

COMBINED STAGE 1/STAGE 2

GEO-ENVIRONMENTAL REPORT

AT

195 LEEDS ROAD

HECKMONDWIKE

ON BEHALF OF

ORION HOMES LTD

ARP GEOTECHNICAL LTD

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CONTENTS

		Page
1.0	Executive Summary	4 - 5
2.0	Terms of Reference	6 - 7
3.0	Site Description	8 - 10
4.0	Environmental Setting	11 - 14
5.0	Preliminary Risk Assessment and Conceptual Model	15 - 19
6.0	Site Investigation	20 - 21
7.0	Summary of Ground Conditions	22 - 23
8.0	Contamination Assessment	24 - 29
9.0	Geotechnical Testing	30 - 31
10.0	Geotechnical Assessment	32 - 35

APPENDICES

Appendix A	Site Location Plan and Aerial Photograph
Appendix B	Site Walkover Photographs
Appendix C	Ordnance Survey Archive Maps
Appendix D	Landmark Geology Maps
Appendix E	Coal Mining Report
Appendix F	Landmark Envirocheck Report
Appendix G	Risk Categorisation Tables
Appendix H	Indicative Proposed Site Layout and Conceptual Site Model
Appendix J	Borehole and Trial Pit Location Plan and Logs
Appendix K	Laboratory Test Certificates and Screening Values
Appendix L	Method Statement for Assessment of Imported Soils

1.0 EXECUTIVE SUMMARY

The pertinent conclusions of the report are tabulated below. However, the information below is not exhaustive, and it is recommended the report is read in its entirety.

Proposed Development	Residential dwellings with private gardens.
Existing Site Description	Vast majority of site comprises undeveloped grassed grazing fields. Small area in the southeast is existing residential and outbuildings.
Site History	Only fields shown to have been present on majority of site. Limited residential development in a small area of the southeastern corner.
Geology	Undifferentiated strata (mudstones, siltstones and minor sandstones) of the Lower Coal Measures. No superficial deposits. A fault and a coal seam outcrop are shown to cross the site.
Coal Mining	Potential risk from shallow workings beneath the site – rotary borehole investigation is recommended
Hydrogeology	Site underlain by Minor Aquifer. No abstractions within 1km.
Hydrology	No watercourses shown within 500m downslope of the site. No active abstractions for sensitive uses within 1km. Not at risk of river flooding.
Radon	Basic radon protection measures recommended, to minimise conveyancing issues.
Ground Gas	Gas monitoring is ongoing, and the results will be reported separately on completion.
Ground Conditions	Made ground only found at one location, 0.4m thick. Sequence of gravelly clays onto clayey gravels onto mudstone, consistent with in situ weathering of Coal Measures mudstone. 0.7m thick weathered coal found in one borehole on the north of the site.
Ground Contamination	None detected; however, access was not available to the small existing residential area in the southeastern corner.
Contamination Action	Asbestos survey of existing buildings and outbuildings in the southeastern corner. Any made ground (other than natural aggregate) uncovered during the development works shall be

	inspected, sampled and tested. Works on the affected materials shall cease until the appraisal is complete and, if necessary, a Remediation Statement is to be prepared and approved by the Planning Authority before work is recommenced. Control of any imported soil is required.
Foundations	The natural firm to stiff clays (below any soft clay) are suitable for the use of strip/trench fill foundations. Tree survey required.
Excavations	Likely to remain stable in the short term. Groundwater ingress may occur but should be controllable by pumping. Bedrock as shallow as 1.4m in some areas, may require a breaker, as may have existing foundations and buried structures in the existing residential area.
Concrete	GEN1 designation for unreinforced buried concrete. For any reinforced buried concrete, other design-specific mixes will apply.
Soakaways	A Soakaway Feasibility Assessment was carried out for the site by ARP (reference ORH/25/JRjcl2 dated 7th November 2024). The report concluded that soakaways are not appropriate on the site.
Road Pavement	A design CBR value of 3% is considered applicable on the natural clay.

2.0 TERMS OF REFERENCE

2.1 Orion Homes Ltd is considering developing the site at 195 Leeds Road, Heckmondwike, West Yorkshire, with residential properties. It was considered appropriate to implement a desk study and ground investigation to provide information to aid the planning process, viability assessment, and design of any subsequent development.

2.2 ARP Geotechnical Ltd was appointed by Orion Homes Ltd to carry out the investigation, which involved a desk study assessment of the geological and coal mining aspects, Ordnance Survey archive maps, radon gas, indicative flood risk, hydrogeology, landfill, and other environmental issues, primarily by assessment of a Landmark Envirocheck Report. This was supplemented by an intrusive investigation to assess the ground conditions.

2.3 The investigation was implemented generally in accordance with BS 5930:2015 +A1:2020 "Code of practice for site investigations", NHBC Standard Chapter 4.1 "Land quality - managing ground conditions", Environment Agency LCRM "Land Contamination Risk Management" and BS10175 : 2011 + A2 : 2017 "Investigation of potentially contaminated sites - Code of practice". This report is limited to the data obtained as part of this investigation. It should be noted that there is a possibility of variation in ground conditions between test locations and interpretation of strata is given for guidance only. No liability is accepted for changes to site conditions, including groundwater levels, after the preparation of this report.

2.4 The general observation and assessment of the ground surface, and the identification/classification of vegetation is made in general terms only. It would be prudent for a specialist to undertake a more detailed survey, including for any invasive/harmful weeds.

2.5 The assessment of any topsoil is carried out in terms of potential chemical effects on human health only, and no account is taken of aesthetic or horticultural properties. Such considerations should be referred to a horticulturist or landscape architect.

2.6 The report has been prepared for the use and reliance of the Client only. The report shall not be relied upon or transferred to any other parties without the written agreement of ARP Geotechnical Ltd. For the avoidance of any doubt, where ARP Geotechnical Ltd enters into a letter of reliance for the benefit of a third party, that third party will be permitted to rely on the report. No responsibility will be accepted where this report is used, either in its entirety or in part, by any other party without ARP Geotechnical Ltd.'s consent.

2.7 Attention is drawn to the requirements of the Construction Design and Management Regulations 2015, and in particular the duties and obligation of the Client.

2.8 The report refers to, and includes, a copy of an indicative proposed layout. This is only for the purposes of generating a conceptual site model for the contamination risk assessment. Unless the proposed layout changes significantly, such that the conceptual model and risk assessment is affected, there is no requirement to re-issue this report when the layout is revised.

3.0 SITE DESCRIPTION

Site Location

3.1 The site, which is centred on Ordnance Survey Grid Reference 421500, 424740 , is located off Leeds Road, on the northern edge of Heckmondwike, in West Yorkshire.

3.2 A site location plan and aerial photograph are presented in Appendix A.

3.3 A walkover survey was conducted on 17th and 22nd October 2024. Details obtained from the walkover are discussed below, and a selection of photographs taken during the survey are presented in Appendix B.

3.4 The site has overall dimensions of approximately 115m (northwest – southeast) by 115m (northeast – southwest).

On-Site Features

3.5 The vast majority of the site comprises four undeveloped grassed agricultural fields with the appearance of being used for grazing animals. Other vegetation (bushes and trees) is limited mainly to the southern and western boundaries. There are some bushes also along parts of the northern and northeastern boundaries.

3.6 The fields are separated by post and wire fences. A narrow grassed area provides access from the farm road at the northeastern boundary. A smaller area of the site comprises the buildings, gardens and outbuildings associated with two semi-detached dwellings in the southeastern corner of the site. This area was inaccessible at the time of the investigation and walkover, and equates to a size of approximately 60m long by an average of 20m wide.

3.7 The site and surrounding area slope down to the south, at a gradient of around 1 in 20, although a steeper slope is present off-site to the north, of around 1 in 7.

Site Boundaries and Surrounding Land Use

3.8 The site is bounded to the north, and part of the northeast, by an access track to a farm adjacent to the northern boundary. Residential properties abut the eastern, southeastern, and southwestern boundaries of the site. Farmland is present across the track to the north (surrounding the farm) to the northeast, and northwest.

Site History

3.9 Ordnance Survey archive maps were obtained for the site. Copies of the maps are included in Appendix C, and a summary of the findings is given below.

Map Date	On-Site	Off-Site
1854	The site is part of a larger field.	Coal pits 20m and 30m to the southeast. A farm or dwelling called "Stubley" is adjacent to the north/northwest. The remaining adjacent areas are undeveloped. The main road (Later named Leeds Road) is already present, adjacent to the southern boundary of the site.
1894	More detail is evident. There is a small enclosure in the northwestern corner of the site (removed by 1938).	Coal pits no longer shown.
1932	Two dwellings are now present on the southern protruding section of the site, adjacent to Leeds Road.	Residential properties are adjacent to the southwest and south/southeast.
Later maps	No significant change. Recent aerial imagery shows the site has been informally sectioned into several fields.	No significant change.

3.10 In summary, there is no indication of any potentially contaminating use of the site, or of significant development, except for limited residential development in the southeastern corner. Made ground and contamination is considered unlikely, but if present, is most likely to occur within any fill material used for the existing residential development in the southeast. Occasionally, fill may have been used on farmland to fill in low or poorly drained areas or create access, and this fill can contain man-made material with contaminants (for example ash, clinker, or asbestos cement fragments).

4.0 ENVIRONMENTAL SETTING

Geology

4.1 Extracts from the British Geological Survey 1:50,000 Series Geology Maps are included within the Envirocheck Geology Report in Appendix D. The maps show the site to be underlain by undifferentiated strata (mudstones, siltstones and minor sandstones) of the Pennine Lower Coal Measures of the Carboniferous Period. No superficial deposits are indicated on or near the site.

4.2 A significant fault is conjectured to cross the western section of the site, trending northwest – southeast, between 10m and 35m inside the southwestern boundary. A further fault is shown trending almost north to south, between approximately 15m and 20m outside the eastern site boundary.

4.3 A coal seam (the Flockton Thick) is conjectured to outcrop on the site, with the outcrop crossing approximately east-west on the northern quarter, at an elevation of 124mAOD at the western boundary and 122mAOD at the eastern boundary.

Coal Mining

4.4 A CON29M Coal Mining Report was obtained from Terrafirma, as part of a Coal Mining Risk Assessment Desk Study (CMRA) carried out by ARP (reference ORH/25/JRjcl1, dated 7th November 2024). A copy of the CON29M report is included in Appendix E, and a summary of the findings of the CMRA is given below.

4.5 The Flockton Thick coal seam is concluded to pose a potential risk to ground stability on the northern quarter of the site (north of its outcrop). There is also a potential risk, including on the wider site, from workings in the underlying Flockton Thin Coal, possibly present at depths of between 5m and 20m.

4.6 A rock drilling investigation will need to be carried out to check for any evidence of workings within the upper 30m of strata below the site, and determine the depths, seam thicknesses, and extraction thickness. The Coal Authority should be contacted to determine what abandonment plans may be available for the shallow seams. For the area west of the fault that crosses the southwestern edge of the site, there is uncertainty, due to contradictions in the published geology and the seams present.

4.7 There is one recorded mine entry within 20m of the site (an adit located 15m to the north, and heading away from the site). The adit is stated not to present any significant risk of ground instability to the site. There is a risk of unrecorded mine entries, considered to be slight on most of the site and higher on the northern quarter of the site. However, this can be addressed by Geotechnical Engineer inspection of the ground surface following the topsoil strip. In addition, site workers should be notified of their possible presence, and if any suspect features are identified during the site works, these should be inspected by a Geotechnical Engineer.

Hydrogeology

4.8 The Landmark Envirocheck Report, included in Appendix F, indicates the Bedrock Aquifer Designation to be "Secondary A". These Aquifers comprise "permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers".

4.9 There are no groundwater abstractions within 1km of the site, and the site is not within a groundwater Source Protection Zone.

Hydrology

4.10 The general area slopes to the south. There are no watercourses shown within 500m downslope of the site, although archive maps show a small stream or open drain

approximately 100m west of the site. Development to the south and southwest of the site is likely to have picked up minor drainage features.

4.11 The site is not in an area at risk from river flooding. The risks of flooding from other causes such as adverse topography or insufficient surface water drainage, are not considered here. If such risk needs to be quantified, a separate specialist Flood Risk and Drainage Report should be commissioned, if not already available. BGS data show the site has limited potential for groundwater flooding. However, 68m to the south, there is potential for groundwater flooding of property situated below ground level (e.g. basements).

4.12 There are no surface water abstractions for sensitive uses within 1km of the site.

Other Environmental Data

4.13 The Landmark Envirocheck Report, included in Appendix F, contains information on numerous environmental aspects. A summary of the pertinent findings, not already covered, with additional comments, is given below.

4.13.1 There are several Pollution Control Authorisations within 1km of the site including Control of Major Accidents Hazards (COMAH) sites relating to chemical works around 500m to the northwest. However, none are within 400m of the site.

4.13.2 There are no discharge consents relating to, or adjacent to, the site.

4.13.3 There are no closed or currently licenced landfills within 250m of the site.

4.13.4 No radon protective measures are stated to be necessary for new dwellings or extensions on the site. However, the site is in an intermediate probability radon area, as between 1% and 3% of homes are above the action level. In these circumstances of apparent conflict, it may be prudent to assume basic radon protection is required, to prevent conveyancing difficulties. This is normally achieved by incorporating a radon barrier within a solid floor system, and extending the barrier through the cavity wall.

4.13.5 There are no contemporary trade directory entries relating to any activities which could have significant impact on the site.

4.13.6 There are no fuel station entries within 250m of the site.

5.0 PRELIMINARY RISK ASSESSMENT AND CONCEPTUAL MODEL

5.1 Part II A of the Environmental Protection Act (EPA) 1990 became effective from 1st April 2000. The Regime was introduced by the Contaminated Land (England) Regulations 2000 (SI 2000, No. 227) along with the associated DEFRA Circular February 2000.

5.2 Section 78A (2) of the Act defines "Contaminated land is any land ……. in such a condition, by reason of substances in, on or under that land that –

(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 caused, or there is a significant possibility of such pollution being caused".

From S78A (4) "Harm" : means harm to the health of living organisms or other interference with the ecological systems of which they form part and, in the case of man, includes harm to his property.

Controlled waters are defined as "..the waters in any relevant lake or pond, or of so much of any relevant river or watercourse as is above the freshwater limit, and ground waters, that is to say, any waters contained in underground strata". From the 1st October 2004, the definition of groundwater in relation to Part IIA was amended, by the Second Water Act Commencement Order SI 2004 No 2528. This makes clear that "ground waters" does not include waters above the saturation zone, i.e. does not include any soil water and pore water present in the unsaturated zone.

5.3 The objectives of the regime are to ensure that risks associated with contaminated land are reduced to an acceptable level, having regard to the costs of doing so. The costs should be proportionate, manageable and economically sustainable.

5.4 In assessing risk, it is necessary to consider the probability, or frequency, of occurrence of the hazard and the magnitude/seriousness of the consequences. Consequently, for land to be classified as contaminated, it must have, or be very likely to have, a detrimental effect on humans or the environment before it can be classified as contaminated land.

5.5 In establishing risk, the concept of the pollutant source/pathway/receptor linkage model, based on current and proposed site use, is to be considered. Therefore for a site to be deemed contaminated under the Regime, all three linkages must be in place i.e. the site must not only contain harmful substances, but the substances must have a pathway by which to leak out and cause significant harm to a receptor.

5.6 The Environment Agency has published guidance on contaminated land, in the form of online documents referred to as LCRM "Land Contamination Risk Management". The documents are intended to provide the technical framework for structured decision making about land contamination, and to assist all those involved in "managing" the land, in particular landowners, developers, financial service providers, planners and regulators. As the documents currently provide the framework for best practice, the general principles are, therefore, followed in conducting the assessment below.

5.7 The categorisations of risk adopted in this report are adapted from CIRIA Report C552 (Contaminated Land Risk Assessment: A Guide to Good Practice, 2001). This approach assesses the potential severity of any pollution event and the probability of the event occurring, to arrive at a risk category, for the various potential source - pathway - receptor linkages. The relevant tables used, with the definitions, are presented in Appendix G.

Conceptual Site Model

5.8 It is known that the site is proposed for residential dwellings, including private gardens. An indicative proposed site layout is included in Appendix H. The site is shown to be underlain by undifferentiated strata (mudstones, siltstones and minor sandstones) of the Pennine Lower Coal Measures, that are likely to have been weathered in the upper few metres to

stony clays. A fault and coal seam outcrop also cross the site, and there are suspected to be shallow underground coal workings beneath the site. The solid strata beneath the site are designated a Secondary A Aquifer. There are no groundwater abstractions within 1km of the site. There are no watercourses shown within 500m downslope of the site, although archive maps show a small stream or open drain approximately 100m west of the site. Development to the south and southwest of the site is likely to have picked up minor drainage features. There are no surface water abstractions for sensitive uses within 1km of the site.

5.9 There is no indication of any previous development on the site, other than houses on the southern margin of the site, fronting Leeds Road. The most likely contamination sources are considered to be:

5.9.1 Possible made ground (most likely on the south, least likely further north): – metals inorganics, total petroleum hydrocarbons (TPH), polyaromatic hydrocarbons (PAH), phenol, asbestos.

5.9.2 Possible asbestos within existing buildings on the southern margins of the site.

5.9.3 Possible harmful gases from coal/workings: - methane, carbon dioxide.

5.10 The conceptual model needs to consider sources of contamination, pathways along which contaminants could migrate and the receptors, which may become exposed. Guidance published by the Environment Agency has been consulted with regard to pathways and receptors. The potential sources, pathways, and receptors, applicable to the proposed development are identified on the table below. Any pathways in italics are deemed not to be viable, and the reason given.

Potential Source - Pathway - Receptor Matrix (Finished Development)

Contamination Sources	Pathways	Receptors	Severity of Consequence	Probability of Event	Risk
Possible made ground: - metals, inorganics, TPH, PAH, phenol	• Inhalation, ingestion and dermal contact with soil and dust	**Humans:-** • Future occupants • Maintenance workers • Adjacent residents and general public	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Fruit and vegetable intake, with soil	**Humans (as above)**	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Vapour inhalation outdoor	**Humans (as above)**	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Vapour inhalation indoor	**Humans (as above)**	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Migration in surface water	• Surface water (none within 500m downslope. No sensitive abstractions within 1km)	**Mild**	**Unlikely**	**Very Low**
	• Migration in groundwater	• Groundwater (Secondary A Aquifer, no abstractions within 1km)	**Mild**	**Unlikely**	**Very Low**
	• Root uptake	**Vegetation:-** • Landscape areas • Private gardens	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Migration	**Services/Utilities:-** • Potable water supply	**Medium**	**Low Likelihood**	**Moderate/ Low**
Possible shallow workings/coal:- methane and carbon dioxide	• Asphyxiation • Explosive risk	• Construction/de-molition workers • Future occupants • Buildings	**Severe**	**Low Likelihood**	**Moderate**
Possible asbestos within existing buildings and possible made ground	• Inhalation	• Future occupants • Maintenance workers • Adjacent residents and general public	**Severe**	**Low Likelihood**	**Moderate**

5.11 A diagrammatic Conceptual Site Model for the finished development based on the potential contamination sources above, is presented in Appendix H. The above matrix indicates there are several potential source – pathway – receptor linkages applicable to the proposed development, ranging from moderate to very low risk.

5.12 The assessment was used to inform the design of the subsequent ground investigation. To fully characterise the site, in accordance with BS10175 : 2011 + A2 : 2017 "Investigation of potentially contaminated sites - Code of practice", and to address the above concerns, it was decided that, in addition to geotechnical information required, the site investigation should include:

5.12.1 Trial pits and windowless sample boreholes on a grid basis, preferably 25m maximum spacing.

5.12.2 Samples of the made ground issued for testing for a broad suite of determinands, including metals, inorganics, asbestos, phenols, speciated PAH, and TPH.

5.12.3 Ground gas monitoring due to the presence of a coal seam outcrop crossing the site, and potential shallow underground coal workings.

5.12.4 Upon receipt of contamination test results, any elevated TPH would be speciated to allow further risk assessment, and leachability testing undertaken on all elevated determinands, to give indication of mobility.

6.0 SITE INVESTIGATION

6.1 A site investigation was undertaken by ARP Geotechnical Ltd on 17th October 2024 and 22nd October 2024. The purpose of the investigation was to produce an assessment of the site in accordance with BS10175 : 2011 + A2 : 2017 "Investigation of potentially contaminated sites - Code of practice", and to provide geotechnical information to aid design of the development.

6.2 The site was gridded on a maximum 25m spacing and trial pits and windowless sample boreholes were sampled on the grid, to satisfy the requirements of the British Standard, along with any targeted locations. 10No. trial pits (TP1 to TP10) and 6No. boreholes (WS1 to WS6) were implemented, to depths of between 1.4m and 3.0m. Access to the existing residential development in the southeastern corner of the site was not available at the time of the investigation. The trial pits and boreholes were organised, supervised and logged by an Engineer from ARP Geotechnical Ltd. Justifications for the trial pit locations are given below.

LOCATION	REASON
TP1 to TP10	Part of grid
WS1	Part of grid and to install gas well above expected shallow coal/potential very shallow underground coal workings.
WS5	Part of grid and to install gas well close to geological fault potentially connected to underground coal workings within 30m depth.
WS6	Part of grid and to install gas well to determine levels close to the fault where shallow workings are absent.
WS2, WS3 & WS4	Part of grid

6.3 Three gas monitoring wells were installed, in WS1, WS5 and WS6, and subsequently monitored by ARP Geotechnical Ltd. The wells were installed to depths of between 2.0m and 2.5m, with the bottom 1m to 2m comprising slotted pipe with gravel surround, and the upper 0.5m to 1m comprising plain pipe with bentonite seal and lockable flush cover.

6.4 The trial pit and borehole logs are included in Appendix J, along with the location plan.

6.5 Chemical analysis of 8No. soil samples for metals, inorganics, speciated PAH, TPH, phenols, and asbestos was undertaken by the UKAS accredited Chemtest Laboratory in Newmarket. The test certificates are included in Appendix K.

6.6 Analysis for Atterberg Limits and moisture content was undertaken by the UKAS accredited TTL Laboratory in Doncaster. Geochemical testing comprising pH and water soluble sulphate was undertaken by Chemtest. The test certificates are included in Appendix K.

7.0 SUMMARY OF GROUND CONDITIONS

Strata and Groundwater

7.1 Made ground was only encountered in WS1, comprising made ground topsoil to 0.2m depth including gravel of sandstone and brick, overlying clay to 0.4m depth which contained gravel of brick, coal and sandstone. At all remaining locations, natural topsoil was present at the surface, to depths of between 0.2m and 0.3m.

7.2 The made ground and topsoil was found to be underlain by slightly gravelly clays, with the gravel usually of mudstone and rare coal. In all but WS1 and WS3, the clay was soft in the upper 0.2m to 0.3m thickness (to depths of between 0.5m and 0.6m). Below this, the clays were generally firm and stiff, with an increasing granular content of mudstone with increasing depth, including cobbles, typical of in situ weathering of Coal Measures strata. In TP8, the clay continued to be soft to a depth of 1.4m.

7.3 From depths of between 1.0m and 1.9m, the clays transitioned to generally clayey sandy gravel with moderate cobble content. The granular content comprised mudstone, generally subangular. In WS1 (only), coal was found to be present between 1.6m and 2.3m depth (0.7m thick) and was clayey and weathered in nature. The presence of coal corresponds with the geological maps, which show a coal seam outcrop to cross the site to the south of WS1.

7.4 Cone SPTs refused at depths of between 2.04m and 2.72m, indicating solid strata, presumed to be mudstone. All the trial pits were halted by solid mudstone at depths of between 1.4m and 3.0m.

7.5 The excavations generally remained stable for the short period of exposure and the pits were backfilled with the arisings on completion. In around half of the trial pits (TP2 to TP4, and TP7 to TP9), slight to moderate groundwater ingress was observed between depths of 1.0m (TP3 and TP8) and 2.2m (TP2 and TP7). In TP8, the strata were also noted to be wet from 0.8m depth.

Gas Monitoring

7.6 Gas monitoring is currently being undertaken in accordance with BS 8576: 2013 "Guidance on investigations for ground gas – Permanent gases and Volatile Organic Compounds (VOCs)". The findings will be reported separately on completion of the monitoring.

Coal Mining

7.7 A need for a rotary borehole investigation has been identified, to assess risks to the site from underground coal mining. This is programmed for the near future and the findings will be reported separately on completion.

7.8 There is a risk of unrecorded mine entries, considered to be slight on most of the site and higher on the northern quarter of the site. However, this can be addressed by Geotechnical Engineer inspection of the ground surface following the topsoil strip (mine entries often show as a patch of differently coloured material). In addition, site workers should be notified of their possible presence, and if any suspect features are identified during the site works, these should be inspected by a Geotechnical Engineer.

8.0 CONTAMINATION ASSESSMENT

Screening Values - Soils

8.1 In March 2014, DEFRA published Category 4 Screening Levels (C4SLs) for six contaminants: arsenic, benzene, benzo(a)pyrene, cadmium, chromium VI and lead for soils which should be used in contamination assessment for proposed development. Two further C4SLs for naphthalene and inorganic mercury were added in 2024. The values are based on the toxicological benchmark of a "low level of toxicological concern" (LLTC) rather than the previous regulatory approach of "minimal or tolerable level of risk". As the C4SLs are less protective of health than the previous approach, the Chartered Institute of Environmental Health (CIEH) has advocated an alternative approach based on minimal risk, but with some adjustment of exposure parameters to more realistic scenarios than those previously used. To this end, the CIEH has collaborated with Land Quality Management to publish "Suitable 4 Use Levels" (S4Uls) "The LQM/CIEH S4Uls for Human Health Risk Assessment", November 2014 (LQM/CIEH). However, DEFRA has reiterated its intention that the C4SLs should be used in generic risk assessment for proposed development, and there is indication that other parties will collaborate, in the near future, to extend the range of C4SL determinands beyond the eight published so far.

8.2 Soil contamination test results in this report have been compared first against the more conservative S4UL, and where a C4SL exists for the same determinand, consideration given to the use of the C4SL for any exceedances of the S4UL, within the site-specific context (including the use of benzo(a)pyrene as a surrogate marker for genotoxic PAH compounds, where appropriate). Where no S4UL exists for a determinand, for example lead, the C4SL has been used. The LQM/CIEH screening values have been calculated for soil organic matter contents of 1% and 2.5%, as well as 6%, and the appropriate screening value is used for the organic matter content of the soil. All the C4SL values published are for a soil organic matter content of 6%.

8.3 A table showing the screening values utilised is included in Appendix K.

Soils Analysis

8.4 Eight soil samples were issued to the UKAS accredited Derwentside Environmental Testing Services in Consett for a suite of testing (As, Cd, Cr (VI), Cr(III), Cu, Hg, Ni, Pb, Se, Zn, Total Sulphate, Water Soluble Sulphate, pH, Phenol-monohydric, Speciated PAH, Total TPH, Asbestos, and Organic Matter). The testing comprised:

- 1No. sample of Made Ground from WS1 (made ground was only found at this location)
- 3No. samples of Natural Topsoil from WS3, TP3 and TP10
- 4No. samples of Natural clay from TP2, TP6 (two samples) and TP7

Natural Topsoil and Clay

8.5 A results summary table for determinands within the natural topsoil and clay found to be above screening values is given below

Sample	Arsenic	Nickel	Material
WS3	12	10	Natural Topsoil
TP3	39	27	Natural Topsoil
TP10	16	16	Natural Topsoil
TP2	13	54	Natural Clay
TP6	11	24	Natural Clay
TP6	3.0	16	Natural Clay
TP7	3.3	16	Natural Clay
Screen Values	**37.0**	**50.0**	
95% UCL *	**22.8**	**34.1**	

All values in mg/kg unless indicated otherwise

Exceedance

Acceptable (and no outliers)

8.6 The testing revealed isolated slight exceedances of the screening values for arsenic and nickel within the natural topsoil and clay. However, when the overall concentrations are considered, it can be seen from the table that the 95% UCL concentrations are below the screening value, with no outliers and the slight exceedances are attributed to part of the range caused by random variation. No further assessment or remedial measures are considered to be required.

Made Ground

8.7 The one sample of made ground obtained (made ground was only found in WS1) did not reveal any exceedances of screening values.

Updated Risk Assessment and Conceptual Model

8.8 The site investigation did not reveal any ground contamination. However, the existing residential area in the southeastern corner of the site was not accessible at the time of the investigation and, as a result, the absence of any made ground and contamination in this area cannot be ruled out. The updated source – pathway – receptor matrix is presented on the following page, taking into account the findings of the investigation. Any pathways in italics are deemed not to be viable, and the reason given.

Potential Source - Pathway - Receptor Matrix (Finished Development)

Contamination Sources	Pathways	Receptors	Severity of Consequence	Probability of Event	Risk
Possible made ground **(southeastern existing residential area only)**: - metals, inorganics, TPH, PAH, phenol	• Inhalation, ingestion and dermal contact with soil and dust	**Humans:-** • Future occupants • Maintenance workers • Adjacent residents and general public	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Fruit and vegetable intake, with soil	**Humans (as above)**	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Vapour inhalation outdoor	**Humans (as above)**	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Vapour inhalation indoor	**Humans (as above)**	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Migration in surface water	• Surface water (none within 500m downslope. No sensitive abstractions within 1km)	**Mild**	**Unlikely**	**Very Low**
	• Migration in groundwater	• Groundwater (Secondary A Aquifer, no abstractions within 1km)	**Mild**	**Unlikely**	**Very Low**
	• Root uptake	**Vegetation:-** • Landscape areas • Private gardens	**Medium**	**Low Likelihood**	**Moderate/ Low**
	• Migration	**Services/Utilities:-** • Potable water supply	**Medium**	**Low Likelihood**	**Moderate/ Low**
Possible shallow workings, and known shallow coal:- methane and carbon dioxide	• Asphyxiation • Explosive risk	• Construction/de-molition workers • Future occupants • Buildings	**Severe**	**Low Likelihood**	**Moderate**
Possible asbestos within existing buildings and possible made ground **(southeastern existing residential area only)**	• Inhalation	• Future occupants • Maintenance workers • Adjacent residents and general public	**Severe**	**Low Likelihood**	**Moderate**

8.9 On the existing residential area in the southeastern corner of the site, the presence of made ground (with potential contamination) could not be ruled out during the investigation due to lack of access. If made ground is present, several pathways to receptors are potentially

operative. The remainder of the site was found to be free from ground contamination, with the topsoil and subsoil environmentally suitable for reuse on the site without any contamination remedial measures.

Further Contamination Requirements

Asbestos Within Buildings on Existing Residential Area

8.10 Provided an asbestos survey is carried out prior to any demolition or work on the existing buildings and outbuildings on the site, and any identified asbestos is removed and disposed to a licenced facility, then the risk to receptors is low. The work should be carried out by appropriately qualified Contractors.

Mine/Coal Gases

8.11 To address the potential risk from Coal and Mine Gases, monitoring of borehole wells is in progress. This will determine whether or not protection measures are likely to be necessary. This will be confirmed by separate letter report on completion of the monitoring.

Possible Made Ground on Existing Residential Area

8.12 The applicability of the several potential pathways identified on the existing residential area is dependent on the presence/absence of any made ground. Any made ground (other than natural aggregate) uncovered during the development works shall be inspected, sampled and analysed in laboratory for the suite of determinands contained in Appendix K and compared to the maximum concentration levels listed on the enclosure. Works on the affected materials shall cease until the appraisal is complete and, if necessary, a Remediation Statement is to be prepared and approved by the Planning Authority before work is recommenced.

Risks During Construction Period

8.13 It is also necessary to consider the effects of the contamination present on the site in relation to the risks to adjacent residents, construction workers and the general public during construction. This is assessed in the following matrix.

Source	Pathway	Potential risk	Risk after employing suitable Health and Safety plan.
Possible Asbestos in existing buildings	Inhalation	High	Provided an asbestos survey is carried out, and any identified asbestos is removed from site prior to any other works commencing, the pathway is blocked and the risk is negligible.

Imported Soils

8.14 Any imported soils proposed for use on the site will need to be verified as suitable by inspection and testing, in accordance with guidance supplied in the document produced by the Yorkshire and Lincolnshire Pollution Advisory Group (YALPAG): "Guidance on the Verification Requirements for Cover Systems".

8.15 A Method Statement for Assessment of Imported Soils is included in Appendix L

9.0 GEOTECHNICAL TESTING

9.1 Selected samples of the natural strata were delivered to PSL in Doncaster for testing with regard to plasticity indices and moisture content. Test certificates are presented in Appendix K and a summary of the results, including Modified Plasticity Indices, is given below.

Location	Depth (m)	MC	LL	PL	PI	% <425µm	I'p
TP1	1.0	24	44	21	23	77	17.7
TP5	1.6	21	38	22	16	91	14.6
TP9	0.6	29	52	27	25	100	25.0
	Max.	29	52	27	25	100	25.0

I'p	VCP
>40%	High
20% - <40%	Medium
10% - <20%	Low

MC= Moisture Content (%) LL= Liquid Limit (%) PL= Plastic Limit (%)
PI= Plasticity Index (%) I'p= Modified PI (%) VCP= NHBC Standard Chapter 4.2 Volume Change Potential

9.2 The plasticity test data show clays of intermediate to high plasticity, in accordance with BS 5930:2015 +A1:2020 "Code of Practice for Site Investigations". When the percentage retained on the 425 micron BS sieve is considered, the Modified Plasticity Index, in accordance with NHBC Standard Chapter 4.2 "Building Near Trees" is a maximum of 25. In accordance with the Standard, this equates to Medium Volume Change Potential.

9.3 Geochemical testing (water soluble sulphate and pH) was undertaken on selected samples by DETS, comprising seven. samples of natural strata and one sample of made ground (made ground was only found at one location). In accordance with the BRE Special Digest 1 "Concrete in aggressive ground", the characteristic values for the two materials are given below:

Characteristic Values

Material	pH	SO_4
Made Ground	8.1	10
Natural Strata	6.1	14.5

SO_4 = Sulphate content in mg/l on a 2:1 water : soil extract pH = Acidity

9.4 The geochemical analyses show the natural strata to have low water soluble sulphate content and near slightly acidic pH. The Aggressive Chemical Environment for Concrete (ACEC) class is AC-1. Testing on the made ground also indicates class AC-1. Therefore, the use of GEN1 designated concrete will be satisfactory for unreinforced buried concrete, in accordance with BS 8500-1:2015+A2:2019. For any reinforced buried concrete, other design-specific mixes will apply.

10.0 GEOTECHNICAL ASSESSMENT

Coal Mining and Coal Recovery

10.1 A need for a rotary borehole investigation has been identified, to assess risks to the site from underground coal mining. This is programmed for the near future and the findings will be reported separately on completion.

10.2 There is a risk of unrecorded mine entries, considered to be slight on most of the site and higher on the northern quarter of the site. However, this can be addressed by Geotechnical Engineer inspection of the ground surface following the topsoil strip (mine entries often show as a patch of differently coloured material). In addition, site workers should be notified of their possible presence, and if any suspect features are identified during the site works, these should be inspected by a Geotechnical Engineer.

Foundations

10.3 The natural firm to stiff clays on the site (below any soft clay found generally above 0.6m depth but locally to 1.4m depth), are considered suitable for the use of strip/trench fill foundations. An allowable bearing pressure of 80kN/m^2 is considered applicable.

10.4 The clays were shown to be of Medium Volume Change Potential. Therefore, in accordance with NHBC Standard Chapter 4.2 "Building Near trees", in the absence of trees, a minimum foundation depth of 0.9m below existing or proposed ground level is applicable, whichever is the lower. However, in the presence of any proposed, existing or removed trees, the foundation may need to be deepened, depending on the type of tree and its distance from the face of the foundation. If not already available, a tree survey may be required to enable a foundation schedule to be prepared. The tree survey will also need to consider trees on third party properties.

10.5 The foundation should be taken below the depth of any existing foundations or obstructions, onto natural ground. The whole plan area of the foundation should be placed on similar natural material. Foundations should be reinforced where it is necessary to transition from suitable granular to suitable cohesive strata within a proposed building footprint.

10.6 If bedrock is encountered on part of a foundation excavation, the rest of the plot should be deepened to ensure founding on similar material. However, if rock is not encountered by 2.5m depth on the remainder of the plot, then the Engineer should be contacted for further advice.

10.7 If underground mine workings are found that require drilling and grouting, the foundations will need to be 300mm thick and reinforced with two layers of B503 mesh – one near the bottom and one near the top. In any event, such reinforced foundations should be provided on the southwestern half of the site (i.e. the western side of the proposed road on the site) due to the presence of a significant geological fault.

Excavations

10.8 It is likely that excavations into the natural strata will remain stable in the short term, requiring minimal trench support, in accordance with the prevailing statutory guidance.

10.9 Groundwater ingress was recorded in around half the trial pits excavated on the site, from depths as shallow as 1.0m. Such encounters should be controllable by pumping from an artificial sump.

10.10 Excavations within the natural clays and mudstone gravel/cobbles should be readily achieved using conventional hydraulic plant. However, excavations into intact bedrock, (present as shallow as 1.4m in TP10) or any buried foundations and structures, may require a hydraulic breaker.

Chemical Precautions

10.11 The Aggressive Chemical Environment for Concrete (ACEC) class is AC-1 for both the natural strata and made ground. Therefore, the use of GEN1 designated concrete will be satisfactory for unreinforced buried concrete, in accordance with BS 8500-1:2015+A2:2019. For any reinforced buried concrete, other design-specific mixes will apply.

Road Pavement Construction

10.12 For any areas of road pavement, including parking areas, the formation will probably be the natural clays. Based on the observed characteristics of the material, and the results of the plasticity testing, a design California Bearing Ratio (CBR) value of 3% is considered applicable, below any obvious soft spots, and at equilibrium moisture content. If considered necessary, this should be confirmed by testing at proposed subgrade level before construction. Formation of roads on the existing made ground will not be acceptable.

Flooding and Soakaways

10.13 The site is not at risk from river flooding. The risks of flooding from other causes such as adverse topography or insufficient surface water drainage, are not considered here. If such risk needs to be quantified, a separate specialist Flood Risk and Drainage Report should be commissioned, if not already available.

10.14 A Soakaway Feasibility Assessment was carried out for the site by ARP (reference ORH/25/JRjcl2 dated 7th November 2024). The report concluded that soakaways are not appropriate for use on the site.

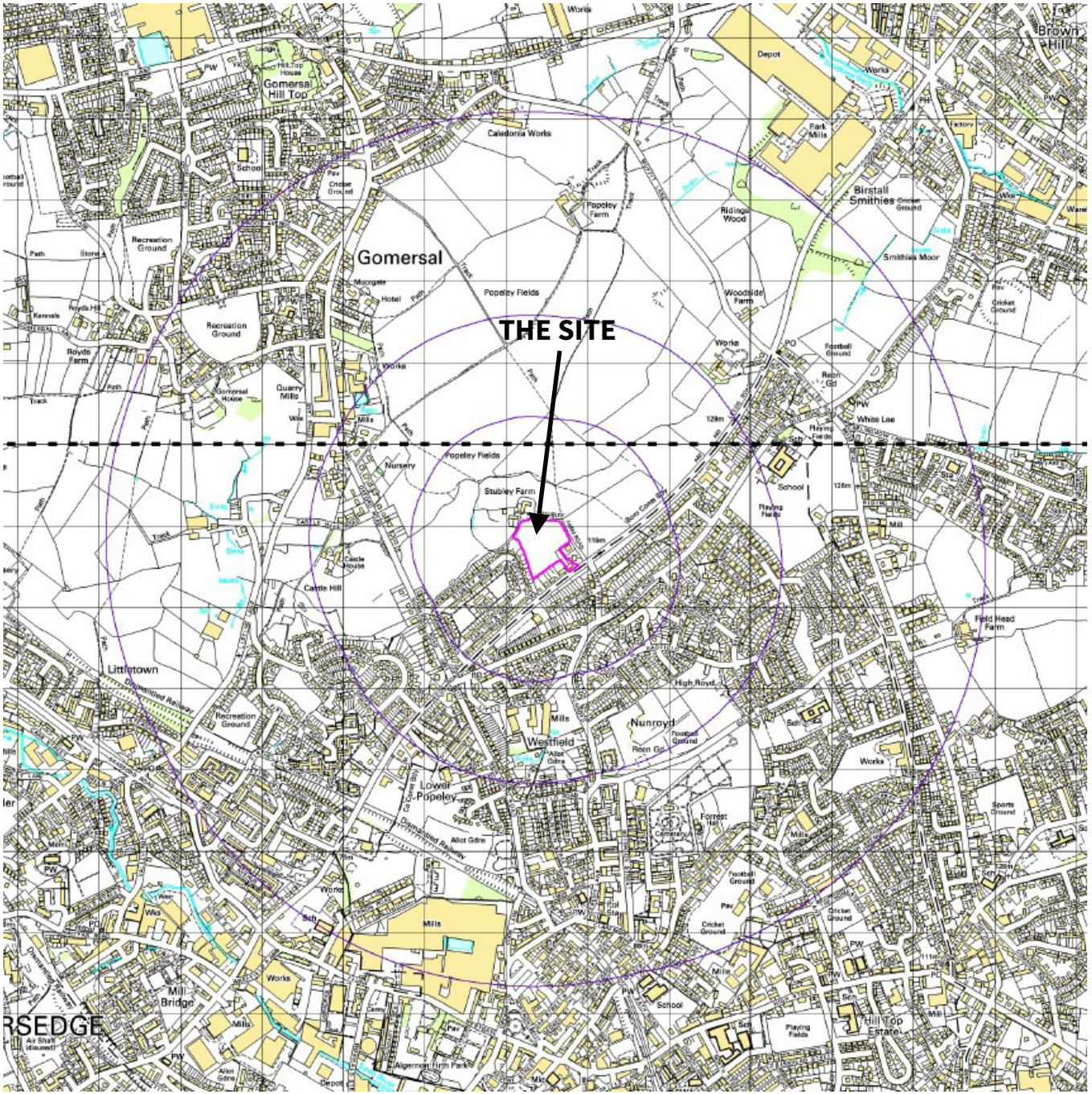
Gas Protection

10.15 Basic radon protection is recommended for the site. This is usually achieved by incorporating an appropriate barrier within a solid floor system, and extending the barrier through the cavity wall.

10.16 Due to the presence of shallow coal beneath the site, and potential shallow underground coal workings, gas monitoring is ongoing and the results will be reported separately on completion.

APPENDIX A

SITE LOCATION PLAN AND AERIAL PHOTOGRAPH



0m 500m

Approximate Scale

ARP GEOTECHNICAL LTD
CHARTERED CONSULTING ENGINEERS
Northwest House 5-6 Northwest Business Park Servia Hill · Leeds LS6 2QH
Telephone : 0113 245 8498 Fax : 0113 244 3864 E-Mail : leeds@arpassociates.co.uk

Project
LAND AT 195 LEEDS ROAD
HECKMONDWIKE

Client
ORION HOMES LTD

Title
SITE LOCATION PLAN

Date
OCTOBER 2024

Drawn	Scale
JR	AS SHOWN

Job No.
ORH/25



0m 40m

Approximate Scale

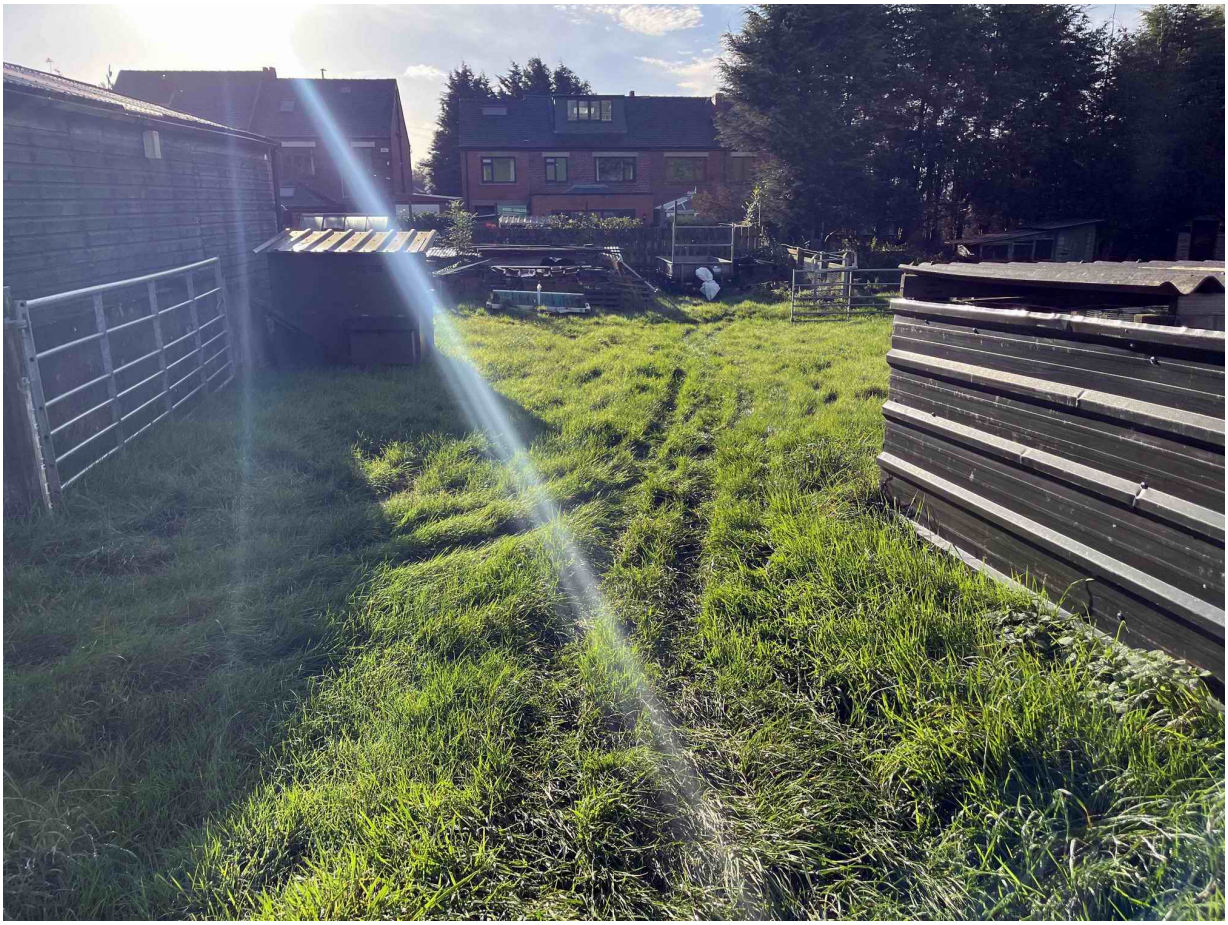
ARP GEOTECHNICAL LTD
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Project	LAND AT 195 LEEDS ROAD HECKMONDWIKE
Client	ORION HOMES LTD
Title	AERIAL PHOTOGRAPH
Date	OCTOBER 2024
Drawn: JR	Scale: AS SHOWN
Job No.	**ORH/25**

APPENDIX B

SITE WALKOVER PHOTOGRAPHS

ORH/25 – 195 LEEDS RD, HECKMONDWIKE – ORION HOMES LTD
SITE WALKOVER PHOTOGRAPHS - 17TH & 22ND OCTOBER 2024



Photograph 1: Looking south towards the houses on the southern extremity of the site



Photograph 2: Looking southwest along the southern boundary



Photograph 3: Looking northeast, from the mid south of the site



Photograph 4: Looking north from the mid south of the site