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ENVIRONMENT

Oxfordshire Railfreight Ltd
Oxfordshire RFI
Ardley, Oxon

Phase 2 Geo-Environmental Assessment

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Notice

EXECUTIVE SUMMARY

EXECUTIVE SUMMARY	
Site Address	The site is located near Arden, Oxfordshire located at National Grid Reference 453909E, 226366N.
Proposed Development	Multiple plot warehouse development with associated hardstand areas including parking, loading and road access. The development will also include a new rail freight terminal in the north of the site adjacent to the existing railway and the relocation of a waste treatment facility (compositing) which is currently situated in the southern portion of the site. Ashgrove Farm located in the east of the site will be retained. The site will be served by new access routes including Ardley bypass to the north linking to the M40 Motorway and Middleton Stoney bypass to the south east. To accommodate the proposed development, a significant earthworks exercise will be completed. This report focusses on the main development site area. Preliminary Geo-environmental ground investigation and assessment of the access routes will be undertaken in due course.
Site Setting	The site is located near the village of Ardley with mixed residential, agricultural and commercial surroundings. The site itself consists of a mixture of predominantly arable and pasture fields but with small areas covered by a farm, soil treatment facility and covered reservoir. Its topography is generally gently sloping towards the centre and south. The site is irregular in shape, covers an area of approximately 260ha and stretches from Baynard's Green field north of Junction 10 of the M40 down south to Middleton Stoney village along the B340 road. The Chiltern Mainline Railway forms the northern site boundary.
Published Ground Conditions	The site is underlain by bedrock of the White Limestone Formation (a Principal Aquifer) with localised superficial deposits mapped comprising head and Alluvium deposits aligned along watercourses. Available borehole logs in the vicinity of the site, based on records provided by the British Geological Survey (BGS), indicate ground conditions to comprise topsoil over weathered deposits of the White Limestone formation with solid bedrock from approximately 1m. The site is not located in a Coal Mining Reporting Area, as classified by the Coal Authority.
Ground Investigation	Ground investigation comprised • Thirty Dynamic Sample (DS) boreholes; Eight Rotary Open Hole (RO) boreholes; Sixty machine excavated trial pits (TP) spread across the site to obtain good site coverage. • Installation of thirty-one gas and groundwater monitoring wells across the site providing coverage for preliminary groundwater and ground gas risk assessment as well as preliminary hydrogeological profiles. • Eleven soakaway drainage tests (BRE 365) and Variable Head Permeability Testing in seven RO borehole, for permeability assessment for site drainage. • Chemical analysis of soils and groundwater for suite of analysis capturing the identified contaminants of concern. • Geotechnical testing of soil. • Four gas and groundwater level monitoring visits, with groundwater samples collected on one occasion.
Ground Conditions Encountered	Encountered ground conditions generally confirmed the geological sequence identified in published geology. Limited Made Ground was encountered in three locations with a maximum depth of 1.3m bgl in one location.

	Topsoil was encountered across the site, and was generally shallow (typically around 0.3m thick), deeper topsoil was encountered in one location to a maximum thickness of 1.0m bgl. Limestone deposits identified were generally of the White Limestone Formation (WLF) with the Rutland Formation identified in a single location close to the stream lower down in the valley. Superficial deposits of alluvium were identified in the vicinity of streams as anticipated and comprised a mixture of clays, sands, and gravels. Competent bedrock of the White Limestone Formation was typically encountered between 0.5m and 1.5m bgl. No significant visual or olfactory evidence of contamination was observed. Shallow groundwater was encountered in localised areas of the site, confirmed between clay layers, considered to be localised and discontinuous. Deeper groundwater was record in the White Limestone Formation across the site with monitored resting levels confirming as south east flow direction.
Geotechnical Appraisal	Most proposed units are located on existing slopes with a portion of cut and fill required on each plot. Currently, only Units 10, 11 and 12 are placed wholly in cut. Given the shallow bedrock, the rock will need to be removed by ripping and/or blasting (drill and blast). Volumes and extractions methods will need consideration and it is likely that specific additional ground investigation will be require in the areas of greatest cut to finalise that best method(s). Based on the proposed earthworks strategy, assuming that material is placed to a suitable specification then shallow footings and ground bearing floor slabs are expected to be suitable for the proposed development. The fill will need to be placed to an end-product specification to avoid differential settlement issues and special measures such as additional reinforcement is likely to be required where structures span over cut and fill areas. Some areas of the site are likely to have permanent cut into the groundwater table notably at the rear of Units 5, 6 and 12 and at the Rail Freight Terminal, which will likely need a permanent drainage solution to manage groundwater. This is expected to be achieved by appropriate drainage design. Internal and external slopes will need to be designed for long term stability and to ensure safety, relatively steep angles in cut should be achievable in the limestone rock though any fill slopes will be slacker. Steeper rock slopes will require some form of protection due to the potential for fractured materials to spall, this could be n the form of rock netting, fence protection, shotcreting and/ or isolation by fence and/ or bunds. Limestone is likely to form a strong competent base for road construction, though it is frost susceptible and will probably require a minimum thickness of sub base material of 450mm. Excavation for services may be problematic given rock strength and competency and may require extended periods of breaking.
Environmental Appraisal	Soil, leachate and groundwater concentrations recorded across the site are not considered to represent a significant risk to the identified receptors. Gas monitoring has not identified an existing onsite gas issue. However, given the proximity of Ardley Landfill to the east, the gas assessment for the eastern area of the site where Units 1 to 3 are proposed is currently only preliminary. Details of Ardley Landfill have been requested to better understand the risk. Following this further assessment may be required which could comprise additional spot monitoring, additional monitoring points and/or continuous monitoring.
Waste Assessment	Soil samples have been characterised against hazardous waste criteria using Hazwaste Online. The assessment indicates that the soils analysed are likely to be classified as non-hazardous.
Recommendations - Environmental	The risk to Units 1 to 3 from ground gas migration from Ardley Landfill is currently unclear. A data request with the Environment Agency is currently pending which may provide much more clarify on the plausible ground gas source and risk ground gases may present to the site. Additional gas monitoring and/or well

	points may be recommended following this review if a plausible risk remains. Monitoring should be undertaken during a period of rapidly falling pressure to represent the worst case. Ground investigation to assess the contamination status of the soil treatment facility would be required to both inform planning for development and to facilitate licence surrender. A discovery strategy should be put in place for redevelopment works should unexpected contamination be identified. Consideration of the requirement for materials management is recommended during earthworks. Prior to offsite disposal of soils, specific waste classification of soils should be undertaken by a competent person. Investigation within the wider access route alignments to identify risks associated with potential sources identified within and in the vicinity of these areas. Further investigation in the area of the onsite landfill and confirmation of the ground gas regime. Confirmation of the remediation works at Upper Heyfield and supplementary groundwater analysis to increase site coverage.
Recommendations - Geotechnical	Liaison with Network Rail will be required to manage geotechnical risk on the interfaces with their infrastructure. Detailed geotechnical assessment will be required to manage geotechnical risks on the project including rock excavation, settlement issues, foundation solutions, retaining structures and slope stability. Further ground investigation will be required to inform detailed design. Once design proposals are nearing finalisation, a specialist hydrogeologist should be consulted to ensure the drainage design appropriately manages groundwater. Investigation within the wider access route alignments to identify potential geotechnical constraints should be undertaken. especially around the extreme east of the site where the rail and road access will require excavation of the historic quarry and potentially landfill. The landfill is still likely to be managed under an Environmental Permit and the Environment Agency will have concerns in relation to waste stability, gas and leachate emissions, handling of any waste during excavation and the potential for any breach of containment systems, eg by piling.
This summary should be read in conjunction with BWB's full report (ref. OFRI-BWB-ZZ-XX-RP-YE-0001-Ph2_P1) and reflects an assessment of the site based on information received by BWB at the time of production.	

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FIGURES

TABLES

APPENDICES

Drawings

1. INTRODUCTION

Instruction

1.1 BWB Consulting (BWB) was instructed by Oxfordshire Railfreight Ltd (the Client) to carry out a Phase 2 Geo-Environmental Assessment. Details of the project brief are included in BWB proposal reference 210707/P02/01/NTH2479/KES/RTR dated 07/07/2021.

1.2 BWB has been approached by Oxalis Planning, on behalf of their Client Cuvette Property Consulting Ltd to support the application for a proposed multi-modal Strategic Railfreight Interchange (SRFI) in line with the National Policy Statement (NPS) for National Networks (2014). Given the national significance of the proposed development, the Client is therefore applying to the Secretary of State (via the Planning Inspectorate, or 'PINS') for a Development Consent Order (DCO) under the Planning Act 2008.

1.3 The proposed development is anticipated to comprise a multiple steel portal frame warehouse development with associated hardstand areas including parking, loading and road access. The development will also include a new rail freight terminal in the north of the site adjacent to the existing Chiltern Mainline Railway and the relocation of a waste treatment facility (composting) which is currently situated in the southern portion of the site. Ashgrove Farm located in the east of the site will be retained. The site will be served by new access routes including Ardley bypass to the north linking to the M40 Motorway and Middleton Stoney bypass to the south east. A copy of the draft masterplan is presented in **Drawing 1**. At this point, this report focusses on the main development site area. Preliminary Geo-environmental ground investigation and assessment of the access routes will be undertaken in due course.

1.4 To accommodate the proposed development, a significant earthworks exercise will be completed. The current earthworks strategy and proposed finished floor levels are presented as **Drawing 2** and **Drawing 3** respectively.

Previous Reports

1.5 The following geo-environmental reports have previously been completed for the site and made available for BWB to review:

- '*Oxfordshire SRFI- Off-site Highways Phase 1 Geotechnical and Geoenvironmental Desk Study*' by Hydrock for Oxfordshire Railfreight Ltd, reference 15560-HYD-OSH-XX-GE-RP-1002-S2-P1, dated July 2021;
- 'Land to the NE, E, SE of RAF Heyford Oxfordshire Explosive Ordnance Desktop Study Project 21056' by EOD Contracts Ltd, reference EOD/21/21056/DTS/HYDROCK/(Land to the NE, E, SE of) RAF Heyford, Oxfordshire, dated February 2021;
- Land east of the former Royal Air Force (RAF) Upper Heyford, near Bicester, Oxfordshire; Radiological Desk Study; ref. P11031-21; dated 11 th September 2021; and

- '*Oxfordshire RFI Ardley, Oxon Factual Ground Investigation Report'* by Exploration & Testing Associates for BWB Consulting Ltd, reference C10172-FGIR-01, dated November 2021.

1.6 It is understood that the Client has reliance on the above reports and therefore pertinent information has been included within this report.

1.7 Additionally, several previous reports relating to the site and immediate surroundings are referenced within the Hydrock (2021) desk study report:

- 'Heyford Park Development. Locations of Possible Contamination Sources' by Arup, reference 120643-00 GG_G.2 – 01, dated June 2007;
- 'Ardley Energy from Waste Facility, Ardley, Oxfordshire. Post Application Response: Hydrology and Hydrogeology' by SLR Consulting Limited, reference 409-0036-00349, dated July 2009;
- 'Ardley Quarry EfW. EIA Extract. Chapter 9. Geology Hydrology and Hydrogeology' by SLR, Unreferenced, Undated;
- 'Ardley Quarry EfW. EIA Extract. Chapter 11. Palaeontology' by SLR, Unreferenced, Undated;
- 'Heyford Park – Flying Field, Hydrogeological Characterisation and Groundwater Quality Assessment' by Waterman Energy, Environment & Design Ltd (Waterman), reference EED10658-109_R_9.3.1.FA, dated March 2012;
- 'Land at Ashgrove Farm, Ardley, Oxon. Desk Study Report' by Hydrock, reference R/12421/001 Version 2, dated August 2014. (Included in this report were copies of boreholes by SLR from 2006);
- 'Geo-Environmental Site Investigation, Ashgrove Farm, Ardley' by BRD Environmental Ltd, reference BRD2409-OR-1, dated October 2015; and
- 'Preliminary Environmental Risk Assessment Southern Bomb Store, Former RAF Upper Heyford, Oxfordshire' by Waterman Infrastructure & Environment Ltd, reference WIB14371-R-100-2-3-3.FA, dated June 2016.

1.8 Information from the Hydrock (2021) desk study report in relation to the above reports has been included where relevant.

Objectives

1.9 The objectives of the report are to assess:

- The prevailing ground and groundwater conditions across the site;
- The potential presence and extent of contamination in shallow soil and groundwater beneath the site;
- The significance and magnitude of any observed contamination through comparison of analytical data to appropriate published environmental screening criteria;
- The strength properties of the soil beneath the site to assess potential foundation solutions together with other geotechnical constraints; and
- The ground gas regime beneath the site.

1.10 The above objectives will allow the preliminary Conceptual Site Model presented in the Phase 1 report to be verified and updated. The report has been completed in accordance with BS10175:2011(+A2:2017) 'Investigation of Potentially Contaminated Sites, Code of Practice' and EA Guidance on Risk Management of Land Contamination https://www.gov.uk/government/publications/land-contamination-risk-management-lcrm.

1.11 This report presents the information obtained from a desk study and the ground investigation and contains relevant factual information from the previous reports undertaken by others. The report, together with the associated Figures and Appendices, provides a Ground Investigation Report (GIR), as defined in BS EN 1997-1:2004 and BS EN 1997-2:2007

Scope of Works

1.12 The ground investigation scope of works was completed between 09/09/2021 and 23/09/2021 and comprised the following:

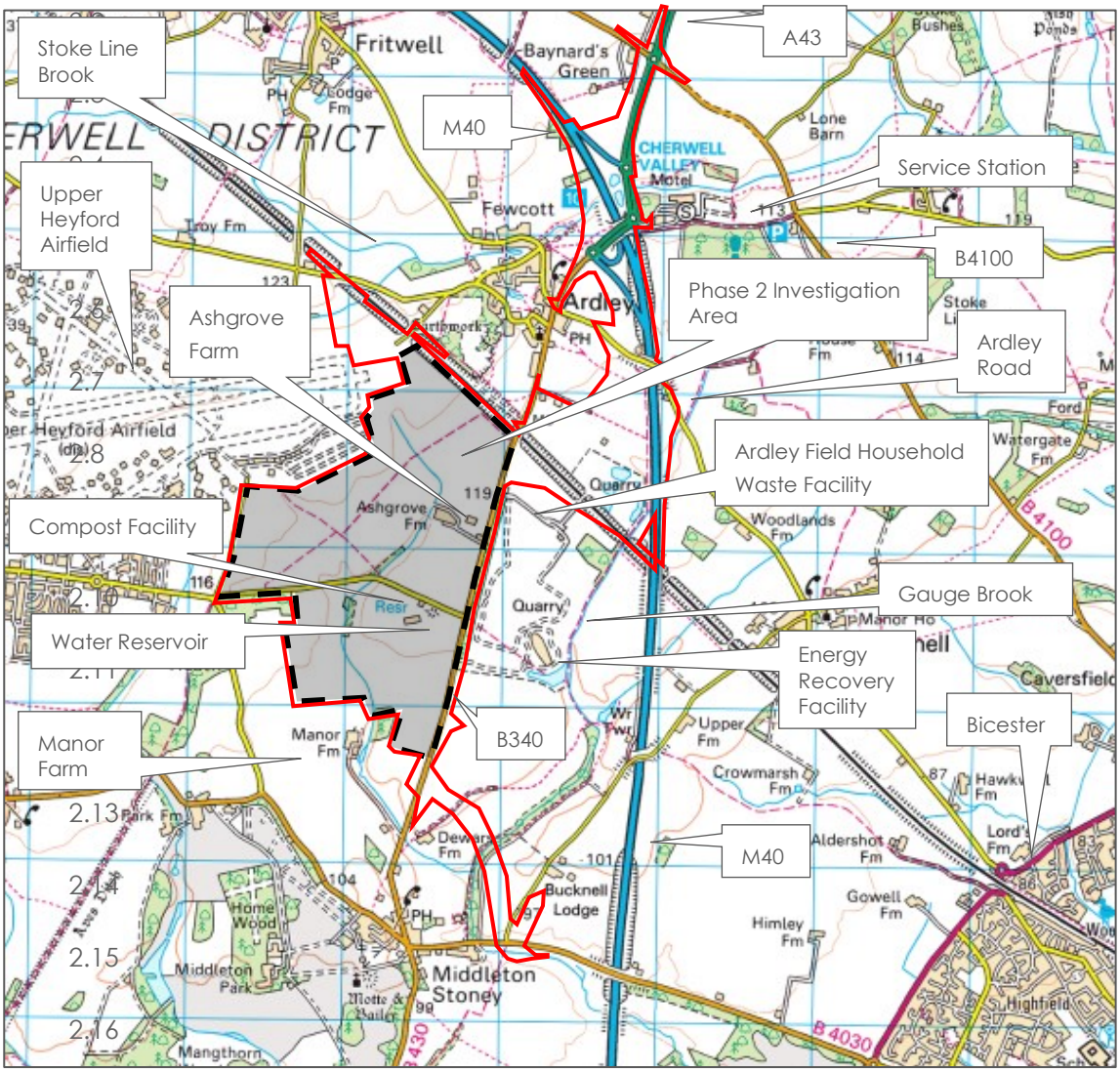
- Clearance of investigation locations by a specialist buried services tracing company;
- Surveying of coordinates and elevations of exploratory hole locations;
- Three days of UXO supervision;
- Thirty Dynamic Sample (DS) boreholes;
- Eight Rotary Open Hole (RO) boreholes;
- Sixty machine excavated trial pits (TP);
- Installation of thirty-one gas and groundwater monitoring wells;
- Eleven soakaway drainage tests (BRE 365);
- Variable Head Permeability Testing in seven Rotary boreholes;
- Chemical analysis of soils and groundwater;
- Geotechnical testing of soil; and
- Four gas and groundwater level monitoring visits, with groundwater samples collected on one occasion.

2. THE SITE

Site Location

2.1 The site is located in Arden, Oxfordshire located at National Grid Reference 453909E, 226366N. The location of the site is shown in Figure 2:1 (**Drawing 1**). It is noted that the 2021 ground investigation boundary is also presented in **Figure 2:1**, with the wider site represented by the local road networks and are subject to change.

Figure 2:1: Site Location Plan

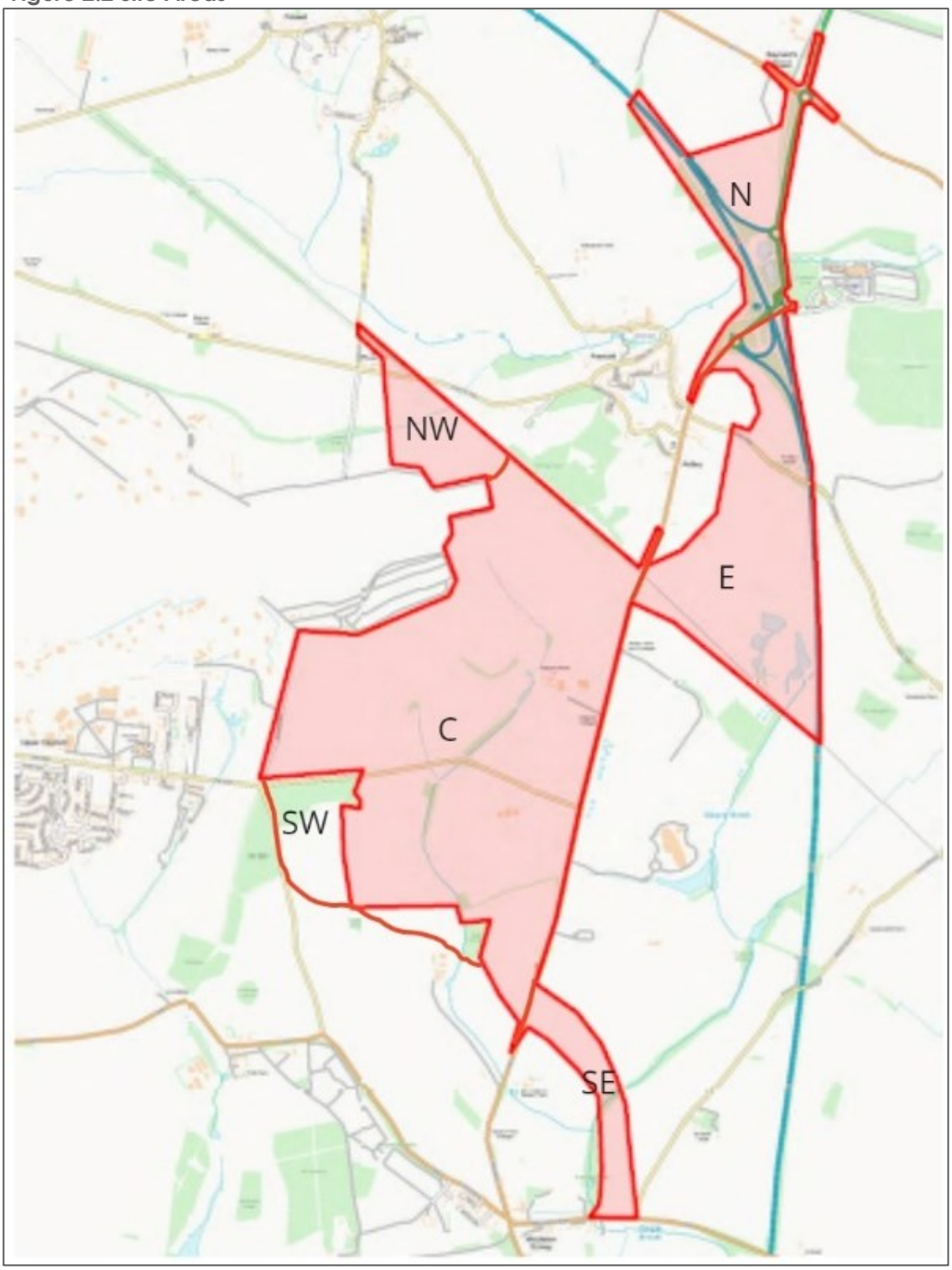


Site Description

2.17 The site is irregular in shape and stretches from Baynard's Green field north of Junction 10 of the M40 down south to Middleton Stoney village along the B340 road.

2.18 The site was visited by BWB personnel on the 09/09/2021 when it was possible to interview the Ashgrove Farm landlord. Site areas described below are outlined on **Figure 2.2** and described in **Section 2.4.**

Figure 2:2 Site Areas



Area between the North of J10 M40 and South of J10 M40 (north(N))

2.19 The area to the north includes an agricultural field between the M40, the A43 and B4100, most of the area is generally flat and at an elevation of approximately 120m above Ordnance Datum (AOD). The field is divided in two by the junction slip road, with an isolated parcel of land with two balancing ponds to the south. The slip roads

associated with Junction 10 of the M40 are on embankments and lead to the A34 to the northeast through a roundabout, and southwest towards Ardley through Padbury roundabout. The junction lies within the valley of Stoke Lyne Brook that runs east to west, sloping down from an elevation of approximately 120m to 110m AOD. A portion of the valley and its watercourse is included within the site to the west of the M40 and to the north of Ardley. A free flow link construction is anticipated on this area.

Area between the South of J10 M40 and Railway Cutting (east (E))

2.20 South of the junction the site includes agricultural fields between the B340, the M40 (here low cutting then at grade) and the Chiltern Main Line rail (on cutting) with exclusion to a quarry area to the southeast. The area is cut in two fields by Ardley Road and generally slopes to the southeast and includes farm buildings close to the B340. Small portions of fields are included east of the M40 and south of the railway, in an area accessed by Ardley Field Household Waste facility.

Ground Investigation Area (central)

2.21 The largest site surface is located within an open agricultural field including Ashgrove Farm, bounded by the Chiltern Main Line rail to the northeast, the B340 the east, Chilgrove Drive and the former Upper Heyford airbase to the west and northwest, and extending further south Camp Road towards parcels of land belonging to Manor Farm. The area generally gently slopes from an elevation of 115m to 105m AOD from north to south, and it includes an unnamed watercourse tributary to the Gauge Brook which flows north to south. The field parcels are separated by hedgerows and strips of land with dense tree vegetation are present in the vicinity of the watercourse. Ashgrove Farm cottages and buildings are present within the field, and an infilled pond surface has been identified through consultation with the landlord. To the south of Camp Road, two adjacent fenced areas are present which hosts Ardley Composting Facility and a covered Water Reservoir on earthwork. The ground investigation boundary comprises the full proposed development area with the remaining wider site areas proposed road corridors.

Railway Cutting Area to the northwest (northwest(NW))

2.22 A railway cutting and agricultural fields are located in the northwest of the site, north of Upper Heyford airbase (which is outside of the ground investigation area but was included within the Hydrock 2021 desk study report boundary).

Area between Camp Road and Manor Farm (southwest (SW))

2.23 An additional parcel of agricultural land is located to the south of Camp Road and to the north of Manor Farm, which is outside of the ground investigation area but was included within the Hydrock (2021) desk study report boundary.

Area to the Southeast of BB340 (southeast (SE))

2.24 The village of Middleton Stoney lies several kilometres to the south of the site. A strip of land running to the east of the B340 with a northwest to southeast direction terminating

into the B4030 Road, is included within the masterplan for the development of Middleton Stoney Relief Road. The area itself consists of a mixture of predominately arable and pasture fields with Gagle Brook flowing from the northeast to the south. Its topography is generally flat but slopes gently towards the watercourse towards the south of the site. In addition, dense vegetation exists in the vicinity of the watercourse.

Previous Report Summary – Hydrock 2021 Desk Study Report

Introduction

2.25 It is noted that the desk study boundary in the Hydrock report is different to the wider site boundary. The desk study boundary is similar to that of the current BWB ground investigation site boundary, which encompasses the central portion of the site and the areas in the northwest and southwest of the site (as outlined in **Section 2.22** and **Section 2.23**).

2.26 The report illustrates the geotechnical and environmental background for the site and includes a site walkover. It is noted that the Hydrock report refers to several other previous reports listed in **Section 1.7**

2.27 A summary of the ground conditions including geology, hydrology and hydrogeology have been included within this report within **Section 3**.

Site History

2.28 Historically, the site has remained predominately agricultural land, with Ashgrove Farm present since the earliest available mapping (1870s) and several smaller farm buildings in the west. By the late 1910s, a railway line was constructed aligned southeast to northwest to the east of Upper Heyford Airfield (offsite). By the 1980s, several tanks were present in the vicinity of the offsite airfield, an electrical substation was constructed opposite Ashgrove Farm, and a caravan park in the west of the ground investigation area. From the late 1980s, a water tower was present towards the south of the ground investigation area, later replaced as the present-day water pumping station, along with a covered reservoir. No significant changes take place with the ground investigation boundary until the early 2010s when a composting facility was constructed adjacent to the covered reservoir.

2.29 Ardley Quarry is shown to the east of the investigation area (beyond Ardley Fields Farm) from the late 1890s, which appears to expand north to south by the 1980s into the current site boundary (south of the railway). Limestone extraction continued at Ardley Quarry until the late 1990s and progressively backfilled as Ardley Landfill; a refuse tip is labelled to the north of the quarry from the early 2000s. The northern portion of the quarry appears to have been infilled by 2010, with the majority of Ardley Quarry infilled by 2019.

2.30 Historically, offsite features relate to several farms and barns to the south and east of the site and several small quarries to the north, east and northwest of the site from the mid-1870s. By 1919, the majority of quarries are listed as old or disused. It is noted that the Upper Heyford Airfield (to the west of the site) was used as a former RAF grass aerodrome in World War 1 which is not labelled on historical mapping (understood to

be for national security reasons) until the 1950s; the airfield is shown to expand to adjacent the northwest boundary of the ground investigation area by the 1980s. The majority of former quarries are no longer shown from the mid-1960s. Ardley Wood Quarry is shown to the north of the ground investigation area on the northern side of the railway from the early-1980s and appears to have been infilled by the early 2000s; it is noted that the quarry was operational since the late 1800s and was mined more extensively in the late 1970s and early 1980s. Ardley / Dewars Farm Quarry is shown from 2013 to the south of Ardley Quarry and the Viridor Ardley Energy Recovery Facility (ERF) in which the ERF was under construction to the east of the ground investigation area in 2013. By the late 2010s, the ERF has been constructed. By 2020, Ardley / Dewars Farm quarry has been extended south and remains active, with the north western part appearing to be in the process of restoration.

2.31 It is noted in the report that the offsite airfield to the northwest of the site was sold in 1994 and is in the process of being redeveloped as a mixed residential and commercial development at the time of the Hydrock report.

Summary of Potential Contamination

2.32 A review of historical ground investigation reports for evidence of historical contamination was undertaken by Hydrock and is summarised in **Table 2:1** below, BWB has provided some clarity on location in bold and in brackets:

Table 2:1 Evidence of Historical Contamination

Contamination Evidence from Hydrock Report	Location
On Site	
Historical and current use/storage of petroleum hydrocarbons, including above ground (diesel and paraffin) and underground tanks (diesel) and an oil store. Elevated metal concentrations in Made Ground. Hydrocarbon evidence in the vicinity of the former underground tank. Elevated total petroleum hydrocarbons (TPH), polyaromatic hydrocarbons (PAH) and benzene, toluene, ethylene, and xylene (BTEX) concentrations in groundwater in the vicinity of the former underground tank. Asbestos Containing Materials (ACMs) on the ground surface and in/on buildings. Potential for PCBs and oil associated with an electrical substation at the entrance to Ashgrove Farm dated 1974. Remediation works in 2014/2015 of several tanks, comprising removal and infilling with imported stone.	Ashgrove Farm (**central onsite**)
Off Site	
Significant elevated concentrations of ground gas (methane and carbon dioxide) at the landfill. Occasional elevated nickel concentrations recorded in groundwater.	Former Ardley Landfill
Historical storage of petroleum hydrocarbons, including multiple underground tanks (diesel, gasoline, and jet fuel) and	Upper Heyford Airfield (**northwest offsite**)

infrastructure (BWB note this is outside of the current site boundary). Elevated concentrations of petroleum hydrocarbons and phenols in groundwater. Occasional phenol concentrations recorded above detection limit in surface water samples in the vicinity. Remediation works in March 2012 comprising emptying cleaning and backfilling tanks and filling buried pipelines with foam.	

Mining

2.33 The site is not located within an area at risk of coal mining; however, several small-scale areas of mineral extractions (limestone pits and quarries) were located in the vicinity, with significant operations identified by Hydrock listed in

2.34 **Table 2:**2 below, BWB has provided some clarity on location in bold and in brackets:

Table 2:2 Significant Mining Operations

Significant Mining Operations in the Vicinity of the Site	Location
The historical Ardley / Fields Farm Quarry	Main quarry east off site (**east off site, but encroaches onto the northern bypass alignment**)
The historical Ardley Wood Quarry Extension	North of the proposed highway works on the northern side of the railway line (**north off site**)
The operational Ardley / Dewar's Farm Quarry. Historically, the quarry produced gabion stone, single size stone, crusher run and dust. At the current time the quarry is producing 6F5.	South of the former Ardley Quarry (**south east off site)**

Waste Management Facilities

2.35 A review of waste management in the vicinity of the site was undertaken and a summary of the Hydrock findings is presented in **Table 2:3** below:

Table 2:3 Waste Management

Waste Management in the Vicinity of the Site	Location
Operational composting facility (The Agrivert IVC) for the composting of waste. Dated from 2007.	South of Ashgrove Farm (**central on site**)
Historical Landfill (Ardley Landfill / Ardley Fields Farm) was licenced for inert, non-hazardous, stable non-reactive hazardous waste (in the form of asbestos) and hazardous waste. Dated from 1979 to 2014. The southern extension was operated as a co disposal landfill from July 2000.	Main landfill to the east offsite, but encroaches into the northern bypass road alignment (**east off site**)
Operational Household, Commercial & Industrial Waste Transfer Station, located at the former Ardley Landfill/Ardley Fields Farm Landfill. Wastes accepted include household, commercial and industrial waste.	Northern portion of former Ardley Landfill (**east off site**)

Operational ERF (Viridor) for the incineration of waste. Wastes accepted include household, commercial and industrial waste. Dated from 2014.	Southern portion of the former Ardley Landfill (**east off site**)
An **active biological treatment facility (Ardley Leachate Treatment Plant**) at Viridor ERF	Southern portion of the former Ardley Landfill (**east off site**)
Historical landfill (Ardley Wood) was licenced for inert, industrial, commercial, household, and liquid sludge. Dated from 1940 to 1980.	North of the proposed highway works on the northern side of the railway line (**north off site**)
There are several waste exemptions in the vicinity of the site. However, Hydrock considered these not to be relevant to the site and are not considered further.	

2.36 Several regulatory controls were identified within the immediate area of the site, however, Hydrock considered these not to be a risk and are not considered further.

Site of Special Scientific Interest (SSSI)

2.37 Two SSSI's are recorded within the vicinity of the site and further details are provided in **Table 2:4** below:

Table 2:4 Site of Special Scientific Interest (SSSI)

Site of Special Scientific Interest (SSSI) in the Vicinity of the Site	Location (Site Area)
Ardley Cutting and Quarry, which is designated due to geological interest for its exposures of Jurassic rocks and has biological interest associated with limestone grassland, scrub, ancient woodland, and wetland habitats. Dated from 1988. It is noted that this SSSI is listed as 'unfavourable – recovering'.	Along the railway cutting, (**east on site**)
Ardley Trackways, which is designated due to the presence of fossilised dinosaur (sauropod and theropod footprints) which form trackways. Dated from 2010.	Southern unit at Ardley / Dewars Farm Quarry (**southeast off site**). Northern unit north of the railway line (**east off site**).

Other Considerations made by Hydrock

2.38 Sections of the site in the far north and south are in Radon Affected Areas (radon levels in 1-3% of homes are above the action level). The majority of the site is not in a Radon Affected Area and radon protection measures are not required for new buildings.

2.39 A specialist UXO risk assessment was completed as part of the desk study report and the site was assessed as a medium risk that items of UXO could be located within the site boundary and a risk mitigation strategy was recommended for excavation works within the site area.

Hydrock Conclusions

2.40 Hydrock conclude that the following Geo-environmental risks are associated with the site considering a commercial redevelopment:

- Uncontrolled Made Ground;
- Soft / loose compressible ground;
- Shrinkage / swelling of clay;
- Lateral and vertical changes in ground conditions;
- High sulphate concentrations in solids;
- Obstructions including foundations, historical structures, and drainage;
- Difficulty excavating limestone bedrock;
- Existing below ground structures which will remain (Ashgrove Farm and covered reservoir);
- Shallow groundwater;
- Changing groundwater conditions and impact in cuttings and excavations;
- Runnings sands and / or loose Made Ground in excavations;
- Risk from flooding;
- Suitability of material excavated for use as fill material including selection and processing;
- Differential bearing capacity and settlement;
- Poor bearing capacity of new fill;
- Slope stability issues including existing slopes, instability of cut and fill slopes and retaining walls;
- Effect of railway cutting;
- Problematic soils including silts and rewetting;
- Faults;
- Impacts on SSSIs including the Ardley Cutting and Quarry and the Ardley Trackways; and

Mineral Resource.

2.41 Hydrock conclude that it is unlikely that the site or significant parts of it could be classified as Contaminated Land under Part 2A of the Environmental Protection Act 1990. They also conclude that the overall risk from land contamination at the site is considered to be low for the majority of the proposed development (as it has generally remained undeveloped), with some small areas of moderate to high risk (in historically developed areas, mainly Ashgrove Farm). Identified Pollutant linkages are assessed in the preliminary conceptual site model (**Table 4:1**).

2.42 Hydrock recommended that an intrusive investigation is completed to confirm the identified potential geotechnical and geo-environmental risks.

3. PUBLISHED GROUND CONDITIONS

Published Geology

3.1 British Geological Survey (BGS) mapping for the site indicates that the site is predominantly underlain by White Limestone Formation (comprising limestone, wackestone, packstone, grainstone and mudstone), with superficial deposits generally absent. The entire site area is underlain by Sedimentary Bedrock formed during the Jurassic Period. A geological fault is shown to transect the north and northwest corner of the site, trending west to northeast and downthrown to the north.

3.2 The site is also interspersed with smaller areas of Rutland Formation (comprising mudstone, siltstone, and sandstone), and Forest Marble Formation Limestone (comprising mudstone, limestone, and sandstone) in the northwest of the site. Superficial deposits of Head (comprising Clay, Silt, Sand and Gravel) and Alluvium (comprising Clay, Silt, Sand and Gravel) are recorded along stream courses running through the centre of the site trending north to south and in the northwest corner of the site.

3.3 It is noted in the Hydrock (2021) desk study report, that the White Limestone Formation is subdivided into the Blandon Member (clay/mudstone), the Ardley Member (limestone, wackestone, packstone and mudstone) and the Shipton Member (limestone, wackestone, packstone and mudstone), based on geological cross sections of the area.

3.4 BGS boreholes records and previous ground investigation records generally indicate topsoil or Made Ground underlain by shallow limestone. Further details are provided within the Hydrock (2021) desk study report.

3.5 The Groundsure report also indicates that an area of artificial ground is present in the east of the site described as infilled ground (Ardley Landfill). Several areas of artificial ground are present immediately to the northwest (airfield, railway cutting and Ardley Wood), north (M40 and service station) and east of the site (Ardley / Fields Farm Quarry and Ardley Landfill).

Hydrogeology

3.6 The groundwater body beneath the majority of the site is the Tackley Jurassic and is classified as Good Chemical and Quantitative status under the Water Framework Directive (EEA, 2021) for the latest available year (2019). The Upper Bedford Ouse Oolite Principal 1 groundwater body is present beneath the far northern portion of the site and is classified as Good Chemical and Quantitative status for the same year.

3.7 The underlying ground conditions have been classified by the Environment Agency (EA) as follows:

Superficial Deposits

- Alluvium: Secondary (A) Aquifer; and

- Head Deposit: Secondary Undifferentiated Aquifer.

Bedrock

- White Limestone Formation: Principal Aquifer;
- Forest Marble Formation: Principal Aquifer; and
- Rutland Formation: Secondary (B) Aquifer.

3.8 There is one active licensed groundwater abstraction recorded as located on the site at Manor Farm in the south for general farming and domestic use. However, Manor Farm is located outside of the development boundary. There are no active licensed potable groundwater abstractions on or within 1km of the site. The site is not located in a groundwater Source Protection Zone.

3.9 Hydrock state that previous ground investigations on site reported groundwater in the White Limestone Formation at depths between 3.4 and 3.7m below ground level (bgl). Previous investigations did not encounter superficial deposits; however, perched groundwater could be present at shallow depths. Two groundwater bodies were expected by Hydrock at the base of each of the limestones, with the less permeable mudstone/siltstones/clays acting as an aquitard between the shallower and deeper groundwater bodies.

3.10 Groundwater is considered by Hydrock to be in hydraulic continuity with the surface water features on the site. Hydrock state that groundwater generally flows towards the southeast, although there may be some localised flow towards the railway cutting in the north, and the streams at the base of valleys in the south.

Hydrology

3.11 Several surface watercourses are present in and in the vicinity of the site which is presented in below:

Table 3:1 Surface Water Features

Surface Water Feature	Location (Site Area)	Location (Flow)
Gagle Brook All options of the Middleton Stoney Relief Road will cross the brook and it runs approximately 100m south-east of the proposed M40 J10 south facing slips.	Generally, to the east of the site but crosses the site boundary in the southeast (**southeast on site**) flowing to the southeast.	Overall, hydraulically downgradient
Padbury Brook Classified as Good Chemical and Moderate Ecological status under the Water Framework Directive for the latest available year (2019). It is noted to be heavily modified.	North of the site crossing the M40 to the north of J10 (**north onsite**) flowing to the east	Hydraulically upgradient
M40 J10 balancing ponds Two balancing ponds are located between the M40 (west) and the A43 (east).	North of the site (**north on site**)	Hydraulically upgradient
Covered Reservoir	Centre west of the site (**central onsite**)	Hydraulically cross-gradient.

Surface Water Feature	Location (Site Area)	Location (Flow)
Appears to have been constructed in the 1980s. Reservoir to be retained as part of proposed development.		No continuity is expected.
Unnamed watercourses Two issues located central onsite which join the Gagle Brook offsite in the south. The proposed link to Heyford Park via Camp Road will cross this watercourse.	Centre of the site (**central on site**) flowing southeast	Hydraulically up/ cross-gradient
Gallos Brook (& Leys Farms Ditch) Classified as Good Chemical and Moderate Ecological status under the Water Framework Directive for the latest available year (2019).	200m west (**west off site**) flowing south	Hydraulically upgradient
Balancing ponds Two balancing ponds are located at the Viridor Ardley Energy Recovery Facility.	400m east (**east off site**)	Hydraulically cross/downgradient
River Cherwell Classified as Good Chemical and Moderate Ecological status under the Water Framework Directive for the latest available year (2019).	3km west (**west off site**) flowing south	Hydraulically upgradient
River Ray Classified as Good Chemical and Bad Ecological status under the Water Framework Directive for the latest available year (2019).	10km southeast (**southeast off site**) flowing southwest	Hydraulically downgradient

3.12 Several small drains and ponds and historic springs are also located towards the south of the site.

3.13 There are no active licensed surface water abstractions on or within 1km of the site.

3.14 There are four active licensed surface water discharges within 1km of the site which all discharge into Leys Farm Ditch for either trade discharge (site drainage) or sewage discharge (final/treated effluent).

3.15 The majority of the site is considered by the EA to be at low risk of flooding (less than 1 in 1000 (0.1%) from rivers and the sea, with no noted flood defences or flood water storage areas in the vicinity of the site. However, small parts of the site (in the north and south) are in Flood Zone 3 in the location of the streams (Padbury Brook, Gagle Brook and Unnamed watercourses). A detailed flood risk assessment will be provided under a separate cover (BWB Baseline Flood Baseline Data Review OXR-BWB-ZZ-XX-RP-YE-0001_S0_P01_Baseline Data Review).

4. PRELIMINARY ENVIRONMENTAL RISK ASSESSMENT

4.1 From herein, this report focuses on the ground investigation boundary only as shown in **Figure 2:1** and 'the site' refers to this area only. The assessment of the remainder of remaining wider site (road networks) will be provided under a separate cover.

Introduction

4.2 The risk posed by any contaminants in soil or groundwater will depend on the nature of the hazard, the probability of exposure, the pathway by which exposure occurs, and the likely effects on the receptors. A contaminant is defined as a substance that has the potential to cause harm, while a risk is considered to exist if such a substance is present in sufficient concentration to cause harm and a pathway exists for a receptor to be exposed to the substance.

4.3 The following sections discuss all the identified potential onsite and offsite sources, pathways, and receptors in the context of the proposed development and plausible pollutant linkages which may represent a risk to identified receptors such as human health and/or controlled waters from the data gained from the desk study. At this stage the assessment is qualitative and aimed to determine all pollutant linkages, irrespective of significance or allowing for uncertainty.

4.4 Three impact potentials exist for any given site; these are:

- The site impacting upon itself;
- The site impacting on its surroundings; and
- The surroundings impacting on the site.

4.5 All three impacts need to be considered in a risk assessment.

4.6 A Source, Pathway, Receptor analysis has been undertaken for the site based on the information provided in the preceding sections. This is presented as **Table 4:1** and further information about the risk classification scheme is included within **Appendix 1.**

- Sources (S); These are potential or known sources of contamination that may relate to a former land use or present site feature or process (e.g., fuel storage tanks).
- Pathways (P); A pathway is defined as a mechanism or route by which a contaminant comes into contact with, or otherwise affects a receptor. Pathways by which the identified receptors may be impacted upon in the context of the proposed development.
- Receptors (R); Receptors are defined as people, living organisms, ecological systems, controlled waters, atmosphere, structures, and utilities that could be adversely affected by contaminant(s).

4.7 It is noted that the initial CSM is based on the Hydrock 2021 desk study report and 'Site users' refer to current and future site users, site workers and maintenance workers.

Table 4:1 Preliminary Conceptual Site Model

Source	Pathway	Receptor	Con	Prob	Risk	Mitigation/Investigation
S1: Onsite: Localised Made Ground associated with isolated areas of historical development and field spreading. Potential contaminants may include metals, asbestos and PAHs.	**P1:** Direct contact, incidental ingestion, and inhalation of particulates.	**R1**: Site users	Md	Lw	M/L	Ground investigation should be undertaken in order to characterise the chemical status of the Made Ground anticipated in limited areas of the site. The exposure to construction workers/services personnel can be mitigated by utilising appropriate PPE and maintaining good hygiene levels. A ground investigation and subsequent laboratory analysis should be undertaken to inform the design of new services. Mitigation (where required) would generally comprise materials management and reuse of Made Ground soils at depth in landscaped areas.
	P2: Inhalation of fugitive dust.	**R2:** Site Neighbours	Md	Ul	L	
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer	Md	Ul	L	
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Md	Lw	M/L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	Lw	M/L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
	P6: Direct contact.	**R6:** Water supply pipes	Md	Ul	L	
	P7: Root uptake.	**R7:** Landscape planning	Mr	Lw	VL	Ground Investigation and appropriate testing to confirm the presence or otherwise of heavy metals Mitigation (where required) would generally comprise hand picking and possibly disposal, along with materials management and reuse of Made Ground soils at depth in landscaped areas.
S2: Onsite – Leaking from former and current above and below ground	**P1:** Direct contact, incidental ingestion, and inhalation of particulates.	**R1**: Site users	Md	Lw	M/L	Ground investigation should be undertaken in order to characterise the ground and groundwater conditions in

Source	Pathway	Receptor	Con	Prob	Risk	Mitigation/Investigation
storage tanks and oil storage at Ashgrove Farm. Potential contaminants may include petroleum hydrocarbons and VOCs.	**P8:** Vapour inhalation.	**R2:** Site Neighbours	Md	Ul	L	the area of the site in the vicinity of identified tank storage and chemical storage. The exposure to construction workers/services personnel can be mitigated by utilising appropriate PPE and maintaining good hygiene levels.
	P2: Inhalation of fugitive dust.		Md	Ul	L	
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer and possible abstractors	Md	Lw	M/L	
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Md	Lw	M/L	
		R5: Surface water receptors and possible abstractors	Md	Lw	M/L	
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	Lw	M/L	
		R5: Surface water receptors and possible abstractors	Md	Lw	M/L	
	P6: Direct contact.	**R6:** Water supply pipes	Md	Lw	M/L	
S3: Onsite – leaking from the transforms in the electrical substation at Ashgrove Farm. Potential contaminants may include PCBs and oils.	**P1:** Direct contact and incidental ingestion.	**R1**: Site users	Md	Ul	L	Ground investigation should be undertaken in order to characterise the ground and groundwater conditions in the area of the site in the vicinity of identified electrical substation The exposure to construction workers/services personnel can be mitigated by utilising appropriate PPE and maintaining good hygiene levels.
	P2: Inhalation and ingestion of fugitive dust.	**R1**: Site users	Md	Ul	L	
		R2: Site Neighbours	Md	Ul	L	
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer	Md	Ul	L	
S4: Onsite – ground gases (carbon dioxide and	**P9:** Migration, build up and asphyxiation.	**R1**: Site users	Md	Ul	L	Ground investigation should be undertaken in order to understand the gas regime at the site. Given that

Source	Pathway	Receptor	Con	Prob	Risk	Mitigation/Investigation
methane) from organic materials in the Made Ground below the site.	**P10:** Migration, build up and explosion.	**R1**: Site users	Md	Ul	L	significant Made Ground is unlikely any gas being generated is likely to be limited to low level carbon dioxide.
		R8: Buildings on site	Md	Ul	L	
S5: Onsite – Asbestos fibres from insulation or ACMs in the buildings.	**P2:** Inhalation of fugitive dust.	**R1**: Site users	Md	Ul	L	It is understood that Ashgrove Farm is to be retained and therefore does not present a risk during demolition activities.
		R2: Site Neighbours	Md	Ul	L	
S6: Onsite **–** Herbicides / pesticides / agrochemicals used historically on farms and stored in storage facilities. Potential contaminants may include pesticides and herbicides.	**P1:** Direct contact, incidental ingestion, and inhalation of particulates.	**R1**: Site users	Md	Ul	L	Ground Investigation to confirm ground and groundwater conditions beneath the agricultural land use areas of the site and in areas of chemical storage. Chemical testing to include screening for the presence of pesticides and herbicides.
	P2: Inhalation of fugitive dust.	**R2:** Site Neighbours	Md	Ul	L	
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer and possible abstractors	Md	Ul	L	
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Md	Lw	M/L	
		R5: Surface water receptors and possible abstractors	Md	Lw	M/L	
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	Ul	L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
S7: Offsite - Landfill Made Ground materials present	**P1:** Direct contact, incidental ingestion, and inhalation of particulates.	**R1**: Site users	Md	Lw	M/L	A landfill is present to the northeast of the site. Investigation to confirm the ground conditions, presence or otherwise of landfill material within the site boundary.

Source	Pathway	Receptor	Con	Prob	Risk	Mitigation/Investigation
in the historical landfill in the east of the site. Potential contaminants may include metals, asbestos fibres, PAHs and petroleum hydrocarbons, phenols, VOCs and SVOCs.	**P2:** Inhalation of fugitive dust.	**R1**: Site users	Md	Ul	L	Ground investigation should allow for assessment of the ground gas regime to be undertaken.
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer	Md	Ul	L	
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Md	Lw	M/L	
		R5: Surface water receptors and possible abstractors	Md	Lw	M/L	
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	Lw	M/L	
		R5: Surface water receptors and possible abstractors	Md	Lw	M/L	
	P6: Direct contact.	**R6:** Water supply pipes	Md	Ul	L	
S7: Offsite – ground gases (carbon dioxide and methane) from organic materials from Ardley Landfill to the east of site.	**P9:** Migration, build up and asphyxiation.	**R1**: Site users	Md / Sv	Lw	M	A ground investigation and subsequent monitoring should be undertaken in order to understand the gas regime at the site, targeting the eastern boundary bordering the landfill.
	P10: Migration, build up and explosion.	**R1**: Site users	Md / Sv	Lw	M	
		R8: Buildings on site	Md / Sv	Lw	M	
S8: Impacted Groundwater associated with Offsite – Former Upper Heyford Airfield as an	**P1:** Direct contact and incidental ingestion.	**R1**: Site users	Mi	Lw	L	Ground investigation and groundwater monitoring should be undertaken in order to characterise the ground and groundwater conditions. No testing of PFAS / PFOS has been undertaken to date.
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Md	Lw	M/L	

Source	Pathway	Receptor	Con	Prob	Risk	Mitigation/Investigation
airbase and leakage from petrol, oil, and lubrication (POL) storage. Potential contaminants may include phenols and petroleum hydrocarbons PFAS and PFOS.		**R5:** Surface water receptors and possible abstractors	Md	Ul	L	
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	Lw	M/L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
S9: Offsite - Landfill Made Ground materials present in the historical landfill approximately 10m north of the site. Potential contaminants may include metals, PAHs and petroleum hydrocarbons, phenols, VOCs and SVOCs. Ground gases (carbon dioxide and methane) from organic materials.	**P4:** Surface run-off.	**R4:** Aquatic ecosystems	Md	Ul	L	Given the landfill is the opposite site of the railway, which is within a deep cutting, plausible linkages are limited to on site receptors .
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	Ul	L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
	P9: Migration, build up and asphyxiation.	**R1**: Site users	Md / Sv	Ul	M/L	Given the landfill is the opposite site of the railway, which is within a deep cutting, plausible linkages are limited to on site receptors. Buildings proposed as part of the development are also some distance from the railway. The rating is largely dictated by the severity should significant gas migration occur. Gas monitoring should be completed to inform protection requirements.
	P10: Migration, build up and explosion.	**R1**: Site users	Md / Sv	Ul	M/L	
		R8: Buildings on site	Md / Sv	Ul	M/L	

Source	Pathway	Receptor	Con	Prob	Risk	Mitigation/Investigation

VH = Very High, H = High, M = Moderate, M/L = Moderate/Low, L = Low, VL = Very Low

KEY: Sv = Severe, Md = Medium, Mi = Mild, Mr = Minor Hi = High, Li = Likely, Lw = Low Likelihood, Ul = Unlikely

Pollutant Linkage Assessment Summary

When considered in the context of the conceptual site model and the historical activities that have taken place (agricultural land and former landfill) and the proposed development, the contaminated land risk is considered to be LOW / MODERATE. A MODERATE risk to human health has been identified associated with the adjacent Ardley landfill.

The risk posed to controlled waters is predominantly considered to be MODERATE due to sensitivity of the aquifers and potential contamination associated with onsite sources in particular the onsite landfill.

It is recommended that a ground investigation be undertaken to assess the identified pollutant linkages and assess likely mitigation measures.

Uncertainty

Hydrock indicated that ground investigation has been undertaken at Ashgrove Farm and at Heyford Airfield, these reports are not available to BWB. Preliminary Conceptual Model undertaken by Hydrock is based on a site boundary that differs to the wider redline boundary and the investigation boundary, it is noted that the entire investigation boundary is included within the Hydrock site boundary.

5. PHASE II ENVIRONMENTAL AND GEOTECHNICAL GROUND INVESTIGATION

5.1 Intrusive ground investigation works were undertaken between 09/09/2021 and 23/09/2021 and comprised the following works:

- Clearance of investigation locations by a specialist buried services tracing company;
- Surveying of coordinates and elevations of exploratory hole locations;
- Three days of UXO supervision;
- The advancement of thirty boreholes (DS101 – DS130) by dynamic sampling drilling techniques, to a maximum depth of 3.0m bgl with completion of Standard Penetration Tests (SPTs) and Hand Shear Vane (HSV) testing;
- The advancement of eight rotary open-hole boreholes (RO01 – RO08) with water flush system to depths of 10.0m bgl;
- The advancement of sixty machine excavated trial pits (TP103 – TP160, TP163 and TP188) to a maximum depth of 2.4m bgl with HSV testing;
- Variable Head Permeability Testing undertaken in seven RO borehole locations (RO01 – RO04 and RO06 to RO08) across the site;
- Soakaway drainage tests (BRE 365) undertaken in eleven (SA01 – SA11) trial pit locations across the site;
- Installation of thirty-one gas and groundwater monitoring wells within selected DS and RO boreholes;
- Collection of environmental soil and groundwater water samples for chemical analysis at a UKAS and MCERTS accredited laboratory;
- Collection of bulk and disturbed soil samples for geotechnical analysis at a UKAS accredited laboratory; and
- Four post investigation ground gas and groundwater level monitoring visits, with groundwater collected on one occasion.

5.2 An exploratory hole location plan is presented as **Drawing 4**. Exploratory hole records, permeability testing records and post investigation gas and groundwater monitoring data are presented as Appendix 2, Appendix 3, and Appendix 4 of the Factual Ground Investigation Report (**Appendix 2**).

5.3 The ground investigation works were carried out in general accordance with BS5930:2015+A1:2020 'Code of Practice for ground Investigations' and BS10175:2011+A2:2017 'Investigation of Potentially Contaminated Sites'.

Chemical Sampling Strategy

5.4 The sampling strategy was designed to generally understand the initial contamination status across the site (Made Ground) while targeting potential localised sources where access could be arranged; this included locations at Ashgrove Farm (to assess hydrocarbon impact from current/former tanks and oil storage) and the eastern boundary (to assess potential gas migration from Ardley Landfill).

5.5 Thirty-one ground gas and groundwater monitoring wells were installed within Rotary and Dynamic sampler boreholes across the site. The response zones of the installations are provided in **Table 5:1** below:

Table 5:1 Borehole Response Zones

Location	Response Zone
DS101 to DS107, DS111to DS115, DS117, DS118, DS120 to DS122, DS125, DS128, DS130, RO01 to RO08	White Limestone Formation
DS108 and DS123	Cross-boundary Topsoil and White Limestone Formation
DS110	Cross-boundary Alluvium and Rutland Formation

Chemical Analytical Strategy

Soil Strategy

5.6 The chemical strategy was to assess the general site contamination status including pesticides and herbicides with additional testing near structures and where Made Ground was encountered.

5.7 Selected soil samples collected from exploratory hole locations were sent to i2 Analytical Testing Services (UKAS and MCERTS accredited) for chemical analysis. The following chemical analytical testing was undertaken:

- Thirty-six soil samples tested for a soil suite (BWB Standard Suite) comprising arsenic, barium, beryllium, water soluble boron, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc, sulphate, total sulphur, total phenols, total cyanide, free cyanide, complex cyanide, soil organic matter (SOM), pH, Polycyclic Aromatic Hydrocarbons (PAHs) (United States Environment Protection Agency priority 16 compounds) and Total Petroleum Hydrocarbons (TPH) C6-C10 and C10-C40;
- Two soil samples tested for TPH speciated to the UK Criteria Working Group (TPHCWG) aliphatic and aromatic compounds, BTEX, VOC and SVOCs;
- Three soil samples for asbestos screening in deep Made Ground encountered at one location;
- Ten soil samples for herbicide and pesticide screening; and
- Sixteen soil samples tested for a suite of common leachable contaminants (BWB Standard Leachate Suite), namely arsenic, barium, beryllium, water soluble boron, cadmium, chromium, hexavalent chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc, sulphate, total cyanide, and pH.

5.8 The results of the soil chemical testing are presented as Appendix 6 within the Factual Ground Investigation Report (**Appendix 2**).

Table 5:2 Analytical Strategy

Location	Depth (m bgl)	Stratum	Analysis	Reason
DS102	0.20	WLF	BWB Standard Suite	General site contamination status
DS110	0.20	Topsoil		
DS112	0.30	Topsoil		
DS114	0.15	Topsoil		
DS115	0.20	Topsoil		
DS115	0.50	WLF		
DS117	0.25	WLF		
DS120	0.20	Topsoil		
DS122	0.20	WLF		
DS123	0.70	Topsoil		
DS126	0.20	Topsoil		
DS128	0.5	WLF		
SA10	0.4	WLF		
TP103	0.50	WLF		
TP107	0.4	WLF		
TP115	1.4	WLF		
TP120	2.00	WLF		
TP137	0.10	Topsoil		
TP137	0.30	WLF		
TP146	0.40	WLF		
TP152	0.3	WLF		
TP163	0.3	WLF		
TP103	0.20	Topsoil	BWB Standard Suite, Pesticides/Herbicides	General site contamination status and along vegetation areas across the site
TP106	0.20	Topsoil		
DS110	1.00	Alluvium		
DS124	0.20	Topsoil		
DS130	0.20	Topsoil		
TP122	0.20	Topsoil		
TP142	0.20	Topsoil		
TP146	0.20	Topsoil		
TP149	0.4	WLF		
TP151	0.1	Topsoil		
DS114	0.40	WLF	BWB Standard suite, VOCs and SVOCs	General site contamination status and opposite waste facility
TP115	0.10	Made Ground	Asbestos	General Made Ground screening
TP115	0.4	Made Ground	BWB Standard suite, Asbestos, Speciated TPH, BTEX	
TP115	1.2	Made Ground	BWB Standard suite, Asbestos, Speciated TPH, BTEX, VOCs and SVOCs	
DS116a	0.02	Made Ground	BWB Standard Suite	
Note: WLF = White Limestone Formation.				

Groundwater Strategy

5.9 Groundwater samples obtained using a bailer following the removal of 3 times the well volume of water or the well bailed dry and was allowed to recharge. The groundwater samples were sent to i2 Analytical Services (UKAS and MCERTS accredited) for the following suite of groundwater chemical testing:

- Four groundwater samples tested for arsenic, barium, beryllium, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium, zinc, conductivity, soluble sulphate, ammoniacal nitrogen, total phenols, total cyanide, pH, total organic carbon, PAHs (US EPA priority 16 compounds).

5.10 The results of the water chemical testing are presented as Appendix 6 within the Factual Ground Investigation Report (**Appendix 2**).

5.11 Further groundwater samples and surface water samples from onsite water courses are currently being obtained and analysed and will be reported in due course.

Geotechnical Strategy

5.12 The geotechnical strategy was to provide site coverage to assess initial high-level constraints particularly to inform the earthworks strategy and assess the bedrock profile which was anticipated at shallow depth.

5.13 In-situ soil strength testing comprising SPTs were undertaken with the cable percussive. HSV testing was also undertaken in cohesive materials in-situ at DS and TP locations. SPT 'N' values and HVP values are included on the exploratory hole logs presented as Appendix 2 within the Factual Ground Investigation Report (**Appendix 2**).

5.14 Selected disturbed and bulk samples were collected from the investigation locations and geotechnical testing was carried out by the drilling contractor (ETA), in which the laboratory is UKAS accredited. The following geotechnical testing was undertaken;

- Thirty-one samples tested for moisture content;
- Fourteen samples tested for Atterberg (liquid and plastic) limits;
- Fourteen samples tested for particle size distribution by pipette;
- Eleven samples tested for BRE Suite comprising aqueous sulphate and pH;
- Fifteen samples (two 2.5kg and thirteen 4.5kg) tested for compaction testing; and
- Variable head permeability testing at seven RO locations.

5.15 The results of the geotechnical testing are presented as Appendix 3 (permeability testing), Appendix 5 (geotechnical testing) and Appendix 6 (BRE suite) within the Factual Ground Investigation Report (**Appendix 2**).

Limitations and Uncertainty

5.16 Access was not permitted towards the south of the ground investigation boundary, in the location of the composting facility and covered reservoir areas. Additionally, there were stand offs from parts of the northern, western, and eastern boundaries due to Great Crested Newts and from many individual field boundaries due to badger sets. Ecological constraints drawings are included as **Drawing 5a and 5b**. There were also many services and field drains, which meant the relocation of several exploratory holes.

5.17 Within the Ashgrove Farm area, a single exploratory hole was advanced to gauge general contamination status in this area with limitations on placement.

6. GROUND CONDITIONS ENCOUNTERED

Geological Summary

6.1 The 2021 ground investigation undertaken on the site by BWB and third parties confirmed the anticipated sequence of ground conditions indicated by BGS mapping. Ground conditions generally comprised topsoil overlying slightly clayey to clayey, sandy, limestone gravel with low to medium cobble and boulder contents.

6.2 The recorded ground conditions are summarised in **Table 6:1** below. Uncorrected SPT results collected from the borehole locations are presented on the exploratory hole records presented as Appendix 2 within the Factual Ground Investigation Report (**Appendix 2**).

Table 6:1 Summary of Ground Conditions

Stratum	Top Depth (m)		Base Depth (m)		Thickness (m)		SPT N Value	
	Min	Max	Min	Max	Min	Max	Min	Max
Topsoil	0.00	0.00	0.20	1.00	0.20	1.00	NR	NR
Made Ground	0.00	0.00	0.05	1.30	0.05	1.30	NR	NR
Alluvium	0.30	1.80	2.38	2.40	0.58	2.10	NR	NR
White Limestone Formation	0.00	1.30	0.31	10.00	0.26	9.80	NR	NR
Rutland Formation	2.40	2.40	3.03	3.03	0.63	0.63	NR	NR

Geological Descriptions

Topsoil

6.3 Topsoil was encountered consistently across the site, generally at thicknesses of between 0.20m and 0.4m, with greater thicknesses of 0.5m to 1.0m towards the north (DS112), east (RO05) and south (RO08 and DS108) of the site and in the vicinity of the covered reservoir (DS123). The composition also displayed consistency, typically comprising dark brown slightly gravelly sandy clay with rootlets. Topsoil comprising clayey gravelly sand with rootlets was generally recorded in the east and southeast of the site, with sandy clayey gravel with rootlets in the northwest of the site at one location (DS102).

6.4 The depth of topsoil over the site may vary from that encountered at the locations investigated within the scope of this investigation which may result in inaccurate estimations of topsoil quantities on the site.

Made Ground

6.5 Made Ground was encountered in three exploratory holes (TP115, TP152 and DS116a) at the site with thicknesses ranging from 0.05m (DS116a) to 1.3m (TP115); TP115 is located immediately south of Ashgrove Farm, while DS116a is located at Ashgrove Farm. TP152 is located to the southwest of the composting facility.

6.6 The composition of Made Ground comprised gravelly sandy clay, clayey sandy gravel, or silty sandy gravel. Gravels of limestone, brick, slate, concrete and ceramic and fragments of plastic and glass were recorded within the Made Ground at TP115. Anecdotal evidence provided by the landowner indicated that a backfilled pond was present in this location. Metal artifacts (bolts) were recorded at DS116a. At TP152, Made Ground comprised gravels of brick, ceramic pottery, glass and limestone with rare plastic fragments and fabric cloth.

6.7 SPT N_{60} values within the Made Ground were recorded at 50 blows. It is noted that only one location was tested (DS116a). No additional geotechnical testing was carried out on the Made Ground material.

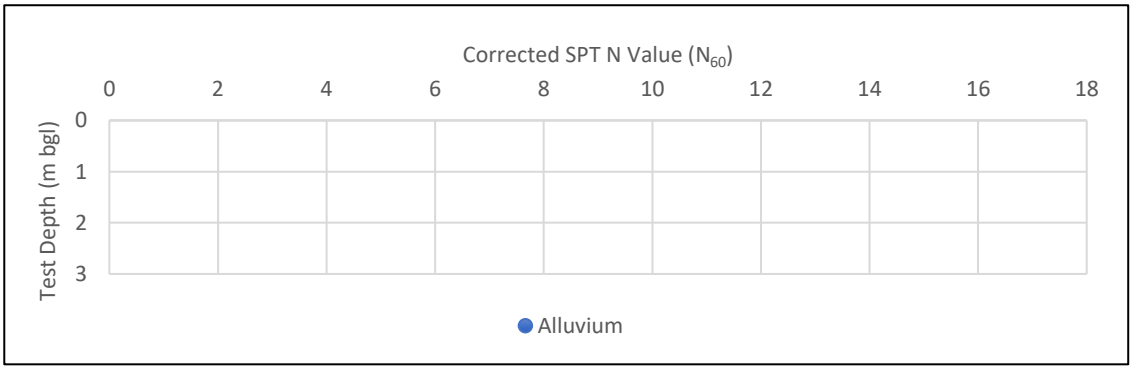
Alluvium

6.8 Alluvial deposits of sand and gravel were encountered in one location (TP121) to the northwest of Ashgrove Farm from ground level to 1.45m bgl overlying firm to very stiff clay with mudstone gravel to 2.4m bgl. Cohesive alluvial deposits were encountered in a second location (DS110) to the southwest of Ashgrove Farm from ground level to 2.4m bgl. Alluvial deposits are mapped at both of these locations as indicated on BGS mapping.

6.9 Cohesive deposits tested (DS110) were typically low to medium strength, soft and typically composed of clayey silt and or silty clay, and brown and grey in colour.

6.10 SPT N_{60} values within the Alluvium were recorded in the range 8 and 16 blows. It is noted that only one location was tested, within the silt and sand stratums. A graph presenting the SPT results is presented below in **Figure 6:1**. The uncorrected SPT results obtained are presented on the exploratory hole records presented as Appendix 2 within the Factual Ground Investigation Report (**Appendix 2**).

Figure 6:1 Corrected SPT 'N' Value (N60) Versus Depth Alluvium



6.11 The geotechnical laboratory testing has indicated the PI of 18% (intermediate plasticity) on the one sample tested.

White Limestone Formation

6.12 The White Limestone Formation was encountered across the site at thicknesses ranging between 0.26m and 9.80m, generally comprising very dense, greyish/orangish brown slightly clayey sandy gravel and gravelly sand, with gravels of limestone and some shell fragments and calcareous concretions. Interbedded layers of very dense grey slightly sandy gravel of limestone and orange, brown clayey sand were encountered towards the southeast of the site (DS117 to DS120, DS126, DS127 and DS130). Cohesive deposits of firm to stiff brown sandy gravelly clay underlain by typically very dense grey sandy gravel of limestone were encountered across the site. Limestone with clay bands were encountered at RO03 to RO08.

6.13 Fourteen PSD tests were undertaken on samples from the White Limestone Formation, a summary of the results is provided in **Table 6:2** below. The PSD results obtained at trial pits are presented as Appendix 5 within the Factual Ground Investigation Report (**Appendix 2**).

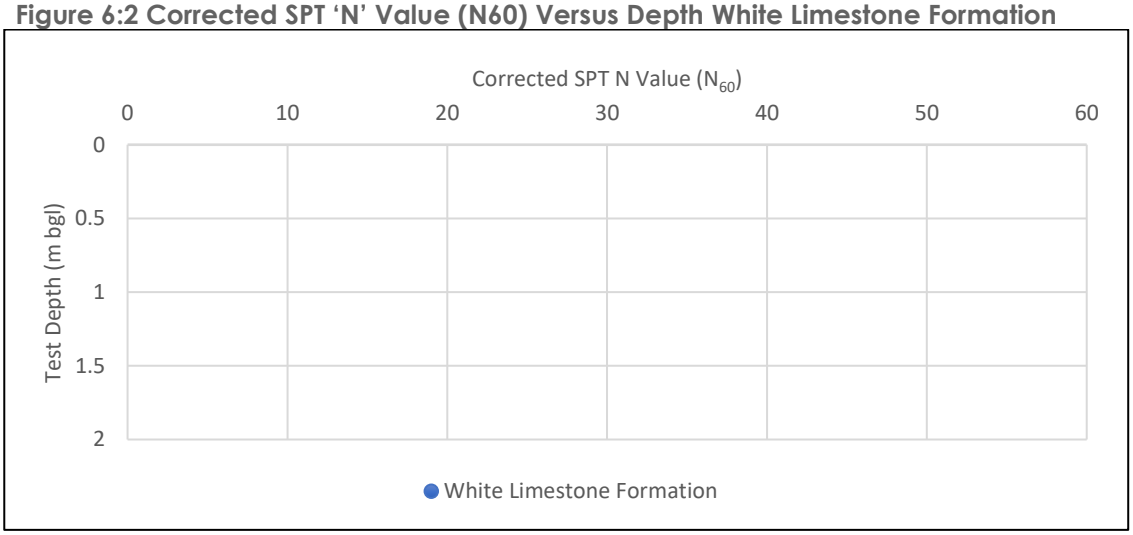
Table 6:2 PSD Results Summary

Stratum	Location	Depth (m)	Cobble Content (%)	Gravel Content (%)	Sand Content (%)	Clay/ Silt Content (%)	Earthworks Classification
White Limestone Formation	SA08	1.1	6.9	61	16.9	15.2	1C
White Limestone Formation	SA09	0.7	20.2	52.5	15.1	12.2	1A
White Limestone Formation	TP109	0.6	13.9	64.4	13.6	8	1A
White Limestone Formation	TP119	0.5	32.7	27.5	17.2	22.6	1C
White Limestone Formation	TP121	1	0	53.7	38.2	8.1	1A
White Limestone Formation	TP121	1.9	0	1.1	8.4	90.5	2A&2B
White Limestone Formation	TP124	1.6	0	8.1	40	51.9	2A&2B
White Limestone Formation	TP131	0.8	10.3	55.3	23.3	11.1	1A
White Limestone Formation	TP136	1.2	36.7	31.1	20.7	11.5	1A
White Limestone Formation	TP140	0.5	0	67.1	16.8	16.1	2C
White Limestone Formation	TP149	0.9	10.7	55.1	21.7	12.5	1A

Stratum	Location	Depth (m)	Cobble Content (%)	Gravel Content (%)	Sand Content (%)	Clay/ Silt Content (%)	Earthworks Classification
White Limestone Formation	TP150	0.5	0	57.1	26	16.9	2C
White Limestone Formation	TP154	1	0	1	21.1	77.9	2A&2B
White Limestone Formation	TP163	0.7	37.2	46	9.6	7.2	1A

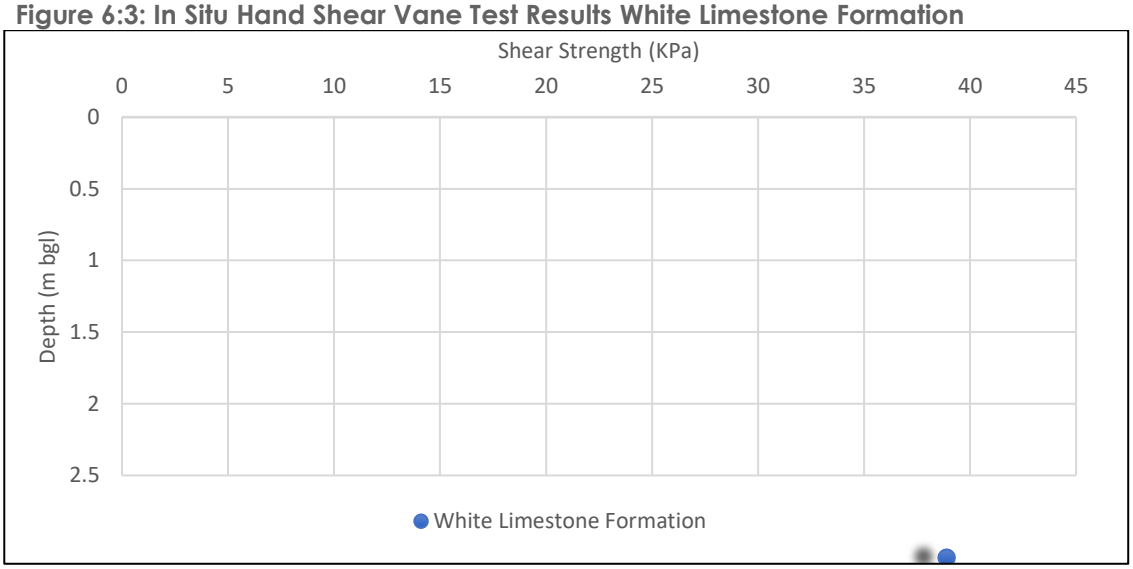
6.14 SPT N_{60} values within the White Limestone Formation were recorded in the range 11 to 50 blows. A graph presenting the SPT results is presented below in **Figure 6:2**Figure 6:1. The uncorrected SPT results obtained are presented on the exploratory hole records presented as Appendix 2 within the Factual Ground Investigation Report (**Appendix 2**).

Figure 6:2 Corrected SPT 'N' Value (N60) Versus Depth White Limestone Formation



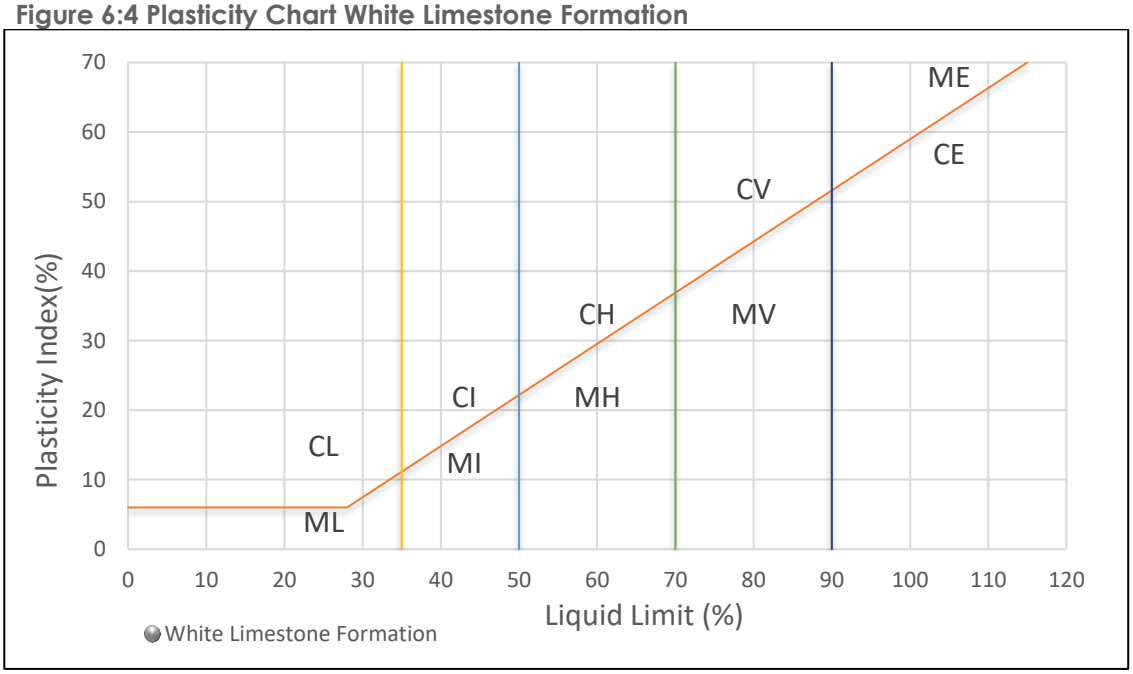
6.15 Where suitable cohesive deposits were encountered hand shear vane tests were undertaken. The tests comprised three tests with the average taken as the peak results and presented as a graph below as **Figure 6:3**. The HSV results obtained at trial pits are presented on the exploratory hole records presented as Appendix 2 within the Factual Ground Investigation Report (**Appendix 2**).

Figure 6:3: In Situ Hand Shear Vane Test Results White Limestone Formation



6.16 The geotechnical laboratory testing has indicated PIs to be in the range 7% (low plasticity) and 38% (high plasticity). A Plasticity Chart is presented below as **Figure 6:4**. The PIs results obtained at trial pits are presented as Appendix 5 within the Factual Ground Investigation Report (**Appendix 2**).

Figure 6:4 Plasticity Chart White Limestone Formation



6.17 The geotechnical laboratory testing has indicated OMC to be in the range 7.5% and 16%. The OMC results obtained at trial pits are presented as Appendix 5 within the Factual Ground Investigation Report (**Appendix 2**).

Rutland Formation

6.18 Rutland Formation was encountered at one location (DS110) to the southwest of Ashgrove Farm from 2.4m to 3.03m bgl, comprising firm greenish grey slightly silty, sandy, slightly gravelly clay with occasional shell fragments and gravels of limestone.

6.19 SPT N_{60} values within the Rutland Formation were recorded at 50 blows. It is noted that only one location was tested (DS110). No additional geotechnical testing was carried out on the Made Ground material.

In Situ Testing

Soakaway Permeability Testing

6.20 Permeability testing in line with BRE 365 guidance was undertaken in eleven locations (SA01 to SA11) across the site. The results of the testing undertaken are presented as Appendix 3 within the Factual Ground Investigation Report (**Appendix 2**) and are summarised within Table 6:3 below:

Table 6:3 BRE 365 Soakaway Testing Results

Test Location	Geology	Test no.	Soil Infiltration Rate (m/s)	Permeability Class	Drainage Characteristics
SA01	White Limestone Formation	1	$4.3x10^{-06}$	Low	Good
SA02	White Limestone Formation	1	$5.81x10^{-05}$	Medium	Good
		2	$4.35x10^{-05}$	Medium	Good
		3*	$2.47x10^{-05}$	Medium	Good
SA03	White Limestone Formation	1	$1.17x10^{-05}$	Medium	Good
		2*	$1.02x10^{-05}$	Medium	Good
SA04	White Limestone Formation	1	$1.66x10^{-04}$	Medium	Good
		2	$1.31x10^{-04}$	Medium	Good
		3	$1.19x10^{-04}$	Medium	Good
SA05	White Limestone Formation	1**	N/A	N/A	N/A
SA06	White Limestone Formation	1	$1.34x10^{-04}$	Medium	Good
		2	$1.31x10^{-04}$	Medium	Good

Test Location	Geology	Test no.	Soil Infiltration Rate (m/s)	Permeability Class	Drainage Characteristics
		3	$1.46x10^{-04}$	Medium	Good
SA07	White Limestone Formation	1	$3.00x10^{-05}$	Medium	Good
		2***	N/A	N/A	N/A
SA08	White Limestone Formation	1	$7.10x10^{-05}$	Medium	Good
		2	$6.01x10^{-05}$	Medium	Good
		3	$4.07x10^{-05}$	Medium	Good
SA09	White Limestone Formation	1	$1.53x10^{-05}$	Medium	Good
SA10	White Limestone Formation	1*	$4.56x10^{-06}$	Low	Good
SA11	White Limestone Formation	1*	$7.18x10^{-06}$	Low	Good
Note: * = Test ended early due to time constraints. ** = Test failed. *** = Not completed due to time constraints.					

Variable Head Permeability Testing

6.21 Permeability testing was undertaken within the limestone at RO01 to RO08 (excluding RO05) located across the site, with a testing section between 3.00m and 10.00m. The results of the testing undertaken are presented as Appendix 3 within the Factual Ground Investigation Report (**Appendix 2**) and are summarised within Table 6:4 below:

Table 6:4 Permeability Testing Results

Test Location	Geology	Calculation Methodology	Permeability (m/s)	Permeability Class	Drainage Characteristics
RO01	Limestone	Basic Time Lag Method	$6.51x10^{-06}$	Low	Good
		General Method	$6.01x10^{-06}$	Low	Good
RO02	Limestone	Basic Time Lag Method	$4.16x10^{-06}$	Low	Good
		General Method	$4.44x10^{-06}$	Low	Good
RO03	Limestone	Basic Time Lag Method	$3.00x10^{-06}$	Low	Good

Test Location	Geology	Calculation Methodology	Permeability (m/s)	Permeability Class	Drainage Characteristics
		General Method	$1.40x10^{-06}$	Low	Good
RO04	Limestone	Basic Time Lag Method	$1.15x10^{-06}$	Low	Good
		General Method	$1.02x10^{-06}$	Low	Good
RO05	Limestone	Unable to generate a measurable head by either test method	N/A	N/A	N/A
RO06	Limestone	Basic Time Lag Method	$6.58x10^{-07}$	Low	Poor
		General Method	$4.52x10^{-07}$	Low	Poor
RO07	Limestone	Basic Time Lag Method	$9.80x10^{-07}$	Low	Poor
		General Method	$9.70x10^{-07}$	Low	Poor
RO08	Limestone	Basic Time Lag Method	$4.70x10^{-06}$	Low	Good
		General Method	$4.30x10^{-06}$	Low	Good

6.22 Consideration of the suitability of soakaways and drainage is made in **Section 7** of this report.

Hydrogeology

6.23 During the 2021 limited ground investigation, shallow groundwater strikes during excavation and drilling were encountered at depths between 1.3m and 2.0m bgl. Water strikes were generally noted to be confined, with stratum of cohesive material identified above and below the water strike. During deeper rotary open hole drilling air mist flush was used with resting water levels recorded at the completion of drilling works The groundwater strikes and water levels recorded on completion of drilling of rotary open hole are presented on the exploratory hole records presented as Appendix 6 within the Factual Ground Investigation Report (**Appendix 2**) and summarised in **Table 6:5** below:

Table 6:5 Water Strikes

Location	Depth (m bgl)	Stratum
DS110	2.0	Alluvium (Sand)

Location	Depth (m bgl)	Stratum
SA03	1.3	White Limestone Formation (Limestone)
TP106	1.68	White Limestone Formation (Limestone)
TP120	1.6	White Limestone Formation (Sand)
TP121	1.45	Alluvium (Sand and Gravel)
TP146	1.6	White Limestone Formation (Gravel)
RO01	9.8	White Limestone Formation (Limestone)
RO02	9.8	White Limestone Formation (Limestone)
RO03	6.3	White Limestone Formation (Limestone)
RO04	7.1	White Limestone Formation (Limestone with Clay)
RO05	3.5	White Limestone Formation (Limestone)
RO06	8.1	White Limestone Formation (Clay with Limestone)
RO07	7.2	White Limestone Formation (Clay with Limestone)
RO08	7.2	White Limestone Formation (Clay with Limestone)

6.24 It is considered that two groundwater bodies are present at the site; one is considered to be present within shallow deposits, while the second is within the deeper limestone deposits.

6.25 For the shallow groundwater unit, during the post-ground investigation monitoring programme resting groundwater levels were measured at depths ranging between 0.35m bgl (recorded on 04/10/2021) and 1.43m bgl (recorded on 11/10/2021). The resting levels were recorded at elevations raging between 106.42m AOD (recorded on 11/10/2021) and 107.77m AOD (recorded on 04/10/2021). The shallow groundwater body is considered to be a discontinuous groundwater unit, which was only identified in two locations at the site, as such no flow direction or hydraulic gradient has been calculated.

6.26 For deeper groundwater unit, during the post-ground investigation monitoring programme resting groundwater levels were measured at depths ranging between 2.62m bgl (recorded on 18/10/2021) and 5.9m bgl (recorded on 04/10/2021). The resting levels were recorded at elevations raging between 93.68m AOD (recorded on 28/09/2021) and 115.1m AOD (recorded on 11/10/2021). The resting groundwater levels and GPS positions have been used to infer the likely groundwater flow direction at the site, which is indicated to be in a south easterly direction with a gradient of approximately 1.74%. The inferred groundwater flow profile is presented as **Drawing 5**.

Contamination Observations

6.27 No significant visual or olfactory contamination observations were noted during the intrusive investigation works. However, moderate natural organic odours were identified in localised locations associated with natural organic deposits (alluvium).

6.28 No contamination observations were noted during the groundwater sampling visit and during the subsequent gas and groundwater monitoring period.

7. GEOTECHNICAL ASSESSMENT

Introduction

7.1 It is anticipated that the site is to be developed for a commercial end use. The proposed development plan is presented as **Drawing 1**.

7.2 At the time of writing, specific column loads for the proposed developments are unknown, floor slab loadings of 50kPa and column loads of 150kpa have been assumed for a preliminary assessment.

7.3 Ground Conditions at the site typically comprised:

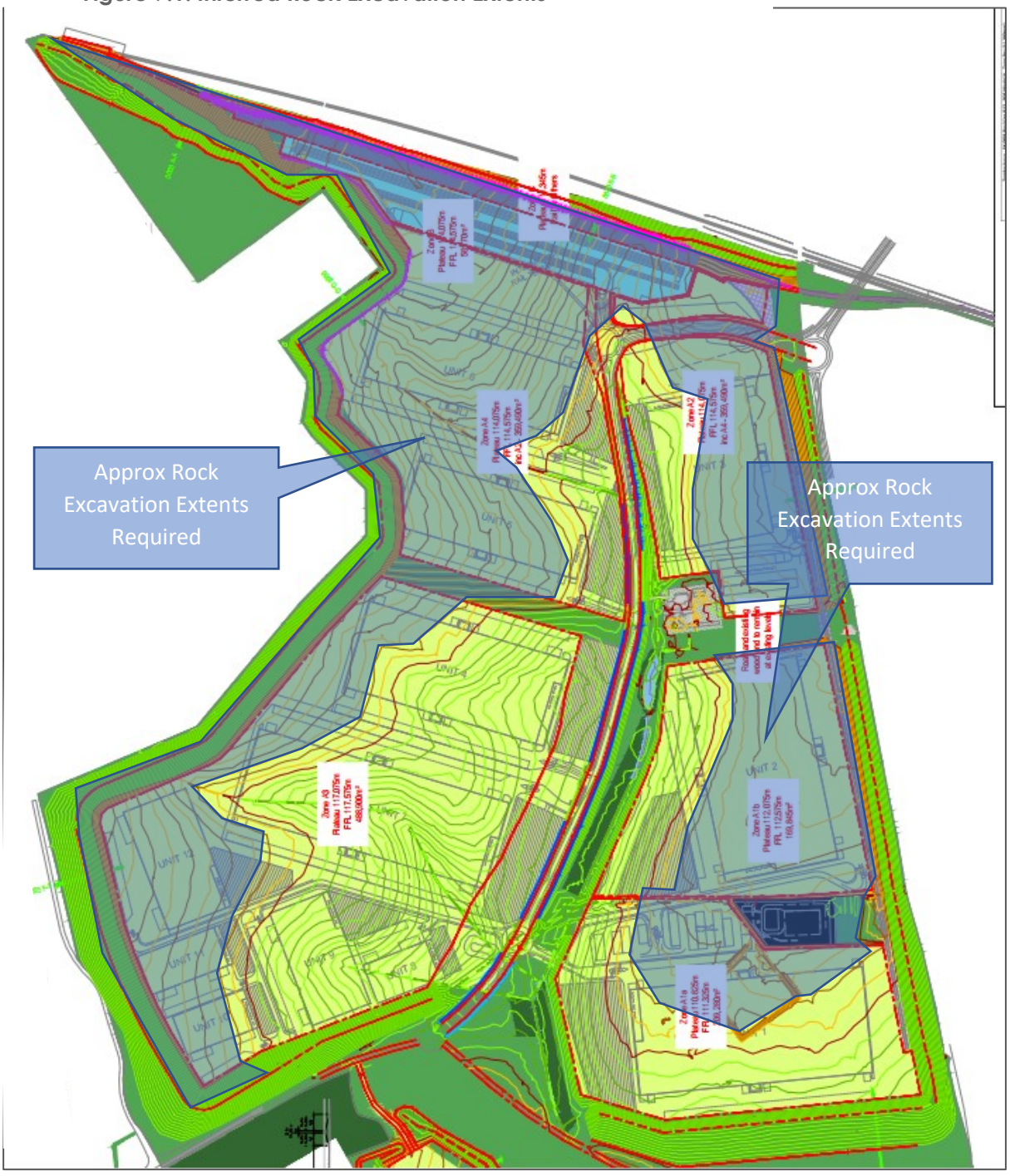
- Topsoil consistently across the site, generally at thicknesses of between 0.20m and 0.4m;
- Alluvial deposits localised along the brook in the central valley bottom comprising of sand and gravel and clay and proven to 2.4m bgl.
- Weathered deposits of the White Limestone Formation typically from beneath the Topsoil to between the site surface and 1.3m bgl comprising cohesive deposits of firm to stiff brown sandy gravelly clay underlain by typically very dense grey sandy gravel of limestone were encountered across the site. Interbedded layers of very dense grey slightly sandy gravel of limestone and orange, brown clayey sand were encountered towards the southeast of the site (DS117 to DS120, DS126, DS127 and DS130).
- Competent White Limestone Formation bedrock which was encountered across the site to depths of up to 9.80m. Dynamic sample borehole and trial pits refused on this stratum at depths of between 0.31 and 2.4m bgl but typically between 0.5 and 1.5m bgl. Limestone with clay bands were encountered at RO03 to RO08.
- Resting groundwater levels were typically encountered between 2.62m bgl and 5.9m bgl in deeper strata. For geotechnical assessment purposes, perched groundwater has been discounted.

Geotechnical Constraints

7.4 A large earthworks operation will be required at the site to create level development plateaus. The current earthworks strategy is presented as **Drawing 2** which indicates in excess of 7.0m of cut is required in parts of the site. Most units are located on plateaus? with a portion of cut and fill required on each plot. Currently, only Units 10, 11 and 12 are placed wholly on cut.

7.5 Given the shallow bedrock, breaking out competent rock will create a significant constraint at the site. The rock will need to be removed by ripping and/or blasting (drill and blast). An indication of the potential extents of rock excavation is presented on **Figure 7**:1 overleaf.

Figure 7:1: Inferred Rock Excavation Extents



Foundation Solutions

7.6 Based on the proposed earthworks strategy, assuming that material is placed to a suitable specification then shallow footings and ground bearing floor slabs are expected to be suitable for the proposed development. Due to many of the units being placed on a combination of cut (into solid limestone bedrock) and fill (excavated soils and/or rock), there is the potential for differential settlement issues arising. On this basis, the fill will need to be placed to an end-product specification to avoid differential settlement issues and additional reinforcement is likely to provide support where any structures span over cut and fill areas.

7.7 A typical thickness of between 0.2 and 0.4m of topsoil has been identified across the site with organic contents typically above 3% and up to 10%. Due to the organic nature of this material it is not considered suitable foundation material and should be stripped prior to construction.

Roads and Pavements

7.8 No specific CBR testing has been undertaken at this early stage of the project. However, roads and pavements are expected to be on a combination of bedrock, weathered bedrock geology and engineered fill material. As a guide it is recommended that roads be designed for 5% CBR, which should be confirmed by in-situ testing once detailed designs are available. Interim Advice Note 73/06 (IAN73/06) Revision 1 2009 advises that where the in-situ subgrade has an estimated CBR value less than 2.5% it must be improved. Limestone is typically frost susceptible and so it is likely that a minimum sub base of 450mm will be required to address this.

Drainage

7.9 Both shallow BRE soakaway testing and deeper permeability testing in wells installed in limestone bedrock have been undertaken to inform drainage design with permeabilities in the range $6.51x10^{-06}$ m/s and $4.52x10^{-07}$ m/s in the limestone bedrock and between $1.46x10^{-04}$ m/s and $4.56x10^{-06}$ m/s in shallow soakaway locations terminating on the limestone.

Excavations

Ease of Excavation

7.10 Any excavation taken deeper than 1.5m is likely to require at least a breaker and specialist equipment for more significant excavation. This is also likely to be required at shallower depth in parts of the site. It is likely that blasting of rock may be required where excavation depths exceed around 3m.

Stability of Excavation

7.11 Excavations displayed generally good stability during the ground investigation although excavation may become unstable if left open for any significant periods. Where personnel entry is required for inspection; excavations should be sufficiently enlarged and an assessment of safe temporary angles should be made. Alternatively, temporary shoring should be provided.

7.12 Long term cut slopes within the limestones at the site are likely to be able to stand at steep angles with a suitable global factor of safety, this is subject to further ground investigation and geotechnical design. Slope protection will be required to guard against spalling or face degradation and protect people and other receptors, which could include netting, shotcreting, fencing, bunding and/ or access restrictions.

Legislation on Personnel Entry to Excavations

7.13 It is recommended that no excavations should be entered without appropriate support and a full risk assessment should be completed prior to entry. Mitigation measures to protect from accumulating ground gases should be implemented.

Groundwater

7.14 During the 2021 limited ground investigation, shallow groundwater strikes during excavation and drilling were encountered at depths between 1.3m and 2.0m bgl. Water strikes were generally noted to be confined, with stratum of cohesive material identified above and below the water strike. Resting groundwater levels were recorded between 0.35m and 5.9m bgl.

7.15 It is expected that shallow groundwater within the weathered White Limestone Formation deposits may be removed using conventional construction of sumps and submersible pumps, depending on depths and any shoring techniques in place.

7.16 Where deeper excavations are proposed, typically greater than around 5.0m bgl, then groundwater may be encountered. During excavations then its expected to be removed using conventional construction of sumps and submersible pumps.

7.17 Some areas of the site are likely to have permanent cut into the groundwater table notably at the rear of Units 5, 6 and 12 and at the Rail Freight Terminal, which will likely need a permanent drainage solution to manage groundwater. . A specialist hydrogeologist should be consulted to ensure the drainage design appropriately manages groundwater, potentially in conjunction with a hydrologist and wider surface water management strategy.

Chemical Attack on Buried Concrete

7.18 A summary of the pH, sulphur and total soluble sulphate concentrations in the different soil strata types encountered at the site is presented in Table X below

Strata	Soil - pH Range	Soil - Sulphur Range (mg/kg)	Soil - Water Soluble Sulphate (mg/l)	Groundwater - pH Range	Groundwater - Water Soluble Sulphate (mg/l)	Design Sulphate Class	ACEC Class
Made Ground	8.3 – 9.6	490 - 580	8.4 – 120	N/A	N/A	DS1	AC1
Topsoil	8.1 – 8.6	270 - 1200	5.3 – 73	N/A	N/A	DS1	AC1
Alluvium	8.3 – 8.4	380 - 1200	11 – 23	N/A	N/A	DS1	AC1
White Limestone Formation	8.0 – 8.7	120 – 720	3.3 – 15	7.3 – 7.6	29.8 – 34.2	DS1	AC1

7.19 In accordance with the recommendations of BRE Special Digest 1, 'Concrete in Aggressive Ground' 2005, the conditions of the soils at the site would therefore be classified as Design Sulphate Class DS-1 and ACEC Class AC-1 for soils and groundwater, when considering the most appropriate type of concrete to be used at the site in order to resist chemical attack from elevated sulphate present in the soils (assuming mobile groundwater in non pyritic soils).

Earthworks

7.20 As previously discussed, a large earthworks exercise will be required to facilitate the proposed development with the earthworks strategy presented as **Drawing 2**. To manage the earthworks placement an earthworks specification will be required, and it is recommended that this is specified, supervised and validated by a suitably qualified Geotechnical Engineer.

7.21 PSD testing of shallow weathered white limestone soils has indicated that they typically conform to type 1 granular material or type 2 cohesive. 15 samples have been subject to compact testing using either a 2.5kg or 4.5kg rammer. As received moisture contents were between 2.7 and 6.4% with optimum moisture contents of between 7.5 and 16%. This indicates soils to be dry of optimum at the time of sampling. However, it should be noted that sampling was undertaken in September and moisture contents, and therefore modification requirements, are likely to vary seasonally.

7.22 Extensive rock excavation will be required to facilitate proposed site levels. This is likely to require ripping and also potentially blasting of deeper rock strata. The rock excavated should then be processed by crushing and screening to create the desired rock type which could include general fill, road subbase material and/or drainage medium particularly where retaining structures may be required. Blasting will be subject to constraints relating to nuisance and potential to damage structures, the water reservoir on site being one structure that may be particularly affected.

7.23 The suitability of earthworks materials has been assessed based on the testing carried out as part of this investigation. The materials encountered onsite may vary from those analysed; furthermore, inclement weather or winter working may result in materials being unsuitable for incorporation within the works without modification by lime, cement, or other methods. In particular, cohesive soils are very susceptible to 'wet weather working' and consideration should be given to lime and/or cement stabilisation of these materials if the earthworks are undertaken during inclement weather or the winter period.

7.24 Stockpiled materials often deteriorate due to water infiltration and they may become unsuitable for incorporation in the works; further testing and re-assessment should be made prior to the finalisation and implementation of the earthworks design.

8. GROUND GAS ASSESSMENT

Introduction

8.1 Ground gas assessment has been undertaken to assess the risks associated with ground gases and volatile vapours to new buildings and their occupants. The results obtained have been assessed in line with relevant guidance (notably CIRIA C665).

8.2 Based on the desk study and the ground investigation undertaken, the following potential sources of hazardous ground gas have been identified:

- Very localised Made Ground across the site;
- Ardley Landfill to the northeast – east/ south-east of the site;
- Natural organic material associated with alluvium has potential for low level gas generating, although this is considered to be limited; and
- Ardley Wood Landfill approximately 10m north of the site, beyond the railway cutting.

8.3 Based on the potential sources identified, CIRIA C665 guidance indicates that the potential for gas generation at the site is generally very low with areas in the north and east with moderate to high gas generation potential and a low sensitivity to development (for the proposed commercial land use), a typical monitoring programme may comprise six to twelve visits over a period of three to six months.

8.4 Given the majority of the site has a very low gas generation potential, BWB have undertaken four visits over a period of one month. BWB have completed the prescribed monitoring programme as set out in CIRIA C665.

8.5 However, given that parts of the site, notably eastern areas adjacent to Ardley Landfill, are considered to be a moderate gas generation potential, this assessment should be considered to be preliminary and additional monitoring may be required to appropriately assess the gas risk and confirm localised gas regimes. However, BWB would propose to engage with local authorities to understand the potential risk and what further monitoring (if any) needs to be completed.

Methodology

8.6 The assessment of potential ground gas generation is based on the observation of trends and changes in gas evolution by the direct measurement of ground gases from gas wells. The works included measurement of methane, carbon dioxide, oxygen, hydrogen sulphide, carbon monoxide, gas flows and barometric pressure. A PID survey was undertaken to measure volatile organic compounds within the borehole response zones.

Results

8.7 The minimum and maximum steady state concentrations recorded for borehole flow, oxygen, carbon dioxide and methane are summarised below in **Table 8:1**. The full ground gas monitoring results are presented in **Appendix 3**.

Table 8:1 Summary of Recorded Ground Gas Results

Borehole ID	Targeted Geology	Steady Flow (l/hr)		Carbon Dioxide (%v/v)		Methane (%v/v)	
		min.	max.	min.	max.	min.	max.
DS101	WLF	<0.1	0.4	1.0	1.5	<0.1	0.3
DS102	WLF	<0.1	0.3	0.6	1.6	<0.1	0.3
DS103	WLF	<0.1	0.2	0.3	0.7	<0.1	0.3
DS104	WLF	<0.1	0.3	0.3	0.7	<0.1	0.3
DS105	WLF	<0.1	0.3	0.2	0.8	<0.1	0.3
DS106	WLF	<0.1	0.4	0.2	0.9	<0.1	0.3
DS107	WLF	<0.1	0.4	0.2	0.4	<0.1	0.3
DS108	Topsoil / WLF	<0.1	0.4	0.7	0.9	<0.1	0.3
DS110	Alluvium / RF	<0.1	*6.1*	0.1	0.8	<0.1	*0.4*
DS111	WLF	<0.1	0.1	0.3	0.7	<0.1	0.3
DS112	WLF	<0.1	0.3	0.3	1.4	<0.1	0.3
DS113	WLF	0.1	0.3	0.2	0.7	<0.1	0.3
DS114	WLF	0.2	0.3	0.7	1.2	<0.1	*0.4*
DS115*	WLF	0.2	0.2	1.0	1.7	<0.1	0.3
DS117	WLF	<0.1	0.3	0.3	0.9	<0.1	0.3
DS118	WLF	<0.1	0.5	0.5	0.8	<0.1	0.3
DS120	WLF	<0.1	0.4	0.9	1.3	<0.1	0.3
DS121	WLF	<0.1	0.4	1.2	1.5	<0.1	0.3
DS122	WLF	<0.1	0.3	0.2	1.4	<0.1	0.3
DS123	Topsoil / WLF	<0.1	0.3	1.2	*5.1*	<0.1	0.3
DS125	WLF	<0.1	0.5	0.8	1.2	<0.1	0.3
DS128	WLF	<0.1	0.3	0.1	1.3	<0.1	0.3
DS130	WLF	<0.1	0.2	0.8	1.2	<0.1	0.3
RO01	WLF	<0.1	0.4	0.2	0.7	<0.1	0.3
RO02	WLF	<0.1	0.3	0.1	0.3	<0.1	0.3
RO03	WLF	<0.1	0.3	0.3	0.9	<0.1	0.3
RO04	WLF	<0.1	0.4	0.2	0.5	<0.1	0.3
RO05*	WLF	0.2	0.2	0.1	0.2	<0.1	0.3
RO06	WLF	<0.1	0.4	0.2	0.2	<0.1	0.3
RO07	WLF	<0.1	0.3	0.2	2.0	<0.1	0.3
RO08	WLF	<0.1	0.4	0.1	0.7	<0.1	0.3

*Atmospheric pressure ranged between 992mb and 992mb during the monitoring period.
Note: WLF = White Limestone Formation. RF = Rutland Formation.

8.8 The atmospheric pressures were recorded as follows:

- Round 1 – A rising pressure trend was recorded in the preceding 12 hours, and rising to 1008mB and falling to 1003mB during the site visit;
- Round 2 – A falling pressure trend was recorded in the preceding 12 hours, and rising to 1000mB and falling to 999mB during the site visit;
- Round 3 – A falling pressure trend was recorded in the preceding 12 hours, and rising and steady at 1022mB during the site visit;
- Round 4 – A falling pressure trend was recorded in the preceding 12 hours, and rising and steady at 1006mB during the site visit;

8.9 On this basis, gas monitoring has not been undertaken in a period of rapid falling pressure which would be considered to represent the worst-case gassing scenario at the site as generally, ground gas emissions tend to increase when atmospheric pressure falls rapidly. However, monitoring has been undertaken during steady, falling, and rising pressure and is considered to provide suitable data for the initial assessment of the ground gas regime at the site.

8.10 Hydrogen sulphide and carbon monoxide concentrations were recorded at concentrations of up to 2ppm in several locations across Round 2 to Round 4. A summary is provided in **Table 8:2** below:

Table 8:2 Summary of Recorded Hydrogen Sulphide and Carbon Monoxide Results

Borehole ID	Targeted Geology	Round	Hydrogen Sulphide (ppm)	Round	Carbon monoxide (ppm)
			max.		max.
DS105	WLF	4	2	3 & 4	2
DS110	Alluvium / RF	2	2	<1.0ppm	
DS114	WLF	2	2		
DS115	WLF	2	2		
DS117	WLF	2	2		
DS118	WLF	2	2		
RO01	WLF	2 & 4	2		
RO05	WLF	2	2		
RO06	WLF	2	2		
RO07	WLF	3	2		
Note: All remaining concentrations were either below or at the limit of detection (<1.0ppm). WLF = White Limestone Formation. RF = Rutland Formation.					

8.11 PID concentrations were recorded between <0.1ppm (the limit of detection of the equipment) and a maximum of 0.9ppm in borehole DS110 on 11/10/2021 (Round 3).

Risk Assessment

8.12 A suitability assessment of the available gas monitoring data is provided below in **Table 8:3**.

Table 8:3 Gas Data Suitability Assessment

Query	Comment
Number and distribution of gas wells	Reasonable coverage across the site, with a total of thirty-one wells installed including on each of the boundaries of the site. Two wells (DS108 and DS110) were installed cross boundary between cohesive topsoil and granular natural materials, and cohesive alluvium and cohesive bedrock deposits respectively due to shallow bedrock. DS110 is considered to be installed within natural cohesive deposits. DS108 minimally crosses the topsoil boundary (20cm).
Design of gas monitoring wells	Wells were installed within the natural deposits across the site. A considerable thickness of Made Ground was encountered at one trial pit location only and so had no installation; the closest installs are DS110, DS115 and DS117. Sufficient plain pipe is present in all wells to form an adequate seal, along with bentonite and the concrete headworks.
Flooded Wells	DS110, RO04 and RO05 were flooded during all gas monitoring rounds. RO07 and RO08 were partially flooded in round 4 and RO2 in Round 3 with less than one metre of unsaturated well screen. Gas monitoring data is unlikely to be representative of ground gas conditions where flooding occurs. Groundwater levels ranged between 93.68m AOD and 115.1m AOD. The gas monitoring data is unlikely to be representative of the ground gas conditions at DS110, RO04 and RO05 and are therefore excluded from this assessment.
Frequency and duration of monitoring	Thirty-one installations were monitored on four occasions over a 4-week period. Atmospheric pressure ranged from 999mb to 1022mb during the monitoring visits.
Presence of TPH	TPH concentrations can influence the gas results recorded. No elevated concentrations of TPH were recorded in groundwater samples.

8.13 CIRIA Report 665 "Assessing Risks Posed by Hazardous Ground Gases to Buildings" presents current best practice on the assessment of ground gases for commercial and residential buildings (with the exception of low-rise traditional housing). The report presents a risk-based approach based on gas screening levels which depend on both the concentration and emission rate of gas from the ground. Gas screening levels are calculated as follows:

$$Gas\ screening\ value\ (l/hr) = \frac{gas\ concentration\ (\%)\ X\ measured\ borehole\ flow\ rate\ (l/h)}{100}$$

8.14 Gas screening values should be calculated on a borehole basis in the first instance. Consideration of worst case i.e., highest flow and highest concentrations should only be considered if the CSM warrants it. The gas screening results are provided in **Appendix 2**.

8.15 A maximum gas screening value for carbon dioxide of 0.0255l/hr was recorded giving a classification of CS1. However, carbon dioxide was recorded above 5%v/v (DS123 5.1%v/s Round 4) and close to 5%v/v (DS123 4.5%v/s Round 2) in DS123 and the guidance suggests that consideration should be given as to whether there is justification to upgrade to CS2.

8.16 A maximum gas screening value for methane of 0.002l/hr was recorded giving a classification of CS1.

8.17 It is noted that all boreholes recorded a classification of CS1 with the exception of DS123; maximum carbon dioxide concentrations were recorded at 5.1%v/v (peak and steady) on one monitoring occasion only (Round 4) with carbon dioxide recorded between 1.2 and 4.5%v/v on the three previous monitoring rounds. DS123 is located in between the covered reservoir onsite and Ardley Landfill to the east of the site. It should be noted that the response zone was placed between the White Limestone Formation and the Topsoil. As the only well with this situation and the only well with elevated concentrations, its expected that the topsoil is the source of the slightly elevated carbon dioxide concentrations. As topsoil will be stripped from the surface and not used beneath building footprints and so the source will be removed.

8.18 Based on the available data, the gas regime is assessed as CS1 across the site. The gas data indicates no shallow ground gas risk in the east of the site adjacent to Ardley Landfill. However, finished floor levels of the buildings in this area will be around 3.0m below existing ground levels and so the main gas risk will be via gas migration through fracturing in the deeper limestone.

Recommendations

8.19 Based on the proximity of Ardley Landfill and it being known to be gassing, further gas monitoring should be undertaken. However, it's possible that control measures are in place to manage the gas migration and so further monitoring may not be justified. BWB are currently awaiting a response from the EA as to whether there is any data that can be shared to better understand the potential risk. The potential risk relates to units 1 to 3 on the masterplan (see **Drawing 1**) with a very low risk to other areas of the site for which no further monitoring or gas protection are required. With a high gas generation potential and low sensitivity commercial development CIRIA C665 prescribes 12 visits over a 6-month period. Four visits have been completed to date a so a further 8 visits would be required over a 5-month period, if required.

8.20 For Units 1 to 3, it is possible that gas protection measures will need to be installed but further assessment is required to identify this. Obtaining any specific information regarding Ardley Landfill will be key to appropriately assessing the risk and identifying any further monitoring and/or gas protection requirements.

9. CONTAMINANT DISTRIBUTION

Soils

9.1 Contamination data have been compared to generic site assessment criteria (GSAC) for a commercial end use. The soil screening is presented as **Appendix 4** and details of the derivation of the GSACs are presented in **Appendix 5**. The criteria includes reference to the LQM/CIEH S4ULs for Human Health Risk Assessment Copyright Land Quality Management Limited reproduced with permission; publication number S4UL3271.

9.2 A total of thirty-seven soil samples were collected scheduled for selected analysis from across the site. No exceedances were recorded in soil samples. Three samples (Made Ground) were tested for asbestos, all results were recorded as not detected.

Onsite sources

9.3 No significant contamination was recorded, visual, olfactory or through chemical testing, at the electrical substation or former/current fuel and oil storage at Ashgrove Farm. Access could not be gained at the composting facility and covered reservoir; however, it is unlikely that significant contamination is present.

9.4 Made Ground was limited to two locations in the vicinity of Ashgrove Farm up to 1.3m bgl, with no significant contamination recorded. No Made Ground was recorded in the northeast of the site in the location of the former Ardley Landfill.

Soil Leachate

9.5 Contamination data have been compared to GSAC where the primary receptor is considered to be the underlying Principal Aquifer. The soil leachate screening is presented as **Appendix 6**. The criteria includes reference to UK Drinking Water Standards (DWS), Guidelines for Drinking Water Quality (EQS Freshwater) and World Health Organisation (WHO) health standards (WHO).

9.6 A total of sixteen soil leachate samples were collected from across the site. A summary of the soil leachate screening is presented in **Table 9:1** below.

Table 9:1 Summary of Soil Leachate Chemical Testing Results

Contaminant	No of Samples	Range of Concentrations	Generic Screening level (mg/l)	No of Exceedances
Chromium (III)	16	0.4 to 8.9µg/l	4.7 (EQS)	1 of 16
Nickel	16	2.2 to 28.0µg/l	20 (UK DWS)	1 of 16
Zinc	16	4.2 to 20.0µg/l	12.9 (EQS)	7 of 16

Groundwater

9.7 Contamination data have been compared to GSAC where the primary receptor is considered to be the underlying Principal Aquifer. The groundwater screening is presented as **Appendix 7**. The criteria includes reference to UK Drinking Water Standards (DWS), Guidelines for Drinking Water Quality (EQS Freshwater) and WHO health standards (WHO).

9.8 A total of four groundwater samples were collected from the site on one monitoring occasion. No groundwater samples exceeded the relevant screening criteria.

10. HUMAN HEALTH RISK ASSESSMENT

10.1 Soil contaminant data have been compared against Generic Site Assessment Criteria (GSAC) developed by BWB using the CLEA model 1.06 and the updated CLEA framework (2009) for assessing risk from soil contamination to human health. Details of the derivation of the GSACs are presented in **Appendix 5**. The results of soil screening are presented as **Appendix 4**.

10.2 The GSACs have been developed with the following assumptions which have been changed from the CLEA default parameter set. Soil type is a sandy loam with an organic matter content of 1%. This is considered to be more representative of shallow Made Ground found on most Brownfield sites than the CLEA default of 6% organic matter. The building type for a commercial development is assumed to be a post 1970s office which is representative of new commercial buildings.

Pathways

10.3 Contamination data have been compared to GSAC for a commercial end use based on an organic matter content of 1% in order to be conservative. The site is to be developed for commercial end use and therefore the key receptor is considered to be an adult female worker and GSACs for a commercial industrial end use have been adopted. Exposure pathways considered in this assessment are presented in **Table 10:1.**

Table 10:1 Commercial Exposure Pathways

Source	Shallow Soils		Deep Soils
Pathway	Commercial / Industrial with managed landscaped areas	Commercial / Industrial with Hard standing areas	Commercial / Industrial
Ingestion of Soil	✓	×	×
Ingestion of site derived household dust	✓	×	×
Ingestion of contaminated vegetables	×	×	×
Ingestion of soil attached to vegetables	×	×	×
Dermal contact with Soil	✓	×	×
Dermal contact with site derived household dust	✓	×	×
Inhalation of fugitive soil dust	✓	×	×
Inhalation of fugitive site derived household dust	✓	×	×
Inhalation of vapours outside	✓	✓	✓
Inhalation of vapours inside	✓	✓	✓

Sources

10.4 A summary of the soil concentrations and adopted guideline concentrations are presented within **Appendix 4**. All concentrations are below the adopted guideline

concentrations. The updated environmental risk assessment is presented in **Section 12** with conclusions and recommendations presented in **Section 15**.

11. CONTROLLED WATERS RISK ASSESSMENT

Receptors

11.1 The controlled waters assessment considers the potential impact of onsite contamination to pertinent controlled waters receptors identified at the site including:

- Secondary (A) Aquifer beneath the site within the alluvial superficial deposits;
- Secondary Undifferentiated Aquifer beneath the site within the head superficial deposits;
- Principal Aquifer beneath the site within the White Limestone Formation;
- Principal Aquifer beneath the site within the Forest Marble Formation; and
- Secondary (B) Aquifer beneath the site within the Rutland Formation.

Pathways

11.2 Controlled water risk assessment has been undertaken through assessment of leachable concentrations of contaminants in soil referring to exposure pathways considered and referencing **Table 11:1**.

Table 11:1 Controlled Water Exposure Pathways

Controlled Waters Exposure Pathway	Receptor
Leaching of soil contamination into recharge infiltration	✓
Vertical migration of impacted pore water through unsaturated zone into underlying aquifer	✓
Horizontal migration of groundwater through aquifer to offsite receptors	✓

11.3 The site is generally absent of superficial deposits; however, localised alluvial deposits were encountered at the site (Secondary A Aquifer), underlain by the White Limestone Formation (Principal Aquifer) and localised areas of the Rutland Formation (Secondary B Aquifer). Therefore, given the presence of a Principal Aquifer, it is considered appropriate to adopt the UK Drinking Water Standards (DWS) when assessing groundwater quality and soil leachate concentrations. Where DWS are not available, the environmental quality standards (EQS) and World Health Organisation Standards (WHO) have been adopted as the relevant screening criteria.

Soil Leachability

11.4 A summary of the soil leachate concentrations and adopted guideline concentrations are presented within **Appendix 6**.

11.5 Following a direct comparison of leachate laboratory results to water quality standards, one exceedance of the EQS standard for Chromium III of 4.7µg/l at 8.9µg/l and one exceedance of the UK DWS for Nickel of 20µg/l at 28.0µg/l was recorded in exploratory hole DS116a (0.02m bgl). Made Ground was recorded at 0.0m to 0.05m bgl at this location comprising gravels of limestone with metal artifacts (bolts). These

exceedances are considered to be associated with the presence of metal artifacts within the soil sample, which were not widespread across the site.

11.6 Seven exceedances of the EQS for Zinc (12.9µg/l) was noted in exploratory holes DS114, DS116a, DS117, DS123, TP103, TP107 and TP137 ranging between 13.0µg/l and 20.0µg/l.

11.7 The samples from TP103, TP107, DS114 and DS117 were collected from granular material within the White Limestone Formation, towards the northern and eastern boundaries of the site. The sample from TP137 was collected from cohesive material within the White Limestone Formation, towards the western boundary and centre of the site.

11.8 The sample from DS123 was collected from the topsoil and is located in between the covered reservoir and adjacent Ardley Landfill to the east. The thickness of topsoil (1.0m) was considerably greater at this location compared to the rest of the site.

11.9 The sample from DS116a was collected from the Made Ground at Ashgrove Farm, comprising gravels of limestone with rare iron bolts.

11.10 The zinc exceedances are considered to be localised exceedances in shallow soils of various compositions spread across the site.

Groundwater

11.11 A groundwater concentration screening sheet is presented as **Appendix 7**.

11.12 Following a direct comparison of groundwater laboratory results to water quality standards, no exceedances were recorded.

11.13 Concentrations of pesticides and herbicides were not recorded in soil.

11.14 To date one groundwater monitoring round was completed from four of the installed wells (in the south and east of the site portions of the site only). Further assessment may therefore be required.

11.15 Identified leachable concentrations of Zinc, Chromium III and Nickel were not recorded within groundwater.

12. UPDATED ENVIRONMENTAL RISK ASSESSMENT

Introduction

12.1 The risk posed by any contaminants in soil or groundwater will depend on the nature of the hazard, the probability of exposure, the pathway by which exposure occurs, and the likely effects on the receptors. A contaminant is defined as a substance that has the potential to cause harm, while a risk is considered to exist if such a substance is present in sufficient concentration to cause harm and a pathway exists for a receptor to be exposed to the substance.

12.2 The following sections discuss all the identified potential onsite and offsite sources, pathways, and receptors in the context of the proposed development and plausible pollutant linkages which may represent a risk to identified receptors such as human health and/or controlled waters from the data gained from the desk study. The initial CSM and risk ratings have been updated following the 2021 ground investigation and subsequent risk assessments provided in **Section 10** and **Section 11**. This is presented as **Table 12:1** and further information about the risk classification scheme is included within **Appendix 1**.

Table 12:1 Updated Conceptual Site Model

Source	Pathway	Receptor	Con	Prob	Risk	Discussion
S1: Onsite: Made Ground associated with isolated areas of historical development and field spreading. Potential contaminants may include metals, asbestos and PAHs. .	**P1:** Direct contact, incidental ingestion, and inhalation of particulates.	**R1**: Site users	Mi	Lw	L	Ground investigation identified no exceedances in soils and limited leachate exceedances of metals in relation to controlled waters. Made Ground was limited to a small area in the centre of the site away from site boundaries. Access was limited in several areas of the site due to ecological and access constraints. While no significant contamination has been identified, the presence of unexpected contamination cannot be fully discounted and localised areas may exist in relation to former buildings and structures. Contact with these materials is likely to be limited to areas of landscaping, especially at the proposed conversion of Ashgrove Farm. However, over the majority of the site, the risk will be low as the proposed development will comprise hardstanding and building footprints. Should asbestos be identified during redevelopment works mitigation would typically comprise hand picking and disposal, along with materials management and reuse of Made Ground soils at depth below hardstanding and away from service corridors. Assessment of re-use of soils containing asbestos should be undertaken by a competent person. The exposure to construction workers/services personnel can be mitigated by utilising appropriate PPE and maintaining good hygiene levels, considered to be managed through CDM regulations.
	P2: Inhalation of fugitive dust.	**R2:** Site Neighbours	Md	Ul	L	
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer	Md	Ul	L	
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Md	Ul	L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	Ul	L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
	P6: Direct contact.	**R6:** Water supply pipes	Md	Ul	L	

Source	Pathway	Receptor	Con	Prob	Risk	Discussion
						The site is underlain by high permeability strata. Groundwater flow is calculated to be to the southeast. Leachable concentrations identified in localised soils were not identified in groundwater. No hydrocarbons were encountered during the ground investigation, and it is unlikely that water supply pipes would be impacted.
	P7: Root uptake.	**R7:** Landscape planning	Mr	UI	VL	Made Ground was encountered in limited areas of historical development (as above). Limited exceedances were recorded in soil leachates. Suitability of Made Ground for reuse should be considered and assessment of soils as suitable growth medium should be undertaken in planned landscaped areas. This requirement will be informed by the future landscaped design. Whilst root uptake is possible in areas of landscaping, the plants currently on site did not show any signs of growth issues.
S2: Onsite – Leaking from former and current above and below ground storage tanks and oil storage at Ashgrove Farm. Potential contaminants may include petroleum hydrocarbons and VOCs.	**P1:** Direct contact, incidental ingestion, and inhalation of particulates.	**R1**: Site users	Md	UI	L	Ground investigation identified no exceedances in soils and limited leachate exceedances of metals in relation to controlled waters. Access was limited in several areas of the site due to ecological and access constraints. While no significant contamination has been identified, the presence cannot be fully discounted and localised areas of unexpected contamination may exist in relation to former buildings and structures. No significant vapours detected in historical investigations and most recent investigation.
	P8: Vapour inhalation.	**R2:** Site Neighbours	Md	UI	L	
	P2: Inhalation of fugitive dust.		Md	UI	L	
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer and possible abstractors	Md	UI	L	
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Md	UI	L	

Source	Pathway	Receptor	Con	Prob	Risk	Discussion
		R5: Surface water receptors and possible abstractors	Md	UI	L	The risk of significant generation of dust is likely only during site development process and can therefore be controlled. Mitigation may be required if unexpected contamination is identified. Currently, no redevelopment is proposed at Ashgrove Farm
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	UI	L	
		R5: Surface water receptors and possible abstractors	Md	UI	L	
	P6: Direct contact.	**R6:** Water supply pipes	Md	UI	L	
S3: Onsite – leaking from the transforms in the electrical substation at Ashgrove Farm. Potential contaminants may include PCBs and oils.	**P1:** Direct contact and incidental ingestion.	**R1**: Site users	Md	UI	L	An electrical substation has been present on the site, which has the potential to have leaked. While no significant contamination has been identified, the presence cannot be fully discounted. No PCB testing was completed. However, concentrations of TPH were recorded below detection limits. Additionally, no redevelopment is currently proposed at Ashgrove Farm. Contact with these materials is likely to be limited to localised areas. However, over the majority of the site, the risk is considered to be low. No significant dust generation is not anticipated in this area of the site; however, dust generation should be managed through good practice in this area if required during the redevelopment works. If unexpected contamination is identified, mitigation may comprise small scale excavation, reuse of Made Ground / impacted soils at depth in landscaped areas and possibly small-scale bioremediation or disposal.
	P2: Inhalation and ingestion of fugitive dust.	**R1**: Site users	Md	UI	L	
		R2: Site Neighbours	Md	UI	L	
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer	Md	UI	L	

Source	Pathway	Receptor	Con	Prob	Risk	Discussion
S4: Onsite – ground gases (carbon dioxide and methane) from organic materials in the Made Ground and in natural ground below the site.	**P9:** Migration, build up and asphyxiation.	**R1**: Site users	Sv	Ul	M/L	Made ground was limited across the site and monitoring installs were generally installed in natural deposits. One installation was completed in deeped topsoil in which the gas regime has been assessed as CS2, however, topsoil will be stripped and is not suitable for use beneath buildings. The site has been assessed as CS1 low risk.
	P10: Migration, build up and explosion.	**R1**: Site users	Sv	Ul	M/L	
		R8: Buildings on site	Sv	Ul	M/L	
S5: On site – Asbestos fibres from insulation or ACMs in the buildings.	**P2:** Inhalation of fugitive dust.	**R1**: Site users	Md	Ul	L	Potential Asbestos was noted to be present in buildings (suspected asbestos cement roofs) and structures onsite at Ashgrove Farm. No asbestos was identified in the Made Ground samples collected in this location. However, its is anticipated that no redevelopment will be undertaken within this area with buildings retained as a farm
		R2: Site Neighbours	Md	Ul	L	
S6: On site - Herbicides / pesticides / agrochemicals used historically on farms and stored in storage facilities. Potential contaminants may include pesticides and herbicides.	**P1:** Direct contact, incidental ingestion, and inhalation of particulates.	**R1**: Site users	Mi	Ul	VL	No pesticides or herbicides were recorded during the current ground investigation. In the future development scenario contact with soils is likely in limited areas of landscaping. However, over the majority of the site, the risk will be low as the proposed development will comprise hardstanding and building footprint. The risk of significant generation of dust is likely only during site development process and can therefore be controlled.
	P2: Inhalation of fugitive dust.	**R2:** Site Neighbours	Mi	Ul	VL	
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer and possible abstractors	Mi	Ul	VL	
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Mi	Ul	VL	

Source	Pathway	Receptor	Con	Prob	Risk	Discussion
		R5: Surface water receptors and possible abstractors	Mi	Ul	VL	The site is underlain by high permeability strata and Principal Aquifers. There are no groundwater abstractions within 1km of the site. The topography of the site would cause surface water to run into onsite drainage ditches.
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Mi	Ul	VL	
		R5: Surface water receptors and possible abstractors	Mi	Ul	VL	
S7: Off site - Landfill Made Ground materials present in the historical landfill to the east of the site. Potential contaminants may include metals, asbestos fibres, PAHs and petroleum hydrocarbons, phenols, VOCs and SVOCs.	**P1:** Direct contact, incidental ingestion, and inhalation of particulates.	**R1**: Site users	Md	Lw	M/L	Further assessment of the soils and groundwater in this area cannot be undertaken as ground investigation locations were not advanced within the Ardley Landfill area. Further assessment of this source will be required for the future road/railway corridor works.
	P2: Inhalation of fugitive dust.	**R1**: Site users	Md	Ul	L	
	P3: Vertical migration of contaminants in the soil leachate through the unsaturated zone.	**R3:** Underlying Principal Aquifer	Md	Ul	L	
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Mi	Lw	L	
		R5: Surface water receptors and possible abstractors	Mi	Lw	L	
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Mi	Lw	L	
		R5: Surface water receptors and possible abstractors	Mi	Lw	L	
	P6: Direct contact.	**R6:** Water supply pipes	Md	Ul	L	

Source	Pathway	Receptor	Con	Prob	Risk	Discussion
S7: Off site – ground gases (carbon dioxide and methane) from organic materials from Ardley Landfill to the east of site.	**P9:** Migration, build up and asphyxiation.	**R1**: Site users	Md / Sv	Lw	M	No investigation was undertaken within the Ardley Landfill. Information on the permit surrender, ongoing gassing and the construction of the landfill should be sought prior to ground investigation and gas monitoring in this area. Further gas monitoring is recommended along with a gas assessment during rapidly falling pressure to assess the worst case. Any gas risk is considered to be limited to proposed units 1 to 3.
	P10: Migration, build up and explosion.	**R1**: Site users	Md / Sv	Lw	M	
		R8: Buildings on site	Md / Sv	Lw	M	
S8: Contaminated water associated with Offsite – Former Upper Heyford Airfield as an airbase and leakage from petrol, oil, and lubrication (POL) storage. Potential contaminants may include phenols and petroleum hydrocarbons. PFAS and PFOS.	**P1:** Direct contact and incidental ingestion.	**R1**: Site users	Md	Ul	L	Groundwater flow direction has been calculated to be southeast at the site, and the former airfield is considered to be upgradient. No petroleum hydrocarbons or phenol was recorded at elevated concentrations in groundwater at the site. It is understood that remediation works have been completed at the former airfield and if available these documents should be reviewed. It is recommended that additional groundwater monitoring is completed to confirm the groundwater condition beneath the site. No testing of PFAS / PFOS has been undertaken to date. The adjacent former airfield closed in December 1993. Given the length of time since its closure and the potential limited use of PFAS/PFOS firefighting foam products on the airfield, this contaminant source is not considered further.
	P4: Surface run-off.	**R4:** Aquatic ecosystems	Md	Ul	L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	Ul	L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
S9: Offsite - Landfill Made Ground materials present in the historical landfill	**P4:** Surface run-off.	**R4:** Aquatic ecosystems	Md	Ul	L	Given the landfill is the opposite site of the railway, which is within a deep cutting, plausible linkages are limited to on site receptors. Users of this part of the site are likely to be limited to rail workers, and

Source	Pathway	Receptor	Con	Prob	Risk	Discussion
approximately 10m north of the site. Potential contaminants may include metals, PAHs and petroleum hydrocarbons, phenols, VOCs and SVOCs. Ground gases (carbon dioxide and methane) from organic materials		**R5:** Surface water receptors and possible abstractors	Md	Ul	L	therefore unlikely to encounter the soils. No landscaping likely for this part of the site (railway siding). No exceedances were recorded at elevated concentrations in groundwater at the site. It is recommended that additional groundwater monitoring is completed to cover the whole site. Surface run-off will be limited by the woodland in this area. Confirmation of the construction of the landfill should be sought, it is assumed in this assessment that the landfill is capped.
	P5: Base flow from contaminated groundwater.	**R4:** Aquatic ecosystems	Md	Ul	L	
		R5: Surface water receptors and possible abstractors	Md	Ul	L	
	P9: Migration, build up and asphyxiation.	**R1**: Site users	Md	Ul	L	Given the landfill is the opposite site of the railway, which is within a deep cutting, plausible linkages are limited to on site receptors. Buildings proposed as part of the development are also some distance from the railway. The rating is largely dictated by the severity should significant gas migration occur.
	P10: Migration, build up and explosion.	**R1**: Site users	Md	Ul	L	
		R8: Buildings on site	Md	Ul	L	

VH = Very High, H = High, M = Moderate, M/L = Moderate/Low, L = Low, VL = Very Low

KEY: Sv = Severe, Md = Medium, Mi = Mild, Mr = Minor Hi = High, Li = Likely, Lw = Low Likelihood, Ul = Unlikely

Pollutant Linkage Assessment Summary

When considered in the context of the conceptual site model and the historical activities that have taken place (agricultural land and former landfill), the proposed development is considered to pose a **LOW / MODERATE** risk to human health. It is considered that the main driver for the risk rating for human health is the onsite landfill, which requires further investigation.

The risk posed to controlled waters is predominantly considered to be **LOW / MODERATE** due to sensitivity of the aquifer and potential contamination associated with onsite sources in particular the onsite landfill.

It is recommended that additional gas and groundwater monitoring take place along the northern and eastern boundaries of the site to further quantify the identified pollutant linkages and assess likely mitigation measures.

Uncertainty

Source	Pathway	Receptor	Con	Prob	Risk	Discussion
Ecological and access constraints. No investigation of the Ardley Landfill in the northeast of the site. Confirmation of landfill construction to assess the risk of onsite migration from the well installations.						

13. ENVIRONMENT LIABILITY ASSESSMENT AND DEVELOPMENT CONSTRAINTS

Statutory Liability

13.1 Given the history of the site as predominately agricultural land, it is considered unlikely that the site would be classified as Contaminated Land under Part2A of the EPA 1990. It is recommended that the red line boundary in the northeast of the site is confirmed due to the presence of Ardley Landfill. It is also recommended that the licence surrender for Ardley Landfill is confirmed.

13.2 Under statutory guidance for definition of contaminated land site may be classified into 4 categories: Categories 1 and 2 would meet the definition of contaminated land and categories 3 and 4 would not meet the definition. Sites assessed under planning would normally be expected to fall within Category 4 as a minimum standard, to allow for a suitable factor of safety should standards change in the future.

13.3 It is considered that the site would fall within Category 4 following the completion of additional investigation based on the majority of the site classified as low risk, with further investigation recommended in areas of moderate risk or above.

13.4 The contaminated land regime has implications for those who cause or knowingly permit land to be contaminated, or who own or occupy land that is contaminated. Contaminated land is defined in Section 78A(2) of Part IIA of the Environmental Protection Act 1990 as:

a) *Significant harm is being caused or there is a significant possibility of such harm being caused; or*
b) *Pollution of controlled waters is being or is likely to be, caused*."

13.5 Harm is defined in Section 78A(4) of the Environmental Protection Act 1990 as:

13.6 "Harm to the health of living organisms or other interference with ecological systems of which them form part and, in the case of man, includes harm to property."

13.7 Once an area of land has been identified as contaminated land, appropriate persons will be identified as being responsible for the cost of cleaning up the land by the enforcing authority. The appropriate person will be liable for all or part of the remediation of the land. Two classes of appropriate person have been identified:

- Class A appropriate persons are those who cause or knowingly permit the pollutants to be in, on or under the land.
- Class B appropriate persons are the owners(s) or occupier(s) of the land.

13.8 Where no Class A appropriate persons can be identified, then Class B appropriate persons may become liable.

13.9 Based on the information available regarding the site, the potential for Statutory Authority action based on "*pollution of controlled water*" or "*significant harm*" as

defined by Part IIA of the Environmental Protection Act 1990 is considered to be unlikely based on the following findings: minimal exceedances in controlled waters and no identified sources, and no exceedances of the human health risk assessment. The remaining risks are associated with the landfill to the east which may form a small part of the proposed relief road alignment, which requires further assessment.

Third Party Liability

13.10 Based on the information contained in this report, it is the opinion of BWB that the potential for legal action by surrounding landowners, based on the potential for contamination to migrate offsite, is considered to be unlikely when considering the former land uses of the surrounding area which includes a former airfield with tank storage and infrastructure and several quarry and landfilling operations in the vicinity of the site. It is understood that remediation works have taken place at the former airfield to the northwest of the site, and that suitable capping and/or leachate collection systems are in place at the landfills.

Public Relations

13.11 Limited elevated concentrations were recorded in soil leachate samples; however, no exceedances were recorded in soil samples and limited exceedances in groundwater.

13.12 The proposed development is considered to be of low to moderate sensitivity (commercial end use). There are several small towns in the vicinity of the site (Upper Heyford, Fewcott, Ardley and Middleton Stoney), along with several farms (Dewars Farm and Manor Farm). Other surrounding land uses include a waste treatment facility, quarry, and energy recovery facility.

13.13 The effect of noise, vibration, dust, and odour should be considered throughout the redevelopment works in consideration of the residential properties in the vicinity of the site. Additional vibration monitoring may be required along the northern boundary of the site along the railway, dependent on consultation with the local railway network. Controls during rock excavation will also need to be considered. These factors should be outlined and monitored through the development Environmental Management Plan. Additional measure for odours and dust may be required during works on former landfill sites, these shall be further assessed following completion of ground investigation in this area.

Development Implications

13.14 Some areas of the site are likely to have permanent cut into the groundwater table notably at the rear of Units 5, 6 and 12 and possibly around the rail freight terminal, which will likely need a permanent drainage solution to manage groundwater. This is expected to be achieved by appropriate drainage design rather than requirement for permanent mechanical groundwater management. Once design proposals are nearing finalisation, a specialist hydrogeologist should be consulted to ensure the drainage design appropriately manages groundwater. Any designs around the rail freight terminal will need to consider any similar mitigation / drainage the in place for the existing railway

13.15 Further, information surrounding the construction of the adjacent landfills should be sought in order to support the preliminary gas risk assessment outlined in this report. Further implications to the redevelopment works in the landfill area are to be defined following the completion of ground investigation works along proposed road alignments, which are to be completed and reported under separate cover.

13.16 Limited leachable concentrations of metals were identified in shallow soils in localised areas of the site. In line with best practise, consideration should be made for appropriate drainage during the redevelopment works so not to negatively impact the physical and chemical quality of the surface water courses. This should be managed through measures outlined and implemented in the development's environmental management plan.

13.17 Whilst limited contamination was identified, protection of drainage systems and surface water courses should be undertaken during the redevelopment works to protect against silting during the works.

13.18 An ammonia tank was identified during site walkover which is noted to be in a visually poor condition. Appropriate decommissioning, removal and disposal of this tank and other chemical storage / tanks should be undertaken in-line with industry best practise.

13.19 The presence along the field boundaries of badgers and newts provided constraints to ground investigation works. Similar constraints should be considered during programming and design of the development. Ecological constraints are understood to be addressed under separate cover.

13.20 No access was available to the composting facility at the time of the ground investigation. Liaison with the operator shall be required during development works in line with CDM regulations.

13.21 In areas of proposed soft landscaping, a suitable growth medium is required though existing topsoil may be suitable subject to approval by the landscape architect.

13.22 A Radiological Assessment has been procured for the site. The report produced by Zetica concludes that no evidence has been found to indicate the presence of a radiological or other nonconventional contaminant hazard on the site. The report has been included as **Appendix 9**.

13.23 1st Line Defence has assessed that the risk from items of UXO is not considered to be homogenous across the site. There is an assessed Medium Risk from items of German aerial delivered UXO, items of anti-aircraft UXO and items of Allied UXO within the north-western section of the site. Whereas there is an assessed Low Risk from items of German aerial delivered UXO, items of anti-aircraft UXO and items of Allied UXO across the remainder of the site. A risk map is presented in Annex P of the report which is presented as **Appendix 10**. The recommended mitigation measures comprise ins all Areas of the Site:

- Site Specific Unexploded Ordnance Awareness Briefings – a service recommended to all personnel conducting intrusive works.
- UXO Risk Management Plan.

13.24 In Medium Risk Areas of the site:

- Non-Intrusive UXO Magnetometer Survey and Target Investigation (where appropriate).
- Unexploded Ordnance Specialist - a service to support open intrusive works.
- Intrusive Magnetometer Survey – a service to support any borehole or pile locations/clusters down to an assessed maximum bomb penetration depth.

14. WASTE MANAGEMENT

Waste Classification

14.1 Soil samples have been characterised against hazardous waste criteria using Hazwasteonline. The results of the waste classification are presented in **Appendix 8**. The assessment indicates that the soils analysed are likely to be classified as non-hazardous. The waste classification assessment only applies to those soils that have been tested. If other soils are to be disposed of offsite, then further analysis may be required.

14.2 Asbestos has not been found at the site. The presence of visible asbestos containing materials in waste or at concentrations exceeding 0.1% by weight will classify the waste as mixed and require disposal as hazardous waste irrespective of the chemical properties of the waste.

14.3 Should any soils require disposal offsite an assessment of waste classification of the soils for disposal should be made by a competent person. Further chemical analysis may be required to fully characterise waste soils for disposal to landfill or re-use offsite. WAC analysis would be required for disposal of soils as inert or hazardous.

15. CONCLUSION AND RECOMMENDATIONS

Conclusions

15.1 Ground Conditions at the site typically comprised Topsoil (typically to between 0.20m and 0.4m), over weathered deposits of the White Limestone Formation (typically cohesive deposits of firm to stiff brown sandy gravelly clay underlain by typically very dense grey sandy gravel of limestone) with competent White Limestone Formation bedrock typically encountered from between 0.5 and 1.5m bgl. Alluvial deposits were localised along the brook in the central valley bottom comprising of sand and gravel and clay and proven to 2.4m bgl.

15.2 Resting groundwater levels were typically encountered between 2.62m bgl and 5.9m bgl in deeper strata. Perched groundwater was also encountered within shallow cohesive deposits.

Environmental

15.3 Soil concentrations in excess of the applied Human Health screening criteria were not identified. Areas of the site remain as un-investigated and potential for localised unidentified contamination remains, notably the soil treatment facility.

15.4 Leachable concentrations of Chromium III and Nickel above the applied water quality standards were identified in one location, considered to be associated with metal artifacts identified within the shallow soil. Leachable Zinc concentrations above the applied water quality standard were identified in various shallow soil units across the site. Concentrations were of the same order of magnitude as the applied criteria with no concentrations identified within the groundwaters beneath the site. As such no active linkage has been identified and leachable soil concentration are not considered to represent a risk to the controlled water receptors identified.

15.5 Significant thicknesses of Made Ground and naturally occurring organic soils were generally not identified across the site. It is noted that the investigation did not include the area of landfill that encroaches into the redline boundary, however gas monitoring wells were installed within the vicinity. An initial assessment of the ground gas regime (four monitoring events over a one-month period) identified a worst-case characteristic situation of CS2 at one location located on the eastern boundary of the site with a response within Topsoil which is likely to be the source of the site. A request for additional information regarding Ardley Landfill has been submitted and information is awaited. At this stage, the majority of the site is considered to have been appropriately assessed and no gas protection measures are required (CS1). Units 1 to 3 in the east of the site may be

Geotechnical

15.6 A large earthworks operation will be required at the site to create level development plateaus. Most units will be located on plateaus with a portion of cut and fill required on each plot. Currently, only Units 10, 11 and 12 are placed wholly in cut.

15.7 Given the shallow bedrock, breaking out competent rock will create a significant constraint at the site. The rock will need to be removed by ripping and/or blasting (drill and blast). Volumes and extraction methods will need consideration and it is likely that specific additional ground investigation will be required in the areas of greatest cut to finalise that best method(s).

15.8 Based on the proposed earthworks strategy, assuming that material is placed to a suitable specification then shallow footings and ground bearing floor slabs are expected to be suitable for the proposed development. Due to many of the units being placed on a combination of cut (into solid limestone bedrock) and fill (excavated soils and/or rock), there is the potential for differential settlement issues arising. On this basis, the fill will need to be placed to a controlled specification to avoid differential settlement issues.

15.9 Some areas of the site are likely to have permanent cut into the groundwater table notably at the rear of Units 5, 6 and 12 and at the Rail Freight Terminal, which will likely need a permanent drainage solution to manage groundwater. This is expected to be achieved by appropriate drainage design rather than requirement for permanent mechanical groundwater management.

15.10 Cut and fill slopes will need to be suitably designed to achieve global stability and ensure health and safety of any workers and the public is ensured.

Recommendations

Environmental

15.11 Various lines of inquiry are pending and so this report will need to be updated in due course. Additional groundwater and surface water sampling and chemical analysis is in progress to clarify the wider groundwater and surface water condition particularly ground and surface water potentially originating from the Heyford Airfield.

15.12 The risk to Units 1 to 3 from ground gas migration from Ardley Landfill is currently unclear. A data request with the Environment Agency is currently pending which may provide much more clarify on the plausible ground gas source and risk ground gases may present to the site. Additional gas monitoring and/or well points may be recommended following this review if a plausible risk remains. Monitoring should be undertaken during a period of rapidly falling pressure to represent the worst case.

15.13 Whilst limited contamination was identified, protection of drainage systems and surface water courses should be undertaken during the redevelopment works to protect against silting during the works.

15.14 It is understood that Ashgrove Farm is to be retained. However, should it be redeveloped, prior to the demolition of existing structures, a pre-demolition asbestos survey should be undertaken, with asbestos removal undertaken prior to demolition. Limited investigation has also been undertaken in and around this area to identify prevailing ground conditions. Additional ground investigation would be required to clarify contamination around the identified point features if it was to be redeveloped.

15.15 Ground investigation to assess the contamination status of the soil treatment facility would be required to both inform planning for development and to facilitate licence surrender.

15.16 A discovery strategy should be put in place for redevelopment works should unexpected contamination be identified.

15.17 Once the final levels are confirmed and the cut and fill requirements are understood. Consideration of the requirement for materials management is recommended.

15.18 Prior to offsite disposal of soils, waste classification of soils should be undertaken by a competent person. WAC testing will likely be required.

15.19 Ground Investigation works reported within this report covers the main redevelopment site. Investigation within the wider redline boundary is recommended to identify risks associated with potential sources identified within and in the vicinity of these areas.

Geotechnical

15.20 Liaison with Network Rail will be required to manage geotechnical risk on the interfaces with Network Rail infrastructure including the new bypass and construction of the Rail Freight Port.

15.21 Prior to development, once the Masterplan is progressed, detailed geotechnical assessment will be required to manage geotechnical risks on the project including rock excavation, potential differential and total settlement issues, foundation solutions, retaining structures and slope stability. Further ground investigation will be required to inform detailed design including testing for earthworks design, detail rock quality and fracturing information to inform exaction techniques, and monitoring wells to assess hydrogeological interaction. Further ground investigation may also be required to inform slope stability and retaining structure design.

15.22 Once design proposals are nearing finalisation, a specialist hydrogeologist should be consulted to ensure the drainage design appropriately manages groundwater, and the interaction between surface water and groundwater is understood and suitably dealt with.

16. REFERENCES

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5. British Standards Institution, (BSI), BS EN 1997-2:2007 Incorporating corrigendum June 2010, Eurocode 7 – Geotechnical Design – Part 2: Ground Investigation and testing.

6. Building Research Establishment Special Digest 1 *Third Edition*. Concrete in Aggressive Ground (2005)

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8. Department for Communities and Local Government (DCLG), 2021, National Planning Policy Framework.

9. Department for Environment Food and Rural Affairs (DEFRA), 2012, Environmental Protection Act 1990: Part 2A Contaminated Land Statutory Guidance.

10. Environment Agency report Land Contamination Risk Management, 2020.

11. Environment Agency 2008, Updated technical background to the CLEA model Science Report – SC050021/SR3

12. Environment Agency 2009, CLEA Software (Version 1.05) Handbook Better Regulation Science Programme Science report: SC050021/SR4

13. Environment Agency 2008, A review of body weight and height data used within the Contaminated Land Exposure Assessment model (CLEA) Project SC050021/ Technical Review 1

14. European Environment Agency, 2021. Water Framework Directive 2nd River Basin Management Plans. Available from: https://www.eea.europa.eu/data-and-maps/explore-interactive-maps/water-framework-directive-2nd-rbmp

15. Health and Safety Executive (HSE) 'Protection of workers and the general public during the Development of Contaminated Land (1991).

DRAWINGS

Drawing 1: Masterplan

TO BANBURY

A43 Baynard's Green ro
as part of Oxfordshire H
Growth Deal improveme
(delivered by Highways

Bridge crossing of link roads

A43 southbound to M40 southbound free flow link road (new J10A)

A43 northbound realigned to allow it to cross southbound free flow link

Bridge over southbound exit slip

Improvements to Padbury Roundabout as part of Oxfordshire Housing Growth Deal improvement (delivered by Highways England)

J10A southbound merge uses redundant carriageway

Alterations to MSA exit to direct traffic to new south slip road

Existing J10 southbound

Existing J10 southbound entry slip amended so nose length is compliant to current standards

Existing J10 northbound exit slip stopped up

Access to severed land via new field access from link road or roundabouts

New bridge over M40 for new J10 south facing slip

Existing B430 stopped up south of Ardley

Ardley bypass and OxSRFI link road

J10 south facing slips relocated

Principal OxSRFI access

Bridge over Chiltern Mainline

Roundabout on existing B430

OxSRFI access for buses, emergency vehicles and pedestrians/cyclists

Link to Heyford Park via Camp Road

Heyford Park Link Road northern option

Middleton Stoney relief road, central option

Combined Heyford Park Link Road and Middleton Stoney relief road

Middleton Stoney relief road, south option

Middleton Road realigned

Drawing 2: Earthworks Strategy

Notes: DO NOT SCALE DRAWING.

Dimensions provided are indicative only, and should be confirmed and read in conjunction with the Architect's construction drawings at such times as they are available, and/or from site measurement.
All setting out to be in accordance with the Architect's drawings, any ambiguities to be raised prior to construction.

RESIDUAL RISK REGISTER

No.	Description of Hazard	Control Measures	Action By
-	Standard construction	-	-

PRELIMINARY

P12 AM	Minor amendments, more etl added to sections	19.07.21
P11 AM	Cut/Fill balanced, Latest Parameter/ MSA layout added and bunding/retaining amended/added	17.07.21
P10 AM	Amended to suit latest layout and comments	09.07.21
P9 AM	Rhines/pond/retained existing landscape coloured and 'cut' contours colour amended	02.07.21
P8 AM	Plateaus amended	11.05.21
P7 AM	Levels and bunds amended to suit meeting comments	26.10.20
P6 AM	Detailed topo and additional ponds/landscaping included	15.07.20
P5 AM	Amended to suit discussions with FPCR	29.04.20
P4 AM	Rail and zones A1-A2 & B1 amended, site C/F balanced and x-sec's	29.04.20
P3 AM	Zone B1 lowered to suit rail. Other plateaus amended to balance C/F	03.04.20
P2 AM	Plateau's amended	31.03.20
P1 AM	Preliminary Issue	27.03.20
Rev By	Details	Date

(P=Preliminary, T=Tender, C=Construction, R=Record)

Client: *Cuvette/Mountpark*

Project: *Ardley, Oxfordshire*

Drawing Title: *Preliminary Earthworks*

Primary "CUT" contour
Secondary "CUT" contour
Zero "CUT/FILL" contour
Secondary "FILL" contour
Primary "FILL" contour

NOTE
The proposed FFL's are subject to final cut and fill design/construction depths and could be raised or lowered by 500mm at final design stage

Tender Issue - SK 0001 Revision P12 - PDS Model K - Topo Rev 3 (-200mm)

	Cons Depth	Cut	Fill	E/O Cut	E/O Fill
	0mm	3447113.1	3633713.3		186600.2
Proposed Plateaus/Bunds					
Attenuation	130,000m³	130000.0		130000.0	
Total Cut/Fill		3577113.1	3633713.3		
Extra Over Cut/Fill				130000.0	186600.2
Site Total import (to be 0m³ export at detailed design)				=	56600.2

No volumes for drainage and foundation excavations have been taken into account at this stage. Further additional topo information is required in future for more detailed Cut/Fill calculations

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Date: Mar 20
Scale: 1:2,500 @ A0
Drawn: AM
Chkd:

Drawing No. 19-7709-SK 0001

Issue Rev. P 12

Drawing 3: Proposed Finished Floor Levels

Notes:

DO NOT SCALE DRAWING.

Dimensions provided are indicative only, and should be confirmed and read in conjunction with the Architect's construction drawings at such times as they are available, and/or from site measurement.
All setting out to be in accordance with the Architect's drawings, any ambiguities to be raised prior to construction.

RESIDUAL RISK REGISTER

No.	Description of Hazard	Control Measures	Action By
-	Standard construction	-	-

Zone A3
Plateau 117.075m
FFL 117.575m
488,900m²

Zone A4
Plateau 114.075m
FFL 114.575m
inc A2 - 359,490m²

Zone A2
Plateau 114.075m
FFL 114.575m
inc A4 - 359,490m²

Zone A1a
Plateau 110.825m
FFL 111.325m
209,280m²

Zone A1b
Plateau 112.075m
FFL 112.575m
169,845m²

Zone B
Plateau 114.075m
FFL 114.575m
58,170m²

Zone C
Plateau 111.345m
Rail by Others

Waste Facility
Ex GL 110.500m
31,500m²

Road and existing wood land to remain at existing levels

UNIT 1
UNIT 2
UNIT 3
UNIT 4
UNIT 5
UNIT 6
UNIT 7
UNIT 8
UNIT 9
UNIT 10
UNIT 11
UNIT 12

INTERMODAL RAIL TERMINAL

Access Road
Tie In Level 116.110m
Waste 111.000m
Length 195m
Gradient 1:40

Access Road
Tie In Level 116.110m
Island 112.000m
Length 225m
Gradient 1:55

Access Road
Island 112.000m
Ex Landscape 105.000m
Length 310m
Gradient 1:45

Access Road
Ex Landscape 105.300m
Ex Landscape 109.200m
Length 400m
Gradient 1:40 - Flat

Access Road
Ex Landscape 108.200m
Island Tie in 106.000m
Length 360m
Gradient 1:160 - Flat

Unit Access
Plateau Level 117.075m
Road Level 113.100m
Access Length 175m
Gradient 1:45

Unit Access
Plateau Level 117.075m
Road Level 114.400m
Access Length 110m
Gradient 1:40

Unit Access
Plateau Level 117.075m
Road Level 114.400m
Access Length 90m
Gradient 1:35

Unit Access
Plateau Level 114.075m
Road Level 114.400m
Access Length 120m
Gradient Flat

Unit Access
Plateau Level 114.075m
Road Level 114.400m
Access Length 140m
Gradient Flat

Unit Access
Plateau Level 110.825m
Road Level 113.100m
Access Length 110m
Gradient 1:50

Unit Access
Plateau Level 111.345m
Road Level 113.900m
Access Length 100m
Gradient 1:40

Unit Access
Plateau Level 111.800m
Road Level 114.500m
amend to 113.6m
Access Length 60m
Gradient 1:22
amend to 1:30

Unit Access
Plateau Level 114.075m
Road Level 114.500m
Access Length 65m
Gradient Flat

Unit Access
Ste Island 113.900m
B430 Island 118.900m
Access Length 400m
Gradient 1:80

PRELIMINARY

Rev	By	Details	Date
P2	AM	Minor amendments, more etl added to sections	19.07.21
P1	AM	Preliminary Issue	17.07.21

(P=Preliminary, T=Tender, C=Construction, R=Record)

Client:
Cuvette/Mountpark

Project:
Ardley, Oxfordshire

Drawing Title:
Site Levels

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Date: July 21
Scale: 1:2,500 @ A0
Drawn: AM
Chkd:

Drawing No.
19-7709-SK 0003

Issue Rev.
P 2

Drawing 4: Exploratory Hole Location Plan