Phase II Geo-environmental Report

Project: Green Lane
Chesterton

Client: Wates Developments

Reference: C86354-JNP-XX-XX-RP-G-1004 P02

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FOR AND ON BEHALF OF JNP GROUP

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Contents

EXECUTIVE SUMMARY

Site location	Land South of Green Lane, Chesterton OX26 1DF	
Development scheme	Residential development on greenfield site.	
NGR	455701 220981	
Current use	Fields	Off-site: Residential, school, fields, sports ground.
Geology (from GI)	< 0.70 m of made ground (limited to DS2 and DS6 in the north-east of the site) and topsoil was found to be underlain by both granular and cohesive **Superficial Deposit**s in the west of the site. In the remainder of the site, where superficial deposits were not encountered, the **Cornbrash Formation** was encountered, this consisted of sandy silts and clays, in addition to silty clayey gravel, overlying limestone. The Kellaways Clay Member was only encountered in the south-east of the site.	
Groundwater	**Shallow groundwater** was encountered in the Cornbrash Formation during the intrusive investigation and subsequent monitoring period between 0.58 – 1.80 m bgl. **Prudent to allow for groundwater control** measures during construction particularly during wet periods.	
Foundation design	**Traditional foundations feasible** at a minimum depth of 0.90 m in the Superficial Deposits or Weathered Cornbrash Formation, depths and heave precautions are subject to tree influence for clays of medium volume change potential. Design Sulphate Class of DS5, with an ACEC of AC-5 in the Kellaways Clay Member. (outside proposed area of construction) A Design Sulphate Class of **DS1, with an ACEC of AC-1 i**n the Weathered Cornbrash Formation and made ground.	
Road construction	A **CBR of 4%** is anticipated in the Weathered Cornbrash Formation.	
Contamination	**No risk to human health** as no contaminants identified above screening values. Watching brief recommended during site clearance works for unanticipated areas of contamination.	
Ground gas	Characteristic situation 1 / Green – **no gas protection measures required** (slightly elevated CO_2). No radon protection measures required.	

1 INTRODUCTION

1.1 General

1.1.1 JNP Group was instructed by Wates Developments to undertake a ground investigation of:

Land South of Green Lane

Chesterton

OX26 1DF

hereinafter referred to as 'the site'. This report is subject to the limitations presented in Appendix A:.

1.1.2 It is understood that the site will be subject to residential development and includes residential development across the north and west of the site, with sports facilities and recreation space in the east of the site and public open space and attenuation basins in the south-west. The latest proposed redevelopment layout (reference Allen Pyke Drawing 2903-LA-02, dated April 2022) is included in Appendix B:.

1.1.3 All comments given are based on the understanding that the proposed redevelopment will be as detailed above.

1.2 Objectives

1.2.1 The purpose of the investigation was to determine the geotechnical and geo-environmental ground conditions at the site and assess the implications of such relative to the proposed residential redevelopment. The scope of work comprised investigation, laboratory testing, and gas and groundwater level monitoring. This report contains details of the site, the work and laboratory testing undertaken, strata encountered, geotechnical and chemical laboratory test results, monitoring results, and provides an interpretative assessment of the ground conditions with regard to geotechnical and contaminated land issues.

1.2.2 This report has been produced in support of an outline planning application for the aforementioned development.

1.3 Methodology

1.3.1 This report has been compiled in accordance with the on-line Land contamination: risk management (LCRM) guidance produced by the Environment Agency (June 2019). This can be found on the UK government website: https://www.gov.uk/guidance/land-contamination-how-to-manage-the-risks.

1.3.2 With regard to geotechnical aspects, reference is also made to the requirements of BS EN 1997, Eurocode 7, Geotechnical Design, and associated standards.

1.3.3 This report should be read in conjunction with the following JNP Group Report:

- C86453-JNP-XX-XX-RP-G-1001. Desk Study, dated December 2021.

2 SITE DESCRIPTION

2.1.1 The site is located off Green Lane, in Chesterton, Oxfordshire approximately 3 km south-west of Bicester town centre (see Figure 1 Key Plan). The centre of the site is located at National Grid Reference SP 5570 2098. The site covers an area of approximately 14.8 hectares.

2.1.2 A site walkover was undertaken by JNP Group on 8th December 2021. Photographs of the site are included within Appendix C.

2.1.3 The site comprises two open fields. The western field is the larger field and measures 10.8 hectares, with dimensions of 425 m north to south and 390 m from east to west. The field is approximately pentagonal in shape and slopes gently to the south from a high point at the north of 74.4 m Above Ordnance Datum (AOD) to a level of 71.2 m AOD in the southern corner. A shallow ridge, up to 0.50 m in height crosses the field in an approximate north to south direction.

2.1.4 The western field is a cropped field. The site walkover was undertaken following a period of heavy rain and the ground surface was generally dry in the centre and north of the field. However, it was very wet and muddy, with some standing water present, in the south-eastern and south-western corners. These areas became drier during the monitoring period.

2.1.5 The topsoil within the field comprises a mid brown clay with abundant limestone fragments in areas in the north-east and north-west. Within the south of the field, and on the ridge feature, the topsoil was darker, and more clayey, with little to no limestone fragments.

2.1.6 The eastern field is triangular in shape and measures 3.9 hectares, with maximum dimensions of 260 m from north to south and 330 m from east to west. The field slopes gently to the south from 73.5 m AOD in the north, to 71.3 m AOD at the southern corner. A shallow depression of no more than 0.3 m depth is present in the central western part of the eastern field.

2.1.7 The eastern field is covered with long grass and weeds. Taller scrub vegetation is present in the north-western corner of the field. Where the soil was visible, a few limestone fragments were visible, and the surface was generally firm.

2.1.8 The site's boundaries are generally demarcated with post-and-wire- fencing and hedges, with some semi-mature and mature trees. However, the boundary of the northern side of the eastern field is demarcated by fencing only. A similar fence and hedge boundary is present between the east and west fields. Stands of mature trees are located at the eastern, southern and south-western corners of the site.

2.1.9 Drainage ditches are present along the south-eastern and south-western boundaries of the eastern field and along the western half of the southern boundary of the western field. The ditch along the south-western boundary of the eastern field contained water. This ditch continued off-site to the south-east. A section of ditch at the far south-western corner of the west field contained water, which continues off-site to the south. The remaining ditches were dry.

2.1.10 No structures or hardstanding are present on the site.

2.1.11 The surrounding land uses are summarised in Table 2.1 that follows.

Table 2.1 Surrounding Land Use

Direction	Land Use
North	Residential, open land, playing field
East	Fields
South	Fields
West	Fields, sports pitches

2.1.12 Reference should be made to JNP Group Drawing No. C86354-JNP-XX-XX-SK-7001 for full details of the site features and setting at the time of inspection.

3 UK CONTAMINATED LAND LEGISLATIVE FRAMEWORK

3.1 General

3.1.1 Given that the site is being assessed with the potential for future development, the most applicable appraisal relates to the requirements of the Planning Regime as described in the National Planning Policy Framework.

3.1.2 In order to proceed with an assessment of contamination issues it is essential that there is compliance with UK guidance as detailed in the on-line Land contamination: risk management (LCRM) guidance produced by the Environment Agency (June 2019). This can be found on the UK government website: https://www.gov.uk/guidance/land-contamination-how-to-manage-the-risks.

3.1.3 Part IIA of the Environmental Protection Act, 1990, which was enacted by Section 57 of the Environment Act 1995, and the associated Contaminated Land (England) Regulations 2000 (SI 2000/227), was introduced on 1 April 2000. It created a new statutory regime for the identification and remediation of land where contamination poses an unacceptable risk to human health and the environment. The guidance was subject to a review by DEFRA in 2012, and a revision was published.

3.1.4 Part IIA provides a statutory definition of contaminated land:

3.1.5 *"any land which appears to the Local Authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land, that significant harm is being caused, or that there is a significant possibility of significant harm being caused, or that pollution of controlled waters is being or is likely to be caused".*

3.1.6 Controlled waters are considered to be all groundwaters, inland surface waters, and estuarine and coastal waters.

3.1.7 To determine whether land falls under the Part IIA definition of contaminated land, the site should be evaluated in the context of a risk-based framework. The assessment of contaminated land is typically a two-phase process, which is initially based on a qualitative assessment of the likelihood of complete pollution linkages, with a quantitative element that seeks to determine the degree and the significance of the harm. Land is only defined as 'Contaminated Land' if a "significant pollutant linkage" is present.

3.1.8 A pollutant linkage must comprise the following:

Source *- a contaminant at a concentration capable of causing adverse health or environmental effects.*

Receptor *- there must be a receptor (e.g. human, controlled waters, ecological, or property) present, which may be at risk of harm or impact from the source.*

Pathway *- there must be an exposure pathway through which the receptor comes into contact with the contamination source.*

3.1.9 Each of these elements can exist independently, but they create risk only when they are linked together, so that a particular contaminant affects a particular receptor, through a particular pathway.

3.1.10 The responsible authority then needs to consider whether the identified pollution linkage:

- is resulting in significant harm being caused to the receptor in the pollutant linkage;

- presents a significant possibility of significant harm being caused to that receptor;
- is resulting in the pollution of controlled waters, which constitute the receptor; or is likely to result in such pollution.

3.1.11 If a pollutant linkage is demonstrated, then the Part IIA legislation provides powers for remedial action to be enforced by the Local Authority in whose area the contaminated land is situated.

3.1.12 In addition, JNP Group has undertaken a preliminary risk assessment based on the probability of receptor exposure to the identified source and the consequences of such exposure.

3.1.13 Risk management, which can include site surfacing, formal management systems, legal requirements; is then considered to provide an overall residual risk. The categories of environmental risk used by JNP Group are given in the table that follows.

Table 3.1 Risk Matrix

Environmental Risks		
HIGH		Issues within this category likely to provide a significant cost or liability. Further detailed investigation may be required to clarify the risk.
MEDIUM		It is possible that issues within this category may provide a cost or liability. Further investigation may be required to clarify the risk.
LOW		It is unlikely that issues within this category will provide a significant cost or liability. Basic investigation may be required to clarify the risk.
NONE		No source – pathway – receptor linkage present.

4 CONCEPTUAL SITE MODEL AND PRELIMINARY RISK ASSESSMENT

4.1 General

4.1.1 This section uses information from field observations and all the data sources presented herein to provide a conceptual model and qualitative assessment of the potential risks posed to human health and environmental receptors from potential on-site and off-site sources of contamination. The assessment is presented as a 'source-pathway-receptor' model in accordance with Part IIA of the Environmental Protection Act 1990.

4.1.2 The conceptual site model has been developed assuming that the site will be redeveloped for residential housing with private gardens.

4.2 Potential Sources of Contamination

4.2.1 Potential On-Site Sources of Contamination

- A small, backfilled pit is present within the eastern field. The pit was backfilled prior to 1900. Made ground within this pit is considered a potential source of metals and hydrocarbons.
- If the area was backfilled or partially backfilled with material, JNP Group consider that material used would have most likely to have been inert, with a low organic content, such as recycled soils, or rubble rather than domestic waste, chemical or industrial waste.
- Based upon guidance given in CL:AIRE research bulletin RB17 (CL:AIRE 2012), as likely depth of the infilled ground is unlikely to be greater than 5.00 m, and the soil atmosphere is likely to be aerobic and of small area, the former pit is unlikely to generate significant volumes of ground gas. RB17 indicates that even where ground gas is present from made ground and recycled soils, it generally does not pose a risk. In addition, RB17 indicates that based upon available case studies, sites where fill is > 30 years old, the gassing regime results in a characteristic situation 1 classification, where gas protection measures are not required. The backfill is anticipated to be at least 100 years in age.

4.2.2 Potential Off-Site Sources of Contamination

- There are no potential off-site sources of soil or groundwater contamination that could impact on ground conditions at the site. The site is surrounded by residential properties and their associated gardens and fields.
- The former quarry located 15 m from the site - from the historical maps, this was denoted in 1887 but was no longer denoted by 1895. Based on the local geology, it is considered likely that the quarry was to extract the Cornbrash limestone There is also no evidence of how deep the pit might have extended. However, as it is a historical surface ground working JNP Group consider it likely to have been shallow (less than 5 m below ground level).
- If the area was backfilled or partially backfilled with material, JNP Group consider that material used would have most likely to have been inert, with a low organic content, such as recycled soils, or rubble rather than domestic waste, chemical or industrial waste.

- Based upon guidance given in CL:AIRE research bulletin RB17 (CL:AIRE 2012), as likely depth of the infilled ground is unlikely to be greater than 5 m, and the soil atmosphere is likely to be aerobic and of small area, the former pit is unlikely to generate significant volumes of ground gas. RB17 indicates that even where ground gas is present from made ground and recycled soils, it generally does not pose a risk. In addition, RB17 indicates that based upon available case studies, sites where fill is > 30 years old, the gassing regime results in a characteristic situation 1 classification, where gas protection measures are not required.

4.3 Receptors

4.3.1 The site is to be redeveloped for residential housing with private gardens. In addition, the site overlies a Secondary-A Aquifer (River Terrace Deposits, Cornbrash and Forest Marble) and is has ditches that connect to controlled surface waters. The primary receptors, considered to be potentially at risk from any identified contamination are as follows:

Human Health

- Construction workers during the redevelopment phase;
- Residential end users.

Controlled Waters

- The River Terrace Deposits, Cornbrash and Forest Marble beneath the site are classified as Secondary-A Aquifers. JNP Group therefore considers groundwater to be a sensitive receptor;
- The nearest controlled surface water is 2 m to the west of the site, and drainage ditches on-site connect to surface controlled water features. Hence, surface controlled waters are considered a potential receptor.

Ecological

- The site is not located within an environmentally designated sensitive area;
- Given the site setting sensitive species are considered likely to be present at the site (subject to any ecological survey undertaken).

Property / Infrastructure

- Concrete vulnerability to aggressive ground conditions;
- Build-up of gases with potential for explosion;
- Water supply pipework.

4.4 Pathways

4.4.1 Potential contaminant migration pathways considered relevant to the site are:

Human Health

- Ingestion of contaminated soils and dust particles;
- Direct physical contact with near surface soils and contaminated dust particles;

- Inhalation of wind-blown contaminated dust;
- Inhalation of vapours and gases, migrating vertically into the atmosphere;
- Inhalation of vapours and gases, migrating vertically into buildings and confined spaces;
- Consumption of vegetables cultivated in contaminated soils;
- Consumption of soil attached to vegetables cultivated in contaminated soils.
- Consumption of contaminated potable water.

Controlled Waters

- Leaching of contaminants in made ground / natural ground into groundwater;
- Lateral migration of contaminated groundwater into the Langford Brook tributary system;
- Vertical migration of contaminated shallow groundwater impacting deeper groundwater in the aquifer sequence;
- Run-off of site-derived contamination into the Langford Brook tributary system during construction.

Ecological

- Migration of contamination through groundwater and subsequent uptake by plant roots;
- Direct contact between ecological receptors and contaminated surface water;
- Direct contact between ecological receptors and contaminated soils;
- Ingestion of contaminated soils/surface waters by ecological receptors;
- Inhalation of vapours or wind-blown dust by ecological receptors.

Property

- Direct physical contact with near surface soils;
- Migration of vapours and gases into buildings and confined spaces.

4.5 Pollutant Linkages

4.5.1 A 'pollutant linkage' describes the relationship between a contaminant, a pathway and a receptor, a 'pollutant' being the contaminant in a pollutant linkage. A contaminant, pathway and receptor must all be present for a pollutant linkage to exist, which forms the basis for determination that a piece of land is Contaminated Land. Potential sources, pathways and receptors have been assessed. The following Tables summarise the significant pollutant linkages potentially active at the site.

Table 4.1 Potential Source-Pathway-Receptor Linkages for Human Health Risk Assessment

Source	Pathway	Receptor
Contaminated soils and waters	Ingestion of soil	On-site female child: 0 - 6 yrs old
		On-site construction worker
	Ingestion of household dust	On-site female child: 0 - 6 yrs old
	Ingestion of contaminated vegetables	On-site female child: 0 - 6 yrs old
	Ingestion of soil attached to vegetables	On-site female child: 0 - 6 yrs old
	Dermal contact	On-site female child: 0 - 6 yrs old
		On-site construction worker
	Dermal contact with household dust	On-site female child: 0 - 6 yrs old
	Inhalation of fugitive soil dust	On-site construction worker
		On-site female child: 0 - 6 yrs old
	Inhalation of fugitive household dust	On-site female child: 0 - 6 yrs old
	Inhalation of vapours in outdoor air	On-site female child: 0 - 6 yrs old
		On-site construction worker
	Inhalation of vapours in indoor air	On-site female child: 0 - 6 yrs old
	Consumption of contaminated potable water	On-site female child: 0 - 6 yrs old
Ground gas and landfill gas	Vertical and lateral migration	End users

Table 4.2 Potential Source Pathway Receptor Linkages for Controlled Waters Risk Assessment

Source	Pathway	Receptor
Contaminated soils	Leaching mechanisms	Groundwater stored in the River Terrace Deposits, Cornbrash and Forest Marble
	Run-off during construction works	Langford Brook tributary system
Contaminated groundwater	Vertical migration	Groundwater stored in the River Terrace Deposits, Cornbrash and Forest Marble
	Lateral and vertical migration (baseflow)	Langford Brook tributary system

Table 4.3 Potential Source-Pathway-Receptor Linkages for Ecological Risk Assessment

Source	Pathway	Receptor
Contaminated soils and waters	Migration of contamination through groundwater and subsequent uptake by plant roots;	Ecological receptors
	Direct contact between ecological receptors and contaminated surface water;	
	Direct contact between ecological receptors and contaminated soils;	
	Ingestion of contaminated soils/surface waters by ecological receptors;	
	Inhalation of vapours or wind-blown dust by ecological receptors.	
Ground gas and landfill gas	Inhalation of gases	

Table 4.4 Potential Source-Pathway-Receptor Linkages for Property Risk Assessment

Source	Pathway	Receptor
Contaminated soils	Contact with contaminated soils	Concrete
		Water supply pipe materials
Ground gas and landfill gas	Vertical and lateral migration and accumulation in voids	Residential housing / Commercial properties

4.6 Preliminary Risk Assessment

4.6.1 From the information obtained from the desk study JNP Group has undertaken a preliminary risk assessment.

,Table 4.5 Preliminary Risk Assessment

Risk Receptor	Risk		Justification
HUMAN HEALTH	LOW, locally MEDIUM		The majority of the site comprises previously undeveloped open fields. A small area within the east of the site has historically been used for gravel extraction and has subsequently been backfilled. Made ground in this localised area is considered a potential source of contamination and ground gas.
GROUNDWATER	LOW, locally MEDIUM		The site is located on productive strata (Secondary Aquifer) and is not within a SPZ. A single, localised area of made ground has been identified that is a potential source of contamination, however no sources of contamination have been identified across the remainder of the site.
SURFACE WATER	LOW, locally MEDIUM		The nearest watercourse is denoted 2 m west of the site, and additional drains and ditches on site flow into the surface watercourse network. A single, localised area of made ground has been identified that is a potential source of contamination, however no sources of contamination have been identified across the remainder of the site.
ECOLOGY	LOW		The environmental setting of the site indicates that sensitive species may be present on site (subject to any ecological survey undertaken) however gross or pervasive contamination is not anticipated.
PROPERTY & INFRASTRUCURE	LOW, locally MEDIUM		The majority of the site comprises previously undeveloped open fields. A small area within the east of the site has historically been used for gravel extraction and has subsequently been backfilled. Made ground in this localised area is considered a potential source of contamination and ground gas. An additional offsite backfilled pit is located 18 m north of the site, which is considered a potential source of ground gas.

4.6.2 In line with BS ISO 18400-202:2018 based on the conceptual site model as above the site is considered to be probably contaminated in localised areas (the backfilled pit).

5 SITE WORK AND MONITORING

5.1 Introduction

5.1.1 The intrusive site work was undertaken by JNP Group on 14th and 15th March 2022, and 17th February 2022, and comprised five rotary open boreholes, seven dynamic sample boreholes and four shallow hand excavated sampling points. Six return gas and groundwater level monitoring visits were undertaken during a period from 3rd March 2022 to 18th May 2022.

5.1.2 All site work was completed under the instruction and supervision of JNP Group with the ground investigation procedures and sample descriptions given in the following publications:

- BS 5930 (2015).Code of Practice for Site Investigations;
- BS 10175 (2001+A1:2013+A2:2017). Investigation of potentially contaminated sites - code of practice;
- BS EN ISO 14688-1. "Soil - Identification and Description;
- BS EN ISO 14688-2. Soil - Classification principles and quantification of descriptive characteristics;
- BS EN ISO 14689. Rock - Identification and description;
- BS 18400-104:2018. Soil Quality – Sampling. Part 104: Strategies;
- BS 18400-202:2018. Soil Quality – Sampling. Part 202: Preliminary Investigations;
- BS 18400-203: 2018. Soil Quality – Sampling. Part 203: Investigation of potentially contaminated sites;
- BS 18400-205: 2018. Soil Quality – Sampling. Part 205: Guidance on the procedure for investigation of natural, near natural and cultivated sites;

5.1.3 For sites affected by asbestos impacted soils, the guidance given in the following publications has been followed:

- Industry Guidance on Interpretation for Managing & Working with Asbestos in Soil and Construction and Demolition Materials (CL:AIRE 2016);
- Asbestos in Soil and made ground: a guide to understanding and managing risks (CIRIA C733 2014).

5.1.4 The design and installation of groundwater quality monitoring points has been undertaken following the guidance given in the Environment Agency science report:

- SC020093. Guidance on the design and installation of groundwater quality monitoring points. 2006.

5.1.5 The locations of the exploratory holes are shown on JNP Group Drawing No. C86354-JNP-XX-XX-SK-G-7002. The exploratory hole records including strata and groundwater encountered, in-situ testing and samples taken are presented in Appendix D:. The full details of the site work undertaken are summarised in the following sections.

5.1.6 The purpose of the intrusive sitework was to obtain data to support an outline planning application for the aforementioned development.

5.1.7 The site investigation strategy comprised a systemic distribution across the site to suit the proposed redevelopment and address relevant spatial locations considered most likely to be sensitive. Table 5.1 shows the rationale for the location of each exploratory hole.

Table 5.1 Exploratory Hole Location Rationale

Exploratory Hole Reference	Rationale
DS2	To target historical backfilled pit (including groundwater and gas monitoring)
DS1, DS3-DS7 and RB1-RB5	General site coverage (including groundwater and gas monitoring)
HP1 – HP4	General site coverage for shallow contamination screening

5.1.8 The general sampling strategy was to take representative soil samples from the ground to characterise the strata encountered and to provide suitable horizontal distribution, however, where visible contamination was present or suspected, targeted spot samples were taken.

5.1.9 DS2 was located to target the historic backfilled pit to provide information on ground and ground gas conditions.

5.2 Dynamic Sampling Boreholes

5.2.1 Seven dynamic sampling boreholes, designated DS1 to DS7 (inclusive) were formed on 17 February 2022, to depths of between 1.00 m and 2.45 m below ground level (bgl) at various locations across the site. SPT refusal in the Kellaways Clay Member and the Cornbrash Formation limited the depths of all exploratory hole locations

5.2.2 The dynamic sampling technique uses a lightweight tracked rig to advance a borehole by 1 m intervals using 1 m long steel sampler tubes, at diameters of 100 mm, reducing to 70 mm. The soils are then recovered from each sample tube as continuous core samples, which are logged and sub-sampled on site. Environmental soil samples were generally taken from each made ground material, together with any materials suspected of containing elevated concentrations of contaminants, based on visual and olfactory evidence. The environmental samples comprised a small volatiles jar, and an amber glass jar. Bulk and small plastic tub samples were also taken from selected materials, for laboratory geotechnical testing. In situ Standard Penetration Tests (SPTs) were undertaken in accordance with BS 5930 (2015) at 1.0 m depth intervals in the boreholes in order to obtain in situ strength or relative density parameters for geotechnical design.

5.2.3 Inert filter gravel was placed as the response zone, with a bentonite seal placed to ground level.

5.2.4 Response zones within the installations were installed between depths of 0.50 m bgl to 2.10 m bgl in order to target the underlying Kellaways Clay Member (in DS1 only) and between 0.50 – 2.00 to target the underlying Cornbrash Formation in the remainder of the locations.

5.3 Rotary Boreholes

5.3.1 Five boreholes (RB1-5) were formed by dynamic sampling and rotary open hole drilling techniques to a maximum depth of 5.00 m bgl.

5.3.2 50 mm diameter monitoring standpipes were installed, the response zones were from 0.40 – 5.00 m bgl in order to target the underlying Cornbrash Formation. Inert filter gravel was placed as the response zone, with a bentonite seal placed to ground level.

5.4 Hand Pits

5.4.1 Four shallow hand pits (HD1-4) were undertaken for the purpose of near-surface chemical assessment.

5.5 Monitoring

5.5.1 Gas monitoring of the installed standpipes/wells was undertaken on six occasions over three months at approximate alternate-weekly intervals (3rd – 31st March, 21st April, and 6th – 18th May 2022) after the completion of the site work.

5.5.2 Monitoring involved the measurement of the ground gas composition at each of the installations for methane (CH_4), carbon dioxide (CO_2) and oxygen (O_2) concentrations, together with atmospheric pressure, downhole pressure and flow rates, using a Gas Data GFM430 / Geotech GA5000 gas meter. After the measurement of gas concentrations, the depth to any groundwater within the standpipe was recorded. At least two of the monitoring visits were undertaken during periods of low and falling atmospheric pressure.

5.5.3 The frequency and duration of gas monitoring was selected based on the guidance given in the following publications:

- CIRIA C665. Assessing risks posed by hazardous gases to buildings. 2007;
- BS 8485. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings. 2015;
- CL:AIRE RB 17. A Pragmatic Approach to Ground Gas Risk Assessment. 2012.

5.5.4 Groundwater monitoring was undertaken on seven occasions at bi-weekly intervals (17th February, 3rd – 31st March, 21st April, and 6th – 18th May) after the completion of the site work. Table 5.2 justifies the response zones selected for each monitoring borehole.

Table 5.2 Response Zone Rationale

Exploratory Hole Reference	Response Zone (m bgl)	Rationale
RB1-5	0.40 – 5.00 m	To monitor groundwater levels within the Cornbrash Formation.
DS1	0.50 – 2.10 m	To monitor groundwater levels within the Kellaways Clay Member
DS2-7	0.50 – 2.00 m	To monitor groundwater levels within the Cornbrash Formation

5.5.5 It should be noted that long-term groundwater levels may vary from those reported due to seasonal fluctuation or weather events, such as droughts, significant rainfall, or recent flooding.

5.5.6 The monitoring results are presented in Appendix E:.

5.5.7 If should be noted that once the groundwater monitoring boreholes are no longer required they need to be decommissioned following the guidance given in the EA science report SC020093 (EA 2008).

6 LABORATORY TESTING

6.1 Geotechnical

6.1.1 A programme of laboratory testing was scheduled by JNP Group to determine geotechnical properties of selected soil samples obtained from the investigation. The details of the geotechnical testing are summarised below:

Table 6.1 Scheduled Geotechnical Laboratory Tests

Test Description	Number of Tests
Atterberg limits including moisture content	5
Particle size distributions	1
Ground Aggressivity Suite (in accordance with BRE SD1)	6

6.1.2 Tests were undertaken in accordance with BS1377 (1990) "Methods of test for Soils for Civil Engineering purposes". The results of the geotechnical testing are presented in Appendix F:.

6.2 Environmental

6.2.1 A programme of chemical laboratory testing was scheduled by JNP Group on selected soil samples taken from various depths in the made ground and natural ground recovered from the exploratory holes. Samples of any soils displaying visual or olfactory evidence of contamination were also collected and submitted for laboratory analyses. The samples were placed into suitable containers for the required chemical analyses.

6.2.2 All samples were transported, on the day of collection, to i2 Analytical Testing Services in Watford which is accredited under UKAS and MCerts. The following table summarises the contaminants scheduled:

Table 6.2 Scheduled Soil Chemical Analyses

Determinant	No
Metals and semi-metals (arsenic, beryllium, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium, vanadium and zinc)	8
Polycyclic Aromatic Hydrocarbons (PAH) 16 USEPA Speciated	8
Total Petroleum Hydrocarbons (TPH) Carbon banded	4
Asbestos screening	8
Pesticide Screen	4

7 GROUND AND GROUNDWATER CONDITIONS

7.1 Strata Encountered

7.1.1 The ground conditions encountered during the intrusive investigation were generally consistent with the published geological map. A variable thickness (< 0.70 m) of made ground (limited to DS2 and DS6 in the north-east of the site) and topsoil was found to be underlain by both granular and cohesive Superficial Deposits in the west of the site. In the remainder of the site, where superficial deposits were not encountered, the Cornbrash Formation was encountered, this consisted of sandy silts and clays, in addition to silty clayey gravel, overlying limestone. The Kellaways Clay Member was only encountered in the south-east of the site.

7.1.2 A summary of the stratigraphy encountered during the investigation is presented in Table 7.1 and described in the following sections, but for full details and descriptions, reference should be made to the exploratory hole records presented in Appendix D:.

Table 7.1 Stratigraphy Encountered

Stratum	Depth to Top (m bgl)	Depth to Base (m bgl)	Thickness (m)
Topsoil All locations except DS2 and DS6	Surface	0.20 – 0.45	0.20 – 0.45
Made ground DS2 and DS6	Surface	0.25 – 0.70	0.25 – 0.70
Superficial Deposits DS1 and RB1	0.40 - 0.45	0.90 – 2.20	0.50 – 1.75
Kellaways Clay Member DS1	0.90	Not proven	Not proven
Cornbrash Formation* All locations except DS1	0.20 – 2.20	Not proven	Not proven

*including Weathered Cornbrash Formation

7.2 Made Ground

7.2.1 Made ground was encountered in DS2 and comprised of dark grey brown sandy gravelly clay with brick, limestone and coal gravel. Made ground topsoil was encountered in DS6 and comprised dark brown clayey gravelly topsoil, with limestone and rare tile fragments. The made ground was proven to depths of 0.70 m bgl and 0.25 m bgl in DS2 and DS6, respectively.

7.3 Topsoil

7.3.1 Dark brown clayey gravelly topsoil with roots and limestone gravel was encountered across the site.

7.4 Superficial Deposits

7.4.1 Superficial deposits were encountered in the west of the site, and comprised of soft orange brown clayey gravelly sands and sandy gravelly clays, the gravel fraction comprised angular to sub-rounded fine to coarse limestone. The top of the lithological unit was encountered at depths of between 0.40 m and 0.45 m bgl, extending to depths of between 0.90 m and 2.20 m bgl, with a maximum thickness of 1.75 m encountered in RB1.

7.5 Cornbrash Formation

7.5.1 Strata of the Cornbrash Formation were encountered in all of the exploratory holes except DS1 which was terminated in the Kellaways Clay Member. The depth to the top of the Cornbrash Formation varied from 0.20 m – 2.20 m bgl. The base of the lithology was not proven, with the maximum depth penetrated 5.00m bgl in RB1-4.

7.5.2 The lithological unit was found to comprise weathered Cornbrash Formation which consisted of firm to stiff brown bluish grey gravelly and sandy silts and clays, in addition to silty clayey gravel, overlying blueish grey to pale brown limestone bedrock of the Cornbrash Formation. The gravel fraction comprised limestone.

Table 7.2 Weathered Cornbrash Formation – Geotechnical Laboratory Test Results Summary

Property	Number of Tests	Range	Mean	Assessment
Natural Moisture Content	4	16 – 27	20	Medium volume change potential. High plasticity Clays (CH).
% passing 425 sieve	4	48 – 88	65	
Liquid Limit %	4	32 – 57	46	
Plastic Limit %	4	17 – 28	21	
Plasticity Index %	4	19 – 32	25	
Modified Plasticity Index %	4	8 - 22	17	
SPT 'N' Values	3	14 - 23	19	Medium to high strength (high strength)
c_u = 4.5 x SPT 'N' Value (kN/m^2)	3	63 - 104	86	
Gravel Content %	1	62	-	Clayey sandy GRAVEL.
Sand Content %	1	23	-	
Silt / Clay Content %	1	15	-	

7.5.3 The SPT N value / depth profile is presented as Figure 2, the undrained shear strength / depth profile as Figure 3, and a plasticity chart is presented as Figure 4.

7.5.4 Seven SPT tests were undertaken in the Cornbrash Formation (bedrock), recording N Values of between 39 and >50.

7.6 Kellaways Clay Member

7.6.1 Strata of the Kellaways Clay Member was encountered in DS1 only, underlying superficial deposits, at a depth of 0.90 – 2.45 m bgl.

7.6.2 The lithological unit was found to comprise of stiff to very stiff brown grey to dark grey clay, becoming dark grey mudstone from 2.10 m bgl.

Table 7.3 Kellaways Clay Member – Geotechnical Laboratory Test Results Summary

Property	Number of Tests	Range	Mean	Assessment
Natural Moisture Content	1	25	N/A	Low volume change very high plasticity silts (MV)
% passing 425 sieve	1	41	N/A	
Liquid Limit %	1	74	N/A	
Plastic Limit %	1	30	N/A	

Property	Number of Tests	Range	Mean	Assessment
Plasticity Index %	1	44	N/A	
Modified Plasticity Index %	1	18	N/A	
SPT 'N' Values	2	18 – 50	34	Stiff
c_u = 4.5 x SPT 'N' Value (kN/m^2)	1	81	N/A	

The SPT N value / depth profile is presented as Figure 2, the undrained shear strength / depth profile as Figure 3, and a plasticity chart is presented as Figure 4.

7.7 Groundwater

7.7.1 Details of groundwater entries recorded during the site work period, and levels recorded subsequently during the monitoring visits, are summarised in the table which follows.

Table 7.4 Summary of groundwater observations

Exploratory Location	Groundwater during site work		Groundwater during monitoring
	Strikes (m bgl)	Comments	Range (m AOD)
RB1	1.000	Rise to 0.95 in an hour	0.95 – 1.93
RB2	1.000	Rise to 0.95 in an hour	0.80 – 1.80
RB3	0.900	Rise to 0.75 in an hour	1.08 – 0.54
RB4	1.200	Rise to 0.95 in an hour	1.13 – 0.94
RB5	0.900	Rise to 0.75 in an hour	0.83 – 0.68
DS1	2.050	Water level at 2.05 m after one hour.	0.47 – 2.05
DS2	0.600	Water level at 0.60 m after one hour.	0.59 – 1.21
DS3	0.970	Water level at 0.97 m after one hour.	0.97 – 1.68
DS4	0.680	Water level at 0.68 m after one hour.	0.58 – 1.35
DS5	1.160	Water level at 1.16 m after one hour.	1.06 – 1.51
DS6	0.900	Water level at 0.90 m after one hour.	0.86 – 0.99
DS7	0.95	Damp at base on drilling. Water level at 0.85 m after one hour.	0.78 – 0.92

7.7.2 During the intrusive investigation, groundwater was encountered in the overlying Superficial Deposits (including Weathered Cornbrash Formation) between 0.60 – 2.05 m bgl. During the subsequent monitoring period groundwater was recorded between 0.58 – 1.80 m bgl, and was generally shallowest in the south of the site.

7.7.3 In the south-east of the site, in DS1, groundwater was encountered at 0.47 - 2.05 m bgl in the underlying Kellaways Clay Member.

7.7.4 During the subsequent monitoring period, groundwater levels peaked in early March 2022 and slowly declined thereafter.

7.8 Ground Contamination and Deleterious Material

7.8.1 Made ground was encountered locally in DS2 and DS6 and included: brick, coal, and tile in varying proportions. These fragments are not large or frequent enough to be considered as deleterious materials. Deep (>1m), highly organic or putrescible made ground was not encountered during the ground investigation.

7.9 Ground Gas Conditions

7.9.1 During the six monitoring visits, negligible methane concentrations (0.2%) were recorded, and a maximum concentration of carbon dioxide of 3.2% was recorded, with negligible positive flow, negative flow rates were recorded in RB2. Full details of the gas concentrations and flow rates recorded during the monitoring period are presented in Appendix E:.

7.10 Trees and Tree Roots

7.10.1 Mature trees and hedges were present around the margins of the site.

7.11 Desiccation

7.11.1 Following laboratory testing of cohesive soils, two commonly accepted methods for determining the degree of desiccation (as stated in BRE 412 'Desiccation in Clay Soils') are as follows:

1. *Desiccation has occurred when the moisture content is less than the modified Plastic Limit;*
2. *Significant desiccation has occurred when the moisture content is less than 0.4 x the modified Liquid Limit (this is known as the Driscoll Limit).*

7.11.2 When the results of laboratory testing are compared with both methods, ,none of the samples are indicated to be desiccated.

7.11.3 A plot comparing moisture contents with the Liquid Limits and the Driscoll Limits is included as Figure 5.

7.12 Obstructions

7.12.1 Anthropogenic obstructions were not recorded on site. However, all dynamic sampler boreholes terminated at shallow depth on bedrock due to SPT refusal.

7.13 Data Gaps and Uncertainties

7.13.1 JNP Group was able to access the majority of the site without constraint and the works undertaken are considered sufficient to characterise the site without significant uncertainties remaining. In the cultivated areas of the site, the locations were re-located to the margins of the site.

8 HUMAN HEALTH DETAILED QUANTITATIVE RISK ASSESSMENT

8.1 Introduction

8.1.1 Qualitative assessment of risks may be sufficient in many cases to eliminate the possibility of significant pollutant linkages. However, quantitative risk assessment is formally required to determine whether there is a 'significant possibility of significant harm being caused'. Part IIA of the Environmental Protection Act 1990 recommends that 'authoritative and scientifically based guideline values for concentrations of the potential pollutants in or under the land' be used to quantify the risk posed by contamination.

8.1.2 Under the Planning Regime, a quantitative risk assessment can be used to decide whether the site is suitable for the proposed use. In addition, the National Planning Policy Framework (March 2012) also indicates that after remediation, as a minimum land should not be capable of being determined as contaminated land under Part IIA.

8.2 Current UK Screening Values

8.2.1 The UK technical guidance for assessing risks to human health is issued from various UK bodies, including the Environment Agency (EA), DEFRA, Contaminated Land: Applications in Real Environment (CL:AIRE), Chartered Institute of Environmental Health (CIEH), and Land Quality Management (LQM) Ltd (part of the University of Nottingham).

8.2.2 New and updated screening values in the form of provisional Category 4 Screening Levels (C4SL) (published in 2014), and Suitable for Use Levels (S4UL), (published 2015), have been produced by DEFRA and CIEH / LQM respectively using modified versions of the EA's Contaminated Land Exposure Assessment (CLEA) software.

8.2.3 C4SL

8.2.4 Provisional C4SL have been derived by CL:AIRE (project team for DEFRA's SP1010 project) following revised statutory guidance, and as a tool to assist in applying the Part IIA Category 1- 4 classifications to a site. The purpose of the C4SL is to provide a simple test for deciding that land is suitable for use, and definitely not contaminated land under Part IIA. They describe a level of risk that is above minimal, but is still low.

8.2.5 In calculating provisional C4SL some of the exposure modelling scenarios and exposure parameters used in the CLEA software have been modified. These modifications are not discussed further, but reference should be made to the original CL:AIRE / DEFRA publications should further information or clarification be required. A list of the new publications is included in the references section at the end of this report.

8.2.6 To date, six contaminants have been assigned provisional C4SL: arsenic; benzene; benzo[a]pyrene; cadmium; chromium VI, and lead, for the standard land uses (residential with, and without plant uptake, allotments, commercial, and public open space (parks and residential).

8.2.7 The C4SL are also considered suitable to be used under the planning regime, and DEFRA have confirmed this to all local authorities.

8.2.8 S4UL

8.2.9 The LQM / CIEH S4UL represent generic assessment criteria based on minimal or tolerable risk that are intended to be protective of human health. They have been derived in

accordance with current UK legislation using a modified version of the CLEA software, and are still based on many conservative assumptions. They represent values above which further assessment of the risks or remedial actions may be needed.

8.2.10 S4UL have been derived for a comprehensive list of metals, non–metals, petroleum hydrocarbons, polycyclic aromatic hydrocarbons, chlorinated hydrocarbons, phenolic compounds, explosives, and pesticides, for the standard land uses (residential with, and without plant uptake, allotments, commercial, and public open space (residential and park)).

8.2.11 For details of the exposure parameters and scenarios used to derive the S4UL the reader is reference to the original LQM / CIEH document "The LQM/CIEH S4UL for Human Health Risk Assessment" (2015).

8.2.12 Both sets of screening values can be used to undertake a generic risk assessment by comparing the data directly to the screening value which is considered a conservative approach or statistically to the screening value. Alternatively and if a sufficient dataset is available, a statistical assessment can be undertaken following the guidance given in the joint Chartered Institute of Environmental Health (CIEH) and the Contaminated Land: Applications in Real Environment (CL:AIRE) organisation publication "Guidance On Comparing Soil Contamination Data with a Critical Concentration" (CIEH / CL:AIRE May 2008).

8.3 Petroleum Hydrocarbons

8.3.1 JNP Group have followed the guidance given in the Environment Agency publication 'The UK Approach for Evaluating Human Health Risks from Petroleum Hydrocarbons in Soils' (Environment Agency, 2005). LQM S4UL values have been published based on carbon banded hydrocarbons with aliphatic and aromatic split, corresponding to the TPH CWG bands. JNP Group undertook carbon banded analysis using wider bands than used by TPH CWG without aliphatic and aromatic split.

8.3.2 JNP Group have compared the results of carbon-banded hydrocarbon analysis with the most sensitive LQM S4UL value within the band under scrutiny. Generally, the most sensitive band comprises the lightest aromatic fraction within the carbon band under scrutiny.

9 SOIL ASSESSMENT RESULTS

9.1 Soil Results

9.1.1 The results of chemical testing of two samples of made ground and six samples of natural soils have been compared with the C4SL and the LQM S4UL values for a 'residential with gardens end use'. These comparisons are summarised in the following tables.

9.1.2 The following determinants were recorded at concentrations less than their respective limits of laboratory detection, and hence have not been included in this assessment: asbestos, pesticides, PAH, TPH, cadmium, mercury and selenium.

Table 9.1 Comparison of Soil Chemical Test Results with Residential with plant uptake Guideline Values

Determinant	Maximum Measured Concentration		Background Concentration	LQM/CIEH S4UL: Residential with plant uptake (mg/kg)	Number of tests	Number of exceedances
	Made ground	Natural Ground				
Arsenic	37	24	25	37	8	0
Beryllium	1.1	1	-	1.7	8	0
Boron	1.5	2	-	290	8	0
Chromium*	31	28	65	910	8	0
Copper	21	19	20	2400	8	0
Lead	23	56	45	200**	8	0
Nickel	34	25	30	180	8	0
Vanadium	60	50	75	410	8	0
Zinc	87	79	110	3700	8	0

*assumes all chromium on site is in trivalent form
** provisional C4SL

9.2 Interpretation

9.2.1 The analyses recorded no elevated concentrations of some heavy metals with respect to the selected screening values. The presence of asbestos, pesticides or hydrocarbons was not recorded.

9.2.2 From the results above, highly mobile hydrocarbons were not recorded at the site. From table 9.1, the metal concentrations recorded across the site are within the same order of magnitude as the background concentrations. Thus, any leaching of metals is considered likely to be within the natural conditions. Therefore, JNP Group consider that the site does not pose a significant risk to controlled waters.

9.3 Summary

9.3.1 Consequently, the site is considered to not be contaminated and remedial actions are not required.

9.4 Risk to Controlled Waters

9.4.1 The nearest controlled surface water is 2 m to the west of the site, and drainage ditches on-site connect to surface controlled water features. Hence, surface controlled waters are considered a potential receptor.

9.4.2 Based upon a review of the contaminants recorded in Table 9.1, highly mobile organic hydrocarbons, such as BTEX, lighter TPH fractions, or naphthalene, were not recorded within the made ground or at the site. The metal concentrations recorded are similar to typical background concentrations. pH values for the site are neutral to weakly basic.

9.4.3 Consequently, no risk to controlled waters has been identified.

10 GROUND GAS PROTECTION REQUIREMENTS

10.1 Guidance and Standards

10.1.1 JNP Group has used the guidance given in the following document to assess the risks from ground gases

- CIRIA C665. Assessing risks posed by hazardous gases to buildings. 2007;
- BS 8485. Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings. 2015 +A1 2019;
- CL:AIRE RB 17. A Pragmatic Approach to Ground Gas Risk Assessment. 2012.

10.1.2 It is intended that the proposed new build will be low rise housing. In addition, suspended floors are required due to the plasticity of the underlying soils.

10.1.3 The level of gas protection is determined by comparing the following parameters to reference values prescribed within BS 8485 (2015):

- "Typical Maximum Concentrations" for initial screening purposes;
- Risk based "Gas Screening Values" (GSV) for consideration where the typical maximum concentrations are exceeded.

10.1.4 The GSV is calculated using the following equation, and the resulting GSVs are compared to the Site Characteristic GSV given in Table 2 of BS 8485: 2015 +A1 2019.

- Maximum gas concentration (%) x worst case borehole flow rate (l/h)

10.2 Definitions

10.2.1 In accordance with Table 4 of BS 8485: 2015 +A1 2019, varying levels of protection are required for each category of risk for 'Type A' buildings (private housing), 'Type B' buildings (hotels, managed apartments, small commercial/retail), 'Type C' buildings (commercial, retail, industrial), and 'Type D' buildings (large industrial / commercial / warehouse).

- A 'CS1' determination requires no ground gas protection measures to be installed.
- A 'CS2' determination requires ground gas protection measures to be installed. The level of ground gas protection required should be equal or greater than 3.5 points for a Type A building, when at least two items from the following three: Table 5 (structural barrier); Table 6 (ventilation), and Table 7 (gas resistant membrane) within BS 8485: 2015 +A1 2019 are selected.

10.3 Results

10.3.1 The maximum carbon dioxide and methane concentrations, the maximum flow rate, and the screening values for each borehole during the site work periods, are summarised in the following table.

10.3.2 The raw and collated results of the ground gas monitoring undertaken are presented in Appendix E:. This includes a graph showing the atmospheric pressure trend throughout the monitoring period.

Table 10.1 Calculated Gas Screening Values

Location	Maximum CH_4 Concentration (% v/v)	Maximum CO_2 Concentration (% v/v)	Maximum Flow Rate (l/hr)	Maximum Gas Screening Value (l/hr)
DS1	< 0.2	2.20	<0.1	0.0022
DS2	< 0.2	2.10	<0.1	0.0021
DS3	< 0.2	2.90	<0.1	0.0029
DS4	< 0.2	3.20	<0.1	0.0032
DS5	< 0.2	1.80	<0.1	0.0018
DS6	< 0.2	1.60	<0.1	0.0016
DS7	< 0.2	2.10	<0.1	0.0021
RB1	< 0.2	0.80	<0.1	0.0080
RB2	< 0.2	0.80	<0.1	0.0080
RB3	< 0.2	0.70	<0.1	0.0070
RB4	< 0.2	1.50	<0.1	0.0015
RB5	< 0.2	1.80	<0.1	0.0018

10.4 Interpretation

10.4.1 A 'CS1' determination was derived from the monitoring results from all locations. The results of the ground gas assessment indicate that the site would not require ground gas protection measures.

11 REVISED CONCEPTUAL SITE MODEL AND OVERALL ENVIRONMENTAL RISK

11.1 Summary

11.1.1 Following the ground investigation and subsequent assessment undertaken, the conceptual site model and overall environmental risk assessment have been updated as detailed in the following table.

Table 11.1 Updated Conceptual Model and Risk Assessment

Issue	Risk		Justification
HUMAN HEALTH	LOW		No contamination was found to be in excess of the selected screening values. No elevated concentrations of gases have been recorded. Credible source-pathway -receptor linkages are not considered to be present.
GROUNDWATER AND SURFACE WATER	LOW		Contamination concentrations are similar to background, and no mobile species of metals or hydrocarbons present.
PROPERTY & INFRASTRUCTURE	NONE		Localised made ground was encountered to depths of < 0.70 m bgl during the intrusive investigation. Negligible concentrations of gases have been recorded to a CS1, hence gas protection measures are not required.
ECOLOGY	NONE		Based on the assumption that there are no sensitive/ protected species on site (subject to any ecological survey undertaken)

12 GEOTECHNICAL ENGINEERING ASSESSMENT

12.1 Proposed Development / Redevelopment

12.1.1 It is understood that the site will be subject to residential development. And includes residential development across the north and west of te site, with sports facilities and recreation space in the east of the site and public open space and attenuation basins in the south-west. The latest proposed redevelopment layout (reference Allen Pyke Drawing 2903-LA-02, dated April 2022) is included in Appendix B:.

12.2 Summary of Ground and Groundwater Conditions

12.2.1 The ground conditions encountered during the intrusive investigation were generally consistent with the published geological map. A variable thickness (< 0.70 m) of made ground (limited to DS2 and DS6) and topsoil was found to be underlain by both granular and cohesive Superficial Deposits in the east of the site. In the remainder of the site, where superficial deposits were not encountered, the Cornbrash Formation was encountered, this consisted of sandy silts and clays, in addition to silty clayey gravel, overlying limestone. The Kellaways Clay Member was only encountered in the south-east of the site.

12.1 Site Preparation and Earthworks

12.1.1 Should there be a requirement for extensive soils movement as a result of any cut and fill or other development requirements, then JNP Group recommend that materials management is undertaken following the Definition of Waste Code of Practice (DoWCoP). In following this guidance, a materials management plan (MMP) will need to be produced, independently checked by a suitably qualified person (QP) and an official declaration be made to and accepted by CL:ARIE.

12.1.2 DoWCoP is a voluntary scheme and alternative waste regulatory options, such as Environmental Permitting / Waste exemption can be used. However, any waste and material re-use must be managed correctly to avoid incurring HMRC Landfill Tax and possible penalties.

12.2 Shallow Foundations

12.2.1 Traditional shallow strip or pad foundations are considered feasible, placed within the Weathered Cornbrash Formation. In the south-east of the site, this would be applicable where the Kellaways Clay Member was instead encountered.

12.2.2 Foundation excavations should be taken through all topsoil and made ground deposits, and foundations placed within the Weathered Cornbrash Formation at a minimum founding depth of 0.90 m bgl, based upon soils of medium volume change potential. An allowable bearing pressure of 110 kN/m^2 would be available at 0.90 m bgl, based upon standard 0.60 m wide foundations.

12.2.3 The allowable bearing capacity includes an overall factor of safety of 3 against bearing capacity failure, whilst ensuring total settlements are maintained at less than 25mm. However, there are several trees, bushes and hedges along the field boundaries, and the influence of these may be the controlling criteria for determining foundation type and depth.

12.2.4 Allowable bearing pressures of 150 kN/^{2} and above could easily be achieved if foundations are deepened to encounter the bedrock of the Cornbrash Formation. It should be noted that

within the central and southern parts of the site, excavations to encounter the bedrock will encounter groundwater, hence groundwater management will be required.

12.2.5 The Weathered Cornbrash Formation have been proved by the ground investigation to vary significantly in clay content, with frequent granular layers. Therefore, in order to control differential movements/cracking where foundations are spanning cohesive and granular soils, it is recommended that steel reinforcement is incorporated into all foundations, both top and bottom where foundations are placed into cohesive or granular materials or span from bedrock to weathered materials. Reinforcement will not be required where foundations are fully placed onto limestone bedrock.

12.2.6 When the natural moisture content of a soil lies close or less than the value of the modified Plastic Limit, the soil can be considered desiccated. In addition, Driscoll (1983) suggested that desiccation is assumed to be present when the moisture content falls below a level of 40% of the modified Liquid Limit. The index tests indicate that none of the samples are desiccated.

12.2.7 Where foundations are to be constructed within the influence of existing, felled, or proposed trees, they are likely to need deepening, and heave precautions adopted in accordance with National House Building Council (NHBC) Chapter 4.2 'Building Near Trees', based upon soils of medium volume change potential. It is recommended that collapsible materials are used between foundations and cohesive soils to reduce heave pressures. JNP Group recommends that a tree species survey is undertaken, and the results are used to calculate their zones of influence, in order to define areas where foundations would require deepening.

12.2.8 It should be noted that deepening of foundations would not be required beyond the upper surface of the limestone bedrock, or within granular weathered Cornbrash, hence maximum foundation depths are unlikely to exceed 2 m, however shallow groundwater may present practical difficulties with excavations to these depths.

12.2.9

12.3 Ground Floor Slabs

12.3.1 The underlying soils are considered to have medium volume change potential, and consequently may heave. Therefore, suspended ground floor slabs should be used incorporating suitable underfloor voids, based on the recommendations in NHBC Chapter 4.2, with reference to soils of medium volume change potential.

12.4 Groundwater and Excavations

12.4.1 Groundwater was encountered at shallow depth during the site work and subsequent monitoring period. However, the groundwater levels may fluctuate due to seasonal or other effects, such as extreme, prolonged meteorological events or periods.

12.4.2 JNP Group considers that groundwater inflow or excavation collapse may present practical difficulties during foundation excavation.

12.4.3 Groundwater control / dewatering measures, such as sump pumping / well pointing should be considered for all excavations should works be undertaken during periods of high groundwater levels.

12.4.4 Boreholes carried out as part of this investigation may represent soft spots and conduits/sumps for groundwater or surface water. Unless specifically stated, exploratory hole locations should be regarded as approximate. Consideration should be given to accurate

location of such features where it is considered they may impact on the proposed development.

12.5 Pavement Design

California Bearing Ratio

12.5.1 It is assumed that the pavement subgrade/formation would be in near surface soils at an approximate depth of 0.60 m below existing ground levels. If ground levels are to be reduced, the formation level would need to be adjusted accordingly, and the specifying geotechnical engineer informed, so that an assessment of the appropriate soil layer can be made.

12.5.2 A mean Plasticity Index value of 26 % was recorded in the near surface soils of the Weathered Cornbrash Formation (DS4 at 0.60 m bgl and DS7 at 0.80 m bgl), which indicates an equilibrium subgrade CBR value of 4 % (based upon Table 3.1 in Interim Advice Note 73/06 Rev 1 2009), assuming average construction conditions, and high water table.

12.5.3 It is recommended that the subgrade CBR value is verified immediately before placement of the pavement capping/subbase to confirm the minimum design CBR value. The design CBR value should not be increased on the basis of these tests. Should testing indicate a subgrade CBR less than the design value, then measures should be taken to improve the subgrade before proceeding with pavement construction.

Frost Susceptibility

Cohesive Soils

12.5.4 Soils with a Plasticity Index of greater than 15% would not generally be frost-susceptible (i.e. susceptible to ice lenses formation in frosty conditions) (Croney and Jacobs, 1967). Two of the four tests undertaken on soils of the weathered Cornbrash recorded modified plasticity indices of less than 15 %, hence the soils are considered frost-susceptible.

Granular Soils

12.5.5 Granular soils are considered frost susceptible if the fines content is greater than 10% (TRL RN 29). A single grading undertaken on the weathered Cornbrash indicate that the fines content is greater than 10%, hence, these soils are considered frost susceptible.

12.6 Ground Aggressivity to Buried Concrete

12.6.1 Chemical analyses of six samples have been undertaken in accordance with BRE SD1 2005 “Concrete in aggressive ground” to determine their concrete classification.

Table 12.1 Concrete Classification Assessment

Strata	Details	Range	Concrete Class
Made Ground	Number of Tests	1	DS1 – AC1
	Water Soluble Sulphates (mg/l)	28	
	pH	8	
	Total Potential Sulphate %	0.17	
Kellaways Clay Member	Number of Tests	2	DS5 – AC5
	Water Soluble Sulphates (mg/l)	590 - 1300	
	pH	7.3 – 7.5	

Strata	Details	Range	Concrete Class
	Total Potential Sulphate %	0.88 – 5.73	
Weathered Cornbrash Formation	Number of Tests	3	DS1 – AC1
	Water Soluble Sulphates (mg/l)	15 - 32	
	pH	8.3 – 8.5	
	Total Potential Sulphate %	0.13 – 0.15	

12.6.2 On the basis of the above assessment, and in accordance with BRE SD1 (2005) "Concrete in aggressive ground", a Design Sulphate Class of DS5, with an ACEC of AC-5, would apply for all buried concrete in the Kellaways Clay Member.

12.6.3 However, the Kellaways Clay Member was only encountered in the south-east of the site, in an area where construction is not currently proposed.

12.6.4 On the basis of the current proposed layout, a Design Sulphate Class of DS1, with an ACEC of AC-1, would apply for all buried concrete in the Superficial Deposits, Weathered Cornbrash Formation and made ground.

13 CONCLUSIONS AND RECOMMENDATIONS

13.1 Conclusions

13.1.1 JNP Group has determined through desk-based research, intrusive investigation, laboratory testing, monitoring, and assessment that:

- Ground conditions at the site comprise a variable thickness (< 0.70 m) of made ground limited in the north-east of the site, and topsoil was found to be underlain by both granular and cohesive Superficial Deposits in the west of the site. In the remainder of the site, where superficial deposits were not encountered, the Cornbrash Formation was encountered, this consisted of sandy silts and clays, in addition to silty clayey gravel, overlying limestone. The Kellaways Clay Member was only encountered in the south-east of the site.
- Elevated concentrations of contaminants were not recorded at the site.
- No risk to human health has been identified.
- No risk to controlled waters has been identified.
- Ground gas protection measures are not required.
- The presence of very shallow groundwater, typically within 1 m of the surface, indicates that infiltration drainage will not be feasible at the site.
- Traditional shallow strip or pad foundations are considered feasible, placed within the Weathered Cornbrash Formation. An allowable bearing pressure of 110 kN/m^2 would be available at 0.90 m bgl, based upon standard 0.6 m wide foundations.
- The site contains several mature trees and hedgerows at the field boundaries, which would require foundations within influencing distance to be deepened, based upon soils of medium volume change potential.
- Due to the cohesive nature of near-surface soils, suspended ground floor slabs are required for all new structures.
- Groundwater control / dewatering measures, such as sump pumping / well pointing should be considered for all excavations.
- The pavement subgrade at an approximate depth of 0.6 m below existing ground level in the Weathered Cornbrash Formation has an equilibrium subgrade CBR value of 4 %. The subgrade soils are considered frost-susceptible.

13.2 Recommendations

13.2.1 In line with the guidelines given LCRM and consequent to the ground investigation conclusions; JNP Group recommends that:

- A tree survey be undertaken at the site, in order to be able to assess their impact upon foundations types and depths.
- A copy of this report is submitted to the Regulatory Authorities for their approval before any further work is undertaken at the site.

13.2.2 In addition, JNP Group recommends that the proposed development works are undertaken in accordance with the definition of Waste Code of Practice (DoWCoP); in following this guidance and to ensure materials are managed correctly, a Materials Management Plan will need to be prepared and declared in advance by a Qualified Person, then implemented and documented in a Verification Report. If this process is not undertaken, then following recent changes in Landfill Tax Regulations by HMRC. There is a risk of penalties equating to twice the Landfill Tax being applied to the re-use of material o site. If the proposed works are to be undertaken outside the DoWCoP, there would need to be some of Environmental Permitting or suitable equivalent. The requirements of such are likely to be more onerous and may take longer to be granted.

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FIGURES / DRAWINGS

Figure 1

Site Location Plan

Project:

Green Lane, Chesterton

Project No:

C86354

Figure 2

SPT / Depth Relationship

Project:

Green Lane, Chesterton

Project No:

C86354

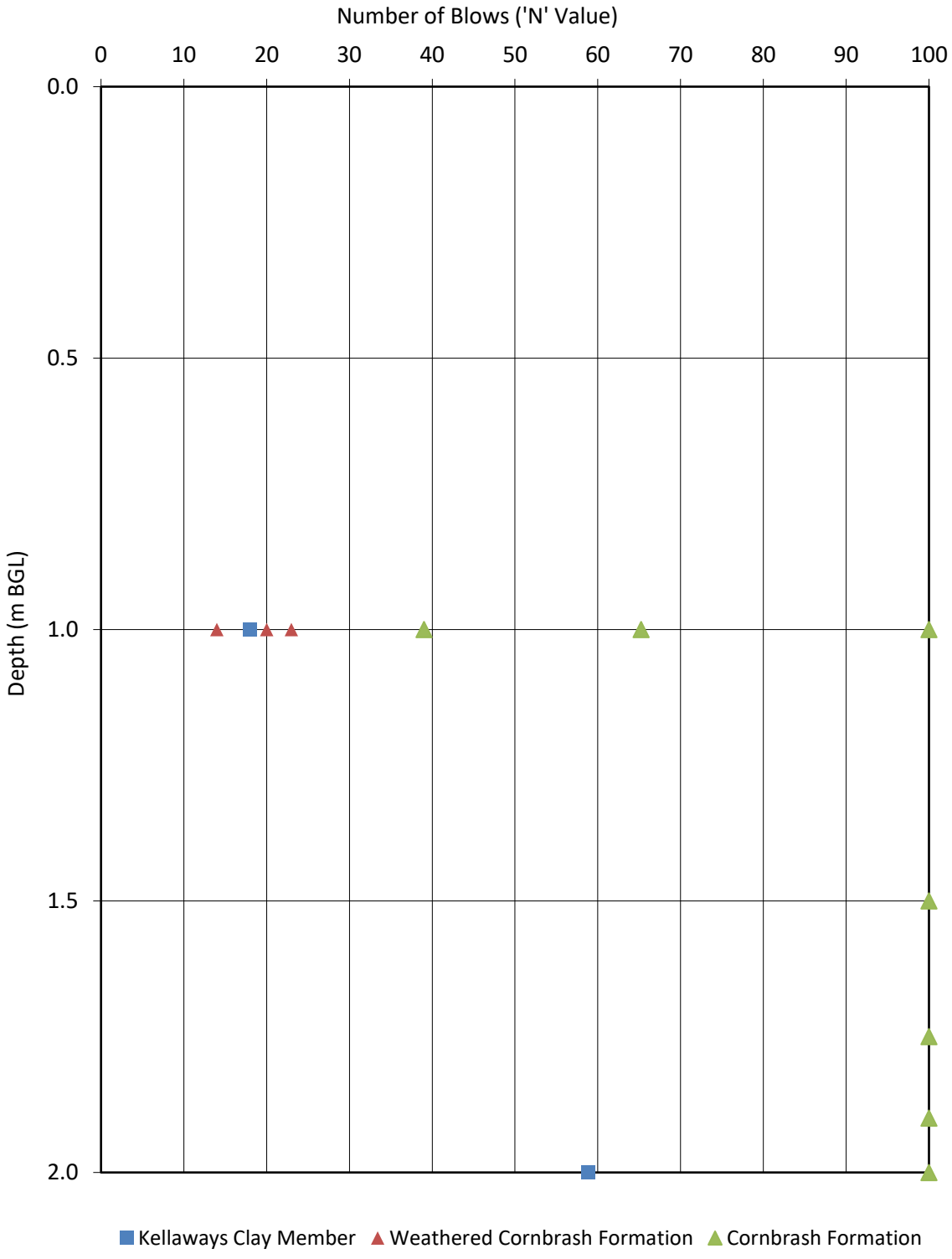


Figure 3

Undrained Shear Strength / Depth Relationship

Project:

Green Lane, Chesterton

Project No:

C86354

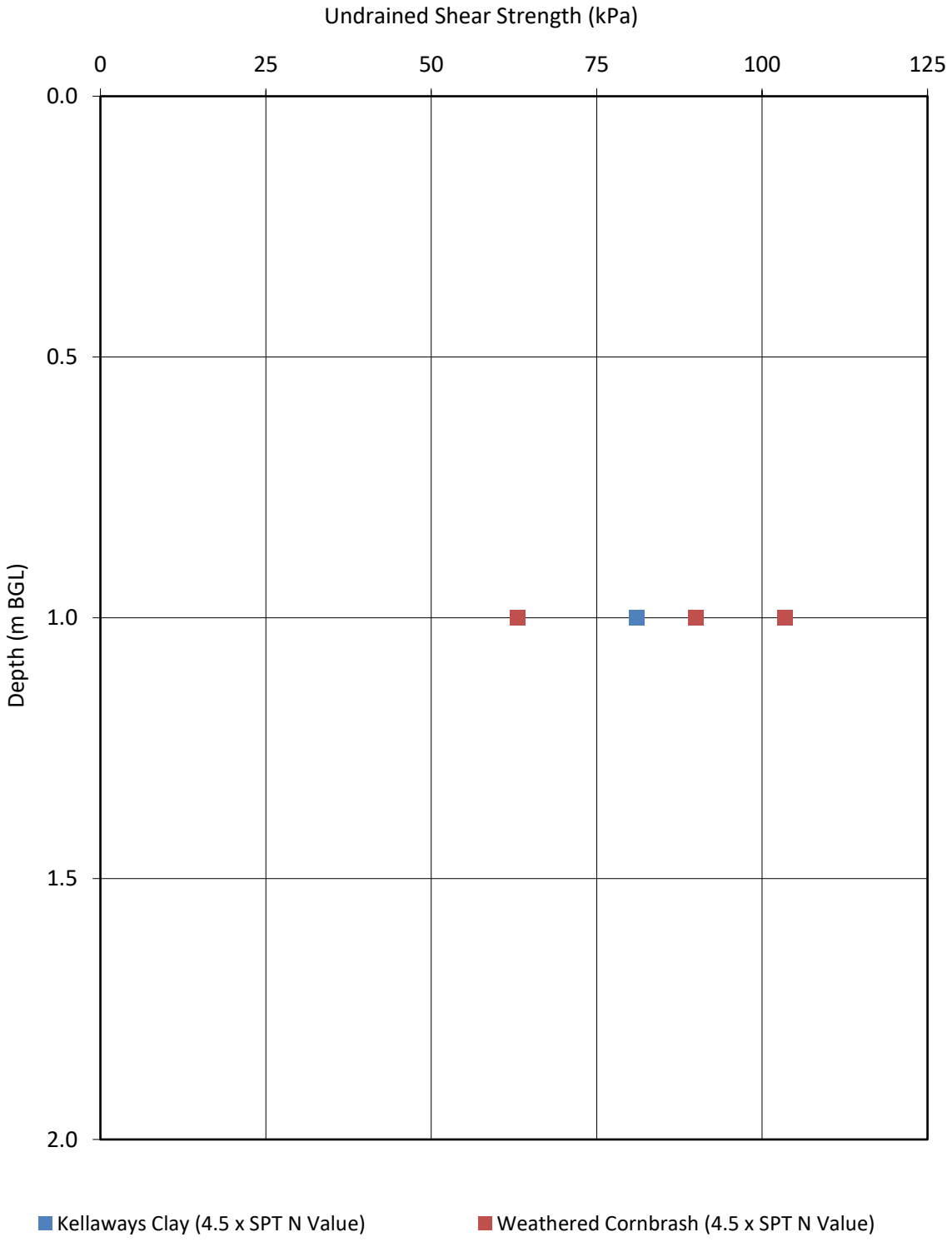


Figure 4

Plasticity Index Chart

Project:

Green Lane, Chesterton

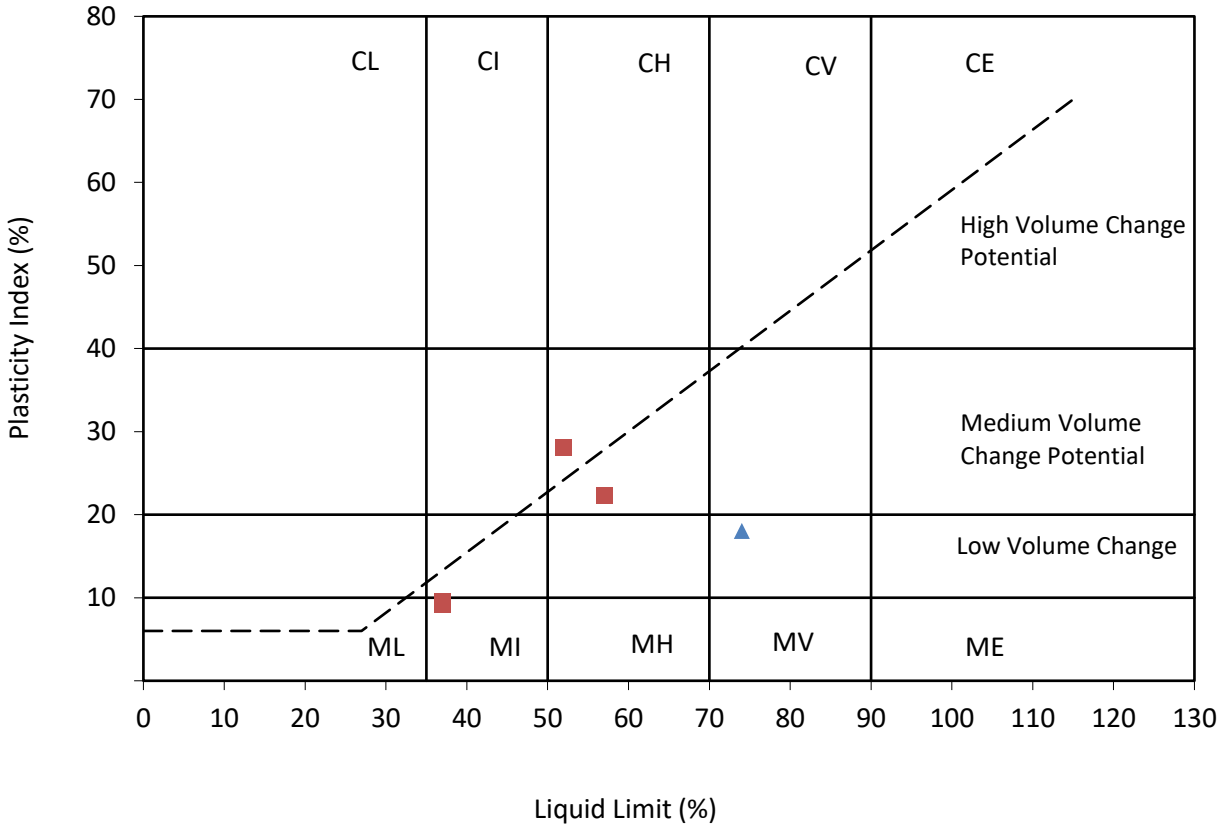
Project No:

C86354

Key:

C Clay M Silt

L Low plasticity
I Intermediate plasticity
H High plasticity
V Very high plasticity
E Extremely high plasticity



▲ Kellaways Clay Member ■ Weathered Cornbrash — — — A Line

Figure 5

Moisture Content / Depth Relationship

Project:

Green Lane, Chesterton

Project No:

C86354

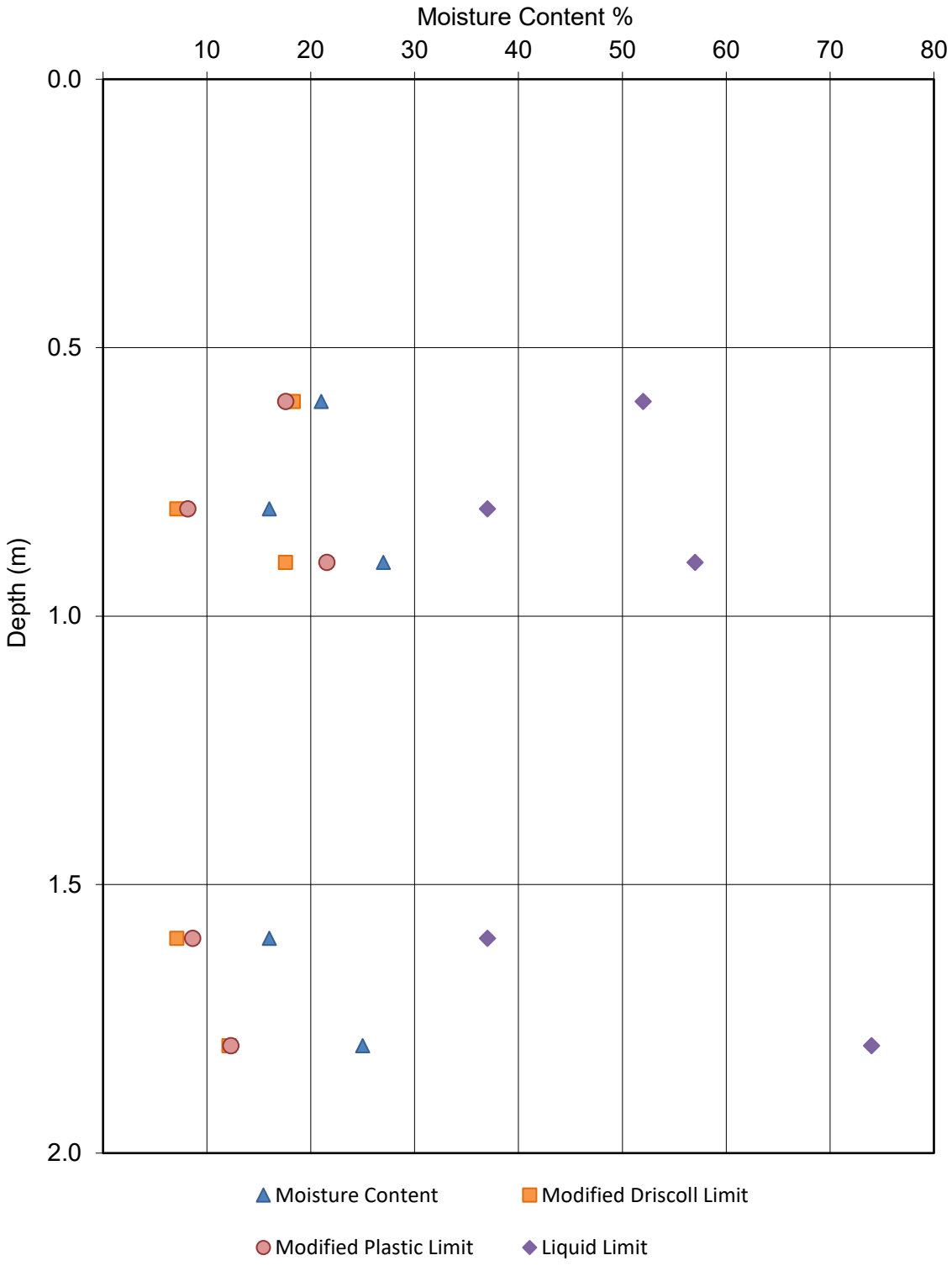


Figure 6

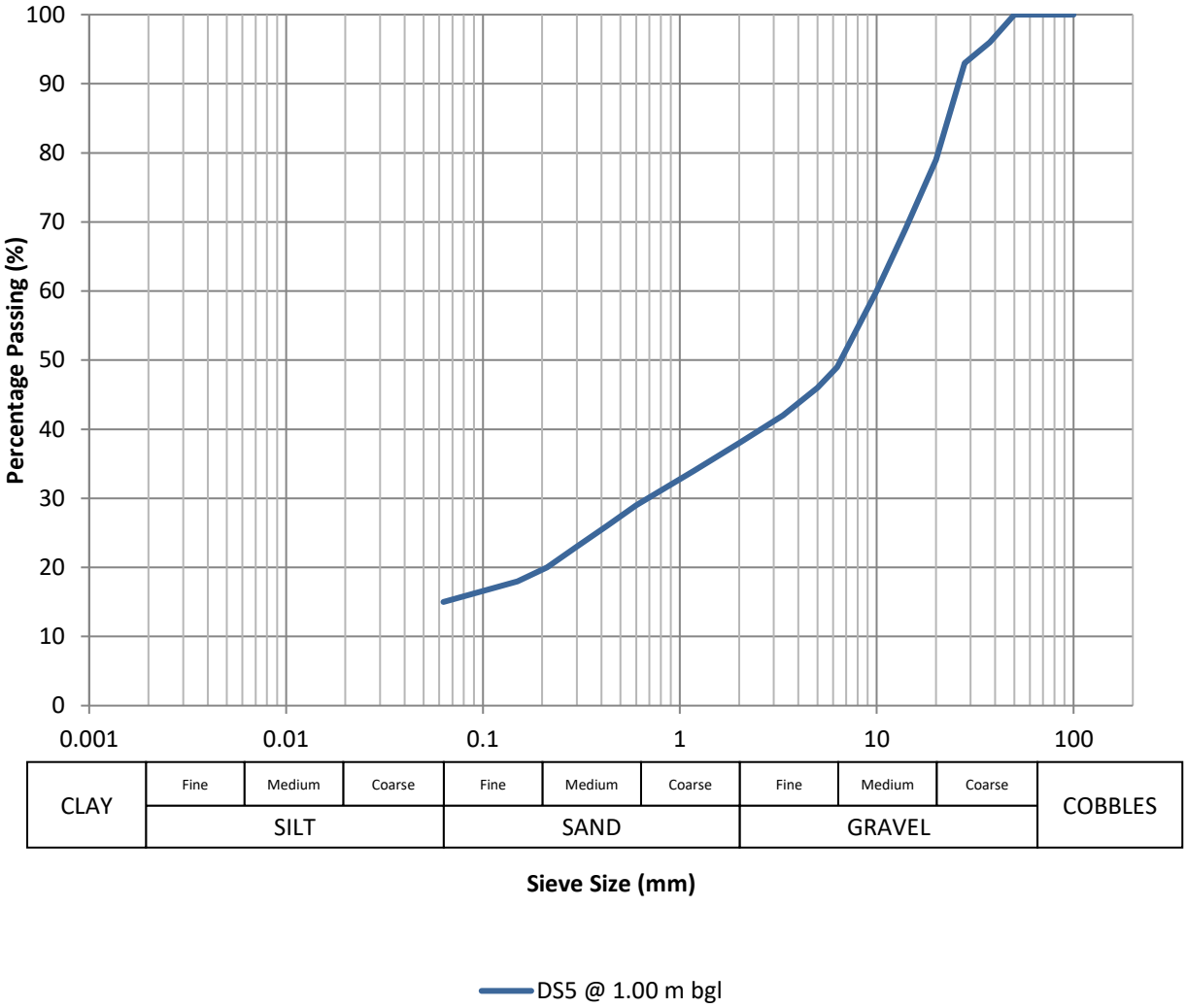
Particle Size Distributions

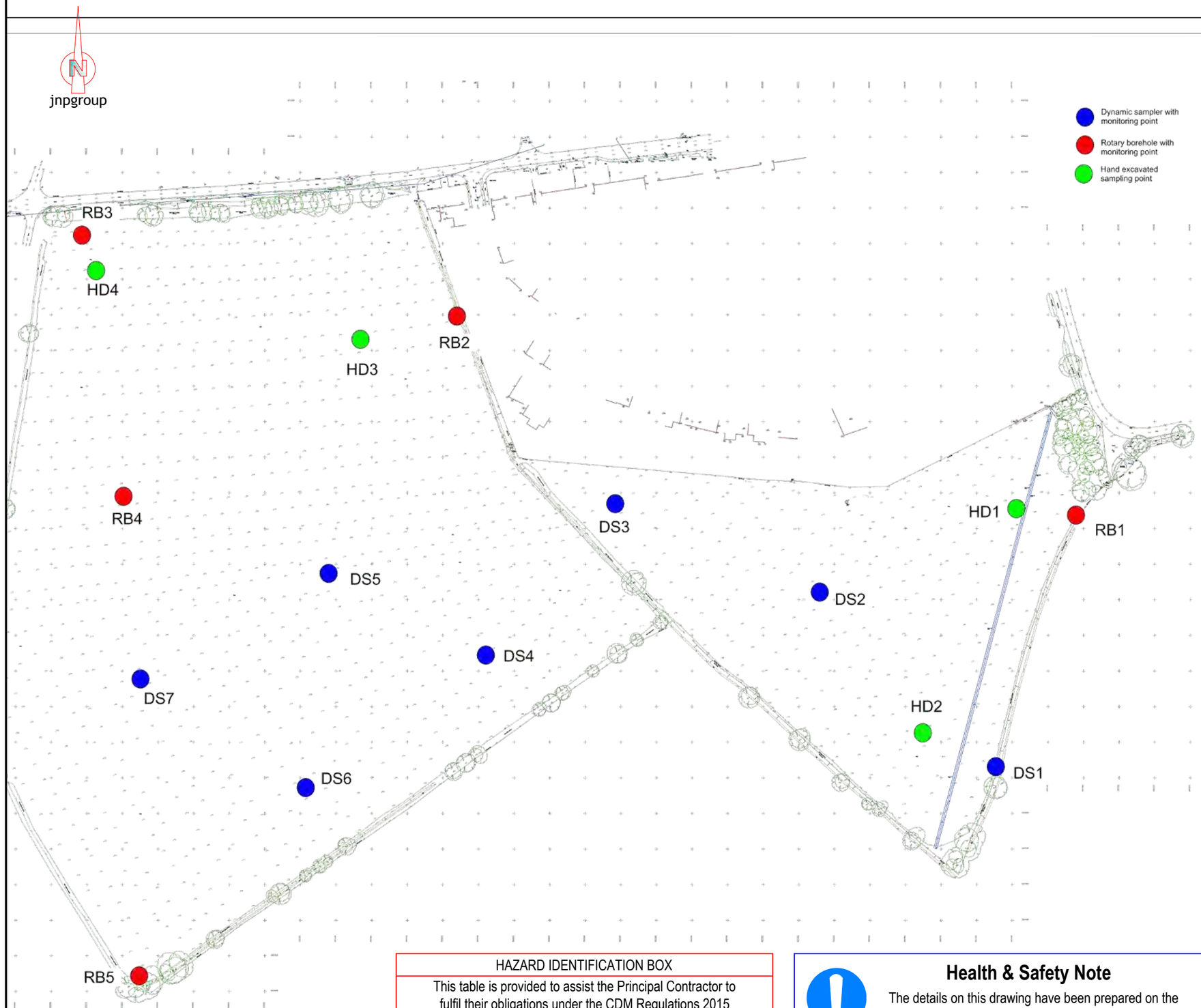
Project:

Green Lane, Chesterton

Project No:

C86354





HAZARD IDENTIFICATION BOX			
This table is provided to assist the Principal Contractor to fulfil their obligations under the CDM Regulations 2015			
Hazard Ref	Hazard Type (Construction/Maintenance/ Cleaning/Demolition/Adaptation)	Hazard Description	Mitigation Measures/ Residual Risk
1			

Health & Safety Note

The details on this drawing have been prepared on the assumption that a competent contractor will be carrying out the works. If the contractor(s) considers that there is insufficient Health and Safety information on this drawing, this should immediately be brought to the attention of the designer.

Rev.	Date	Description	Drn / Chk'd / App'd
P01	26/05/2022	First issue	JP/CAW/CAW

Suitability:

S2 - Suitable for Information

JNP GROUP
CONSULTING ENGINEERS
Chesham • Brighouse • Bristol • Glasgow • Hartlepool • Leamington Spa • Sheffield
www.jnpgroup.co.uk

Client:

Wates Developments

Job:

Green Lane, Chesterton

Title:

Exploratory Hole Location Plan

Classification: FI_60_20

Scale @ A3: NTS

Project - Originator - Volume/System - Level/Location - Type - Discipline - Number

C86354 - JNP-XX-XX- SK -G- 7002

Document/Drawing Number

Revision: P01

JNP Group Internal Project Number: C86354

APPENDIX A: LIMITATIONS

INTRODUCTION

This report is confidential and has been prepared solely for the benefit of the client and those parties with whom a warranty agreement has been executed, or with whom an assignment has been agreed. Should any third party wish to use or rely upon the contents of the report, written approval must be sought from JNP Group; a charge may be levied against such approval. JNP Group accepts no responsibility or liability for the consequences of this document being used for any purpose or project other than for which it was commissioned, and: this document to any third party with whom and agreement has not been executed.

Any comments given within this report are based on the understanding that the proposed works to be undertaken will be as described in the introduction and the information referred to and provided by others and will be assumed to be correct and will not have been checked by JNP Group and JNP Group will not accept any liability or responsibility for any inaccuracy in such information.

Any deviation from the recommendations or conclusions contained in this report should be referred to JNP Group in writing for comment and JNP Group reserve the right to reconsider their recommendations and conclusions contained within. JNP Group will not accept any liability or responsibility for any changes or deviations from the recommendations noted in this report without prior consultation and our full approval.

The details contained within this report reflect the site conditions prevailing at the time of investigation. JNP Group warrants the accuracy of this report up to and including that date. Additional information, improved practice or changes in legislation may necessitate this report having to be reviewed in whole or in part after that date. If necessary, this report should be referred back to JNP Group for re-assessment and, if necessary, re-appraisal.

This report is only valid when used in its entirety. Any information or advice included in the report should not be relied upon until considered in the context of the whole report. Whilst this report and the opinion made herein are correct to the best of JNP Group' belief, JNP Group cannot guarantee the accuracy or completeness of any information provided by third parties.

The report represents the finding and opinions of experience geotechnical and geo-environmental engineers. JNP Group does not provide legal advice and the advice of lawyers may also be required.

It should be noted that the following were not included as part of the agreed scope of works with the client: detailed ecological surveys and assessment; groundwater sampling.

JNP Group has provided advice and made recommendations based on the findings of the work undertaken, however this is subject to the approval / acceptance by the relevant Regulatory Authorities.

Objectives

The work undertaken to provide the basis of this report comprised a study of available documented information from a variety of sources (including the Client), together with (where appropriate) a brief walk over inspection of the site. The opinions given in this report have been dictated by the finite data on which they are based and are relevant only to the purpose for which the report was commissioned. The information reviewed should not be considered exhaustive and has been accepted in good faith as providing true and representative data pertaining to site conditions. Should additional information become available which may affect the opinions expressed in this report, JNP Group reserves the right to review such information and, if warranted, to modify the opinions accordingly. It should be noted

that any risks identified in this report are perceived risks based on the information reviewed; actual risks can only be assessed following a physical investigation of the site.

Phase II Intrusive Investigations

The investigation of the site has been carried out to provide sufficient information concerning the type and degree of contamination, and ground and groundwater conditions to allow a reasonable risk assessment to be made.

Where intrusive investigations have been undertaken, they have been designed to provide a reasonable level of assurance on the conditions. Given the discrete nature sampling, no investigation technique is capable of identifying all conditions present in all areas. The number of sampling points and the methods of sampling and testing do not preclude the existence of localised “hotspots” of contamination where concentrations may be significantly higher than those actually encountered. The risk assessment and opinions provided, inter alia, take into consideration currently available guidance relating to acceptable contamination concentrations; no liability can be accepted for the retrospective effects of any future changes or amendments to these values.

The objectives of the investigation have been linked to establishing the risks associated with potential human targets, building materials, the environment (including adjacent land), and to surface and ground water. The amount of exploratory work and chemical testing undertaken has necessarily been restricted by the short timescale available, and the locations of exploratory holes have been restricted to areas unoccupied by the building(s) on the site and by buried services.

Gas and groundwater levels may vary from those reported due to seasonal, or other effects.

APPENDIX B: THIRD PARTY DRAWINGS

Proposed redevelopment layout - Allen Pyke Drawing 2903-LA-02, dated April 2022

DRAFT FOR DISCUSSION

Allen Pyke
Landscape • Urban • Environmental
The Factory, 2 Acre Road, Kingston upon Thames, Surrey KT2 6EF
T 020 8549 3434 www.allenpyke.co.uk
KINGSTON UPON THAMES • CAMBRIDGE

Green Lane, Chesterton

Illustrative Landscape Masterplan

Client: WATES DEVELOPMENTS

Drawing Number: 2930-LA-02
Project Number: 2930
Scale: NTS @ A3
Date: 19/04/22
Revision: -
Status: DRAFT
Drawn by/ Chk: CR/CR

APPENDIX C: PHOTO DOCUMENT

C86354
Green Lane, Chesterton
Photographs of Site

1- Western field from west

2- North-east across western field showing limestone gravel in soil

3- Looking west across north of western field showing end of shallow ridge

4- Looking south along east of western field showing limestone gravel in soil

5- Looking north along east of western field showing limestone gravel in soil

6- Looking south along eastern boundary of western field near mid-point

7- South-east of western field showing wet soil

8- Looking north-west from south-eastern corner of western field

9- South-western corner of western field

10- Western field from adjacent road

11- Looking west to north across eastern field

12- Looking north across eastern field from southern corner

13- Looking north across centre of eastern field

14- Looking east along northern boundary of eastern field

15- Looking east along northern boundary of eastern field

Ditch along east of western field

Ditch along east of western field

Ditch along east of western field

Ditch along south of western field

C86354
Green Lane, Chesterton
Photographs of Site

Ditch at southern corner of western field

Ditch at southern corner of western field

Ditch along east of eastern field

Ditch along west of eastern field

Ditch along west of eastern field