapours, Carbon Dioxide, Methane
Historical Munitions Works	Heavy Metals & Metal Compounds, Inorganic Compounds, Explosive Compounds and Propellants (inc. TNT, RDX, HMX, Tetryl, PETN, Nitroguanidine, Nitroglycerine and Picric Acid), Acids, Organic Solvents, TPHs, VOCs	Primary and Secondary Explosive Compounds and Propellants, Acids, Organic Solvents, TPHs, VOCs	Volatile Vapours
Made Ground	Heavy Metals, Non-Volatile PAHs, ACM, TPHs, VOCs, SVOCs, Sulphates (slag, clinker, ashy deposits)	TPHs, VOCs, SVOCs	Volatile vapours, Carbon Dioxide, Methane
Railway/Tramway Sidings	Heavy Metals, Non-Volatile PAHs, TPHs, VOCs, Sulphates (slag, clinker, ashy deposits)	TPHs, VOCs,	Volatile vapours, Carbon Dioxide, Methane
Historical & Current Oven Manufacturing Factory (inc. Tanks)	Heavy Metals, Non-Volatile PAHs, ACM, TPHs, VOCs, SVOCs, PFAS/PFOA	TPHs, VOCs, SVOCs, PFAS/PFOA	Volatile vapours, Carbon Dioxide, Methane
Electricity Substations	PCBs	Unlikely	Unlikely
Historical Infilled Ponds (centre south, southeast and northeast)	Heavy Metals, Non-Volatile PAHs, ACM, Organic Compounds	Unlikely	Organic Deposits (Carbon Dioxide, Methane)
OFF-SITE			
Whiston Hospital	Heavy Metals, Non-Volatile PAHs, TPHs, VOCs	Unlikely	Unlikely



After reviewing all environmentally pertinent information and the potential contaminant sources, the following initial conceptual site model has been developed for the site.

Table 20 Initial Conceptual Model

CONTAMINANT RISK			LIKELIHOOD	SEVERITY	LEVEL OF RISK	JUSTIFICATION
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
HUMAN HEALTH						
Iron Foundry, Made Ground, Railway / Tramway Sidings, Oven Manufacturing Factory and Historical Infilled Ponds Metals, Non-Volatile PAHs, Sulphates (slag, clinker, ashy deposits) Electricity Substations PCBs Munitions Works, Heavy Metals and Metal Compounds, Inorganic Compounds, Explosive Compounds and Propellants, Acids, Organic Solvents, TPHs, VOCs Oven Manufacturing Factory PFAS/PFOA	Accidental ingestion and/or dermal contact with contaminated soil and/or leachate. PL1/PL2 Inhalation of contaminated dust. PL3	Human Health – construction workers	Low likelihood	Medium	Moderate/Low	The initial CSM has identified contaminants of concern as above assessment criteria. Site personnel have a greater chance of coming into contact with contaminated soils.
		Human Health – end users	Low likelihood	Medium	Moderate/Low	Intrusive ground investigation and assessment to determine the potential extent of any contamination will be required.



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	LEVEL OF RISK	JUSTIFICATION
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
Tanks (Iron Foundry / Oven Manufacturing Factory) and Made Ground Volatile PAHs (naphthalene), TPHs, VOCs Munitions Works, Explosive Compounds and Propellants, Organic Solvents, TPHs, VOCs	Inhalation of vapours. PL4 Migration through permeable strata and preferential pathways.	Human Health – end users Human Health – Off-site receptors	Likely	Medium	Moderate	Based upon the historical mapping and initial site walkover, the presence of fuel and chemical storage tanks has been identified, which may be a significant source of volatile PAHs, TPHs and VOCs. The site's historical use as a Munitions Works may also be a significant source of Explosive Compounds, Propellants, and Organic Solvents. Intrusive ground investigation and assessment will be required to determine the level of mitigation measures and/or remediation.
Made Ground, Iron Foundry/Munitions Works/Oven Manufacturing Factory and Historical Infilled Ponds Asbestos (Asbestos containing materials (ACM) and loose fibres)	Inhalation (of fibres). Construction works disturbing bound and releasing fibres. PL3	Human Health – construction workers, end land users, and users of adjacent sites	Likely	Medium	Moderate	Risk of inhalation of fibres during Ground Investigation and construction works. Disturbance of ACMs and dust derivatives from construction would increase risk to adjacent sites. Intrusive ground investigation will be required to determine the presence of ACMs and develop appropriate mitigation measures.



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	LEVEL OF RISK	JUSTIFICATION
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
Iron Foundry, Made Ground and Railway/Tramway Sidings Sulphates (slag, clinker, ashy deposits) Munitions Works Acids, Sulphates	Sulphate attack on concrete. PL6	Building concrete	Likely	Medium	Moderate/Low	Due to the presence of Made Ground on the site, the potential for sulphate in ashy deposits is high. The site's historical use as a Munitions Works may also be a significant source of Acids and Sulphates; both of which may impact the proposed building concrete. Intrusive ground investigation will be required to assess the concrete classification.
Iron Foundry, Made Ground, Oven Manufacturing Factory and Historical Infilled Ponds Organic contaminants (hydrocarbons and solvents) Munitions Works Explosive Compounds and Propellants (Nitroglycerine and Picric Acid), Organic Compounds, Acids	Ingestion of tainted water supply. PL7	Human Health – End Users Water pipeline	Low likelihood	Medium	Moderate	Likely probability as significant contamination is anticipated at pipeline depth across the west and centre of the site (0.75–1.35 m). Explosive Compounds and Propellants (Nitroglycerine and Picric Acid) may be capable of permeating plastic water supply pipes. An intrusive ground investigation to confirm the presence of any contaminants is required.



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	LEVEL OF RISK	JUSTIFICATION
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
Iron Foundry, Munitions Works, Made Ground, Railway/Tramway Sidings and Oven Manufacturing Factory Phytotoxic contaminants	Direct contact (plant uptake). PL8	Flora	Low likelihood	Medium	Moderate/Low	Likely probability as contamination is considered possible, which may be taken up by flora in soft landscaping/gardens. An intrusive ground investigation to confirm the presence of any contaminants is required.
Munitions Works Explosive Compounds and Propellants	Accidental Detonation. PL9	Human Health – construction workers, end land users, and users of adjacent sites Buildings and Structures	Low likelihood	High	Moderate/High	Although the overall probability is low, due to site's historical use as a Munitions Works, there may be a significant source of Explosive Compounds and Propellants on-site which presents a potential unacceptable risk to receptors via accidental detonation. Recommended mitigation measures should include explosive ordnance safety and awareness briefings and site safety inductions during all ground investigations and remediation works. Safe working practices and sampling procedures should be implemented. Transport of samples for off-site analysis may be regulated by the Road Transport (Carriage of Explosives) Regulation 1989. Authorisation from HM Inspector of Explosives may also be required for certain investigative or redevelopment works including sampling and laboratory analysis.



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	LEVEL OF RISK	JUSTIFICATION
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
CONTROLLED WATERS						
Iron Foundry, Made Ground, Railway / Tramway Sidings, Oven Manufacturing Factory and Historical Infilled Ponds TPHs, VOCs, SVOCs Munitions Works, Primary and Secondary Explosive Compounds and Propellants, Acids, Organic Solvents, TPHs, VOCs Oven Manufacturing Factory PFAS/PFOA	Leaching of contaminants from Made Ground through infiltration and percolation of rainwater. PL5	Controlled waters, underlying Principal Aquifer	Likely	High	High	Based upon the historical mapping and initial site walkover, the presence of fuel and chemical storage tanks has been identified, which may be a significant source of TPHs, VOCs and SVOCs. The site's historical use as a Munitions Works may also be a significant source of Explosive Compounds and Propellants, Acids and Organic Solvents; all of which may impact the underlying Principal Aquifer. The current development and associated hardstanding will assist in reducing the leachate produced from contaminated soils, and therefore reduce the impact to groundwater. An intrusive ground investigation to confirm the presence of any contaminants within groundwater is required.
		Infrastructure and services	Likely	High	High	The development of proposed estate roads (hardstanding and drainage) will reduce the leachate produced from contaminated soils. Infrastructure and services shall be designed to resist chemical attack and ingress. An intrusive ground investigation to confirm the presence of any contaminants within groundwater is required.



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	LEVEL OF RISK	JUSTIFICATION
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
Groundwater TPHs, VOCs, SVOCs, Explosive Compounds and Propellants, Acids, Organic Solvents, PFAS/PFOA	Contact with contaminated groundwater. PL2	Human Health – site personnel	Unlikely	Low	Low	Shallow groundwater is not anticipated on-site and is assumed if present would be significantly lower than the construction level.
	Contaminants leached from the Made Ground and from off-site sources may be mobilised to greater distances through advective flow. PL5	Human Health – end users	Low likelihood	Medium	Moderate	Impacted groundwater could transport contaminants vertically and horizontally through permeable strata. However, the site works will not exacerbate this, and site work will be undertaken above the water table. Groundwater will need to be considered for surrounding developments.
GROUND GAS						
Ground gases Methane and Carbon Dioxide in the Made Ground Volatile Vapours associated with Tanks and Munition Works	Inhalation of ground gas. PL4	Human Health – site personnel	Low likelihood	Medium	Moderate/Low	Ground gases may migrate through permeable strata to enter proposed buildings.
	Accumulation of ground gas in confined spaces (asphyxiation or explosion)	Human Health – end users	Low likelihood	Medium	Moderate/Low	
		Infrastructure and services	Low likelihood	Medium	Moderate/Low	A period of ground gas monitoring will be required to determine the gas regime for the site.
Radon	Inhalation of ground gas. PL4	Human Health – site personnel	Unlikely	Low	Very low	Radon mapping has identified the site is not within an area at risk from radon. No radon mitigation measures will be required.
	Accumulation of ground gas in confined spaces (carcinogenic)	Human Health – end users	Unlikely	Low	Very low	



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	LEVEL OF RISK	JUSTIFICATION
SOURCES	MIGRATION PATHWAYS	RECEPTORS				

Main exposure pathways:

PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = dust inhalation; PL4 = Vapour/Gas Inhalation; PL5 = Vertical / Lateral Migration; PL6 = Corrosion of concrete; PL7=Tainting of water supply; PL8 = Uptake by plants. PL9 = Accidental Detonation.

Level of Risk

Very Low	
Low	
Low/Moderate	
Moderate	
Moderate/High	
High	



8. E3P PRELIMINARY GROUND INVESTIGATION

8.1. GENERAL OVERVIEW

A preliminary intrusive ground investigation has been designed based on the findings of the desk study, with exploratory holes advanced to target specific potential contaminant sources summarised in Section 7.0. The investigation has also been used to collect geotechnical information to assist in the design and construction of the proposed development.

Exploratory fieldwork was completed between 19th and 21st March 2024. The works are summarised in Table 21.

8.2. LIMITATIONS OF THE INVESTIGATION

As the Glen Dimplex Homes Appliances Manufacturing Factory was still active, additional considerations of exploratory hole locations were required to take account for live services, active traffic routes, and for the insurance of public safety. This rendered a large proportion of the site inaccessible, including within the footprint of the main factory structure comprising the majority of the site.

A borehole was preliminarily situated adjacent to the electricity substation towards the southern boundary of the site to test for the potential presence of PCB compounds. However, multiple live 11kV cables not recorded within statutory service plans, and an earthing mat to the south of the substation were detected during GPR surveying and utility clearance. Therefore, a sufficient easement (>5.00 m) was imposed and subsequently the borehole was moved approximately 6.00 m north from the substation. This limits the likelihood of PCBs being detected due to the significantly low mobility of the compounds and are more likely to be present within the footprint of, and immediate vicinity (>1.00 m) of the electricity substation.

8.3. SCOPE OF INVESTIGATION

A summary of the fieldwork completed are included in Table 21.

Table 21 Summary of Fieldwork

POTENTIAL SOURCE/RATIONALE	LOCATION HOLE	TYPE	MAXIMUM DEPTH (M BGL)	MONITORING WELLS RESPONSE ZONE (M BGL)
General Ground Conditions Including the Presence/Nature of Obstructions	WS101	Window Sample Borehole	5.45	1.00–1.50
	WS102		5.16	2.00–4.00
	WS104		4.42	1.30–3.30
	WS105		3.40	1.00–3.00
	WS106		4.44	0.50–1.90
	WS107		4.24	1.00–4.00
	WS110		3.40	0.50–1.00
Electricity Substation (PCBs)	WS103	Cable Percussive Borehole	5.45	0.50–1.40
Proximity to Polystyrene Manufacturing Plant	WS108		1.74	0.50–1.00
	WS109		4.31	1.00–4.00
Investigation of Deeper Soil Horizons	CP101		9.09	3.00–7.50
	CP102		9.37	3.50–9.00



Window sample boreholes were advanced to undertake in-situ detailed geotechnical testing, obtain environmental samples and install groundwater and ground gas monitoring wells.

Cable Percussive boreholes were advanced to investigate deeper strata, undertake in-situ detailed geotechnical testing, obtain environmental samples and install deep groundwater and ground gas monitoring wells.

The sampling locations are illustrated in Drawing 17-500-005 (APPENDIX IV). The ground conditions encountered are indicated on the logs, which are provided in APPENDIX VII.

The locations were surveyed by GPS to Ordnance Survey with an accuracy of < 10 mm.

Return visits were made to monitor installations for groundwater level and gas concentrations. In addition, selected wells were purged and samples of groundwater recovered for chemical analysis.

8.4. IN-SITU STANDARD PENETRATION TESTING (SPT)

In-situ geotechnical testing was conducted using the standard penetration test (SPT) and, where the ground is granular, a 60° cone (SPT(C)) was used instead of the sampling tube. The results are shown in the borehole logs in APPENDIX VII, presented in Table 40 and discussed in Section 11.0.

8.5. LABORATORY ANALYSIS

Selected soil samples were submitted for a range of chemical and geotechnical analysis, summarised in Table 22.

Table 22 Summary of Laboratory Analysis
CHEMICAL ANALYSIS

-  Metals;
-  pH, total sulphate, water-soluble sulphate (2:1 extract);
-  Sulphide;
-  Cyanide;
-  Phenols;
-  Total and speciated polycyclic aromatic hydrocarbons (PAHs);
-  Asbestos identification and quantification;
-  Speciated and banded total petroleum hydrocarbons (TPHs);
-  Total Organic Carbon (TOC);
-  Volatile Organic Compounds (VOCs);
-  Semi-Volatile Organic Compounds (SVOCs); and
-  Polychlorinated biphenyls (PCBs).



GEOTECHNICAL ANALYSIS

- ✿ Moisture content;
- ✿ Atterberg limits determinations;
- ✿ Particle size distribution (PSD);
- ✿ Single-stage triaxial tests;
- ✿ Multi-stage triaxial tests; and,
- ✿ Consolidation.

8.6. STORAGE, PRESERVATION AND TRANSPORT OF SAMPLES

Measures taken to ensure the quality and integrity of the collected samples, from collection to receipt of the samples by the laboratory, are summarised in Table 23.

Table 23 Sample Integrity Information

SUBJECT	CHEMICAL SAMPLING	
Storage	Soil	Groundwater
	Glass jars supplied by the laboratory were used for the collection of soil samples to be analysed for SVOCs, VOCs, and in a singular instance PCBs. Plastic tubs were used to collect soil samples for metals analysis, and asbestos screening.	Glass vials supplied by the laboratory were used for the collection of samples to be analysed for VOCs. Samples to be analysed for lower volatility compounds were stored in laboratory-prepared glass jars.
Preservation	Soil and groundwater sample containers were filled to minimise headspace prior to sealing and stored at a low temperature within cool boxes with cooling aids to minimise the loss of volatile contaminants and reduce microbial activity during the collection of samples.	
Sample Integrity	Soil	Groundwater
	Dedicated disposable nitrile gloves were worn and changed between sample collections to prevent cross-contamination.	Groundwater samples were collected using dedicated plastic tubing, which was changed between monitoring well locations to prevent cross-contamination.
Transport	Samples were stored and shipped in dedicated sample boxes provided by the laboratory. Sample details were recorded on the laboratory chain of custody form enclosed with the samples prior to dispatch. Scheduling information for the samples was confirmed with the laboratory via email.	

Chemical analysis has been undertaken by an accredited laboratory with the testing results summarised and discussed in Section 10 and the testing certificates included in APPENDIX VIII.

Geotechnical samples were collected as required per location immediately after excavation, labelled and sealed to minimise moisture loss. The geotechnical samples were collected and couriered by a dedicated courier to an accredited geotechnical testing laboratory. The testing results are summarised and discussed in Section 11 and the testing certificates included in APPENDIX IX.



9. GROUND AND GROUNDWATER CONDITIONS

9.1. SUMMARY OF GROUND CONDITIONS

The preliminary ground investigation generally confirms the published geology and identifies the strata set out in Table 24.

Table 24 Summary of Strata

HOLE	DEPTH TO STRATUM (M BGL)						
	MADE GROUND	SANDY CLAY	CLAYEY F-M SAND	CLAY WITH SAND POCKETS	SAND WITH CLAY POCKETS	SAND AND GRAVEL	BEDROCK
WS101	0.00–1.70	3.00–4.10	1.70–3.00	4.10–5.45	–	–	–
WS102	0.00–0.70	0.70–5.16	–	–	–	–	–
WS103	0.00–1.40	3.00–5.45	–	–	1.40–3.00	–	–
WS104	0.00–1.30	1.60–4.42	1.30–1.60	–	–	–	–
WS105	0.00–0.60	–	–	0.60–3.40	–	–	–
WS106	0.00–1.90	–	2.00–4.44	1.90–2.00	–	–	–
WS107	0.00–0.70	–	0.70–0.90	0.90–4.00	–	–	4.00–4.24
WS108	0.00–1.74	–	–	–	–	–	–
WS109	0.00–0.90	–	0.90–4.00	–	–	–	4.00–4.31
WS110	0.00–1.10	2.20–3.40	–	1.10–2.20	–	–	–
CP101	0.00–2.70	2.70–8.70	–	–	–	–	8.70–9.09
CP102	0.00–3.00	3.50–9.00	–	–	–	3.00–3.50	9.00–9.37

9.2. MADE GROUND

Made Ground deposits were encountered within all exploratory hole locations to depths of between 0.00 m and in excess of 3.00 m bgl although, in general, Made Ground was encountered to a depth of less than 1.50 m bgl.

Made Ground deposits were varied across the site, however all generally comprised concrete in the upper 300 mm in the majority of locations. The exception of this was WS104–WS106 which encountered asphalt within the upper 150 mm of the boreholes as they were situated in the car park.

Typically, the concrete or asphalt was underlain by a slightly clayey sandy gravel, with gravel of brick, concrete, mudstone, limestone, coal and slag with rare fragments of glass, plastic, and timber in some locations. These deposits were encountered from 0.15–0.80 m bgl, and were typically overlaying a reworked gravelly clay, with gravel of brick, sandstone, mudstone and in rare instances coal to a maximum proven depth of 3.00 m bgl (CP102).

Hydrocarbon odours were noted within six locations (summarised in

Table 26), situated across the site within the Made Ground deposits. The depths the hydrocarbon odour was encountered ranged from 0.50–1.90 m bgl (WS106) and was typically noted within a reworked very gravelly clay with gravel of sandstone, mudstone, concrete, ash, and slag.

A Depth of Made Ground Plan is presented as Drawing 17-500-006 in APPENDIX IV.



9.3. SUPERFICIAL DEPOSITS

Superficial deposits were encountered within all exploratory locations, with the superficial deposits varying across the site. The most common stratum recorded was an orangish brown sandy gravelly CLAY with gravel of sandstone, mudstone, and instances of coal and quartz. Typically, the CLAY was locally interbedded with an orange very clayey fine to medium SAND from 0.70–4.44 m bgl.

In five locations, a very sandy CLAY with pockets of orange fine to medium SAND was noted, which was typically towards the east, with the exception of WS107 which recorded this stratum from 0.90–4.00 m bgl.

In CP102, a band of SAND and GRAVEL approximately 500 mm thick was recorded from 3.00–3.50 m bgl, with gravel of sandstone. This was in turn underlain by the orange-brown mottled sandy gravelly CLAY from 3.50–9.00 m bgl.

A rare band of clayey fine to medium SAND with pockets of grey CLAY was noted in WS103, from 1.40–3.00 m bgl.

9.4. BEDROCK GEOLOGY

The bedrock geology was encountered between 4.00–9.37 m bgl during the preliminary ground investigation as highly weathered SANDSTONE recovered as a red very gravelly medium to coarse SAND.

Generally, bedrock was encountered at shallower depths (<5.00 m bgl) towards the north of the site, in WS107 and WS109, deepening to 9.00 m bgl towards the south of the site (CP101 and CP102).

A Depth to Bedrock Plan is presented as Drawing 17-500-012 in APPENDIX IV.

9.5. GROUNDWATER

Groundwater strikes were encountered as seepages. The depth of the seepages are shown on the exploratory hole records in APPENDIX VII and are summarised in Table 25.

Table 25 Summary of Groundwater Strikes

LOCATION	DEPTH TO STRIKE (M)	NOTES
WS104	1.00	Seepage
CP101	3.50	Seepage
CP101	7.00	Seepage

Monitoring was undertaken using an electronic dip meter to record the depth to groundwater, if present in environmental monitoring wells. These results are summarised in Table 34.

9.6. VISUAL AND OLFACTORY EVIDENCE OF CONTAMINATION

Visual and olfactory evidence of potential contamination has been identified during the preliminary ground investigation and these are summarised in Table 26.

Table 26 Summary of Visual and Olfactory Evidence of Contamination

LOCATION	DEPTH (M)	STRATUM	NOTES
WS101	1.20–1.70	MADE GROUND	Slight Hydrocarbon Odour



LOCATION	DEPTH (M)	STRATUM	NOTES
WS102	0.50–0.70	MADE GROUND	Slag and ash inclusions
WS102	0.70–1.30	Natural CLAY	Strong Hydrocarbon Odour
WS103	0.70–1.40	Natural SAND	Strong Hydrocarbon Odour
WS105	0.15–0.60	MADE GROUND	Slag
WS106	0.30–0.70	MADE GROUND	Slag and ash inclusions
WS106	0.70–1.90	MADE GROUND	Slight Hydrocarbon Odour, slag and ash inclusions.
WS110	0.10–1.10	MADE GROUND	Strong Hydrocarbon Odour

9.7. OBSTRUCTIONS

Obstructions were identified in several locations across the site, with their positions summarised in Table 27, marked on the Development Constraints Plan (Drawing 17-500-015, APPENDIX IV).

Table 27 Summary of Obstructions

LOCATION	DEPTH (M)	STRATUM	NOTES
WS108	1.74	Made Ground	Potential Concrete Slab



10. TIER 2 QUALITATIVE CONTAMINATED LAND RISK ASSESSMENT

E3P has undertaken a Tier 2 qualitative land risk assessment with respect to human health, controlled waters and ground gas to determine if any potential contaminants within the underlying soils and groundwater pose an unacceptable level of risk to the identified receptors.

10.1. SAMPLE ANALYSIS POPULATION

Table 28 summarises the chemical analysis testing scheduled.

It is noted that analysis for PFAS/PFOA, Explosive Compounds and Propellants has not been undertaken at this stage of intrusive ground investigation due to restricted access to the main factory structure's interior (i.e. where the potential sources may be located). Analysis for PFAS/PFOA, Explosive Compounds and Propellants in soils and groundwater will be undertaken during further stages of intrusive ground investigation once access to the interior of the main factory structure can be obtained.

Table 28 Summary of Testing Schedule

TYPE OF SAMPLE	NO. OF SAMPLES	DETERMINANDS
MADE GROUND: Ash and Clinker	8	Speciated PAH, pH, total metals, asbestos ID, TOC, Banded TPHs
	3	Leachable metals and PAHs
MADE GROUND: Hydrocarbon Odours	6	VOCs, SVOCs.
Natural CLAY	4	Speciated PAH, total metals, Banded TPHs
Natural SAND	1	Speciated PAH, total metals, Banded TPHs, VOCs, SVOCs

10.2. HUMAN HEALTH RISK ASSESSMENT

At Tier 2 stage, the long term (chronic) human health toxicity of the soil has been assessed by comparing the on-site concentrations of organic and inorganic compounds with reference values published in LQM/CIEH S4UL (S4UL3267).

Where Tier 2 screening values are not provided by LQM, other screening values have been used and these are referenced in Table 29.

The Tier 2 screening values for residential with plant uptake have been utilised for this assessment due to the proposed development being a residential end use. To remain conservative at an early stage, the screening values based on a 1% SOM have been utilised for this assessment.

The results of the comparison have been summarised in Table 29.



Table 29 Summary of Inorganic and Hydrocarbon Toxicity Assessment for a Residential End Use (with plant uptake)

DETERMINANT	UNIT	GAC	N	MC	LOC. OF EX	PL	ASSESSMENT
Arsenic	mg/kg	37	13	67	WS110 0.70 m	1	Further Action
Cadmium	mg/kg	11	13	0.65	N/A	1	No Further Action
Chromium (VI)	mg/kg	6.0	13	< 0.50	N/A	1	No Further Action
Lead	mg/kg	200**	13	690	WS108 1.30 m	1	Further Action
Mercury	mg/kg	1.2	13	0.27	N/A	4	No Further Action
Nickel	mg/kg	130	13	170	WS110 0.70 m	1	Further Action
Selenium	mg/kg	250	13	1.1	N/A	1	No Further Action
Copper	mg/kg	2400	13	280	N/A	1	No Further Action
Zinc	mg/kg	3700	13	330	N/A	1	No Further Action
Cyanide – Total	mg/kg	791	13	<0.50	N/A	1	No Further Action
Phenols – Total	mg/kg	120	6	< 0.1	N/A	1	No Further Action
Asbestos	Fibres	NFD	6	NFD	N/A	3	No Further Action
Naphthalene	mg/kg	2.3	13	0.53	N/A	4	No Further Action
Acenaphthylene	mg/kg	170	13	<0.10	N/A	2	No Further Action
Acenaphthene	mg/kg	210	13	<0.10	N/A	1	No Further Action
Fluorene	mg/kg	170	13	<0.10	N/A	1	No Further Action
Phenanthrene	mg/kg	95	13	1.20	N/A	2	No Further Action
Anthracene	mg/kg	2400	13	0.30	N/A	2	No Further Action
Fluoranthene	mg/kg	280	13	1.9	N/A	2	No Further Action
Pyrene	mg/kg	620	13	1.6	N/A	2	No Further Action
Benzo(a)Anthracene	mg/kg	7.2	13	0.77	N/A	2	No Further Action
Chrysene	mg/kg	15	13	0.78	N/A	2	No Further Action
Benzo(b)Fluoranthene	mg/kg	2.6	13	1.1	N/A	2	No Further Action
Benzo(k)Fluoranthene	mg/kg	77	13	0.42	N/A	2	No Further Action
Benzo(a)Pyrene	mg/kg	2.2	13	0.78	N/A	2	No Further Action
Indeno(123-cd)Pyrene	mg/kg	27	13	0.50	N/A	2	No Further Action
Dibenzo(a,h)Anthracene	mg/kg	0.24	13	0.14	N/A	2	No Further Action
Benzo(ghi)Perylene	mg/kg	320	13	0.21	N/A	2	No Further Action
TPH C6-C8 (aliphatic)*	mg/kg	100	13	< 1.0	N/A	4	No Further Action
TPH C8-C10 (aliphatic)*	mg/kg	27	20	< 1.0	N/A	4	No Further Action
TPH C10-C12 (aromatic)*	mg/kg	74	20	3.9	N/A	4	No Further Action
TPH C12-C16 (aromatic)*	mg/kg	140	20	25	N/A	4	No Further Action
TPH C16-C21 (aromatic)*	mg/kg	260	20	160	N/A	1	No Further Action
TPH C21-C35 (aromatic)*	mg/kg	1100	20	170	N/A	1	No Further Action
Total PCBs	mg/kg	-	1	< 0.10	N/A	1	No Further Action
Trichloroethene (TCE)	mg/kg	0.0016	5	1.1	WS101 1.30 m WS102 0.90 m WS102 1.40 m WS103 0.80 m WS103 0.60 m	4	Further Action
cis 1,2-Dichloroethene	mg/kg	0.11***	5	4.6	WS102 0.90 m WS102 1.40 m WS103 0.80 m WS103 0.60 m	4	Further Action
Trans 1,2-Dichloroethene	mg/kg	0.19***	5	0.12	WS102 0.90 m WS103 0.80 m	4	Further Action
1,1-Dichloroethene	mg/kg	2.4***	5	0.0035	N/A	4	No Further Action
Vinyl Chloride	mg/kg	0.00064	5	0.017	WS102 0.90 m WS102 1.40 m	4	Further Action
Ethylbenzene	mg/kg	47	5	0.0031	N/A	4	No Further Action
Toluene	mg/kg	130	5	0.0034	N/A	4	No Further Action
o-Xylene	mg/kg	60	5	0.0021	N/A	4	No Further Action

Notes

PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = dust inhalation; PL4 = Vapour/Gas Inhalation

Abbreviations: GAC = general assessment criteria, N = number of samples, MC = maximum concentration; Loc of Ex = location of exceedance; PL = Contaminant Pathway; NFD = no fibres detected.

The pathway noted in the table is the primary pathway, however it may not be the only pathway of that contaminant



* The Tier 2 GAC for the hydrocarbon fraction is derived from the CIEH assessment for petroleum hydrocarbons Criteria Working Group (CWG) for both aliphatic and aromatic compounds. E3P has utilised the Tier 2 values for aliphatic compounds for the volatile and semi volatile fractions (C5-C12) and the Tier 2 values for aromatic compound for the non-volatile fractions (C12-C35). The comparison of a total (aliphatic/aromatic) compounds to an individual fraction is considered to be a conservative approach and satisfactory for the protection of human health.

**The Tier 2 GAC for lead has been taken from CL:AIRE C4SL.

*** The Tier 2 GAC for Dichloroethene (cis 1,2-Dichloroethene, Trans 1,2-Dichloroethene and 1,1-Dichloroethene) has been taken from CL:AIRE GAC.

Referring to Table 29, the result of this direct comparison indicates that the data exceeds the screening criteria for a residential end use for the following contaminants:

Inorganics

- ✳ Arsenic
- ✳ Lead
- ✳ Nickel

Organics

- ✳ Trichloroethene (TCE)
- ✳ cis 1,2-Dichloroethene
- ✳ Trans 1,2-Dichloroethene
- ✳ Vinyl Chloride

The soil in WS103 was tested for PCBs due to the proximity to an electricity substation. No PCBs exceeding the GAC screening values were recorded, however due to live services the samples were taken >5.00 m from the electricity substation. Therefore, due to the low mobility of PCB compounds, further investigation and testing of soils within the footprint of the substation are recommended following decommission of live services.

Significant concentrations of VOCs were identified in both the natural and MADE GROUND samples within the soils towards the south of site submitted for chemical analysis.

10.2.1. EXPOSURE PATHWAYS

The main exposure pathways based on the Tier 2 exceedances are:

- ✳ Soil ingestion (PL1);
- ✳ Vapour inhalation (indoor) (PL4);
- ✳ Dermal contact and ingestion (PL2); and
- ✳ Consumption of homegrown vegetables (PL1)



10.2.2. HUMAN HEALTH RISK ASSESSMENT AND MITIGATION

Inorganic Heavy Metals

All of the identified elevated concentrations have primary exposure pathways related to dermal contact and ingestion of soils (PL2), inhalation of particulate (PL3) and consumption of homegrown vegetables (PL1). All three instances of exceedances of inorganic heavy metals were identified within the Made Ground deposits in the upper 1.30 m bgl of the ground, predominantly towards the north of the site. Further investigation following the demolition of the structure is required to understand the potential extent of exceedances of inorganic heavy metals to infer a suitable mitigation measure.

Based on the present known exceedances of the GACs and risks to chronic human health associated with the elevated concentrations of inorganic heavy metal compounds, these can be mitigated through the installation of a suitable cover system in all proposed private gardens, landscaping and public open space to remove any potential for direct exposure to impacted soils.

The specific design and installation process for the appropriate cover systems will be clearly defined within the site remediation and enabling works strategy.

Volatile Organic Compounds (VOCs)

Localised areas of elevated Trichloroethene (TCE), Dichloroethene (cis 1,2-Dichloroethene, and Trans 1,2-Dichloroethene), and Vinyl Chloride have been identified within soils in three locations (WS101 to WS103) across the southern boundary of the site, directly to the south of the main factory structure. It is noted that WS102 and WS103 are located within the immediate vicinity of the enamel slurry waste storage area, located to the southeast of the main factory structure. As such, the enamel slurry waste storage area may be the potential source of these exceedances.

These elevated compounds present a primary exposure pathway linked to the potential volatilisation to indoor air risk, in addition to exposure pathways of dermal contact and ingestion of soils (PL2) and consumption of homegrown vegetables (PL1) within impacted areas.

Furthermore, the identified VOC exceedances are known to be highly mobile, presenting a risk of further migration of Trichloroethene (TCE) which is known to subsequently degrade into Dichloroethene (cis 1,2-Dichloroethene and Trans 1,2-Dichloroethene), and Vinyl Chloride. As the final degradation product (Vinyl Chloride) has only been identified within WS102, it is assumed at this stage of testing that WS102 is the likely source of TCE, which is subsequently migrating to WS101 and WS103, which is further degrading into Dichloroethene in the latter location.

Further investigation and subsequent testing will be required in order to determine the spatial extent of the VOC contamination identified within the soils across the southern boundary of the site and to understand whether leaching has occurred into the underlying natural strata, particularly in WS101 and WS103 where exceedances were only recorded within Made Ground Deposits.

If the enamel slurry waste storage area is deemed to be the source, removal of the impacted material is required to mitigate any further migration and degradation of TCE into further areas of the site.

Subject to the findings of further phases of intrusive ground investigation, further assessment in the form of a Detailed Quantitative Risk Assessment (DQRA) may also be required.



Asbestos

No asbestos contamination was identified within any samples submitted for laboratory testing; however the fabric of the current main factory structure is known to contain asbestos throughout.

Following demolition of the main factory structure, further investigation and subsequent testing is recommended in order to obtain representative soil samples of the underlying strata and determine whether the underlying soils are impacted with asbestos.

If Asbestos fibres are encountered, a primary exposure pathway of inhalation of fibres (PL3) would be presented to site personnel and end users. Impacted soils should be managed according to the asbestos risk mitigation conceptual site model shown in Figure 8.

Figure 8 Asbestos Risk Mitigation Conceptual Site Model



Notes

ND None Detect

0.001% Soils may contain $\leq 0.001\%$ asbestos using composite testing to ensure there is no potential risk to human health. This value is present within areas where there may be a short-term low-level exposure of soils containing trace asbestos fibres by construction workers where an appropriate level of asbestos management is employed (dust suppression)

0.1% Soils at a depth of >1.00 m bgl may contain $<0.1\%$ asbestos using composite testing where they will not be likely to be disturbed in the future and will therefore be in an area of low sensitivity. Risk assessment completed in accordance with Asbestos JIWG risk assessment tools.

Undefined- this will be dependent upon soils encountered during earthworks, which may be placed at these depths to ensure no potential risk to human health.

PFAS/PFOA

The site is considered to be at a moderate risk from PFAS/PFOA contamination, due to the sites historical and current use as an oven manufacturing factory.

Due to the active nature of the site and the limited volume of material available to be collected from individual exploratory hole locations, PFAS/PFOA testing within the soils could not be completed during this phase of intrusive ground investigation.



Further investigation and subsequent testing will be required to confirm the presence or absence of PFAS/PFOA compounds within both the soils and groundwater within the footprint of the main factory structure.

PFAS/PFOA poses a significant human health risk if found to be present, which will require further sampling of soil and groundwater to understand the potential extent of compounds if found to be present within any ground materials on-site.

Explosive Compounds and Propellants

The site is considered to be at a moderate risk of contamination from Explosive Compounds and Propellants, due to the sites historical use as a Munitions Works during the First and Second World Wars.

Due to the active nature of the site and the limited volume of material available to be collected from individual exploratory hole locations, testing for Explosive Compounds and Propellants within the soils could not be completed during this phase of intrusive ground investigation.

Further investigation and subsequent testing will be required to confirm the presence or absence of Explosive Compounds and Propellants within both the soils and groundwater within the footprint of the main factory structure.

Explosive Compounds and Propellants poses a significant human health risk if found to be present, which will require further sampling of soil and groundwater to understand the potential extent of compounds if found to be present within any ground materials on-site.

Safe working practices and sampling procedures are essential for the analysis of soils from explosive sites. If contamination is anticipated to be significant, transport of samples for off-site analysis may be regulated by the Road Transport (Carriage of Explosives) Regulation 1989. Authorisation from HM Inspector of Explosives may also be required for certain investigative or redevelopment works including sampling and laboratory analysis.

Natural Strata

Chemical analysis of the natural clay superficial deposits has identified these soils to be acceptable for use as subsoil within the proposed garden areas; however, further chemical samples will be required in areas not investigated to meet regulatory sampling frequency. There are no suitable sources of topsoil available on the site.

A Human Health Contamination Issues Plan is presented as Drawing 17-500-026 in APPENDIX IV.

10.3. CONTROLLED WATERS RISK ASSESSMENT

E3P has undertaken a controlled waters risk assessment for the site based on the consideration of the conceptual site model and the sensitive receptors which are summarised in Table 30.

Table 30 Controlled Waters Conceptual Model and Sensitivity Profile

DISCUSSION	SENSITIVITY RATING
Contaminant Source MADE GROUND Heavy metal and VOC contamination has been identified within Made Ground infill materials, with the heavy metals recorded towards the north and VOCs identified towards the south. Variable Made Ground with high-level (predominantly low-solubility in water; LQM/CIEH 2014) VOC impact is present throughout the Made Ground which has subsequently leached into underlying natural deposits to a depth of 1.40 m bgl.	High

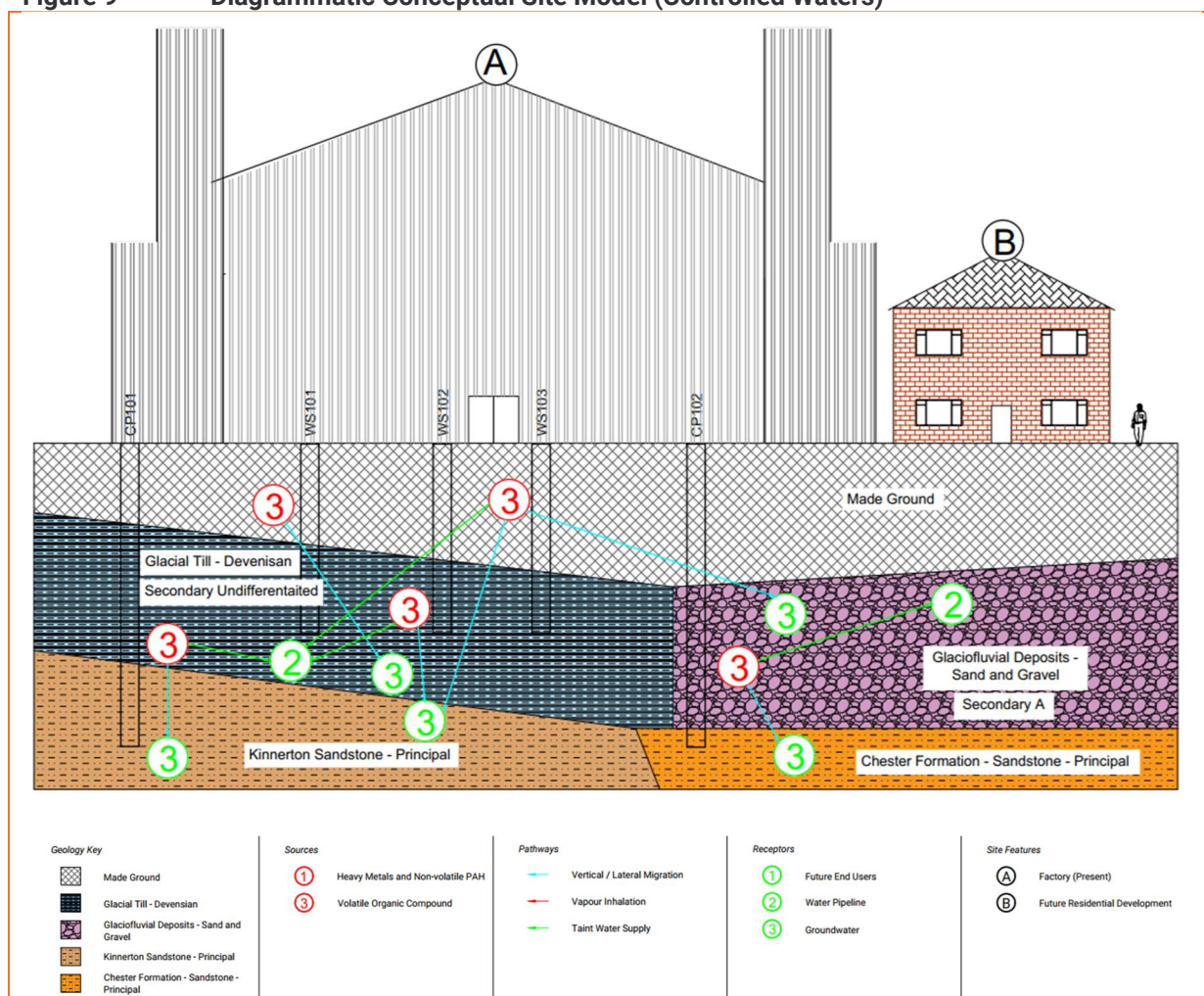


DISCUSSION		SENSITIVITY RATING
OVEN FACTORY The oven manufacturing factory is situated in the centre of the site and a known enamel slurry waste storage area is located towards the southeast of the site, adjacent to WS103. Due to the industrial usage of the site, significant potential sources of VOCs and SVOCs are anticipated which may leach into the underlying ground within areas of below ground tanks.		High
Pathway		
Vertical Migration The majority of the site is underlain by low permeability superficial deposits which will offer some protection to the underlying aquifer and inhibit vertical migration of any contaminants towards the underlying principal aquifer. However, towards the north of the site, shallow bedrock (<5.00 m bgl) was encountered, therefore these areas are at increased risk of vertical migration as a sufficient clay aquitard is not present to afford protection to the underlying principal aquifer.		High
Lateral migration Lateral migration of contaminants is considered possible due to the presence of granular alluvium deposits across the site. However, the majority of identified deposits consist of low permeability CLAY therefore reducing the overall likelihood of lateral migration.		Medium
Receptor		
Aquifer Classification in Superficial Deposits	Secondary Undifferentiated aquifer and Secondary A aquifer (eastern sector)	Medium
Aquifer Classification in Bedrock	Principal aquifer	High
Groundwater Source Protection Zone or Drinking Water Safeguard Zone	The site is situated within a Source Protection Zone 3 – therefore the total area needed to support the abstraction or discharge from the protected groundwater source.	High
Distance to the Closest Groundwater Abstraction Point	An active groundwater abstraction point located 16 m SE of the site, pertaining to Elis UK Ltd and used for laundry purposes. This increases the sensitivity of the underlying aquifer.	High
Is the site Located Within 50 m of a Surface Watercourse?	No surface watercourses are situated within 50 m of the site boundary.	Low
The ICSM developed within the context of the site setting has viable pollutant pathway, which would be the downward migration of potentially mobile phase-soluble contaminants towards the underlying principal aquifer.		

In addition to above, E3P has developed a diagrammatic controlled waters conceptual model which considers the factors in Table 30. This is presented as Drawing 17-500-027 in APPENDIX IV and a snapshot is included in Figure 9.



Figure 9 Diagrammatic Conceptual Site Model (Controlled Waters)



The Tier 2 assessment in line with LCRM (2023) has included a comparison of leachate analysis from samples of the Made Ground and groundwater samples to drinking water standards (DWS).

DWS will be viewed as a priority given the highly sensitive underlying aquifer and the lack of surface receptors in proximity for EQS, however where there are no regulatory guidance values for DWS, the EQS thresholds will be utilised in their absence.

These are presented in Table 31.

Water samples were obtained utilising a bailer. During the second water sampling visit, a full bailer was inspected for light non-aqueous phase liquid (LNAPL) or dense non-aqueous phase liquids (DNAPL) due to the identified volatile organic compound contamination identified towards the south of the site within soils. However, no visible indicators of LNAPL/DNAPL were identified from the sampled environmental monitoring wells.



Table 31 Comparison of Groundwater and Leachate Analysis with Tier 2 Screening Levels

DETERMINAND	UNIT	DWS _{3,4}	NO. OF GW SAMPLES	MAX CONC. IN GROUNDWATER	LOCATION OF EXCEEDANCE	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
Arsenic	µg/l	10	8	3.6	N/A	3	5.2	N/A	No Further Action
Cadmium	µg/l	5	8	0.31	N/A	3	0.51	N/A	No Further Action
Chromium (VI)	µg/l	–	8	< 20	N/A	3	< 20	N/A	No Further Action
Chromium (III)	µg/l	50	8	0.89	N/A	3	10	N/A	No Further Action
Copper	µg/l	2000	8	2.6	N/A	3	15	N/A	No Further Action
Total Cyanide	µg/l	50	8	< 0.0050	N/A	3	< 0.0050	N/A	No Further Action
Lead	µg/l	10	8	< 0.50	N/A	3	4.8	N/A	No Further Action
Mercury	µg/l	1.0	8	< 0.010	N/A	3	< 0.05	N/A	No Further Action
Nickel	µg/l	20	8	29	CP101	3	7.9	N/A	Further Action
Selenium	µg/l	10	8	1.3	N/A	3	1.7	N/A	No Further Action
Zinc	µg/l	–	8	13	N/A	3	14	N/A	No Further Action
pH	–	6–9	8	5.7	CP101	3	8.0	N/A	Further Action
Polycyclic Aromatic Hydrocarbons									
Naphthalene	µg/l	10*	8	< 0.50	N/A	3	< 0.010	N/A	No Further Action
Anthracene	µg/l	10*	8	< 0.50	N/A	3	< 0.010	N/A	No Further Action
Benzo[b]fluoranthene	µg/l	10*	8	< 0.50	N/A	3	< 0.010	N/A	No Further Action
Benzo[k]fluoranthene	µg/l	10*	8	< 0.50	N/A	3	< 0.010	N/A	No Further Action
Benzo(a)pyrene	µg/l	10*	8	< 0.50	N/A	3	< 0.010	N/A	No Further Action
Indeno(123-cd)pyrene	µg/l	10*	8	< 0.50	N/A	3	< 0.010	N/A	No Further Action
Fluoranthene	µg/l	10*	8	< 0.50	N/A	3	< 0.010	N/A	No Further Action
Benzo(ghi)perylene	µg/l	10*	8	< 0.50	N/A	3	< 0.010	N/A	No Further Action
Aromatic Hydrocarbon									
TPH C5-C7 (benzene)	µg/l	1	8	8.0	WS102	3	< 0.10	N/A	Further Action
TPH C7-C8 (toluene)	µg/l	700	8	18	N/A	3	< 0.10	N/A	No Further Action
TPH C8-C10	µg/l	300	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action



DETERMINAND	UNIT	DWS _{3,4}	NO. OF GW SAMPLES	MAX CONC. IN GROUNDWATER	LOCATION OF EXCEEDANCE	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
(xylene)									
TPH C10-C12 (naphthalene)	µg/l	90	8	< 5.0	N/A	3	< 0.10	N/A	No Further Action
TPH C12-C16	µg/l	90	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action
TPH C16-C35	µg/l	90	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action
Aliphatic Hydrocarbon									
TPH C5-C6	µg/l	1000 ⁵	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action
TPH C6-C8	µg/l	1000 ⁵	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action
TPH C8-C10	µg/l	300	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action
TPH C10-C12	µg/l	300	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action
TPH C12-C16	µg/l	300	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action
TPH C16-C21	µg/l	300**	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action
TPH C21-C35	µg/l	300**	8	< 0.10	N/A	3	< 0.10	N/A	No Further Action
Volatile Organic Compounds									
Tetrachloroethene	µg/l	10	8	5.3	N/A	–	–	–	No Further Action
Trichloroethene (TCE)	µg/l	10	8	>10 000	WS102 WS103 WS107 CP101 CP102	–	–	–	Further Action
Trichlorobenzene	µg/l	–	8	< 10	–	–	–	–	No Further Action
Trichloromethane	µg/l	–	8	< 1.0	N/A	–	–	–	No Further Action
Dichloromethane	µg/l	200	8	< 1.0	N/A	–	–	–	No Further Action
Cis 1,2-Dichloroethene	µg/l	–	8	> 10 000	WS102 WS103 WS107	–	–	–	Further Action



DETERMINAND	UNIT	DWS 3,4	NO. OF GW SAMPLES	MAX CONC. IN GROUNDWATER	LOCATION OF EXCEEDANCE	NO. OF LEACHATE SAMPLES	MAX CONC. IN LEACHATE	LOCATION OF EXCEEDANCE	ASSESSMENT
					CP101 CP102				
Trans 1,2-Dichloroethene	µg/l	–	8	150	WS102 CP102	–	–	–	Further Action
1,1-Dichloroethene	µg/l	–	8	27	WS102 CP102	–	–	–	Further Action
Vinyl Chloride	µg/l	0.3	8	>10 000	WS102 WS103 WS107 CP102	–	–	–	Further Action



10.3.1. CONTROLLED WATER RISK ASSESSMENT AND MITIGATION

This comparison indicates that the data exceeds the DWS values for the following inorganic compounds:

- ✳ Nickel;
- ✳ pH;
- ✳ TPH C5-C7 (Benzene);
- ✳ Trichloroethene (TCE);
- ✳ Cis 1,2-Dichloroethene;
- ✳ Trans 1,2-Dichloroethene;
- ✳ 1,1-Dichloroethene; and
- ✳ Vinyl chloride.

In relation to the elevated Nickel and pH, these were only found to be elevated against DWS thresholds in CP101 groundwater samples.

No exceedances of the DWS thresholds were identified within any of the tested leachate samples.

In relation to the VOC exceedances, Table 32 provides a summary. Where multiple data from a singular well groundwater monitoring data has been obtained (WS102, WS107, CP101), the largest concentration over the two visits has been recorded below.

Table 32 Summary of Elevated Contaminants in Groundwater

CONTAMINANT	CONTAMINANT SOURCE				
	WS102 (µG/L)	WS103 (µG/L)	WS107 (µG/L)	CP101 (µG/L)	CP102 (µG/L)
TPH C5–C7 (Benzene)	8	–	–	–	–
Trichloroethene (TCE)	>10,000	27	20	2.1	6900
1,1-Dichloroethene	18	–	–	–	27
Trans 1,2-Dichloroethene	190	–	–	–	73
Cis 1,2-Dichloroethene	>10,000	38	12	3.7	9600
Vinyl Chloride	6100	3.4	1.3	–	400

PFAS/PFOA

The site is considered to be at a moderate risk from PFAS/PFOA contamination, due to the sites historical and current use as an oven manufacturing factory.

Due to the active nature of the site and the limited volume of groundwater available to be collected within individual exploratory hole locations, PFAS/PFOA testing of the groundwater could not be completed during this phase of intrusive ground investigation.

Further investigation and subsequent testing will be required to confirm the presence or absence of PFAS/PFOA compounds within both the soils and groundwater within the footprint of the main factory structure.



PFAS/PFOA poses a significant risk to controlled waters if found to be present, which will require further sampling of soil and groundwater to understand the potential extent of compounds if found to be present within any ground materials on-site.

Explosive Compounds and Propellants

The site is considered to be at a moderate risk of contamination from Explosive Compounds and Propellants, due to the sites historical use as a Munitions Works during the First and Second World Wars.

Explosive Compounds and Propellants are generally only sparingly soluble in water and therefore of fairly low mobility. However, nitroglycerine is more soluble in water, may be significantly more mobile and may migrate considerable distances from the source of contamination. The lack of mobility in the majority of particulate explosive compounds and propellants (TNT, RDX, HMX, Teteryl, etc) may mean that absorbed materials provide an on-going source of groundwater contamination owing to desorption and continuous leaching during rainfall, though this will be reduced due to the presence of hardstanding across the majority of site.

Due to the active nature of the site and the limited volume of groundwater available to be collected within individual exploratory hole locations,, testing for Explosive Compounds and Propellants within the soils could not be completed during this phase of intrusive ground investigation.

Further investigation and subsequent testing will be required to confirm the presence or absence of Explosive Compounds and Propellants within both the soils and groundwater within the footprint of the main factory structure.

Explosive Compounds and Propellants pose a significant risk to controlled waters if found to be present, which will require further sampling of soil and groundwater to understand the potential extent of compounds if found to be present within any ground materials on-site.

10.3.2. DISCUSSION OF CONTROLLED WATERS RISK ASSESSMENT

Historically, the site has been subjected to extensive infilling and a number of industrial uses including an Iron Foundry and Oven Manufacturing Factory which, at the time of writing the report is still present and active. Chemical by-products of manufacturing processes and compounds within the Made Ground may have subsequently leached down into underlying ground and contaminated groundwater both within Made Ground and natural superficial deposits.

The site is underlain by a mixed geology, generally cohesive clay in the south of the site with discrete areas of interbedded cohesive and granular materials towards the north. The granular deposits will afford less protection to the underlying principal aquifer in the bedrock in comparison to the remainder of the site, where generally clay deposits are anticipated to, or proven in excess of 5.00 m in areas. Furthermore, towards the northern sector of the site, bedrock was encountered at lesser depths (<5.00 m bgl), which further increases the risk of vertical migration of compounds towards the underlying bedrock aquifer as a result of cohesive material is not present within suitable quantities to afford protection to the underlying aquifer.

The site is also situated within a Source Protection Zone 3, which further increases the sensitivity of the underlying aquifer. Overall, it is deemed the Principal Bedrock Aquifer is deemed to be at a high risk to on-site contamination, particularly in the north of the site, as extensive sources of contamination and potential pathways (vertical migration) have been established.

Widespread Trichloroethene (TCE), Dichloroethene (cis 1,2-Dichloroethene, and Trans 1,2-Dichloroethene), and Vinyl Chloride contamination and localised heavy metal exceedances have been identified in the groundwater analysis at the site.



It is noted that where there are exceedances of VOCs in soils, exceedances in groundwater were often recorded. Therefore, it is considered that there is a likely on-site source of contamination which may be leaching across the site and into the underlying groundwater, and subsequently the principal aquifer.

Based upon the significantly higher concentrations of VOCs recorded within two sets of groundwater samples within WS102, and in addition to a larger number of different compounds recorded, WS102 is considered the most likely point-source of contamination which is subsequently leaching into the surrounding areas. Based upon the location of WS102, and the identified visual/olfactory impact within both the natural and MADE GROUND deposits, it is assumed the contamination is leaching from the main factory structure and the enamel slurry waste storage area located to the north / northeast of the borehole.

A plume of Trichloroethene (TCE), Dichloroethene variants, and Vinyl Chloride has been identified within groundwater monitoring data, extending from WS107 towards the northwestern entrance of the site, through to CP102 towards the southeast of the factory. No groundwater samples were obtained from WS101, as the environmental monitoring well did not contain enough groundwater for laboratory testing, however as exceedances of the known Trichloroethene, Dichloroethene variants, and Vinyl Chloride were identified within the soil testing, it is considered likely groundwater within the vicinity of WS101 will be contaminated with the aforementioned VOCs. It is noted that concentrations of VOCs were significantly higher in deeper groundwater monitoring wells, which suggests the plume is formed of DNAPL.

A Groundwater Contamination Issues Plan is presented as Drawing 17-500-018 in APPENDIX IV.

The groundwater flow plan (Drawing 17-500-029) shows that, in general, groundwater is flowing in a south-westerly direction. When consulting the cross section plans of the site (APPENDIX IV) it can be seen that groundwater levels range between 58.00 m AOD in the northeast and 54.00 m AOD in the southwest. At present, the cross sections show that the groundwater flows through both Made Ground and natural deposits at the site, particularly in the south of the site. This is potentially allowing for the dispersion of the identified elevated contaminants within the groundwater.

The site is currently an industrial factory building, with extensive hardstanding surface cover, rainfall is currently being intercepted which limits the potential for additional mobilisation of the identified contaminants.

The proposed development will create hardstanding cover across the site, thus reducing the amount of infiltration generated. This will in turn, reduce the amount of contaminants present in leachate off the site and reduce the risk further to the underlying aquifer. Given that the majority of the site is underlain by low permeability clay, the leaching of contaminants in this sector will be significantly reduced as the Made Ground will be contained beneath the impermeable surface covering, with the exception of garden areas, and above the natural clay aquitard.

Principal Aquifer

Site wide Trichloroethene (TCE), Dichloroethene variants, and Vinyl Chloride impact has been identified with the soils and groundwaters across the site.

The Tier 2 assessment has identified multiple exceedances of VOCs and a localised TPH (Benzene) in the groundwater samples. To remove the risk of vertical migration into the aquifer, a process of hotspot removal and/or treatment may be applied during remediation works within the locations where the elevated VOCs have been identified (WS102, WS103, WS107, CP101, CP102). As a result of this exercise, the source and further leaching potential of the soil would be removed.

The Tier 2 assessment shows elevated VOCs, against DWS values, on a site wide basis. These contaminants may leach vertically through soils, into the underlying aquifer which is recorded at depths <10.00 m bgl. Specialist remediation works and deep groundwater monitoring wells will be required in order to treat the DNAPL plume. A Controlled Waters DQRA is also recommended.



Given the significantly elevated concentrations of the VOC impact within both shallow and the deeper groundwater wells (CP101, CP102) in the south of the site, stabilisation of material may be required to stabilise the impacted soils and ensure no long-term risk to the wider environs.

It must be noted that no environmental monitoring wells have been advanced into the principal aquifer (bedrock) and so, it is not yet proven whether the source-pathway-receptor linkage is complete. Without samples of the principal aquifer, the extent, if any, of VOC impact cannot be proven.

10.4. GROUND GAS RISK ASSESSMENT

10.4.1. RATIONALE

Hazardous ground gas qualitative risk assessment is based on a conceptual site model (CSM) similar to that used for soil and groundwater contamination sources (i.e., source-pathway-receptor pollutant linkages).

The risk can be assessed based on knowledge of the ground conditions and CSM and a measure of hazardous gas concentrations and gas flow at the site within monitoring standpipes.

10.4.2. GROUND CONDITIONS

Made Ground

Made Ground deposits were encountered within all exploratory hole locations to depths of between 0.00 m and in excess of 3.00 m bgl although, in general, Made Ground was encountered to a depth of less than 1.50 m bgl.

Typically, the concrete or asphalt was underlain by a slightly clayey sandy gravel, with gravel of brick, concrete, mudstone, limestone, coal and slag with rare fragments of glass, plastic, and timber in some locations. These deposits were encountered from 0.15–0.80 m bgl, and were typically overlaying a reworked gravelly clay, with gravel of brick, sandstone, mudstone and in rare instances coal to a maximum proven depth of 3.00 m bgl (CP102).

Hydrocarbon odours were noted within six locations, situated across the site within the Made Ground deposits. The depths the hydrocarbon odour was encountered ranged from 0.50–1.90 m bgl (WS106) and was typically noted within a reworked very gravelly clay with gravel of sandstone, mudstone, concrete, ash, and rare instances of slag.

Superficial Strata

Superficial deposits were encountered within all exploratory locations, with the superficial deposits varying across the site. The most common stratum recorded was an orangish brown sandy gravelly CLAY with gravel of sandstone, mudstone, and instances of coal and quartz. Typically, the CLAY was locally interbedded with an orange very clayey fine to medium SAND from 0.70–4.44 m bgl.

In five locations, a very sandy CLAY with pockets of orange fine to medium SAND was noted, which was typically towards the east, with the exception of WS107 which recorded this stratum from 0.90–4.00 m bgl.

In CP102, a band of SAND and GRAVEL approximately 500 mm thick was recorded from 3.00–3.50 m bgl, with gravel of sandstone. This was in turn underlain by the orange-brown mottled sandy gravelly CLAY from 3.50–9.00 m bgl. A rare band of clayey fine to medium SAND with pockets of grey CLAY was noted in WS103, from 1.40–3.00 m bgl.



Bedrock Strata

The bedrock geology was encountered between 4.00–9.37 m bgl during the preliminary ground investigation as highly weathered SANDSTONE recovered as a red very gravelly medium to coarse SAND.

Generally, bedrock was encountered at shallower depths (<5.00 m bgl) towards the north of the site, in WS109 and WS109, deepening to 9.00.m bgl towards the south of the site.

The site is situated within a coal mining reporting area, but not within a development high risk zone.

Groundwater

Groundwater strikes were encountered as seepages in two locations at depths from 1.00–7.00 m bgl. During the monitoring programme, groundwater was recorded at depths ranging from 0.60 m to 5.47 m bgl.

10.4.3. SOURCES AND PATHWAYS OF GROUND GAS

Based on the CSM, the following potential sources and pathways of ground gas have been identified:

- ✳ Made Ground;
- ✳ Three infilled ponds within the site boundary;
- ✳ No landfills have been identified within 250 m of the site and the site is not in an area affected by Radon;
- ✳ VOC impacted soils and groundwater - potential sources of volatile vapours as dichlorination (degradation) of compounds occurs.

There is potential for localised ground gas migration in proximity of the identified sources, albeit reduced by predominantly low permeability strata.

The CIRIA C665 guidance on gas risk assessment includes recommendations for periods and frequencies for monitoring visits. These recommendations take into account the nature of the proposed development and the likely generation potential of the source.

The proposed development comprises private residential properties, which would be classified as a Type A development (high sensitivity) in accordance with BS8485:2015+A1:2019. However, it is considered that the likely generation potential of the identified gas sources (taking into account the likelihood of future increases in gas generation) would be best classified as high.

Therefore, within the context of the proposed residential end-use and ground gas generation potential, the gas assessment requires twelve visits over nine months, with at least two sets of readings at low or falling atmospheric pressure. However, as this is a preliminary investigation, four visits over one month have been conducted to form an initial assessment of gas risk prior to the decommission of the factory.

10.4.4. GROUND GAS RISK ASSESSMENT METHODOLOGY

The potential impact on the development from ground gases has been assessed with reference to standards and guidelines published in:



- ✿ CIRIA Report 665 – Assessing risks posed by hazardous ground gases to buildings (2007)
- ✿ BS8485:2015+A1:2019 – Code of Practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings

BS8485 provides guidance on the level of gas protection requirements based upon the characteristic situation (CS) and the proposed development based on building type.

Therefore, in accordance with BS8485, based on the measured flow rates and hazardous gas concentrations, individual hazardous gas flow rates (Q_{hg}) shall be derived for each monitoring point, from which the site characteristic hazardous gas flow rate (Q_{hgs}), and then the Characteristic Situation (CS) can be determined.

The following equation should be utilised:

$$Q_{hg} = q \left(\frac{C_{hg}}{100} \right)$$

Where:

q is the measured flow rate (in litres per hour) of combined gases from the monitoring standpipe
 C_{hg} is the measured hazardous gas concentration (in percentage volume/volume).

The subsequent derived gas screening value (GSV) should be the maximum Q_{hg} (flow rate x concentration as a percentage volume) for all the monitoring events.

A 'worst case check' may be carried out using the maximum recorded flow in any hole with the maximum concentration in any hole to present the plausible worst case conditions. Adoption of the worst case Q_{hg} requires thorough justification and reference to the CSM.

The final derived GSV can then be used to characterise the site as summarised in Table 33.

Table 33 Site Characterisation by GSV (BS8485:2015)

CS	HAZARD POTENTIAL	GSV (L/HR) FOR METHANE AND CARBON DIOXIDE	ADDITIONAL FACTORS
CS1	Very Low	< 0.07	Typically <1% methane concentration and <5% carbon dioxide concentration (otherwise consider an increase to CS2)
CS2	Low	< 0.70	Typical measured flow rate <70 l/h (otherwise consider an increase to CS3)
CS3	Moderate	< 3.5	N/A
CS4	Moderate to High	< 15	N/A
CS5	High	< 70	N/A
CS6	Very High	> 70	N/A

Notes

- 1) The CS is equivalent to the characteristic GSV in CIRIA C665.
- 2) The worst-case ground gas regime identified on the site, either methane or carbon dioxide, at the worst-case temporal conditions that the site may be expected to encounter should be considered.
- 3) Gas Screening Value is the Borehole Gas Volume Flow Rate, in litres per hour, multiplied by the concentration in the air stream of the particular gas being considered.
- 4) The Gas Screening Value thresholds should not generally be exceeded without the completion of a detailed ground gas risk assessment taking into account site-specific conditions.



10.4.5. MONITORING METHODOLOGY

Concentrations of methane (CH₄), carbon dioxide (CO₂) and oxygen (O₂) were measured using a calibrated infrared gas analyser (GFM435) with gas flow rates measured using an integrated flow meter.

Gas measurements were recorded for a minimum of 300 seconds (5 minutes) at each location, increasing to 600 seconds if elevated concentrations identified, at which point the maximum concentration of CH₄ and CO₂, together with the lowest concentration of O₂ were recorded.

In addition, during the third and fourth monitoring rounds, concentrations of VOC gases were also measured using a Minirae 3000 Photo Ionisation Detector (PID) Monitor calibrated to Isobutylene.

The results of the ground gas monitoring are presented in Table 34.

In addition to the raw data, the results for each individual standpipe have been assessed with reference to guidance provided in BS8485:2015. Based on the initial peak measured flow rates and hazardous gas concentrations, individual hazardous gas flow rates (Q_{hg}) have been derived for each monitoring point, from which an individual Characteristic Situation (CS) can ultimately be determined.

10.4.6. SUMMARY OF MONITORING RESULTS

Table 34 presents of the ground gas and groundwater monitoring results to date.



Table 34 Summary of Ground Gas Monitoring Results

WELL	DATE	CH ₄ INITIAL (%V/V)	CH ₄ STEADY (%V/V)	CH ₄ GSV (l/hr)	CO ₂ INITIAL (%V/V)	CO ₂ STEADY (%V/V)	CO ₂ GSV (l/hr)	O ₂ (%V/V)	VOCs PEAK (PPM)	VOCs STEADY (PPM)	ATMOS (mb)	ATMOS. DYNAMIC	FLOW (l/hr)	RESPONSE ZONE (m bgl)	DEPTH TO BASE (m bgl)	DEPTH TO WATER (m bgl)
WS101	04/04/24	0.1	0.1	0.0001	0.3	0.3	0.0003	20.4	-	-	991	Steady	0.1	1.00– 1.50	1.51	1.14
	11/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.4	-	-	1016	Rising	0.1		1.50	1.02
	23/04/24	0.1	0.1	0.0002	0.1	0.1	0.0002	20.3	0	0	1016	Falling	0.1		1.50	1.22
	03/05/24	0.1	0.1	0.0002	0.1	0.1	0.0002	20.5	0	0	997	Steady	0.2		1.50	1.33
WS102	04/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.5	-	-	992	Steady	0.1	2.00– 4.00	4.01	0.62
	11/04/24	0.1	0.1	0.0001	0.3	0.2	0.0003	18.6	-	-	1017	Rising	0.1		4.00	3.52
	23/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.4	0	0	1017	Falling	0.1		4.00	3.32
	03/05/24	0.1	0.1	0.0004	0.2	0.1	0.0008	20.1	0	0	1017	Steady	0.4		4.00	3.08
WS103	04/04/24	2.7	0.1	0.0054	3.4	1.0	0.0068	17.6	-	-	992	Steady	0.2	0.50– 1.40	1.63	1.47
	11/04/24	0.1	0.1	0.0001	0.3	0.3	0.0003	20.4	-	-	1016	Rising	0.1		1.62	1.09
	23/04/24	0.1	0.1	0.0001	0.3	0.3	0.0003	20.5	0.7	0.6	1016	Falling	0.1		1.62	1.17
	03/05/24	0.1	0.1	0.0001	0.5	0.4	0.0005	20.1	0	0	997	Steady	0.1		1.62	1.52
WS104	04/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.6	-	-	991	Steady	0.1	1.30– 3.30	2.78	0.95
	11/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.7	-	-	1016	Rising	0.1		2.85	0.93
	23/04/24	0.1	0.1	0.0001	0.2	0.1	0.0002	20.4	0	0	1016	Falling	0.1		2.85	2.35
	03/05/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.4	0	0	998	Steady	0.1		2.85	2.45
WS105	04/04/24	1.9	0.3	0.0019	1.2	0.7	0.0012	16.9	-	-	991	Steady	0.1	1.00– 3.00	2.88	2.71
	11/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.6	-	-	1017	Rising	0.1		2.88	2.64
	23/04/24	0.1	0.1	0.0001	0.4	0.3	0.0004	20.2	0	0	1019	Falling	0.1		2.88	2.72
	03/05/24	0.1	0.1	0.0001	0.2	0.1	0.0002	20.4	0	0	998	Steady	0.1		2.88	2.78
WS106	04/04/24	0.1	0.1	0.0001	0.8	0.8	0.0008	10.3	-	-	991	Steady	0.1	0.50– 1.90	2.17	2.13
	11/04/24	0.1	0.1	0.0001	0.4	0.4	0.0004	17.5	-	-	1016	Rising	0.1		2.15	2.11
	23/04/24	0.1	0.1	0.0001	1.4	0.9	0.0014	16.6	0	0	1017	Falling	0.1		2.15	Dry
	03/05/24	0.1	0.1	0.0001	0.7	0.4	0.0007	19.6	0	0	996	Steady	0.1		2.15	Dry
WS107	04/04/24	0.1	0.1	0.0001	1.5	1.5	0.0015	12.3	-	-	992	Steady	0.1	1.00– 4.00	3.98	2.72
	11/04/24	0.1	0.1	0.0001	17.0	1.7	0.0170	12.7	-	-	1016	Rising	0.1		3.99	2.73
	23/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.6	0	0	1016	Falling	0.1		3.99	2.81
	03/05/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.6	0	0	998	Steady	0.1		3.99	2.78
WS108	04/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	15.5	-	-	992	Steady	0.1	0.50–	1.01	0.79
	11/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.0	-	-	1016	Rising	0.1	1.00	1.02	0.80



WELL	DATE	CH ₄ INITIAL (%V/V)	CH ₄ STEADY (%V/V)	CH ₄ GSV (l/hr)	CO ₂ INITIAL (%V/V)	CO ₂ STEADY (%V/V)	CO ₂ GSV (l/hr)	O ₂ (%V/V)	VOCs PEAK (PPM)	VOCs STEADY (PPM)	ATMOS (mb)	ATMOS. DYNAMIC	FLOW (l/hr)	RESPONSE ZONE (m bgl)	DEPTH TO BASE (m bgl)	DEPTH TO WATER (m bgl)
WS109	23/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	19.7	0	0	1015	Falling	0.1	1.00– 4.00	1.02	0.98
	03/05/24	0.1	0.1	0.0001	0.1	0.1	0.0001	19.9	0	0	998	Steady	0.1		1.02	0.95
	04/04/24	0.1	0.1	0.0001	2.0	2.0	0.0020	6.5	-	-	992	Steady	0.1		3.99	3.95
	11/04/24	6	1.2	0.0060	2.6	2.6	0.0026	4.5	-	-	1016	Rising	0.1		3.98	3.86
	23/04/24	0.1	0.1	0.0001	2.4	2.4	0.0024	10.9	0	0	1016	Falling	0.1		3.98	3.78
	03/05/24	0.1	0.1	0.0001	2.7	2.7	0.0027	4.1	0	0	996	Steady	0.1		3.98	3.89
WS110	04/04/24	0.1	0.1	0.0001	1.2	1.1	0.0012	15.8	-	-	992	Steady	0.1	0.50– 1.00	1.12	0.99
	11/04/24	0.1	0.1	0.0001	0.4	0.4	0.0004	20.0	-	-	1016	Rising	0.1		1.11	0.97
	23/04/24	0.1	0.1	0.0001	1.5	1.5	0.0015	14.7	0	0	1016	Falling	0.1		1.11	Dry
	03/05/24	0.1	0.1	0.0001	1.6	1.6	0.0016	16.7	0	0	995	Steady	0.1		1.11	Dry
CP101	04/04/24	0.1	0.1	0.0001	0.2	0.2	0.0002	20.5	-	-	992	Steady	0.1	3.00– 7.50	7.17	2.38
	11/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.5	-	-	1016	Rising	0.1		7.18	5.47
	23/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.4	0	0	1016	Falling	0.1		7.18	3.99
	03/05/24	0.1	0.1	0.0001	0.2	0.1	0.0002	20.5	0	0	995	Steady	0.1		7.18	3.14
CP102	04/04/24	0.1	0.1	0.0001	0.1	0.1	0.0001	18.1	-	-	992	Steady	0.1	3.50– 9.00	7.22	4.60
	11/04/24	0.1	0.1	0.0000	0.1	0.1	0.0001	20.5	-	-	1017	Rising	0.1		7.22	4.60
	23/04/24	0.1	0.1	0.0000	0.1	0.1	0.0001	20.2	0	0	1016	Falling	0.1		7.82	4.02
	03/05/24	0.1	0.1	0.0001	0.1	0.1	0.0001	20.4	0	0	996	Steady	0.1		7.82	4.60

Notes

CIRIA Characteristic Situation

Q_{hg}

CS1

<0.07

Typical Max CO₂ <5 % Typical Max CH₄ <1 %

Values in **BOLD** exceed CS1 Thresholds

CS2

<0.7

Flow rate not to exceed 70 l/hr otherwise consider increase to CS3

Values in **BLUE** denote water above level of response zone (flooded)

CS3

<3.5

CS4

<15

Quantitative Risk Assessment required to evaluate scope of protective measures



10.4.7. GROUNDWATER

The water level within several of the monitoring wells was recorded to be above the top of the response zone (flooded) on a number of occasions, as summarised in Table 35, thus rendering some of the monitoring data unreliable. Therefore, each time a flooded well was encountered, the well was bailed and left to re-equilibrate. Wells were re-monitored after a period of 20–30 minutes.

Table 35 Flooded Monitoring Well Data

WELL	VISIT 1 04/04/2024	VISIT 2 11/04/2024
WS102	Y	-
WS104	Y	Y
CP101	Y	-

Within remaining monitoring wells, groundwater levels were variable across monitoring wells and visits. Therefore, it is considered likely groundwater flow is present within the upper 2.00 m bgl of the ground within the site.

10.4.8. BAROMETRIC PRESSURE

Visits 1 and 4 were undertaken during a period of steady low pressure, with a recorded low of 992 mbar.

Visit 2 was undertaken during a period of rising high pressure, with a recorded high of 1017 mbar.

Visit 3 was undertaken during a period of falling high pressure with a recorded high of 1016 mbar.

It is therefore considered that the visits have been undertaken over representative conditions.

10.4.9. GAS FLOW

Throughout the monitoring period, the majority of flow rates were recorded to be 0.1 l/hr (limit of detection of the analyser).

However, elevated flow rates were recorded within WS101 and WS102 during visit 4, which were recorded at 0.2 l/hr and 0.4 l/hr, respectively. Additionally, elevated flow rates were recorded during visit 1 within WS103, recorded at 0.2 l/hr.

Both elevated flow rates instances were recorded during steady low pressure events.

10.4.10. GAS CONCENTRATIONS

The majority of maximum methane value recorded within the monitoring wells was 0.1% v/v (limit of detection of the analyser). However, elevated initial flow readings were noted within WS103 and WS105 during visit 1 with peak readings of 2.7% v/v and 1.9% v/v, respectively.

The highest initial methane value was recorded within WS109 during visit 2 with peak flow recorded at 6.0% v/v and steady flow readings at 1.7% v/v.

Carbon dioxide concentrations were recorded at concentrations ranging from 0.1% v/v to 3.4% v/v. A peak initial flow reading of 17 % v/v was recorded within WS107 during visit 2, however the steady flow dropped to 1.7% v/v due to low subsequent readings.



10.4.11. RADON RISK

The site is in an area where less than 1% of homes are above the Radon Action Level, therefore, no radon protection measures are required for any proposed new dwellings.

All sites registered from 1st December 2022 onwards will have been assessed against the updated radon maps by NHBC and will be required to have radon protection measures installed in accordance with the updated mapping.

Figure 10 indicates that based on the less than 1% area observed, the site falls under a Radon Potential Class of 1 within the User Guide for the HPA-BGS Joint Radon Potential Dataset for Great Britain (Ref: IR/11/044, dated 2011). A Radon potential class of 1 indicates that the site is not within a radon affected area, which requires no radon protective measures as illustrated in Figure 11.

Figure 10 Radon Affected Area Potential Class

Radon Potential Class*	Is the property in a Radon Affected Area?	Additional information
1	No	The property is in a Lower probability radon area (less than 1% of homes are estimated to be at or above the Action Level). The property is not in a radon affected area.
2	Yes	The property is in an Intermediate probability radon area (1 to 3% of homes are estimated to be at or above the Action Level). The property is in a radon affected area.
3	Yes	The property is in an Intermediate probability radon area (3 to 5% of homes are estimated to be at or above the Action Level). The property is in a radon affected area.
4	Yes	The property is in an Intermediate probability radon area (5 to 10% of homes are estimated to be at or above the Action Level). The property is in a radon affected area.
5	Yes	The property is in a Higher probability radon area (10 to 30% of homes are estimated to be at or above the Action Level). The property is in a radon affected area.
6	Yes	The property is in a Higher probability radon area (more than 30% of homes are estimated to be at or above the Action Level). The property is in a radon affected area.

*The Radon Potential Class number should not be included in answers.

Source: User Guide for the HPA-BGS Joint Radon Potential Dataset for Great Britain (Ref: IR/11/044, dated 2011)



Figure 11 Radon Affected Area Measures Required

Radon Potential Class*	What level of radon protective measures are required for new buildings in England and Wales?	What level of radon protective measures are required for new dwellings in Scotland?
1	None**	None**
2	None	Stage 1
3	Basic	Stage 1
4	Basic	Stage 1
5	Full	Stage 2
6	Full	Stage 2

*The Radon Potential Class number should not be included in answers.

** in 2008 HPA recommended that building regulations be amended to ensure that all new buildings, extensions etc. include basic radon protective measures. At the time of writing, relevant UK authorities were considering this advice.

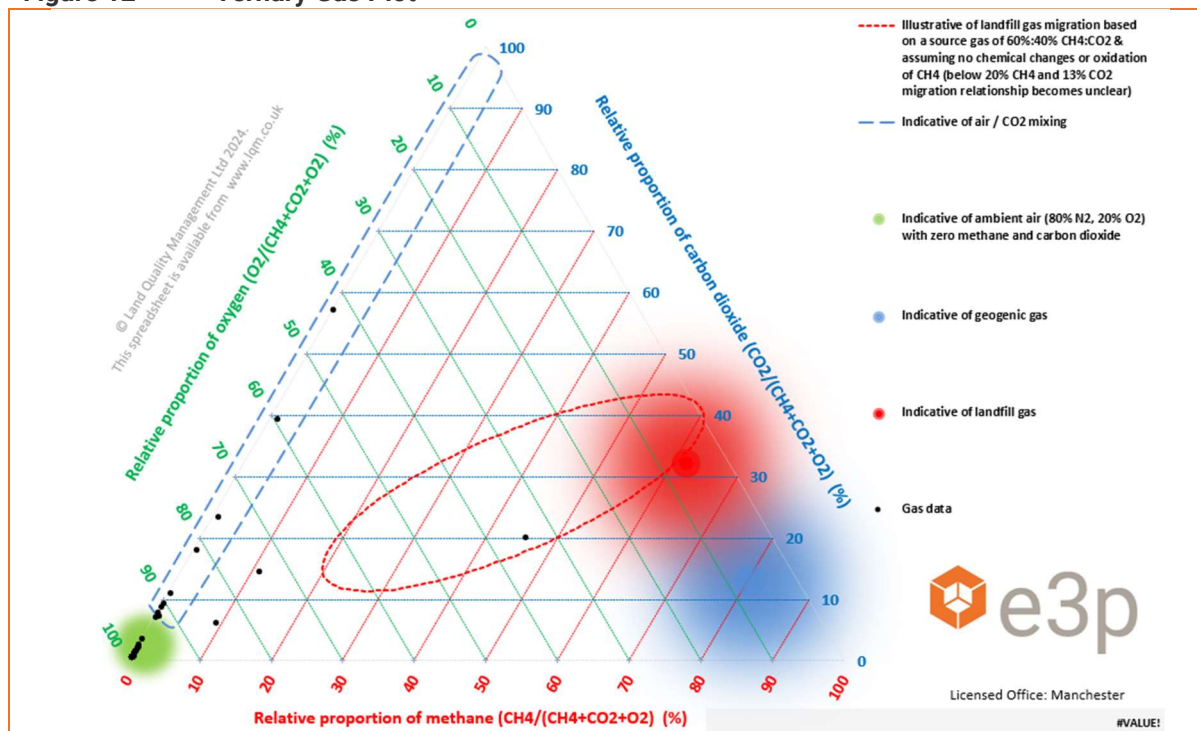
Source: User Guide for the HPA-BGS Joint Radon Potential Dataset for Great Britain (Ref: IR/11/044, dated 2011)

10.4.12. TERNARY PLOT FOR GROUND GAS

A ternary gas plot is a triangular plot of three variables which equal 100%. They allow the composition of gas to be identified and can help to identify the potential source of gas. As carbon dioxide is present in natural soils (such as Glacial Till), this can lead to uncertainty about whether it is necessary to increase the gas regime. On this basis, a ternary plot has been used as an assessment tool for the gas monitoring data to identify if there is a true risk.

Figure 12 shows the ternary gas plot for the gas monitoring data.

Figure 12 Ternary Gas Plot





The ternary gas plot indicates the majority of the ground gas monitoring results have standard oxygen and generally low carbon dioxide concentrations with limited occasions of carbon dioxide concentrations above 5%, and no elevated methane, which is indicative of natural sources (green area on the ternary plot).

On three occasions within WS103, WS105 and WS107, elevated methane and carbon dioxide and partially depleted oxygen were recorded, which could indicate organic material, Made Ground or organic contamination undergoing anaerobic degradation.

On one occasion in WS109, elevated methane concentrations with no elevated carbon dioxide and depleted oxygen were recorded, which is indicative of the 'cross-gas' effect from potential volatile contamination in the ground. Further investigation into these elevated concentrations is recommended.

10.4.13. CONCLUSION

The determined Characteristic Situation for each standpipe for each visit is presented in Table 36. This indicates that based on the peak flow rates the majority of the monitoring visits classify as Characteristic Situation (CS)1 – Very Low Gas Risk. However, WS103 and WS105 are noted to be classified within CS2, and WS107 and WS109 classified within CS3.

Table 36 Gas Risk Profile and Location

WELL	DEPTH TO WATER (m bgl)	MAX FLOW (l/hr)	MAX CH ₄ (%V/V)	MAX CH ₄ Q _{hg} (l/hr)	MAX CO ₂ (%V/V)	MAX CO ₂ Q _{hg} (l/hr)	CHARACTERISTIC SITUATION
WS101	1.02	0.2	0.100	0.001	0.300	0.001	CS1
WS102	0.62	0.4	0.100	0.001	0.300	0.001	CS1
WS103	1.09	0.2	2.700	0.005	3.400	0.007	CS2
WS104	0.93	0.1	0.100	0.001	0.200	0.001	CS1
WS105	2.64	0.1	1.900	0.002	1.200	0.001	CS2
WS106	2.11	0.1	0.100	0.001	1.400	0.001	CS1
WS107	2.72	0.1	0.100	0.001	17.000	0.017	CS3
WS108	0.79	0.1	0.100	0.001	0.100	0.001	CS1
WS109	3.78	0.1	6.000	0.006	2.700	0.003	CS3
WS110	0.97	0.1	0.100	0.001	1.600	0.002	CS1
CP101	3.14	0.1	0.100	0.001	0.200	0.001	CS1
CP102	4.02	0.1	0.100	0.001	0.100	0.001	CS1

Based on the above, the site is variable with the majority of site situated within Characteristic Situation 1 (CS1), however there are two noted areas falling within Characteristic Situation 2 (CS2), and an additional two areas falling within Characteristic Situation 3 (CS3). Therefore, as a precautionary measure, it is recommended that the whole site should be categorised within CS2, which will require basic gas protection measures, with any proposed plots within the area of CS3 classification potentially requiring further precautions.

Further environmental monitoring wells are required within the footprint of the main factory structure in addition to further ground gas monitoring regimes under lower pressure conditions and further falling and rising pressure events due to elevated readings and known VOC impacted soils and groundwater.

Furthermore, with regards to the elevated volatile contaminants identified within soils and groundwater across the southern boundary of the site, vapour resistant membranes may be required to be installed during the build phase for any proposed buildings situated within the immediate vicinity of the impacted soils.



It is recommended that the full ground gas assessment and recommended protection measures (if applicable) are agreed with the local authority prior to their adoption on-site. Furthermore, all protection measures adopted should be validated by a suitably qualified engineer.

A Radon Class 1 has been applied to the site, therefore no protective measures are required in the construction of residential dwellings.

10.5. POTABLE WATER SUPPLY

This section provides a summary of the preliminary ground investigation data with reference to the selection of potable water supply pipework. The assessment is made with reference to the UK Water Industry Research (UKWIR) publication "Guidance on the selection of Water Supply Pipes to be used in Brownfield Sites".

Table 37 Pipeline Selection PE Threshold Concentrations

CONTAMINANT GROUP	PE-THRESHOLD (MG/KG)	CONCENTRATIONS AT CURRENT PIPELINE DEPTH (MG/KG)
Total VOC	0.5	>1.0
Total BTEX And MTBE	0.1	<0.001
Total SVOCs (Excluding PAH and those substances marked with an *)	2	<1.0
EC5-EC10 Aliphatic and Aromatic Hydrocarbons	2	<1.0
EC10-EC16- Aliphatic and Aromatic Hydrocarbons	10	<1.0
EC16-EC40 Aliphatic and Aromatic Hydrocarbons	500	<1.0
Phenols (From SVOC Analysis)*	2	<0.10
Cresols and Chlorinated Phenols (From SVOC Analysis)	2	NA
Ethers*	0.5	<0.50
Nitrobenzene*	0.5	<0.50
Ketones*	0.5	NA
Aldehydes*	0.5	NA
Amines	Fail	<0.50
Other Consideration		
Are there any exceedances of the PE threshold outside of the pipeline depth?	Yes – known VOC impact was recorded outside of the pipeline depth within multiple exploratory locations towards the southern boundary of the main factory structure.	
Is free product present in soil and groundwater?	Yes – VOC impact was recorded within groundwater within multiple exploratory locations towards the northwest and southern boundary of the main factory structure.	
Could hydrocarbon impact at greater depth than current pipeline depth be mobilised by rising groundwater levels?	Yes – groundwater monitoring visits indicate the groundwater in the south of the site is mobilising compounds.	
Will soils impacted with above determinands likely be utilised elsewhere on-site?	No	
Will soils be imported to site as part of any future earth works	Currently unknown, however it is unlikely soils will be required to be imported to site.	

Notes - Pipe line depth normally between 0.75 m–1.35 m

Based on the assessment of current site conditions it is likely that barrier pipe will be required at the proposed development.



10.6. DEVELOPED CONCEPTUAL SITE MODEL

Following the completion of the preliminary intrusive ground investigation, chemical analysis and risk assessment, the developed conceptual site model shown in Table 38 has been prepared for the site. Diagrammatic human health and controlled waters developed conceptual site models are presented as Drawings 17-500-010 and 17-500-027 in APPENDIX IV.

Table 38 **Developed Conceptual Model**

CONTAMINANT RISK			LIKELIHOOD	SEVERITY	MITIGATION DISCUSSION	RESIDUAL RISK
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
SOIL						
HUMAN HEALTH						
Made Ground Metals (Arsenic, Lead, Nickel) – encountered along the northern boundary of the site.	Accidental ingestion and/or dermal contact with contaminated soil and/or leachate. PL1/PL2	Human Health – construction workers Human Health – end users	Likely	Medium	The CSM has identified contaminants of concern as above assessment criteria. Site personnel have a greater chance of coming into contact with contaminated soils. Particularly during excavation and soil recovery works. Recommendation: Further investigation is required across the site to assess site wide contamination levels. Construction works to be completed with appropriate PPE and welfare facilities.	Low



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	MITIGATION DISCUSSION	RESIDUAL RISK
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
Oven Manufacturing Factory (Main Factory Structure) VOCs (Trichloroethene (TCE), cis 1,2-Dichloroethene, Trans 1,2-Dichloroethene, Vinyl Chloride) - encountered along the southern boundary of the site.	Inhalation of vapours. PL4 Migration through permeable strata and preferential pathways.	Human Health – end users Human Health – Off-site receptors	Likely	High	Intrusive ground investigation has identified the presence of enamel slurry waste storage tanks which may be a significant source of TPHs/VOCs. Soil analysis has confirmed the presence of VOCs in three locations across the southern boundary of the site. No sources of TPHs have been identified. Recommendation: Further intrusive ground investigation is required to determine the spatial extent of contamination within the soils and understand whether leaching has occurred into the underlying natural strata. Visual and olfactory evidence of contamination has been identified in a number of locations; therefore, a watching brief should be completed during remediation works to monitor the locations where visual or olfactory hydrocarbon impact has been identified during all phases of investigation completed to date.	High



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	MITIGATION DISCUSSION	RESIDUAL RISK
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
Made Ground & Main Factory Structure Asbestos (Asbestos containing materials (ACM) and loose fibres)	Inhalation (of fibres). Construction works disturbing bound material and releasing fibres. PL3	Human Health - Site personnel, end land users, and users of adjacent sites	Likely	Medium	Risk of inhalation of fibres during Ground Investigation and construction works. Disturbance of ACMs and dust derivatives from construction would increase risk to adjacent sites. Recommendation: Cover system to garden and landscaped areas will prevent exposure to future site users. Construction works completed with PPE and provision of welfare.	Moderate/High
Made Ground Sulphate from potential ash within the Made Ground.	Sulphate attack on concrete. PL6	Building concrete	Unlikely	Low	Chemical soil analysis categorises the soils as within DS1, AC1s. Further investigation and sampling is required to confirm concrete classification in areas not investigated. Recommendation: Classification based upon chemical soil analysis falls within DS1-AC1s, all concrete design should be in accordance with appropriate classification. Construction works to be completed with appropriate PPE and welfare facilities.	Low



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	MITIGATION DISCUSSION	RESIDUAL RISK
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
Made Ground Organic contaminants such as hydrocarbons, solvents	Ingestion of tainted water supply. PL7	Human Health – End Users Water pipeline	Likely	High	Significant VOC contamination has been identified at and below pipeline depth (0.75–1.35 m). Recommendation: Barrier pipe is likely to be required following a pipeline risk assessment.	High
Made Ground Phytotoxic contaminants	Direct contact (plant uptake). PL8	Flora	Likely	Medium	Likely probability as contamination considered possible, which may be taken up by flora in soft landscaping/gardens. Recommendation: Hotspot removal / treatment of impacted material.	Moderate
CONTROLLED WATERS						
Made Ground VOCs (Trichloroethene (TCE), cis 1,2-Dichloroethene, 1,1-Dichloroethene, Trans 1,2-Dichloroethene, Vinyl Chloride)	Leaching of contaminants from Made Ground through infiltration and percolation of rainwater. PL5	Controlled waters, underlying Principal Aquifer	Likely	High	The current development and associated hardstanding will assist in reducing the leachate produced from contaminated soils, and therefore reduce the impact to groundwater. On-site sources including historical industrial processes are still likely to be predominant mechanisms of contamination to controlled waters. Recommendation: Further testing is required to determine the spatial extent of contamination within the groundwater and understand the	High



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	MITIGATION DISCUSSION	RESIDUAL RISK
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
					full nature and extent of the VOC plume.	
		Infrastructure and services	Likely	High	The development of proposed estate roads (hardstanding and drainage) will reduce the leachate produced from contaminated soils. Infrastructure and services shall be designed to resist chemical attack and ingress.	High
Groundwater VOCs (Trichloroethene (TCE), cis 1,2-Dichloroethene, Trans 1,2-Dichloroethene, Vinyl Chloride).	Contact with contaminated groundwater. PL2	Human Health – site personnel	Likely	High	Groundwater is known to be below construction level and as such, is expected to not rise above ground level or the final level of the road. Recommendation: Construction works to be completed with appropriate PPE and welfare facilities.	High
	Contaminants leached from the Made Ground and from off-site sources may be mobilised to greater distances through advective flow. PL5	Human Health – end users	Likely	High	Impacted groundwater could transport contaminants vertically. Recommendation: Further investigation is required to understand the groundwater regime. Groundwater will need to be considered for surrounding developments.	High



CONTAMINANT RISK			LIKELIHOOD	SEVERITY	MITIGATION DISCUSSION	RESIDUAL RISK
SOURCES	MIGRATION PATHWAYS	RECEPTORS				
GROUND GAS						
Ground gases Methane and Carbon Dioxide	Inhalation of ground gas. PL4	Human Health – site personnel	Likely	Medium	The site is classified within CS1–CS3, precautionary CS2 measures recommended across the site with localised areas of CS3. No elevated readings of volatile vapours were encountered during monitoring visits. Recommendation: Further investigation and monitoring required in order to determine full ground gas regime.	Moderate
		Human Health – end users	Likely	High		High
		Infrastructure and services	Likely	High		High
Volatile Vapours VOCs (Trichloroethene (TCE), cis 1,2-Dichloroethene, Trans 1,2-Dichloroethene, Vinyl Chloride)	Accumulation of ground gas in confined spaces (asphyxiation or explosion)					
Radon	Inhalation of ground gas. PL4	Human Health – site personnel	Unlikely	Low	The site is situated within a Radon Class 1 and therefore no radon protection measures are required.	Very low
		Human Health – end users	Unlikely	Low		Very low
	Accumulation of ground gas in confined spaces (carcinogenic)					

Main Exposure Pathways:

PL1 = soil ingestion, PL2 = dermal contact and ingestion, PL3 = dust inhalation; PL4 = vapour/gas inhalation; PL5 = vertical / lateral migration; PL6 = corrosion of concrete; PL7=tainting of water supply; PL8 = uptake by plants.

LEVEL OF RISK

Very Low	
Low	
Low/Moderate	
Moderate	
Moderate/High	
High	



11. GEOTECHNICAL ASSESSMENT

11.1. SOIL CONSISTENCY

Undrained shear strength values were measured using both field hand shear vane tests and laboratory undrained triaxial tests. Results of the tests are presented in Table 39, respectively, which indicate the clay soils to be very stiff. Strength test data is generally consistent with the field descriptions of the aforementioned soils.

Results of the standard penetration tests, including undrained shear strengths derived from SPTs are included in Table 40.

Table 39 Summary of Undrained Shear Strength in Triaxial Compression – Laboratory Test				
LOCATION	SAMPLE DEPTH (m)	LAB DESCRIPTION	UNDRAINED SHEAR STRENGTH (kN/m²)	CONSISTENCY
WS103	3.50–4.00	Brown silty slightly sandy slightly gravelly CLAY.	211	Very Stiff
WS105	2.50–3.00	Brown silty slightly sandy slightly gravelly CLAY.	244	Very Stiff
WS109	1.50–2.00	Brown silty slightly sandy slightly gravelly CLAY.	208	Very Stiff



Table 40 Standard/Cone Penetration Test Results

BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING CAPACITY (kN/m ²)*
WS101	1	MADE GROUND	6	6.05	Loose	N/A	N/A	N/A	60.49
WS101	2	Very clayey fine to medium SAND	7	6.39	Loose	N/A	N/A	N/A	63.95
WS101	3	Light brown mottled red slightly gravelly very sandy CLAY	8	6.96	N/A	Low strength	Firm	34.79	71.52
WS101	4	Slightly gravelly very sandy CLAY	21	17.74	N/A	High strength	Very Stiff	88.71	182.39
WS101	5	Brown very sandy CLAY	20	16.59	N/A	High strength	Very Stiff	82.96	170.57
WS102	1	Black slightly gravelly CLAY	5	5.04	N/A	Low strength	Firm	25.20	51.82
WS102	2	Light orange mottled brown slightly sandy gravelly CLAY	8	7.31	N/A	Low strength	Firm	36.54	75.13
WS102	3	Light orange mottled brown slightly sandy gravelly CLAY	13	11.31	N/A	Medium strength	Stiff	56.53	116.22
WS102	4	Light orange mottled brown slightly sandy gravelly CLAY	33	27.88	N/A	High strength	Very Stiff	139.40	286.61



BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING CAPACITY (kN/m ²)*
WS102	4.8	Light orange mottled brown slightly sandy gravelly CLAY	50	41.61	N/A	Very high strength	Very Stiff	208.03	427.72
WS103	1	MADE GROUND	5	5.04	Loose	N/A	N/A	N/A	50.41
WS103	2	Light grey and orange very clayey very silty fine to medium SAND	7	6.39	Loose	N/A	N/A	N/A	63.95
WS103	3	Dark reddish brown slightly gravelly sandy CLAY	19	16.52	N/A	High strength	Very Stiff	82.62	169.86
WS103	4	Dark reddish brown slightly gravelly sandy CLAY	28	23.66	N/A	High strength	Very Stiff	118.28	243.18
WS103	5	Dark reddish brown slightly gravelly sandy CLAY	43	35.67	N/A	Very high strength	Very Stiff	178.37	366.73
WS104	1	MADE GROUND	8	8.07	Loose	N/A	N/A	N/A	80.65
WS104	2	Dark reddish brown very sandy CLAY	10	9.14	N/A	Medium strength	Stiff	45.68	93.91
WS104	3	Dark reddish brown very sandy CLAY	38	33.05	N/A	Very high strength	Very Stiff	165.23	339.72



BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING CAPACITY (kN/m ²)*
WS104	4	Dark reddish brown very sandy CLAY	50	42.24	N/A	Very high strength	Very Stiff	211.21	434.25
WS105	1	Brown mottled grey silty sandy CLAY	8	8.07	N/A	Medium strength	Stiff	40.33	82.91
WS105	2	Brown mottled grey silty sandy CLAY	37	33.80	N/A	Very high strength	Very Stiff	169.00	347.47
WS105	3	Brown mottled grey silty sandy CLAY	50	43.48	N/A	Very high strength	Very Stiff	217.41	447.00
WS106	1	MADE GROUND	6	6.05	Loose	N/A	N/A	N/A	60.49
WS106	2	Orange slightly clayey fine to medium SAND	33	30.15	Dense	N/A	N/A	N/A	301.47
WS106	3	Orange slightly clayey fine to medium SAND	32	27.83	Medium Dense	N/A	N/A	N/A	278.29
WS106	4	Orange slightly clayey fine to medium SAND	50	42.24	Dense	N/A	N/A	N/A	422.43
WS107	1	Orange mottled grey slightly sandy slightly gravelly CLAY	6	6.05	N/A	Low strength	Firm	30.24	62.18
WS107	2	Orange mottled grey slightly sandy slightly	12	10.96	N/A	Medium strength	Stiff	54.81	112.69



BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING CAPACITY (kN/m ²)*
WS107	3	gravelly CLAY Orange mottled grey slightly sandy slightly gravelly CLAY	29	25.22	N/A	High strength	Very Stiff	126.10	259.26
WS107	3.9	Orange mottled grey slightly sandy slightly gravelly CLAY	50	42.34	N/A	Very high strength	Very Stiff	211.70	435.26
WS108	1	MADE GROUND	23	23.19	Medium Dense	N/A	N/A	N/A	231.87
WS108	1.6	MADE GROUND	50	47.08	N/A	Very high strength	Very Stiff	235.40	483.98
WS109	1	Brown sandy gravelly CLAY	15	15.12	N/A	High strength	Very Stiff	75.61	155.46
WS109	2	Reddish orange clayey fine to medium SAND	35	31.97	Dense	N/A	N/A	N/A	319.74
WS109	3	Reddish orange clayey fine to medium SAND	30	26.09	Medium Dense	N/A	N/A	N/A	260.90
WS109	4	Very gravelly medium to coarse SAND	50	42.24	Dense	N/A	N/A	N/A	422.43
WS110	1	MADE GROUND	7	7.06	Loose	N/A	N/A	N/A	70.57
WS110	2	Orangish brown mottled grey slightly sandy CLAY	8	7.31	N/A	Low strength	Firm	36.54	75.13



BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING CAPACITY (kN/m ²)*
WS110	3	Brown slightly gravelly CLAY	50	43.48	N/A	Very high strength	Very Stiff	217.41	447.00
CP101	1.2	MADE GROUND	4	3.92	Very Loose	N/A	N/A	N/A	39.25
CP101	2	MADE GROUND	6	5.48	Loose	N/A	N/A	N/A	54.81
CP101	4	Firm orangish brown mottled grey gravelly CLAY	14	11.83	N/A	Medium strength	Stiff	59.14	121.59
CP101	6	Orangish brown mottled grey sandy gravelly CLAY	32	26.24	N/A	High strength	Very Stiff	131.18	269.71
CP101	7.5	Orangish brown mottled grey sandy gravelly CLAY	21	17.04	N/A	High strength	Very Stiff	85.19	175.14
CP101	8.7	Dark orangish red very gravelly medium to coarse SAND. (Highly Weathered SANDSTONE)	50	40.38	Dense	N/A	N/A	N/A	403.75
CP101	9	Dark orangish red very gravelly medium to coarse SAND (Highly Weathered	50	40.34	Dense	N/A	N/A	N/A	403.42



BOREHOLES	DEPTH (m bgl)	MATERIAL FIELD DESCRIPTION	CPT/SPT "N" VALUE	CORRECTED "N" VALUE (N ₁) ₆₀	TERZAGHI & PECK RELATIVE DENSITY (SANDS)	EUROCODE SOIL STRENGTH	CONSISTENCY (BS 5930)	TERZAGHI & PECK APPROXIMATE UNDRAINED SHEAR STRENGTH (kN/m ²)	ALLOWABLE BEARING CAPACITY (kN/m ²)*
		SANDSTONE).							
CP102	1.2	MADE GROUND	4	3.92	Very Loose	N/A	N/A	N/A	39.25
CP102	2	MADE GROUND	7	6.39	Loose	N/A	N/A	N/A	63.95
CP102	3	Dark orangish red very clayey fine to medium SAND and GRAVEL	50	43.48	Dense	N/A	N/A	N/A	434.83
CP102	5	Orangish brown mottled grey gravelly CLAY	40	33.18	N/A	Very high strength	Very Stiff	165.92	341.14
CP102	7.5	Orangish brown mottled grey gravelly CLAY	46	37.32	N/A	Very high strength	Very Stiff	186.60	383.64
CP102	9	Dark orangish red very gravelly medium to coarse SAND. (Highly Weathered SANDSTONE)	50	40.34	Dense	N/A	N/A	N/A	403.42
CP102	9.3	Dark orangish red very gravelly medium to coarse SAND (Highly Weathered SANDSTONE)	50	40.31	Dense	N/A	N/A	N/A	403.14



NOTES

* The Allowable Bearing Capacity (ABC) should be considered indicative.

The interpretation of in situ mass undrained shear strength (c_u) data from SPT Blow Count (N) results and the influence of the Plasticity Index (PI) was reported in Standard Penetration Test in Insensitive Clays and Soft Rocks. Stroud (1974). The standard penetration test and the engineering properties of glacial materials subsequently. Stroud and Butler (1975) and (1989).

Allowable bearing capacity on sands. Soil Mechanics in Engineering Practice Terzaghi, K. & Peck, R.B. 1996.



11.2. CONSOLIDATION

Two undisturbed samples of Glacial Till were submitted for oedometer analysis. The results are provided in Table 41.

Table 41 Oedometer Consolidation Results

LOCATION	DEPTH (M)	SAMPLE TYPE	MOISTURE CONTENT (%)	OEDOMETER CONSOLIDATION		
				PRESSURE RANGE (kPa)	Mv (m ² /MN)	Cv (m ² /year)
CP101	5.00–5.45	U100	11.1	0–115	0.20	7.99
				115–230	0.14	3.15
				230–460	0.08	6.60
				460–920	0.04	3.65
				920–115	0.02	–
CP102	6.00–6.45	U100	14.8	0–135	1.01	18.81
				135–270	0.27	7.34
				270–540	0.09	4.16
				540–1080	0.04	2.61
				1080–135	0.00	–

When considered at over-burden pressure with an additional load of 110 kPa, the coefficient of volume compressibility (Mv) ranged from 0.00 m²/MN up to 1.01 m²/MN. The material is considered to be low to high compressibility.

The rate at which settlement is likely to occur is determined by the coefficient of consolidation (Cv). As shown in Table 41, the coefficient ranges from 2.61 m²/yr to 18.81 m²/yr. The rate at which settlement will occur is increased by the presence of sand within the Glacial Till and it is likely that settlement will occur over a period of months to years.

11.3. PARTICLE SIZE DISTRIBUTION

Particle Size Distribution Tests have been undertaken on selected samples of granular material via wet sieve to obtain information on the soil fractions. The results are included in Table 42. The full results can be found in APPENDIX IX.

Table 42 Summary of Particle Size Distribution Test Results

LOCATION	DEPTH (M)	SOIL FRACTION (%)			
		COBBLES	GRAVEL	SAND	SILT/CLAY
CP101	3.00 (Natural)	0	22	49	29

11.4. SOIL INFILTRATION

Based upon the initial investigation and surrounding geology it is considered the significant volumes of low permeable CLAY deposits on the site, extensive depths of Made Ground and VOC contamination likely preclude the use of soakaway drainage for the proposed development.

However, the application of soakaway drainage will ultimately be dependent on the specific requirements of the development. All soakaways should be designed in accordance with BRE Special Digest 365 – *Soakaway Design*.



11.5. SOIL PLASTICITY

The liquid and plastic limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average plasticity index (PI) for each “type” of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth.

E3P typically only consider a soil to be shrinkable if the proportion finer than 63 µm is > 35%.

PI results are compared against guidance given in the NHBC standards, Chapter 4.2 (revised January 2014), which advocates the use of modified plasticity index (I_p), defined as:

$$I_p = I_p \times (\% < 425 \mu\text{m}/100)$$

In other words, if PI is 30%, but the soil contains 80% < 425 µm, then I_p = 30 × 80/100 = 24%.

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425 µm sieve is routinely reported by testing labs.

E3P apply engineering judgement where PI results are spread over a range of classifications. Consideration is given to the average values for each particular soil type (differentiate between residual soil and alluvium), the number of results in each class and the actual values.

The Atterberg limits determinations, summarised in

Table 43, show the clay to be of predominantly low plasticity with discrete areas of moderate plasticity clay.

Table 43 Summary of Plasticity Index Test results

LOCATION	DEPTH (M)	NATURAL MOISTURE CONTENT (%)	PLASTIC LIMIT (%)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	PASSING 425 MM SIEVE (%)	MODIFIED PLASTICITY INDEX	NHBC VOLUME CHANGE POTENTIAL
WS101	3.00–3.45	15.7	15	27	12	97	11.64	Low
WS102	2.00–2.45	20.2	15	29	14	95	13.30	Low
WS103	3.50–4.00	12	10	28	18	96	17.68	Low
WS104	2.00–2.45	11.2	10	27	17	97	16.49	Low
WS105	2.50–3.00	10.1	10	28	18	98	17.64	Low
WS107	2.00–2.45	14.8	11	29	18	95	17.10	Low
WS109	1.50–2.00	11.8	12	28	16	92	14.72	Low

The results of the Atterberg limits testing confirmed that the soils would be deemed to be “Low Volume Change Potential” in accordance with the classification system utilised by the LABC/NHBC industry guidance.



11.6. PH AND SULPHATE

Chemical analyses for pH and soluble sulphate content contained in APPENDIX VIII (summarised in Table 44), shows that the soils at the site generally meet Class DS-1, Aggressive Chemical Environment for Concrete Classification (ACEC) AC-1s in accordance with BRE *Special Digest 1* (2005).

Table 44 Summary of pH and Sulphate Data

LOCATION	DEPTH (M)	SO ₄ IN 2:1 WATER/SOIL (G/L)	PH VALUE	CLASSIFICATION
WS101	1.3	0.022	8.1	DS1, AC-1s
WS102	0.9	0.028	7.1	DS1, AC-1s
WS102	1.4	<0.010	7.2	DS1, AC-1s
WS103	0.8	0.028	7.8	DS1, AC-1s
WS103	1.6	<0.010	7.3	DS1, AC-1s
WS104	1.5	<0.010	7.9	DS1, AC-1s
WS105	0.4	0.050	8.7	DS1, AC-1s
WS106	2.2	0.017	9.2	DS1, AC-1s
WS108	0.6	0.016	8.2	DS1, AC-1s
WS107	0.4	0.043	9.0	DS1, AC-1s
WS108	1.3	0.012	8.7	DS1, AC-1s
WS109	0.6	0.24	8.7	DS1, AC-1s
WS110	0.7	0.016	8.6	DS1, AC-1s

11.6.1. HIGHWAYS AND CONCRETE

MCHW Series 600 provides a criteria of 1500 mg/l for water-soluble sulphate within 500 mm of any concrete structure. A second criteria of 300 mg/l is given with respect to soils within 500 mm of steel structures.

11.7. GROUNDWATER

Table 45 Summary of Groundwater Strikes

LOCATION	DEPTH RANGE (M BGL)	DESCRIPTION OF STRIKE	STRATA	EVIDENCE OF CONTAMINATION
Preliminary Ground Investigation Water Strike Information				
WS104	1.00	Seepage	MADE GROUND	None identified
CP101	3.50	Seepage	CLAY	None identified
CP101	7.00	Seepage	CLAY	None identified
Groundwater Monitoring Summary from Installations				
LOCATION	DEPTH RANGE (M BGL)	PERIOD OF MONITORING	WEATHER CONDITIONS DURING MONITORING	COMMENTS
WS101	1.02–1.33	April–May	Overcast	–
WS102	0.62–3.52			No LNAPL/DNAPL Identified
WS103	1.09–1.52			No LNAPL/DNAPL Identified
WS104	0.93–2.45			
WS105	2.64–2.78			–
WS106	2.11–2.13			



LOCATION	DEPTH RANGE (M BGL)	PERIOD OF MONITORING	WEATHER CONDITIONS DURING MONITORING	COMMENTS
WS107	2.72–2.81	April–May	Overcast	No LNAPL/DNAPL Identified.
WS108	0.79–0.98			–
WS109	3.78–3.95			
WS110	0.97–0.99			
CP101	2.38–5.47			No LNAPL/DNAPL Identified.
CP102	4.02–4.60			No LNAPL/DNAPL Identified.

The presence of groundwater appears common to bedrock levels both within the overlying superficial deposits and the bedrock.

Groundwater levels indicate a shallow groundwater level, which is significantly lower towards the south of the site.

11.7.1. INFLUENCING FUNCTIONAL WATERBODIES

Long term monitoring of groundwater has not been conducted as a part of this investigation and interpreted levels are approximate and may be dependent on seasonal variation. It should be noted that seasonal variation is likely to result in potentially significant changes in groundwater levels beneath the site.

The water table can have significant effects on the foundation of a building, including:

-  **Soil settlement:** Changes in the water table can cause soil to expand or contract, which can result in foundation settlement or movement. This can lead to cracks in the foundation, walls, or floors of a building.
-  **Soil erosion:** High water tables can cause soil erosion, which can lead to the loss of soil support beneath the foundation. This can result in foundation settling or movement, which can be dangerous for the stability of the structure.
-  **Hydrostatic pressure:** When the water table rises, the water exerts hydrostatic pressure on the foundation. This can cause foundation walls to crack or bow, which can compromise the structural integrity of the building.
-  **Moisture infiltration:** High water tables can result in moisture infiltration into the foundation and surrounding soil. This can lead to Mold growth, decay, and deterioration of building materials.
-  **Drainage problems:** Poor drainage around a building can cause water to pool around the foundation, increasing the likelihood of soil erosion and hydrostatic pressure. This can lead to foundation settling or movement and can also cause flooding in the basement or crawl space.

It is important to consider the effects of the water table on the foundation when designing and constructing a building. Proper drainage and foundation waterproofing can help to mitigate the effects of the water table on the foundation and improve the longevity and stability of the structure.



11.8. SITE PREPARATION

Our assessment has been based on the fact that the site will be cleared and any vegetation below areas of proposed development stripped in accordance with Series 200 of the *Manual of Contract Documents for Highway Works (MCHW)*. This should include the following:

- ✳ Roots present below the footprint of proposed structures and infrastructure should be grubbed out and the resulting void infilled with suitable compacted engineered fill.
- ✳ Demolition of all existing buildings and removal of all concrete hardstanding.
- ✳ Redundant services should be sealed off and grubbed out and replaced with suitable compacted engineered fill.
- ✳ Buried structures and old foundations have been encountered on-site. These should be excavated from below the proposed development footprint with the resulting void backfilled.

11.9. FOUNDATION CONDITIONS AND ASSESSMENT OF POTENTIAL BEARING CAPACITIES

In due consideration of the identified ground conditions, in-situ and laboratory geotechnical testing, E3P has undertaken an assessment of the safe allowable bearing capacity (ABC) within the underlying natural stratum to assist in the detailed design of foundations and infrastructure and determine the target founding stratum. The results of this assessment are summarised in

Table 46.

Table 46 Summary of ABC

GRANULAR SOILS			
Description	Depth (Range m bgl)	Relative Density	Allowable Bearing Capacity (kN/m ²)
Clayey fine to medium SAND (WS101, WS103)	2.00–2.45	Loose	63.95
Clayey fine to medium SAND (WS106, WS109)	3.00–5.00	Medium Dense	231.87–278.29
Clayey fine to medium SAND (WS106, WS109)	2.00–4.45	Dense	301.47–422.43
SAND and GRAVEL (CP102)	3.00–3.50	Dense	434.83
Weathered SANDSTONE (CP101, CP102)	8.70–9.30	Dense	403



COHESIVE SOILS			
Description	Depth (range m bgl)	Undrained Shear Strength (Cu) (kN/m²)	Allowable Bearing Capacity (kN/m²)
Firm Gravelly CLAY (WS101, WS102, WS107, WS110)	1.00-3.45	25.20–36.54	51.82–75.13
Stiff Gravelly CLAY (WS102, WS104, WS105, WS107, CP101)	1.00-4.45	40.33–59.14	82.91–121.59
Very Stiff, Gravelly CLAY (10 Locations)	1.00–9.00	75.61–244.00	155.46–447.00

The above ABC data demonstrates that suitable materials for founding have been identified at 1.00 m bgl within the natural firm to very stiff CLAY in WS102, WS105, WS107 and WS109, with all other locations containing Made Ground exceeding 1.40 m bgl.

Within three other locations, a suitable ABC was identified at 2.00 m bgl, in the firm to very stiff gravelly CLAY in WS104 and WS110, and in the dense clayey fine to medium SAND in WS106.

Towards the south of the site, the remaining four exploratory hole locations (WS101, WS103, CP101 and CP102), reached a material considered a suitable ABC at 3.00 m bgl, in either the firm to very stiff gravelly CLAY or the dense SAND & GRAVEL, with CP101 recorded at 4.00 m bgl due to extensive MADE GROUND.

Loose SAND was identified in two locations (WS101 and WS103) and 2.00 m bgl, overlying the firm to very stiff gravelly CLAY.

No instances of very soft or soft CLAY were identified during this phase of preliminary intrusive ground investigation.

11.10. FOUNDATIONS OPTIONS APPRAISAL

Based on the assessment of the relative undrained shear strength, relative in-situ densities and corresponding safe allowable bearing capacity, the following recommendations have been developed for the site of the potential foundation solutions that may be adopted for the future residential development. The suitable target founding stratum has been identified as the underlying firm to very stiff glacial clays and localised areas of medium dense to dense sands.

Following this assessment, the following foundation recommendations have been determined:

- ✚ Shallow strip foundations bearing upon the firm to very stiff CLAY at 1.45 m bgl;
- ✚ Reinforced trench fill to support reinforced strip foundations should be considered where the target bearing stratum is greater than 1.50 m below the proposed level and in areas of softer variable ground and/or potential tree influence;
- ✚ Driven pile foundations within areas of extensive MADE GROUND (>2.50 m bgl) or anomalies.



Within the site, there are areas of variable ground conditions that will preclude the use of a shallow spread foundation. This includes the footprint of the main factory structure and outbuildings, where extensive Made Ground deposits are anticipated. Therefore, consideration should be given to the use of Ground Improvement by Vibro Stone Column (VSC) to ensure the treatment achieves a suitable ABC to support a doubly reinforced strip foundation or construction of piled foundations.

To determine if VSC is viable at the subject site, E3P has completed a Ground Improvement Design Risk Matrix that is summarised in Table 47.

Table 47 Ground Improvement Design Risk Matrix

RISK ITEM	COMMENT	PASS/FAIL
Soft clays with an undrained shear strength less than 30 kN/m²	All clays identified contain a CU >30 kN/m ² however further investigation is required to confirm no soft deposits are present on-site.	PASS – on completion of further investigation
Ground with peat layers close to foundation level or the base of the stone column, or where intermediate layers of peat are thicker than 200 mm, either as a single layer or the sum of the thicknesses of individual layers throughout the length of the stone column	No peat or highly organic deposits have been identified during this phase of investigation. However, three historical infilled ponds have been identified which may contain peat layers within the immediate vicinity.	PASS – on completion of further investigation
Voided filled ground, e.g. old water tanks, pottery, glass bottles, concrete rubble or brick fill of unsuitable grading	Made Ground beneath the site will likely require removal and processing to render the site suitable for VSC. The existing buildings substructure will also require excavation and processing into a graded aggregate suitable for vibro treatment.	PASS – on completion of enabling works
Loose or non-engineered fill not previously subject to rising or fluctuating water levels saturation	None identified.	PASS – on completion of further investigation
Filled ground still settling or expected to settle under its own weight or due to the effects of surcharging/upfilling where there is a high organic content or where decay is continuing	None identified – the site was historically filled in excess of 100 years ago with a mixture of clayey SAND and sandy CLAY and engineered fill. It is considered that the material has consolidated under self-weight settlement.	PASS
Fill, containing degradable material where organic material forms more than 15% of fill by volume	None identified.	PASS
Clays with a plasticity index greater than 40%	None identified.	PASS
Highly sensitive soils liable to collapse or remoulding	None identified.	PASS
Cohesive soils with trees in influencing distance	Plots where tree influence has been modelled and will either be subject to a piled or mass trench-fill solution.	PASS
Overall Risk Rating and Suitability for Vibratory Ground Improvement		PASS



It is advisable to consult with geotechnical engineers and foundation specialists who can assess the specific ground conditions and design an appropriate Vibro Stone Column system to meet the project's requirements. They will consider factors such as soil composition, depth, and spacing of the stone columns to ensure effective ground improvement and proper load distribution for the strip foundation.

The exception to this would be in the location of the footprint of the area where Made Ground was identified to be deep and within the footprint of the main factory structure where no intrusive ground investigation was completed. Dependent on development levels, plots in this area may require a driven pile foundation.

Foundation depths should take account of the presence of existing and proposed trees, with foundations deepened locally to mitigate the potential for volumetric instability attributed to fluctuations in moisture content, in accordance with the requirements of NHBC standards.

It is recommended that at working drawing stage a foundation schedule is prepared for the development, taking account of the physical change of natural clay soils and the current/proposed locations of trees.

At this time, it is not possible to accurately define the foundation types due to the absence of a full ground investigation and final development levels; however, based on our extensive experience of similar sites, we would anticipate that the final foundation solution would be a combination of the following:

- ✧ Shallow strip foundations bearing on the firm to very stiff gravelly CLAY at 1.45 m bgl;
- ✧ Reinforced trench fill to support reinforced strip foundations should be considered where the target bearing stratum is greater than 1.50 m below the proposed level and in areas of softer variable ground and/or potential tree influence.
- ✧ Driven pile foundations within areas of extensive MADE GROUND (> 2.50 m bgl) or anomalies; and
- ✧ Ground improvement by Vibro Stone Columns to ensure the treatment achieves a suitable design ABC to support a doubly reinforced strip foundations or piled foundations within the footprint of the main factory site and outbuildings.

11.11. GROUND FLOOR SLABS

Current building control regulations require that where infilled ground is present to depths in excess of 600 mm, or where the substratum is variable in terms of the structure and settlement potential, or where clay soils are present within the influence of existing or proposed trees, a suspended floor slab is required.

In this instance, it is considered that for the majority of substructures, the underlying stratum would have in excess of 600 mm of infill and, as such, a suspended floor slab will be required.

Where a cast in-situ suspended slab is utilised with no subfloor void, appropriate compressible material (heave precautions) will be required in the construction of the substructure.

In clay soils, if the foundation depth is greater than 1.50 m, allowance should be made in the design for heave. This must incorporate either a clear void of a specified minimum depth under the suspended floor, or a proprietary compressible material/void former below the underside of the floor construction.



Ground bearing slabs should not be used in ground conditions where heave can occur or where the foundation depth is greater than 1.50 m. Under these circumstances a suspended floor construction should be used.

11.12. HEAVE PRECAUTIONS

The site has been proven to be underlain by clay soils which are susceptible to volumetric instability due to fluctuations in moisture content, particularly within influencing distance of trees as per the NHBC/LABC conjectures zones of influence.

The clay has been determined as being of low volume change potential. Table 48 shows where heave precautions are required for a trench fill, pier and beam and pile and beam foundation types which are in the zone of influence of trees which are to remain or be removed.

Table 48 Position of Heave Precautions

SITUATION	TRENCH FILL	PIER AND BEAM	PILE AND BEAM
External trench fill and pier foundations. Unless NHBC is satisfied that the soil is not desiccated compressible material should be provided to the:	Inside faces of external wall foundations deeper than 1.50 m, based on the appropriate tree height.	All faces of pier foundations deeper than 1.50 m, based on the appropriate tree height.	N/A
External ground beams. Unless NHBC is satisfied that the soil is not desiccated, compressible material or void formers should be provided to the:	N/A	Inside faces	Inside faces
Internal trench fill foundations and ground beams. Compressible material required:	No	No	No
External and internal ground beams. Compressible material, void former or void should be provided to the underside of:	N/A	All	All
Heave precautions required for proposed trees where the soil is not desiccated:	No	No	No

Note: Information taken from NHBC Standards 2024, Chapter 4.2, Table 8 – Position of heave precautions

A summary of heave precautions is presented in Table 49.

Table 49 Summary of Heave Precautions

VOLUME CHANGE POTENTIAL	VOID DIMENSION AGAINST SIDE OF FOUNDATION AND GROUND BEAM	VOID DIMENSION UNDER GROUND AND IN-SITU GROUND BEAMS, SUSPENDED CONCRETE FLOOR	VOID DIMENSION UNDER PRECAST AND CONCRETE FLOORS ⁽¹⁾ AND SUSPENDED CONCRETE TIMBER
High	35 mm	150 mm	300 mm
Medium	25 mm	100 mm	250 mm
Low	0 mm	50 mm	200 mm



In addition to the requirements of the 'Drainage' section, drainage near trees should incorporate additional provisions. Where there is a volume change potential within the ground, the provisions include:

- ✳ Increased falls to cater for any ground movement.
- ✳ Deeper and wider backfill of granular material.
- ✳ A drainage system that is capable of movement should heave and shrinkage occur.
- ✳ Drainage pipes should not be encased in concrete.
- ✳ Additional clearance is required where drains pass through the structure of a building to allow for additional movement.

11.13. HIGHWAYS CONSTRUCTION

Unsuitable materials are potentially present within areas of the infilled ponds.

A programme of remediation and enabling works will be required to remediate the proposed road subgrade in accordance with the requirements of the Manual of Contract Documents for Highway Works Volume 1 Specification For Highway Works (Series 600-Earthworks) for a method compaction.

11.14. DRAINAGE

Where loose or soft materials have been identified at drainage invert levels, there will need to be consideration for the use of reinforced pipe bedding.

Shrinkage and heave of clay soils can affect pipelines. To protect against the effects of heave, drainage should be designed:

- ✳ To take account of potential ground movement as shown in
- ✳ Table 50 , including where pipes and services pass through substructure walls or foundations.
- ✳ With gradients which may need to be steeper.
- ✳ To use alternative means of catering for the movement when sufficient falls cannot be provided, for example, by deepening the excavation and laying pipework on a granular bedding of suitable thickness to reduce the extent of potential movement.

Table 50 Potential Ground Movement for Drainage

VOLUME CHANGE POTENTIAL	HIGH	MEDIUM	LOW
Potential ground movement	150 mm	100 mm	50 mm

11.15. EXCAVATIONS

Site observations indicated that excavations may be limited in the near surface within the footprint of the main factory structure utilising normal plant due to former foundations and former floor slabs. It is anticipated that any obstructions will be grubbed out during the reduced-level dig for the substructure works.



However, due to the depth and variability of the Made Ground and likelihood of trench collapse, it is considered that all excavations are supported or battered back in accordance with guidance contained in CIRIA R97.

If local pumping of groundwater is required during the advancement of excavations for the proposed foundations then consideration should be given to the potential for dewatering gravels in the surrounding areas that may cause structural damage to building substructures in close proximity to the site.

Table 51 Civil Engineering Excavation Risk Matrix

RISK ITEM	PRESENT	COMMENT
Running Sands	No	No running sand has been identified.
Minor Water Ingress	No	Minor water ingress will require localised dewatering/sump pumping during the construction of site drainage infrastructure. Ingress of water into foundation excavation will potentially flood foundation excavations, limiting the viability of spread foundations to be constructed.
Shallow Bedrock	Yes	Bedrock has been identified towards the northern part of site at depths less than 5.00 m bgl, decreasing to 7.00 m bgl towards the southwest, and further deepening to 9.00 m towards the southeast of the site. However, bedrock is considered likely to be deep enough not to significantly impede excavation for drainage infrastructure using traditional excavation plant and equipment.

11.16. CONSTRUCTION ACTIVITY AND INSPECTION

The following activities and inspections should be incorporated into the site works:

- ✳ Due to the variability of the soils at the site, it is recommended that sufficient allowance is made for the inspection of formations and sub formations to foundations and pavement construction.
- ✳ Excavations where access is required should be subject to a risk assessment from a competent person and, where appropriate, mitigation measures such as benching back the sides or use of support systems in accordance with CIRIA R97 should be utilised.
- ✳ It is considered that dewatering may be required, especially following periods of heavy rainfall. Removal of surface water and water within trenches should be possible with conventional sump pumping. Discharge of any water should be agreed with the relevant regulatory body and be undertaken under a trade effluent discharge, where required.
- ✳ Where access to confined spaces is required, appropriate mitigation measures should be addressed within the construction stage health and safety plan. Particular account should be taken of the gas results.
- ✳ The presence of potential contamination and mitigation measures should be addressed as part of the construction stage health and safety plan and should include measures to design out the risks, reduce their impact and, finally, to include the use of personnel protective equipment (PPE).



11.17. DEVELOPED GEOTECHNICAL RISK REGISTER

Table 52 Developed Geotechnical Risk Register

POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON-SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Remediation of contaminated soils		On-site	TBC	Extensive sources of VOCs have been identified within MADE GROUND and natural soil chemical analysis and within groundwater, with the primary source likely to be within the vicinity of WS102 (enamel slurry waste storage area). Due to the extensive impact identified, a hotspot removal and/or treatment is required within WS102 to remove the source to mitigate further spread across the site. At this stage, further investigation is required to determine the spatial extent of contamination within the soils and understand whether leaching has occurred into the underlying natural strata, particularly in WS101 and WS103, where exceedances were only recorded within the MADE GROUND deposits. Minor instances of heavy metalloid contamination was identified within MADE GROUND deposits in the northern part of the site, which may require removal prior to the construction.
Bedrock		On-site	TBC	Bedrock has been identified towards the northern part of site at depths less than 5.00 m bgl, decreasing to 7.00 m bgl towards the southwest, and further deepening to 9.00 m towards the southeast of the site. However, bedrock is considered likely to be deep enough not to significantly impede excavations and earthworks prior to the development.
Obstructions		All	100	Site has been subject to significant historical development with all above ground structures still present. Further extensive potential subsurface obstructions from relict foundations, railway/tramway sidings and slabs potentially remain.
Artificially levelled and filled platforms		N/A	100	The site appears to have been levelled and artificially backfilled.
Trench collapse		All	100	Made Ground present beneath the site is likely to be loosely compacted and possibly prone to collapse.
Volume change potential clay		On-site	80	The site is likely to be underlain by predominantly cohesive soils. The assessment of volume change potential denoted all tested soils are of low volume change potential. Further assessment following further investigation into previously inaccessible areas is required to complete a full assessment.



POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON-SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Running sands		N/A	N/A	Data searches indicate very low risk.
Ground dissolution		N/A	N/A	Data searches indicate no hazard.
Concrete design		TBC	-	Based upon the chemical soil analysis, the concrete classification is within DS1, AC-1s. All concrete should be designed in accordance with this classification. Further sampling is required within areas not investigated to confirm concrete classification in these areas.
Low-permeability ground		On-site	70	Soakaways unlikely to be effective within the site due to the presence of extensive low permeability cohesive deposits are present. Additionally, towards the south where areas of potentially contaminated soil and groundwater are present precluding the use of soakaway drainage.
Abnormal foundation solutions		TBC	TBC	Within the footprint of the current main factory structure, extensive MADE GROUND is anticipated which may require abnormal foundations. Furthermore, three historically infilled ponds were recorded towards the centre south, southeast and northeast boundaries of the site which may contain soft clay or silty deposits to unknown depths which may require abnormal foundation solutions.
Areas not investigated		On-site	75	A large portion of the site was inaccessible during the preliminary intrusive ground investigation due to the oven manufacturing factory still being active. This included the main factory structure occupying the centre of the site, areas of car parking towards the southwestern sector, and within proximity to electricity sub stations towards the south. Further investigation into the footprint of the main factory structure and all other areas not investigated is required to obtain additional soil and groundwater samples, across the southern boundary to determine potential VOC plume extent and within the footprint of the main factory structure to determine the potential presence of PFAS/PFOA, Explosive Compounds and Propellants.
Historically infilled ponds		On-site	15	Three small historical infilled ponds were recorded towards the centre south, southeast and northeast boundaries of the site, which were infilled approximately 52 years ago (southeast) and over 100 years ago (centre south and northeast). The historical infilled ponds present potential geotechnical risk associated with soft clay, silts and potentially peat deposits within the footprint. A small outbuilding structure was present where the infilled pond to the southeast was, and therefore could not be investigated; further investigation following demolition is recommended.



POTENTIAL CONSTRAINT	ABNORMAL	LOCATION ON-SITE	ESTIMATED AREA OF SITE AT RISK (%)	ASSESSMENT AND MITIGATION
Consolidation & Settlement		On-site	100	The presence of variable historical Made Ground represent an unacceptable risk associated with the consolidation of materials that could induce unacceptable settlement to structures and infrastructure. A detailed settlement analysis will be required as part of a Geotechnical Design Report.
Enabling Earthworks		On-site	100	All proposed earthworks will need to be designed by a suitably qualified geotechnical engineer in accordance with NHBC Chapter 4.6. The earthworks design will incorporate a Geotechnical Specification for Earthworks that will define protocols to ensure no unacceptable future risk.



11.18. FURTHER WORKS

Based on the findings of the preliminary intrusive ground investigation, the following additional works are recommended to be completed in due course:

- ✦ Further intrusive ground investigation, including delineation of VOC impacted soils and groundwater and determination of any potential PFAS/PFOA, Explosive Compounds and Propellant contamination;
- ✦ Further intrusive ground investigation of inaccessible areas (main factory structure and outbuildings);
- ✦ Human Health DQRA of VOC impacted soils (subject to findings of further phases of intrusive ground investigation);
- ✦ Controlled Waters DQRA of VOC DNAPL plume;
- ✦ Plot-specific foundation schedule (upon receipt of the final development levels);
- ✦ Geotechnical Design Report (GDR), including settlement analysis;
- ✦ Geotechnical Earthworks Specification (infrastructure);
- ✦ Remediation and enabling works strategy; and
- ✦ Specification for Mitigation of Hazardous Ground Gasses & Verification Plan.

END OF REPORT

APPENDIX I LIMITATIONS



GENERAL

1. This report and any associated works (together comprising the "Services") were compiled and carried out by E3P for the client (as present in Section 1) under the E3P "Terms of Business" or with those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed and outlined in the body of the report.
2. Unless explicitly agreed otherwise, in writing, this report has been prepared under E3P Standard Terms and Business as included within our proposal to the Client.
3. Project-specific appointment documents may be agreed upon at our discretion and a charge may be levied for both the time to review and finalise appointment documents and also for associated changes to the appointment terms. E3P reserves the right to amend the fee should any changes to the appointment terms create an increased risk to E3P.
4. The report needs to be considered in light of the proposal and associated limitations of scope. The report needs to be read in full and isolated sections cannot be used without full reference to other elements of the report and any previous works referenced within the report.

PHASE 1 GEOENVIRONMENTAL AND PRELIMINARY RISK ASSESSMENTS

5. Coverage: This section covers reports with the following titles or combination of titles: Phase 1; Desktop Study; Geoenvironmental Assessment; Development Appraisal; Preliminary Environmental Risk Assessment; Constraints Report; Due Diligence Report; Geotechnical Development Review; Environmental Statement; Environmental Chapter; Baseline Environmental Assessment; Project Scope Summary Report (PSSR), Program Environmental Impact Report (PEIR), Geotechnical Development Risk Register; Agricultural Land Assessment; Mineral Safeguarding Assessment; Desk Top Coal Mining Risk Assessment; Hydrogeological Appraisal; Construction Environmental Management Plan; and Site Water Management Plan.
6. The works undertaken to prepare this report comprised a study of available and easily documented information from a variety of sources (including the Client), together with (where appropriate) a brief walkover inspection of the Site and correspondence with relevant authorities and other interested parties. Due to the short timescales associated with these projects responses may not have been received from all parties. E3P cannot be held responsible for any disclosures that are provided post-production of our report and will not automatically update our report.
7. The opinions given in this report have been dictated by the finite data on which they are based and are relevant only for the purpose for which the report was commissioned. The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data pertaining to site conditions. Should additional information become available which may affect the opinions expressed in this report, E3P reserves the right to review such information and, if warranted, to modify the opinions accordingly.
8. It should be noted that any risks identified in this report are perceived risks based on the information reviewed. Actual risks can only be assessed following intrusive investigations of the site.



9. Where mention has been made to the identification of Japanese Knotweed and other invasive plant species and asbestos or asbestos-containing materials, this is for indicative purposes only and does not constitute or replace full and proper surveys completed by suitably qualified and experienced specialists in these fields.
10. E3P does not warrant work/data undertaken/provided by others.

INTRUSIVE INVESTIGATION REPORTS

11. Coverage: The following report titles (or combination) may cover this category of work: Geoenvironmental Ground Investigation; Geotechnical Assessment; GIR (Ground Investigation Reports); Preliminary Environmental And Geotechnical Risk Assessment; Preliminary Summary; Coal Mining Risk Assessment, Ground Gas Addendum; and Geotechnical Risk Register.
12. The investigation has been undertaken to provide information concerning either:
 - I. The type and degree of contamination present at the site in order to allow a generic quantitative risk assessment to be undertaken; or
 - II. Information on the soil properties present at the site to allow for geotechnical development constraints to be considered.
13. The scope of the investigation was selected on the basis of the specific development and land use scenario proposed by the Client and may be inappropriate to another form of development or scheme. If the development layout was not known at the time of the investigation the report findings may need revisiting once the development layout is confirmed.
14. Unless otherwise specified in the scope of works, any site drawing(s) provided in this report is (are) not meant to be an accurate base plan but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (intrusive and sample locations etc) annotated on-site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.
15. For contamination purposes, the objectives of the investigation are limited to establishing the risks associated with potential contamination sources with the potential to cause harm to human health, building materials, the environment (including adjacent land), or controlled waters.
16. For geotechnical investigations, the purpose is to broadly consider potential development constraints associated with the physical property of the soils underlying the site within the context of the proposed future or continued use of the site, as stated within the report.
17. The amount of exploratory work, soil property testing and chemical testing undertaken has necessarily been restricted by various factors which may include accessibility, the presence of services; existing buildings; current site usage or short timescales. The exploratory holes completed assess only a small percentage of the area in relation to the overall size of the Site, and as such can only provide a general indication of conditions.



18. The number of sampling points and the methods of sampling and testing do not preclude the possible existence of contamination where concentrations may be significantly higher than those actually encountered or ground conditions that vary from those identified. In addition, there may be exceptional ground conditions elsewhere on the site which have not been disclosed by this investigation and which have therefore not been taken into account in this report.
19. The inspection, testing and monitoring records relate specifically to the investigation points and the timeframe that the works were undertaken. They will also be limited by the techniques employed. As part of this assessment, E3P has used reasonable skill and care to extrapolate conditions between these points based on assumptions to develop our interpretation and conclusions.
20. The assumption made in forming our conclusions is that the ground and groundwater conditions (both chemically and physically) are the same as have been encountered during the works undertaken at the specific points of investigation and at the time of the investigation.
21. Conditions can change between investigation points both spatially and over time and these interpretations should therefore be considered indicative. The assessment of extreme weather events and their impact on ground conditions is not within the scope of E3P's work.
22. The risk assessment and opinions provided are based on currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values. Specific assumptions associated with the risk assessment process have been outlined within the body or associated appendix of the report.
23. Additional investigations may be required in order to satisfy relevant planning conditions or to resolve any engineering and environmental issues.
24. Where soil contamination concentrations recorded as part of this investigation are used for commentary on the potential waste classification of soils for disposal purposes, these should be classed as indicative only. Due consideration should be given to the variability of contaminant concentrations taken from targeted samples versus bulk excavated soils and the potential variability of contaminant concentrations between sampling locations. Where major waste disposal operations are considered, targeted waste classification investigations should be designed and the waste classification and any subsequent disposal option agreed upon with licenced subcontractors and/or the relevant regulators.
25. The results of the asbestos testing are factually reported and interpretation is given as to how this relates to the previous use of the site, the types of ground encountered and site conceptualisation. This does not however constitute a formal asbestos assessment. These results should be treated cautiously and should not be relied upon to provide detailed and representative information on the delineation, type and extent of bulk ACMs and/or trace loose asbestos fibres within the soil matrix at the site.
26. If costs have been included in relation to additional site works, and/or site remediation works these must be considered as indicative only and must be confirmed by a qualified quantity surveyor.



EUROCODE 7: GEOTECHNICAL DESIGN

27. On 1st April 2010, BS EN 1997-1:2004 (Eurocode 7: Geotechnical Design – Part 1) became the mandatory baseline standard for geotechnical ground investigations.
28. In terms of geotechnical design for foundations, slopes, retaining walls and earthworks, EC7 sets guidance on design procedures including specific guidance on the numbers and spacings of boreholes for geotechnical design, there are limits to methods of ground investigation and the quality of data obtained and there are also prescriptive methods of assessing soil strengths and methods of design. Unless otherwise explicitly stated, the work has not been undertaken in accordance with EC7. A standard geotechnical interpretative report will not meet the requirements of the Geotechnical Design Report (GDR) under Eurocode 7. The GDR can only be prepared following confirmation of all structural loads and serviceability requirements. The report is likely to represent a Ground Investigation Report (GIR) under the Eurocode 7 guidance.

DETAILED QUANTITATIVE RISK ASSESSMENTS AND REMEDIATION AND ENABLING WORK STRATEGY REPORTS

29. These reports build upon previous report versions and associated notes. The scope of the investigation, further testing and monitoring and associated risk assessments were selected based on the specific development and land use scenario proposed by the Client and may not be appropriate to another form of development or scheme layout. The risk assessment and opinions provided are based on currently available approaches in the generation of Site Specific Assessment Criteria relating to contamination concentrations and are not considered to represent a risk in a specific land use scenario to a specific receptor. No liability can be accepted for the retrospective effects of any future changes or amendments to these values, associated models or associated guidance.
30. The outputs of the Detailed Quantitative Risk Assessments are based upon the manipulation of standard risk assessment models. These are our interpretation of the risk assessment criteria.
31. Before adoption on-site, assessment criteria will need to be discussed and agreed upon with the Regulatory Authorities prior to adoption on-site. The regulatory discussion and engagement process may result in an alternative interpretation being determined and agreed. The process and timescales associated with the Regulatory Authority engagement are not within the control of E3P. All costs and programmes presented as a result of this process should be validated by a quantity surveyor and should be presumed to be indicative.
32. E3P does not accept liability for any subcontract work that has not been completed in strict accordance with an approved E3P Remediation and Enabling Works Strategy.

GEOTECHNICAL DESIGN REPORT (GDR)

33. The GDR can only be prepared following confirmation of all structural loads and serviceability requirements. All the relevant information needs to be provided to allow for a GDR to be produced.



MONITORING (INCLUDING REMEDIATION MONITORING REPORTS AND BUILD PHASE MITIGATION)

34. These reports are factual and comprise monitoring, normally groundwater and ground gas and data provided by contractors as part of earthworks or remedial works.
35. The data is presented and will be compared with assessment criteria.

APPENDIX II

GLOSSARY



TERMS

ACM	Asbestos-containing material	MMP	Materials management plan
ADS	Acoustic design statement	ND	Not detected
AST	Above-ground storage tank	NDP	Nuclear density probe
BGS	British Geological Survey	NMP	Noise management plan
BSI	British Standards Institute	NPSE	Noise policy statement for England
BTEX	Benzene, toluene, ethylbenzene, xylenes	NR	Not recorded
CA	Coal Authority	PAH	Polycyclic aromatic hydrocarbon
CBR	California bearing ratio	PCB	Polychlorinated biphenyl
CIEH	Chartered Institute of Environmental Health	PI	Plasticity index
CIRIA	Construction Industry Research Association	PID	Photo ionisation detector
CLEA	Contaminated land exposure assessment	POS	Public open space
CML	Council of Mortgage Lenders	PPE	Personnel protective equipment
CoC	Contaminants of concern	ProPG	Professional practice guidance
CSM	Conceptual site model	QA	Quality assurance
DNAPL	Dense non-aqueous phase liquid (chlorinated solvents, PCB)	SGV	Soil guideline value
DWS	Drinking water standard	SPH	Separate-phase hydrocarbon
EA	Environment Agency	SPT	Standard penetration test
EQS	Environmental quality standard	SVOC	Semi-volatile organic compound
FFL	Finished floor level	TPH	Total and speciated petroleum hydrocarbon
GAC	General assessment criteria	TPH CWG	Total Petroleum Hydrocarbon (Criteria Working Group)
GL	Ground level	UKWIR	United Kingdom Water Infrastructure Risk
GSV	Gas screening value	UST	Underground storage tank
HCV	Health criteria value	VCC	Vibro-concrete column
ICSM	Initial conceptual site model	VOC	Volatile organic compound
LEL	Lower explosive limit	VRSC	Vibro-replacement stone columns
LMRL	Lower method reporting limit	VSC	Vibro-stone columns
LNAPL	Light non-aqueous phase liquid (petrol, diesel, kerosene)	WHO	World Health Organisation



MCV	Moisture condition value	WRAP	Waste and Resources Action Programme
MIBK	Methyl isobutyl ketone	WTE	Water table elevation
m	Metres	ppm	Parts per million
km	Kilometres	mg/m³	Milligram per metre cubed
% v/v	Percent volume in air	m bgl	Metres below ground level
mb	Millibars (atmospheric pressure)	m bcl	Metre below cover level
l/hr	Litres per hour	mAOD	Metres above ordnance datum (sea level)
µg/l	Micrograms per litre (parts per billion)	kN/m²	Kilonewtons per metre squared
ppb	Parts per billion	µm	Micrometre
mg/kg	Milligrams per kilogram (parts per million)	SSRT	Site Specific Remediation Target
PSD	Particle Size Distribution	DD	Dry Density
CL:AIRE	Contaminated Land: Applications in Real Environments	Mc	Moisture Content
ρ	Bulk Density	GPR	Ground Penetrating Radar
NDP	Nuclear Density Probe	FFL	Finished Floor Level
LEL	Lower Explosive Limit	UKWIR	UK Water Industry Research
CIRIA	Construction Industry Research and Information Association	LOD	Limit of Detection
PFAS	Per- and Poly-Fluorinated Substances	PFOA	Perfluorooctanoic Acid

APPENDIX III

RISK CLASSIFICATION



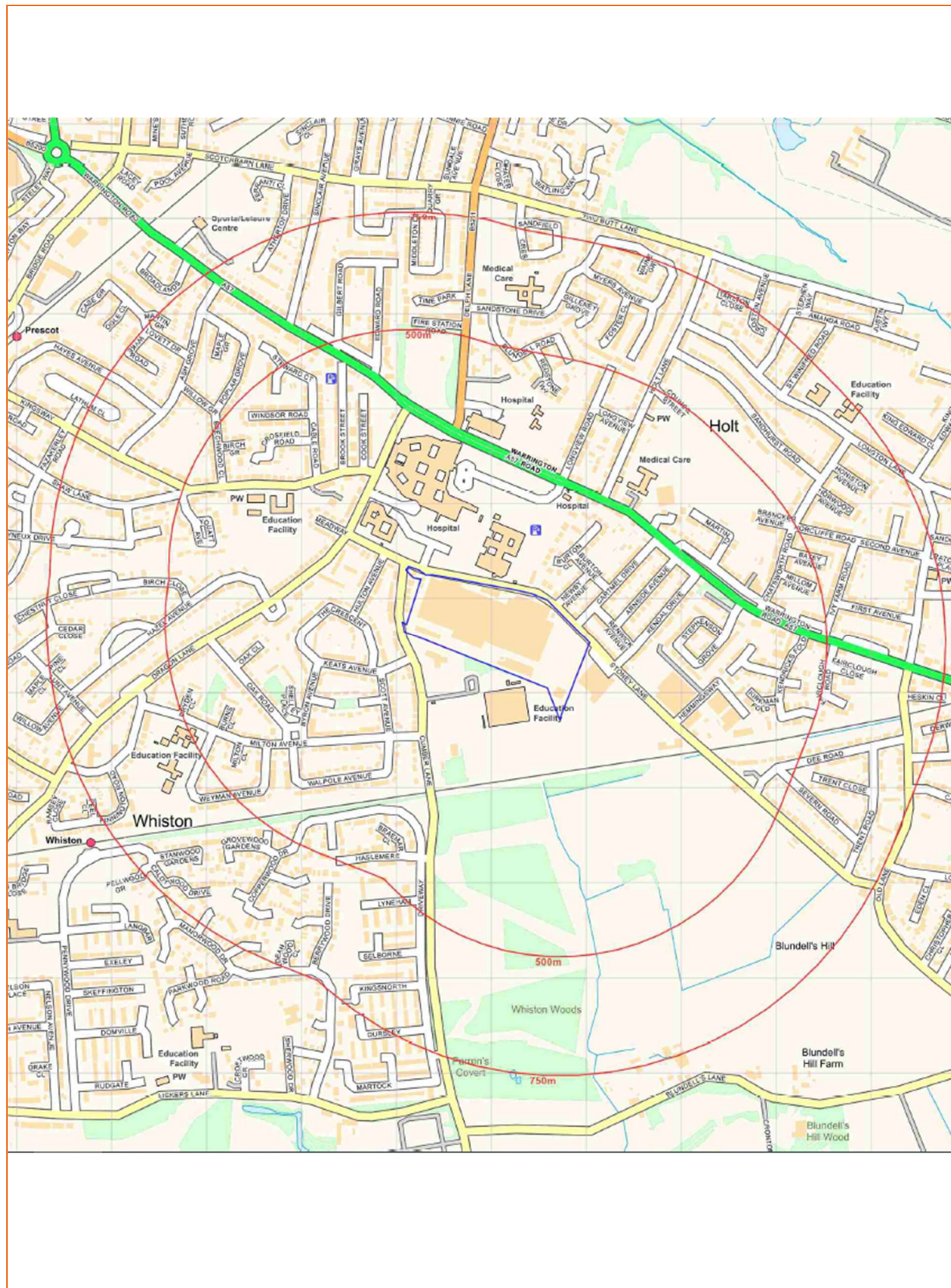
RISK CLASSIFICATION

RISK	DEFINITION
Low	There are unlikely to be significant contaminated land liabilities/geotechnical constraints associated with the property.
Low Moderate	There are unlikely to be significant contaminated land liabilities/geotechnical constraints associated with the property with regard to the proposed use. However, minor issues may require further consideration in the event of future redevelopment of the site.
Moderate	Some potential contaminated land liabilities/geotechnical constraints are likely to affect the property as a result of historical and/or current activities. The risks identified are unlikely to pose an immediate significant issue but the purchaser/developer may wish to make further enquiries of the vendor or undertake further environmental improvements. Redevelopment of the site will likely require further ground investigation.
Moderate High	Some potentially significant contaminated land liabilities/geotechnical constraints have been identified at the property that requires further assessment, including intrusive ground investigations.
High	Significant potential contaminated land liabilities/geotechnical constraints have been identified at the property. Further assessment including intrusive ground investigation will be required to determine the level of risk and associated liability.

APPENDIX IV DRAWINGS



DRAWING 17-500-001 – Site Location Plan





Site Features

	Factory Building (Active)		Soft Cover
	Loading Bays (Sheltered)		Enamel Slurry UST
	Skip / Waste Storage		Localised Fly Tipped Material
	Vacant Buildings		Foul UST
	Asphalt Car Parking		Site Entrance (Security Manned)
	Concrete Roadways		
	Electricity Substation (active)		
	Hydrants		
	Gas House / Gas Governor		

Notes:

P1	REVB	13.05.2024	EB	ID	MW
P1	REVA	22.03.2024	EB	MW	MW
Phase	Issue	Date	Drawn	Checked	PM

Client:

Glen Dimplex

Job Title:

Prescott

Job No:

17-500

Drawing No:

004

Date:

13.05.2024

Scale:

NTS@ A3

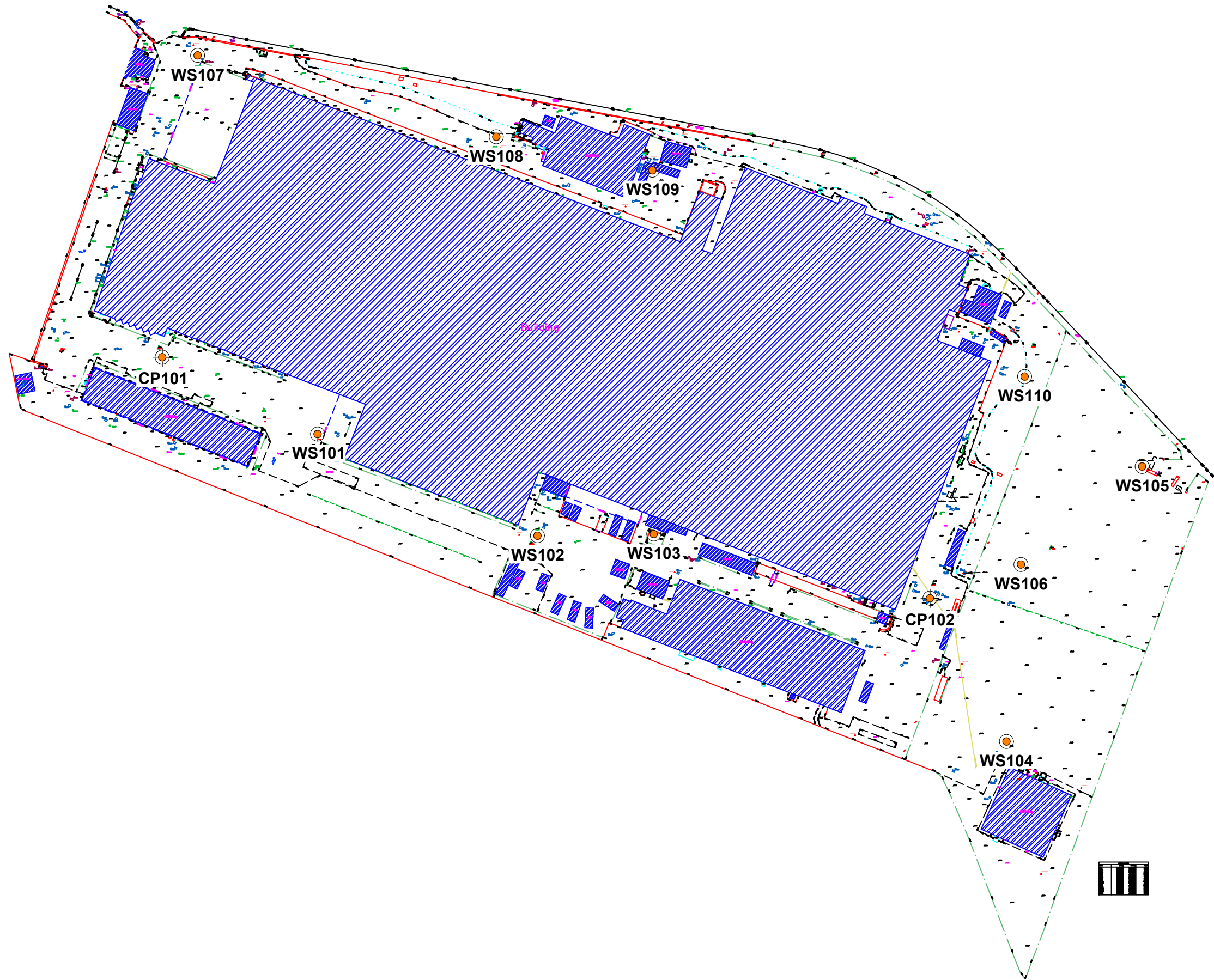
Drawing Title:

Site Features Plan



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Location Symbols

-  Approximate Window Sample Probehole Location (E3P February 2024)
-  Approximate Cable Percussive Borehole Location (E3P February 2024)

Notes:

P1	REVB	13.05.2024	EB	ID	MW
P1	REVA	22.03.2024	EB	ID	MW
Phase	Issue	Date	Drawn	Checked	PM

Client:

Glen Dimplex

Job Title:

Prescott

Job No:

17-500

Drawing No:

005

Date:

13.05.2024

Scale:

NTS @ A3

Drawing Title:

Exploratory Hole Location Plan



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- Location Symbols**
- Approximate Window Sample Probehole Location (E3P February 2024)
 - Approximate Cable Percussive Borehole Location (E3P February 2024)

- Made Ground Depth (m)**
- Depth of Made Ground 0.50 - 0.74m
 - Depth of Made Ground 0.75 - 0.99m
 - Depth of Made Ground 1.00 - 1.24m
 - Depth of Made Ground 1.25 - 1.49m
 - Depth of Made Ground 1.50 - 1.74m
 - Depth of Made Ground 1.75 - 1.99m
 - Depth of Made Ground >2.00m

Notes:					
P1	REVC	21.05.2024	OW	MW	MW
P1	REVB	13.05.2024	EB	ID	MW
P1	REVA	25.03.2024	EB	ID	MW
Phase	Issue	Date	Drawn	Checked	PM

Client:	Glen Dimplex
Job Title:	Prescott

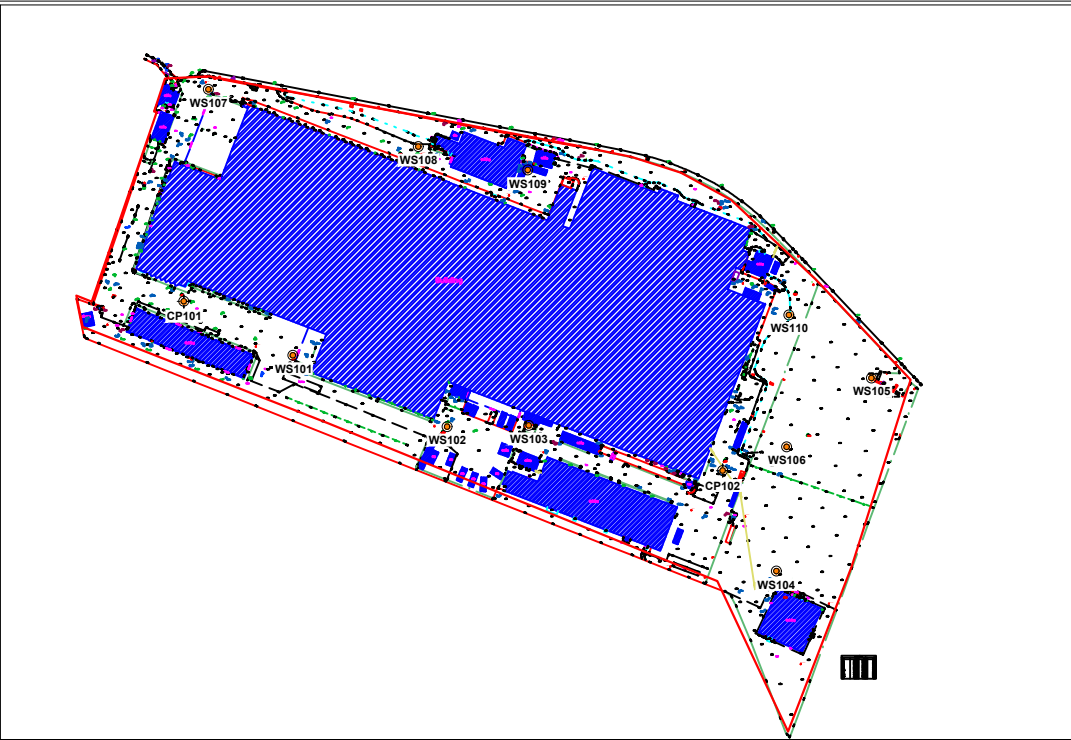
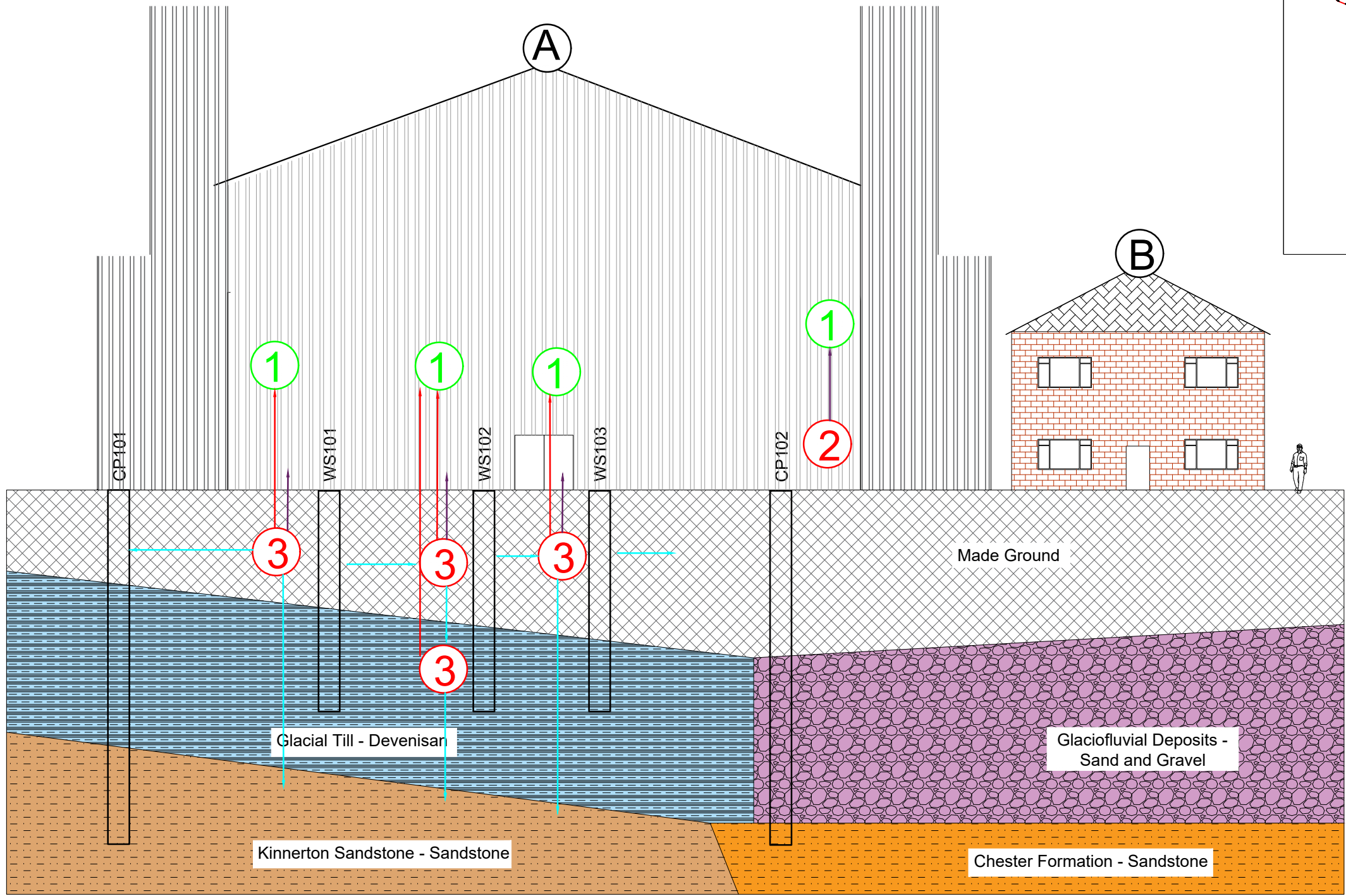
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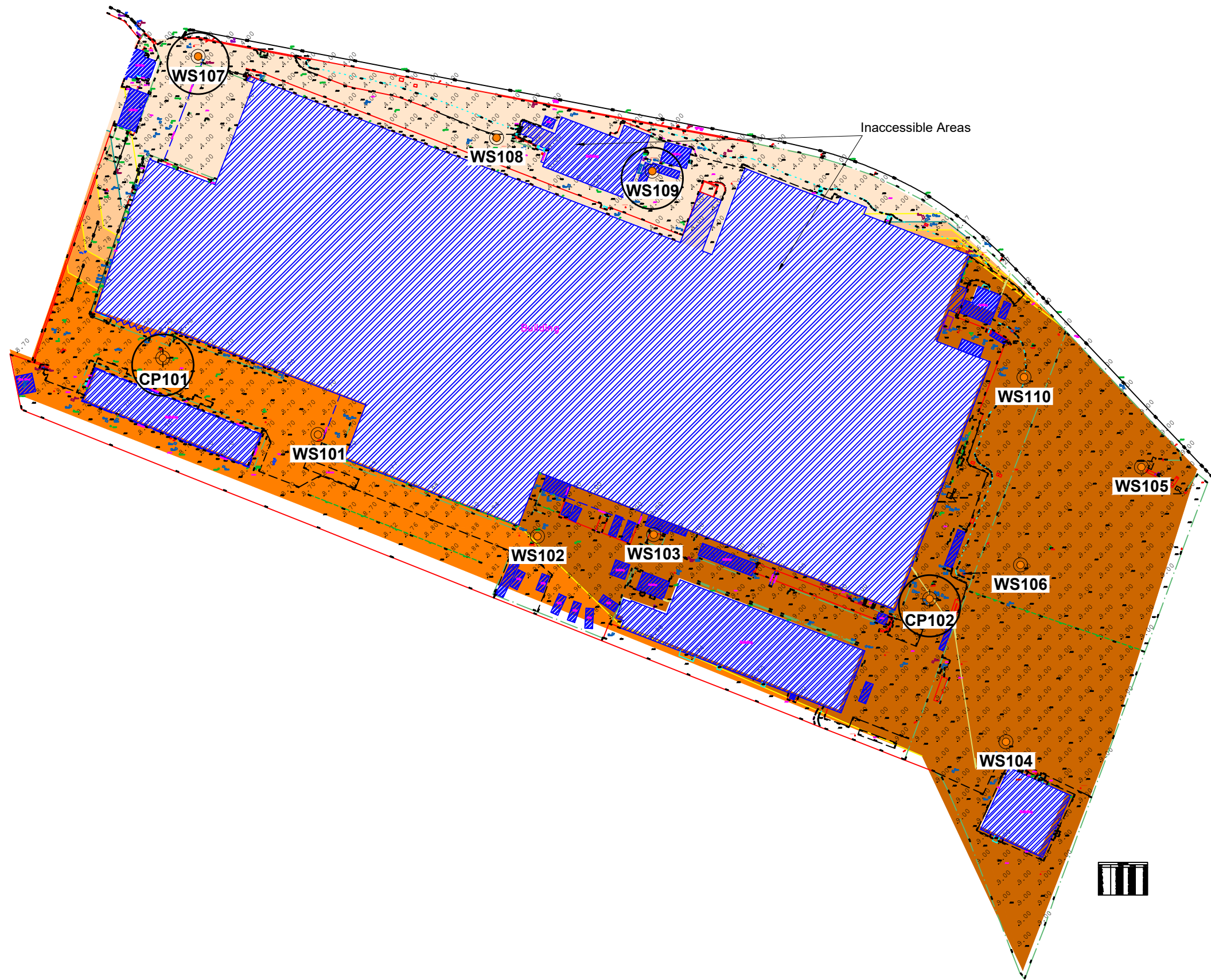
Drawing Title:	Depth of Made Ground Plan
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Geology Key  Made Ground  Glacial Till - Devensian  Glaciofluvial Deposits - Sand and Gravel  Kinnerton Sandstone - Principal  Chester Formation - Sandstone - Principal		Sources  ① Heavy Metals (Arsenic, Lead, Nickel)  ② Asbestos Fibres  ③ VOC's (Trichlorethene, Cis 1,2 - Dichloroethene, Trans 1,2 - Dichloroethene, Vinyl Chloride)		Pathways  Vertical / Lateral Migration  Volatile Vapour  Inhalation / Accumulation		Receptors  ① Future End Users		Site Features  A Factory (Present)  B Future Residential Development		Notes:						Client: Glen Dimplex		Job No: 17-500		Date: 13.05.2024		 Environmental Engineering Partnership Ltd Taylor Road, Trafford Park Urmston, Manchester, M41 7JG Tel: 0161 707 9612 E-mail: info@e3p.co.uk Website: www.e3p.co.uk					
P1 Phase REVA Issue 13.05.2024 Date EB Drawn ID Checked MW PM						Job Title: Prescott		Drawing No: 010		Scale: NTS																	
The client must not amend any drawing, design or other intellectual property produced by E3P Ltd without permission in writing from E3P Ltd in advance of any amendments being made. In the event that such written permission is not obtained in advance of the amendments being made, E3P Ltd shall not be liable for any damage and/or losses occurring as a result of the amended drawing, design or intellectual property.																											



Location Symbols

- WS101 Approximate Window Sample Probehole Location (E3P February 2024)
- CP101 Approximate Cable Percussive Borehole Location (E3P February 2024)

Bedrock Depth (m)

- Depth to Bedrock 4.00 - 4.99m
- Depth to Bedrock 5.00 - 5.99m
- Depth to Bedrock 6.00 - 6.99m
- Depth to Bedrock 7.00 - 7.99m
- Depth to Bedrock 8.00 - 8.99m
- Depth to Bedrock 9.00 - 9.99m
- Location of Bedrock Encountered

Notes:					
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Phase	Issue	Date	Drawn	Checked	PM

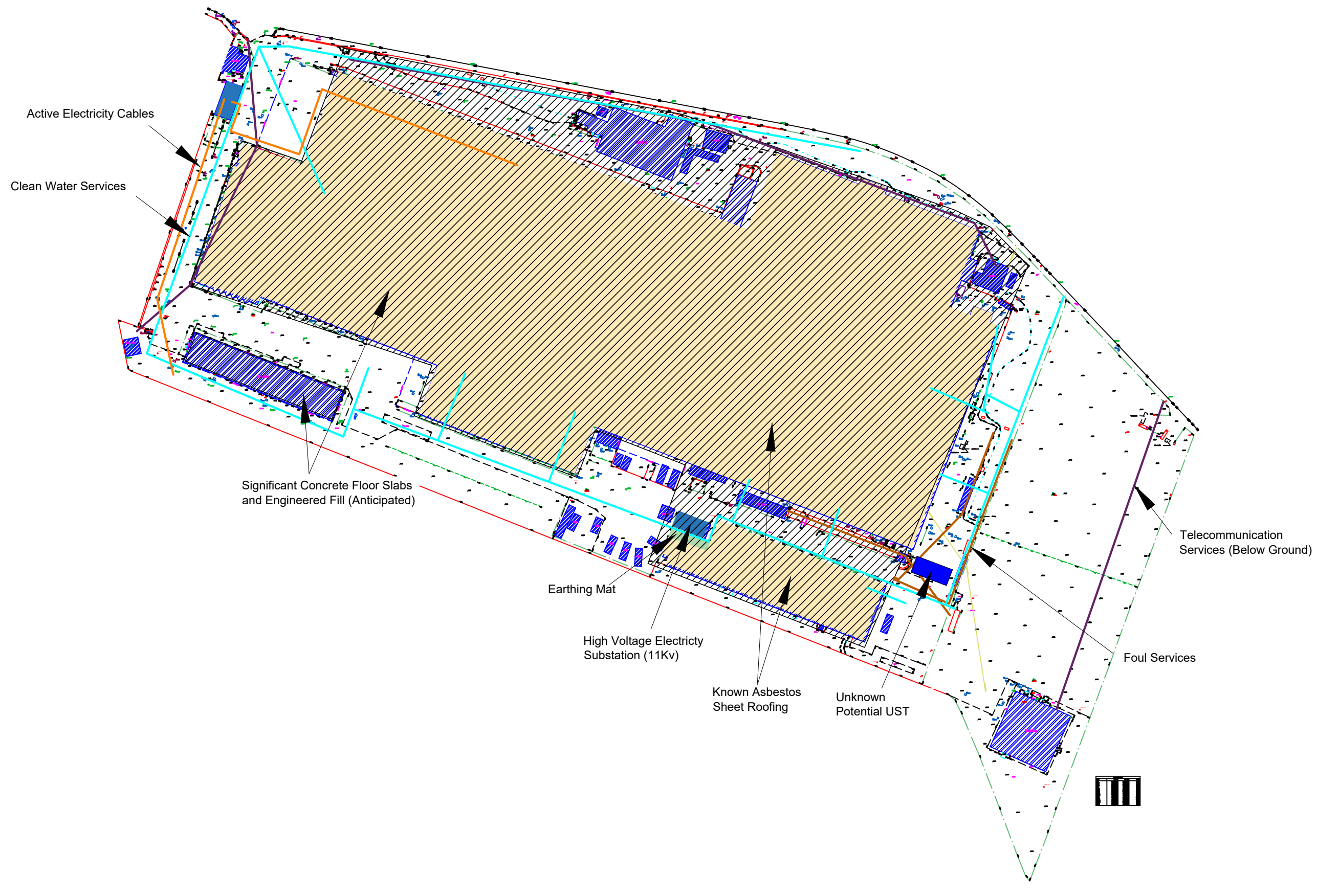
Client:		Glen Dimplex	
Job Title:		Prescott	

Job No:	17-500	Date:	25.03.2024
Drawing No:	012	Scale:	NTS @ A3
Drawing Title:		Depth to Bedrock Plan	



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- Site Features
- Significant Concrete Floor Slabs and Engineered Fill (Anticipated)
 - Earthing Mat
 - High Voltage Electricity Substation (11Kv)
 - Known Asbestos Sheet Roofing
 - Unknown Potential UST
 - Foul Services
 - Telecommunication Services (Below Ground)
 - Community Water Services
 - Active Electricity Cables

Notes:					
P1	REVB	13.05.2024	EB	ID	MW
P1	REVA	25.03.2024	EB	MW	MW
Phase	Issue	Date	Drawn	Checked	PM

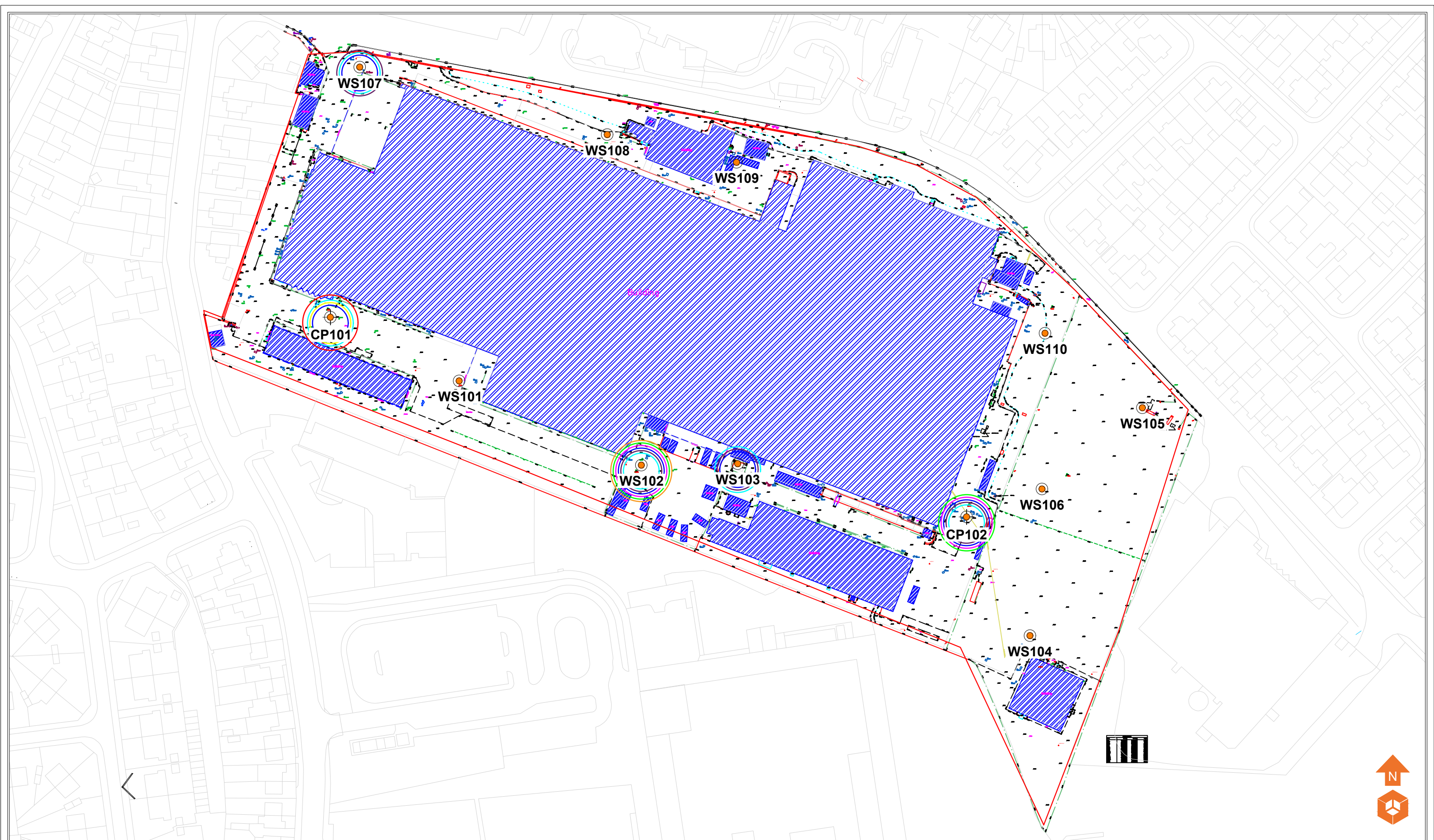
Client:	Glen Dimplex
Job Title:	Prescott

Job No:	17-500
Drawing No:	015
Date:	13.05.2024
Scale:	NTS@ A3
Drawing Title:	Development Constraints Plan



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- Location Symbols**
- WS101 Approximate Window Sample Probehole Location (E3P February 2024)
 - CP101 Approximate Cable Percussive Borehole Location (E3P February 2024)

- Contamination Exceedances**
- Trichloroethene
 - Vinyl Chloride
 - Cis 1, 2 - Dichloroethene
 - Trans 1, 2 - Dichloroethene
 - 1 - 1 Dichloroethene
 - Benzene
 - Nickel
 - pH

Notes:

Client:

Glen Dimplex

Job No:

17-500

Date:

21.05.2024

Drawing No:

018

Scale:

NTS @ A3



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Notes:

Job Title:

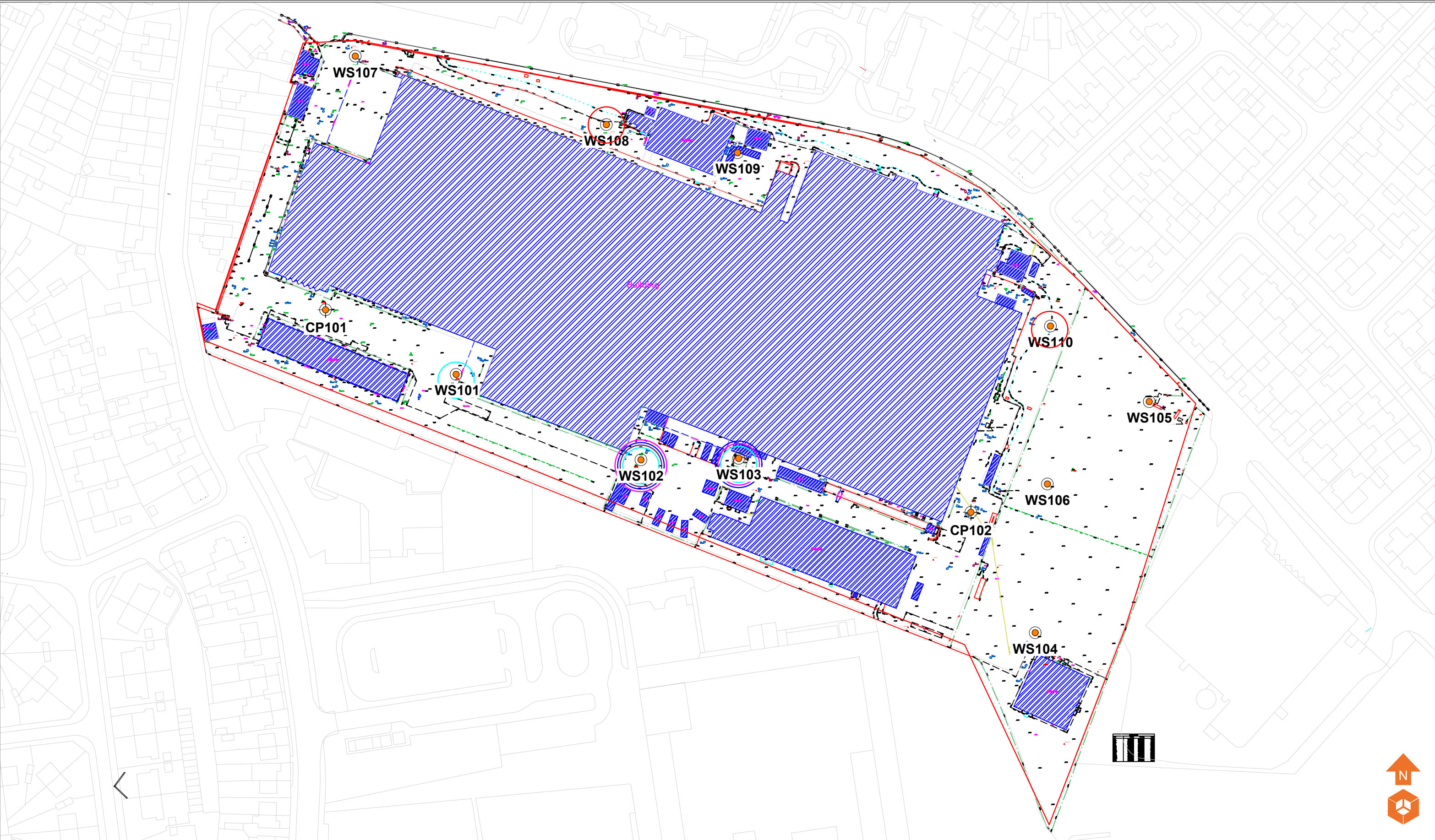
Prescott

Drawing Title:

Groundwater Contamination
Exceedances Plan

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P1	REVB	21.05.2024	OW	ID	MW
P1	REVA	13.05.2024	EB	ID	MW
Phase	Issue	Date	Drawn	Checked	PM



- Location Symbols**
- WS101 Approximate Window Sample Probehole Location (E3P February 2024)
 - CP101 Approximate Cable Percussive Borehole Location (E3P February 2024)

- Contamination Exceedances**
- Trichloroethene
 - Vinyl Chloride
 - Cis 1, 2 - Dichloroethene
 - Trans 1, 2 - Dichloroethene
 - Heavy Metal

Notes:

Client:

Glen Dimplex

Job No:

17-500

Date:

21.05.2024

Drawing No:

026

Scale:

NTS @ A3



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Notes:

Job Title:

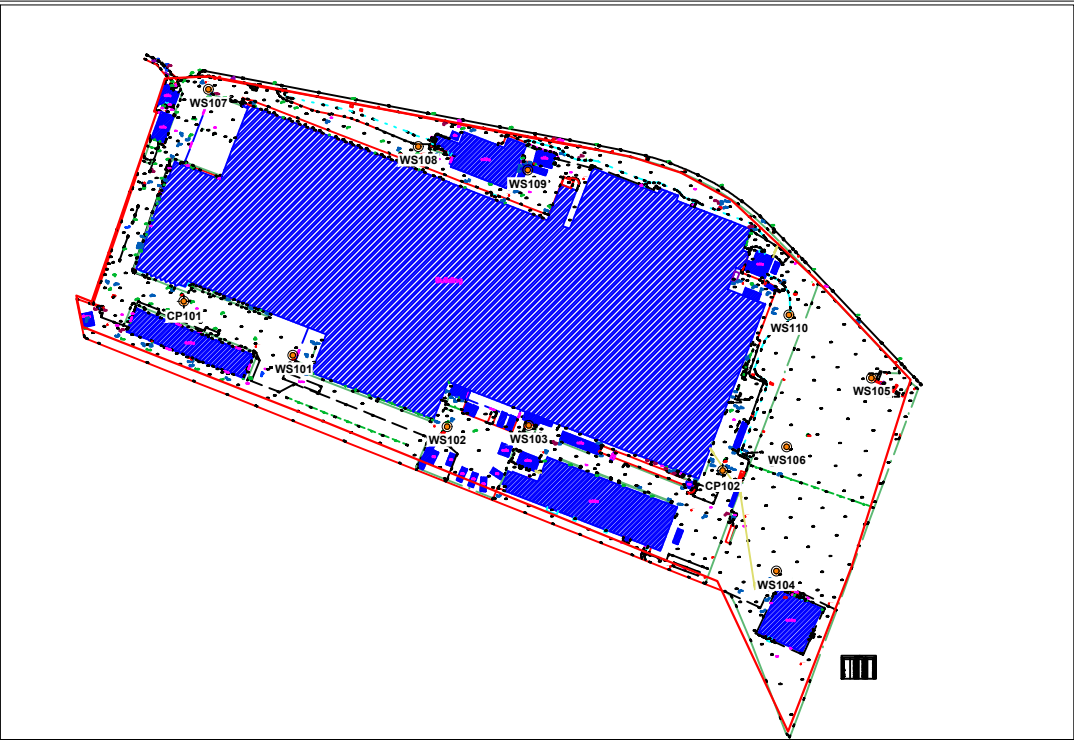
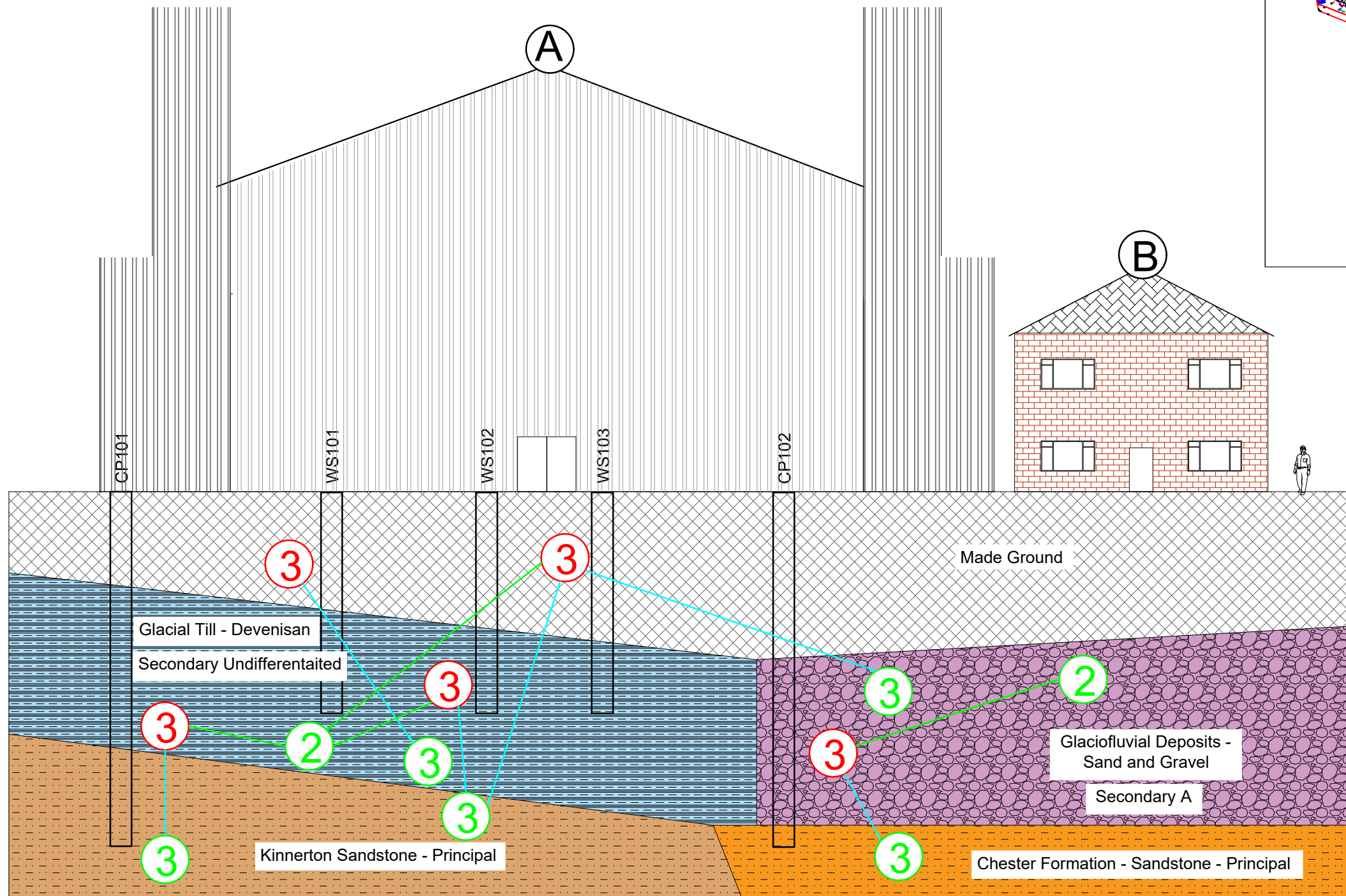
Prescott

Drawing Title:

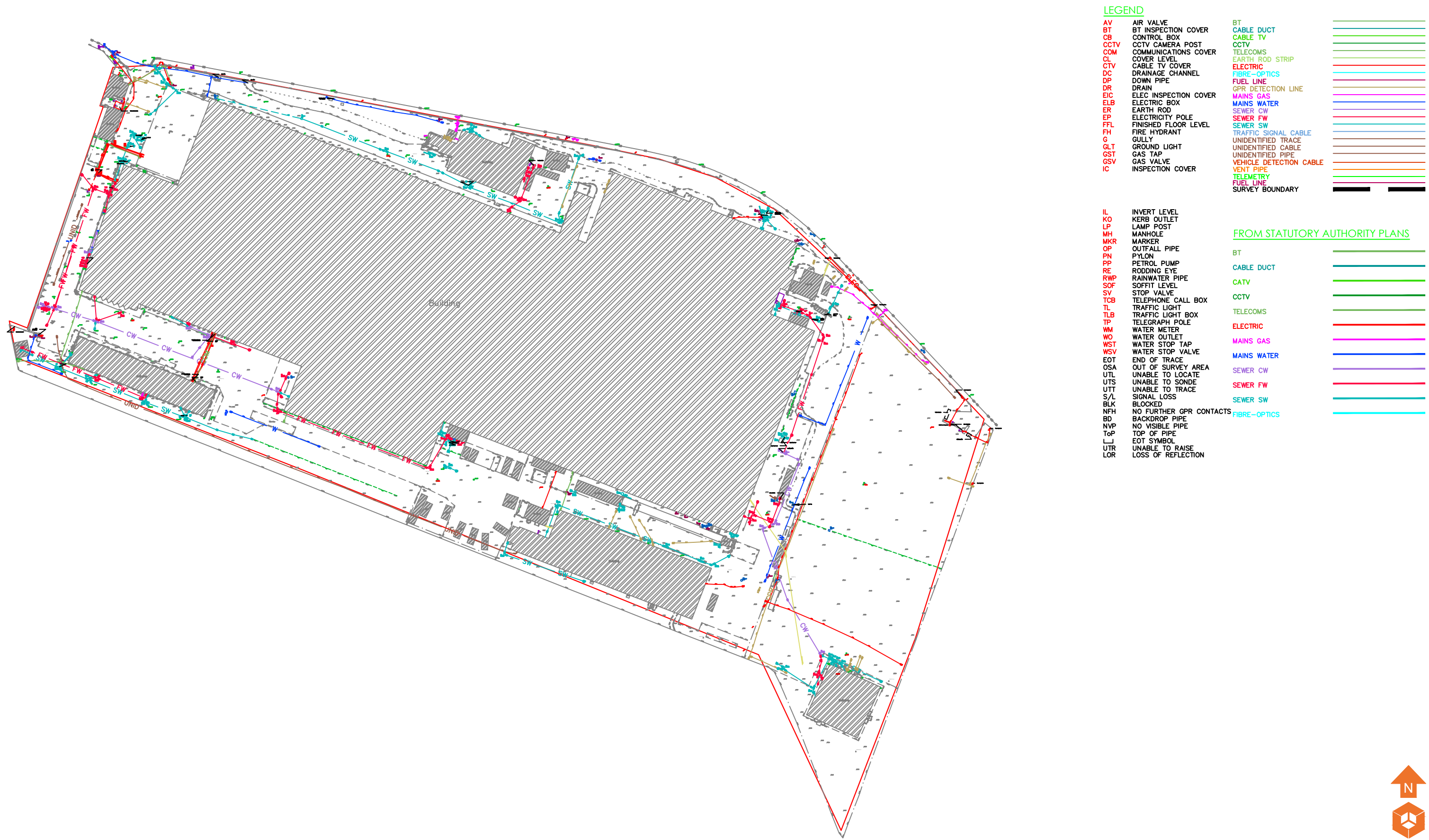
Human Health Contamination
Exceedances Plan

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P1	REVB	21.05.2024	OW	MW	MW
P1	REVA	13.05.2024	EB	ID	MW
Phase	Issue	Date	Drawn	Checked	PM



Geology Key  Made Ground  Glacial Till - Devensian  Glaciofluvial Deposits - Sand and Gravel  Kinnerton Sandstone - Principal  Chester Formation - Sandstone - Principal		Sources ① Heavy Metals and Non-volatile PAH ③ Volatile Organic Compound		Pathways  Vertical / Lateral Migration  Vapour Inhalation  Taint Water Supply		Receptors ① Future End Users ② Water Pipeline ③ Groundwater		Site Features A Factory (Present) B Future Residential Development		Notes:						Client: Glen Dimplex		Job No: 17-500		Date: 21.05.2024		 Environmental Engineering Partnership Ltd Taylor Road, Trafford Park Urmston, Manchester, M41 7JQ Tel: 0161 707 9612 E-mail: info@e3p.co.uk Website: www.e3p.co.uk															
P1 P1		REVB REVA		21.05.2024 13.05.2024		OW EB		MW ID		MW MW		Job Title: Prescott						Drawing No: 027				Scale: NTS				Drawing Title: Controlled Waters Conceptual Site Model						The client must not amend any drawing, design or other intellectual property produced by E3P Ltd without permission in writing from E3P Ltd in advance of any amendments being made. In the event that such written permission is not obtained in advance of the amendments being made, E3P Ltd shall not be liable for any damage and/or losses occurring as a result of the amended drawing, design or intellectual property.					



Notes:					
P1	REVA	17.05.2024	EB	MW	MW
Phase	Issue	Date	Drawn	Checked	PM

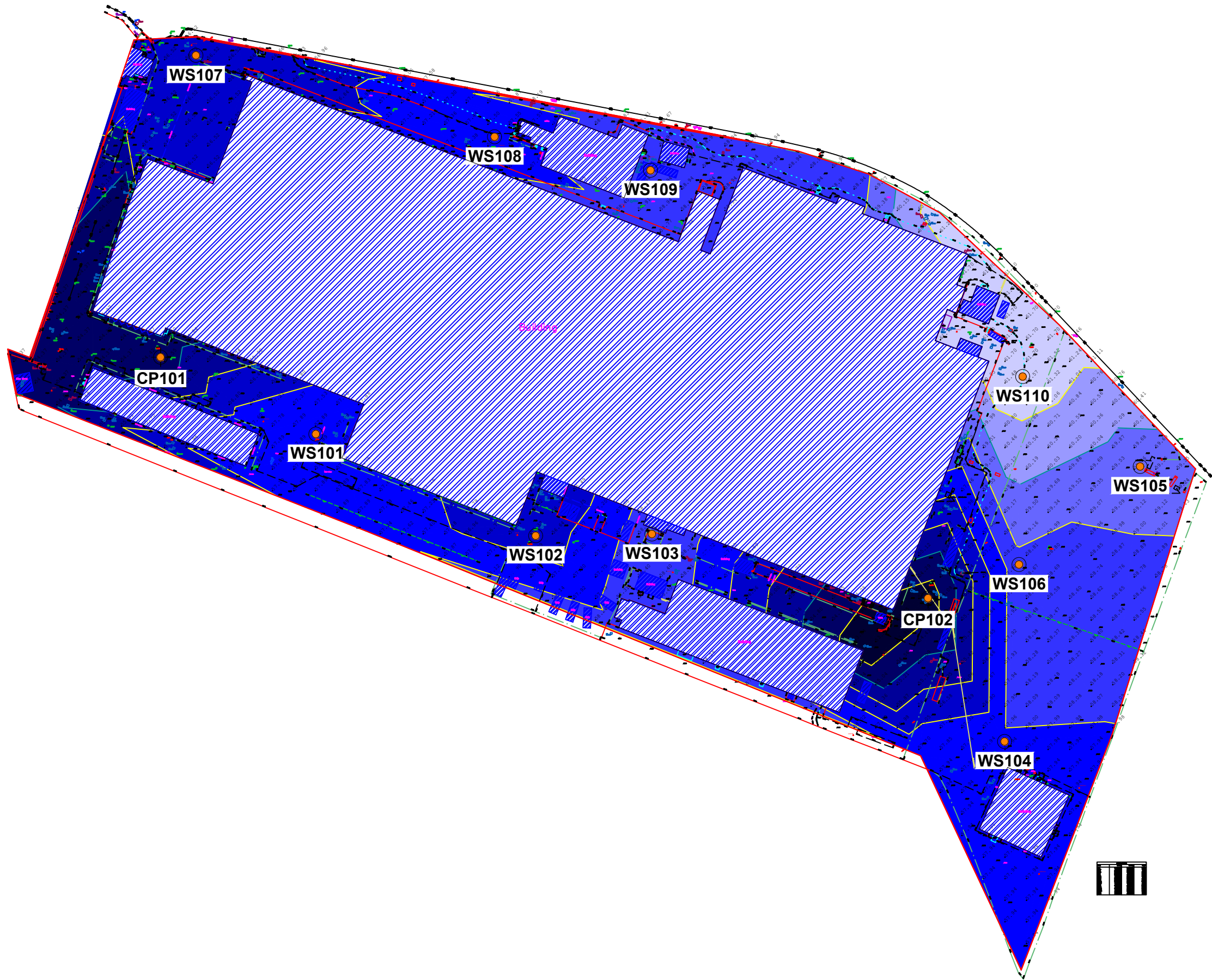
Client:	Glen Dimplex
Job Title:	Prescott

Job No:	17-500
Drawing No:	028
Date:	17.05.2024
Scale:	NTS@ A3
Drawing Title:	Utility Plan



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Location Symbols

- WS101 Approximate Window Sample Probehole Location (E3P February 2024)
- CP101 Approximate Cable Percussive Borehole Location (E3P February 2024)

Groundwater Depth (m AOD)

- Depth of Groundwater 53.00 - 53.99m AOD
- Depth of Groundwater 54.00 - 54.99m AOD
- Depth of Groundwater 55.00 - 55.99m AOD
- Depth of Groundwater 56.00 - 56.99m AOD
- Depth of Groundwater 57.00 - 57.99m AOD
- Depth of Groundwater 58.00 - 58.99m AOD
- Depth of Groundwater 59.00 - 59.99m AOD
- Depth of Groundwater 60.00 - 60.99m AOD
- Depth of Groundwater >61.00m AOD

Notes:

P1	REVA	22.05.2024	EB	MW	MW
Phase	Issue	Date	Drawn	Checked	PM

Client:

Glen Dimplex

Job Title:

Prescott

Job No:

17-500

Drawing No:

029

Date:

22.05.2024

Scale:

NTS @ A3

Drawing Title:

Depth to Groundwater Plan



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APPENDIX V

PHOTOGRAPHS



PLATE 1 WESTERN BOUNDARY OF FACTORY BUILDING (FACING SOUTH)



PLATE 2 ENAMEL SLURRY WASTE STORAGE AREA (FACING SOUTH)





PLATE 3 ABOVE-GROUND STORAGE TANKS ALONG SOUTHERN BOUNDARY (FACING NORTH)



PLATE 4 SHELTERED SERVICE ROAD ALONG NORTHERN BOUNDARY (FACING NORTHEAST)

