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Our ref: JAS/JL/SH10534-LET-011 *Date: 10 October 2017*
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Dear Luke

APPENDIX AA8.6 - North Bierley – Updated Ground Contamination Risk Assessment

Please find below our revised ground contamination risk assessment which has been updated following the change in layout since we issued our Phase II Site Investigation report dated November 2015 (SH10534-RPT-002B).

Introduction
The site is North Bierley WWTW, and is located as shown on the site location plan, Drawing No. SH10534-001 (1:50,000 scale), and more detailed site plan SH10534-008C (1:2,500 scale). The site is located approximately 6km south of Bradford city centre, adjacent to the junction of the M606 and M62 motorways and comprises a disused wastewater treatment works and fields. The site is bounded by the M606 motorway to the west, Hunsworth Beck to the east, the M62 motorway to the south and fields to the north.

It is proposed that the site is redeveloped for commercial land use. The previous site investigation covered a larger site area than the proposed commercial development layout. The proposed commercial development layout boundary and the site investigation boundaries are shown on drawing SH10534-008C and attached at Appendix II.

Site History
The site history indicates that a sewage works was present on part of the site in 1893. The Valley Pit Coal and Ironstone workings were also present in the west of the site at this time along with an Old Coal pit in the south. A tramway is reported extending across the western part of the site. By 1908 the pits were reported to be closed and the sewage works had expanded. Subsequent maps show further expansion and changes to the layout up until 2004.

Site Investigation

Within the site investigation boundary, a total of seven cable percussion boreholes (to a maximum depth of 10.7mbgl), three of which had rotary follow-on (to a maximum depth of 30mbgl), ten window sample boreholes (2.0m to 5.0mbgl) and nineteen trial pits (1.4m-3.6mbgl) were completed. Observations from the intrusive work have confirmed the presence of Made Ground between 0.15m and 8.3m thick over the majority of the site. This was underlain by soft to stiff, orange-brown mottled grey, sandy, gravelly clay which was locally cobbly with rare boulders and mudstone bedrock of the Middle Coal Measures geology.

Thirty soil and six groundwater samples from across the site investigation area were tested for a suite of potential chemicals of concern comprising: volatile and semi-volatile organic compounds; aliphatic, aromatic petroleum hydrocarbons, polycyclic aromatic hydrocarbons, metals and other inorganic elements

Generic Quantitative Risk Assessment (GQRA)

Our Phase II Site Investigation Report dated November 2015 presented a GQRA of soil and groundwater concentrations with respect to potential risk to human health and the environment and also a ground gas assessment for new buildings. The GQRA has been updated in accordance with updated guidance and best practice and is summarised below. The source data is presented within the appendices of the Phase II Site Investigation Report (SH10534-RPT-002B).

The risk assessment has included a comparison of Generic Assessment Criteria (GAC) for human health and controlled waters against soil and groundwater concentrations recorded on site. Guidance is attached at the appendices.

Human Health – Future Occupiers

The geometric mean soil organic matter content at the site is 3.67%. Therefore Generic Assessment Criteria (GAC) values derived using 2.5% SOM have been selected in this assessment.

The soil concentrations for heavy metals, Polycyclic Aromatic Hydrocarbons (PAHs), petroleum hydrocarbons (TPHCWG) were below their respective GAC for commercial land use. Therefore, these contaminants are not considered to present a significant risk to human health in a commercial land use.

Thirteen soil samples were screened for asbestos and no asbestos fibres were detected. In addition, no visual evidence of asbestos was recorded during site investigation works. Therefore, asbestos in soil contamination is unlikely to pose a risk to future site occupiers.

Human Health – Construction Workers

Thirteen samples tested for asbestos in made ground across the site recorded non-detect at screening level. These areas are not likely to pose a significant risk to construction workers.

However, as with groundworks on all sites where made ground is present, it would be prudent to employ good site practices such as wearing of PPE and hazard awareness etc. during the

groundworks. In addition, in the event that asbestos is visually identified during the groundworks, all works within the vicinity should cease and further advice should be sought.

If further testing demonstrates that asbestos is present the following additional precautions may be required:

- Use of personal protective equipment such as gloves and masks during excavations;
- Dust suppression employed in the form of a water mist during excavations;
- Dust monitoring of generation and levels employed throughout the works; include visual checks and use of a portable, hand held nephelometer; and
- Any stockpiles of excavated material will need to be kept damp and placed in a designated area lined and securely covered with polythene sheets or similar.

Controlled Waters

From a comparison of soil and groundwater concentrations recorded on site against environmental quality standards, the recorded concentrations of medium to long chain petroleum hydrocarbons in groundwater are elevated with respect to the UKDWS in BH5 and BH6 which are located outside of the proposed development area to the south. No significantly elevated petroleum hydrocarbon concentrations were identified in soil and the concentrations of petroleum hydrocarbons in groundwater across the development area are generally below the LOD and/or UKDWS, therefore the risk to surface water and groundwater can be considered more towards low than moderate for the development area.

Ground Gas Assessment

The ground gas assessment has been carried out in consultation with the following guidance:

- Code of practice for the design of protective measures for methane and carbon dioxide ground gases for new buildings (BS 8485:2015);
- Assessing Risks Posed by Hazardous Ground Gases to Buildings, CIRIA C665, 2007.

The ground gas assessment has been undertaken using the Wilson and Card classification adopted by BS 8485: 2015 to derive a Characteristic Situation.

Development Area

The monitoring wells within the development area are characterised by low concentrations of methane (max 1.6%) and moderate concentrations of carbon dioxide (max 3.7%) (Table I overleaf). Flow rates for the boreholes were typically 0.1l/hr with a peak reading of 0.4l/hr and barometric pressures ranging from 978mb to 1014mb.

Using the Wilson and Card classification system and based on the monitoring results, a GSV of 0.015l/hr has been calculated. This corresponds to Characteristic Situation 1 (green or very low risk) classification.

Outside of Development Area – BH5

An exception to the general site trend was borehole BH5 to the south of the site (outside of the proposed development layout) which recorded very high concentrations of methane (max 34.6%) and moderate concentrations of carbon dioxide (max 3.0%). Flow rates for BH5 ranged from 0.0-0.2l/hr.

Using the Wilson and Card classification system and based on the monitoring results for BH5, a GSV of 0.07l/hr has been calculated. This corresponds to Characteristic Situation 2 for area around BH5. If the area around BH5 is developed in the future then consideration of ground gas protection measures appropriate to Characteristic Situation 2 and/or further monitoring will be required.

TABLE I: SUMMARY OF GROUND GAS MONITORING DATA						
Borehole	**Response Zone/Strata**	**No. Tests**	**CH_4 (%)**	**CO_2 (%)**	**Flow (l/hr)**	**Atmospheric Pressure (mb)**
BH1	1m-6.4m/ Natural	6	0.0	0.0-3.4	0.0-0.2	980-1014
BH5	1m-10m/MG, Natural	5	0.0-34.6	0.2-3.0	0.0-0.2	981-1014
BH6	1m-10m/MG, Natural	5	0.0	0.3-3.4	0.0-0.1	981-1014
BH7	1m-7.8m/MG, Natural	5	0.0-1.6	0.0-1.4	0.0-0.3	978-1013
WS102	1m-5m/ Natural	6	0.0	0.1-1.4	0.0-0.1	980-1014
WS104	1m-5m/MG, Natural	6	0.0	0.0-3.7	0.0-0.4	981-1014
WS105	1m-6.4m/MG, Natural	6	0.0	0.0-2.4	0.0-0.1	981-1014
WS107	1m-6.4m/MG, Natural	6	0.0	0.0-2.0	0.0-0.3	980-1014
WS110	1m-6.4m/MG, Natural	3	0.0	0.0-1.3	0.0-0.1	1005-1014

Ground Gas Protection Measures

CIRIA Report C735, entitled *'Good Practice and verification of protection systems for buildings against hazardous ground gases'* presents guidance on the approach for verification of gas protection systems and describes how it should be reported.

The calculation of the GSV using the ground gas data from the monitoring wells at the site indicates a classification of Characteristic Situation 1 and no special ground gas protection measures are required for the development area.

Although outside of the development area, the monitoring results from BH5 indicates a classification of Characteristic Situation 2. If the area around BH5 is developed in the future then consideration of ground gas protection measures appropriate to Characteristic Situation 2 and/or further monitoring will be required.

Building Materials Concrete
Concentrations of total sulphate were measured in order to indicate the potential for concrete attack. Concentrations on site ranged between 0.005% and 0.456% indicating that there is potential for concrete attack on site.

Results from sulphate (2:1 extract) for materials on site ranged between 0.008g/l and 0.204g/l. These results indicate that a worst case design sulphate class of DS-2 and Aggressive Chemical for Concrete (ACEC) class of AC-2 may be appropriate for the site. Relevant guidelines are given in BRE Special Digest 1: Concrete in Aggressive Ground.

Ecology
The phytotoxic metals were analysed against the ECO-SSL threshold values for risk to sensitive plants. The results displayed numerous samples to have elevated metals considered likely to hinder sensitive plant growth in planned areas of landscaping.

Remediation / Further Work
The Phase II Site Investigation Report recommended further work with respect to elevated heavy metal concentrations in the formerly proposed residential area in the north west area. However, as this area is now proposed for commercial land use and the soil concentrations are below their respective commercial GAC, this work is no longer considered necessary.

We trust that the above is suitable for your requirements. Please contact us if you have any queries or wish to discuss this assessment further.

Yours Sincerely
for Wardell Armstrong LLP

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Enclosed.
Appendix I– Standard Terms and Conditions and Limitations to Reports
Appendix II – Summary of Technical Guidance
Drawings SH10534-001 and SH10534-008C

APPENDIX I

Standard Terms and Conditions and Limitations to Reports

STANDARD TERMS AND CONDITIONS AND LIMITATIONS TO REPORTS

This Report is provided for the stated purpose and for the sole use of the client in accordance with the Terms and Conditions of Appointment under which the services were performed. The Report is confidential to the client and no other warranty, expressed or implied, is made as to the professional advice included in the Report or any other services provided by Wardell Armstrong LLP. This Report may not be disclosed by the Client nor relied upon by any other party without the prior and express written agreement of Wardell Armstrong LLP.

The conclusions and recommendations contained in this Report are based upon information provided by others including details supplied by the client and/or professional advisors on the assumption that all relevant information from whom it has been requested and/or supplied is accurate. Information so provided and/or supplied has not been verified independently by Wardell Armstrong LLP, unless otherwise stated in the Report.

The methodology adopted and the sources of information used by Wardell Armstrong LLP in providing the services are outlined in this Report. The work described in this Report is based on the conditions and information as stated at the date the Report was completed. The scope of this Report and the services are accordingly limited by these circumstances. The findings outlined in the Report together with any opinions expressed and recommendations made are considered to be valid and appropriate at the time of preparation and for the specific purpose or purposes intended. Whilst a walk over site visit may have been carried out as part of the work this has been limited to observations only and no other physical investigations, sampling and testing work has been carried out as part of this work.

Wardell Armstrong LLP disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report which may come or be brought to Wardell Armstrong LLP's attention after the date of the Report. Unless otherwise stated in this Report, the assessments made assume that the sites and facilities will continue to be used for their current purpose without significant changes.

Where any site observations have been carried out, these have been restricted to a level of detail required to meet the stated objectives of the services. The results from any site observations made may vary and further confirmatory work should be made after the issuance of this Report. Wardell Armstrong LLP does not guarantee or warrant any estimates or projections contained in this Report.

APPENDIX II

Summary of Technical Guidance

CONTAMINATION RISK ASSESSMENT

The assessment provides information that is fit for purpose given the regulatory context and completed in accordance with UK best practice. A summary of the risk assessment process is presented below. More detailed information on risk assessments is contained in various reports published by the Environment Agency and DEFRA including:

- Contaminated Land Science Reports (SR2 to 4); and
- Model Procedures for the Management of Land Contamination (CLR 11).

General Soil Contamination Guidance

The first stage in the assessment of a site is development of a conceptual model. This includes consideration of all possible sources of contamination on the site, the potential receptors and whether there is a plausible pathway between the two. This allows evaluation of whether further more complicated risk assessment for an identified receptor is necessary.

The Contaminated Land Exposure Assessment (CLEA) model is a framework for estimating the likely exposure to contaminants in soil as part of the wider approach of the UK's assessment of risk and suitability for use. The methodology adopted for CLEA builds upon the source-pathway-receptor model for the assessment of risk. The investigation will follow the CLEA model and appropriate Generic Assessment Criteria (GAC) will be used to act as triggers for intervention in the appropriate land use. A limited number of GAC, known as Soil Guideline Values (SGVs) were developed by the Environment Agency to act as triggers for intervention in a number of end-use scenarios.

The CLEA software allows parameters to be changed and where appropriate site specific assessment criteria (SSAC) will be developed.

The GAC derived from the CLEA model are intended for use in assessing the risk to long term human users of the site. The potential for harm from short-term exposure to contaminants at the site will also be considered, e.g. to construction workers who may be exposed to risk via inhalation of dust or dermal contact with the contaminated material.

In the absence of SGVs published under the new CLEA methodology, Land Quality Management (LQM) and the Chartered Institute of Environmental Health (CIEH) published their third edition of generic assessment criteria (GAC) for 82 inorganic and organic substances in January 2015 which are termed Suitable 4 Use Levels or S4UL's. In addition, GAC values for 30 separate organic compounds were published in December 2009 by the Environmental Industries Commission (EIC), the Association of Geotechnical and

Geoenvironmental Specialists (AGS) and CL:AIRE. These GAC values have been derived in the same vein as SGVs and are intended to be used in the same manner. Additionally, the GAC values have been produced for varying soil organic matter content (i.e. 1%, 2.5% and 6%).

In March 2014, DEFRA published C4SLs for four generic land-uses comprising residential, commercial, allotments and public open space for six substances – arsenic, benzene, benzo(a)pyrene, cadmium, chromium (VI) and lead. The C4SLs have been derived in support of Defra's revised Statutory Guidance for Part 2A of the Environmental Protection Act 1990 but it was anticipated that they could be used under the planning regime as generic screening criteria within a GQRA, albeit describing a higher level of risk than the currently or previously available SGVs. In the case of lead where the former SGV was removed in 2008 and was not replaced, the C4SL for lead is considered a suitable generic screening value.

Statistical Analysis

Statistical analysis will be completed to identify if the data set for each substance tested contains outliers, has a normal or non-normal distribution and if there is significant evidence that the mean concentration, as defined by the 95% upper confidence level (UCL), is less than the adopted screening value. This process follows the CL:AIRE/CIEH Guidance on Comparing Soil Contamination Data with a Critical Concentration, May 2008. Results from this statistical testing will be used to inform decisions on whether the land is suitable for use under the land use planning system without mitigation to break identified pollutant linkages.

General Water Contamination Guidance

Concentrations of contaminants detected in groundwater have been compared to the UK Drinking Water Standards (UKDWS) encompassing the Water Supply (Water Quality) Regulations 1989 and Water Supply (Water Quality) Regulations 2016 where drinking water is the receptor. Where surface water is the receptor, Water Framework Directive, Environmental Quality Standards (EQS) and The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 have also been used.

Where no UKDWS and EQS are available or applicable, reference is made to other appropriate guidance. This includes the World Health Organisation (WHO) Guidelines for Drinking-water Quality (2011) and the United States Environmental Protection Agency (US EPA) Regional Screening Levels (RSL's) for tap water.

D R A W I N G S

CLIENT	DRG No.	SCALE	DATE
KEYLAND DEVELOPMENTS LTD	SH10534-001	1:50000	15/06/11

PROJECT	DRAWN BY	CHECKED BY	APPROVED BY
NORTH BIERLEY WWTW	DP	JL	GW

DRAWING TITLE

SITE LOCATION PLAN

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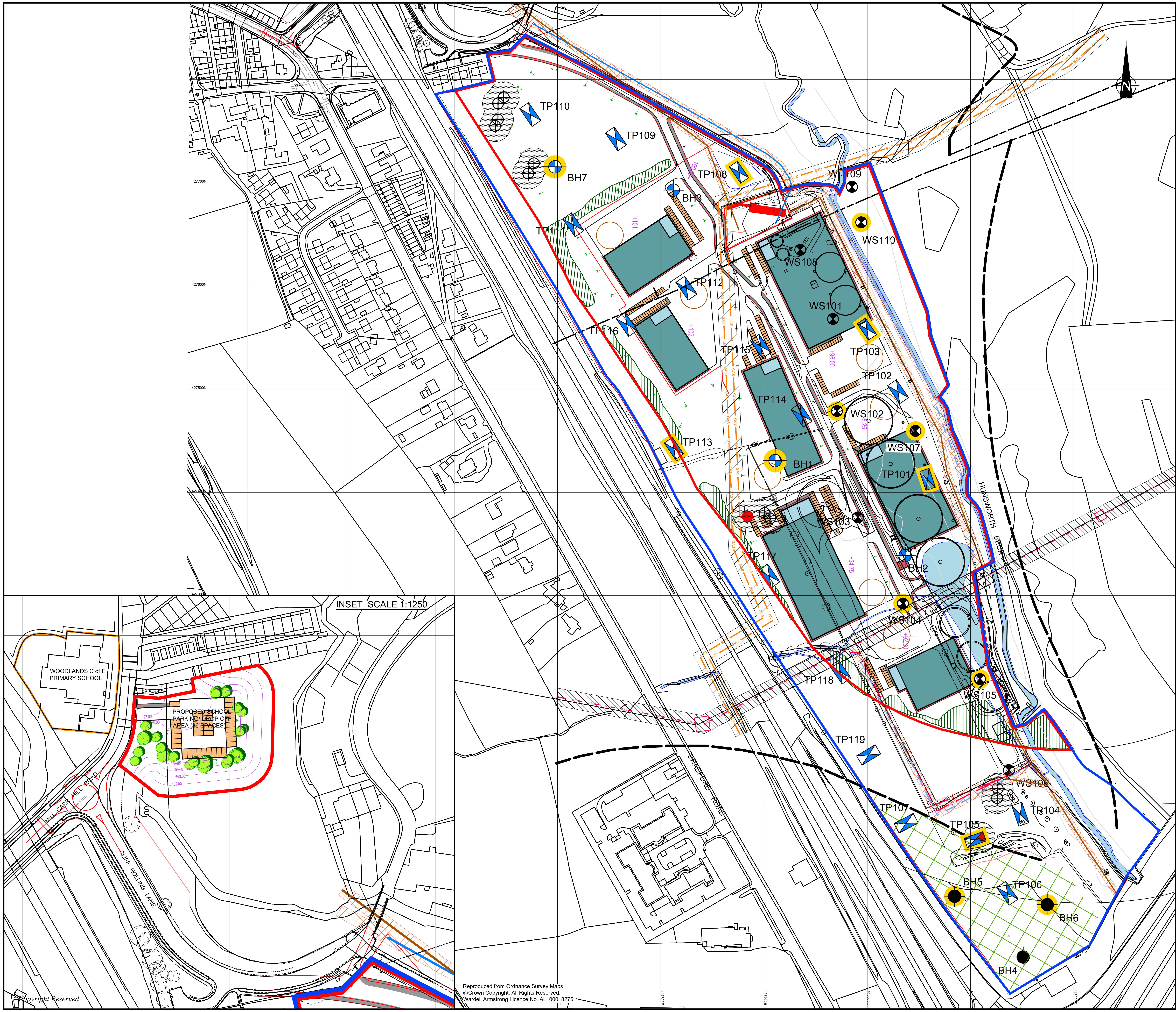
your earth our world



DO NOT SCALE FROM THIS DRAWING | A2

REFERENCE

SITE INVESTIGATION BOUNDARY

DEVELOPMENT AREA BOUNDARY

APPROXIMATE LOCATION OF SHELL & AUGER BOREHOLE TO A NOMINAL DEPTH OF 10m BGL — BH2

APPROXIMATE LOCATION OF SHELL & AUGER B OREHOLE TO A NOMINAL DEPTH OF 10m bgl WITH ROTARY FOLLOW ON TO 30m BGL — BH4

APPROXIMATE LOCATION OF WINDOW SAMPLE BOREHOLE TO A NOMINAL DEPTH OF 5m BGL — WS101

(BOREHOLES SHOWN HIGHLIGHTED HAVE INSTALLATIONS)

APPROXIMATE LOCATION OF TRIAL PIT EXCAVATION — TP102

APPROXIMATE LOCATION OF TRIAL PIT EXCAVATION WITH SOAKAWAY — TP101

APPROXIMATE ROUTE OF FOUL SEWER WITH EASEMENT

APPROXIMATE ROUTE OF SW SEWER WITH EASEMENT

APPROXIMATE ROUTE OF WATER WITH EASEMENT

APPROXIMATE ROUTE OF ELECTRICITY WITH EASEMENT

APPROXIMATE ROUTE OF O/H ELECTRICITY WITH EASEMENT

APPROXIMATE ROUTE OF GAS WITH EASEMENT

POSSIBLE AREA OF SHALLOW MINING

GEOLOGY:

SHERTCLIFFE BED COAL OUTCROP

FAULT

SHAFT (after BGS) WITH 15m RADIUS ZONE OF UNCERTAINTY

SHAFT (after CA) WITH 15m RADIUS ZONE OF UNCERTAINTY

NOTES

1. APPROXIMATE LOCATION OF YORKSHIRE WATER APPARATUS (TAKEN FROM YW DRG No C411-05/104) SHOWN IN RED.
2. DEVELOPMENT LAYOUT TAKEN FROM ILLUSTRATIVE MASTER PLAN DATED 26.09.17

REVISION	DETAILS	DATE	DRAWN	CHK'D	APP'D
C	Layout Revised.	06/10/17	DP	JL	JS
B	Layout Revised.	18/04/16	DP	PAL	GW
A	First Issue	25/11/15	DP	JL	GW

CLIENT
KEYLAND DEVELOPMENTS LTD

PROJECT
NORTH BIERLEY WWTW

DRAWING TITLE
SITE INVESTIGATION DEVELOPMENT PLAN

DRG No.	SCALE	DATE
SH10534-008	1:2500 @ A2	22/05/15
DRAWN BY	CHECKED BY	APPROVED BY
DP	JL	GW

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