LITHOS

Remediation Strategy

Land at Crossley Lane, Dalton (Parcels 4 & 5)

For Minerva Developments Ltd & Crest Nicholson Yorkshire

Report no: 3435/2

Date: October 2024

CONTENTS

APPENDICES

Appendix A : Drawings

Drawing	Revision	Title
3435/201	-	Site Location Plan
3435/202	-	Proposed Site Layout (Parcels 4 & 5)
3435/203	-	Site Features
3435/204A	-	1893 Historical Features
3435/204B	-	1918 Historical Features
3435/204C	-	1958 Historical Features
3435/204D	-	1993 Historical Features
3435/204E	-	All Historical Features
3435/208	-	Revised Conceptual Site Model
3435/210	-	Contamination Summary
3435/211	-	Depth of Made Ground
3435/212	-	'Internal' boundary within Parcel 5

Appendix B : Lithos Tier 1 Values

Appendix C : Protocol for Placement of Non-Engineered General Fill

Appendix D : Protocol for Importation & Use of Soil Cover (Capping)

REMEDIATION STRATEGY
for land at
CROSSLEY LANE, DALTON (PARCELS 4 & 5)

1 INTRODUCTION

1.1 The commission and brief

1.1.1 Lithos Consulting Limited have been commissioned by Minerva Developments Ltd & Crest Nicholson Yorkshire to prepare a Remediation Strategy for Parcels 4 & 5 at Crossley Lane, Dalton.

1.1.2 Lithos have already issued the following reports for the **wider** site:

- Supplementary Geoenvironmental Appraisal: Land at Crossley Lane, Dalton (Parcels 4 & 5). Report No. 3435/1, dated March 2020
- Crossley Lane, Dalton – Gas risk assessment. Letter No. 020/3435/LH/rh, dated 19th June 2020

1.1.3 The appointed Remediation Contractor will need to familiarise themselves with the above Reports, and comply with all relevant recommendations contained therein.

1.1.4 This document outlines the remediation objectives necessary to protect environmental receptors, and render the site suitable for the proposed development. A Method Statement should be prepared in order to detail how the objectives will be achieved.

1.1.5 The Method Statement should be accompanied by a Designer's Risk Assessment in accordance with the CDM Regulations, 2015. The Method Statement and Risk Assessment should be submitted to, and approved by the Engineer.

1.2 The proposed development

1.2.1 The current site can be considered as two areas comprising:

- Parcel 4 – an area of derelict land to the north of Crossley Lane, formerly occupied by Minerva Works
- Parcel 5 – derelict land to the south of Crossley Lane.

1.2.2 The proposed development comprises part of a wider site which includes:

- Parcel 1 – a Greenfield area in the south-west
- Parcel 2 - former industrial building in the north-west
- Parcel 3 - an area of derelict land to the north of Crossley Lane, formerly occupied by Minerva Works

1.2.3 The approximate extent of Parcels 1 to 5 are shown on Drawing 3435/203.

1.2.4 A proposed layout showing two storey domestic dwellings, associated gardens, POS, adoptable roads and sewers has been provided and is reproduced as Drawing 3435/202, presented in Appendix A. Access to the development will be from Crossley Lane.

1.2.5 The houses will be likely be constructed on piled foundations.

1.2.6 It is understood remediation are works are required in the west of Parcel 5 to enable the installation of highway and drainage infrastructure which will serve the proposed residential redevelopment in Parcel 4. Ultimately, residential redevelopment is also proposed in Parcel 5, and remediation works to enable infrastructure will also need to render the site suitable for a residential end use.

1.2.7 It is also understood that consideration is being given to leasing the east of Parcel 5 to Network Rail in the short-term, with residential redevelopment to follow in the future. Consequently, this Remediation Strategy considers implications of undertaking work within Parcel 5 in two phases; the western half in early 2025 (in order to enable installation of drainage infrastructure etc), and the eastern half a few years later.

1.2.8 The Local Planning Authority has agreed planning permission for redevelopment of this site (ref. 2015/60/90430/W). There are several Conditions associated with remediation, most notably:

- **Condition 10** which states a Remediation Strategy is required to be approved prior to redevelopment of the site
- **Condition 11** which relates to unforeseen contamination and revision of the Remediation Strategy as necessary
- **Condition 12** which requires a Validation Report to be prepared following completion of any remediation works.

1.2.9 This report has been prepared to satisfy the requirements of **Condition 10**.

2 BACKGROUND

2.1 Site description & history

2.1.1 The site currently comprises two parcels of derelict land, one to the north (Parcel 4) and one to the south (Parcel 5) of Crossley Lane. Both are predominantly covered by overgrown concrete hardstand.

2.1.2 A raised (c. 2.4m high) area of concrete is present in the north of Parcel 4 with a c. 7m high retaining wall along the northern boundary which retains the land to the north of the site. A bunded area with two large circular tanks (labelled calcium hydroxide suspension and ferric chloride) is present in the far west.

2.1.3 Parcel 5 is split over two levels with concrete/tarmac hardstand in the northwest c. 1.2m below the centre and east. A large circular concrete base (approximately 10m in diameter) is present in the centre south. An area secured by fencing in the far east houses 3 propane gas tanks. There is also a former fuel filling pump in this area.

2.1.4 Site details are summarised below:

Detail	Remarks
Location	3.0 km east of Huddersfield town centre
NGR	SE 174 173
Area	Parcel 4 – 1.4ha (3.5 acres) Parcel 5 – 2.8ha (6.9 acres)
Known live services	Underground electric, water, sewer, fibre optic & telecom Overhead telecom

2.1.5 Ox Field Beck and Lee Head Beck flow west along southern boundary.

2.1.6 The site location and current salient features are shown on Drawings 3435/201 and 3435/203 in Appendix A.

2.1.7 The site has been formerly used as a:

- Gas works in the southeast between c. 1870 and c. 1920 (Parcel 5)
- Coal tar colour works in the north between c. 1890 and c. 1910 (Parcels 3 & 4)
- Bleaching and dye works (Minerva Works) across the north and south between 1910 and c. 2000 (Parcels 3, 4 & 5). These works went through several phases of expansion until the majority of the site was covered by factory buildings.

2.1.8 There is a former gas holder and tar well in the south of Parcel 5; see Drawing 3435/210.

2.1.9 It is known the gas works was a relatively small operation to provide gas for the surrounding villages. It is likely to have had a retort house with condensers and purifiers/scrubbers and will have produced by-products/wastes including coal tar and cyanide impacted lime. Based on the age of the gas works, benzole and naphthalene would not have been recovered.

2.1.10 The coal tar colour works and dye works would have required significant amounts of water for processing. A suspected lagoon noted on historical OS plans around 1950 may have been a settlement pond for liquid waste, with water draining off into Ox Field Beck via the trench to the south.

2.1.11 Drawing 3435/204E also shows the approximate location of several former fuel storage tanks.

2.2 Ground investigation

2.2.1 Following completion of a review of third party data and desk study which culminated in a preliminary conceptual site model, ground investigation fieldwork across the wider site was supervised by Lithos between 23rd January and 11th February 2020. Fieldwork comprised 34 trial pits, 15 window sample boreholes & 7 cable percussion boreholes.

2.2.2 Chemical testing of shallow soil samples was undertaken as part of the investigation to determine the extent (lateral and vertical) of any contamination associated with the site's industrial history.

2.2.3 Following completion of the investigation, gas monitoring was undertaken (6 visits over a 3-month period) with a Gas Risk Assessment produced for the wider site.

Made Ground

2.2.4 Made ground was encountered across the whole site to between 0.5m and 3.3m depth (average 1.4m). The thickest made ground was predominantly encountered in the west of Parcel 5).

2.2.5 The made ground can be categorised as one of 8 broad types: Concrete Hardstand, Macadam Hardstand, Sub-Base, Granular Made Ground, Cohesive Made Ground, Ash & Clinker, Reworked Natural Ground and Brickfill.

Obstructions

2.2.6 Historical plans and previous reports show that buildings have been present across most of the site, with concrete hardstand (typically 200mm thick) present across the area. Drawing 3435/203 shows the areas of hardstand with former structures shown on Drawings 3435/204A to 204E.

2.2.7 Trial pits were excavated at locations where relict foundations were anticipated (based on superimposition of the historical buildings and infrastructure on the current site layout). Obstructions encountered are summarised below:

Hole ID	Area of site/former feature	Depth	Obstruction encountered
TP109	Parcel 5 – Minerva Works building (1985 to 2012)	1.7m to 1.9m	Cobbles of brick – possible former floor
TP112E	Parcel 4 – Minerva Works buildings (1918 to 2012)	0.2m to 1.8m	Brick wall running north-south through middle of pit
TP112W		1.8m	Concrete slab
TP113	Parcel 4 – Minerva Works buildings (1958 to 2012)	0.5m	200mm concrete slab in south of pit
TP115	Parcel 4 – Minerva Works buildings (1893 to 2012)	0.2m to 1.2m	Brick wall in east of pit
TP124S	Parcel 5 – Gas works & Minerva Works (1893 to 2012)	0.6m to >2.1m	Brick wall in south of pit
TP131		0.7m	250mm thick concrete slab in east of pit

2.2.8 Given the above, it is apparent that whilst former buildings have been demolished, substantial foundations, concrete, bases etc remain below ground.

2.2.9 In the vicinity of the former gas works, some evidence of coating and/or impregnation by oily contamination was noted on the coarse fragments (brick, concrete, etc).

2.2.10 In addition to the obstructions described above, the made ground locally comprised large oversize materials such as sandstone slabs, boulders and steel girders.

2.2.11 The depth and distribution of the in-situ relict foundations/floor slabs etc suggests that at least two "generations" of buildings are present. Drawings 3435/204A to 204E show how the site evolved between 1893 and 1993.

Natural ground

2.2.12 Natural ground was encountered in the majority of holes and typically comprised Head (firm/stiff gravelly Clay) in the north of Parcel 4, with Cohesive & Granular Alluvium (soft/firm Clay and loose to medium dense Sand/Gravel) across the remaining area.

2.2.13 Granular Glaciofluvial Deposits (medium dense to dense Gravel) were encountered from c. 2.3m depth with weathered bedrock at c. 9m depth.

Mining

2.2.14 The site is located within a Coal Mining Development Low Risk Area (within the defined coalfield, but no known defined risks have been recorded by the Coal Authority; there may be unrecorded issues).

2.2.15 No significant risks have been identified and an intrusive mining investigation will not be required.

Hazardous gas

2.2.16 No significant concentrations of methane or carbon dioxide were detected during the gas monitoring. However, given the likely presence of hydrocarbon vapours, Amber 1 (broadly equivalent to **Characteristic Situation 2 (CS2)** protection measures were recommended across Parcels 4 & 5, to include a hydrocarbon resistant membrane.

2.2.17 The site is in an area where **between 1% and 3%** of homes are estimated to be above the radon action level.

2.2.18 Consequently, basic radon protection measures are not required. However, the CS2 gas protection measures will provide basic radon protection.

Groundwater

2.2.19 Across the wider site, groundwater was encountered as seepages in 10 trial pits at between 0.4m and 3.2m depth (average 1.9m) and as inflows in a further 15 trial pits at between 0.8m and 3.7m (average 1.9m). Permeability of the ground is quite high.

2.2.20 Based on dip data recorded between March and May 2020, it appears there is a shallow water table across the site (typically within 1.5m of ground level) although it is unclear if perched waters in the made ground are in hydraulic continuity with groundwater in drift soils. Groundwater is flowing to the southwest.

2.2.21 To date, no chemical testing of the groundwater has been undertaken and therefore it is unknown to what degree (nature, concentrations & vertical/lateral extent) contamination exists within the underlying aquifer.

Contamination

2.2.22 The made ground has yielded elevated concentrations of a number of metals; most notably arsenic, copper, lead and zinc. Low concentrations of cyanide have been detected in the made ground although, given the acute risk associated with cyanide, further consideration may be required in relation to both end-users of the site (i.e. future residents) and site workers.

2.2.23 The existing data indicates a potentially significant area of hydrocarbon contamination, believed to be associated with the former lagoon and drain, across Parcel 5 and in the southwest portion of Parcel 4. Drawing 3435/210, shows the approximate extent of the area that is suspected to be impacted, although further contamination, associated with former tanks, pipes and drains should also be anticipated in both Parcels 4 & 5.

2.2.24 Significant hydrocarbon contamination has also been encountered in a suspected tar well in the vicinity of the former gas works in the southeast of Parcel 5.

2.2.25 There was some visual &\or olfactory evidence of hydrocarbon impact within natural soils (see Section 8.5 of Report 3435/1, dated March 2020). However, none of the 12 samples of natural soil analysed for a range of BTEX, phenols, speciated PAH and banded TPH yielded results above Tier 1 criteria.

2.2.26 Assessment of the site investigation data enabled formulation of a conceptual model, which is presented as Drawing 3435/208 in Appendix A.

2.2.27 In terms of the proposed redevelopment plausible contaminant linkages, and feasible remediation options, are summarised below:

Receptors	**Pathways**	**Contaminants**	**Plausible pollutant linkage? (and remediation options where required)**
Human health (Future residents) ◊	Consumption of contaminated vegetables	Metals, cyanide, pH & hydrocarbons in the made ground	Isolation beneath at least 600mm clean soil cover with 150mm "hard dig" layer in garden and landscaped areas
	Ingestion		
	Dermal contact		
	Inhalation (dust and/or vapours)		Treatment or removal of volatile organic hydrocarbons
	Infiltration of water supply pipes	BTEX, hydrocarbons, phenol, CN, sulphate, sulphide & chloride in the made ground	Treatment or removal of hydrocarbons Water company will insist of "protectaline" pipework
Buildings	Migration & accumulation of explosive gas	Hydrocarbons in the made ground	Amber 1 (CS2) protection measures including hydrocarbon resistant membrane
Plants	Uptake of phytotoxic elements	Cu, Ni, Zn & B in the made ground	Placement of clean soil cover in garden and landscaped areas
Groundwater Ox Field Beck & Lee Head Beck	Migration of dissolved and/or free phase hydrocarbons	Hydrocarbons (leaking from tanks, and/or faults in the site drainage system, and/or spills)	Treatment or removal of hydrocarbons determined via detailed risk assessment
	Surface water run-off	Metals, hydrocarbons in the made ground	
	Disturbance of contaminant-rich silts within redundant drains	Metals, hydrocarbons in contaminant-rich silts possibly within redundant drains	Removal, sealing-off or diversion of all former (redundant) site drainage

◊ Transient risks to construction workers will be addressed by the adoption of appropriate health and safety measures in accordance with the Health and Safety at Work Act 1974, and regulations made under the Act including for example the COSHH Regulations.

3 UNCERTAINTIES

3.1 Contamination and obstructions

3.1.1 Due to the nature of ground investigation, there is always the possibility that further contamination/obstructions could be present.

3.1.2 A potentially significant area of hydrocarbon contamination has been identified based on visual and olfactory evidence and chemical testing. This hydrocarbon impact appears to broadly follow the line of the suspected lagoon and associated trench although it is unknown if this has solely impacted made ground or if it extends into underlying groundwater.

3.1.3 Obstructions have been encountered in a number of exploratory holes, predominantly within the footprints of former buildings. However, Lithos' investigation was not designed to record the full extent of obstructions, which may only be possible with partial turnover of made ground, where obstructions can be exposed and locations surveyed.

3.1.4 It is highly likely that further obstructions, not currently identified, will be present beneath former buildings, and given the historic record of lagoons, channels and tanks, the presence of obstructions beyond building footprints cannot be entirely discounted.

3.1.5 The depth to which obstructions extend is likely to be highly variable ranging from shallow, thin slabs to deep walls and relict foundations.

3.1.6 The extent of reinforcement in surface slabs appears to be variable. Some reinforced bars were noted in concrete, but locally this could be more extensive with reinforced steel mesh.

3.2 Groundwater

3.2.1 Perched water is present in the made ground across the majority of the site. No testing of this has been undertaken to date and therefore the chemical loading is unknown and this will be required in order to determine the level of treatment needed.

3.2.2 Likewise, no testing of true groundwater in the underlying alluvium/glaciofluvial deposits has been carried out, which will be required to determine any necessary remedial works. Additionally, no detailed groundwater monitoring to determine groundwater flow direction has been undertaken. Based on the existing data the likely direction groundwater flow appears to be to the southwest.

3.2.3 Given the above, the nature and location of the source material(s) the potentially significant area of hydrocarbon contamination described in Section 3.1 above requires further assessment. Source areas should be anticipated during excavation of made ground across both Parcels (notably tanks in the west of Parcel 4, and former gas holders in the south & tanks in the west of Parcel 5).

3.2.4 The content of this Remediation Strategy may require **revision** once further assessment has been undertaken. Remediation works should not commence prior to completion of the necessary supplementary groundwater investigation and, if required, issue of a revised Remediation Strategy.

3.3 Foundations

3.3.1 The Geoenvironmental Appraisal Report (No. 3435/1), indicates that plots across Parcels 4 & 5 will be founded on piles (likely end-bearing in bedrock) due to the presence of made ground, soft/loose alluvium and raising of ground levels (by up to 2.5m in the north).

3.3.2 Head deposits (firm/stiff gravelly Clay) in the north of Parcel 4 should provide sufficient bearing capacity to adopt traditional strip/trench-fill footings. However, assuming final levels in the north of Parcel 4 are still being raised by c. 2.5m it may not be feasible to adopt trench-fill footings due to constructability issues.

3.3.3 Some revision of the foundation solutions outlined above is likely to be necessary on completion of the site preparatory and remediation earthworks, especially where deeper excavation is necessary to remove relict obstructions.

4 RISK ASSESSMENT & TARGET CONCENTRATIONS

4.1 Following closure and decommissioning of the works more than 10 years ago, most primary sources (above ground tanks, storage drums and IBCs) were removed from site. Some below ground tanks and pipework may remain in-situ, although locations are not mapped. Furthermore there is a former gas holder and tar well in the south of Parcel 5.

4.2 Secondary sources of contamination include free product within made ground and possibly locally within drift soils. This product could continually 'load' soil and groundwater with contamination and therefore remediation must remove free product (including any encountered in natural soils).

4.3 At this stage, in advance of the necessary supplementary groundwater investigation (see Section 7.2 below), it is proposed that Lithos' generic soil screening values for a residential-with-gardens end use (assuming gardens with 600mm clean soil cover) be adopted as remedial targets for soils contamination within Parcels 4 & 5.

4.4 Information on the derivation and use of these screening values is presented in Appendix B.

4.5 These screening values are based on an inhalation pathway. However, some contaminants reach residual saturation before a vapour risk is predicted to occur by the QRA model. Lithos recognise that it is unacceptable to leave free product in the ground where redevelopment of a site is proposed. Consequently, this Remediation Strategy advocates the removal/ treatment of soils that contain significant free product at all depths.

4.6 In this context, significant free product is readily identifiable by the naked eye, and pervasive throughout the soil mass, probably with noticeable seepages. Traces of free product in fissures or localised, cobble-sized pockets would not normally be considered significant.

4.7 Following completion of supplementary groundwater investigation, a detailed qualitative assessment of risks to controlled waters (most notably Ox Field Beck & Lee Head Beck) will be required.

4.8 As the compliance point (the watercourse) and the source of contamination are adjacent to one another a quantitative risk assessment is unlikely to be possible.

4.9 Depending on the outcome qualitative assessment of risks to controlled waters it might be necessary to revise soil clean-up criteria. It might also be necessary to derive remedial targets for groundwater contamination and undertake some groundwater remediation.

4.10 If revised soil and\or groundwater criteria are considered necessary, a revision of this Remediation Strategy will be issued prior to commencement of any remediation works within Parcels 4 & 5.

5 EARTHWORKS LEVELS & REGRADE

5.1 Any digital terrain modelling undertaken by the Earthworks Contractor should be designed with a view to enabling a "materials balance" (i.e. volume of cut to broadly equals the volume of fill), and be made available to Minerva & Crest's Engineering Designer. The digital terrain modeller should consider:

- Volume reduction caused by turnover (compaction of loose made ground; removal of obstructions/tanks etc)
- Whether or not processed arisings/treated soils are retained on site
- The thickness of the soil cover required in garden areas
- Implications for foundations (i.e. those indicated in the geoenvironmental appraisal report may no longer be the most appropriate)

5.2 Final site levels should then be issued by the Engineering Designer, via an External Works Drawing, which should show:

- Proposed finished floor levels
- Proposed finished road levels
- Garden & driveway levels and gradients

6 REMEDIATION STRATEGY (GENERAL)

6.1 Aims

6.1.1 Remediation aims are to:

- Resolve contamination issues in order to protect environmental receptors, and render the site suitable for the proposed development
- Provide a stable development platform (to agreed levels and gradients) for subsequent construction of the proposed development and associated infrastructure
- Satisfy requirements of the Local Planning Authority and warranty provider

6.2 Overview

6.2.1 The following remediation works are required:

- General site clearance of surface materials and vegetation
- Break-up of slabs and hardstand
- Crushing of all suitable artificial hard material (i.e. concrete/brick etc)
- Turnover (excavation, screening/sorting and replacement in engineered layers, with compaction) of the full thickness of made ground to enable:
    - Removal of Ash & Clinker; with subsequent isolation beneath areas of hardstand or 1,000mm cover in garden/landscaped areas
    - Removal of fuel/oil/hydrocarbon contamination and any associated below ground structures, pipes and drains; with subsequent treatment and/or off-site disposal
    - Inspection of the made ground
    - Removal of below ground obstructions
    - Preparation of the ground for highway construction
- Backfill of all resultant excavations, with appropriate compaction
- Creation of "clean corridors" for subsequent placement of sewers (and an attenuation tank)
- Treatment of hydrocarbon impacted soil by ex-situ on-site bioremediation, for subsequent re-use on site
- Regrade of site to levels specified by Minerva & Crest (approximately 750mm below final "soft" end use areas and 1,000mm below proposed slab levels)
- Within proposed adoptable road footprints, controlled re-engineering of selected materials in layers to approximately 600mm below final road levels
- Removal of underground and above ground tanks
- Spreading and compaction of 6F2 graded artificial hard material to provide a "running surface" over the entire site
- Provision of a minimum 600mm thick cover layer of 'clean' soils with 150mm "hard dig" layer in all garden and landscaped areas underlain by made ground (increased to 1,000mm where Ash & Clinker remains)

6.2.2 All new plots within the development will incorporate a vapour resistant membrane (protective against aromatic hydrocarbons), breaking plausible indoor inhalation pathways to future site residents.

6.2.3 However, irrespective of the absence of significant pollutant linkages following the adoption of vapour resistant membranes and clean cover in gardens, remediation is required to ensure: areas of free product are removed; drains and obstructions are chased out; and to provide environmental betterment.

6.3 Site set-up, organisation and safety

6.3.1 Site cabins and welfare facilities are to be established at a location to be agreed with the Engineer. All welfare facilities must be established in accordance with the relevant health & safety statutory requirements. Provision should be provided on site for car parking for all site employees.

6.3.2 All site personnel should undergo a site-specific health and safety induction prior to commencement of work on site.

6.3.3 The Engineer should be informed prior to any proposed entry of a confined space or deep excavation. Entry must be restricted to suitably qualified and equipped personnel.

6.3.4 Access into excavations etc. must be controlled and undertaken in accordance with the CDM Regulations 2015, most notably Regulation 22, to mitigate risk of collapse or asphyxiation.

6.3.5 During the remediation works, all personnel on site will comply with guidance provided in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land". In summary, the following should be provided:

- A designated "clean" area should be fenced off and suitable warning signs posted. The only access to or from the "dirty" area should be via a hygiene facility (personnel) or wheel wash (vehicles)
- Protective clothing, footwear and gloves. (Personnel should be instructed in why and how they are to be used)
- Hand-washing and boot-washing facilities
- Designated smoking areas

6.3.6 If at any time during the works personnel begin to feel unwell, they are to inform the Engineer, who will determine appropriate action.

6.3.7 All visitors to site must enter and register at the main Site Office.

6.4 Contractor's responsibilities

6.4.1 Prior to the commencement of any works the Contractor, in agreement with the Engineer, should:

- Comply with any requirements of Minerva & Crest's contract documentation
- Establish the boundaries of the site and the working areas
- Undertake a dilapidation survey of site boundaries, adjacent properties and highways, via dated photographs or video footage
- Liaise with the Local Authority regarding working hours, noise/dust/odour control, and protected trees
- Liaise with the Local Water Company regarding any proposed discharge to sewer
- Liaise with the Canal & River Trust (formerly British Waterways) and the Environment Agency regarding any work in close proximity to Lees Head Beck/ Ox Field Beckk
- Complete a full services search and liaise with all relevant utility companies regarding work in close proximity to their apparatus
- Prepare a detailed Method Statement outlining how the objectives of this Remediation Strategy will be achieved (and obtain approvals)
- Inform the Engineer of any risk, identified and assessed, which could impact upon the Engineer's activities

- Prepare the necessary COSHH statements and Health & Safety Plan in accordance with CDM regulations
- Provide and erect secure Heras-type fence to protect monitoring wells

6.4.2 The Contractor should satisfy the Health & Safety Executive with regard to all matters concerning the health, safety and welfare of persons on the site.

6.4.3 The Contractor should ensure that:

- Personnel, plant, materials and other equipment related to the contract are confined within the boundaries of the site.
- Any live services lying within the site boundary are marked and protected, or appropriate arrangements made to truncate them.
- Good practices relating to personal hygiene are adopted.
- Suitable precautions are implemented at all times to prevent off-site migration of contaminants via airborne dust and vapours.
- Suitable precautions are taken to prevent the spread of mud and debris on public highways.
- Refuelling of mobile plant is undertaken in a designated area. Above ground oil storage tanks should comply with the requirements of Pollution Prevention Guideline PPG2. A spill kit should be kept on site, adjacent to the designated refuelling area. (Lithos are aware that some of the EA PPG documents have been withdrawn from the gov.uk website. However, whilst some references to UK legislation and guidance are now outdated; the PPGs still set out key principles and provide a useful, concise overview).

6.5 Materials Management Plan

6.5.1 This project will involve the re-use of both natural and made ground soils on site, and the import of natural soils from another development site(s). Therefore, the Contractor will need to prepare a Materials Management Plan (MMP) in accordance with the CL:AIRE Code of Practice (v2, March 2011).

6.5.2 The MMP will document how all of the materials to be excavated during the proposed site preparatory and remediation earthworks are to be dealt with. In summary the MMP should provide:

- Details of the parties that will be involved with the implementation of the MMP
- A description of the materials in terms of potential use and relative quantities of each category
- The specification for use of materials against which proposed materials will be assessed, underpinned by an appropriate risk assessment related to the place where they are to be used
- Details of where and, if appropriate, how these materials will be stored
- Details of the intended final destination and use of these materials
- Details of how these materials are to be tracked
- Contingency arrangements that must be put in place prior to movement of these materials
- Verification Plan

6.5.3 The MMP should include consideration of the following factors:

- Any risks posed by the excavated materials to both human health and the environment
- Suitability for use
- Certainty of use
- Anticipated quantities of materials

6.5.4 The MMP should also detail how materials will be tracked throughout the earthworks in order that the subsequent Verification Report can provide an auditable trail. The tracking system must include:

- Annotated plans of the site(s) identifying different excavation areas, stockpile locations, treatment areas (if applicable) and placement locations
- Inspection procedures
- Registered waste carrier and non-waste haulier
- Tracking form / control sheets
- Treatment results (if applicable)
- Delivery tickets for non-waste materials (if moving from one site to another)
- Acceptance procedures for non-waste materials

6.5.5 Finally, the MMP will have to set out a Verification Plan that identifies how the placement of materials is to be recorded and the quantities of material to be used. It will contain a statement on how the use of the materials relate to the remediation or design objectives.

6.5.6 Once completed, the MMP will need to be reviewed by a Qualified Person (QP), who will submit an online Declaration to CL:AIRE and send a copy to Minerva & Crest. It should be noted that in accordance with the Code of Practice, Lithos cannot act as the Qualified Person because we have undertaken the site investigation and prepared this Remediation Strategy.

6.6 Engineering supervision and verification

6.6.1 Site works should be supervised **throughout** by a suitably qualified Engineer, who will report to a Project Manager. Supervision may be part-time for certain activities, but must be full-time during the removal of any grossly contaminated soil/fill and any placement of fill to an engineering specification.

6.6.2 The Engineer will ensure that the requirements of this Remediation Strategy are complied with in a safe and orderly manner.

6.6.3 The responsibilities of the Engineer should include, but not be limited to, the following:

- Ensuring that all site personnel are suitably qualified and given an appropriate induction at the beginning of their first day
- Supervision of the remediation and ground preparatory works
- Provision of advice on the correct handling of materials and conditions encountered
- Provision of guidance on the appropriate protective clothing and safety equipment that is to be made available and used
- Ensuring that personal hygiene arrangements are adequate
- Retrieval of soil and water samples and the subsequent scheduling of appropriate laboratory analysis to enable verification of various aspects of the works, and to advise the Project Manager of progress
- Liaison with statutory authorities as required

6.6.4 The Engineer will maintain records of the works to include the following:

- Daily record sheets to include a summary of the day's activities
- Date and weather conditions
- Plant, personnel and visitors present
- Aspects relating to Health and Safety, Environmental Control, or non-compliance with either this Remediation Strategy or the Contractor's Method Statement
- Site surveys as necessary to record the locations of demolition, excavation and filling activity
- Test results

6.6.5 On satisfactory completion of all the works the Engineer will prepare a Verification Report, in accordance with the Environment Agency's online guidance "Land Contamination Risk Management" which replaced CLR11 in October 2020. Copies of the Verification Report will be issued to the Minerva & Crest, the Local Authority and NHBC.

6.6.6 The Verification Report will stand as certification that the remediation and ground preparatory works have been carried out in accordance with this Remediation Strategy.

6.6.7 The Verification Report will include:

- A summary of the preparatory & remediation works undertaken, including any works associated with unforeseen ground conditions
- Verification test results associated with "hot-spot" treatment, including plans showing sample locations & levels, and the extent of any "hot-spot" excavations
- Details of the fate of any arisings excavated from "hot-spot"
- Verification test results associated with proposed source materials for clean cover
- Moisture content and plate bearing test results associated with ground improvement beneath proposed highways
- Copies of any correspondence with Regulators relating to specific aspects of the remediation works
- Reference to the MMP and associated tracking system, including alterations made and why.
- Treatment records
- Reference to waste transfer documentation, including return loads (if applicable)
- Signed delivery tickets (if applicable)
- Record of quantity of materials used
- A receipted copy of the Qualified Person's Declaration

6.6.8 The Verification Report will also provide recommendations with respect to:

- Foundation Solution(s)
- Gas Measures
- Placement of Soil Cover
- Handling of Contaminated Soils

6.6.9 The above recommendations will take account of the actual remediation works undertaken, and may differ significantly from recommendations originally presented in the site investigation report.

7 REMEDIATION STRATEGY (SPECIFIC OBJECTIVES)

7.1 Contingency for unknowns

7.1.1 Even after an appropriate preliminary investigation and ground investigation, with exploratory holes on a closely spaced grid (say trial pits at 30m centres), a geoenvironmental appraisal is typically based on inspection of the ground underlying less than 0.5% of the total site area (and much less at depths in excess of about 3.5m). Consequently, there is always a possibility that unanticipated ground conditions will be encountered during the remediation works.

7.1.2 If unanticipated ground is encountered during the remediation works, the Contractor should immediately seek further advice from the Engineer.

7.1.3 In accordance with the requirements of Condition 11 of the planning permission all works (apart from investigation works) should cease immediately and the Local Planning Authority should be notified in writing within 2 working days. Condition 11 also prohibits the recommencement of works until a revised Remediation Strategy is submitted to, and approved in writing, by the Local Planning Authority.

7.1.4 In order to assess the nature of any unanticipated grossly contaminated soil/fill, and (if necessary) allow revision of this Strategy document, it should be placed in temporary stockpiles on hardstand or an impermeable membrane, suitably covered and bunded.

7.1.5 Analysis of at least 6 samples, for an appropriate range of determinands should be undertaken. On receipt of the results, the Engineer will liaise with the Contractor regarding the most appropriate remediation option.

7.1.6 The Contractor might consider it appropriate to commission additional ground investigation in order to obtain a better picture of ground conditions in advance of the proposed remediation works. A simple 1 or 2 day trial pit dig could yield useful data.

7.1.7 As noted in Section 3.2, remediation works should not commence prior to completion of the necessary supplementary groundwater investigation (see Section 7.2 below) and, if required, issue of a revised Remediation Strategy.

7.2 Supplementary ground investigation

7.2.1 Given uncertainties regarding the nature and location of source areas/material, and the direction of groundwater flow beneath the site, some additional ground investigation is required.

7.2.2 Following a site visit by Lithos in September 2024, it has been determined that only 9 of the existing 22 boreholes are still present, and these were found to be in varying stages of disrepair and typically silted up. Consequently, it will be necessary to install monitoring wells in 10 new boreholes across Parcels 4 & 5. Boreholes can be advanced by dynamic sampling using a mini percussion drilling rig equipped with a concrete corer.

7.2.3 Prior to obtaining groundwater samples, the 10 wells will be 'developed' and subsequently purged.

7.2.4 Water samples should also be taken from Lees Head Beck/Ox Field Beck. Sampling should be recovered from 4 locations, upstream and downstream of the wider site, and at two mid-points close to the former gas works and at the suspected 'outlet' of a former historical drainage feature.

7.2.5 Groundwater and surface water should be sampled on two occasions.

7.2.6 Recovered groundwater and surface water samples should be scheduled for a chemical suite including: pH & metals, ammoniacal nitrogen, cyanide, conductivity, speciated TPH, VOCs and SVOCs.

7.2.7 Analytical results should be reviewed, and if the results indicate that groundwater is significantly contaminated and requires treatment, or that it might be impacting the adjacent beck, it will be necessary to undertake a Detailed Qualitative Risk Assessment.

7.2.8 On completion of hardstand grubbing-up, consideration could be given to the excavation of additional trial pits in particular areas of interest, most notably the former gas holder and tar well, former lagoon/channel, and tank areas.

7.2.9 All pits should be supervised by the Engineer and be excavated to sufficient depth to prove the base of made ground and extent of any contamination.

7.2.10 Representative soil/fill samples should be taken by the Engineer. The number of samples taken should be reflective of the fill/geological complexity actually encountered.

7.2.11 Selected samples should be sent to a suitably accredited laboratory and scheduled for appropriate chemical analysis (likely to comprise pH, metals, asbestos, speciated PAH & speciated TPH). Analysis for other determinands may be appropriate and should be requested by the Engineer as necessary.

7.2.12 The investigation should be undertaken in general accordance with current UK guidance (most notably BS10175:2011+A2:2017). The soils encountered during this investigation will be logged in general accordance with BS5930:2015.

7.3 Well decommissioning

7.3.1 There are existing monitoring wells in several boreholes across the site.

7.3.2 New monitoring wells will be installed in boreholes in order to enable groundwater monitoring/sampling. Depending on the timing of remediation works, these wells may be regularly monitored until earthworks necessitate destruction of the headworks. The Contractor should ensure these boreholes are protected by the erection of secure Heras-type fence, until such time as agreed with the Engineer.

7.3.3 Monitoring wells in all boreholes (existing & proposed) should be decommissioned in order to prevent the possibility of gas migration into sub-floor voids and/or cross-contamination between residual contamination in the made ground and the underlying aquifer. Decommissioning could be achieved by filling the well with bentonite pellets (uppermost 3m; to be wetted after placement). The headworks (raised helmet or stop-cock type cover) should then be removed and the surface made good.

7.3.4 Ideally the upper length of HDPE well pipe should be back-screwed and removed from the borehole, with the resultant 'hole' to be filled with bentonite pellets (to be wetted after placement).

7.4 Potential for a phased approach to Parcel 5

7.4.1 As discussed in Section 1.2, it is understood that consideration is being given to leasing the east of Parcel 5 to Network Rail in the short-term, with residential redevelopment to follow in the future.

7.4.2 Consequently, the Client has requested that consideration be given to undertaking remediation works within Parcel 5 in two phases; the western half in early 2025 (in order to enable installation of drainage infrastructure etc), and the eastern half a few years later. The approximate extent of these two areas is shown on Drawing 3435/212.

7.4.3 At this stage, it is not possible to confirm that a phased approach to remediation of Parcel 5 will be possible. This is partly due to the fact that the hydrocarbon impact in soils spans the two sub-areas, but predominantly due to uncertainties regarding the presence\significance of groundwater contamination.

7.4.4 If, following completion of supplementary groundwater investigation and a detailed qualitative assessment of risks to controlled waters some groundwater remediation is considered necessary, this would need to be undertaken in one phase.

7.4.5 If groundwater remediation is not required, the appointed Contractor and Engineer would need to assess the nature of the ground along the 'internal east\west' boundary within Phase 5. Most notably with respect to: the nature (mobility) of contamination within soils; depth to groundwater; thicknesses of made ground; evidence of impact within underlying natural soils etc.

7.4.6 In order for a phased approach to remediation works within Parcel 5 to be acceptable, the appointed Contractor will need to propose works (perhaps a clay 'cut-off' wall) that will ensure residual contamination in the east cannot impact remediated land in the west. Any such proposed works will need to be approved by the Engineer, Client, local authority and building warranty provider.

7.5 Site clearance

7.5.1 Any trees currently under a preservation order should be identified and agreed with relevant authorities prior to the commencement of the works. All trees subject to a TPO should be clearly identified and protected by fencing in accordance with BS5837: 2012.

7.5.2 The site should then be cleared of all residual debris, any vegetation, shrubs, bushes and unprotected trees as instructed by Minerva & Crest.

7.5.3 Topsoil is present in the south and west or Parcel 5 (beyond the former building). No testing of this material has been undertaken to date and therefore the Topsoil should be stripped and placed in a temporary stockpile.

7.5.4 The Engineer should visually inspect the material for any undesirable materials (brick, concrete, sharps, etc) and instruct analysis (pH, metals, asbestos ID, TPH and speciated PAH) of samples from the topsoil stockpile in order to confirm its suitability for re-use.

7.6 Asbestos

7.6.1 Localised fragments of asbestos cement sheeting may be encountered during the 'turnover' works; see Section 7.7. All suspected asbestos-containing material should be recovered by hand and placed in double sealed bags, within a sealed skip for off-site disposal at a suitably licensed landfill site. Personnel involved in this activity should be equipped with appropriate personal protective equipment, including dust masks (minimum FFP3).

7.6.2 An asbestos ID (screen) was scheduled on 29 samples of made ground across the wider site, with asbestos identified in a single sample. Subsequent quantification yielded a result of 0.002% which is only marginally above the limit of detection (<0.001%).

7.6.3 Provided soils are kept damp the risk of airborne fibre release, even during disturbance associated with excavation, should be negligible, and certainly below the control limit (as set by the Control of Asbestos Regulations 2012) of 0.1 f/cm^3 airborne fibres averaged over a 4-hour period.

7.6.4 Any made ground soils where asbestos is positively identified and considered representative of near-surface soils, must be isolated beneath the proposed minimum 600mm thick surface cover of "clean" soil, plus a 150mm hard-dig layer, (garden/landscaped areas), or hardstand (parking areas), or floor slabs (buildings). In line with the principles of sustainable development, there should be no need to export any soil from site.

7.7 Turnover of made ground

7.7.1 Turnover (excavation, screening/sorting and replacement in engineered layers, with compaction) of the full thickness of made ground within Parcels 4 & 5 is required in order:

- To remove relict foundations and obstructions (including USTs, redundant sewers, gas holders, etc)
- To remove the soil/fill grossly contaminated with hydrocarbons
- To provide mitigation against the risk of spontaneous combustion within the Ash & Clinker
- To prepare the ground beneath proposed new estate roads

7.7.2 Shallow groundwater and permeable drift soils will make management of groundwater problematic, and realistically remediation of soils below the water table will be difficult. Nonetheless, it is expected that the full thickness of made ground will be turned and this will require control of water (see Section 7.18).

7.7.3 Furthermore, if/where free product is encountered in deeper natural soils, it must be chased out in order to provide environmental betterment.

7.7.4 Further details of specific operations associated with turnover are described in the following sections.

7.8 General excavation

7.8.1 Excavation of made ground will be undertaken in a controlled manner, working from a line agreed with the Engineer in linear panels.

7.8.2 Excavated material should be removed from each panel and screened to remove oversize (> 200mm) and other unsuitable (e.g. anthropogenic or biodegradable materials), prior to replacement.

7.8.3 Each panel should be inspected by the Engineer, and have its depth and extent recorded by survey, prior to backfilling (see Section 7.31).

7.8.4 Any excavated and screened material that needs to be stockpiled temporarily should be placed in areas designated by the Engineer. Any stockpile of made ground should be assumed to contain elevated concentrations of inorganic contaminants, and it should be ensured that such materials are not allowed to cross-contaminate any clean soils or controlled waters.

7.9 Site regrade

7.9.1 Regrade of site is anticipated to facilitate the proposed housing layout. It is understood that Minerva & Crest will require the appointed earthworks contractor to undertake digital terrain modelling, with a view to:

- Achieving a materials balance (thereby avoiding the need for any significant import or export of soils)
- Confirming final levels, including Plot FFLs
- Achieving acceptable highway and drive gradients
- Minimising foundation abnormals

7.9.2 The earthworks modelling should consider the possibility of using site-won subsoil as cover material (subject to the Engineer's approval), and how excess foundation and drainage arisings will be accommodated.

7.10 Tank removal

7.10.1 Drawing 3435/203 shows the location of all known storage tanks although given the sites history, and presence of a fuel filling pump in the east of Parcel 5, further underground storage tanks (USTs) should be anticipated.

7.10.2 Each tank should be carefully emptied of any residual product, purged of potentially explosive vapour, and safely disposed of from the site by an appropriately qualified and licensed contractor.

7.10.3 Any underground distribution pipe work should be purged of any residual product and explosive vapours and then carefully removed.

7.10.4 The Contractor should inform the local Petroleum Licensing Officer (PLO) prior to undertaking any works in the immediate vicinity of underground petrol tanks (if present). The PLO should be able to provide a list of approved tank removal contractors.

7.10.5 The Engineer will inspect the resultant excavations, and supervise the chasing-out of any grossly contaminated soil/fill encountered (see Section 7.11).

7.11 Excavation of contaminated soil/fill

Fuel-contaminated soils

7.11.1 A potentially significant area of hydrocarbon contamination has been identified as shown on Drawing 3435/210, with further contamination likely to be present in a source area(s). Additionally, the possibility that localised 'hot-spots' beyond this will be encountered during either the supplementary investigation, or during the site preparatory works cannot be discounted.

7.11.2 Consequently, the made ground should be carefully inspected during turnover works (including preparation of the ground beneath highways, foundation and drainage excavations etc).

7.11.3 Any fuel contaminated material encountered during turnover should be excavated under the full-time supervision of the Engineer, who will be equipped with a portable PID instrument to assist with delineation.

7.11.4 Each excavated 'hot-spot' of potentially significant fuel/oil contaminated soil should be placed in a separate stockpile on hardstand or an impermeable membrane, suitably covered and bunded.

7.11.5 Following excavation of the grossly contaminated ground, the Engineer will inspect and sample the resultant excavations.

7.11.6 A minimum of 5 verification samples should be taken from the excavation sidewalls and base. These samples should be tested for TOC, BTEX compounds, speciated PAH & speciated TPH. Analysis for other determinands may be appropriate and will be requested by the Engineer as necessary.

7.11.7 In larger excavations, additional verification samples should be taken from the exposed excavation surfaces on a 10m grid.

7.11.8 The Engineer will instruct continued removal of soil/fill if verification samples yield concentrations in excess of the clean-up criteria outlined in Section 4.

7.11.9 Excavations should not be left open for longer than is necessary, and should be securely cordoned-off using 2m high Heras-type fencing, with appropriate warning signs whenever excavation works are suspended.

7.11.10 Excavated contaminated soils should either be treated or disposed of off-site; see Sections 7.19 and 7.21 respectively.

7.11.11 On completion of tank/soil removal, excavations are to be backfilled (see Section 7.24).

Ash & Clinker

7.11.12 Due to its combustibility near-surface Ash & Clinker is to be removed from proposed garden areas and placed beneath plots or areas of hardstand.

7.11.13 Redistribution (see Section 7.25) will satisfactorily isolate the Ash & Clinker from both end users and potential heat sources.

7.12 Dust, vapour & odour control

7.12.1 The excavation of grossly contaminated soil/fill should not present a significant problem with regard to emission of dust during excavation and transport because the material to be excavated should have a high moisture content. Nonetheless, the monitoring and mitigation measures outlined below will be required.

7.13 Dust & VOC monitoring

7.13.1 Monitoring for dust and total volatile organic compounds (VOCs) in air will be carried out by the Engineer, during the excavation of soil/fill. This monitoring will be undertaken at the up-wind and down-wind site boundaries. Monitoring will be undertaken no less than three times a day, at approximately 09:00, 13:00 and 17:00 hours.

7.13.2 In addition, the atmosphere inside closed cabs of plant involved in the excavation of grossly contaminated soil will be regularly monitored for total VOC concentrations.

7.14 Odour monitoring

7.14.1 Olfactory monitoring for odour nuisance will be undertaken at the site boundary down-wind of the excavation area during all excavation works. Odour monitoring will be carried out at these locations no less than three times a day during active site works.

7.14.2 At each monitoring event, the odour level will be subjectively classified as none, slight, moderate, or high, where:

- A slight odour level is detectable but not particularly noticeable,
- A moderate odour level is noticeable but not offensive, and
- A high odour level is offensive.

7.14.3 If high odour levels are detected in the same location on more than two occasions during any three-day period, then one or more of the actions outlined Section 7.17 below will be undertaken in order to reduce the odour levels.

7.15 Monitoring equipment

7.15.1 Total VOC concentrations will be monitored using pocket photo-ionisation detectors (PID) (or similar. Each PID unit will also serve as a personal alarm, programmed to give an audible alarm at the short-term and long-term exposure limits for benzene. These units should also be capable of logging the concentration of total VOCs at given intervals during a working day. The data should be downloaded to a PC for interrogation, which might result in revision of working procedures to reduce vapour release.

7.15.2 Dust will be monitored using a 'real-time' particulate monitor. The real time particulate monitor will provide an instantaneous measurement of the concentration of particulates in the air stream passing through it. The real-time measurement will allow for rapid initiation of mitigation measures in the event of dust generation becoming problematic.

7.16 Trigger levels

7.16.1 Action limits for requiring respirator protection in the vicinity of the excavations and for taking corrective action to mitigate against the generation of air-borne dust or volatile organic contamination have been agreed with the Local Authority. They are based on EH40/2002, Occupational Exposure Limits, Health and Safety Executive. EH40 trigger levels for total VOCs and dust are:

VOC & dust trigger levels

Determinand	Long-term exposure limit (8 hour time-weighted average)	Short-term exposure limit (15 minute reference period)
Total VOCs	1 ppm	3 ppm
Dust	4 mg/m^3	12 mg/m^3

7.16.2 The long-term exposure limit for total VOCs is based on the EH40/2002 long-term exposure limit (8-hour time-weighted average) for benzene. The short-term exposure limit is set at three times the long-term exposure limit as recommended in EH40/2002.

7.16.3 The long-term exposure limit for dust is based on the EH40/2002 long-term exposure limit (8-hour time-weighted average) for respirable dust, which is taken from the General COSHH Approved Code of Practice, 1997. Again, the short-term exposure limit is set at three times the long-term exposure limit.

7.17 Mitigation

7.17.1 At all times during the excavation works, Best Practicable Means shall be employed to minimise dust, odour and VOC generation and their emission off site.

7.17.2 If dust or VOC concentrations in air exceed the long-term trigger levels in the vicinity of the excavation area, but are below the long-term trigger levels at the site boundary, then respirator protection will be required for all site personnel working in the excavation area.

7.17.3 Respiratory protection that conforms to the European Product Directive (CE) shall be readily available for personnel exposed to odours. Twin cartridge respirators, that conform to EN140, fitted with class A1 filters cartridges, which conform to EN141 (organic gases and vapours), shall be used. If highly odorous material is encountered on site then masks with Class A2 filters shall be used.

7.17.4 In addition, one or more of the following corrective actions to mitigate against the generation of air-borne dust or volatile organic contamination will immediately commence:

- Mist and water spraying to eliminate dust and/or reduce generation of volatile compounds
- Reduction of the exposed active excavation area by backfilling or covering to reduce the generation of volatile compounds

7.17.5 In addition, as a contingency measure, the Engineer may instruct use of de-odourising equipment (as typically used at landfills) and enzyme degraders.

7.17.6 If dust or VOC concentrations in air exceed the long-term trigger levels at the site boundary then excavation activities will be stopped immediately and one or more of the above corrective actions will commence. Work will not begin again until the air quality at the site boundary has returned to an acceptable level and only after all reasonable actions have been taken to prevent the air quality at the site boundary from again declining to an unacceptable level.

7.18 Control of water

7.18.1 Shallow groundwater and permeable drift soils will make management of groundwater problematic. However, it is likely that some pumping and treatment of perched water and shallow groundwater will be necessary during earthworks to manage groundwater ingress and to remove localised areas of free product and drains.

7.18.2 Groundwater should be controlled in accordance with CIRIA report 113 "Control of Groundwater for Temporary Works".

7.18.3 Some perched water **may** be contaminated with hydrocarbons and/or VOCs.

7.18.4 It should be noted that significantly elevated concentrations of hydrocarbons and heavy metals are often associated with sediment within the former drainage network below brownfield sites such as this, and that these, if released, pose potential risk to waters.

7.18.5 Any potentially contaminated water should not be allowed to escape to other areas until the results of the analysis are available and, if required, a suitable means of water treatment has been agreed.

7.18.6 Water should be collected in sumps and it is likely that treatment will require the use of an oil water separator and possibly filtering through a medium such as activated carbon prior to discharge to a foul drain. Oils trapped in the absorbent medium should be disposed of to a suitably licensed landfill site.

7.18.7 Treated water should then be tankered off-site, or be discharged to sewer, subject to analytical results and local water treatment company consent.

7.18.8 If discharge to foul sewer is not acceptable to the Water company, volumes are restricted or discharge impractical, approval could be sought from the Environment Agency to allow discharge back to ground. However, consent to reinject groundwater is by no means a certainty and should be confirmed prior to designing any remediation scheme around this option. Furthermore, this option would require Lithos to derive screening values following the supplementary groundwater investigation.

7.18.9 A Surface Water Management Plan should be prepared by the Contractor, describing the mitigation measures that will be put in place to intercept direct run-off from any disturbed areas, stockpiles etc, thereby preventing any potential impact of adjacent land and nearby watercourses. Surface water run-off will probably require treatment (as a minimum to allow settlement of fines) prior to consented discharge.

7.18.10 The Contractor should make all necessary arrangements to prevent off-site migration of contaminated sediment via surface water run-off, and avoid any pollution of Ox Field Beck and Lees Head Beck beyond the southern boundary. This will necessitate the installation of surface water grips, and removal, sealing-off, or diversion of all redundant former site drains (and any land drains).

7.18.11 Arrangements should be made to prevent ponding in any excavation "hollows"; the Contractor should ensure that ground levels are of sufficient gradient to enable the collection of surface water run-off in sumps or grips.

7.18.12 Pumping from over-excavated sumps may be required to maintain satisfactory working conditions.

7.19 On-site treatment of soil contamination

7.19.1 Grossly contaminated soil/fill from Parcels 4 & 5 is considered suitable for treatment on site. It is anticipated that the volume of soil/fill requiring treatment will exceed 1,000m^3. Therefore, if on-site treatment is proposed, a Mobile Treatment Licence will be required and a Deployment Form must be completed and submitted to the Environment Agency.

7.19.2 At all times during on-site treatment, Best Practicable Means must be employed to minimise dust, odour and VOC generation, and their migration off site.

7.19.3 Excavated soils should be screened, to remove oversize (concrete and brick), and the remaining fines hauled to a treatment area.

7.19.4 Within an impacted mass, contaminant concentrations are likely to vary significantly, and segregation of very heavily contaminated material from less contaminated material may not be practical. However, deliberate "overdig" of soil that has not been impacted, for mixing with contaminated soil, is not acceptable.

7.19.5 If ex-situ bioremediation is proposed, the treatment area should be formed on an impermeable composite liner (clay with polythene membrane, or HDPE sheeting, or concrete hardstand) in an area of site agreed with the Engineer. A collection trench should be constructed along the width of the treatment area to gather any run off.

7.19.6 Sampling of the windrows/stockpiles should be carried out at a rate of one sample per 200m^3, or a minimum of 6 samples, whichever yields the larger number. Chemical analysis of these samples at weekly intervals will enable determination of the average concentration of each contaminant of concern (T_0, T_1, T_2 etc concentrations) in each windrow/stockpile, and the production of degradation curves.

7.19.7 A windrow/stockpile will be deemed to have been successfully treated once two consecutive sampling rounds yield US_{95} concentrations of all the contaminants of concern below agreed clean-up criteria.

7.19.8 As discussed in Section 4, it is proposed that Lithos' generic soil screening values for a residential-with-gardens end-use (assuming gardens with 600mm clean soil cover) be adopted as remedial targets for hydrocarbon contamination in soils on this site. Information on the derivation and use of these screening values is presented in Appendix B.

7.19.9 However, if revised soil and\or groundwater criteria are considered necessary, a revision of this Remediation Strategy will be issued.

7.19.10 It should be noted that treatment of lubricating range organics (C16-C35) may be problematic and require a longer timeframe. Consideration should be given to the range of contamination present when selecting material for on site treatment and timescales

7.19.11 As an alternative to bioremediation, consideration could be given to stabilisation (chemical and physical immobilisation of contaminants). Stabilisation can be achieved by the use of specially modified clays. The process incorporates reactive reagents to bind contaminants chemically within the supporting clay media. A feasibility study will be required to confirm that a significant reduction in leachate potential (mobility) can be achieved by stabilisation.

7.19.12 Stabilisation is likely to provide a more appropriate treatment solution if any "heavy" (lubricating oil range) hydrocarbon contamination is encountered, since ex-situ bioremediation may not feasible.

7.19.13 Following stabilisation, validation samples should be taken at a minimum rate of 1 composite sample per 200m^3 of treated soil (with a minimum of 6 samples if the volume treated is less than 1,200m^3), and results compared against those from the feasibility study to confirm that the treatment achieved the required reduction in leachate potential.

7.19.14 Treated soils should be placed in areas where they will not be subsequently disturbed (e.g. by deep excavations for drainage etc), at a minimum depth of 1.5m below finished ground level, where they will be suitably isolated from end-users of the site. The uppermost 0.6m of which will be "clean" cover, but the lowermost 0.9m could be colliery spoil, demo rubble etc.

7.19.15 Retention and re-use of treated material on site must be undertaken in accordance with the principles of the CL:AIRE Code of Practice (v2, March 2011); i.e. the treated material must be suitable for use, most notably at this site it must not pose risk to controlled waters.

7.19.16 Given the anticipated physical nature of the treated soils, the deposition area may need to surcharged with a stockpile of subsoil to ensure that excessive settlements do not occur.

7.19.17 Once a decision on how the hydrocarbon contamination will be dealt with has been made (i.e. stabilisation/bioremediation or landfill), this should be set out in the Contractor's Method Statement, a copy of which should be kept on site and made available for inspection by regulators should they request.

7.20 Groundwater remediation

7.20.1 The need or not for groundwater remediation has yet to be determined; see Sections 3.2 & 7.2.

7.20.2 None of the remediation works outlined in this Section 7 should commence prior to completion of the necessary supplementary groundwater investigation and, if required, issue of a revised Remediation Strategy.

7.20.3 In the meantime, it is likely that some pumping and treatment of perched water and shallow groundwater will be necessary during earthworks to manage groundwater ingress and to remove localised areas of free product and drains; see Section 7.18.

7.21 Export to landfill

7.21.1 Excavation arisings that are unsuitable for retention and re-use on site should be placed in temporary stockpiles on hardstand or polythene sheeting and be suitably covered to minimise the potential for dust/odour nuisance, and prevent surface water run-off.

7.21.2 Given the proximity of existing housing, and in order to avoid any potential odour nuisance, stockpiles of material should be exported from site as soon as practically possible.

7.21.3 Any material exported from site to landfill should be hauled by a registered waste carrier in accordance with the requirements of the Waste Regulations 2011 and the Landfill (England & Wales) Regulations 2002.

7.21.4 A transfer note should be completed, signed and retained by the parties involved. The transfer note should include the volume of waste, the nature of the material and a statement of its chemical composition, details of the source and destination sites, and details of the haulier.

7.21.5 In order to protect the general public from dust and vapour emissions, wagons that are to be used for the haulage of the contaminated material from the site must be sheeted. In addition, the Contractor must ensure that no fluids seep from the wagons.

7.21.6 In order to provide the landfill facility with information regarding chemical composition of the waste, further analysis of any material that requires removal from site may be required.

Waste classification

7.21.7 Sampling and characterisation of stockpiled materials generated during the site preparatory works is likely to be required if off-site disposal is proposed.

7.21.8 It should be noted that the classification and assessment of waste soils under the Environment Agency's Technical Guidance WM3[1], is a complex process.

7.21.9 It is critical if material is to be exported from site that this is allocated an appropriate waste code, following the steps within WM3. Waste carriers transporting, and sites accepting, this material should have a corresponding code within their permits. It is the responsibility of those generating the waste (i.e. the site), to ensure that the waste is handled and disposed of appropriately.

7.21.10 With respect to **asbestos**, waste soils will be classed hazardous if the soil mass contains more than 0.1% asbestos fibres that are free and dispersed. However, WM3 states that where the waste contains identifiable pieces of asbestos (i.e. any particle of a size that can be identified as potentially being asbestos by a competent person if examined by the naked eye), then the waste is hazardous if the concentration of asbestos in the pieces alone is 0.1%. If a stockpile of soil contained rare fragments of broken asbestos-cement sheeting, the whole stockpile would be classed as hazardous unless all the fragments could be picked-out (even though the concentration of asbestos in the soil mass might be orders of magnitude less than 0.1%).

7.21.11 Tarmac hardstand is present in the centre south of Parcel 4 and northwest of Parcel 5.

7.21.12 This **tarmac** could be recycled and crushed to yield a 6F3 selected granular material, provided the recovered bitumen content is less than 10% (determined in accordance with BS598-1:2011). Crushed tarmac could also be blended with crushed concrete etc to generate 6F2 graded material. 6F2 can contain up to 50% recycled tarmac/asphalt (provided it does not pose a contamination risk to controlled waters and, if the proportion of asphalt is greater than 20%, the recovered bitumen content is less than 2%).

7.21.13 However, if off-site disposal is anticipated, tarmac assessment is based on the amount of coal tar present, this will vary depending on the age of the tarmac. The assessment is based on the amount of benzo(a)pyrene, and has a concertation limit of 50mg/kg.

7.21.14 Speciated PAH analysis has been undertaken on 2 samples of tarmac recovered from the wider site north of Crossley Lane (including Parcel 4), BaP concentrations were >50mg/kg. Consequently, tarmac is likely to fall within waste code 17 03 01:

- 17 - Construction and Demolition wastes,
- 03 – bituminous mixtures, coal tar and tarred products
- 01 – bituminous mixtures containing coal tar

7.21.15 17 03 01 is a mirror **hazardous** entry (17 03 02 is the corresponding mirror non- hazardous entry). This code along with this supporting report, in particular the laboratory results, should be used to complete a paper trail documenting disposal routes for tarmac.

7.21.16 Contractors exporting waste from the site should review the site investigation data and make their own assessment. Alternatively, Lithos could undertake this assessment once exported waste streams have been identified.

[1] Technical Guidance WM3 – Guidance on the classification and assessment of waste. Environment Agency 2015

7.22 Removal of below ground obstructions

7.22.1 All foundations associated with former buildings and other relict structures should be chased out and grubbed-up, in order to remove potential obstructions to new foundations and infrastructure.

7.22.2 Drawings 3435/204A to 3435/204E shows the location of all significant buildings etc recorded on historical OS plans; it should be noted that after initial development in the later 1800s, the site has gone through several generations of development.

7.22.3 Where relict structures are found to retain fluid contaminants, they should be drained first. The drained fluids should be stored in appropriate, sealed tanks/containers and analysed for a range of determinands to be agreed with the Engineer. Fluids may then be tankered off-site, or be discharged to sewer, subject to analytical results and local water treatment company consent.

7.22.4 Deep excavations for the removal of structures etc will be unstable in the short term and continuous side support will be necessary.

7.22.5 Where significantly deep foundations (e.g. piles) cannot be removed by conventional means, they are to be cut at a depth to be agreed with the Engineer and the position of the remaining lower section is to be accurately recorded by survey.

7.22.6 Suitable materials derived from grubbing-up should be stored in a location on site, to be agreed with the Engineer, prior to crushing (see Section 7.23). Any unsuitable materials should be removed to a suitably licensed landfill site (see Section 7.21).

7.22.7 It is possible that subsurface concrete (i.e. below the surface slabs) and brick arisings could be coated with and possibly impregnated by tar/oil contaminants. Consideration could be given to steam-cleaning of these arisings in order to generate material suitable for crushing and re-use, if they can be proven not to have been impregnated.

7.23 Crushing

7.23.1 Production of a selected granular fill should be possible if suitable materials (generated by demolition operations and grubbing-up of floor slabs, foundations and other relict structures) are crushed.

7.23.2 The crushed product should be screened to remove any unsuitable elements and stockpiled for re-use during the subsequent construction works. Generation of a Class 6 material as defined in the Highways Agency Specification (Series 600) should be possible.

7.23.3 Tarmac could be recycled and crushed to yield a 6F3 selected granular material, provided the recovered bitumen content is less than 10% (determined in accordance with BS598-1:2011). Alternatively, crushed tarmac could also be blended with crushed concrete etc to generate 6F2 graded material. 6F2 can contain up to 50% recycled tarmac/asphalt (provided it does not pose a contamination risk to controlled waters and, if the proportion of asphalt is greater than 20%, the recovered bitumen content is less than 2%).

7.23.4 The Engineer should check the suitability of crushed product for re-use, instruct the removal of any unsuitable material and schedule appropriate confirmatory geotechnical or chemical testing.

7.23.5 It should be possible to generate other secondary aggregates from crushed concrete provided it is subject to good sorting prior to crushing and thereby contains little 'impurity' (e.g. brick, breeze block, wood, re-bar etc). The Contractor should liaise with the Local Authority to obtain their views with respect to the use of Type 1 etc generated from recycled concrete.

7.23.6 A minimum of 3 samples (or 1 sample per 500m^3, whichever is the greater) should be taken from any stockpile of specific crushed product and sent to a UKAS accredited laboratory for analysis to assess whether the material conforms to requirements as defined in of the Highways Agency Specification for Highway Works; Series 600 (if 6F2 is anticipated), or Series 800 (if Type 1).

7.23.7 A minimum of 3 samples (or 1 sample per 500m^3, whichever is the greater) should be taken from any stockpile of specific crushed product and sent to a UKAS accredited laboratory for asbestos analysis.

7.24 Backfill of excavations

7.24.1 Excavations (to remove tanks, relict structures, contamination etc) should be backfilled as necessary to achieve the desired levels, with suitable materials and compacted in accordance with Lithos' Protocol for Placement of Non-Engineered General Fill; copy included in Appendix C.

7.24.2 However, where an excavation conflicts with the footprint of a proposed highway, compaction in accordance with the Specification for Highway Works will be required (see Section 7.29).

7.24.3 Trenches for services including site drainage and water supply should be cut over size in order to isolate pipe materials from potential contaminants and to enable maintenance to be conducted in "clean" material.

7.24.4 The site surface should be initially left 750mm below proposed finished garden levels to allow for placement of the cover, increased as necessary where piling mat thickness necessitates. In areas of highways the ground surface will be left approximately 600mm below finished road level.

7.24.5 The anticipated backfill materials (predominantly made ground) were adequately characterised by the site investigation (see Lithos Report 3435/1). Consequently, further testing of backfill materials is not anticipated.

7.24.6 Nonetheless, excavated arisings will be **inspected** by the Engineer, and any suspicious material or material yielding evidence of significant contamination (based on visual/olfactory observations), will be placed in temporary stockpiles from which an adequate number of samples will be taken (typically a minimum of 6 samples). The samples will be scheduled for an appropriate suite of contaminants in order to characterise the material and decide its fate.

7.24.7 Any material considered unsuitable for use as backfill will either be treated on-site (see Section 7.19), or be exported from site (see Section 7.21).

7.25 Placement of Ash & Clinker

7.25.1 Excavated Ash & Clinker is to be placed beneath plots or areas of hardstand in locations to be agreed with the Engineer and Minerva & Crest.

7.25.2 Placed Ash & Clinker should be compacted in accordance with Lithos' Protocol for the Placement of Non-Engineered Fill; copy included in Appendix C.

7.25.3 As further mitigation against the risk of spontaneous combustion, the ash should be placed in approximate 300mm thick layers, wetted and subjected to compaction, comprising at least 2 passes with a towed vibratory roller of at least 2,900 kg per metre width. Compaction will help to prevent the material drying out and reduce the ingress of oxygen.

7.25.4 Alternatively, Ash & Clinker arisings could be exported from site to a suitably licensed landfill facility; see Section 7.21**Error! Reference source not found.**.

7.26 "Clean" corridors

7.26.1 Along the line of proposed new sewers (and within the footprint of a proposed attenuation tank), made ground will be excavated to its full thickness, or at least 1.0m below deepest sewer invert whichever is the lesser, to a width agreed with Minerva & Crest.

7.26.2 The resultant excavation will only be backfilled with "clean" material which might comprise any of:

- site-won natural soils;
- crushed concrete; and/or
- suitable imported natural soils or quarry aggregate.

7.27 Placement of a granular running layer

7.27.1 A minimum 200mm thickness of suitable granular fill (i.e. a "blanket" of 6F2) could be placed along the line of proposed haul roads to provide a firm and stable running layer for the subsequent construction works.

7.28 Placement of a piling mat

7.28.1 Ground conditions at this site are considered likely to require provision of a piling mat (working platform) and further advice should be sought from the appointed specialist-piling contractor regarding the proposed plant loadings and resulting pressures. This data, together with a knowledge of the strength and variability of the near-surface ground conditions is required in order that design of a mat can be undertaken in accordance with guidance provided in the 2004 BRE document, "BR 470: Working platforms for tracked plant".

7.28.2 The design of working platforms for tracked plant is a geotechnical design process and should be carried out by a competent person. The following parties should have input into the design:

- Permanent works designer, to consider additional uses for platform material as part of the overall development
- Principal contractor, to define any other purposes for which the platform might be used
- Contractor or subcontractor, to specify requirements for the platform, including gradients, ramps and edges.

7.29 Highways

7.29.1 The Contractor should consult the adopting authority regarding preparation of the ground beneath new highways (as outlined below, or in any proposed alternative specification) in advance of the works. The Contractor should also agree acceptable performance criteria, with the Engineer and the adopting authority.

7.29.2 However, it is considered that the following options would be suitable to enable the construction of the highways.

7.29.3 During turnover of made ground highways should be raised to formation level, either with:

- Suitable aggregate placed & compacted in accordance with The Highways Agency Specification for Highway Works (SHW) Series 600, or
- Suitable screened & selected site-won material, placed & compacted in accordance with SHW Series 600. Unsuitable materials include any soft or wet materials, biodegradables including topsoil, wood, scrap metal, frozen & oversize material.

7.29.4 In the footprint of proposed highways, the contractor, under supervision, must ensure that relict obstructions are removed to a minimum of 500mm below deepest sewer invert. The resultant sub-formation should then be proof rolled, in accordance with the Specification for Highway Works.

7.29.5 Where excavation associated with ground improvement (e.g. turnover of made ground) beneath a highway results in sub-formation slopes greater than 1:5 (v:h), the sub-formation should be stepped (max. 0.5m high) and benched (min. 1m wide). Where the excavation works exceed 1m in depth, the footprint of earthworks should be extended beyond the highway footprint a minimum of 1m, plus the depth of excavation. The Engineer will keep records of any such work undertaken.

7.29.6 Crushing of demolition/hardstand/foundation arisings will generate aggregate, which (subject to confirmatory testing) should be suitable for use as unbound pavement materials within the highways.

7.29.7 The suitability of site-won material for placement as engineered fill should be confirmed by field trials and geotechnical laboratory testing, which will yield the following information:

- Number of passes with the compaction plant (to be used during subsequent earthworks)
- Maximum layer thickness (plant dependent)
- Acceptance criteria: minimum dry density & moisture content range

7.29.8 The engineered fill should achieve at least 95% maximum dry density, with air voids comprising less than 10%, as determined by 2.5kg laboratory compaction tests.

7.29.9 Where the made ground is re-engineered in accordance with the above specification, it is considered that a CBR value of 5% should be achievable; however, this should be verified by field trials.

7.29.10 The Contractor should ensure that only suitable granular fill is placed within 450mm of estate road formation in order to protect cohesive sub-grade materials (including natural cohesive soils). Such fill should be placed in accordance with the Specification for Highway Works.

7.29.11 The Contractor will arrange for the necessary compliance testing to be undertaken at formation level on road alignments, as required by the adopting authority and Engineer. As a minimum this should comprise plate load tests, carried out to determine the CBR at formation level, at approximate 25m intervals. Test locations should be staggered across the width of the highway to ensure the whole highway area is assessed.

7.30 Boundary issues

7.30.1 Minerva & Crest's Designer should ensure that proposed levels tie in with the surrounding infrastructure, and ground levels of adjacent properties (after allowance for the placement of any required soil cover).

7.30.2 A c. 7m high retaining wall is present along the northern boundary of Parcel 4.

7.30.3 Advice should be sought from the Engineer if mobile contamination or redundant drains/utilities are encountered close to the site's boundaries.

7.31 Surveying

7.31.1 The Contractor should arrange for the following survey work as directed by the Engineer:

- All setting out necessary to allow the works to proceed
- Recording of the depth and lateral extent of excavations to remove obstructions, contaminated soils etc
- Recording of the positions of any relict obstructions (i.e. piles) left in-situ
- Recording the depth & extent of each excavation panel during turnover of made ground, prior to backfilling
- Recording of natural ground levels, where natural ground encountered during the earthworks
- Recording the final location of potentially combustible or treated hydrocarbon-contaminated soils
- Recording the locations and volumes of all stockpiles of suitable materials left on site for Minerva & Crest 's use during the development works
- As-built survey of the finished surface on completion of the remediation contract

7.31.2 The Contractor should supply the results of this survey work to the Engineer for inclusion in the Verification Report.

7.32 Placement of soil cover

7.32.1 Clean inert soil will be placed over the made ground (except Ash & Clinker) in proposed garden and landscaped areas (but not beneath hardstanding). This cover layer is to comprise 600mm of "clean" subsoil and topsoil plus a 150mm 'hard dig' layer.

7.32.2 If Ash & Clinker is placed beneath gardens and/or landscaped areas, the thickness of clean soil cover needs to be increased to 1,000mm. The uppermost 600mm of soil cover must be "clean", but the lowermost 400mm could be demo rubble etc (i.e. not necessarily "clean", but inert).

7.32.3 It is considered unlikely that a significant volume of subsoil suitable for use as cover material will be sourced on site. Consequently, there will be a need for soil import.

7.32.4 Topsoil and subsoil quality should be assessed in accordance with Lithos' Protocol for Importation & Use of Soil Cover (Capping), copied in Appendix D.

7.32.5 This Protocol includes chemical assessment criteria which should not be exceeded.

7.32.6 Any material imported for use as cover should be validated in accordance with Lithos' Protocol for Importation & Use of Soil Cover (Capping), copied in Appendix D. This Protocol includes chemical assessment criteria which should not be exceeded.

7.32.7 This work may be undertaken as part of the contract for the preparatory & remediation works, in which case imported soils should be stockpiled in a location agreed with the Engineer. Alternatively, the developer may choose to import soil at a later stage in the development.

7.33 Topsoil placement

7.33.1 NHBC Conditions require garden areas to be provided with topsoil to a thickness of not less than 100mm. Topsoil thicknesses in excess of 400mm should generally be avoided.

7.33.2 Prior to placement of topsoil, the underlying subsoil should be loosened by ripping or rotovating. Stones and other objects greater than 50mm should be removed from the prepared surface, and the loosened subsoil should be roughly levelled so that an even depth of topsoil can be achieved.

7.33.3 For the loosening to be most effective, it should be undertaken when the subsoil is dry to the full depth of working.

7.33.4 Subsequent trafficking over the loosened subsoil should be minimised.

7.33.5 Topsoil should not be placed during or immediately after heavy rain.

7.33.6 An excavator with a toothed bucket should be used to load the topsoil from stockpile into dumpers, to prevent excessive smearing.

7.33.7 The dumper should tip the topsoil onto the receiving surface, and topsoil should then be spread to the required depth by an excavator. Both the dumper and excavator should avoid tracking over the placed topsoil.

7.33.8 After re-spreading topsoil, any large compacted lumps should be broken down to produce a fine tilth suitable for planting, turfing and seeding (< 10mm maximum aggregate size).

7.34 Hazardous gas protection

7.34.1 Based on the identified gas regime, the proposed foundation solution, and with reference to the gas protection "scoring" system outlined in BS 8485:2015, the following protective measures for **ground gases** and **hydrocarbon vapours** have been recommended:

Charac. situation (Wilson & Card, '99)	Gas "score" req'd by BS8485	Protective measures (Residential) (See footnote for definition of Building Type A)		
		Floor slab (BS8485 "score")	Sub-floor ventilation (BS8485 "score")	Membrane Type (BS8485 score")
2	3.5	*Select one from:* Block & Beam – (0). Reinforced ground bearing slab – (0.5). Reinforced, cast in-situ suspended slab (with minimal and suitably sealed service penetrations & joints) – (1.5). Reinforced ground bearing raft (with limited service penetrations cast into slab). Note: the venting area through any downstand beam should be 3 times greater than that provided by the side ventilation (air bricks) – (1.5).	*Select one from:* Passive sub-floor ventilation; venting layer could be: A min. 150mm clear void (2.5), or A proprietary void former providing an equivalent clear void depth of 60mm; see Section B7 in BS8485 (2.5), or Min. 300mm thick blanket of min. 20mm single size rounded or sub-angular gravel (1.0). Min. ventilation = 1,500 mm²/m run of external wall (via air bricks on each of 2 opposite sides), with 100mm pipes at 1.75m centres or honeycombing of any sub-floor sleeper walls.	Hydrocarbon and gas resistant membrane meeting all of the following criteria: • sufficiently impervious to gases with a methane gas transmission rate <40.0 ml/day/m²/atm (average) for sheet and joints (tested in accordance with BS ISO 15105-1 manometric method); • sufficiently durable to remain serviceable for the anticipated life of the building and duration of gas emissions; • sufficiently strong to withstand in-service stresses (e.g. settlement if placed below a floor slab); • sufficiently strong to withstand the installation process and following trades until covered (e.g. penetration from steel fibres in fibre reinforced concrete, penetration of reinforcement ties, tearing due to working above it, dropping tools, etc); • capable, after installation, of providing a complete barrier to the entry of the relevant gas; • a minimum 0.4 mm thickness (1600g polyethylene) reinforced membrane (virgin polymer); and • verified in accordance with CIRIA C735∞ (2.0)

Footnotes:

∞ In accordance with CIRIA C735, a Verification Plan should be prepared which outlines the activities (inspection and testing), the relevant personnel, and the type of records to be collected. Gas membranes need to be visually inspected to establish possible damage. For CS3 sites inspection & verification should be carried out by an independent third party. However, whilst conflicts of interest in verification should be avoided, the Developer's staff on site could undertake inspection & verification on CS2 sites. In all circumstances, the verifier should be competent, experienced and suitably trained.

1. Building Type A is defined in Table 3 and Section 7 of BS8485:2015+A1:2019 as: private ownership with no building management controls on alterations to the internal structure, the use of rooms, the ventilation of rooms or the structural fabric of the building. Examples include private housing and some retail premises
2. A combination of two or more of the three types of protection measures (slab, ventilation & membrane) should be used to achieve the BS8485 score.
3. The membrane should always be lapped and sealed in accordance with BRE/Environment Agency Report BR 414 (2001) – "Protective Measures for housing on gas-contaminated land". The membrane should be continuous across internal walls & the cavity, and there should be a cavity tray in external walls.
4. In all cases there should be minimum penetration of floor slab by services; any penetrations should be suitably sealed.
5. Check manufacturer's specification if hydrocarbon vapours are present; hydrocarbons will degrade some membrane materials.

7.34.2 In general accordance with CIRIA[2], YALPAG guidance[3] and NHBC guidance[4] a Gas Protection Strategy and Verification Plan (Design Report and Construction Drawings) should be prepared which detail site specific requirements for the gas protection system with respect to the development.

[2] *Good practice on the testing and verification of protection systems for buildings against hazardous ground gases. CIRIA C735, 2014.*

[3] *Verification Requirements for Gas Protection Systems - Technical Guidance for Developers, Landowners and Consultants. Yorkshire and Lincolnshire Pollution Advisory Group, December 2016.*

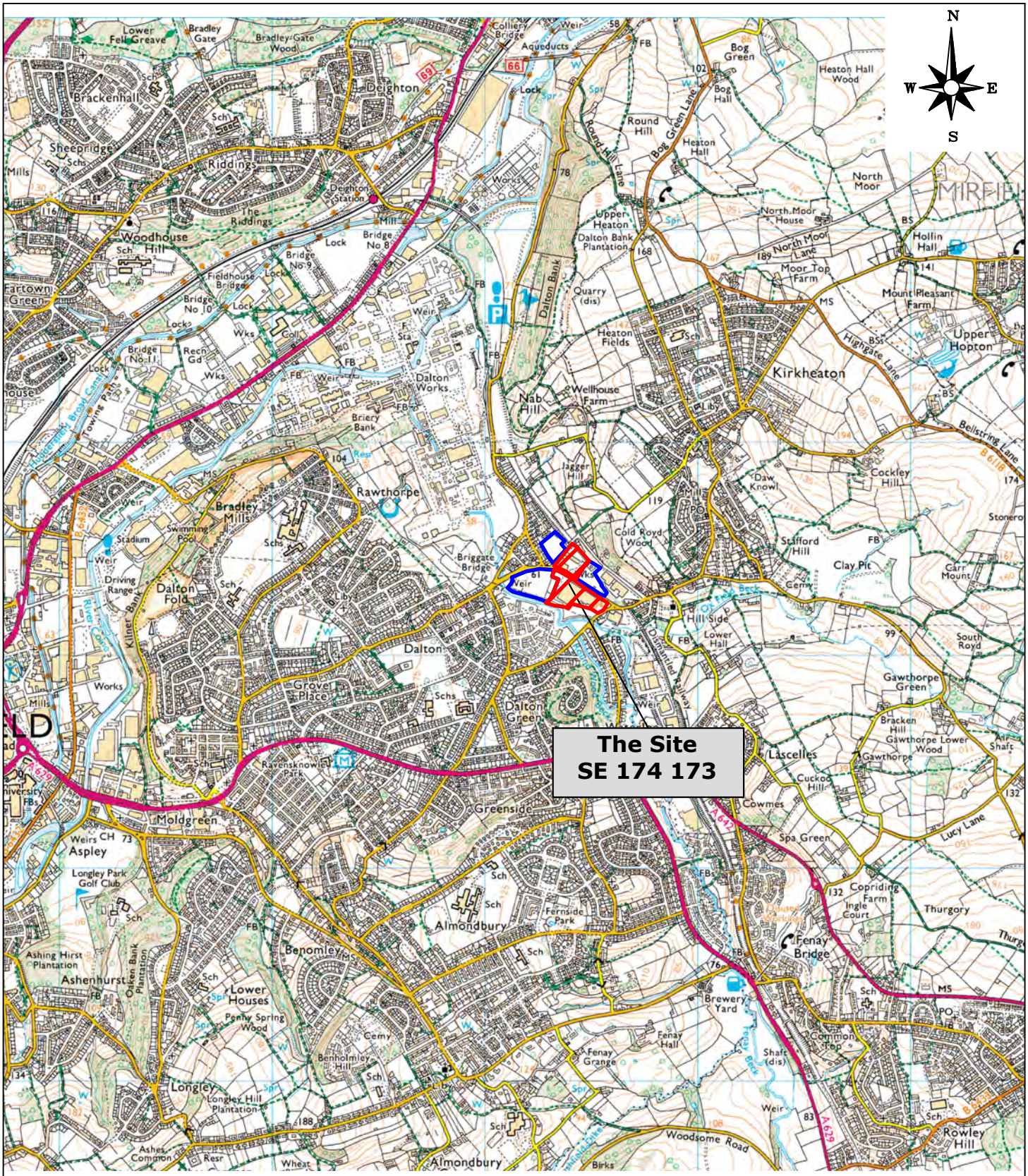
[4] *Hazardous ground gas – as essential guide for housebuilders. NHBC Foundation, April 2023*

7.34.3 The Design Report should include details which specify the required verification for all elements (design and installation) of the gas protection system. The report should be issued to NHBC and Kirklees Council in advance of the construction phase.

7.34.4 Independent third party verification (i.e. not by the installer or any associated company) of gas protection measures is required in accordance with the guidance, which as a minimum should include visual inspection. In all cases the verifier should be competent, experienced and suitably trained. As stipulated in the CIRIA guidance the frequency of verification will be dictated by the experience of the installer.

7.34.5 BRE/Environment Agency Report BR 414 (2001) – "Protective Measures for housing on gas-contaminated land" provides a practical guide to good practice for the detailing and construction of passive soil gas protection measures for new residential development. Of particular relevance are a list of 'Watchpoints', which offer practical information for installation and buildability.

APPENDIX A
DRAWINGS



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CLIENT	MINERVA DEVELOPMENTS LTD & CREST NICHOLSON YORKSHIRE
JOB TITLE	CROSSLEY LANE, DALTON (PARCELS 4 & 5)
DRAWING TITLE	SITE LOCATION PLAN
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CHECKED	REG
DATE	15 10 24
STATUS	FOR COMMENT ☐ DRAFT ☐ FOR APPROVAL ☐ FINAL ☑
SCALE	1:25,000
SHEET	A4
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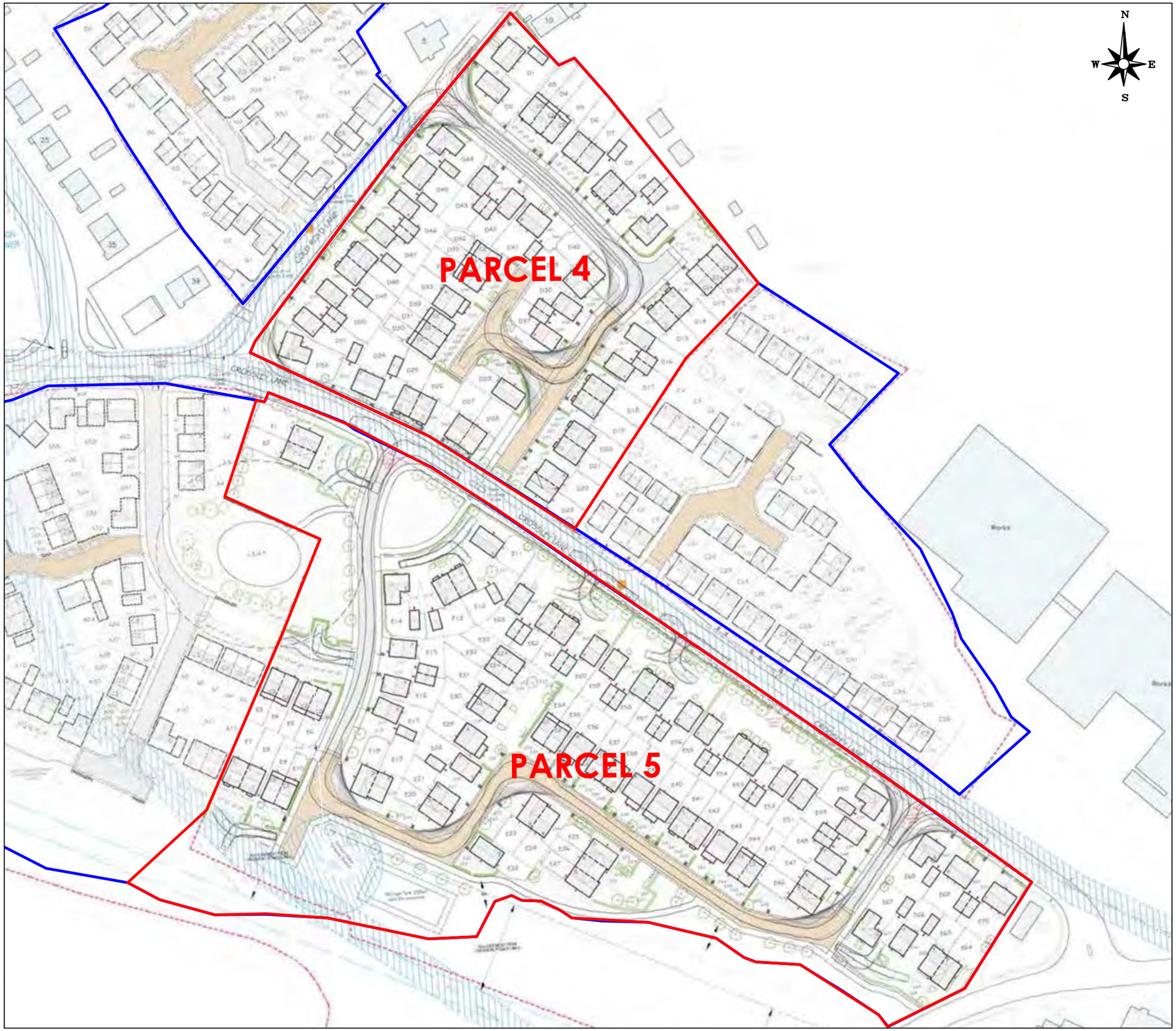
REVISION	



NOTES

APPROXIMATE WIDER SITE BOUNDARY

APPROXIMATE PARCEL BOUNDARY

REPRODUCED FROM JRP DRAWING REFERENCE P09.4267.75N REV. N, DATED 2nd NOVEMBER 2022

REV.	DESCRIPTION	DATE

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MINERVA DEVELOPMENTS LTD & CREST NICHOLSON YORKSHIRE

JOB TITLE

CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

PROPOSED SITE LAYOUT (PARCELS 4 & 5)

DRAWN	DATE	STATUS
LEW	15 10 24	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	15 10 24	DRAFT ☐
		FINAL ☑

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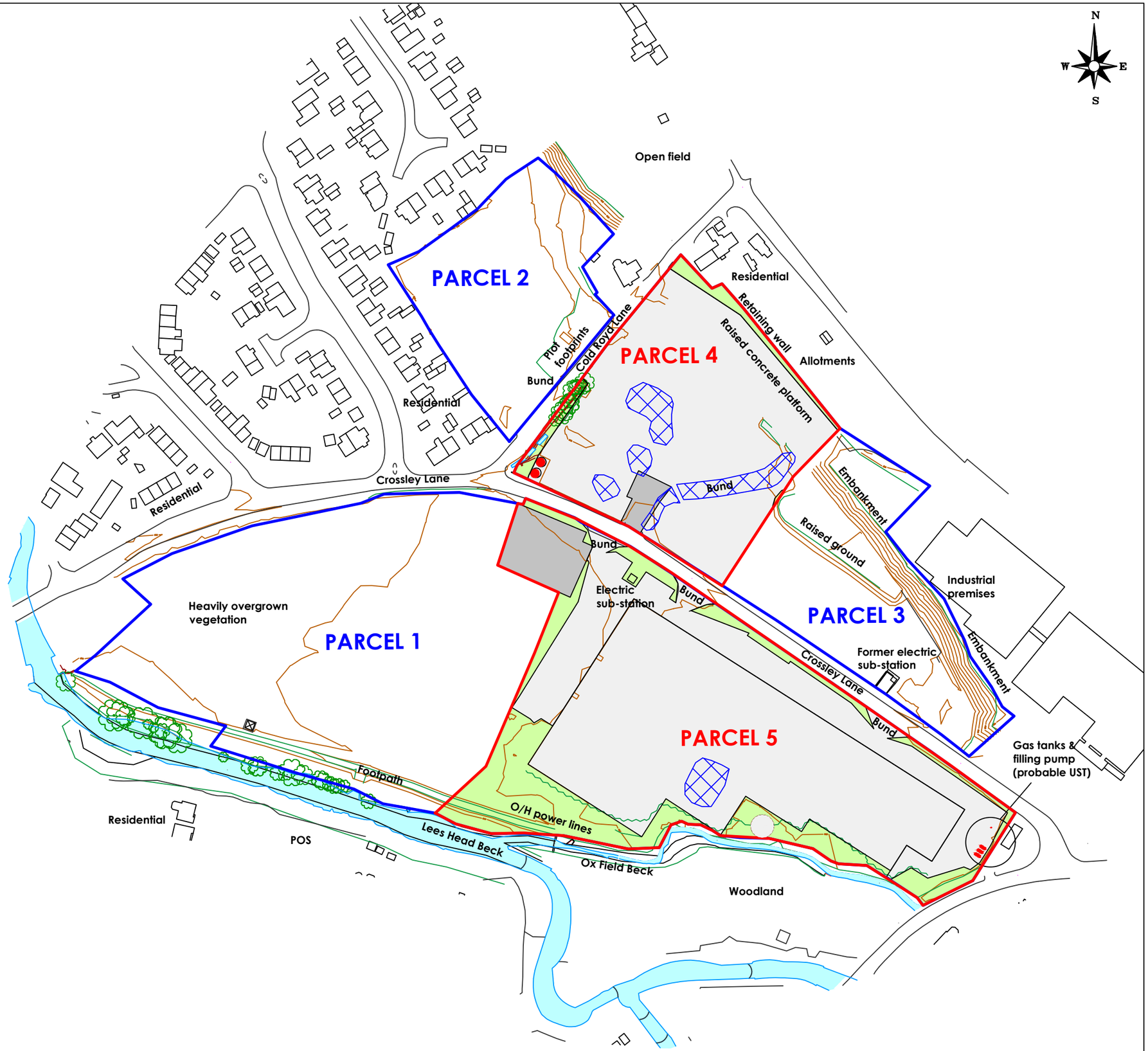

NOTES

- GRASS & OVERGROWN AREAS
- GRAVEL OR HARDCORE SURFACING
- TARMAC HARDSTAND
- CONCRETE HARDSTAND
- STORAGE TANKS
- STOCKPILE
- APPROXIMATE SITE BOUNDARY
- APPROXIMATE WIDER SITE BOUNDARY

REV.	DESCRIPTION	DATE

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MINERVA DEVELOPMENTS LTD & CREST NICHOLSON YORKSHIRE

JOB TITLE

CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

SITE FEATURES

DRAWN	DATE	STATUS
LEW	15 10 24	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	15 10 24	DRAFT ☐
		FINAL ☑

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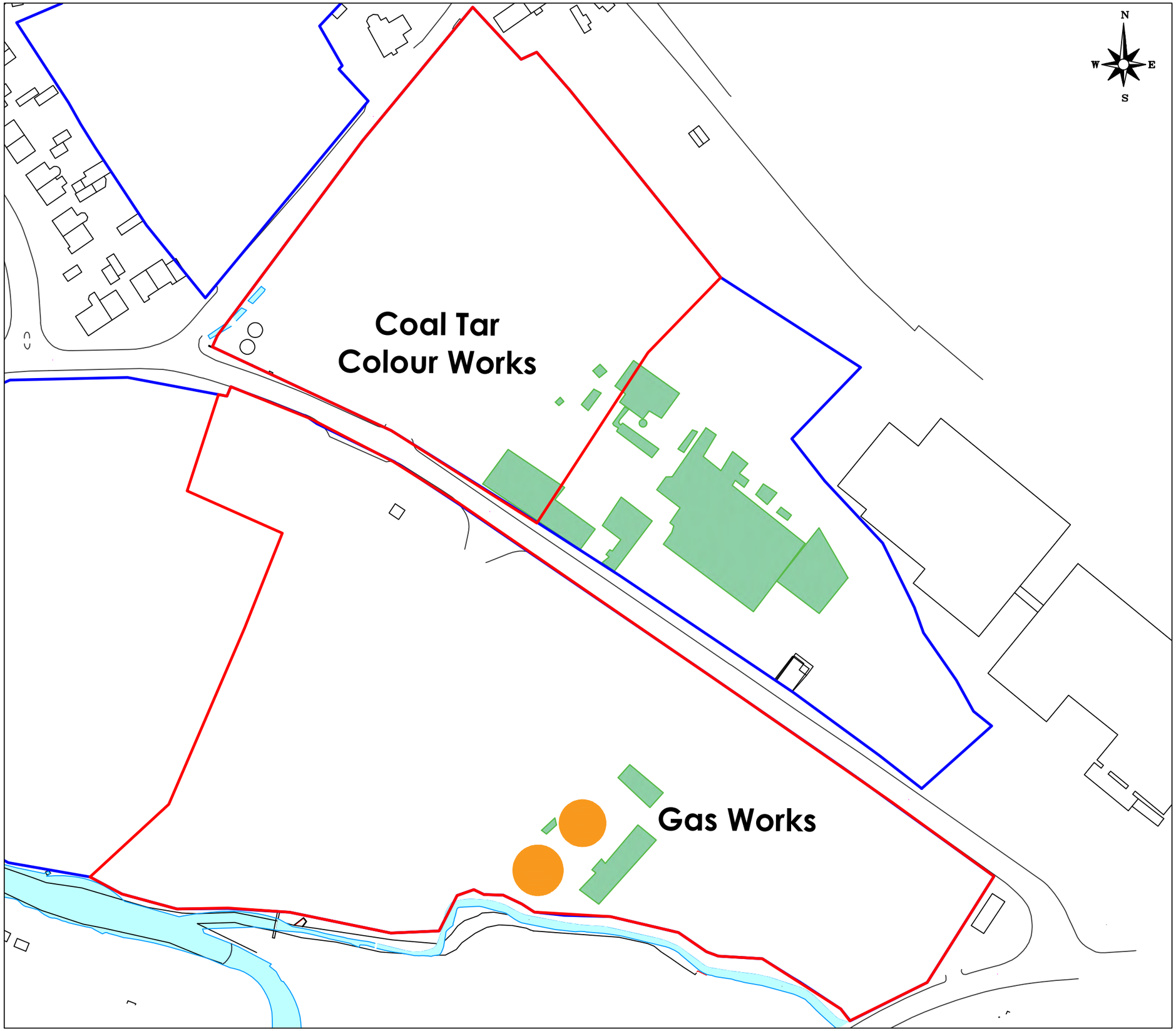

NOTES

HISTORICAL BUILDING FOOTPRINT

HISTORICAL GAS HOLDER(S) &\OR TAR WELL

APPROXIMATE SITE BOUNDARY

APPROXIMATE WIDER SITE BOUNDARY

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CLIENT

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JOB TITLE

CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

1893 HISTORICAL FEATURES

DRAWN	DATE	STATUS
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CHECKED	DATE	FOR APPROVAL ☐
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		FINAL ☑

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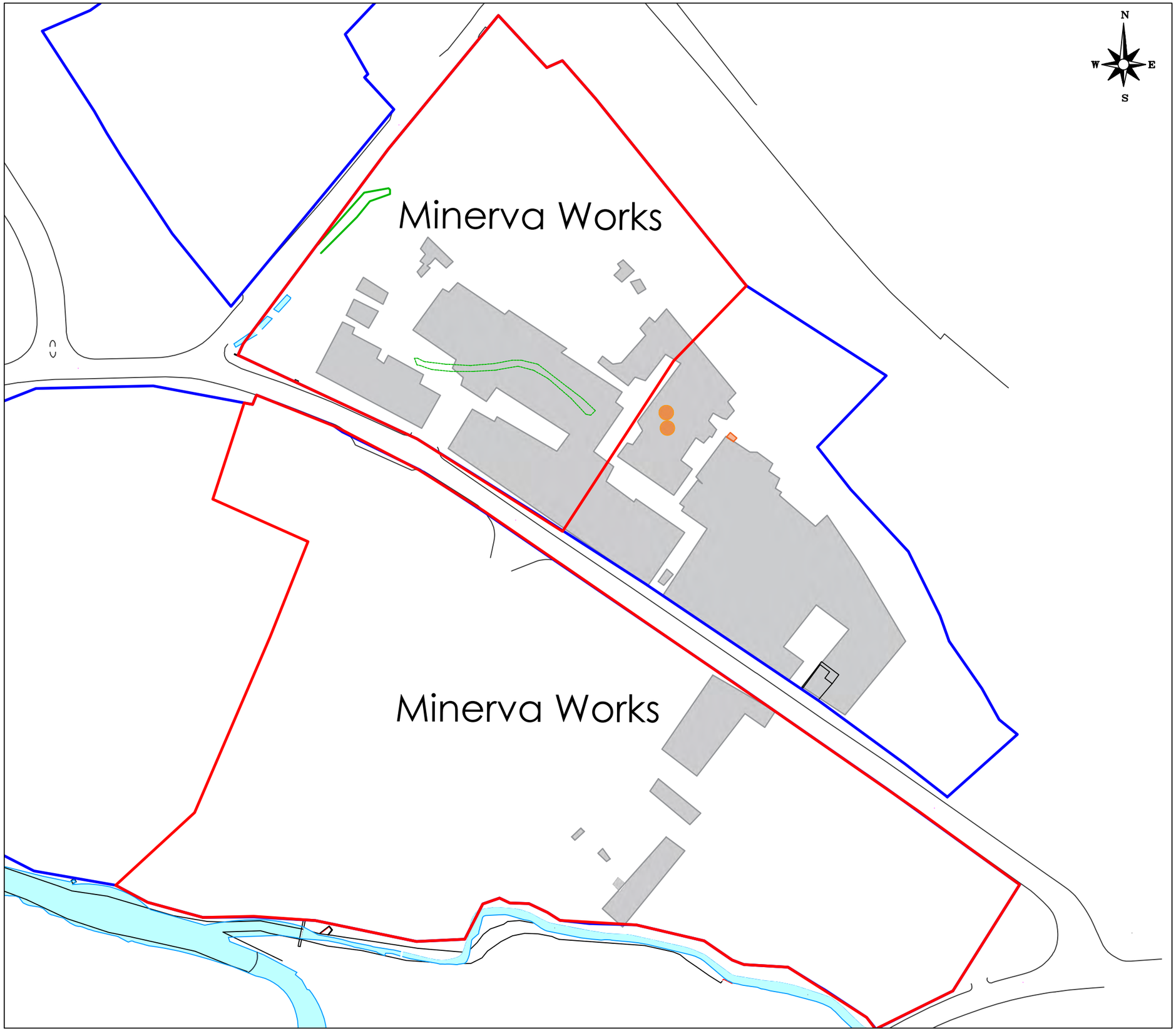

NOTES

- HISTORICAL BUILDING FOOTPRINT
- HISTORICAL FUEL STORAGE TANKS
- HISTORICAL LINEAR FEATURE (1907)
- HISTORICAL LINEAR FEATURE (1918)
- APPROXIMATE SITE BOUNDARY
- APPROXIMATE WIDER SITE BOUNDARY

REV.	DESCRIPTION	DATE

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CLIENT

MINERVA DEVELOPMENTS LTD & CREST NICHOLSON YORKSHIRE

JOB TITLE

CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

1918 HISTORICAL FEATURES

DRAWN	DATE	STATUS
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CHECKED	DATE	FOR APPROVAL ☐
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		FINAL ☑

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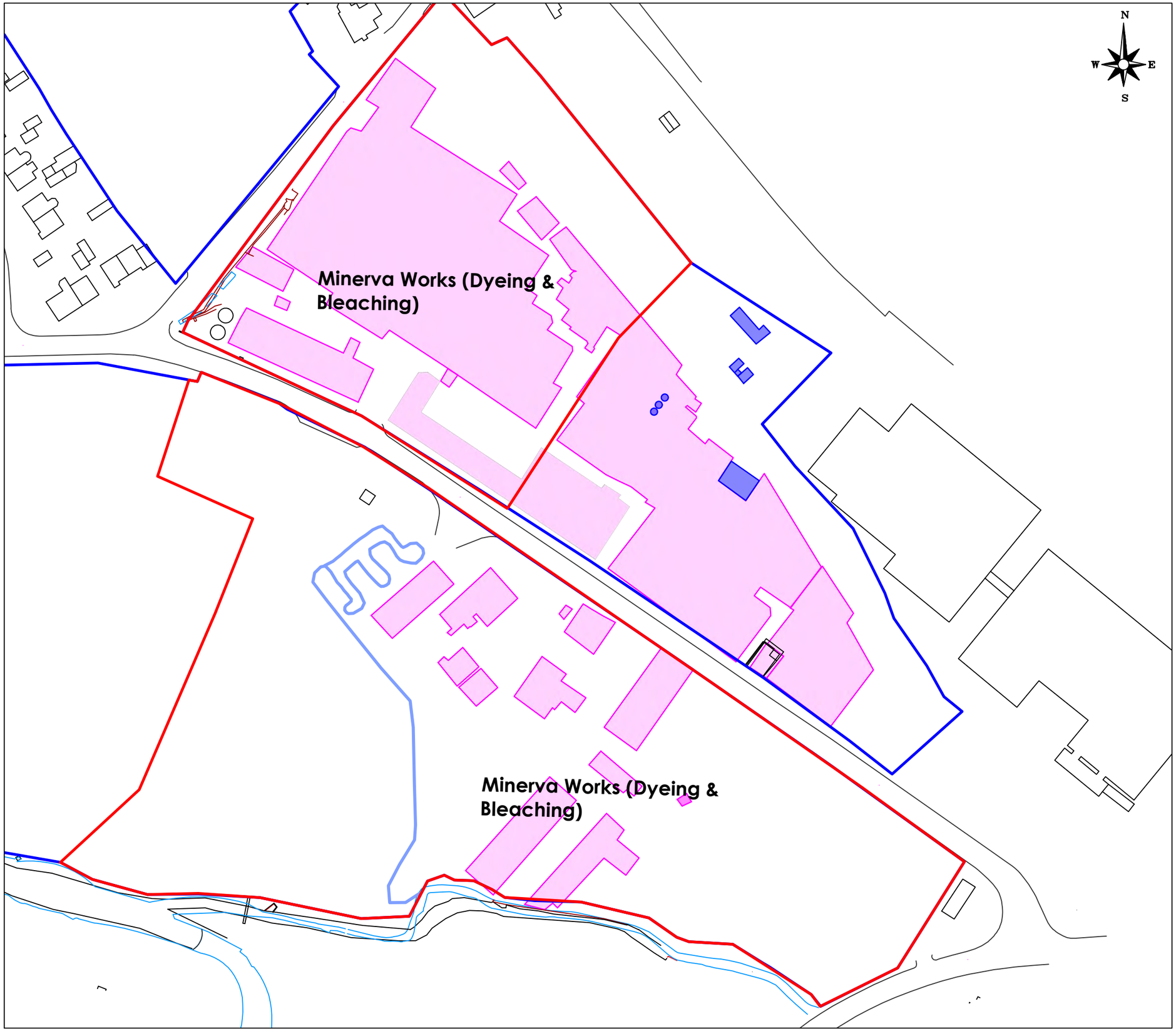

N
W E
S

NOTES

- HISTORICAL BUILDING FOOTPRINT
- HISTORICAL FUEL STORAGE TANKS
- POSSIBLE LAGOON
- APPROXIMATE SITE BOUNDARY
- APPROXIMATE WIDER SITE BOUNDARY

REV.	DESCRIPTION	DATE

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CLIENT

MINERVA DEVELOPMENTS LTD & CREST NICHOLSON YORKSHIRE

JOB TITLE

CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

1958 HISTORICAL FEATURES

DRAWN	DATE	STATUS
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CHECKED	DATE	FOR APPROVAL ☐
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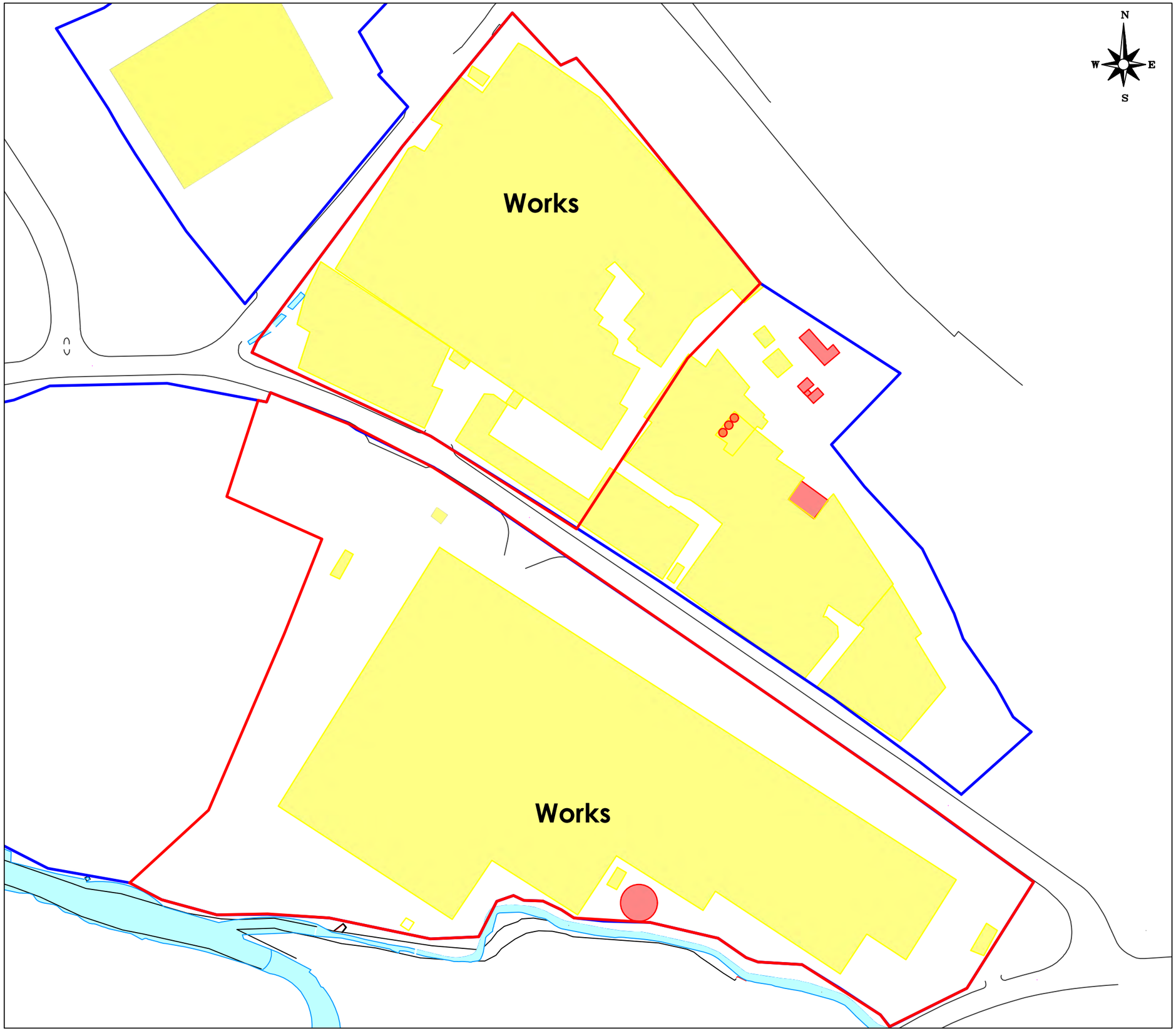

N
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NOTES

- HISTORICAL BUILDING FOOTPRINT
- HISTORICAL FUEL STORAGE TANKS
- APPROXIMATE SITE BOUNDARY
- APPROXIMATE WIDER SITE BOUNDARY

REV.	DESCRIPTION	DATE

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CLIENT

MINERVA DEVELOPMENTS LTD & CREST NICHOLSON YORKSHIRE

JOB TITLE

CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

1993 HISTORICAL FEATURES

DRAWN	DATE	STATUS
LEW	15 10 24	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	15 10 24	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
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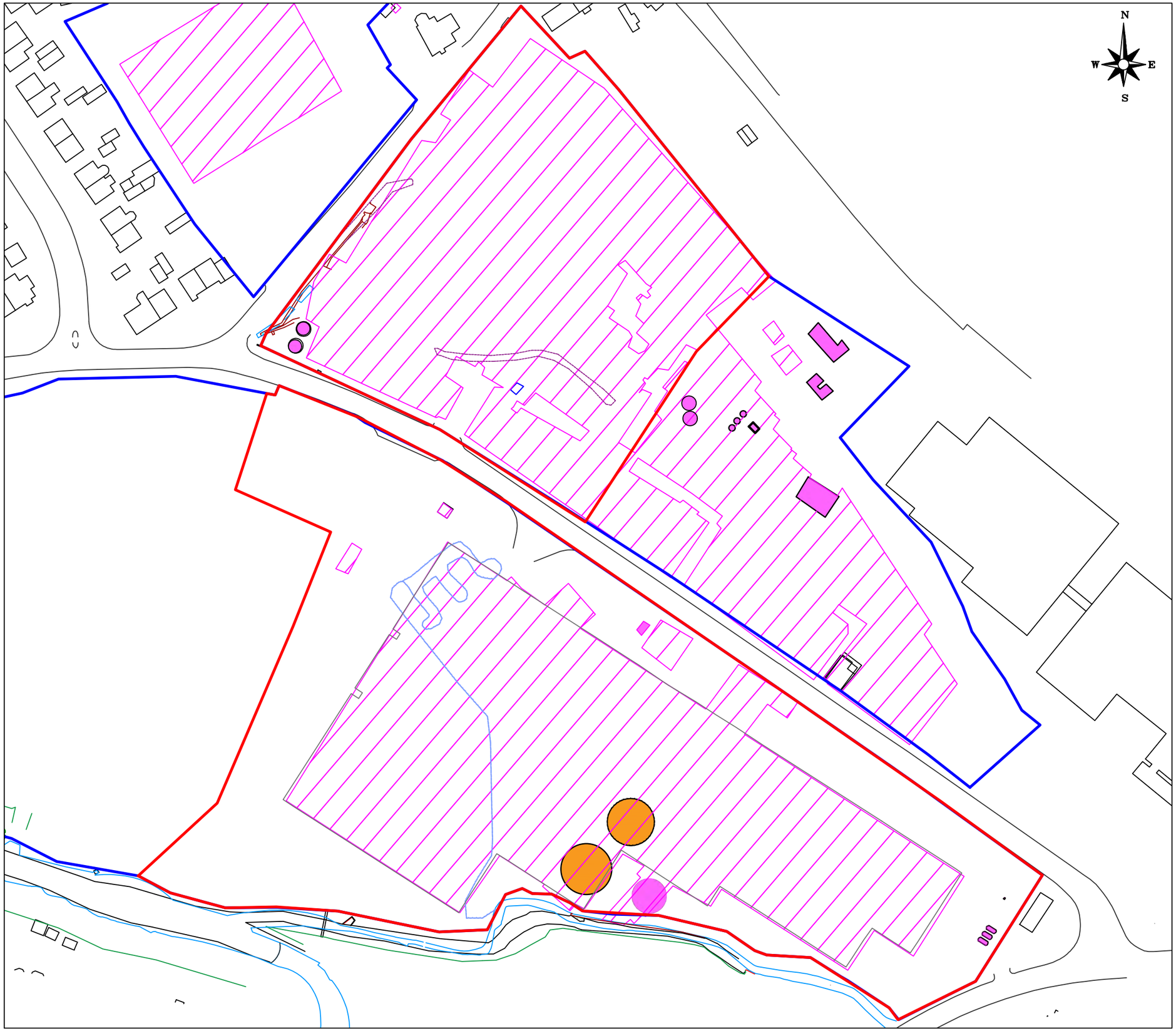

NOTES

- HISTORICAL GAS HOLDER(S) &\OR TAR WELL
- HISTORICAL BUILDING FOOTPRINT
- HISTORICAL FUEL STORAGE TANKS
- POSSIBLE LAGOON
- APPROXIMATE SITE BOUNDARY

REV.	DESCRIPTION	DATE

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JOB TITLE

CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

ALL HISTORICAL FEATURES

DRAWN	DATE	STATUS
LEW	15 10 24	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	15 10 24	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
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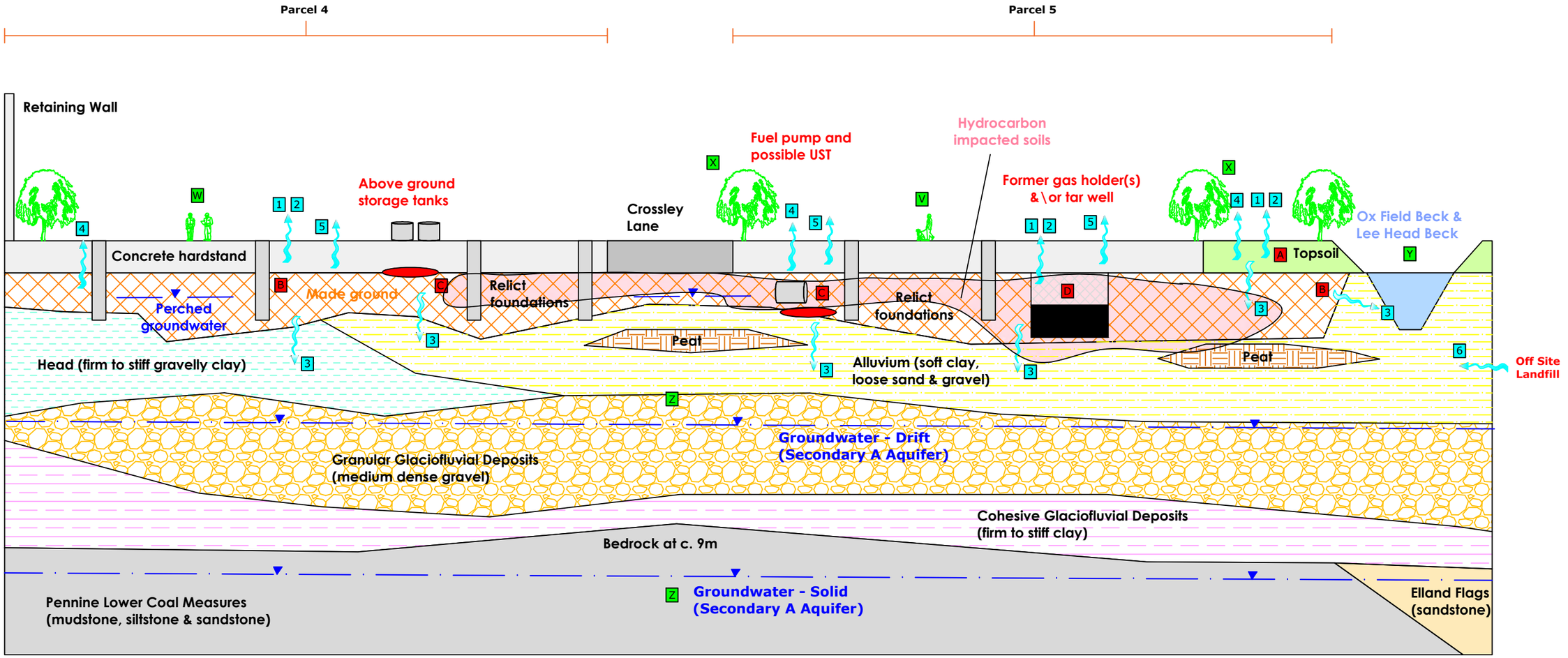

SOURCES	PATHWAYS	RECEPTORS
A NATURALLY OCCURRING CONTAMINANTS (INORGANICS)	1 DERMAL CONTACT	V END USERS (RESIDENTS)
B MADE GROUND (INORGANICS & ORGANICS)	2 INGESTION/INHALATION	W SITE WORKERS
C LEAKAGE/SPILLAGE (ORGANICS)	3 LEACHING OF CONTAMINANTS	X VEGETATION
D GAS HOLDERS (ORGANICS)	4 UPTAKE BY PLANTS	Y SURFACE WATERS
	5 VOLATILISATION	Z GROUNDWATER
	6 MIGRATION OF GAS	

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CLIENT: MINERVA DEVELOPMENTS LTD & CREST NICHOLSON YORKSHIRE

JOB TITLE: CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE: REVISED CONCEPTUAL SITE MODEL

NOTES

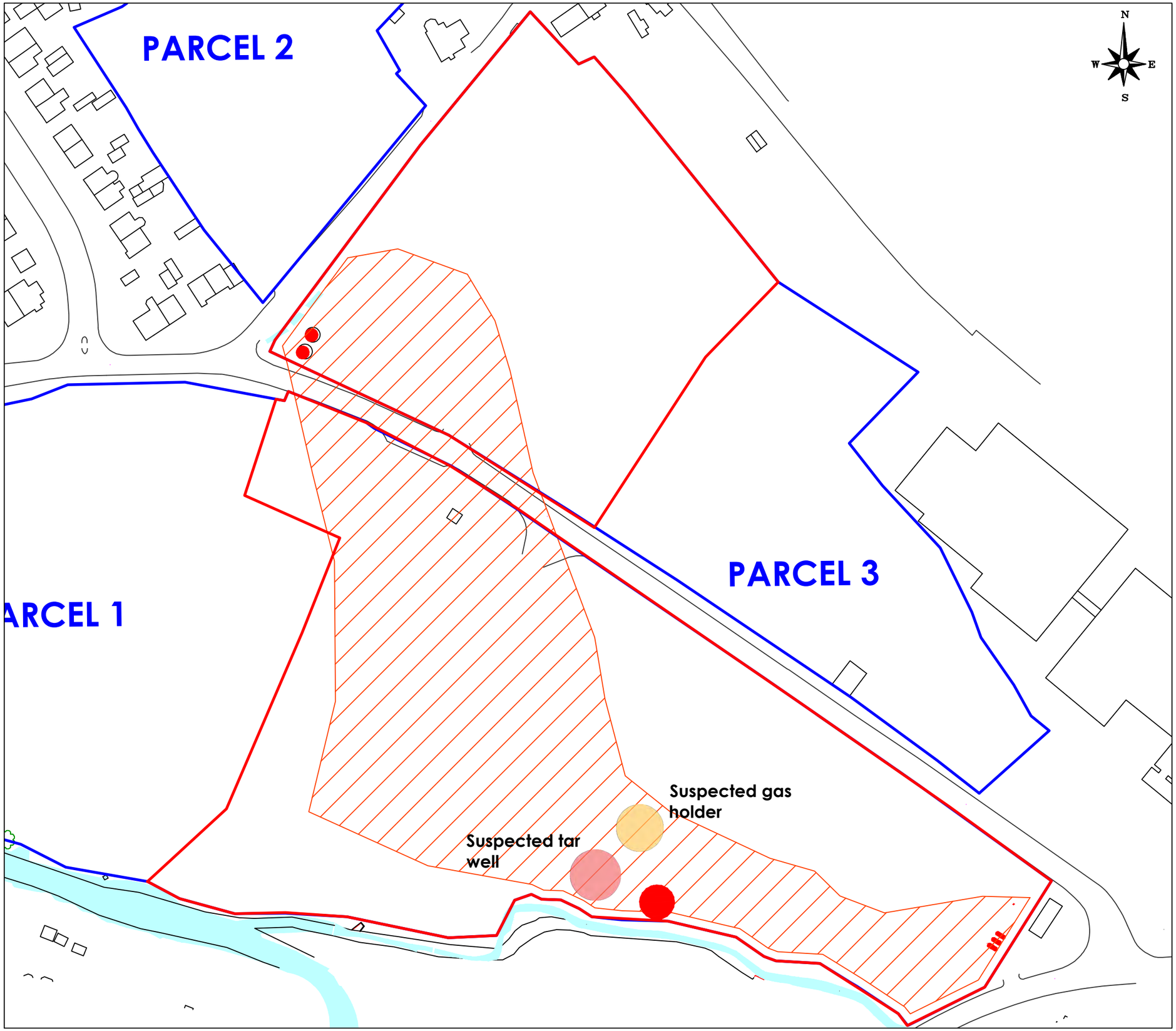
REV.	DESCRIPTION	DATE

STATUS: FOR COMMENT ☐ FOR APPROVAL ☐ DRAFT ☐ FINAL ☑

DRAWN	DATE
LEW	15 10 24
APPROVED	DATE
REG	15 10 24

SCALE	SHEET
Not to scale	A3

DRAWING NO.	REVISION
3435/208	



NOTES

- STORAGE TANKS
- APPROXIMATE EXTENT of HYDROCARBON IMPACTED SOILS - based on visual and olfactory evidence in exploratory holes
- APPROXIMATE SITE BOUNDARY
- APPROXIMATE WIDER SITE BOUNDARY
- POTENTIAL INTERNAL BOUNDARY FOR REMEDIATION WORKS IN PARCEL 5

REV.	DESCRIPTION	DATE

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JOB TITLE

CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

CONTAMINATION SUMMARY

DRAWN	DATE	STATUS
LEW	16 10 24	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	16 10 24	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
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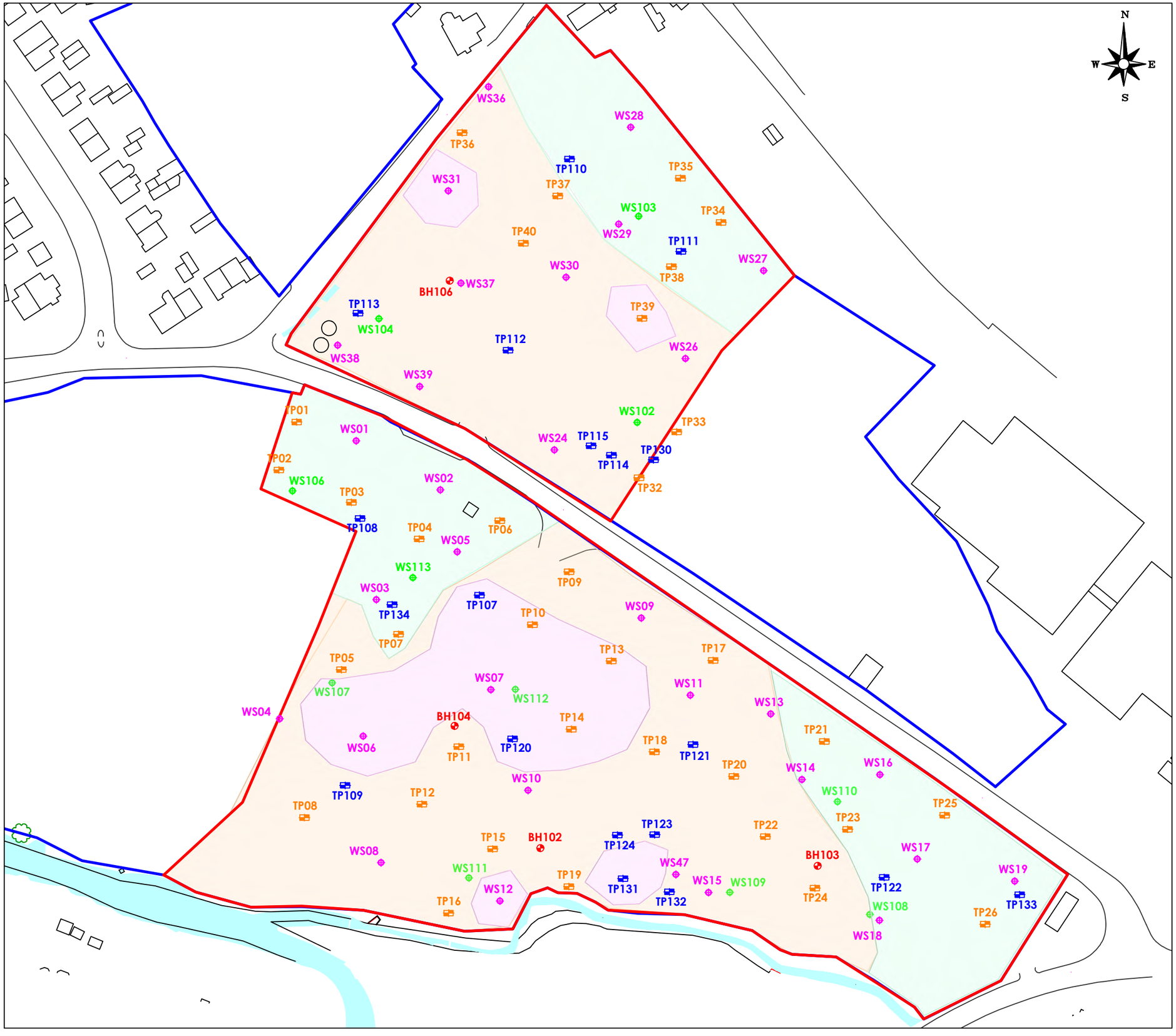

NOTES

< 1.0m

1.0m to 2.5m

> 2.5m

Based on Lithos and ARP exploratory hole - locally depths of made ground may vary.

APPROXIMATE SITE BOUNDARY

APPROXIMATE WIDER SITE BOUNDARY

REV.	DESCRIPTION	DATE

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JOB TITLE

CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

DEPTH OF MADE GROUND

DRAWN	DATE	STATUS
LEW	15 10 24	FOR COMMENT ☐
CHECKED	DATE	FOR APPROVAL ☐
REG	15 10 24	DRAFT ☐
		FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
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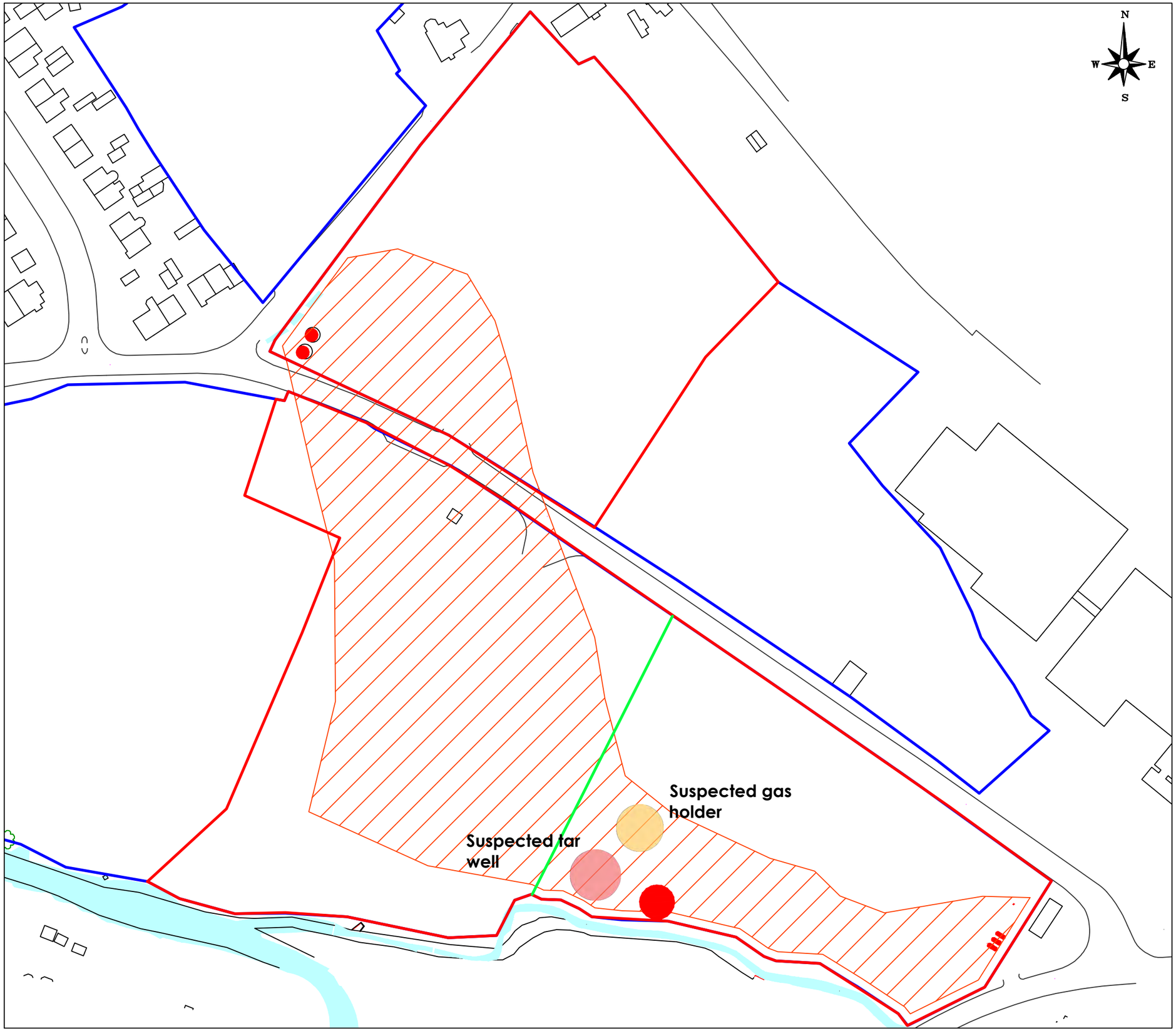

NOTES

STORAGE TANKS

APPROXIMATE EXTENT of HYDROCARBON IMPACTED SOILS - based on visual and olfactory evidence in exploratory holes

APPROXIMATE SITE BOUNDARY

APPROXIMATE WIDER SITE BOUNDARY

POTENTIAL INTERNAL BOUNDARY FOR REMEDIATION WORKS IN PARCEL 5

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CROSSLEY LANE, DALTON (PARCELS 4 & 5)

DRAWING TITLE

CONTAMINATION SUMMARY

DRAWN	DATE	STATUS
LEW	16 10 24	FOR COMMENT ☐
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SCALE	SHEET	DRAWING NO.	REVISION
1:1,250	A3	3435/210	

APPENDIX B
LITHOS TIER 1 VALUES

Soil screening values used by Lithos

In March 2002 DEFRA and the Environment Agency published a series of technical papers (R&D Publications CLR 7, 8, 9 and 10) outlining the UK approach to the assessment of risk to human health from land contamination. In 2008 CLR 7, 9 and 10 and all corresponding SGV and Tox reports were withdrawn and superseded by new guidance including:

- Guidance on Comparing Soil Contamination Data with a Critical Concentration - CL:AIRE and CIEH, May 2008
- Evaluation of models for predicting plant uptake of chemicals from soil - Science Report – SC050021/SR
- Human health toxicological assessment of contaminants in soil - Science Report: SC050021/SR2
- Updated technical background to the CLEA model - Science Report: SC050021/SR3
- CLEA Software Handbook, Science report: SC050021/SR4
- Compilation of data for priority organic pollutants for derivation of Soil Guideline Values - Science Report: SC050021/SR7

In December 2013 Defra published the results of research project SP1010 – Development of Category 4 Screening Levels (C4SLs) for Assessment of Land Affected by Contamination. The objective of this project was to provide technical guidance in support of Defra's revised Statutory Guidance for Part 2 A of the Environmental Protection Act 1990 (Part 2A). The revised Statutory Guidance, published in April 2012, introduced a new four-category system for classifying land under Part 2A where Category 1 includes land where the level of risk is clearly unacceptable, and Category 4 includes land where the level of risk posed is acceptably low. Project SP1010 aimed to deliver:

- A methodology for deriving C4SLs for four generic land-uses comprising residential, commercial, allotments and public open space; and
- Demonstration of the methodology, via derivation of C4SLs for 6 substances – arsenic, cadmium, chromium IV, lead, benzene & benzo(a)pyrene.

The methodology for deriving both the previous Soil Guideline Values and the Category 4 Screening Levels is based on the Environment Agency's Contaminated Land Exposure Assessment (CLEA) methodology. Development of C4SLs has been achieved by modifying the toxicological and\or exposure parameters used within CLEA (while maintaining current exposure parameters).

The Part 2A Statutory Guidance was developed on the basis that C4SLs could be used under the planning regime. Defra anticipate that, where they exist, C4SLs will be used as generic screening criteria, and Lithos consider C4SLs to be suitable for use as Tier 1 Screening Values. Lithos have discussed this matter with both NHBC and YALPAG (collection of Yorkshire & Lincolnshire local authorities) and received confirmation that they are satisfied with this approach.

The CLEA conceptual site model assumes a source located in a sandy loam, with 6% soil organic matter (SOM) - equivalent to 3.5% total organic carbon (TOC). However, many organic contaminants are more mobile when the SOM is lower, and consequently comparison of soil results with revised, lower screening values may be required. Other CLEA default characteristics adopted by Lithos are:

Sandy Loam characteristics (source)	Default values adopted
Total porosity (fraction)	0.53
Water filled porosity (fraction)	0.33
Air filled porosity (fraction)	0.2

Lithos have derived Screening Values for five different CSMs (scenarios); these are:

A - Residential with gardens, but no cover (or only up to 300mm)

B - Residential with gardens and 600mm 'clean' cover

C - Residential apartments with landscaping (i.e. no home grown produce)

D - Commercial/industrial with landscaping

E – Importation of soil cover

The **exposure** pathways considered for each scenario are detailed in the table below.

Scenario	Land use	Pathways	Justification
A	Residential with garden, but no cover (or only up to 300mm)	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	Minimal cover – insufficient to break any pathways therefore all exposure pathways are relevant.
B	Residential with garden minimum 600mm cover	• Inhalation of indoor vapours • Inhalation of outdoor vapours	The 600mm cover removes the risk from all pathways other than inhalation.
C	Residential apartments with landscaped areas and minimum 300mm cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. However consumption of home grown produce not included as unlikely to be grown in landscaped areas. Where vegetables are to be grown site specific QRA may be required.
D	Commercial/ industrial with landscaped areas no cover	• Direct ingestion of soil • Dermal contact • Inhalation of indoor vapours and dust • Inhalation of outdoor vapours and dust	All pathways applicable due to possible exposure from landscaped areas. Assumed the commercial development consists of offices to provide a conservative assessment.
E	Importation of soil for cover in garden and landscaped areas	• Direct ingestion of soil • Dermal contact • Consumption of vegetables & soil attached to vegetables • Inhalation of outdoor vapours and dust	Material used as cover to break existing pathways therefore all direct and indirect pathways relevant; however cover is **not** placed below plots therefore indoor inhalation is not relevant.

Lithos have assumed the source of contamination is directly below the building foundations; i.e. a depth to source of 0.15m as opposed to the CLEA default of 0.65m. This assumption provides for a more conservative approach than the UK default.

Lithos have derived Tier 1 values for a number of inorganic and organic determinands in the context of the five Scenarios A to E. The Tier 1 values are **not** intended to be used when considering potential risks associated with:

- Existing land uses in the context of Part 2A of the Environment Protection Act 1990;
- End uses such as allotments, sports fields, children's playgrounds, care homes, hospitals etc; and
- Controlled waters

Inorganic Tier 1 values for scenarios A to E

Inorganic contaminant	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
As	32	37	37	Use (A) in SI Report for initial "screen" If >5 x A, then consider increase of cover to 1,000mm	40	640	37	C4SL adopted
Cd	10	26	26		149	410	26	C4SL adopted
Cr			4,000		4,000	28,767	4,000	Assumes Cr is CrIII
Pb	450	200	200		314	2,330	200	C4SL adopted
Ni	130		109		123	892	109	Assessment of health risk only
Se	350		434		596	13,018	434	
Hg	170		199		244	3,603	199	Assumes in an inorganic compound
Vn			584		586	4,994	584	
B			5		5	5	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependant)
Cu			100		100	100	100	
Zn			200		200	200	200	

Organic Tier 1 values for scenarios A to E

Organic contaminant (all sourced via CLEA)	Tier 1 assessment criteria (mg/kg) for Scenarios A to E							Comments/notes
	SGV*	C4SL*	A	B	C	D	E	
Benzene	0.33	0.87	0.7	<1^	<1^	63	<1	<1 based on professional judgement and lower than calculated value.
Toluene	610		836	2,048	1,912	5,000	<1	Scenario D based on professional judgement and lower than calculated value.
Ethyl Benzene	350		379	592	566	5,000	<10	
Xylenes	240		535	590	585	5,000	<10	Scenario E based on professional judgement and lower than calculated value.
Phenol	420		1,434	3,360	2,264	5,000	<10	
PCBs			2	8	2	38	N/A	Based on toxicity of EC7
Benzo(a)pyrene		5	5	25	5	76	5	C4SL adopted. Scenario B 5 times scenario A
Naphthalene			6	6	6	619	<10	Scenario E based on professional judgement and lower than calculated value
Gasoline Range Organics			22	23	23	2,178	626	See 3-step assessment of TPH below ^Based on professional judgement and lower than calculated value
Diesel Range Organics			215	218	215	^5,000	1429	
Lubricating Range Org			3,299	5,000	3,829	^5,000	3,299	

* *For a residential end use*

The significance of PAHs can be determined by considering indicator compounds. In most cases benzo(a)pyrene (BaP) is adopted as an indicator due to the amount of toxicological data available and has been used by various authoritative bodies to assess the carcinogenic risk of PAHs in food. A surrogate marker approach can be used to estimate the toxicity of a mixture of PAHs in soil using toxicity data for individual indicator compounds within that mixture. Exposure to the surrogate marker is assumed to represent exposure to all PAHs in that matrix. The surrogate marker approach relies on a number of assumptions:

- Surrogate marker (BaP) must be present in all soil samples
- Profile of the different PAH relative to BaP should be similar in all samples
- PAH profile in the soil samples should be similar to that used in the pivotal toxicity study[1]

To assess the PAH profile in a soil sample, the ratio of the seven genotoxic PAHs (benz[a]anthracene, benzo[b]fluoranthene, benzo[k]fluoranthene, benzo[g,h,i]perylene, chrysene, dibenz[a,h]anthracene and indeno[1,2,3-c,d]pyrene), relative to BaP, should be calculated. The ratio relative to BaP should lie within an order of magnitude above and below the mean ratio to BaP.

Naphthalene should also be considered separately against its generic screen. Whilst classed as a PAH, naphthalene is more volatile and mobile in the environment than most other PAHs. As such the significance of naphthalene cannot be considered within the surrogate marker approach.

Similarly, **TPH** cannot be assessed as a single "total" value, and reference has been made to the Environment Agency's document P5-080/TR3, "The UK approach for evaluating human health risks from petroleum hydrocarbons in soils". This document supports the assumptions and recommendations made by the US Total Petroleum Hydrocarbons Criteria Working Group (TPHCWG). The TPHCWG have broken down "TPH" into representative constituent fractions or "EC Bandings". The TPHCWG have derived a series of physiochemical and toxicological parameters for each of the bandings.

[1] SP1010 Appendix E, Provisional C4SIs for benzo(a)pyrene as a surrogate marker for PAHs, CL:AIRE 2013

The significance of speciated TPH results can be assessed by following the 3 steps outlined in the tables below.

Step	Result	Action
1. Consider indicator compounds: Are BTEX, naphthalene, benzo(a)pyrene above their respective Tier 1 values?	Yes	Remediation or dQRA required
	No	Proceed to Step 2
2. Consider individual TPH fractions: are they above respective screening values?	Yes	Remediation or dQRA required
	No	Proceed to Step 3
3. Assess Cumulative effects: Is the calculated Hazard Index for each source >1	Yes	Remediation or dQRA required
	No	TPH compounds pose no significant risk

The equation used to assess cumulative effects in step 3 is shown below.

$$HI = \sum_{F_i=1}^{16} HQ\ F_i = \frac{Measured\ concentration\ F_i\ (mg\,kg^{-1})}{SGV\ F_i\ (mg\,kg^{-1})}$$

where HI = Hazard Index
HQ = Hazard Quotient
F_i = Fraction $_i$
SGV = Soil Guideline Value

Statistical Assessment

Current UK guidance is provided by CL:AIRE[2], and uses two-way confidence intervals and graphical summaries, to assist assessors when determining whether or not a dataset is adequate to answer the question posed; e.g. "is existing site topsoil suitable for retention & re-use?". To answer such a question, it is necessary to recover and test a large number of samples (a minimum of 10; ideally 20+) in order to undertake meaningful statistical analysis.

However, in the context of site investigation to assess the significance of contamination on brownfield sites which are typically underlain by **heterogenous made ground**, some remediation is almost always required (placement of soil cover, excavation of gross contamination etc). Consequently, in such circumstances, it is not necessary to demonstrate that made ground soils are "clean" and therefore there is no need to test large numbers of samples and undertake statistical analysis. Sample results can simply be compared directly with appropriate screening values (e.g. Lithos Tier 1 values).

The CL:AIRE (2020) guidance replaces the withdrawn "Guidance on Comparing Soil Contamination Data with a Critical Concentration" (2008).

The old approach to statistical analysis was based on a definitive yes/no answer which required limited consideration of the dataset and Conceptual Site Model, it was widely accepted that this did not allow sites or risk to be adequately assessed. The updated approach requires a comprehensive understanding of the datasets within the context of the Conceptual Site Model.

The current guidance requires that:

- A robust CSM is in place which identifies source areas, averaging areas and averaging zones
- Sampling locations are relatively evenly spread across the site and were selected using simple or stratified random sampling with no targeting being undertaken
- The field data and CSM do not suggest the presence of a hotspot of contamination which should be treated as a separate zone
- The samples are all taken from a similar same depth and within the same material type across the zone being assessed
- A minimum of 10 samples have been taken. It should be appreciated that confidence in a dataset increases as the number of samples obtained and tested from a zone increases.

The statistical analysis assumes a homogenous distribution of strata and contamination and therefore the dataset will be normally distributed (symmetric, log symmetric or fat tailed).

The normally distributed dataset is assessed using a number of statistical tools to generate a Dot and Box Plot which includes summary statistics and confidence intervals. The review of statistical data enables the assessor to make a decision, with an associated level of confidence, where the true mean of the sample population lies in relation to the critical concentration.

It is essential when using statistics to assess sample data that all decisions relate back to the conceptual site model. Statistics cannot indicate if contamination on a site is likely to present a risk to the end user, this is the role of the 'competent person' i.e. Lithos.

However, broadly speaking the following applies:

- Mean and UCL below the critical concentration – no further assessment required.
- Mean below the critical concentration, but UCL above – consider the CSM and likely sources.
- Mean and UCL above the critical concentration – further assessment required, remediation likely depending on the CSM.
- LCL, Mean & UCL above the critical concentration – further assessment required, remediation likely.

[2] *CL:AIRE, 2020.Professional Guidance: Comparing Soil Contamination Data with a Critical Concentration.*

Other screening values used by Lithos

Tier 1 risk assessment of **hazardous gas** is undertaken through reference to the following documents (and further information is presented in Generic Note No. 5 – Hazardous Gas):

- Approved Document C, Building Regulations 2000
- Boyle & Witherington (2007) – Guidance on evaluation on development proposals on sites where methane and carbon dioxide are present, incorporating "traffic lights". Report Ref. 10627-R01-(02), for NHBC
- CIRIA C665 (2007) – Assessing risks posed by hazardous ground gases to buildings
- BS 8485:2015 – Code of Practice for the characterisation & remediation from ground gas in affected developments

With respect to the assessment of potential **phytotoxic effects** of contaminants, Lithos refer to The Sewage Sludge in Agriculture: Code of Practice 2018 for copper and zinc (at pH 5.5 to 6.0). The CLEA derived Tier 1 value is adopted for nickel due to its human health effects.

The potential risk to **building materials** is considered through reference to relevant BRE Digests, with particular emphasis on BRE Special Digest 1, 'Concrete in aggressive ground', 2005.

With respect to the interpretation of the **calorific values**, at present there are no accepted methods to assess whether a sample is combustible and under what circumstances it might smoulder. Some guidance is given in ICRCL Note 61/84 "Notes on the fire hazards of contaminated land" which states that: "*In general … it seems likely that materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn*".

Tier 1 **groundwater risk assessments** are always site specific and compare leachate or groundwater concentrations with the appropriate water quality standard based on the CSM and consideration of relevant water quality impacts and assessments.

Waste classification & WAC

In the context of waste soils generated by remediation and\or groundworks activities on brownfield sites, the following definitions (from the Landfill Regulations 2002) apply:

- Inert (e.g. uncontaminated 'natural' soil, bricks, concrete, tiles & ceramics)
- Non-Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances, but at concentrations below prescribed thresholds)
- Hazardous (e.g. soil excavated from a contaminated site which contains dangerous substances at concentrations above prescribed thresholds)

Dangerous substances include compounds containing a variety of determinants commonly found in contaminated soils on brownfield sites, for example arsenic, lead, chromium, benzene etc.

Landfill operators require Waste Acceptance Criteria (WAC) laboratory data, if soil waste is classified as **hazardous**. However, subject to WAC testing it may be possible to classify it as stable, non-reactive hazardous waste, which can be placed within a dedicated cell within the non-hazardous landfill.

Lithos typically only include WAC analysis in site investigation proposals and reports, if significant off-site disposal (of soil classified as hazardous waste) is anticipated, for example where redevelopment proposals include basement construction etc. If off-site disposal of soils classified as hazardous waste during redevelopment is anticipated, then WAC analysis should be scheduled at an early stage in the remediation programme. However, organic compounds (BTEX, TPH, PAH etc) are the most common contaminants that result in soils being classed as hazardous, and these contaminants can often be dealt with by alternative technologies (e.g. by bioremediation or stabilisation) and consequently retention on site is often possible.

It should be noted that **non-hazardous** soil waste can go to a non-hazardous landfill facility; no further testing (e.g. WAC) is required.

APPENDIX C

LITHOS PROTOCOL FOR THE PLACEMENT OF NON-ENGINEERED FILL

1 INTRODUCTION

1.1 This protocol is aimed at providing general guidance to contractors in the placement of general earthworks fill materials in areas of a site that do not require high quality, controlled engineering eg Public Open Space. No guarantee can be made as to the degree of settlement that may occur in such fill masses; however, the protocol should mitigate significant differential settlements.

1.2 General fill will be either inert soil or contaminated soil that is deemed chemically suitable for reuse in certain specific site areas or beneath a specified 'clean' soil cover layer. All soft and compressible soils or existing fill shall, if comprising unsuitable fill be removed from site. Suitable fill materials may be compacted on site.

1.3 Unsuitable fill shall comprise:

- Cohesive soils having a liquid limit in excess of 90% or Plasticity Index in excess of 65%
- Chalk having a fine fraction (<400μm) in excess of 10% at the borrow pit
- Any material containing topsoil, wood, peat or lignite
- Any material containing biodegradables
- Any material containing scrap metal
- Frozen or waterlogged substances
- Material defined as unsuitable by the Engineer because of its type or level of contamination
- Material which, by virtue of its particle size or shape, cannot be properly and effectively compacted (eg oversize material, gravels which are tabular and some slate wastes)
- Expansive steel slag
- Non-inert or contaminated material
- Putresible waste
- Materials containing minerals hostile to the built environment such as pyritic shales, gypsiferous clays, burnt colliery discard, pulverised fuel ash, spent oil shale or incinerator waste

1.4 The base of the area to be filled shall be proof rolled with a dead weight roller and all soft materials removed and replaced with compacted fill. Where unsuitable material has been excavated, the underlying ground shall be compacted to the same specification as adopted for subsequent compaction works.

1.5 Fill shall be placed and compacted in near-horizontal layers of maximum 200mm thicknesses and be brought up at a uniform rate so that all parts of the site or particular sections of the site reach finished (formation) level at the same time. Each layer will be subjected to nominal compaction, comprising at least two passes with a towed vibratory roller of at least 2,900 kg per metre width (or equivalent). If the compacted fill demonstrates excessive rutting, excessive roller 'bow-waving' or other soft behaviour then it shall be deemed unsuitable.

1.6 Cobbles, boulders, rock or waste fragments, the largest dimension of which is greater than two-thirds of the compacted layer thickness (or greater than 250mm in any dimension), shall not be incorporated into the fill.

1.7 When compacting fill in the vicinity of existing trenches, excavations, retaining walls or other structures all work shall be performed in such a way as to ensure that their existing stability is not impaired; this will require careful selection of both compaction plant and compaction method.

1.8 When placing fill against structures the Contractor must only use only the following types of compaction plant for fill within 2m of a structure:

- Vibratory roller, mass per metre width of roll not exceeding 1300 kg and total mass not exceeding 1000 kg
- Vibrating plate compactor, mass not exceeding 1000 kg
- Vibro-tamper, mass not exceeding 75 kg

1.9 If weather conditions are such that the fill is adversely affected, the Contractor shall cease work until such time as the fill can be placed and compacted to meet the protocol requirements. No fill shall be placed and left uncompacted at the end of the working day. Compacted fill shall be graded to falls to ensure free run-off of rainwater without ponding.

1.10 Drainage grips or trenches shall be excavated, as necessary, uphill of the area to be filled to prevent the area becoming flooded. Drainage shall be affected without causing siltation or erosion and water shall be disposed of. The area to be filled shall be graded to falls, and sump pumping or other suitable dewatering facilities shall be provided as necessary by the Contractor to keep the base of the excavation dry at all times.

APPENDIX D

LITHOS PROTOCOL FOR IMPORTATION & USE OF SOIL COVER (CAPPING)

1 INTRODUCTION

1.1 Isolation of made ground in garden and landscaped areas beneath a cover of "clean" subsoil, and topsoil is often recommended on new developments; most notably when the made ground contains inorganic (and non-volatile organic) contaminants at concentrations above relevant guidance threshold values. A cover solution is not appropriate for volatile or semi-volatile organic contaminants (fuels, solvents etc); removal or treatment will usually be required.

1.2 The thickness of cover is dependent on the end use of the development, nature and degree of contamination (and sometimes the Local Authority whose area the site lies within), Typically for a commercial development between 300mm and 1,000mm thickness is required and for a residential development between 600mm and 1,000mm thickness is required. Regardless of the type of development, where contamination is more significant a granular hard-dig layer or geotextile marker membrane may also be required at the base of the cover.

1.3 The "clean" soil cover blocks potential linkages between the contaminated made ground and future site users. Soil cover is not required beneath areas of hardcover including buildings, private drives, carparking and roads.

1.4 If the made ground is essentially "clean", but contains materials generally considered undesirable as near-surface material in garden and landscaped areas (e.g. oversize materials such as construction/demolition rubble) then placement of cover is also required. In private gardens, in accordance with NHBC Standards Chapter 10.2, a 450mm thick soil cover should be adequate. In landscaped areas a 300mm thick soil cover should be adequate. For both gardens and landscaped areas if the made ground is essentially "clean" and comprises reworked natural soil, the only cover likely to be required is 100mm topsoil.

1.5 The **CML initiative** came into force in April 2003 and relates specifically to residential developments. It requires housebuilders to submit to NHBC (or other warranty providers) a validation report confirming the thickness and quality (i.e. contaminant-free) of the placed soil cover. Validation reports should normally be prepared by independent geoenvironmental consultants.

1.6 Failure to submit cover validation reports promptly will delay issue of the cover note by the warranty provider, which will subsequently delay the release of mortgage funds and hence legal completion; i.e. the financial implications are significant. Consequently, it is essential that cover validation is requested at least 2 weeks prior to the anticipated finalling date.

1.7 For all land uses soil cover is usually placed many weeks after completion of the preparatory/remediation works, and issue of the associated Verification Report, typically at a relatively late stage in the construction programme.

1.8 Prior to placement of soil cover, the appointed remediation contractor and/or groundworker should ensure that ground levels are low enough to accommodate the required cover thickness, taking account of any boundary issues, and, where relevant, without compromising the DPC and any sub-floor ventilation.

1.9 Ideally soil quality should initially be determined by sampling of the source (at least 7 working days before importation to the development site) to demonstrate suitability for use. Further sampling of the material at the site may also be required to demonstrate cross contamination did not occur during the importation process. Samples could also be obtained from stockpiles of site won material on site; there may comprise surplus natural ground development arisings. Soil samples could be obtained after placement of the cover layer, but this is not recommended.

1.10 Imported topsoil should be subject to testing, unless it is being sourced from a reputable commercial supplier able to provide robust certification (certificate date less than 2 months prior to import date). In addition, some analysis in accordance with BS3882 may occasionally be appropriate.

1.11 Where sampling of the source has been carried out, and on receipt of the laboratory results, Lithos will issue a confirmation of soil suitability for importation to the client, who will in turn instruct his contractor to commence importation.

1.12 Clearly, if soil cover is imported and placed before confirmation of its suitability, no guarantee can be given that validation work will yield the desired results. It may therefore be necessary to excavate and export the placed soil cover and/or import further "clean" soil.

1.13 It is likely that it will be necessary to stockpile imported soil cover material at the site. Where soils have been confirmed as suitable for use and temporarily stockpiled on site, stockpiles should be fenced-off and marked as containing certified topsoil/subsoil. The soil should be inspected prior to placement to confirm that it is the same material as previously tested, and that it has not been cross-contaminated with miscellaneous arisings generated during the construction works. Where material has been stockpiled on site for an extensive period of time further sampling may be required at the development site to demonstrate cross contamination has not taken place.

1.14 Soil **thickness** can only be checked after placement; this should be done before turfing / landscaping, but ideally after scaffolding has been dismantled.

1.15 ***Sampling Frequency (to check Soil Quality):*** The number of samples tested will be dependent on the nature of the source, and the quantity of material to be imported. However, in accordance with current YALPAG (Yorkshire & Lincolnshire Pollution Advisory Group) guidance[1], the testing frequency should be as follows:

Nature of source	Number of samples (from any single source material)	
	Up to 500m³	Per additional 500m³
Greenfield	At least 3#	1*
Brownfield	At least 6#	1*
Crushed product	At least 3	1*

* To be agreed with the relevant Local Authority

\# But could be up to 10 samples (if 500m³), depending on the Local Authority area within which the site is located.

1.16 On a typical residential development where gardens comprise a total area of 100m² (front and rear), and a soil cover thickness of 600mm including 100mm topsoil, for a brownfield source this testing frequency equates to approximately one topsoil sample per ten plots and one subsoil sample per two plots. Given the requirement to test a minimum number of samples from any one source, the testing frequency effectively increases for sites with only a small number of plots.

[1] *Verification Requirements for Cover Systems: Technical Guidance for Developers, Landowners & Consultants; Version 4.1, June 2021.*

1.17 **Inspection Frequency (to check soil thickness):** The number of inspection pits excavated to check cover thickness (and collect samples, if required) should be dependent on the end use of the development.

1.18 For **residential developments** the number of plots associated with a given site will dictate the number of inspection pits. The following frequencies are recommended for residential plots.

No. plots within development	Frequency of inspection pits	Remarks
1 to 5	1 pit per plot	e.g. for 3 plots, dig 3 inspection pits
6 to 20	1 pit per 2 plots	e.g. for 9 plots, dig 5 inspection pits
21 to 30	1 pit per 3 plots	e.g. for 23 plots, dig 8 inspection pits
≥ 30	1 pit per 4 plots	e.g. for 39 plots, dig 10 inspection pits

1.19 For **areas of landscaping**, regardless of development type, a minimum of 3 pits per area of soft landscaping are recommended where the landscaped area is greater than 25m^2. In individual landscaped areas smaller than 25m^2 inspection pits are not required.

1.20 Photographs should be taken of each inspection pit to show:

- The thickness of cover material present
- The presence of any geotextile marker or granular hard-dig layer (if required)
- The position of each inspection pit in relation to the plot/area of landscaping

1.21 **Soil Material Suitability**: Inspection pits should be excavated through the entire thickness of any proposed in-situ source material, or cover material (if inspection is post-placement). Stockpiles should be assessed from both the surface and by digging into the "core", to ensure the material is reasonably homogenous.

1.22 The soil material should comply with the following requirements:

- Be clean and free of foreign debris, building waste materials, glass sharps, and contaminants
- Topsoil should not have a gravel content of greater than 30% by dry weight and should generally have a maximum stone size of 50mm in any one direction
- Subsoil should generally have a maximum stone size of 75mm in any one direction
- Not have been sourced from an area within 7m laterally, or 3m vertically, of Japanese Knotweed plants, and not contain any Japanese Knotweed fragments (rhizomes, leaves, stems etc)

1.23 **Laboratory Analysis:** Whether samples are taken at source, from stockpiles on site, or from gardens and landscaped areas after placement, they should be forwarded to an analytical laboratory for testing in accordance with one of the Schedules detailed in Table 1 overleaf.

1.24 Additional determinands may be scheduled dependent on the history of the source site, although if this is considered necessary it may suggest the material is unlikely to be suitable for use as clean cover.

Table 1 – Test schedule

Source	Test schedule
Greenfield & Manufactured topsoil	pH, total metals (Cu, Ni, Zn, Cr III, Cr VI, As, Hg, Se, Cd & Pb), water soluble boron. TOC & speciated PAH Asbestos ID
Brownfield & Soil transfer stations	pH, total metals (Cu, Ni, Zn, Cr III, Cr VI, As, Hg, Se, Cd & Pb), water soluble boron. TOC, Speciated PAH & banded TPH* Asbestos ID
Crushed product	pH, total metals (Cu, Ni, Zn, Cr III, Cr VI, As, Hg, Se, Cd & Pb), water soluble boron. TOC & Speciated PAH Asbestos ID

Note: The schedules detailed above have been prepared in accordance with the Secondary Model Procedures and Land Contamination Risk Management, 2020. This document states that analysis should be relevant to potential sources and not merely a set list of parameters applied to each site.

* The YALPAG guidance recommends speciated TPH (TPH CWG) analysis for brownfield sources, but this should not be necessary unless the banded TPH analysis fails the assessment criteria detailed in Table 2 below.

Where crushed product is used at least 600mm below finished garden level, only asbestos analysis will be required.

1.25 Chemical assessment (Tier 1) criteria for imported soils are provided in Table 2, these reflect exposure and toxicological amendments proposed within the C4SL report. Where no C4SL value has been published generic assessment criteria have been derived based on the C4SL assumptions using the CLEA model (version 1.701).

Table 2 - Chemical assessment criteria for imported soils

Contaminant	Source	Tier 1 assessment criteria (mg/kg)	Comments/notes
pH	CLEA		
As	C4SL	37	
Cd	C4SL	26	
Cr (III)	CLEA	4000	
Cr (VI)	C4SL	21	
Pb	C4SL	200	
Ni	CLEA	109	Assessment of human health risk only.
Se	CLEA	434	
Hg	CLEA	199	Assumes mercury present as an inorganic compound (cf elemental metal or within organic compound). See Science Report SC050021/Mercury SGV.
Vn	CLEA	584	
B	Lithos	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependent).
Cu	DoE	100	
Zn	DoE	200	
Benzo(a)pyrene	C4SL	5	
Naphthalene	CLEA	6	
GRO	CLEA	22	Conservative value based on value for aromatic fraction C7 to C8 range, but assuming indoor inhalation pathway still relevant (it shouldn't be).
DRO	CLEA	215	Conservative value based on value for aliphatic fraction C10 to C12 range, but assuming indoor inhalation pathway still relevant (it shouldn't be).
LRO	CLEA	1,000	Calculated value above hazardous waste screen in WM3, therefore 1,000mg/kg adopted. This may be reviewed on a site specific basis depending on the source and nature of transfer.

2 VALIDATION REPORTS

2.1 The analytical testing will usually be undertaken on a 3 or 5-day turnaround and the Client/Contractor will be notified of the soil's suitability (or otherwise) immediately after receipt of the results.

2.2 Interim plot validation certificates for residential plots should be issued to warranty providers on a plot by plot (or block by block) basis as development proceeds. Once the full development has been completed these should be pulled together into a final verification report, for submission to the Local Authority to satisfy planning conditions.

2.3 Interim validation certificates will be issued by Lithos for each landscaped area or set of landscaped areas once completed. After Lithos have been able to confirm placement of agreed thicknesses of suitable soil cover in all landscaped areas across the site, and where required to satisfy a Local Authority planning condition, we will prepare and submit a final validation letter report.