Geoenvironmental Appraisal

Land at Ripon Auction Mart, North Road, Ripon

For Ripon Farmers Livestock Mart Co Ltd

Report no: 2376/1B

Date: July 2016

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SUMMARY OF GEOENVIRONMENTAL ISSUES

Job No.	2376	**Site area/ha**	1.53
Client:	Ripon Farmers Livestock Mart Co Ltd	**NGR:**	SE 316 718
Site:	Ripon Auction Mart, North Road, Ripon	**Nearest postcode:**	HG4 1HT

The site lies approximately 600m north-east of Ripon city centre, and comprises an area of mostly undeveloped land bounded by North Street to the north, and Magdalen's Road to the east. Steel-framed sheds associated with a former livestock market are present in the centre-west, and hardstand covers much of the site.

Originally (late 1800s) the site was part of a large residential garden with glasshouses, but it was developed with an Auction Mart around 1909, with extensions to approximately its current layout in the late 1960s. Station Hotel was first noted fronting North Road in the late 19th Century.

Lithos were commissioned by Ripon Farmers to provide a geoenvironmental appraisal of the site. It is understood that the site is to be redeveloped with about 31 Park Homes or Log Cabins. The Park Homes will be prefabricated units, and sit on concrete pads, with access to mains water, electricity and drainage. Lithos' investigation included a review of previous reports and a ground investigation comprising 38 trial pits and 19 boreholes.

A summary of salient geoenvironmental issues is provided in the Table below.

Issue	**Remarks**
Made Ground	Made ground thicknesses beneath the site vary between 0.2m and 2.5m; average 0.9m. The thickest made ground was encountered immediately south of the Auction Mart sheds. Made ground can be categorised as one of three broad types: • Ash & Clinker: only encountered beneath the tarmacked access road to the west of the Station Hotel to 0.5m depth. • Granular Made Ground: encountered in many of the exploratory holes in the north of the site and comprising reworked sand and gravel deposits locally with fragments of brick and occasionally a clayey matrix. • Cohesive Made Ground: found locally across the site and comprising reworked natural clay deposits with a variable proportion of natural gravel and/or brick/tile fragments.

Natural Ground	Natural ground was encountered to the base of each exploratory hole (except TP208), and is variable both vertically and laterally, but typically comprises:
	• Lacustrine Deposits: identified within each of the historical gypsum dissolution hollows and in the central area of the site and comprising soft and very soft clay, and locally peat. These deposits have typically proven to be less than 6.5m in thickness, but within the historical dissolution hollows they extended down to 15.4m (BH309).
	• Glaciofluvial Deposits: a laterally and vertically variable mixture of firm and stiff gravelly clay, and medium dense sand or sand and gravel deposits.
	• Brotherton Formation: generally only encountered in the north of the site and recovered as gravel and cobble sized fragments of moderately strong grey limestone with brown staining on fracture surfaces.
	• Edlington Formation: generally found as a weak to moderately strong, red brown, calcareous mudstone, with occasional sub-horizontal or irregular veins of fibrous gypsum. Locally beds of massive white alabastine gypsum were observed. This formation showed evidence of gypsum dissolution, including:
	  o Cavity Fill: encountered in several boreholes as a mix of clay and lithorelicts, and often associated with open cavities. This material likely represents collapsed or softened ground in the base of a gypsum dissolution cavity.
	  o Foundered Strata: encountered in 6 boreholes in the south of the site and generally recovered as grey clay with gravel, cobble and likely boulder sized fragments of limestone.
	• Cadeby Formation: encountered in 9 boreholes as a moderately strong grey limestone with a porous texture. There is no gypsum\anhydrite below the top of this stratum.

Contamination	Made ground, with the exception of that adjacent to the former fuel filling station, is essentially free from contamination. One sample of Ash & Clinker from adjacent to the filling station yielded elevated concentrations of a number of inorganic determinands. The made ground does locally contain materials (eg brick), which would generally be considered undesirable as a near-surface material in garden areas. One area of significant organic (hydrocarbon) contamination has been identified immediately adjacent to the former fuel filling station. Full access to this area was constrained due the presence of buildings and live services. It is likely that this contaminated material will require excavation and either treatment or removal from site.

This brief summary should not be assumed to represent a complete account of all the potential geo-environmental issues that may exist at the site. As such it is strongly recommended that the report be read in its entirety.

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Issue	Remarks
Hazardous Gas	Whilst peat deposits have the potential to generate hazardous gas, monitoring suggests no special protective measures are necessary.
Mining & Quarrying	The site lies beyond the CA's defined coalfields. There are no known quarries on site or within influencing distance of its boundary.
Foundations	The prefabricated units will sit on reinforced concrete pads which are typically 150mm thick, and are just slightly larger than the footprint of the proposed Park Home. Ordinarily, made ground and soft clay and peat (Lacustrine Deposits) within subsidence features would not be considered suitable foundation materials, but loadings are expected to be very light, and the Park Homes are not expected to be particularly sensitive to total, or even some differential, settlement. Consequently, at this stage it is anticipated that reinforced concrete pads will be placed on a minimum 500mm thickness of granular sub-base.
Groundwater & Excavations	Based on the results of the investigation it is unlikely that major groundwater flows will be encountered in shallow excavations. Excavations in natural ground should remain stable in the short term but if left open for any significant period of time, may require shoring most notably in granular soils and made ground.
Drainage	Soakaways will not be suitable for drainage at this site.
Highways	Highways at the site require mitigation against the effects of potential gypsum dissolution, particularly where they cross the historical dissolution features, via the incorporation of suitably designed layers of tensile reinforcement within the highway construction.

Significant developer abnormals relating to geoenvironmental issues at the site are:

- Demolition of buildings and break-up of below ground obstructions, slabs and hardstand.
- Removal of UST's and associated fuel\oil contamination; with subsequent treatment and\or off-site disposal.
- Preparation of the ground for highway construction including suitable reinforcement.
- Re-grade of site to desired levels.

This brief summary should not be assumed to represent a complete account of all the potential geo-environmental issues that may exist at the site. As such it is strongly recommended that the report be read in its entirety.

APPENDICES

Appendix A - General notes

01	Environmental setting
02	Ground investigation fieldwork
03	Geotechnical testing
04	Contamination laboratory analysis & interpretation
05	Hazardous gas

Appendix B - Drawings

Drawing	Revision	Title
2376/1	-	Site Location Plan
2376/2	A	Proposed Site Layout
2376/3	-	Existing Site Features
2376/4	-	Site Photographs
2376/5	-	Preliminary Conceptual Site Model
2376/6	-	Exploratory Hole Location Plan
2376/7	-	Revised Conceptual Site Model & Geological Sections

Appendix C - Commission

Appendix D - Historical OS plans#

Appendix E - Search responses & other correspondence#

From	Date	Content
Landmark	23/10/2011	Envirocheck Report
Harrogate Borough Council	04/11/2011	Environmental search data
Environment Agency	31/10/2011	Environmental search data
North Yorkshire CC	10/11/2011	Petroleum Report
Lissett Homes	09/03/2016	Park Homes – typical details

Appendix F & G – Exploratory records

Appendix F	TPs 101 to 111, 135 to 137, 201 to 211, 215 to 219 and 301 to 308
Appendix G	BHs 101, 102, 201 to 207, 213 and 301 to 309

Appendix H - Chemical test results

Appendix I - Geotechnical test results

Appendix J – Photographs of Rock Cores

Appendix K - Gas monitoring results

Appendix L – Ground Stability Declaration Form

Some of this data is not included within the paper or PDF copies of this report; it is all included on the CD.

FOREWORD (geoenvironmental appraisal report)

This report has been prepared for the sole internal use and reliance of the Client named on page 1. This report shall not be relied upon or transferred to any other parties without the express written authorisation of Lithos Consulting Limited (Lithos); such authorisation not to be unreasonably withheld. If any unauthorised third party comes into possession of this report, they rely on it at their peril and the authors owe them no duty of care and skill.

The report presents observations and factual data obtained during our site investigation, and provides an assessment of geoenvironmental issues with respect to information provided by the Client regarding the proposed development. Further advice should be sought from Lithos prior to significant revision of the development proposals.

The report should be read in its entirety, including all associated drawings and appendices. Lithos cannot be held responsible for any misinterpretations arising from the use of extracts that are taken out of context. However, it should be noted that in order to keep the number of sheets of paper in the hard copy to a minimum, some information (e.g. full copy of the Landmark/Groundsure Report) is only included on the accompanying CD.

The findings and opinions conveyed in this report (including review of any third party reports) are based on information obtained from a variety of sources as detailed within this report, and which Lithos believes are reliable. All reasonable care and skill has been applied in examining the information obtained. Nevertheless, Lithos cannot and does not guarantee the authenticity or reliability of the information it has relied upon.

The report represents the findings and opinions of experienced geoenvironmental consultants. Lithos does not provide legal advice and the advice of lawyers may also be required.

Intrusive investigation can only investigate shallow ground beneath a small proportion of the total site area. It is possible therefore that the intrusive investigation undertaken by Lithos, whilst fully appropriate, may not have encountered all significant subsurface conditions. Consequently, no liability can be accepted for conditions not revealed by the exploratory holes. Any opinion expressed as to the possible configuration of strata between or below exploratory holes is for guidance only and no responsibility is accepted as to its accuracy

It should be borne in mind that the timescale over which the investigation was undertaken may not allow the establishment of equilibrium groundwater levels. Particularly relevant in this context is that groundwater levels are susceptible to seasonal and other variations and may be higher during wetter periods than those encountered during this commission.

Where the report refers to the potential presence of invasive weeds such as Japanese Knotweed, or the presence of asbestos containing materials, it should be noted that the observations are for information only and should be verified by a suitably qualified expert.

This report assumes that ground levels will not change significantly from those existing at present and that houses will be of two storey construction. If this is not to be the case, then some modification to this report may be required.

Lithos cannot be responsible for the consequences of changing practices, revisions to waste management legislation etc that may affect the viability of proposed remediation options.

Lithos reserve the right to amend their conclusions and recommendations in the light of further information that may become available.

GEOENVIRONMENTAL APPRAISAL

of land at

RIPON AUCTION MART, NORTH ROAD, RIPON

1 INTRODUCTION

1.1 The commission and brief

1.1.1 Lithos Consulting Limited, were commissioned by Ripon Farmers to prepare a geoenvironmental appraisal report for land at Ripon Auction Mart.

1.1.2 This document is a revision of the Geoenvironmental Appraisal (Report 1249/3C) issued by Lithos in November 2012; Report 1249/3C is now withdrawn. This document considers the site in the context of the revised redevelopment (Log Cabins), and is concerned only with the northernmost two thirds of the site considered in Report 1249/3C.

1.1.3 This document also includes reference to a subsidence event that occurred in Magdalene Road in February 2014; see Section 3.2.

1.1.4 Correspondence regarding Lithos' appointment, including the brief for this investigation, is included in Appendix C. The agreed scope of works included:

- a review of third party reports
- a site walkover and inspection
- an assessment of the land use history
- determination of the site's environmental setting
- an intrusive ground investigation comprising 38 trial pits and 19 boreholes
- assessment of the geotechnical properties of the near surface deposits to enable provision of foundation and highway recommendations
- a qualitative assessment of contamination risks
- recommendations for the necessary site preparatory and remediation works

1.1.4 This report has been prepared by a 'competent person', and a Ground Stability Declaration Form is included in Appendix L to this report.

1.2 The Proposed Development

1.2.1 It is understood that consideration is being given to redevelopment of the site with about 31 Park Homes or Log Cabins, with a private estate roadway. The Park Homes will be prefabricated units, and sit on concrete pads, with access to mains water, electricity and drainage. A site layout has been prepared by MS Architects (Drawing 1082/1.9, dated May 2016) which is reproduced as Drawing No. 2376/2 in Appendix B to this report.

1.3 Report Format and Limitations

1.3.1 All standard definitions, procedures and guidance are contained within Appendix A, which includes background, generic information on:

- Assessment of the site's environmental setting
- Ground investigation fieldwork
- Geotechnical Testing
- Contamination Testing
- Hazardous Gas

1.3.2 General notes and limitations relevant to all Lithos geoenvironmental investigations are described in the Foreword and should be read in conjunction with this report. The text of the report draws specific attention to any modification to these procedures and to any other special techniques employed.

1.3.3 Primary aims of this investigation were to identify salient geoenvironmental issues affecting the site and to support the submission of a planning application.

2 SITE DESCRIPTION

2.1 General

2.1.1 The site's location is shown on Drawing 2376/1 presented in Appendix B to this report. Site details are summarised in the Table below.

Detail	Remarks
Location	600m north-east of Ripon city centre
NGR	SE 316 718
Approximate Area	1.43 ha
Known services	Underground electric, gas, telecom in the north Two sewers cross the site Overhead telecom

2.2 Site Features

2.2.1 A Lithos Engineer completed a walkover survey of the site in May 2011.

Feature	Remarks
Current Access	Off North Road
Approximate areas	3,400m^2 buildings 800m^2 tarmac hardstand 2,000m^2 concrete hardstand Remaining areas are grass or rough vegetation
Nature of boundaries	North – open, public house and brick wall South – trees & hedgerows East – mix of fencing and low brick walls North-west – buildings and brick wall South-west – generally no physical boundaries
Surrounding land uses	North, south, east & west – housing South-west - woodland

2.2.2 The Station Hotel (public house) fronts onto North Street, and extends beyond the current site boundary. To the rear of the Hotel is a two storey concrete block and wood building that was formerly a small maintenance building with tea rooms above. These buildings are generally surrounded by tarmac hardstand. Land slopes down into the site from North Road.

2.2.3 Attached to the western side of the Station Hotel is a single storey brick building; this was formerly a fuel station. Access covers and vent pipes indicating 5 underground fuel tanks were noted, and to the north and west of this building there is evidence of hardstand reinstatement following the removal of 3 pumps.

2.2.4 There is a single large steel portal frame structure with a probable asbestos cement sheet roof in the centre-west. This concrete floored structure was formerly used as covered animal (pig and cow) sheds, with a sale ring in the centre. The sale ring was damaged by fire in early May 2011 and subsequently demolished in late summer 2011. The portal frame structure itself is still standing. An open area of concrete hardstand formerly used as sheep pens lies immediately to the south of the pig and cow sheds. It is likely that an underground slurry tank(s) exists beneath this hardstand.

2.2.5 The east of the site is mainly rough vegetation, with a concrete former wheel wash at its centre. An extension to the west forms a raised area, with ash and gravel surfacing. Debris such as plastic and metal are evident at the margins of this raised area.

2.2.6 Geomorphic assessment of the site has identified a depression in the cut-out of the L shaped auction market sheds; possibly indicative of a historic collapsed dissolution features.

2.2.7 Existing salient features at the time of the walkover survey are presented on Drawing No. 2376/3 in Appendix B to this report; site photographs are included on Drawing No. 2376/4.

3 SITE HISTORY

3.1 Historical maps

3.1.1 Site centred extracts from Ordnance Survey (OS) plans dating back to 1856 have been examined. Some of these plans are presented in Appendix D to this report.

3.1.2 The Table below provides a summary of the salient points relating to the history of the site with respect to the proposed end use. It is not the intention of this report to describe in detail all the changes that have occurred on or adjacent to the site. Significant former uses/operations are highlighted in bold text for ease of reference.

Date	Site	Surrounding Land
1856	Divided into several fields; woodland in the north-west.	North Road and Magdalen's Road to north and east respectively. Generally agricultural land on all sides. 'The pottery' noted 100m north-west. Chapel noted immediately to the east.
1892	Hotel and buildings shown fronting North Road with formal gardens and glass houses to the south. Southern boundary marked by a hedge line.	Terraced properties to the north along North Road. Princess Road formed to the south with some terraced properties. Hospital (Armshouses) noted within the chapel grounds.
1909	Animal pens of 'North Road Auction Mart' including a ring shown in the centre-west of the site.	Further residential development along Princess Road and Magdalen's Road.
1968	Auction Mart extended to include covered areas, sheep and cattle pens. Buildings to east of the Station Hotel have been removed along with all glass houses. **Garage** noted immediately west of the Hotel.	Tax office and North Road Bungalows constructed to the north of North Road. Builder's yard noted to the east.
1979	Site detailed roughly in its current configuration. Garage no longer noted.	Builder's yard now occupied by residential development of Magdalen's Close.
1991	Sheep pens constructed to the south of the main Auction Mart buildings.	

3.1.3 It is understood that the Auction Mart closed in 2001 due to livestock movement restrictions during the foot and mouth outbreak and did not reopen.

3.2 2014 subsidence event in Magdalene Close

3.2.1 On 17th February 2014, large cracks appeared in a detached house in Ripon (No. 26 Magdalene Close), part of the house later collapsed. The collapse was caused by formation of a sinkhole resulting from the dissolution of thick gypsum deposits in the area.

3.2.2 The sinkhole was roughly oval, measuring 11m north-south and 15m east–west. The maximum depression was in the garden between the house and the greenhouse and the depression appeared to be around 0.7m deep in the middle.

3.2.3 Several cracks up to 5cm appeared in the house and paths delineating the maximum extent of the sinkhole. There were also slight movements in neighbouring garden walls and driveways with slight lateral movements towards the hole opening cracks of 2mm to 1cm.

3.2.4 This sinkhole is not an unusual event for the Ripon area. In the 1980s and 1990s, a sinkhole was appearing every two to three years (Cooper, 1998)[1]. The last recorded hole was on the flood plain of the River Ure, north of Ripon (Sargent and Goulty, 2009)[2].

3.2.5 The triggering mechanisms for these sinkholes to collapse can be one, or a combination of mechanisms, the most common being:

- enlargement of the caves due to subsurface dissolution
- infiltration of water from the surface washing down fine materials from the covering deposits
- fluctuations in the groundwater levels rising to wet the covering materials and then falling leaving the cover saturated and without the hydraulic support offered by the water.

[1] *Cooper, A H. 1998. Subsidence hazards caused by the dissolution of Permian gypsum in England: geology, investigation and remediation. In: Maund, J G & Eddleston, M. (eds.)* Geohazards in Engineering Geology. *Engineering Geology Special Publication 15. The Geological Society of London, 265–275.*

[2] *Sargent, C. and Goulty, N R. 2009. Seismic reflection survey for investigation of gypsum dissolution and subsidence at Hell Kettles, Darlington, UK.* Quarterly Journal of Engineering Geology and Hydrogeology, *42, 31–38, doi: 10.1144/1470–9236/07–071.*

4 ENVIRONMENTAL SETTING

4.1 General

4.1.1 Notes describing how the site's environmental setting has been assessed are included in Appendix A to this report. Extracts from the responses received from Landmark, Harrogate Borough Council, North Yorkshire County Council, the BGS and the Environment Agency are presented in Appendix E. These responses are summarised below, together with the findings of our own "desk study" investigation.

Issue	Data reviewed	Summary
Geology	1:10,000 BGS map (Sheet SE37SW) DoE Technical Report[3]	Drift - north and east: glaciofluvial deposits (sand and gravel) Drift – north, central and west: peat (within subsidence hollows) Solid – Brotherton Formation (Upper Magnesian Limestone), over Edlington Formation (Middle Permian Marl). Gypsum – The site lies within a development Area C as recorded by the DoE technical report. Gypsum bearing strata lie at depth beneath the site, and historical dissolution hollows lie 100m to the east and 400m west. See Section 4.2.
Mining	BGS maps	The site lies beyond the CA's defined coalfields
Quarrying	Local Authority search Historical OS Plans	None known within 250m of the site
Landfills	Envirocheck Report Local Authority search	Although there are no known historic landfill sites within 500m of the site. A gas holder located 215m to the south has been backfilled.
Radon	BRE Report BR211	No protective measures required
Hydrogeology	Environment Agency Groundwater Vulnerability map (Sheet 8)	Source Protection Zone? No. Aquifer Secondary (Drift); Primary (Solid) Groundwater abstractions? Only 1 within 1km, located 580m to the east (potable water for two dwellings) Soil leaching potential – Not classified Pollution incidents? None relating to the site
Hydrology	Environment Agency Envirocheck Report	Nearest watercourse – River Ure, 100m north-east Water quality - B. Pollution incidents? None relating to the site Abstractions? Several within 500m extracting irrigation water from the River Ure Discharge consents? None relating to the site
Flood Risk	Environment Agency	The site lies largely in Flood Zone 2 - outlying areas likely to be affected by a major flood, with up to a 0.1 per cent (1 in 1000) chance of occurring each year. In accordance with Chapter 10 of the National Planning Policy Framework, a site-specific flood risk assessment is required for new development in Flood Zone 2.

[3] *Assessment of Subsidence Arising from Gypsum Dissolution: Technical Report for the Department of the Environment, Symonds Travers Morgan 1996*

4.2 Geology and hydrogeology

4.2.1 Gypsum (hydrated calcium sulphate) is an evaporate mineral, formed by precipitation from warm, shallow, saline marine waters. As it becomes buried beneath successive layers of accumulating sediment, compaction and loss of water result in transition to a dehydrated form of calcium sulphate called anhydrite.

4.2.2 Gypsum dissolves rapidly in flowing water that is not already saturated with calcium sulphate. Anhydrite is also soluble, but tends to revert back to gypsum rather than dissolving.

4.2.3 The generalised geological sequence of rocks in this area of North Yorkshire is:

- Sherwood Sandstone (Triassic); youngest bedrock in this sequence. Not present beneath this site.
- Roxby Formation (Upper Permian Marl). Contains significant beds (up to 10m thick) of gypsum/anhydrite at its base. Not present beneath this site.
- Brotherton Formation (Upper Magnesian Limestone). Typically 8m to 15m thick. Only underlies the north of this site.
- Edlington Formation (Middle Permian Marl). Contains significant beds (up to 35m thick) of gypsum/anhydrite. Typically 15m to 50m in thickness.
- Cadeby Formation (Lower Magnesian Limestone); oldest bedrock in this sequence. There is no gypsum\anhydrite below the top of this stratum.

4.2.4 The above strata all dip gently to the east at roughly 2°.

4.2.5 The area which is potentially susceptible to gypsum dissolution is broadly constrained by two factors:

- The limits of outcrop of gypsum bearing strata (in the west), and
- The limit beyond which the easterly dipping gypsum beds give way to unaltered anhydrite deposits at depths typically in excess of 100m (in the east).

4.2.6 Between these limits gypsum may, or may not, be at risk of dissolution depending on groundwater flow and chemistry (principally the degree of gypsum saturation).

4.2.7 Dissolution in the Ripon area is strongly influenced by the presence of a deep (up to around 50m), gravel-filled, buried valley below the current course of the River Ure. The buried valley has enabled direct hydraulic connection between groundwater in the gravels and that in gypsum beds at the base of the Edlington Formation.

4.2.8 On the western side of the Ure valley, groundwater under artesian pressure within the Cadeby Formation is able to move up through fractures, joints and cavities within the gypsum, and breccia pipes within the overlying marls. Groundwater in the Cadeby Formation is not already saturated with gypsum (cf groundwater in the Edlington & Roxby Formations), and is therefore capable of causing gypsum dissolution.

4.2.9 Geological and geomorphological evidence suggest that subsidence activity has been most prevalent above and along the sides of the buried valley.

4.2.10 Geological faults can also provide a pathway for upward groundwater flow.

4.2.11 It is thought that caves underlie much of Ripon, and some of the surrounding area, and follow joints in the rock. Where joints intersect, larger chambers can develop and further dissolution of the gypsum can result in these chambers becoming unstable.

4.2.12 Caves in the gypsum are continually expanding and collapsing. A collapse occurs about once every 10 years in the built up area of Ripon and up to once a year in the wider gypsum affected area[4]. It is well established that although the location and pattern of collapses cannot be predicted, high quality site investigation and appropriate foundation design can mitigate much of the risk.

4.2.13 The size, shape and mode of formation of individual subsidence hollows depend, in part, on the nature and thickness of the material which directly underlies the surface.

4.2.14 On outcrops of thinly-bedded marl or in areas underlain by significant thicknesses of drift, subsidence is most likely to take the form of broad, conical or more Irregular-shaped hollows formed by progressive deepening of an initial sag in the ground surface.

4.2.15 Where gypsum is overlain by more competent Brotherton Formation or Sherwood Sandstone (the Brotherton underlies the far north of this site), the potential exists for more sudden failure. The roof rock initially fails in a piecemeal way, partially filling the void with broken rock. The cavity then works its way upwards leaving a breccia pipe below. Eventually, the cavity nears the surface and the covering 'bridge' of material collapses. Alternatively, where bedrock is overlain by more significant thicknesses of unconsolidated drift soils, the roof of the cavity opens slightly allowing soils to funnel in, rather like sand in an egg-timer.

4.2.16 The increase in volume associated with brecciation may eventually choke a cavity completely before it reaches the surface, thus preventing any further upward migration of the void. However, in theory large voids might migrate up through around 100m of overlying bedrock; in reality probably rather less.

4.2.17 Smaller cavities become choked more easily, and it is probable therefore that much of the gypsum dissolution taking place beneath Ripon will never result in subsidence of the overlying ground.

4.2.18 Previous subsidence events within Area C of the Development Guidance Map for Ripon have been summarised in a 1986 paper prepared by Dr Anthony Cooper of the BGS[5]. Features proximal to the Auction Mart site have typically resulted in sagged subsidence features of between about 4m and 10m diameter (but up to 14m diameter) at surface with the formation of conical shaped collapse features through the superficial deposits down to rockhead. The initial sags are understood to have deepened to around 2m over a period of several days with further deepening to around 4m over the following months. The precipitating cavities at rockhead are likely to be only 2m to 5m in diameter.

4.2.19 It is noteworthy that surface subsidence features, where the underlying geology comprises uncemented Quaternary drift deposits (such as the Auction Mart site), will likely take the form of conical or more irregular-shaped hollows formed by the progressive deepening of an initial sag over days and months. This is in stark contrast to the well documented sudden failures and appearance of vertical sided cylindrical shafts noted immediately to the east of the River Ure where Sherwood Sandstone is present at shallow depth.

4.2.20 Consequently, the DoE Technical Report recognises that "relatively small and gradual displacements may be expected in areas underlain by thick drift deposits or by weathered, thinly bedded marl".

[4] *Harrogate District Local Plan 2001: Appendix 11: Gypsum in Ripon*

[5] *Subsidence and foundering of strata caused by the dissolution of Permian gypsum in the Ripon and Bedale areas, North Yorkshire. A. H. Cooper. Geological Society, London, Special Publications 1986; v. 22; p. 127-139*

4.2.21 Subsidence arising from gypsum dissolution is an irregular and unpredictable process. The foundation recommendations presented in Section 13.5 will the minimise damage that could occur in the unlikely event that dissolution results in surface subsidence. However, no shallow foundation solution can entirely prevent damage if such subsidence were to occur.

4.3 Planning advice for the Ripon area

4.3.1 The problems of gypsum dissolution and its effects on both existing and proposed buildings in the Ripon area have been well documented in a DoE Technical Report[6]. Research contained in the DoE Technical Report resulted in the Ripon neighbourhood being subdivided into three development control areas:

- Area A – no known gypsum present.
- Area B – some gypsum present at depth.
- Area C – gypsum present and susceptible to dissolution.

4.3.2 Whilst the overall probability of a subsidence event occurring in Ripon at any particular point is relatively low, the localised consequences of a major collapse can be very serious. Consequently, in accordance with advice provided in the DoE Report, the local authority (Harrogate Borough Council) take account of the potential for gypsum dissolution in both Forward Planning and Development Control.

4.3.3 Responsibility to investigate the condition or circumstances of any particular site, to determine whether or not land is suitable for development, rests primarily with the developer and/or landowner (not the local authority). Applicants should procure a Ground Stability Report, which should be prepared by a Competent Person (a Chartered Geologist with at least 15 years' experience).

4.3.4 The Ground Stability Report should include details of the site's history, together with the results of a site inspection and a geotechnical desk study, followed in certain circumstances by a more detailed ground Investigation.

4.3.5 The need for, and scope of, a Ground Stability Report is dictated by location of the proposed development, and the nature and scale of the development itself. Requirements described in the DoE Report are only mandatory for larger developments, and often will not apply to minor developments.

4.3.6 This site lies within Development Control Area C, and would likely be considered a larger development.

4.3.7 Within Area C, gypsum and/or anhydrite are likely to be present within the reach of groundwater moving more rapidly towards the River Ure buried valley. Consequently, there is a greater likelihood of gypsum dissolution and associated subsidence activity. This area encompasses virtually all areas of known subsidence activity, as well as some intervening areas which appear to have remained undisturbed for many hundreds, or even thousands of years.

4.3.8 Within Development Control Area C, the DoE Report suggests that ground investigation should identify both existing voids and gypsum/anhydrite deposits. The DoE Report goes to state that in view of this, it would be inappropriate to rely solely on openhole drilling or surface geophysical surveys. These techniques cannot reliably identify gypsum or anhydrite deposits and must be replaced or used in conjunction with more sophisticated methods, such as rotary core drilling and/or downhole geophysical logging.

[6] *Assessment of Subsidence Arising from Gypsum Dissolution: Technical Report for the Department of the Environment, Symonds Travers Morgan 1996*

5 PREVIOUS INVESTIGATION FINDINGS

5.1 BGS data

5.1.1 Lithos have consulted the British Geological Survey (BGS) and gained copies of exploratory holes records from several nearby site investigations including one on the site itself. These include:

- 1991 and 1997: investigation for redevelopment of Inland Revenue Offices (Freemantle Terrace) immediately north of the site on North Road: Two borehole logs have been supplied by the BGS that indicate superficial deposits to approximately 15m depth. One borehole terminated in strong limestone at 18.5m depth. The second borehole identified a sequence of limestone and red mudstone to 41.3m.

  A BGS interpretation of the latter borehole indicates Brotherton Formation (Limestone) from 25.3m to 32.2m depth, with foundered Brotherton Formation and Edlington Formation to at least 41.3m. This borehole was drilled through a significant microgravity anomaly[7]. This is supported by the BGS geological map for the area.
- 1993: investigation for residential development of seven houses immediately south of the site on Princess Road. Four boreholes were drilled to depth of between 27.0m (BH2) and 35.0m (BH4). The boreholes identified drift deposits of sand, gravel, peat, clay and boulder clay overlying limestone at around 25m depth.

  It is highly likely that the material described as 'boulder clay' is in fact Edlington Formation mudstone, with the 'limestone' being massive alabastine gypsum.
- 1993: Investigation of Ripon Farmers Livestock Mart Company. Ten cable percussion boreholes were drilled to depths of between 6.5m and 17.0m.

  The holes generally identified superficial deposits of clay, sand and gravel to their bases. Four of the holes found peat to depths of up to 6.7m. BH8 recorded 'fluid marls' from 15m to 18.5m, with marl and gypsum to its termination at 18.5m. It is possible that a number of other boreholes from this investigation also encountered weathered Edlington Formation (marl).

5.2 Third party reports

5.2.1 Lithos have reviewed copies of the following reports:

- Preliminary Geotechnical Appraisal. Site at Ripon Auction Mart, North Yorkshire. Prepared by Acuity Consulting on behalf of NM – UK. Project No. 1248, dated May 2009.
- Compilation and Summary of Historic Borehole Surveys and Recent Geophysical Surveys undertaken at Ripon Auction Market Site, North Yorkshire. Prepared by Acuity Consulting on behalf of Ripon Property Developments Limited, The Ripon Farmers' Livestock Market Company Limited, Mr Hugh Atkinson, Mr Peter Atkinson and Mr Paul Atkinson. Project No. 1248, dated August 2010.
- Ripon Auction Mart, North Yorkshire. Geophysical Survey. Prepared by Phase Site Investigations Limited on behalf of Ripon Property Developments Limited, The Ripon Farmers' Livestock Mart Company Limited, Mr Hugh Atkinson, Mr Peter Atkinson and Mr Paul Atkinson. Project No. GEO/396/201, dated June 2010.

5.2.2 A summary of each of the report findings is provided in the following sections.

[7] *Patterson, D., Davey, J.C., Cooper, A.H. & Ferris, J.K. 1995. The application of microgravity geophysics in a phased investigation of dissolution subsidence at Ripon, Yorkshire. Quarterly Journal of Engineering Geology (London), 28, 83-94.*

5.3 Preliminary Geotechnical Appraisal (Acuity)

5.3.1 The report provided a brief overview of the development issues at the site and assessed the geology based on the two 1993 site investigations detailed in Section 5.1 above.

5.3.2 Acuity concluded that Cadeby Formation limestone was likely to exist at approximately 25m beneath the site and proposed a ground investigation aimed at determining the presence of gypsum dissolution related cavities in the Edlington Formation above it.

5.4 Compilation & Summary Report, and Geophysical Surveys (Acuity)

5.4.1 This Acuity report reappraises the geotechnical desk study as per Section 5.2 above and provides background as to the specific gypsum related geo-hazards that might be expected at the site.

5.4.2 Following discussions with Dr Anthony Cooper at the BGS (considered an expert on the gypsum related issues in the Ripon area), Acuity procured a detailed geophysical investigation of the site (and adjacent land to the south) that comprised microgravity, electromagnetic and resistivity surveys.

- Microgravity survey: Three areas of low density material were identified in locations corresponding to the surface depressions identified on the topographic survey. Further areas of low density material were identified at the back (south) of the public house, the north western corner, the western edge of the site, and within adjacent land to the south.
- Electromagnetic conductivity survey: The areas of high conductivity at the surface (soft, damp material) correspond with the locations of potentially deep, loose material identified by the microgravity survey. Survey was not possible in areas of reinforced concrete.
- Resistivity: The profiles generally showed good correlation with the results of the microgravity and electromagnetic conductivity surveys.

5.4.3 The results of the topographic, microgravity, electromagnetic and resistivity imaging surveys generally correlate with findings from the historic borehole information, and confirm that gypsum dissolution has occurred beneath the site in the past, creating caverns which have collapsed and subsequently been in-filled with loose material.

5.4.4 Intrusive site investigation was recommended to establish 'ground truth', and confirm the interpretation of the geophysical survey.

5.5 Lithos Comments

5.5.1 Acuity identified limestone at approximately 25m depth immediately to the south of the site that they interpreted as Cadeby Formation. This formation marks the base of the potential gypsum dissolution related cavities in the overlying Edlington Formation. Lithos believe that this is likely to be an error of interpretation (chips of massive alabastine gypsum perhaps mistaken for limestone during openhole drilling), and that a substantial thickness of gypsiferous Edlington Formation is likely to underlie the site.

5.5.2 The detailed geophysical survey summarised within the Acuity report will prove invaluable in targeting areas of potential concern during the ground investigation proposed here.

6 GROUND INVESTIGATION DESIGN

6.1 Anticipated ground conditions & potential issues

6.1.1 Based on the data reviewed in Sections 4 (Environmental Setting) and 5 (Previous Investigation Findings), anticipated ground conditions are expected to comprise:-

Anticipated Condition	Remarks
Made Ground	Potential shallow made ground in the vicinity of structures and hardstand (used to level and stiffen the ground in the north of the site).
Natural Soils	A locally variable mixture of cohesive and granular deposits potentially up to 15m in thickness. Localised deposits of soft clay and peat may be associated with the identified dissolution hollows.
Bedrock	Edlington Formation (red calcareous mudstone with locally massive gypsum) immediately beneath superficial deposits, Cadeby Formation Limestone at depth.
Groundwater	Possible within granular superficial deposits. Potentially significant flows of groundwater within the Edlington Formation.

6.1.2 Based on the data above and that in Sections 2 (Site Description) and 3 (History), potential ground-related issues associated with this site are likely to include:

Type of Issue	Specific Issue	Remarks
Potential on-site contamination sources	1. USTs 2. General made ground	1. Diesel and petrol 2. Heavy metals
Potential off-site contamination sources	1. None anticipated	
Potential geotechnical hazards	1. Soft ground 2. Gypsum related cavities	
Other potential constraints	1. Underground and/or overhead utilities	

6.2 Preliminary Conceptual Site Model

6.2.1 A preliminary conceptual site model, presented as Drawing No. 2376/5 in Appendix B, has been prepared after consideration of all the data presented in Sections 2 to 6.1 inclusive, of this report.

6.2.2 The conceptual model considers the geohazards associated with potential gypsum dissolution beneath the site.

6.2.3 An assessment of potential contaminants associated with the former uses has been undertaken with reference to CLR8 and the following DETR Industry Profiles: *Road vehicle fuelling, service and repair: garages and filling stations*.

6.2.4 The Auction Mart itself is understood only to have been used for the sale of livestock (i.e. not as a slaughterhouse, hide\skin processing plant, tannery, meat processing plant, or gelatine\glue works). As a consequence of this assessment, anticipated potential contaminants, within soil and/or groundwater include:

- Fuels (diesel, petrol, paraffin)
- Oils
- Metals (most notably: Cr, Cu, Pb & Zn)

6.2.5 Potential pollutant linkages are shown on the preliminary conceptual site model.

6.3 Ground Investigation Design & Strategy

6.3.1 The preliminary conceptual site model was used as a basis for design of an appropriate ground investigation, the scope of which is summarised below.

Exploratory Holes	Purpose
Trial Pits	To determine the general nature of soils underlying the site, including the: • nature, distribution and thickness of made ground • nature, degree and extent of contamination • proportion of undesirable elements eg biodegradable matter, foundations etc • suitability of the ground for founding structures and highways
	To delineate potential hydrocarbon contamination around former fuel forecourt
Boreholes	To retrieve geotechnical data from depth in order to determine: • the presence of active gypsum dissolution features • depth and nature of soft deposits within the historical dissolution features
	To install monitoring wells across the site in order to monitor for hazardous gas

6.3.2 Proposed exploratory hole locations were selected to provide a representative view of the strata beneath the site and to target potential areas of interest identified in Sections 4 and 5 above. A nominal 20m grid spacing was proposed.

6.3.3 The number of representative samples taken will be reflective of the geological complexity actually encountered. However, in general about three samples will be taken from most trial pits.

7 FIELDWORK

7.1 Objectives

7.1.1 The original investigation strategy is outlined in Section 6.3 above.

7.2 Exploratory Hole Location Constraints

7.2.1 No access was available within the majority of the buildings due to restricted working height. The presence of live sewers (entire site) and other underground service (only in the north) also restricted exploratory works.

7.3 Scope of Works

7.3.1 Fieldwork was supervised by Lithos in three phases; May 2011, November/December 2011, and February/March 2012 and comprised the exploratory holes listed below.

Technique	Exploratory holes	Final depth(s)	Remarks
Trial pitting (machine dug)	TPs 101 to 111, 135 to 137, 201 to 211, 215 to 219 & 301 to 308	Between 2.0m and 4.8m	Vane tests in cohesive soils.
Cable percussive boreholes	BHs 101, 102, 201 to 207, 213 & 301 to 309	Various	SPTs typically at 1m to 1.5m centres. Monitoring wells installed in BHs 202 & 205
Rotary cored and open-hole boreholes (follow on from cable percussive boreholes)	BHs 101, 102, 201, 203, 204, 206, 207, 213 & 301 to 309	Max. 60m	

7.3.2 The May 2011 investigation targeted the significant geophysical anomalies, reported by Acuity (see Section 5), with boreholes and included site-wide trial pitting in order to identify and delineate soft deposits.

7.3.3 The November/December 2011 and February/March 2012 investigations aimed to provide geotechnical information and further assess the gypsum dissolution risk outside the geophysical anomalies. The investigations also targeted potential contamination at the site.

7.3.4 TPs 201 to 203 were located in the vicinity of the former filling station USTs (north-west corner of the site, adjacent to the Station Hotel).

7.3.5 Notes describing ground investigation techniques, in-situ testing and sampling are included in Appendix A to this report.

7.3.6 Exploratory hole logs are presented in Appendices F and G to this Report. These logs include details of the:

- Samples taken
- Descriptions of the solid strata, and any groundwater encountered.
- Results of the in-situ testing
- The monitoring wells installed

7.3.7 Exploratory hole locations are shown on Drawing No. 2376/6 presented in Appendix B.

8 GROUND CONDITIONS

8.1 General

8.1.1 A complete record of strata encountered beneath the proposed development site is given on the various exploratory hole records, presented in Appendices F and G. However, a summary of the ground conditions is provided below and in the tables on pages 16 to 18.

8.1.2 Typical ground conditions encountered in each of these areas are described below in Sections 8.2 (made ground) and 8.4 (natural ground).

8.2 Made Ground

8.2.1 The made ground on site is a heterogeneous mixture of materials and it is unlikely, even with a huge amount of sampling, that it could be accurately characterised. Nonetheless, the bulk of the made ground can be categorised as one of three broad types:

- **Ash & Clinker**: only encountered beneath the tarmacked access road to the west of the Station Hotel to 0.5m depth.
- **Granular Made Ground**: encountered in many of the exploratory holes and comprising reworked sand and gravel deposits, locally with fragments of brick and occasionally a clayey matrix. Typically less than 1m in thickness.
- **Cohesive Made Ground**: found locally across the site and comprising reworked natural clay deposits with a variable proportion of natural gravel and/or brick/tile fragments.

8.2.2 Review of the trial pit logs suggest made ground thicknesses beneath the site vary between 0.2m and 2.5m; average 0.9m. The thickest made ground (TPs 110, 135, 205, 208 & 209) was encountered immediately south of the Auction Mart sheds.

8.2.3 Anecdotal evidence suggests that a potentially significant quantity of made ground was imported to site in order to level the ground prior to construction of the concrete slab for the sheep pens in the southern end of the Auction Mart area.

8.2.4 Whilst not encountered during this investigation, the possibility of asbestos sheeting, used as shuttering, and/or fragments of asbestos sheeting within the hardcore beneath concrete slabs, cannot be entirely discounted.

8.3 Obstructions

8.3.1 It is apparent from a review of historical OS Plans (see Section 3) that other than the existing structures there have only previously been buildings fronting North Street, to the east of the Station Hotel, and glasshouses in the centre of the northern area.

8.3.2 No significant obstructions were encountered during the investigation. However, some obstructions (services and foundations) should be anticipated associated with the existing structures.

8.4 Natural Ground

8.4.1 Natural ground was encountered to the base of each exploratory hole (except TP208) but is variable both vertically and laterally. The summary tables on pages 16 to 18 illustrate this variability.

8.4.2 Natural deposits typically comprise:

- **Lacustrine Deposits**: identified within each of the historical gypsum dissolution hollows and in the central area of the site and comprising soft and very soft clay, and locally peat. These deposits have typically proven to be less than 6.5m in thickness, but within the historical dissolution hollows they extended down to 15.4m (BH309).
- **Glaciofluvial Deposits**: a laterally and vertically variable mixture of firm and stiff gravelly clay, and sand or sand and gravel deposits. The granular deposits are generally medium dense as determined by in-situ SPTs. These deposits underlie the Lacustrine Deposits and extend to rockhead at depths of between 10m and 16m.
- **Brotherton Formation**: generally only encountered in the north of the site, and recovered as gravel and cobble sized fragments of moderately strong grey limestone with brown staining on fracture surfaces.
- **Edlington Formation**: generally found as a weak to moderately strong, red brown, calcareous mudstone, with occasional sub-horizontal or irregular veins of fibrous gypsum. Locally sections of moderately strong and strong massive white alabastine gypsum were observed. This formation showed evidence of gypsum dissolution (as summarised in the tables on pages 17 and 18 and within Section 8.5), and included:
    - **Cavity Fill**: encountered in several boreholes as a mix of clay and lithorelicts, and often associated with open cavities. This material likely represents collapsed or softened ground in the base of a gypsum dissolution cavity.
    - **Foundered Strata**: encountered in 6 boreholes in the south-west of the site, and generally recovered as grey clay with gravel, cobble and likely boulder sized fragments of grey limestone.
- **Cadeby Formation**: encountered in 9 boreholes as a moderately strong grey medium to coarse grained limestone with a porous texture. There is no gypsum\anhydrite below the top of this stratum.

8.5 Evidence of Gypsum Dissolution

8.5.1 As discussed in Section 4.2 the site is located in an area subject to localised subsidence hazards, associated with both existing cavities and with the on-going dissolution of gypsum deposits by groundwater moving towards the Ure valley.

8.5.2 The table on pages 17 and 18 details evidence of gypsum related dissolution encountered within the boreholes at the site. There are essentially two types of dissolution related features:

Open Cavities

8.5.3 Open cavities (voids), and/or partially or wholly in-filled cavities, with intact rock above and below.

8.5.4 BHs 101 to 105 were drilled through historic dissolution hollows (as defined by geophysical anomalies and confirmed by initial trial pitting (see Drawing No. 2376/7), and encountered open cavities (voids), and/or partially or wholly in-filled cavities, with intact rock above and below. These cavities are more numerous and generally at shallower depths than encountered outside the historical hollows.

8.5.5 Cavities (voids) and/or possible cavity fill indicative of gypsum dissolution were noted within:

- BH203 (32.3m to 34.3m),
- BH301 (49.5m 500mm void),
- BH303 (49.3m to 50.1m),
- BH304 (40.0m 400mm void, 43.0m 400mm void with probable cavity fill 43.4m to 47.2m),
- BH307 (20.5m 400mm void, 22.0m 300mm void and 60.2m 500mm void),
- BH308 (53.9m 500mm void),

8.5.6 The intrusive investigation and geophysical survey suggest that these cavities are, with the exception of BH307, typically at depths in excess of 30m.

8.5.7 BH302 and BH303 were drilled close to BH203 and did not encounter the voided ground at around 33m, suggesting that this cavity is not laterally extensive.

8.5.8 Significant voids (>1.0m high) were only noted at depth (in excess of 30m) within BHs 203 & 307.

Foundered Strata

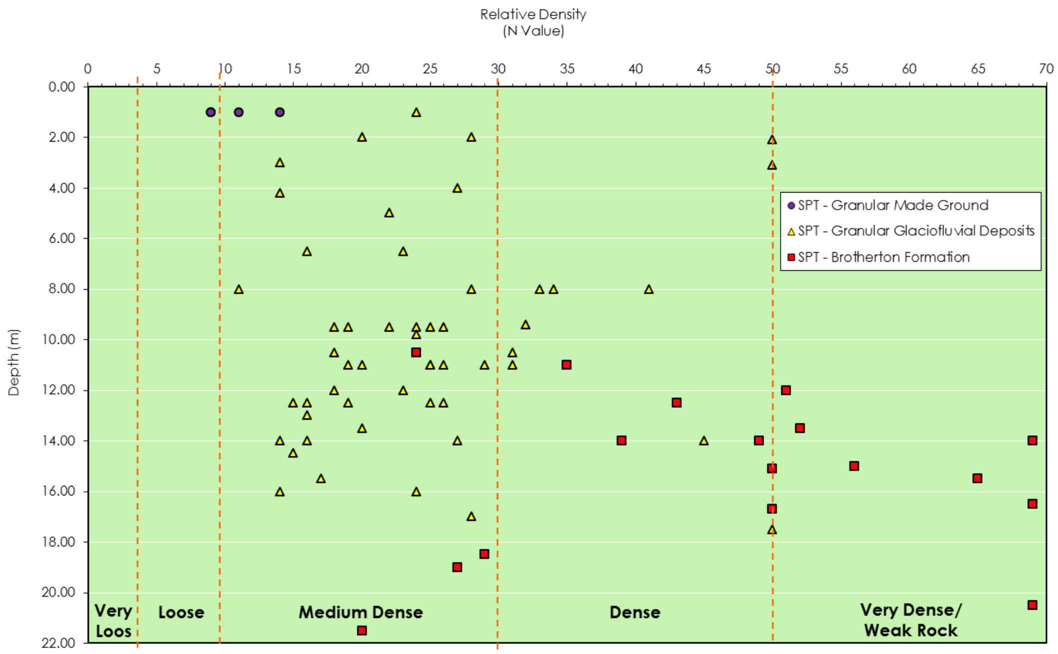
8.5.9 Foundered strata represent sections of the Edlington Formation where gypsum has been dissolved but the residual mudstone has remained in-situ, or where overlying rock has collapsed into an extensive void. Foundered strata were identified in the boreholes detailed below, in an area through the centre of the site:

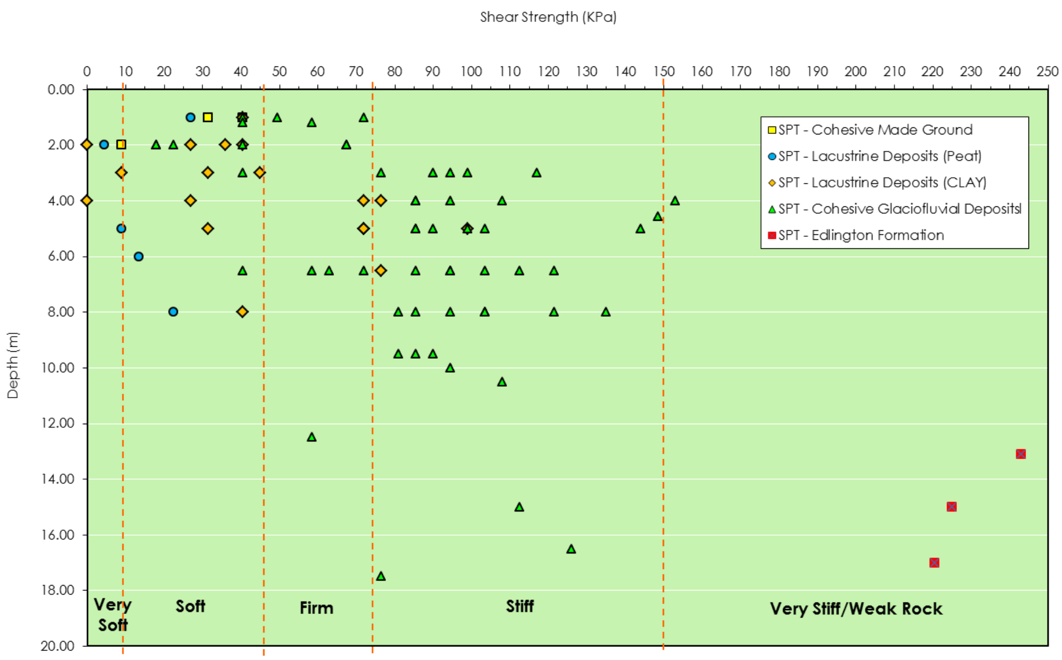
- BH204 (18.0m to >45.75m),
- BH207 (13.1m to 37.2m),
- BH213 (10.5m to >40.0m),
- BH305 (12.85 to 30.2m),
- BH308 (21.5m to 34.0m) and
- BH309 (23.3m to 29.0m).

8.6 In-situ Testing

8.6.1 The in-situ relative density of granular deposits and strength of cohesive deposits on site were established by carrying out SPTs during the drilling of the boreholes.

8.6.2 SPT results are summarised in plots below:





Summary of Ground Conditions Encountered in Trial Pits

Exploratory Hole	Final Depth	Topsoil	Made Ground	Lacustrine Deposits			Glaciofluvial Sheet Deposits		Remarks
				Soft Clay	Peat	Soft Clay	Cohesive	Granular	
TP101	4.20		0.60	2.10	3.60		3.80	>4.20	
TP102	2.70		0.50	1.60	2.00	2.20		>2.70	
TP103	3.60		1.20	2.40				>3.60	
TP104	3.20		0.40	2.20				>3.20	
TP105	2.00		0.40					>2.00	
TP106	4.50		1.00		2.00	>4.50			
TP107	4.80		1.40		>4.80				
TP108	2.00		0.40					>2.00	
TP109	3.00		0.08				2.80	>3.00	
TP110	4.30		1.70				>4.30		
TP111	2.70		0.90				2.20	>2.70	
TP135	3.70	0.20	1.60					>3.70	
TP136	3.30		0.80	2.10			>3.30		2.1m to 2.4m: granular
TP137	3.00		1.20				>3.00		
TP201	3.80		0.50				1.90	>3.80	
TP202	3.40		0.50					>3.40	2.9m to >3.4m: clay
TP203	2.50		0.60				2.00	>2.50	
TP204	3.60		0.50				>3.60		0.8m to 1.3m: granular
TP205	3.50		2.10	2.90				>3.50	
TP206	4.70		0.80	>4.70					
TP207	4.20		0.70	3.10	3.60	>4.20			
TP208	2.50		>2.50						
TP209	4.10		1.80				2.70	>4.10	
TP210	4.00		0.40	2.70	>4.00				
TP211	2.60		1.50				1.90	>2.60	
TP215	3.00		0.40				>3.00		
TP216	4.20		0.70	1.90	2.90	4.00		>4.20	

Summary of Ground Conditions Encountered in Trial Pits

Exploratory Hole	Final Depth	Topsoil	Made Ground	Lacustrine Deposits			Glaciofluvial Sheet Deposits		Remarks
				Soft Clay	Peat	Soft Clay	Cohesive	Granular	
TP217	2.50		0.50				>2.50		
TP218	2.50		0.20				0.60	>2.50	
TP219	2.80		0.80	1.00				>2.80	
TP301	3.00		1.55				2.50	>3.00	
TP302	2.7		0.60				1.90	>2.70	
TP303	3.5		1.40	1.90	2.10	>3.50			
TP304	2.70		0.40				2.10	2.70	
TP305	3.10		0.80					>3.10	
TP306	3.20		0.40				1.90	>3.20	0.4m to 0.8m: Relict Topsoil
TP307	3.00		0.30				2.40	>3.00	
TP308	3.50		0.20	1.30	2.70	>3.50			

Summary of Ground Conditions Encountered in Boreholes

Expl Hole	Final depth (m)	Topsoil	Made Ground	Lacustrine Deposits			Glaciofluvial Sheet Deposits		Brotherton Limestone	Foundered Strata	Edlington Mudstone	Cadeby Formation	Evidence of Gypsum Dissolution	Remarks
				Soft Clay	Peat	Soft Clay	Cohesive	Granular						
BH101	42.50		2.50		3.45	6.10	8.00	18.20	24.00		>42.50		24.5 - 30.5m; possible cavity fill recovered as clay 32.0m - 33.0m; possible cavity fill 34.0m - 34.5m; possible cavity fill	16.5m - 18.0m: granular
BH102	42.00		1.40	2.50	7.50	11.90		18.00			>42.00		34.5m - 35.0m; possible cavity fill 36.0m - 40.0m; possible cavity fill	
BH201	44.30		0.60	2.40			10.20	18.00	27.30		>44.30			2.4m - 4.3m: granular
BH202	10.45		1.70	2.15	3.40	6.40	>10.45							6.4m - 7.4m: granular

Summary of Ground Conditions Encountered in Boreholes

Expl Hole	Final depth (m)	Topsoil	Made Ground	Lacustrine Deposits			Glaciofluvial Sheet Deposits		Brotherton Limestone	Foundered Strata	Edlington Mudstone	Cadeby Formation	Evidence of Gypsum Dissolution	Remarks
				Soft Clay	Peat	Soft Clay	Cohesive	Granular						
BH203	44.30		1.10				11.05	16.00			>44.30		32.3m - 34.3m; void	2.05m - 3.2m: granular
BH204	45.75		1.80	3.00			18.00			>45.75				8.7m - 9.7m & 12.1m to 15.1m: granular
BH205	17.45		0.25	1.40	1.95	5.40	8.00	15.30			>17.45			
BH206	41.00						8.10	14.00	16.90		>41.00			0.0m - 4.0m: granular
BH207	40.00		1.85	4.20				13.10		37.20	>40.00			
BH213	40.00		1.40	2.00	5.30	6.50	8.30			>40.00	10.50			
BH301	54.10		0.50				8.35	14.00	21.50		50.00	>54.10	49.50m – 50.00m; void	
BH302	57.50		2.10				10.10	13.70			46.15	>57.50		
BH303	55.60		2.65				9.90	13.95			50.10	>55.60	49.30m – 50.10; void	
BH304	54.40		0.25				14.00		23.50		47.20	>54.40	40.00m – 40.40m; void 43.00 – 43.40m; void 43.40m – 47.20m; possible cavity fill	9.55 - 10.10m: granular
BH305	49.90		0.42				6.60	12.85		30.20	48.00	>49.90		9.30 - 9.90m: clay
BH306	54.40		0.23				11.10		23.50		48.30	>54.40		
BH307	63.90		0.60				8.35	11.70			61.70	>63.90	20.50m – 20.90m; void 22.00m – 22.30m; void 60.20m – 61.70m; void	0.60 - 2.85m: granular
BH308	60.60		0.40				8.00	10.40	21.50	34.00	56.75	>60.60	53.90m – 54.40m; void	3.75 - 4.60m: granular 9.70 - 10.40m: clay
BH309	60.00			5.60	9.40	15.40			23.20	29.00	46.00	>60.00		

8.7 Groundwater

8.7.1 Groundwater was locally encountered at various levels across the site; although significant flows of groundwater were not typically encountered at shallow depth.

8.8 Stability

8.8.1 The stability of excavations within soft lacustrine deposits and saturated granular glaciofluvial deposits were generally poor.

8.9 Visual & Olfactory Evidence of Organic Contamination

8.9.1 Exploratory locations where evidence of significant organic contamination was noted are summarised below:

Hole ID	Material	Depth m bgl	Observation
TP202	Glaciofluvial Sheet Deposits	1.7 to 2.9	Strong Hydrocarbon odour

8.9.2 TPs 201 & 202 was located in the vicinity of the former filling station USTs (north-west corner of the site, adjacent to the Station Hotel).

8.9.3 Selected samples of potentially contaminated materials were scheduled for chemical testing to determine the nature and extent of the identified contamination; see Section 9.

8.10 Revised conceptual ground model (ground conditions)

8.10.1 The Preliminary Conceptual Site Model has been revised in light of data obtained during the ground investigation, most notably with respect to:

- the nature and distribution of made ground, including the presence of significant buried obstructions
- constraints associated with sewers
- the strength, nature and depth of underlying natural strata
- the presence of gypsum dissolution features (cavities and cavity fill)
- the nature and distribution of contamination (based on visual/olfactory evidence only)

8.10.2 The revised Conceptual Site Model and geological cross-sections are presented in Appendix B, as Drawing No. 2376/7.

8.10.3 Further refinement of the Conceptual Site Model is presented in Section 10.2, where the results of laboratory testing for contaminants have been considered.

9 CONTAMINATION (ANALYSIS)

9.1 General

9.1.1 The site has been formerly used as:

- A hotel
- Fuel filling station (extreme north-west only)
- Possible small scale vehicle service garage
- Animal Auction Mart
- Agricultural land

9.1.2 Raw materials stored and used on site are likely to be limited to fuels (in underground tanks) and lubricating oils in the extreme north-west corner of the site.

9.1.3 The site's former usage is likely to have given rise to some ground contamination. Furthermore, made ground was encountered in many of the exploratory locations during the ground investigation.

9.1.4 An assessment of potential contaminants associated with the former uses has been undertaken; see Section 6.2.

9.1.5 In the context of risks to human health associated with residential use, the Tier 1 Soil Screening Values referenced in this report have been derived via the CLEA default conceptual site model (CSM) used for generating SGVs, but amended, where appropriate, to be more specific to redevelopment within the planning process.

9.1.6 Where available, Category 4 Screening Levels (C4SL) have also been referenced.

9.1.7 This site is brownfield and underlain by made ground. Consequently, for organic compounds, the Tier 1 Soil Screening Values used in this report have been derived with reference to a CSM that assumes a minimum 600mm of clean soil cover will be placed in gardens/landscaped areas (Lithos Scenario B).

9.1.8 Generic Note 04 in Appendix A provides further details with respect to current guidance and the interpretation of analytical data.

9.2 Testing Scheduled

9.2.1 Based on the above assessment, a Lithos Engineer submitted a test schedule (summarised in the table below) to a UKAS accredited laboratory. We have also taken account of visual and olfactory evidence recorded during the ground investigation.

Type of Sample	No. of Samples	Determinands
Made Ground	11	pH, water soluble boron, and total metals (arsenic, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc)
	8	Leachable metals: arsenic, boron, cadmium, chromium, copper, lead, mercury, nickel, selenium and zinc
	3	Asbestos
	2	Calorific Value
	5	Total Organic Carbon (TOC) & speciated PAH
	1	speciated TPH
Glaciofluvial Deposits	5	Total Organic Carbon (TOC), speciated PAH & speciated TPH

9.3 Soil Contamination Results

9.3.1 The soil contamination test results are summarised in the Tables on pages 23 to 25.

9.3.2 Laboratory test certificates as received from the laboratory are presented in Appendix H to this report.

Inorganic Determinands

9.3.3 Of the 11 samples of made ground analysed for inorganic parameters, only 1 sample could be classified as contaminated.

9.3.4 This sample has been classified by comparison of concentrations with Lithos Soil Screening Values for an end use including domestic gardens and any area where plants are to be grown (the most sensitive of the proposed end-uses).

9.3.5 The sample of Ash & Clinker in TP210 yielded elevated concentrations of arsenic, lead, copper and zinc.

Calorific Value

9.3.6 The Calorific Value (CV) of two samples of Ash & Clinker, have yielded a CV of 3.2MJ/kg (TP201, 0.2m) and <1MJ/kg (TP218, 0.1m). Materials whose CV's exceed 10MJ/kg are almost certainly combustible, while those with values below 2MJ/kg are unlikely to burn.

Asbestos

9.3.7 No asbestos fibres were identified in any of the samples screened.

Leachables

9.3.8 Of the leachability tests conducted on 8 samples, only one (Ash & Clinker, TP210) had an arsenic concentration of leachable contaminants above the maximum permissible concentrations as defined in the Water Supply (Water Quality) Regulations 1989, as amended in 2000.

Organic Determinands

9.3.9 Samples have been classified by comparison with Lithos risk-derived Tier 1 screening values (Lithos Scenario B, see Generic Notes 04 in Appendix A). These screening values assume a Soil Organic Matter (SOM) of 6% (equivalent to a TOC of 3.5%). Many organic contaminants are more mobile when the SOM is lower, and consequently lower screening values are then more appropriate for many organic contaminants.

9.3.10 In order to check the validity of Lithos Scenario B screening values, the average TOC for each common fill type (beyond any areas of obvious hydrocarbon impact) have been determined.

Fill Type	Typical TOC/%	Comparison with revised Screening Value necessary?
Ash & Clinker	3.6%	No
Cohesive Made Ground	1.4%	No. Results show a clear split into uncontaminated and significantly contaminated; therefore refinement not considered necessary.
Granular Made Ground	2.9%	
Glaciofluvial Deposits	1.4%	

Total Petroleum Hydrocarbons (TPH)

9.3.11 TPs 201 to 203 were located in the vicinity of the former filling station USTs (north-west corner of the site, adjacent to the Station Hotel). Visual\olfactory evidence of fuel contamination was noted in TP 202, and laboratory results suggest fuel contamination is also present in TPs 201 & 203.

9.3.12 Lithos have used the CLEA model to derive risk based screening values for hydrocarbons, in accordance with the methodology detailed by the TPHCWG, and reviewed by a UK workshop of experts with respect to UK adoption of the method.

9.3.13 Petroleum sources have been identified within the preliminary conceptual model. Consequently, assessment of TPH has been undertaken in accordance with a 3-step approach, (outlined in Generic Note 04 in Appendix A). The first two steps involve review of speciated results. The third step assesses cumulative effects.

9.3.14 Step 1 – Consideration of Indicator Compounds. None of the Indicator Compounds exceed their respective Tier 1 criteria, therefore the more toxic / prevalent compounds are below their representative screening value and the next step can be undertaken to consider mixtures within the fractions.

9.3.15 Step 2 – TPH Fractions (does any individual fraction exceed Tier 1?). There are elevated fractions above the respective Tier 1 value

- Aliphatic: C_8-C_{10}, C_{10}-C_{12} and C_{12}-C_{16}
- Aromatic: C_8-C_{10}, C_{16}-C_{20} and C_{21}-C_{35}

9.3.16 Therefore further site specific assessment will be required. As further action / assessment has been identified, no further assessment of the cumulative effects from fractions is considered necessary.

Poly Aromatic Hydrocarbons (PAH)

9.3.17 Speciated analysis has confirmed elevated concentrations of benzo(a)pyrene in one sample (TP201 @ 0.2m); associated with fuel contamination. However, the analysis has demonstrated the absence of naphthalene in the soils beneath this site.

9.3.18 The next most volatile PAH's are the three benzene ring compounds fluorene, phenanthrene and anthracene. However, due to their relatively low volatility these PAH's will not pose a potential risk to future end users, provided the made ground is isolated beneath 600mm of 'clean' soil cover.

Summary of degree of soils contamination (inorganics)

Hole ID	Depth (m)	Material	Concentrations in mg/kg unless otherwise stated. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in brackets and assume a **residential with gardens** end-use.												
			pH	As (37)∞	Cd (26)∞	Cr (3,000)x	Pb (200)∞	Hg (169)*	Se (350)	B (5)~	Cu ♣ $	Ni (127)	Zn (200)$	CV (2MJ)	Asbestos
TP201	0.20	Ash & Clinker	9.3	**240**	1.1	39	**4,000**	0.4	5.0	1.8	**250**	44	**540**	**3.2**	
TP218	0.10	Ash & Clinker	9.4	4.8	0.3	22	17	< 0.05	1.9	1.4	8.6	7.6	44	< 1.0	
TP205	1.20	Cohesive Made Ground	7.9	5.5	0.5	24	37	0.07	< 0.5	0.8	15	22	57		
TP219	0.70	Cohesive Made Ground	8.2	6.0	0.4	19	23	< 0.05	< 0.5	0.4	16	21	56		
TP204	0.20	Granular Made Ground	8.2	6.4	0.8	21	110	0.1	< 0.5	0.6	19	15	130		Not detected
TP208	0.40	Granular Made Ground	8.5	8.0	0.5	15	110	0.6	< 0.5	0.6	52	13	87		Not detected
TP211	0.90	Granular Made Ground	8.0	8.7	0.5	30	58	0.2	< 0.5	1.5	26	21	84		
TP215	0.20	Granular Made Ground	8.1	6.0	0.6	17	45	0.2	< 0.5	0.9	19	15	86		
TP216	0.30	Granular Made Ground	7.9	11	0.6	18	150	0.2	< 0.5	1.4	31	19	100		
TP217	0.30	Granular Made Ground	8.8	4.0	0.4	8.8	25	< 0.05	< 0.5	0.5	7.4	9.4	71		
TP219	0.10	Granular Made Ground	10.1	6.7	0.2	32	12	< 0.05	1.9	2.4	7.8	9.2	26		Not detected

Key	
36	Parameter tested for and found to be in excess of Tier 1 concentration.
179	Parameter tested for and found to be > 5 x Tier 1 concentration.
12	Parameter tested for but not found to be in excess of Tier 1 concentration.
	Parameter not tested for.
♣	Tier 1 Value is pH dependent.
x	Assumes Cr is CrIII. If demonstrated Cr is CrVI Tier 1 would be 21mg/kg.
*	Assumes mercury present as an inorganic compound (cf elemental metal or within organic compound). See Science Report SC050021/Mercury SGV.

Source of guidance trigger level	
With the exception of those annotated with one of the symbols below (∞, $, ~), all Soil Screening Values in brackets above have been derived using CLEA v1.06.	
∞	Category 4 Screening Level – SP1010, December 2013 (CL:AIRE/Defra).
$	Ministry of Agriculture, Fisheries & Food. Code of Practice for Agricultural Practice for the Protection of Soil, 1998.
~	Engineering judgement (Lithos). Boron is a phytotoxic, although most phytotoxic compounds can pose a risk to human health if sufficient concentrations are present. However, plants represent the most sensitive receptor, and a Tier 1 value which is protective of flora is therefore also protective of human health.

Summary of the Leachability Testing

Hole ID	Depth (m)	Material	Concentration in µg/litre unless otherwise Shown. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are Shown in Brackets.										
			pH	As	Cd	Cr	Cu	Pb	Hg	Ni	Zn	Se	B
				(10)*	(5)*	(50)*	(2000)*	(25)*	(1)*	(20)*	(5,000)*	(10)*	(1000)*
TP201	0.20	Ash & Clinker	8.0	**24**	< 2.0	< 5.0	3.9	14	< 0.05	< 10	31	< 12	160
TP218	0.10	Ash & Clinker	7.0	< 1.0	< 2.0	< 5.0	< 2.0	< 4.0	< 0.05	< 10	< 1.0	< 12	< 100
TP205	1.20	Cohesive Made Ground	8.1	< 1.0	< 2.0	< 5.0	< 2.0	< 4.0	< 0.05	< 10	10	< 12	160
TP208	0.60	Cohesive Made Ground	7.8	< 1.0	< 2.0	< 5.0	< 2.0	< 4.0	< 0.05	< 10	16	< 12	150
TP204	0.20	Granular Made Ground	8.1	< 1.0	< 2.0	< 5.0	< 2.0	< 4.0	< 0.05	< 10	15	< 12	150
TP211	0.90	Granular Made Ground	7.5	< 1.0	< 2.0	< 5.0	< 2.0	< 4.0	< 0.05	< 10	27	< 12	150
TP216	0.30	Granular Made Ground	6.9	< 1.0	< 2.0	< 5.0	< 2.0	< 4.0	< 0.05	< 10	< 1.0	< 12	< 100
TP219	0.10	Granular Made Ground	7.0	< 1.0	< 2.0	< 5.0	< 2.0	< 4.0	< 0.05	< 10	< 1.0	< 12	100

Key	
-	Parameter tested for but not found to be in excess of trigger concentration
	Parameter not tested for

Source of Guidance Trigger Level	
*	Water Supply (Water Quality) Regulations 1989, as amended in 2000

Summary of Degree of Ground Contamination (Organics)

Hole ID	Depth (m)	Material	Concentrations in mg/kg. Results are quoted to 1 decimal place if <10, and whole numbers if >10. Trigger Level Concentrations are shown in brackets and assume a **residential with gardens and 600mm cover** end use					
			TOC	PAH		TPH - C_6 to C_{40}		
			%	B(a)P ∞	Naphthalene	GRO C_6 to C_{10}	DRO C_{10} to C_{21}	LRO C_{21} to C_{35}
				(5)	(4)	(15)~	(151) ◊	(1,000)
TP201	0.20	Ash & Clinker	4.4	**90**	0.19	<0.01	**1,676**	**3,630**
TP218	0.10	Ash & Clinker	2.8	1.0	< 0.03			
TP208	0.40	Granular Made Ground	0.9	< 0.03	< 0.03			
TP211	0.10	Granular Made Ground	5.9	0.26	< 0.03			
TP219	0.10	Granular Made Ground	3.1	0.91	< 0.03			
TP201	2.50	Glaciofluvial Sheet Deposits	0.3	0.11	< 0.03	<0.01	<1.5	<4
TP202	1.80	Glaciofluvial Sheet Deposits	0.9	0.18	2.6	**239**	**2,163**	450
TP202	3.10	Glaciofluvial Sheet Deposits	0.5	< 0.03	< 0.03	<0.01	<1.5	<4
TP203	0.80	Glaciofluvial Sheet Deposits	3.4	< 0.03	< 0.03	<0.01	70	12
TP203	2.10	Glaciofluvial Sheet Deposits	1.4	3.6	0.19	<0.01	**468**	906

Key		**Source of Guidance Trigger Level**	
12	Parameter tested for but not found to be in excess of trigger concentration		All Soil Screening Values in brackets above have been derived using CLEA v1.06. Values assume a source located in a sandy loam, with 6% soil organic matter (SOM). Assumes isolation beneath a **minimum 600mm thickness of soil cover**, see Generic Notes 04 in Appendix A.
	Contaminant not tested for	~	Assumes all GRO is aromatic fraction C7 to C8
∞	Category 4 Screening Level – SP1010, December 2013 (CL:AIRE/Defra).	◊	Assumes all DRO is aliphatic fraction C10 to C12

10 CONTAMINATION (QUALITATIVE RISK ASSESSMENT & REMEDIATION)

10.1 Summary of significant contamination

10.1.1 Made ground, with the exception of that adjacent to the former fuel filling station, is essentially free from elevated concentrations of contaminants.

10.1.2 The made ground does locally contain materials (eg brick), which would generally be considered undesirable as a near-surface material in landscaped areas.

10.1.3 An area of significant organic (hydrocarbon) contamination has been identified immediately adjacent to the former fuel filling station (TPs 201 – 203). Full access to this area was constrained due the presence of buildings and live services.

10.1.4 One sample of Ash & Clinker from this area also yielded elevated concentrations of a number of inorganic determinands and was found to be potentially combustible.

10.2 Revised Conceptual Ground Model (Contamination)

10.2.1 The Preliminary Conceptual Site Model has been amended in light of data obtained during the ground investigation, most notably with respect to the distribution of made ground and contaminants.

10.2.2 A revised Conceptual Site Model is presented as Drawing No. 2376/7 in Appendix B. The Model includes the contaminant sources described in Section 10.1 above, and potential pollutant linkages (summarised below in Section 10.4) to receptors.

10.3 Environmental Setting & End Use

10.3.1 As discussed in Section 10.1 above, contamination exists adjacent to the former fuel filling station. In order to assess the significance of this contamination, consideration must be given to the site's environmental setting and the proposed end use.

10.3.2 The drift deposits underlying are classified as a secondary aquifer, with bedrock being classified as a primary aquifer. The nearest surface watercourse is the River Ure, which flows south, approximately 100m beyond the site's north-eastern boundary. Therefore, the site's environmental setting is considered to be high sensitivity.

10.3.3 With respect to human health, the proposed end use (residential) is also sensitive. Transient risks to construction workers can be addressed by the adoption of appropriate health and safety measures, see Section 14.3.

10.4 Pollutant Linkages

10.4.1 In terms of a proposed redevelopment of this site, plausible pollutant linkages can be summarised as follows.

Sources

10.4.2 The only significant contaminant source has been identified in ground immediately adjacent to the former fuel filling station (TPs 201 to 203).

Pathways

10.4.3 Potential contaminant pathways include:

- ingestion
- dermal contact
- inhalation of contaminated particulates
- surface water run-off, including existing drainage infrastructure
- downward infiltration of leachable/mobile contaminants to groundwater

Receptors

10.4.4 Potential contaminant receptors include:

- the environment - aquifer and/or watercourse
- end users of the site (residents)

10.4.5 It can be concluded that there are plausible pathways between actual contaminant sources and potential receptors. Consequently, some remediation action will be required, either treatment/removal of the source, or "breakage" of the pathway.

10.5 Potential Remediation Options

General

10.5.1 Approval of the recommendations given below should be sought from the appropriate regulatory authorities prior to commencement of site redevelopment.

Inorganic contamination & Combustibility

10.5.2 Where Ash & Clinker in TP201 remains beneath landscaped areas (i.e. not beneath hardstanding) a 1,000mm thick surface cover of "clean" soil comprising 500mm subsoil and 100mm topsoil is recommended. This cover will break potential pollutant linkages between the contaminated made ground and future end-users.

10.5.3 Alternatively, this made ground is considered suitable for redistribution beneath concrete oversite or areas of hardstanding, where they would be satisfactorily isolated from end users and risk of combustion.

10.5.4 Elsewhere made ground contains materials (e.g. brick), which would generally be considered undesirable as a near-surface material in landscaped areas. Consequently, where residual made ground remains beneath landscaped areas (i.e. not beneath hardstanding) a 300mm thick surface cover of "clean" soil is recommended.

Organic Contamination

10.5.5 Evidence of fuel contamination has been found in TPs 201 to 203, located in the vicinity of the former filling station USTs, in the north-west corner of the site, adjacent to the Station Hotel. Such contamination can be mobile and as such may pose a risk to the environment and human health.

10.5.6 Based on a qualitative review of the data obtained to date, it is considered that some grossly contaminated soil will require removal or treatment.

10.5.7 Lithos Screening Values (see Generic Note 4 in Appendix A) could be adopted as target concentrations for remediation. Although these values are based on consideration of human health only, it is considered likely that clean-up to these values would reduce pollution risks to controlled waters to acceptable levels.

10.5.8 Estimation of the volume of grossly contaminated soil requiring removal or treatment can only be approximate at this stage and is dependent on the target concentration(s) agreed with the Local Authority and/or Environment Agency. Contractors with experience of brownfield sites should be asked to review the site investigation data and make their own assessment once target concentrations have been agreed.

10.6 Waste classification

10.6.1 Disposal of the made ground off site is generally not considered appropriate, economically viable, nor in line with current Government philosophy regarding sustainable development. However, some excess arisings may be generated by excavations for foundations, sewers etc. Disposal to landfill (or an appropriate soil / aggregate transfer station) may be the most practical solution, if redistribution and retention on site is not feasible.

10.6.2 It should be noted that the classification and assessment of waste soils under the Environment Agency's Technical Guidance WM3[8], is a complex process (as of 1st July 2015 WM2 was archived, and replaced by technical guidance WM3).

10.6.3 If waste soil is classed as hazardous following classification under WM3, and destined for landfill, waste acceptance criteria (WAC) leachate testing will need to be undertaken. However, non-hazardous soil waste can go to a non-hazardous landfill facility; no further testing (eg WAC) is required.

10.6.4 WAC analysis is different to the 'routine' laboratory testing (such as that included earlier in this Section) undertaken in order to determine hazardous properties. Lithos typically only include WAC analysis if significant off-site disposal (of soil classified as hazardous waste) is anticipated.

10.6.5 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.

10.6.6 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 an orders of magnitude less than 0.1%).

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

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

10.7 Summary of potential pollutant linkages & mitigation

10.7.1 Remediation options can be summarised as follows:

Receptors	Pathways	Contaminants	Remediation Options
Human Health (Future residents) ◊	Consumption of contaminated vegetables	Metals (TP210 only). Hydrocarbons in the made ground adjacent to UST's	Redistribute Ash & Clinker beneath hardstand, or isolate beneath at least 1m of clean soil cover in landscaped areas Excavation and removal from site or treatment of hydrocarbon impacted soils
	Ingestion		
	Inhalation (dust and/or vapours)		
	Dermal contact		
Buildings	Contact with "aggressive" soil and/or groundwater	Sulphate in the made ground	Sub-surface concrete should generally be Design Sulphate Class DS-1, ACEC Classification of AC-1.
Plants	Uptake of phytotoxic elements	Cu, Ni & Zn in Ash & Clinker (TP201 only)	Redistribute Ash & Clinker beneath hardstand, or isolate beneath at least 1m of clean soil cover in landscaped areas
Groundwater River Ure	Migration of dissolved and/or free phase organics	Hydrocarbons (leaking from tanks, and/or faults in the site drainage system, and/or spills)	Removal of UST's and associated pipework Excavation and removal from site or treatment of impacted soils
	Surface water run-off	Hydrocarbons in the made ground	

◊ 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.

11 HAZARDOUS GAS

11.1 General

11.1.1 Although there are no landfill sites, shallow mining or significant thicknesses of made ground on or close to the site, there are locally significant peat deposits that do have the potential to generate hazardous gas.

11.1.2 Therefore, 5 gas monitoring wells have been installed in boreholes across the wider site (i.e. inclusive of adjacent land to the south). Details of the installations are given on the borehole logs presented in Appendix G to this the report.

11.1.3 The generation potential of the gas source was initially considered to be low. Initially and in general accordance with CIRIA Report C665, given the proposed residential end use, 6 visits have been scheduled over a three month period.

11.2 Scope of works

11.2.1 A standard procedure was followed, in accordance with CIRIA guidance:

- Ambient oxygen concentration
- Atmospheric temperature & pressure
- Methane, oxygen and carbon dioxide concentrations and flow rates using a Gas Data LMSx infra-red gas analyser
- Standing water level using a dipmeter
- Ambient oxygen concentration (check for instrument drift)

11.3 Gas Monitoring Results

11.3.1 The monitoring results are enclosed and summarised below:

Well	Response Zone	Range of Methane Concentrations (% v/v)	Range of Carbon Dioxide Concentrations (% v/v)	Range of Steady Flow Rates (litre/hour)
BH202	3.5 – 10.0m (Glaciofluvial Sheet Deposits)	Not Recorded	0.0 – 0.1	0
BH205	1.0 – 5.0m (Lacustrine Deposits)		0.2 – 2.1	0.0 – 0.9
BH218	3.0 – 8.0m (Glaciofluvial Sheet Deposits)		0.2 – 0.5	0
BH219	3.0 – 9.5m (Glaciofluvial Sheet Deposits)		1.1 – 2.1	0
BH220	4.0 – 10.0m (Glaciofluvial Sheet Deposits)		0.2 – 0.4	0

Note: Atmospheric pressures varied between 1018mb and 1027mb.

In accordance with the DETR approach, a default value of 0.1 litres/hour has been used in the absence of any recorded flows; i.e. the limit of detection of the flow rate equipment.

11.3.2 During 3 of the 6 monitoring visits, atmospheric pressure was falling.

11.3.3 If Gas Screening Values (GSVs) are derived using the worst-case gas concentrations in conjunction with the highest flow (an initial peak of 55.5 litres/second recorded in BH205 during the fourth visit), then the computed values for Methane and Carbon Dioxide are 0.00 and 1.7 litres/hour respectively. However, this peak flow is clearly associated with rise of groundwater in the plain casing. "Trapped" air is released as\when the well valve is opened resulting in a short-lived, but high flow.

11.3.4 By definition peak flows are short-lived (typically <60 seconds), so their contribution to hazardous gas concentrations within a large sub-floor void is negligible. Where "peak flows" are maintained for longer than 120 seconds, they should generally be regarded as steady flows. Consequently, we believe steady flows should be used to derive GSVs.

11.4 Current Guidance

11.4.1 Generic Notes (01 Site Characterisation) outlining how monitoring results are interpreted are in Appendix A of this report.

11.5 Current Gas Regime

11.5.1 The proposed development comprises Park Homes or Log Cabins. Consequently, the gas regime has been characterised in accordance with the Situation A (Wilson & Card) methodology outlined in CIRIA Report C665.

11.5.2 Based on worst-case gas concentrations and flows, Gas Screening Values (GSVs) for Methane and Carbon Dioxide are 0.00 and 0.02 litres/hour respectively. These GSVs equate to a Characteristic Situation 1 gas regime for this site.

11.5.3 Based on the site characterisation discussed above, no special gas protection measures are considered necessary.

12 GEOTECHNICAL TESTING

12.1 General

12.1.1 Sixteen samples of natural soil were delivered to a suitably accredited laboratory with a schedule of geotechnical testing drawn up by Lithos.

12.1.2 The geotechnical laboratory test results are presented in Appendix I to this report.

12.2 Atterberg Limits

12.2.1 Results are summarised below.

Soil type	Range of Plasticity Indices* (Average)	Shrinkability
Lacustrine Deposits	14 – 40 (25)	Medium
Glaciofluvial Sheet deposits	11 - 27 (16)	Low

* Modified where appropriate in accordance with revised Chapter 4.2 of the NHBC Standards (April 2003).
Note. The term Shrinkability is equivalent to the term Volume Change Potential used in Chapter 4.2.

12.2.2 For the purposes of foundation design, it is recommended that all cohesive soils be regarded as being of medium shrinkability.

12.3 Soluble Sulphate and pH

12.3.1 In accordance with BRE Special Digest 1:2005, this site has been classified as brownfield with a mobile groundwater regime.

12.3.2 It is envisaged foundations will generally extend to depths of about 1m locally up to 18m through made ground and natural strata and samples taken from this depth range have been submitted for pH and water-soluble sulphate (2:1 soil/water extract).

12.3.3 The concentrations of sulphate in the aqueous natural soil extracts of 36 samples were determined using the gravimetric method. In addition, twelve samples of made ground were tested using ion chromatography as part of the contamination suite. The pH value of each sample was determined by the electrometric method.

12.3.4 The highest water-soluble sulphate concentration and the lowest pH value for each soil type analysed are shown in the Table below.

Soil type	Lowest pH values	Highest Soluble Sulphate Concentration (g/l)
Made Ground	7.2	0.03
Lacustrine Deposits	6.2	0.09 (2.15)
Peat	7.1	0.15
Glaciofluvial Sheet Deposits	7.5	0.32
Edlington Formation	7.8	0.89

12.3.5 In accordance with Tables C1 and C2 of SD1, sub-surface concrete should generally be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1. Within the upper levels of the Edlington Formation Design Sulphate Class DS-2 should be assumed.

12.3.6 However, one sample of soft lacustrine clay that contained a significant proportion of wood fragments yielded a soluble sulphate concentration of 2.15g/l equivalent to Class DS-3.

12.4 One Dimensional Consolidation Tests

12.4.1 To assess the settlement characteristics of the natural cohesive strata, one-dimensional consolidation tests were carried out on five samples of natural cohesive strata. Three loading and two unloading pressures were specified in accordance with BS1377:Part 5:1990.

12.4.2 Laboratory certificates are included in Appendix I to this report. The results are provided as plots of voids ratio and coefficient of consolidation against applied pressure. The coefficient of volume compressibility (mv) has been derived for each test in accordance with BS1377 at a pressure range equal to overburden (p_0) plus 100kPa.

12.4.3 Tests are summarised in the Table below.

Hole ID	Depth (m)	Material	Approx m_v (m^2/MN)*	Compressibility Assessment
BH103	2.0	Cohesive Alluvium	0.25	Medium compressibility
BH104	3.0	Peat	0.25	Medium compressibility
BH104	5.0	Peat	0.7	High compressibility
BH105	2.0	Cohesive Alluvium	1.4	High compressibility
BH105	5.0	Cohesive Alluvium	1.6	Very High compressibility

* Design Mv value calculated for a stress increment of 100kN/m^2 in excess of the effective overburden pressure (BS1377, 1990)

13 GEOTECHNICAL ISSUES

13.1 Conceptual site model

13.1.1 Made ground thicknesses beneath the site vary between 0.2m and 2.5m; average 0.9m. The thickest made ground was encountered immediately south of the Auction Mart sheds. Anecdotal evidence suggests that soil was imported to site in order to level the ground prior to construction of the concrete slab for the sheep pens in the southern end of the Auction Mart area.

13.1.2 Shallow ground conditions comprise a laterally variable sequence of soft clay and peat (Lacustrine Deposits) within subsidence features, typically proven to less than 7m depth, but within the historical dissolution hollows they extended down to a maximum of 15.4m (BH309).

13.1.3 Stiff clay or medium dense granular soils (Glaciofluvial Deposits) underlie the Lacustrine Deposits and extend to rockhead at depths of between 10m and 16m.

13.1.4 Evidence of gypsum-related dissolution was encountered at depth within the boreholes, as open, and/or partially or wholly in-filled, cavities, and foundered strata (sections of the Edlington Formation where gypsum has been dissolved but the residual mudstone has remained in-situ, or where overlying rock has collapsed into an extensive void).

13.2 Gypsum Dissolution

13.2.1 Previous subsidence features proximal to the site have typically resulted in "sags" of between about 8m and 10m diameter (but up to 14m diameter) at surface, with the formation of conical shaped collapse features through the superficial deposits down to bedrock. The precipitating cavities at rockhead are likely to be only 2m to 5m in diameter.

13.2.2 Foundered strata have been identified in the south of the site; ground here is essentially solid and un-voided, with no evidence of active erosion.

13.2.3 A series of dissolution post-glacial hollows (initially defined as geophysical anomalies and confirmed by extensive intrusive site investigation) have been identified. In these areas soft clay and peat deposits overlie Edlington Formation which includes numerous relatively shallow open cavities (voids), and/or partially or wholly in-filled cavities, with intact rock above and below.

13.2.4 The DoE in their 1995 Technical Report[9] Section 6.51 states that "*a reasonable level of protection can be afforded by using measures which help to prevent major structural damage to a building in the event of significant ground movements. Although such measures would not be able to guarantee that no structural damage will occur, the generally low probability of collapse should mean that the risk involved is likely to be an acceptable one to most insurance companies*". The advice of an experienced structural engineer should be sought.

13.3 Site regrade

13.3.1 Proposed development levels have not been finalised, but it is likely that some earthworks regrade will be required in order to create suitable development plateaux and potentially to provide flood protection.

13.3.2 Given the presence of a significant thickness of soft compressible soils locally beneath the site (soft clay & peat), it will be necessary to consider the potential settlement that could be induced by the raising of ground levels once final development levels have been established.

13.3.3 At this stage, in order to mitigate against potential damage to new infrastructure caused by differential settlement, it is recommended that the following precautionary measures be adopted:

- Drainage should be placed at maximum possible gradients using flexible connections to prevent any backfalls should differential settlement occur
- Electricity and communications cabling should be laid with sufficient 'slack' to accommodate a degree of movement
- Flexible joints should be utilised, particularly where service connections extend across a rigid/flexible structure interface (e.g. from the concrete pad into a driveway or landscaped area)

[9] *Assessment of Subsidence Arising from Gypsum Dissolution: Technical Report for the Department of the Environment, Symonds Travers Morgan 1996.*

13.4 Foundation Recommendations

13.4.1 Proposed redevelopment will comprise Park Homes or Log Cabins - prefabricated units that will sit on concrete pads. The concrete pads are typically reinforced, 150mm thick, and are just slightly larger than the footprint of the proposed Park Home. A site layout has been prepared by MS Architects and is reproduced here as Drawing No. 2376/2 in Appendix B.

13.4.2 In accordance with Tables C1 and C2 of SD1, concrete for the pad foundations should be Design Sulphate Class DS-1, with the site allocated an ACEC Classification of AC-1.

13.4.3 Meaningful foundation recommendations require details of anticipated loadings, together with tolerable settlements. However, loadings are expected to be very light; each concrete pad will probably exert a bearing pressure of less than $3kN/m^2$. Furthermore, Park Homes or Log Cabins are not expected to be particularly sensitive to total, or even some differential, settlement.

13.4.4 Pad construction should be sufficient to evenly distribute the load across the pad; it is likely that the Park Homes will be raised off the ground & sit on a number of "feet".

13.4.5 Consequently, at this stage it is anticipated that reinforced concrete pads could simply be placed on a minimum 150mm thickness of DoT granular sub-base product. Granular sub-base should extend laterally for at least 0.5m beyond the pad. The base of the granular sub-base must be at least 600mm below original or finished level, whichever is the lower.

13.4.6 Where pads are within the influence of mature trees, the depth of granular sub-base placed should be equal to 50% of the trench fill foundation depth determined in accordance with NHBC Standards, Chapter 4.2.

13.4.7 Ordinarily, made ground and soft clay and peat (Lacustrine Deposits) within subsidence features would not be considered suitable foundation materials. However, given the very light loadings anticipated here, pads could be placed on such ground, although it would be prudent to inspect the base of excavations prior to placement of granular sub-base. Where necessary any soft spots and/or relic obstructions should be removed and replaced with suitable granular sub-base.

13.4.8 Furthermore, where pads are placed on made ground or soft clay and peat, it would be prudent to increase the thickness of granular sub-base to 500mm.

13.4.9 Ripon Farmers or their groundworker should seek further advice from Lithos if unexpected ground conditions are encountered in foundation or sewer excavations, including any conflict between soft ground associated with a backfilled trial pit excavation and the footprint of a proposed pad.

13.4.10 Due to the potential for future gypsum related subsidence events pad foundations should be designed by an appropriate structural engineer to "*prevent major structural damage to a building*", assuming a progressive sagging subsidence feature (see Section 4.2). Such design is considered good practice by Harrogate Borough Council (Building Control), and has been implemented on previous projects in the immediate area, where foundations are placed above the Edlington Formation.

13.4.11 However, in addition to very low loadings, a key advantage of Park Homes (cf standard housing) is that they can be moved relatively easily. Consequently, in the event of significant (gypsum-related) subsidence, the plot(s) affected could simply be re-located.

13.4.12 Nonetheless, this might have implications for ownership, as relocation would require the site to be run by a management company, rather than specific Park Homes being sold to individuals.

13.5 Landscaped areas

13.5.1 This area of Ripon is vulnerable to ongoing subsidence associated with dissolution of gypsum at depth in the underlying bedrock. However, when subsidence occurs, the presence of significant thicknesses of drift typically results in the gradual formation of broad, conical hollows formed by progressive deepening of an initial sag in the ground surface.

13.5.2 Given this failure mode, there is not considered to be any significant risk to residents of the site from sudden failure, with the creation of an open crown hole (or "shaft"). Such a failure mode can occur further east where the gypsum is overlain by competent bedrock and there is no significant thickness of overlying drift.

13.6 Designated Concrete Mixes

13.6.1 The following designated mixes in accordance with BRE Special Digest SD1 and BS 8500: Part1: 2006 will be suitable for use on this site.

Application	DS-1 conditions (natural ground) ACEC Class AC-1
Reinforced strip/ trench fill footings (mesh reinforcement)	RC25/30*1
Reinforced strip/ trench fill footings (rebar etc)	RC25/30*1
Rafts and ground beams	RC25/30*1
In situ reinforced concrete floor slabs	RC28/35

Note. *1Although RC25/30 is in line with BS8500, Lithos recommend the use of RC28/35 for concrete used in structurally sensitive works, to provide greater certainty of compliance with strength verification tests, enhanced durability and compliance with accepted NHBC practice.

13.7 Excavations

13.7.1 Based on the results of the investigation it is unlikely that major groundwater flows will be encountered in shallow excavations.

13.7.2 Excavations in natural ground should remain stable in the short term but if left open for any significant period of time, may require shoring most notably in granular soils and made ground.

13.8 Drainage

13.8.1 Although soakaways might be an effective means of surface water discharge at the site the DoE Technical Report advises that some of the subsidence phenomena observed in the built-up-area of Ripon may have been triggered, or at least aggravated, by the localised dissolution of gypsum beneath soakaways and therefore their use is discouraged.

13.8.2 Any damage to the existing land drainage system caused by foundation or sewer excavations should be made good; this may require diversion and re-connection.

13.8.3 It is recommended that the developer contact Yorkshire Water Services with respect to capacity in existing foul and surface water sewers in the vicinity of the development area.

13.9 Highways

13.9.1 Highways at this site require mitigation against the effects of potential gypsum dissolution particularly where they cross the historical dissolution features. A 2005[10] study recommends that this is achieved via the incorporation of suitably designed tensile reinforcement or layers of reinforcement within the highway construction.

13.9.2 The DOT report recognises that "geotextiles cannot be expected to prevent the eventual collapse of the ground surface, but they can reduce the impact of such a collapse delaying its onset and thereby providing early warning of the danger". As with building foundations geotextile reinforcement design should assume a progressive sagging subsidence feature (see Section 4.2).

13.9.3 Based on visual inspection of the natural materials and the recorded plasticity indices at the site, published tables (Interim Advice Note 73/06 Revision 1 (2009). Chapter 5. Characterisation of Materials Design Guidance For Road Pavement Foundations - Draft HD25) indicate that the natural deposits will have a CBR value of at least 3%. These values should be verified prior to or during construction.

13.9.4 Made ground is locally present across the site and it is strongly recommended that consultation regarding the specification of the highways should be made with the adopting authority. However, it is considered that the following options would be suitable to enable the construction of the highways.

13.9.5 Where made ground is present its full thickness (up to a maximum of 2m - from existing ground level or proposed highway formation, whichever is the lower) should be excavated and either:

- replaced with suitable aggregate in accordance with Series 600 (Earthworks) of The Highways Agency (HA) "Specification for Highway Works" 1998; or
- screened, to allow selection of suitable material, before being replaced in engineered layers (in accordance with Series 600). Unsuitable materials include any soft or wet materials, biodegradables including topsoil, wood, scrap metal, frozen material and oversize.

13.9.6 Some refinement of the above advice might be possible after highways design (with consideration of the proposed formation level cf existing ground level), and via inspection (and usually CBR testing) of the proposed formation during site preparatory groundworks..

13.9.7 Any residual made ground materials in the base of the excavation (ie in areas where the thickness of made ground exceeds 2m) should be inspected and (where necessary) any soft spots removed and replaced with suitable engineered fill.

13.9.8 Where the made ground is re-engineered it is considered that a CBR value of 5% should be achievable, however, this should be verified by field trials.

13.9.9 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.

13.10 External Works

13.10.1 Any digital terrain modelling undertaken, or commissioned by Ripon Farmers should be made available to their Engineering Designer prior to issue of an External Works Drawing.

[10] C. Jones, A H. Cooper 1995. Road construction over voids caused by active gypsum dissolution, with an example from Ripon, North Yorkshire, England. Environ Geol (2005) 48: 384–394.

14 REDEVELOPMENT ISSUES

14.1 General

14.1.1 This report has presented options with respect to foundation solutions, treatment of contamination etc that are considered technically feasible and in line with current good practice. Consequently, we would expect to obtain regulatory approval for whichever option is adopted, although this cannot be guaranteed. A copy of this report should be forwarded to Harrogate Borough Council for their comment/approval.

14.2 Remediation Strategy

14.2.1 Redevelopment of this site will almost certainly be subject to planning conditions relating to remediation and validation. Once a specific, preferred development strategy has been decided, Lithos could liaise with local Planning Authority and NHBC and prepare a detailed Remediation Strategy document for approval.

14.2.2 The Remediation Strategy document would include:

- General background information, including site location, site description and a summary of ground investigation data
- An overview of existing constraints on development and the aims of the proposed remediation works
- Specific details of the anticipated site remediation/preparatory works
- Details of site supervision, verification and summary of implications for redevelopment

14.2.3 The anticipated remediation works are summarised below:

- General site clearance of surface materials and vegetation
- Demolition of buildings
- Break-up of slabs and hardstand
- Post demolition investigation of the ground beneath the public house, which was inaccessible during the earlier investigations
- Crushing of all suitable artificial hard material (i.e. concrete/brick etc)
- Removal of UST's and associated fuel\oil contamination; with subsequent treatment and\or off-site disposal
- Removal of below ground obstructions
- Preparation of the ground for highway construction
- Re-grade of site to agreed levels
- Provision of 1,000mm of soil over the Ash & Clinker made ground
- Import of topsoil

14.2.4 It is strongly recommended that the demolition contractor should chase-out all significant buried structures, and survey-in the resultant excavations before making them safe by backfilling. At the very least, relevant features should be surveyed-in before "hiding" them beneath a veneer of rubble. Similarly, it would be prudent to complete a drainage survey prior to blading rubble across the site to leave it safe and secure.

14.3 Health & Safety Issues - Construction Workers

14.3.1 The bulk of the made ground will be retained on site. This made ground locally (north-west of the site) contains contaminants at concentrations above the guidance threshold values for an end use that includes domestic gardens. Workers involved in excavations for foundations, drainage, utilities etc are likely to come into direct contact with the made ground.

14.3.2 Although workers will only be exposed to the contaminated soil for a relatively short time, the contaminants represent a risk, and simple precautionary measures are required, i.e. good personal hygiene and basic personnel protective equipment.

14.3.3 Consequently, during the remediation and construction phases of the site development it will be necessary to protect the health and safety of site personnel. General guidance on these matters is given in the Health and Safety Executive (HSE) document "Protection of Workers and the General Public during the Redevelopment of Contaminated Land".

14.3.4 Access into excavations etc. must be controlled and only undertaken in accordance with the Confined Spaces Regulations 1997. The atmosphere in shored trenches in excess of 1.2m should be monitored for oxygen and hazardous gas (methane & carbon dioxide), prior to personnel entering such excavations. Monitoring should continue whilst personnel are working in deep excavations.

14.3.5 Before site operations are started, the necessary COSHH statements and Health & Safety Plan should be drafted in accordance with the CDM regulations.

14.4 Control of Excavation Arisings

14.4.1 Excavations into made ground are likely to yield contaminated arisings. The groundworker should carefully segregate (and stockpile separately) made ground arisings from arisings of "clean" natural soils, in order that an excessive volume of unsuitable material is not generated.

14.4.2 It should be ensured that the groundworker understands the need for good materials management. Most notably the importance of not mixing different materials within a given stockpile; i.e. there should be separate stockpiles of: topsoil; grubbed-up tarmac/concrete hardstand; Ash & Clinker; fuel-contaminated soil; excess clean, natural soil arisings; general construction waste etc.

14.4.3 Further characterisation of stockpiled materials is likely to be required if off-site disposal is proposed. See also comments in Section 10.6 regarding asbestos.

14.4.4 Made ground arisings could be:

- Placed in area deliberately left low on completion of the remediation works in order to accommodate construction arisings
- Redistributed beneath concrete oversite, or areas of hardstanding, where they would be satisfactorily isolated from end users;
- Isolated beneath the 1,000mm thick cover layer in landscaped areas
- Exported from site to a suitably licensed landfill facility

14.4.5 Natural ground arisings should be suitable for use as subsoil in the proposed soil cover..

14.5 New Utilities

14.5.1 It is recommended that trenches for services including site drainage and water supply are cut over size in order to isolate pipe materials from potential contaminants and to enable maintenance to be conducted in "clean" material.

14.5.2 The DoT study suggests that carrier systems should be constructed of materials that are capable of undergoing deformation with minimal distress such as uPVC in preference to clay or cast iron. The study also recognises that incorporation of a layer of high-strength geotextile in the foot of a service trench beneath the granular bedding would provide a measure of temporary support in the event of more serious subsidence.

14.5.3 It would be prudent to combine the incorporation of necessary highway tensile reinforcement to extend beneath the larger sewers within the highway. Again such reinforcement should be designed assuming a progressive sagging subsidence feature (see Section 4.2).

14.5.4 Where possible extra falls should be applied to drainage runs in order to accommodate any reversal that may occur from subsidence. Flexible service connections are advised at the interface of buildings and external areas. It is also recommended that electricity and communications cables be 'snaked' within their trenches in order to allow for some movement.

14.5.5 It is strongly recommended that all statutory service bodies are consulted at an early stage with respect to the ground conditions within which they will lay services in order to enable them to assess at an early stage any potential abnormal costs.

14.5.6 Water Companies have a statutory duty to supply wholesome water, which could be compromised by the selection of an inappropriate pipe material. For example, compounds such as petroleum hydrocarbons and solvents can permeate commonly used plastics pipes, and/or corrosive chemicals can reduce the service life of metallic pipes. Guidance has been developed for the selection of pipes in brownfield sites, and is contained in a UKWIR Report[11].

14.5.7 This site is brownfield, and therefore consideration of soil contaminant concentrations is required. Samples taken must be representative of the soil conditions in which the water pipes are proposed to be laid; normally water pipes are laid 0.7m to 1.3m below finished ground level.

14.5.8 At the time of writing, the proposed route(s), and total length, of pipeline were unknown. Consequently, to date laboratory testing of soil samples in line with UKWIR guidance has not been undertaken.

14.5.9 However, given the site's size, history, and ground conditions encountered, Yorkshire Water may require sampling within 15m of proposed water supply pipes, once infrastructure design has been completed. In the meantime, it is considered likely that Yorkshire Water will request the use of Protectaline mains, with plastic coated copper house connections, given that residual organic contaminants will still be present post-remediation, albeit at acceptable concentrations.

14.6 Potential Development Constraints

14.6.1 Two sewers present a potential development constraint unless they can be relocated. Additional enquiries are required to ascertain the feasibility of such diversionary works and the particular easement required by each service undertaker if they remain in-situ.

[11] *UKWIR Report 10/WM/03/21 – 'Guidance for the Selection of Water Supply Pipes to be used in Brownfield Sites'.*

15 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

15.1 General

15.1.1 It is understood that consideration is being given to redevelopment of the site with about 31 Park Homes or Log Cabins, with a private estate roadway. The Park Homes will be prefabricated units, and sit on concrete pads, with access to mains water, electricity and drainage.

15.1.2 Shallow ground conditions comprise a laterally variable sequence of soft clay and peat (Lacustrine Deposits) within subsidence features, typically proven to less than 7m depth, but within the historical dissolution hollows they extended down to a maximum of 15.4m (BH309).

15.1.3 Stiff clay or medium dense granular soils (Glaciofluvial Deposits) underlie the Lacustrine Deposits and extend to rockhead at depths of between 10m and 16m.

15.1.4 Evidence of gypsum-related dissolution was encountered at depth within the boreholes, as open, and/or partially or wholly in-filled, cavities, and foundered strata (sections of the Edlington Formation where gypsum has been dissolved but the residual mudstone has remained in-situ, or where overlying rock has collapsed into an extensive void).

15.1.5 There are ongoing risks presented by continued dissolution of gypsum beneath the site, as is the case across all the developed areas of Ripon within Planning Area C. Indeed there was a subsidence event in Magdalene Close, immediately east of the site in 2014; see Section 3.2.

15.2 Hazardous Gas

15.2.1 Peat deposits are present beneath the site, within historical gypsum dissolution hollows. Six monitoring visits were undertaken at the site.

15.2.2 Based on worst-case gas concentrations and flows, Gas Screening Values equate to a Characteristic Situation 1 gas regime for this site, and consequently no special gas protection measures are required.

15.3 Mining

15.3.1 This site is located beyond the CA's defined coalfields.

15.4 Contamination & Remediation

15.4.1 Evidence of fuel contamination has been found in TPs 201 to 203, located in the vicinity of the former filling station USTs, in the north-west corner of the site, adjacent to the Station Hotel. Such contamination can be mobile and as such may pose a risk to the environment and human health. Based on a qualitative review of the data obtained to date, it is considered that some grossly contaminated soil will require removal or treatment.

15.4.2 Made ground, with the exception of that adjacent to the former fuel filling station, is essentially free from elevated concentrations of contaminants. However, it does contain materials (e.g. brick), which would generally be considered undesirable as a near-surface material in landscaped areas. Consequently, where residual made ground remains beneath landscaped areas (i.e. not beneath hardstanding) a 300mm thick surface cover of "clean" soil is recommended.

15.4.3 Where Ash & Clinker in TP201 remains beneath landscaped areas (i.e. not beneath hardstanding) a 1,000mm thick surface cover of "clean" soil comprising 500mm subsoil and 100mm topsoil is recommended. This cover will break potential pollutant linkages between the contaminated made ground and future end-users.

15.5 Foundations

15.5.1 The prefabricated Park Home units will sit on reinforced concrete pads which are typically 150mm thick, and just slightly larger than the footprint of the proposed Park Home.

15.5.2 Ordinarily, made ground and soft clay and peat (Lacustrine Deposits) within subsidence features would not be considered suitable foundation materials, but loadings are expected to be very light, and the Park Homes are not expected to be particularly sensitive to total, or even some differential, settlement.

15.5.3 Consequently, at this stage it is anticipated that reinforced concrete pads will be placed on a minimum 500mm thickness of granular sub-base. Pad construction should be sufficient to evenly distribute the load across the pad; it is likely that the Park Homes will be raised off the ground & sit on a number of "feet".

15.5.4 Due to the potential for future gypsum related subsidence events pad foundations should be designed by an appropriate structural engineer to "*prevent major structural damage to a building*", assuming a progressive sagging subsidence feature.

15.5.5 However, in addition to very low loadings, a key advantage of Park Homes (cf standard housing) is that they can be moved relatively easily. Consequently, in the event of significant (gypsum-related) subsidence, the plot(s) affected could simply be re-located, although this might have implications for ownership.

15.6 Drainage & Highways

15.6.1 The DoE Technical Report advises that some of the subsidence phenomena observed in the built-up-area of Ripon may have been triggered, or at least aggravated, by the localised dissolution of gypsum beneath soakaways and therefore their use is discouraged.

15.6.2 A surface water drainage strategy has been proposed whereby storage will reduce the existing discharge from the site by 30% (allowing for climate change), subject to proving the connectivity of the existing drainage on the site. Thus the development will not increase the risk of flooding to others.

15.6.3 Highways at the site require mitigation against the effects of potential gypsum dissolution, particularly where they cross the historical dissolution features, via the incorporation of suitably designed tensile reinforcement, or layers of reinforcement within the highway construction.

15.6.4 Tensile reinforcement is also recommended for service corridors.

15.7 Further Works

15.7.1 Supplementary investigation will be required to fully delineate hydrocarbon contamination in the north-west of the site once buildings (public house) and services have been removed; this work could be undertaken during the site clearance and remediation works.

Appendix A

General notes

Generic notes – geoenvironmental Investigations

General

Third party information obtained from the British Geological Survey (BGS), the Coal Authority, the Local Authority etc is presented in the "Search Responses" Appendix of this Geoenvironmental Report.

Geology, mining & quarrying

In order to establish the geological setting of a site, Lithos refer to BGS maps for the area, and the relevant geological memoir. Further information is sourced from the Local Authority and by reference to current and historical OS plans. A coal mining report is obtained from the Coal Authority (CA).

In July 2011, the CA formalised their requirements in relation to planning applications and introduced some new terminology. The CA, using its extensive records has prepared plans for all coalfield Local Planning Authorities, which effectively refines the defined coalfield areas into areas of higher risk (known as the Coal Mining Development Referral Area) and lower risk (known as the Standing Advice Area). The Coal Mining Development Referral Areas contain a range of specific mining legacy risks to the surface, including mine entries; shallow coal workings; workable coal seam outcrops; mine gas; geological features; and previous surface mining sites. The Standing Advice Area is the remainder of the defined coalfield. In this area no known defined risks have been recorded; although there may still be unrecorded issues.

Landfills

Lithos obtain data from the Landmark Information Group, the Environment Agency and the Local Authority with respect to known areas of landfilling within 250m of the proposed development site. Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Radon

Radon is a colourless, odourless gas, which is radioactive. It is formed in strata that contain uranium and radium (most notably granite), and can move though fissures eventually discharging to atmosphere, or the spaces under and within buildings. Where radon occurs in high concentrations, it can pose a risk to health.

In order to assess potential risks associated with radon gas, Lithos refer to BRE Report BR211, 2007: "Radon: guidance on protective measures for new buildings", and to information from the BGS / HPA (Health Protection Agency) radon potential dataset provided by the Landmark Information Group. The level of protection needed is site-specific and is determined by reference to the maps contained in Annex A of BR211. These maps are derived from the Radon Atlas of England and Wales (2007), and indicate the highest radon potential within each 1km grid square.

Each 1km grid square is classified on the basis of the percentage of existing homes within that grid square estimated to have radon concentrations above the Action Level (average annual radon concentration of 200 Bq.m-3), as follows:

- Unshaded grid squares where less than 3% of homes are estimated to be above the Action Level, and no radon protection is required in new dwellings
- Light grey shaded grid squares where between 3% & 10% of homes are estimated to be above the Action Level, and basic radon protection is required in new dwellings
- Dark grey shaded grid squares where greater than 10% of homes are estimated to be above the Action Level, and full radon protection is required
- Sites where either basic or full radon protective measures are required (i.e. Where greater than 3% of homes are estimated to be above the Action Level) are referred to as Radon Affected Areas

BR211 provides a preliminary indication of the measures required for a particular site, as the Annex A maps indicate the highest geological radon potential within each 1km grid square, but in many cases the radon potential varies considerably within the grid square. The Landmark information is more site-specific and therefore may allow the adoption of a lower level of protection than that indicated in the Annex A maps. Alternatively, a BR211 Radon Report can be obtained from the BGS in order to provide more site-specific information.

It should be noted that in July 2010 the Health Protection Agency (HPA) published new advice (Document RCE-15: "Limitation of Human Exposure to Radon"), in which they recommend that all new buildings, extensions, conversions & refurbished buildings in the UK include (at least) basic radon protective measures. The HPA also widened the definition of Radon Affected Areas to include areas where greater than 1% of homes are estimated to be above the Action Level.

Hydrogeology

Lithos obtain information from the Environment Agency (EA) and the Landmark Information Group with respect to:

- groundwater quality
- recorded pollution incidents
- licensed groundwater abstractions

From April 2010 the EA's Groundwater Protection Policy uses aquifer designations that are consistent with the Water Framework Directive. These designations reflect the importance of aquifers in terms of groundwater as a resource (drinking water supply), but also their role in supporting surface water flows and wetland ecosystems. The aquifer designation data is based on geological mapping provided by the British Geological Survey. The maps are split into two different type of aquifer designation:

- Superficial (Drift) - permeable unconsolidated (loose) deposits. For example, sands and gravels
- Bedrock -solid permeable formations e.g. sandstone, chalk and limestone

The maps display the following aquifer designations:

Principal Aquifers: These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.

Secondary Aquifers: These include a wide range of rock layers or drift deposits with an equally wide range of water permeability and storage. Secondary aquifers are subdivided into two types:

- Secondary A - permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers
- Secondary B - predominantly lower permeability layers which may store and yield limited amounts of groundwater due to localised features such as fissures, thin permeable horizons and weathering. These are generally the water-bearing parts of the former non-aquifers
- Secondary Undifferentiated - has been assigned in cases where it has not been possible to attribute either category A or B to a rock type. In most cases, this means that the layer in question has previously been designated as both minor and non-aquifer in different locations due to the variable characteristics of the rock type

Unproductive Strata: These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.

Note: The maps are only display the principal and secondary aquifers as coloured areas. All uncoloured areas on the bedrock designation map will be unproductive strata. However, for uncoloured areas on the superficial (drift) designation map it is not possible to distinguish between areas of unproductive strata and areas where no drift is present. To do this, it is necessary to consult the published geological survey maps.

For the purposes of our Groundwater Protection Policy the following default position applies, unless there is site specific information to the contrary:

- If no superficial (drift) aquifers are shown, the bedrock designation is adopted
- In areas where the bedrock designation shows unproductive strata (the uncoloured areas) the superficial designation is adopted
- In all other areas, the more sensitive of the two designations is used (e.g. If secondary drift overlies principal bedrock, an overall designation of principal is assumed)

The EA have also designated Source Protection Zones, which are based on proximity to a groundwater source (springs, wells and abstraction boreholes). The size of a Source Protection Zone is a function of the aquifer, volume of groundwater abstracted and the effective rainfall, and may vary from tens to several thousand hectares.

Hydrology

Lithos obtain information from the Environment Agency and the Landmark Information Group with respect to:

- surface water quality
- recorded pollution incidents
- licensed abstractions (groundwater & surface waters)
- licensed discharge consents
- site susceptibility to flooding

Generic notes – geoenvironmental Investigations

The EA have set water quality targets for all rivers. These targets are known as River Quality Objectives (RQOs). The water quality classification scheme used to set RQO planning targets is known as the River Ecosystem scheme. The scheme comprises five classes (RE1 to RE5) which reflect the chemical quality requirements of communities of plants and animals occurring in our rivers.

General Quality Assessment (GQA) grades reflect actual water quality. They are based on the most recent analytical testing undertaken by the EA. There are six GQA grades (denoted A to F) defined by the concentrations of biochemical oxygen demand, total ammonia and dissolved oxygen.

The susceptibility of a site to flooding is assessed by reference to a Flood Map on the Environment Agency's website. These maps provide show natural floodplains - areas potentially at risk of flooding if a river rises above its banks, or high tides and stormy seas cause flooding in coastal areas.

There are two different kinds of area shown on the Flood Map:

1. Dark blue areas could be flooded by the sea by a flood that has a 0.5% (1 in 200) or greater chance of happening each year, or by a river by a flood that has a 1% (1 in 100) or greater chance of happening each year
2. Light blue areas show the additional extent of an extreme flood from rivers or the sea. These outlying areas are likely to be affected by a major flood, with up to a 0.1% (1 in 1000) chance of occurring each year

These two colours show the extent of the natural floodplain if there were no flood defences or certain other manmade structures and channel improvements

The maps also show all flood defences built in the last five years to protect against river floods with a 1% (1 in 100) chance of happening each year, or floods from the sea with a 0.5% (1 in 200) chance of happening each year, together with some, but not all, older defences and defences which protect against smaller floods.

The Agency's assessment of the likelihood of flooding from rivers and the sea at any location is based on the presence and effect of all flood defences, predicted flood levels, and ground levels.

It should also be noted that as the floodplain shown is the 1 in 100 year (or 1 in 200 year as appropriate), areas outside this may be flooded by more extreme floods (e.g. the 1 in 1000 year flood). Also, parts of the areas shown at risk of flooding will be flooded by lesser floods (e.g. the 1 in 5 year flood). In some places due to the shape of the river valley, the smaller floods will flood a very similar extent to larger floods but to a lesser depth.

If a site falls within a floodplain, it is recommended that a flood survey be undertaken by a specialist consultant who can advise on appropriate mitigating measures; ie raising slab levels, provision of storage etc.

COMAH & explosive sites

Lithos obtain information from the Landmark Information Group with respect to COMAH or explosive sites within 1km of the proposed development site. Lithos's report refers to any that are present, and recommends that the Client seeks further advice from the HSE.

Areas around COMAH sites (chemical plants etc) are zoned with respect to the implementation of emergency plans. The HSE are a statutory consultee to the local planning authority for all COMAH sites. The COMAH site may have to revise it's emergency action plan if development occurs. This might be quite straightforward or could entail significant expenditure. Consequently, the COMAH site may object to a proposed development (although it is the Local Authority who have final say, and they are likely to place more weight on advice from the HSE).

Preliminary conceptual ground model

The site's environmental setting (and proposed end use) is used by Lithos to assess the significance of any contamination encountered during the subsequent ground investigation

Assessment of contaminated land is based on an evaluation of pollutant linkages (source-pathway-receptor). Contaminants within the near surface strata represent a potential source of pollution. The environment (most notably groundwater), site workers and end users are potential targets.

Potential pollutant linkages are shown on a preliminary conceptual site model, presented as a Drawing in an Appendix to this Geoenvironmental Report. The preliminary model is revised in light of data arising from the subsequent ground investigation.

Generic notes – geoenvironmental investigations

General

Lithos Ground Investigations are undertaken in accordance with current UK guidance including:

- BS5930:1999 "Code of practice for site investigation"
- BS10175:2011 "Code of practice for the identification of potentially contaminated sites"
- "Technical Aspects of Site Investigation" – EA R&D Technical Report P5-065/TR (2000)
- "Development of appropriate soil sampling strategies for land contamination" – EA R&D Technical Report P5-066/TR (2001)
- Contaminated Land Reports 1 to 6, most notably CLR Report No. 4 "Sampling strategies for contaminated land"
- "Guidance on the protection of housing on contaminated land" – NHBC & EA R&D Publication 66 (2000)
- AGS: 1996 "Guide to the selection of Geotechnical Soil Laboratory Testing"

Exploratory hole logs are presented in Appendices to this Geoenvironmental Report. These logs include details of the:

- Investigation technique adopted
- Samples taken
- Descriptions of the solid strata, and any groundwater encountered.
- Results of any in-situ testing
- Any gas\groundwater monitoring well installed

Exploratory hole locations

Exploratory hole locations are selected by Lithos, prior to commencement of fieldwork, to provide a representative view of the strata beneath the site and to target potential contaminant sources identified during the preliminary investigation (desk study). Additional exploratory locations are often determined by the site engineer in light of the ground conditions actually encountered; this enables better delineation of the depth and lateral extent of organic contamination, poor ground, relict structures etc.

Investigation techniques

Ground conditions can be investigated by a number of techniques; the procedures used are in general accordance with BS5930: 1999 and BS1377: 1990. Techniques most commonly used by Lithos include:

- Machine excavated trial pits, usually equipped with a backactor and a 0.6m wide bucket.
- Cable percussive (Shell & Auger) boreholes, typically using 150mm diameter tools and casing.
- Window or Windowless Sampling boreholes. Constraints associated with existing buildings, operations and underground service runs can render some sites partly or wholly inaccessible to a mechanical excavator. In such circumstances, window sampling is often the most appropriate technique. A window sampling drilling rig can be manoeuvred in areas of restricted access and results in minimal disturbance of the ground (a 150mm diameter tarmac/concrete core can be lifted and put to one side). However, it should be noted that window sampling allows only a limited inspection of the ground (especially made ground with a significant proportion of coarse material).
- Rotary percussive open-hole probeholes are typically drilled using a tricone rock roller bit with air as the flushing medium. Probeholes are generally lined through made ground with temporary steel casing to prevent hole collapse.

Where installed, gas\groundwater monitoring wells typically comprise a lower slotted section, surrounded by a filter pack of 10 mm non-calcareous gravel and an upper plain section surrounded in part by a bentonite seal and in part by gravel or arisings. The top of the plain pipe is cut off below ground level and the monitoring well protected by a square, stopcock type manhole cover set in concrete, or the plain pipe is cut off just above ground level and the well protected by 100mm diameter steel borehole helmet set in concrete. Monitoring well details, including the location of the response zone and bentonite seal are presented on the relevant exploratory hole logs.

In-situ testing

Where relative densities of granular materials given on the trial pit and window sample logs are based on visual inspection only, they do not relate to any specific bearing capacities.

The relative densities of granular materials encountered in cable percussive boreholes are based on Standard Penetration Test (SPT) results. SPTs are carried out boreholes, in accordance with BS 1377 1990, Part 9 Section 3.3. Where full penetration (600mm) is not possible, N values are calculated by linear extrapolation and are shown on the logs as N* = x. The strength of cohesive deposits is determined using a hand shear vane.

Shear strength test results reported on trial pit logs are considered to be more reliable than those reported on window sample logs. Significant sample disturbance occurs during window sampling and consequently shear strength results on disturbed window samples are generally lower than results obtained during trial pitting, in-situ or in large excavated blocks.

Sampling

Typically Lithos collect at least three soil samples from each exploratory hole, although in practice a greater number are often taken. The collection of a sufficient number of samples provides a sound basis upon which to schedule laboratory analysis, ensuring:

- A sufficient number of samples from each (common) site material are tested
- Horizontal and vertical coverage of the site is adequate, thereby providing a robust data set for use in the conceptual ground model
- Any localised, significant, but non-pervasive conditions are considered

Made ground and natural soils encountered in the field during a ground investigation often contain a significant proportion of coarse grained material (e.g. brick etc). Soil samples obtained during most investigations are often only truly representative of the in-situ soil mass where there is an absence of particles coarser than medium gravel; i.e the entire soil mass would pass a 20mm sieve.

Representative bulk samples of the **soil mass** are retrieved from coarse soils for specific geotechnical tests (most notably grading and compaction); this typically requires the collection of at least 10kg of soil, and occasionally >50kg. However, in the context of assessing land contamination, it is generally accepted that samples should be representative of the **soil matrix** of the stratum from which they are taken. Consequently, truly representative samples of coarse soils for subsequent contaminant analysis are not obtained - only the finer fraction is placed in sample containers. Coarse constituents not sampled would typically comprise any 'particles' with an average diameter greater than about 20mm (i.e. coarse gravel, cobble and boulder).

At present, neither ISO/IEC 17025 nor MCERTS specify sample pre-treatment with respect to stone removal. Unsurprisingly therefore UKAS accredited testing laboratories do not adopt the same approach to stones[1] – some crush and test the "as received" soil, whilst others sieve out stones and analyse only the residual soil (the sieve size used varies depending on the laboratory).

In essence, samples taken from coarser soils for contaminant analysis are "screened" by the geoenvironmental engineer in the field, and often sieved again by the laboratory during sample preparation. Geoenvironmental engineers do not typically re-calculate soil mass contaminant concentrations by taking account of the unsampled coarse fraction. Likewise, laboratories that remove stones typically report contaminant concentrations based on the dry weight of soil passing the sieve. In the context of land contamination and human health risk assessment, this is considered reasonable, because it is the soil matrix which is of greatest concern. Stones are unlikely to:

- Provide a significant source for plant uptake (consumption of vegetables)
- Remain on vegetables after washing (consumption of vegetables)
- Be eaten (accidentally by an adult, or deliberately by a child)
- Be whipped-up by the wind for dust generation (inhalation)
- Stick to the skin for any length of time (dermal contact)
- Yield toxic vapour (inhalation)

Consequently, Lithos instruct labs to remove all stones >10mm, and to report the results as dry-weight based on the mass of matrix tested. However, the laboratory are given site-specific instruction where coarse stones are coated in say oil, or impregnated with mobile contaminants such as diesel. Where the stones are predominantly natural, or inert (e.g. brick, concrete etc), removal will clearly result in higher reported concentrations, than if the stones were crushed and added to the matrix.

Where the stones include a significant proportion of contaminant-rich material (e.g. slag, fragments of galvanised metal etc) an argument could be made for crushing and analysing. However, provided the stones are stable (i.e. unlikely to disintegrate or degrade) they should not pose a significant risk to human health for the reasons stated above.

Sometimes it is necessary to obtain samples that are not representative of the wider soil matrix, for example when investigating localised, significant, but non-pervasive conditions. Any such unrepresentative samples are annotated with the suffix '*' (eg 2D*, or 4G*). Lithos' site engineer describes both the unrepresentative sample, and the soil mass from which it was been taken.

[1] *Mark Perrin. Stoned – Sample Preparation for Soils Analysis. Ground Engineering, April 2007.*

Generic notes – geoenvironmental investigations

Sample Containers (for contaminant analysis). Samples of soil for contaminant testing are placed into appropriate containers (see below). Soil samples for organic analysis are stored in cool boxes, at a temperature of approximately 4°C, until delivery to the selected laboratory.

Anticipated testing	Container(s)
pH & metals only	1 kg plastic tub
organics (TPH, PAH) etc only	500ml wide-necked glass jar. Vial required if TPH is to include GRO.
VOCs (incl. naphthalene and\or GRO) only	Glass vial & 1kg plastic tub
pH & metals, and organics	1 litre wide-necked glass jar & 1kg plastic tub
pH & metals, and organics (incl. VOCs or GRO)	Glass vial; 1 litre wide-necked glass jar; & 1kg plastic tub

Sample Containers (for geotechnical analysis). The majority of samples are only scheduled for PI and sulphate testing, for which 500g of sample is required (a full 0.5-litre plastic tub). However, bulk bags are taken where scheduling of compaction or grading tests is proposed.

Groundwater

Where encountered during fieldwork, groundwater is recorded on exploratory hole logs. If monitoring wells are installed, groundwater levels are also recorded on one or more occasions after completion of the fieldwork. Long-term monitoring of standpipes or piezometers is always recommended if water levels are likely to have a significant effect on earthworks or foundation design.

It should be borne in mind that the rapid excavation rates used during a ground investigation may not allow the establishment of equilibrium water levels. Water levels are likely to fluctuate with season/rainfall and could be substantially higher at wetter times of the year than those found during this investigation.

Description of strata

Soils encountered during an Lithos investigation are described (logged) in general accordance with BS 5930. The descriptions and depth of strata encountered are presented on the exploratory hole logs and summarised in the Ground Conditions section within the main body of text. The materials encountered in the trial pits are logged, samples taken, and tests performed on the in-situ materials in the excavation faces, to depths of up to 1.2m; below this depth these operations are conducted at the surface on disturbed samples recovered from the excavation.

Key to exploratory hole logs

Keys to logs are presented in the Appendix(ces) containing the logs. There are two Keys – Symbols & Legends and Terms & Definitions.

Generic notes – geoenvironmental investigations

General

Soil samples are delivered to the laboratory for testing along with a schedule of testing drawn up by Lithos. All tests are carried out in accordance with BS 1377:1990. The following laboratory testing is routinely carried out on a selection of samples:

- Atterberg limits & moisture contents
- Soluble sulphate & pH

The additional tests are typically only scheduled where significant earthworks regrade is anticipated:

- Grading
- Compaction tests
- Particle density

The test results are presented as received in an Appendix to this Geoenvironmental Report.

Atterberg limits & moisture content

The Liquid and Plastic Limits of samples of natural in-situ clay are determined using the cone penetrometer method and the rolling thread test. These tests enable determination of an average Plasticity Index (PI) for each "type" of clay, although judgement is applied where variable results are reported.

PI can be related to shrinkability (low, medium or high) and then to minimum founding depth. Lithos typically only consider a soil to be shrinkable if the proportion finer than 63µm is >35%. PI results are compared against guidance given in the NHBC Standards, Chapter 4.2 (revised April 2003), which advocates the use of modified Plasticity Index (I'p), defined as:

I'p = Ip * (%< 425µm/100)

ie if PI is 30%, but the soil contains 80% < 425µm, then: I'p = 30 * 80/100 = 24%.

It should be noted that in accordance with the requirements of BS 1377, the % passing the 425µm sieve is routinely reported by testing labs. Lithos apply engineering judgment where PI results are spread over a range of classifications. Consideration is given to:

- The average values for each particular soil type (ie differentiate between residual soil and alluvium),
- The number of results in each class and
- The actual values

Unless the judgment strongly indicates otherwise, Lithos typically adopt a conservative approach and recommend assumption of the higher classification.

Soluble sulphate and pH

Sulphates in soil and groundwater are the chemical agents most likely to attack sub-surface concrete, resulting in expansion and softening of the concrete to a mush. Another common cause of concrete deterioration is groundwater acidity.

The rate of chemical attack depends on the concentration of aggressive ions and their replenishment at the reaction surface. The rate of replenishment is related to the presence and mobility of groundwater.

Lithos refer to BRE Special Digest 1 (SD1) "Concrete in aggressive ground. Part 1: Assessing the aggressive chemical environment" (2005). SD 1 provides definitions of:

- The nature of the site (greenfield, brownfield or pyritic)
- The groundwater regime (static, mobile or highly mobile)
- The design sulphate class (DC class) and
- The aggressive chemical environment for concrete (ACEC class)

Lithos reports clearly state each of the above for the site being considered.

The concentrations of sulphate in aqueous soil/fill extracts are determined in the laboratory using the gravimetric method. The results are expressed in terms of SO_4 for direct comparison with BS 5328:1997. The pH value of each sample was determined by the electrometric method.

SD1 also discusses determination of "representative" sulphate concentration from a number of tests. Essentially if <10 samples of a given soil-type have been tested, the highest measured sulphate concentration should be taken. If >10 samples have been tested, the mean of the highest 20% of the sulphate test results can be taken. With respect to groundwater, the highest sulphate concentration should always be taken.

With respect to pH (soil & groundwater) the value used is the lowest value if <10 samples have been tested and the mean of the lowest 20% if >10 samples have been tested.

Determination of analytical suite

An assessment of potential contaminants associated with the former usages of the site is undertaken with reference to CLR 8 "Potential contaminants for the assessment of land" and the relevant DETR Industry Profile(s).

Common Contaminants

Common **Inorganic** Contaminants include:

- metals, most notably cadmium, copper, chromium, mercury, lead, nickel, and zinc.
- semi-metals, most notably arsenic, selenium, and (water soluble) boron
- non-metals, most notably sulphur
- inorganic anions, most notably cyanides (free & complex), sulphates, sulphides, and nitrates.

With respect to the terminology used by most analytical laboratories:

Total cyanide = Free cyanide + Complex cyanide

Total cyanide (CN) is determined by acid extraction; whereas free cyanide is the water soluble fraction.

Complex cyanide is "bound" in compounds and is hard to breakdown. Laboratory determination of complex CN involves subjecting the sample to uv digestion for determination of both free and total CN.

Thiocyanate (SCN) is a different species combined with sulphur.

Elemental sulphur (S) and free sulphur are the same. Total sulphur is all forms, including that present in sulphates (SO4), sulphides etc

There are 2 forms of chromium (Cr), chromium VI and chromium III. Chromium VI is the more toxic of these. In soils, total chromium is determined by a strong aqua regia acid digestion. Chromium VI is an empirical method based on a water extract test.

Common **Organic** Contaminants include hydrocarbons, phenols, and polychlorinated biphenyls.

Petroleum hydrocarbons are a mixture of hydrocarbons produced from the distillation of crude oil. They include aliphatics (alkanes, alkenes and cycloalkanes), aromatics (single or multi benzene ringed compounds) and hydrocarbon-like compounds containing minor amounts of oxygen, sulphur or nitrogen.

Petroleum hydrocarbons can be grouped based on the carbon number range:-

- GRO – Gasoline Range Organics (typically C6 to C10). Also referred to as PRO – Petroleum Range Organics
- DRO – Diesel Range Organics (typically C10 to C28)
- LRO - Lubricating Oil Range Organics (typically C28 to C40)
- MRO – Mineral Oil Range Organics (typically C18 to C44)

However, it should be borne in mind that the terms "GRO" and "DRO" analysis are purely descriptive terms, the exact definition of which varies.

Total Petroleum Hydrocarbons (TPH) is also a poorly defined term; some testing laboratories regard TPH as hydrocarbons ranging from C5-C40, whereas other define TPH as C10-C30.

The composition of a TPH plume migrating through the ground can vary significantly; this is primarily dictated by the nature of the source (eg petrol, diesel, engine oil etc). Furthermore, different hydrocarbons are affected differently by weathering processes, and this can result in further variation in the chemical composition of the TPH.

Gasoline contains light aliphatic hydrocarbons (especially within the C4 to C5 range) that will rapidly evaporate. The aromatic hydrocarbons in gasoline are primarily benzene, toluene, ethylbenzene and xylenes, referred to as BTEX. Small amounts of polyaromatic hydrocarbons (PAHs) such as benzo(a)pyrene may also be present.

Diesel and light fuel oils have higher molecular weights than gasoline. Consequently, they are less volatile and less water soluble. About 25 to 35% is composed of aromatic hydrocarbons. BTEX concentrations are generally low.

Heavy Fuel Oils are typically dark in colour and considerably more viscous than water. They contain 15 to 40% aromatic hydrocarbons. Polar nitrogen, sulphur and oxygen-containing compounds (NSO) compounds are also present.

Lubricating Oils are relatively viscous and insoluble in groundwater. They may contain 10 to 30% aromatics, including the heavier PAHs. NSO compounds are also common.

Polycyclic Aromatic Hydrocarbons (PAHs) have more than two fused benzene rings as a structural characteristic. PAH compounds are present in both petrol and diesel, although in significantly lower concentrations than in coal tars. Certain PAH compounds are carcinogenic (Benzo(a)pyrene) and\or mobile in the environment (naphthalene).

Generic notes – geoenvironmental investigations

Semi-Volatile Organic Compounds (sVOCs) include a variety of compounds, which as the names suggest have relatively low boiling points; however, VOC's are much more volatile than SVOC's. Examples of VOC's include benzene, chloroform and toluene; SVOC's include phenol, florene. Both groups of chemicals are readily absorbed through skin and some, such as benzene, are believed to be linked to tumour growth.

Phenols are compounds that have a hydroxyl group attached to an aromatic ring (ie include a benzene ring and an –OH group). Most are colourless solids. A solution of phenol in water is known as carbolic acid, and is a powerful antiseptic. However, phenol vapour is toxic, and skin contact can result in burns.

Polychlorinated Biphenyls (PCBs) were used in pre-1974 transformers as dielectric fluids. PCB's are of increasing toxicity relative to the degree of chlorination. Acute symptoms of PCB poisoning are irritation of the respiratory tract leading to coughing and shortness of breath. Nausea, vomiting and abdominal pain are caused by ingestion of PCB's.

Dioxins and furans (polychlorinated dibenzodioxins and polychlorinated dibenzofurans) are some of the most toxic chemicals known; in the environment, they tend to bio-accumulate in the food chain. Dioxin is a general term that describes a group of hundreds of chemicals that are highly persistent in the environment. The most toxic compound is 2,3,7,8-tetrachlorodibenzo-p-dioxin or TCDD.

Dioxin is formed by burning chlorine-based chemical compounds with hydrocarbons. The major source of dioxin in the environment comes from waste-burning incinerators and also from backyard burn-barrels. Dioxin pollution is also affiliated with paper mills which use chlorine bleaching in their process and with the production of Polyvinyl Chloride (PVC) plastics and with the production of certain chlorinated chemicals (like many pesticides).

Methods of Analysis (Organic Compounds)

TPH by GC-FID is a more refined analytical technique which only detects hydrocarbons (aliphatic and aromatic) in the range C10 to C40 (volatiles, heavy tars, humic material and sulphur are not detected). The laboratory can provide a breakdown of the TPH results into diesel range organics (DRO) and heavier lubricating oil range organics (LRO).

GRO (PRO) by GC-FID analysis detects the more volatile C6-C9 hydrocarbons (aliphatic and aromatic), including those organic compounds present in petrol.

Speciated VOC (by GC-MS) analysis quantifies the concentrations of 30 USA-EPA priority compounds. These include chlorinated alkanes and alkenes (in the molecular weight range chloroethane to tetrachloroethane); trimethylbenzenes; dichlorobenzenes; and the 4 BTEX compounds (benzene, ethyl-benzene, toluene & xylene).

Speciated sVOC by (GC-MS) analysis quantifies the concentrations of a variety of organic compounds, including the 16 USA-EPA priority PAHs, phenols, 7 USA EPA priority PCB congeners, herbicides & pesticides.

Note: PAHs are hydrocarbons and consequently (where present) will be picked-up when scheduling TPH. by GC-FID. Naphthalene (the lightest PAH) is also one of the 58 US EPA VOCs.

Speciated TPH by GC-FID provides a "banded" TPH, initially split into aromatic and aliphatic fractions and then further divided into fraction specific carbon bandings based upon behavioural characteristics.

Note: Risk assessment models require physiochemical properties (solubilities, toxicities etc) of compounds in order to model their behaviour in the environment. These physiochemical properties cannot be derived from a single "TPH", "GRO" or "DRO" value. However, the carbon banded fractions can be used in risk assessment models.

Current UK guidance

The UK approach to contaminated land is set out in Contaminated Land Report No. 11 (2004) "Model Procedures for the Management of Land Contamination". The approach is based upon risk assessment, where risk is defined as the combination of the probability of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

In the context of land contamination, there are three essential elements to any risk: (1) a contaminant source, (2) a receptor (eg controlled water or people) and (3) a pathway linking the (1) and (2). Risk can only exist where all three elements combine to create a pollutant linkage. Risk assessment requires the formulation of a conceptual model which supports the identification and assessment of pollutant linkages.

Lithos adopt a tiered approach to risk assessment, consistent with UK guidance and best practice. The initial step of such a risk assessment (or Tier 1) is the comparison of site data with appropriate UK guidance levels, Lithos risk-derived screening values, or remedial targets. It should be noted that exceedance of Tier 1 does not necessarily mean that remedial action will be required.

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 (Version 1.05) Handbook Science report: SC050021/SR4
- Compilation of data for priority organic pollutants for derivation of Soil Guideline Values - Science Report: SC050021/SR7

The approach set out in these documents represents current scientific knowledge and thinking; and includes the Contaminated Land Exposure Model (CLEAv1.06). The Environment Agency are in the process of using this updated approach to regenerate a selection of Soil Guideline Values (SGVs).

CLEA SGVs were derived for standard land use scenarios predominantly in the context of Part IIA, using a conceptual site model (CSM) defined in SR3. Lithos have incorporated amendments to the CSM used to derive SGVs, that more accurately reflect redevelopment within the planning regime; consequently, Lithos have not adopted any published SGV as a screening value.

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). Lithos consider it reasonable to adopt the CLEA default TOC for made ground. However, where the average TOC value for a particular soil type is significantly lower than the 3.5%, evaluation of Lithos Screening Values should be undertaken and a site specific risk assessment will usually 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 four 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

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 and 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.

Generic notes – geoenvironmental investigations

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. This adjustment has been included to account for sites where made ground is re-engineered to enable new buildings to be established on raft foundations. In such situations contamination may lie directly beneath the foundation.

The Soil Screening Values referred to in this document are **not** intended to be used when considering potential risks associated with:

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

In December 2013 Defra published the results of research project SP1010 – Development of Category 4 Screening Levels for Assessment of Land Affected by Contamination. The objective of this project was provide technical guidance in support of Defra's revised Statutory Guidance for Part 2A 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 new Category 4 Screening Levels is based on the Environment Agency's Contaminated Land Exposure Assessment (CLEA) methodology. Development of Category 4 Screening Levels 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 Category 4 Screening Levels could be used under the planning regime. However, policy responsibility for the National Planning Policy Framework falls to the Department for Communities and Local Government. 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 YAHPAC (collection of Yorkshire & Humberside local authorities) and received confirmation that they are satisfied with this approach.

With respect to **inorganic** determinands, Lithos derived Tier 1 values for the four Scenarios A to D are presented below:

Inorganic contaminant	Source	Tier 1 assessment criteria (mg/kg) for Scenarios A to D						Comments/notes
		SGV*	C4SL*	A	B	C	D	
As	CLEA	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	C4SL adopted
Cd	CLEA	10	26	26		149	410	C4SL adopted
Cr	CLEA			3,000		3,000	30,000	Assumes Cr is CrIII.
Pb	CLEA	450	200	200		310	2,330	C4SL adopted
Ni	CLEA	130		127		127	1,700	Assessment of health risk only
Se	CLEA	350		350		595	13,000	
Hg	CLEA	170		169		238	3,640	Assumes in an inorganic compound
B	Lithos			5		5	5	Based on phytotoxic risks as plants are the more sensitive receptor (Cu is pH dependant)
Cu	DoE			80-200		80-200	80-200	
Zn	DoE			200		200	200	
Cyanide	CLEA			527		530	14,000	

* For a residential end use

With respect to **organic** determinands, Lithos derived Tier 1 values for the four Scenarios A to D are presented below:

Organic contaminant (all sourced via CLEA)	Tier 1 assessment criteria (mg/kg) for Scenarios A to D						Comments/notes
	SGV*	C4SL*	A	B	C	D	
Benzene	0.33	0.87	0.87	0.87	3.3	98	C4SL adopted
Toluene	610		497	1,440	1,690	4,360	
Ethyl Benzene	350		240	416	498	2,840	
Xylenes	240		127	146	183	2,620	
Phenol	420		412	2,360	557	38,700	
PCBs			1.7	1.8	1.8	1.8	Based on toxicity of EC7.
Benzo(a)pyrene		5	5	25	5.3	76	C4SL adopted. Where source is not a coal tar.
Naphthalene			4	4	5	430	
Gasoline Range Organics			15	16	21	1,000	See 3-step assessment of TPH below.
Diesel Range Organics			151	153	232	5,000	
Lubricating Range Org			1,000	5,000	1,000	5,000	

* *For a residential end use*

Note: **PAH** cannot be assessed as a single "total" value, as each individual PAH compound has different toxicity and mobility in the environment. Speciated analysis is required to determine the concentrations of the various compounds, most notably the key PAHs: benzo(a)pyrene (considered the most toxic of the PAHs); and Naphthalene (the most mobile and volatile of the PAHs).

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 thirteen representative constituent fractions or "EC Bandings". The TPHCWG have derived a series of physiochemical and toxicological parameters for each of the thirteen bandings.

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

Step 1 - Assessing indicator compounds

TPH fraction Indicator compound	End use specific screening value (mg/kg)			
	A: Residential no cover	B: Residential with 600mm cover	C: Residential no gardens	D: Commercial\ industrial
Benzene	0.87	0.87	3.3	98
Toluene	497	1,440	1,690	4,360
Ethyl Benzene	240	416	498	2,840
Xylenes	127	146	183	2,620
Naphthalene	4	4	5	430

Step 2 - Assessing individual TPH fractions

TPH fraction		End use specific screening value (mg/kg)			
		A: Residential no cover	B: Residential with 600mm cover	C: Residential with no gardens	D: Commercial/ industrial
Aliphatic 5-6	GRO	41	41	63	5,000^
Aliphatic 6-8	GRO	123	123	191	
Aliphatic 8-10	GRO	30	31	48	
Aliphatic 10-12	DRO	151	153	232	
Aliphatic 12-16	DRO	500^	500^	500^	
Aliphatic 16-21	DRO	1,000^	5,000#	1,000^	
Aliphatic 21-35	LRO	1,000^	5,000#	1,000^	
Aromatic 5-7	GRO	52	56	72	
Aromatic 7-8	GRO	15	16	21	1,000^
Aromatic 8-10	GRO	47	50	77	5,000^
Aromatic 10-12	DRO	212	282	390	
Aromatic 12-16	DRO	683	1,000*	1,000*	
Aromatic 16-21	DRO	1,000^	5,000#	1,000^	
Aromatic 21-35	LRO	1,000^	5,000#	1,000^	

* Calculated Screening Value exceeded soil saturation limit and could indicate free product, therefore calculated soil saturation limit adopted as a target

^ Calculated Screening Value close to soil saturation limit, screening value selected by Lithos considering visual and olfactory impacts.

Five times the screening value for Scenario A.

Step 3 - Assessing Cumulative Effects

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

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

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 (2006) – Assessing risks posed by hazardous ground gases to buildings
- BS 8485:2007 – 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 Soil Code" (MAFF, 1998) for copper and zinc. The CLEA SGV 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".

Generic notes – geoenvironmental investigations

Tier 1 **groundwater** risk assessments are undertaken by comparing leachate or groundwater concentrations with the appropriate water quality standard. Tier 1 Screening Values have been discussed with the Environment Agency, and typically those in **bold** below are adopted.

Analyte	Source of Tier 1 Screening Value (µg/l)			
	Surface Water (Abstraction for Drinking) 1996	Water Supply Regulations 2000	Water Framework Directive	Environment Agency Advice
Arsenic	50	10	**50**	
Selenium	10	**10**		
Cadmium	5	5	**1.5**	
Chromium	50	50	**32**	
Copper	50	2,000	**28**	
Lead	50	10	**7.2**	
Nickel		20	**20**	
Zinc	3,000		**125**	
Boron		**1,000**		
Mercury	1	1	**0.07**	
Petroleum Hydrocarbons				**10**
1,1,1-Trichloroethane			**100**	
1,1 Dichloroethane				**100**
1,2-Dichloroethane		3	**10**	
1,1-Dichloroethene				**100**
Benzene		1	**10**	
Ethylbenzene				**10**
Tetrachloroethene		10	**10**	
Toluene			**50**	
Trichloroethene		10	**10**	
Vinyl Chloride		**0.5**		
Trichloromethane			**2.5**	
Xylenes			**30**	
Chloroethane				**100**

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**, and such waste must have been subjected to pre-treatment. 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 (eg 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 (eg WAC) is required.

Possible action in event of Tier 1 exceedance

Should any of the Tier 1 criteria detailed above be exceeded, then three potential courses of action are available. (The first is only applicable in terms of human health, but the second and third could also be applied to groundwater or landfill gas).

1. Undertake further statistical analysis following the approach set out in "*Guidance on Comparing Soil Contamination Data* with *a Critical Concentration - CL:AIRE and CIEH, May 2008*" in order to determine whether contaminant concentrations of inorganic contaminants within soil\fill actually present a risk (only applicable to assessing the risk to human health).
2. Carry out a more detailed quantitative risk assessment in order to determine whether contamination risks actually exist.
3. Based on a qualitative risk assessment, advocate an appropriate level of remediation to "break" the pollutant linkage - for example the removal of the contaminated materials or the provision of a clean cover.

Prior to undertaking any statistical analysis the issue of the **averaging area** requires further consideration. The CL:AIRE\CIEH document still refers to CLR 7, which suggests averaging area should reflect receptor behaviour and therefore might be a single garden, or an open area used by the local community as a play area. This approach to averaging areas is considered applicable within the context of Part IIA of the Environmental Protection Act (EPA) 1990, in terms of an existing residential development.

However, Lithos consider the concept of a single garden as an averaging area to be inappropriate with respect to brownfield redevelopment, which is regulated by the planning regime. In this context, contamination across the entire site needs to be characterised by reference to the Conceptual Site Model. Consequently, Lithos gather and analyse sample results by fill type, and\or by former use in a given sub-area of the site, before undertaking statistical analysis; ie the averaging area is associated with the extent of a particular fill type, or an area affected by spillage\leakage.

In terms of brownfield redevelopment, this is considered a more appropriate methodology which provides a more representative sample population for statistical analysis. As such the entire site is considered in terms of the proposed end use, be this residential with, or without gardens.

Analysis by soil\fill type is appropriate for essentially immobile contaminants associated with a particular fill type, for example arsenic in colliery spoil, metals in ash & clinker, sulphate in plaster-rich demolition rubble etc.

Analysis by former use is appropriate where more mobile contaminants have entered the ground, for example diesel associated with leakage from a former fuel tank, downward migration of leachable metals through granular materials, various soluble contaminants present in a wastewater leaking into the ground via a fractured sewer etc. In these circumstances, it may be appropriate to undertake statistical analysis of sample results from a variety of different soil\fill types. However, consideration would have to be given to factors such as porosity which might influence impregnation of a mobile contaminant into the soil mass; ie contamination would normally be more pervasive and significant in granular soils than cohesive soils.

Generic notes – geoenvironmental investigations

General

Hazardous gas is considered to be any mixture of potentially explosive, toxic or asphyxiating gases, most notably methane, carbon dioxide and oxygen (deficiency). In addition, radon, a naturally occurring radioactive gas is also considered. Further information about radon is included in Notes 1. – Environmental Setting.

Assessment of potential risks associated with hazardous gas are based on a review of data obtained from the Landmark Information Group, the Environment Agency and the Local Authority and the British Geological Survey. Reference is also made to historical OS plans, which are inspected for evidence of backfilled quarries, railway cuttings, colliery spoil tips etc.

Where landfilling has occurred within 250m of the site boundary, the Local Planning Authority may request a landfill gas investigation in accordance with the Town and Country Planning General Development Order, 1988.

Sources

Potential sources of hazardous gas are:

- Landfill sites
- Made ground, especially where significant depths are present
- Shallow mineworkings associated with coal extraction
- Geological strata, including peat, organic silts, coal and limestone (reaction with acidic waters), granite (radon)
- Groundwater can sometimes act as a “carrier” for hazardous gas.
- Leakages from pipelines or storage tanks
- Sewers, septic tanks and cess pits

Generation

Wherever biodegradable material is deposited, landfill gas (principally a mixture of methane and carbon dioxide) is likely to be generated by microbial activity. Carbon dioxide is an asphyxiant and toxic; methane is flammable and a mixture containing between 5% and 15% methane by volume in air is explosive. Landfill gas in the ground is unlikely in itself to pose a significant risk, though it may damage vegetation. However, infiltration of landfill gas into confined spaces (e.g. cellars, services, etc) may give rise to considerable risk.

There is no typical figure for the length of time that landfill gas will be evolved, but at many sites significant gas generation continues for at least 15 years after the last deposit of waste.

Migration

Gas migration from a landfill site may occur in several ways. It may migrate through adjacent strata; the distance of migration being dependent on the pressure gradients, volume of gas and permeability of the strata. Where there are faults, cavities and fissures within the strata, gas may move considerable distances. Other migration pathways for gas include man-made features such as mine shafts, roadways and underground services.

Gas migration is influenced by a number of climatic factors, such as atmospheric pressure variations, water table level variations and the influence of a covering of snow or ice over the surface of the site and surrounding area.

Gas monitoring procedure

Lithos adopt a standard gas monitoring procedure, in accordance with CIRIA guidance. This procedure involves the measurement, in the following order of:

- Atmospheric temperature, pressure and ambient oxygen concentration
- Gas emission rate
- Methane, oxygen and carbon dioxide concentrations using an infra-red gas analyser
- Standing water level using a dipmeter.

In addition, ground conditions at each sampling location are recorded together with prevailing weather conditions and any other observations such as any vandalism. Where samples of gas are required for laboratory analysis, Gresham Tubes are used. Gas concentrations in the well are typically recorded immediately before and after retrieval of a sample.

Current guidance

CIRIA Report 151 (1995)[i] identified that there was inadequate guidance on trigger concentrations for ground gases. CIRIA concluded that the most important aspect of a gas regime below or adjacent to a site was the surface emission rate, i.e. how quickly the gas is coming out of the ground. The lower the surface emission rate the lower the risk. CIRIA Report C665 (2006)[ii] advocates two methodologies for characterising sites:

A – All developments except low rise housing. The advocated methodology is that proposed by Wilson & Card, 1999[iii]

B – Low rise housing. An alternative (traffic light) methodology, derived by Boyle and Witherington, 2006[iv] for NHBC

Both methodologies refer to Gas Screening Values (GSV); previously referred to as limiting borehole gas volume flow.

Generic notes – geoenvironmental investigations

A – All developments except low rise housing

(Wilson & Card, 1999)[v] revised Table 28 of CIRIA 149[v] in terms of borehole gas volume flow rate (now GSV) in order to achieve a more consistent design of protection measures. This was done to reflect the importance of recognising the gas surface emission rate. Wilson & Card then developed a method for classifying gassing sites (Table 1 below), which took into account the combined gas concentration and GSV.

Characteristic Situation	Gas Screening Value, CH_4 or CO_2 (l/hr)	Additional limiting factors	Typical source of generation
1	<0.07	Methane not to exceed 1% v/v and carbon dioxide not to exceed 5% v/v	Natural soils with low organic content
2	<0.7	Borehole air flow rate not to exceed 70 litre/hr otherwise increase to Characteristic Situation 3	Natural soil, high peat/organic content
3	<3.5		Old landfill, inert waste, mineworking flooded.
4	<15	Quantitative Risk Assessment required to evaluate scope of protection measures.	Mineworking – susceptible to flooding, completed landfill, inert waste
5	<70		Mineworking unflooded, inactive
6	>70		Recent landfill site

Notes: *Borehole flow rate = volume of gas (regardless of composition) which is escaping from well (l/hr). Gas Screening Value (litre/hour) = gas concentration (%) / 100 x borehole flow rate (l/hr). To facilitate design implementation, the limiting values for both methane and carbon dioxide are identical.*

B – Low rise housing.

NHBC have developed a characterisation system similar to that of Wilson & Card above, but specific to low-rise housing development (Boyle and Witherington) (Table 8.7). This approach compares measured gas emission rates with generic "Traffic Lights". The Traffic Lights include "Typical Maximum Concentrations" for initial screening, and risk-based Gas Screening Values (GSVs) for consideration of situations where the Typical Maximum Concentrations are exceeded. Calculations are carried out for both methane and carbon dioxide and the worst case adopted in order to establish the appropriate protection measures.

Table 8.7 NHBC Traffic light system for 150 mm void

Traffic light	Methane[1]		Carbon dioxide[1]	
	Typical maximum concentration[3] (% v/v)	Gas screening value (GSV)[2,4,5] (litres per hour	Typical maximum concentration[3] (% v/v)	Gas screening value (GSV)[2,3,4,5] (litres per hour
Green				
	1	0.16	5	0.78
Amber 1				
	5	0.63	10	1.56
Amber 2				
	20	1.56	30	3.13
Red				

Notes:

1. The worst gas-regime identified at the site, either methane or carbon dioxide, recorded from monitoring in the worst temporal conditions, will be the decider for which Traffic Light and GSV is allocated.
2. Generic GSVs are based on guidance contained within "The Building Regulations: Approved Document C" (2004) and assume a sub-floor void of 150 mm thickness.
3. The small room is considered to be a downstairs toilet, with dimensions of 1.50 × 1.50 × 2.50 m, with a soil pipe passing into the sub-floor void.
4. The GSV, in litres per hour, is as defined in Wilson and Card (1999) as the borehole flow rate multiplied by the concentration in the air stream of the particular gas being considered.
5. The Typical Maximum Concentrations can be exceeded in certain circumstances should the conceptual site model indicate it is safe to do so. This is where professional judgment will be required, based on a thorough understanding of the gas regime identified at the site where monitoring in the worst temporal conditions has occurred.
6. The GSV thresholds should not generally be exceeded without completion of a detailed gas risk assessment taking into account site-specific conditions.

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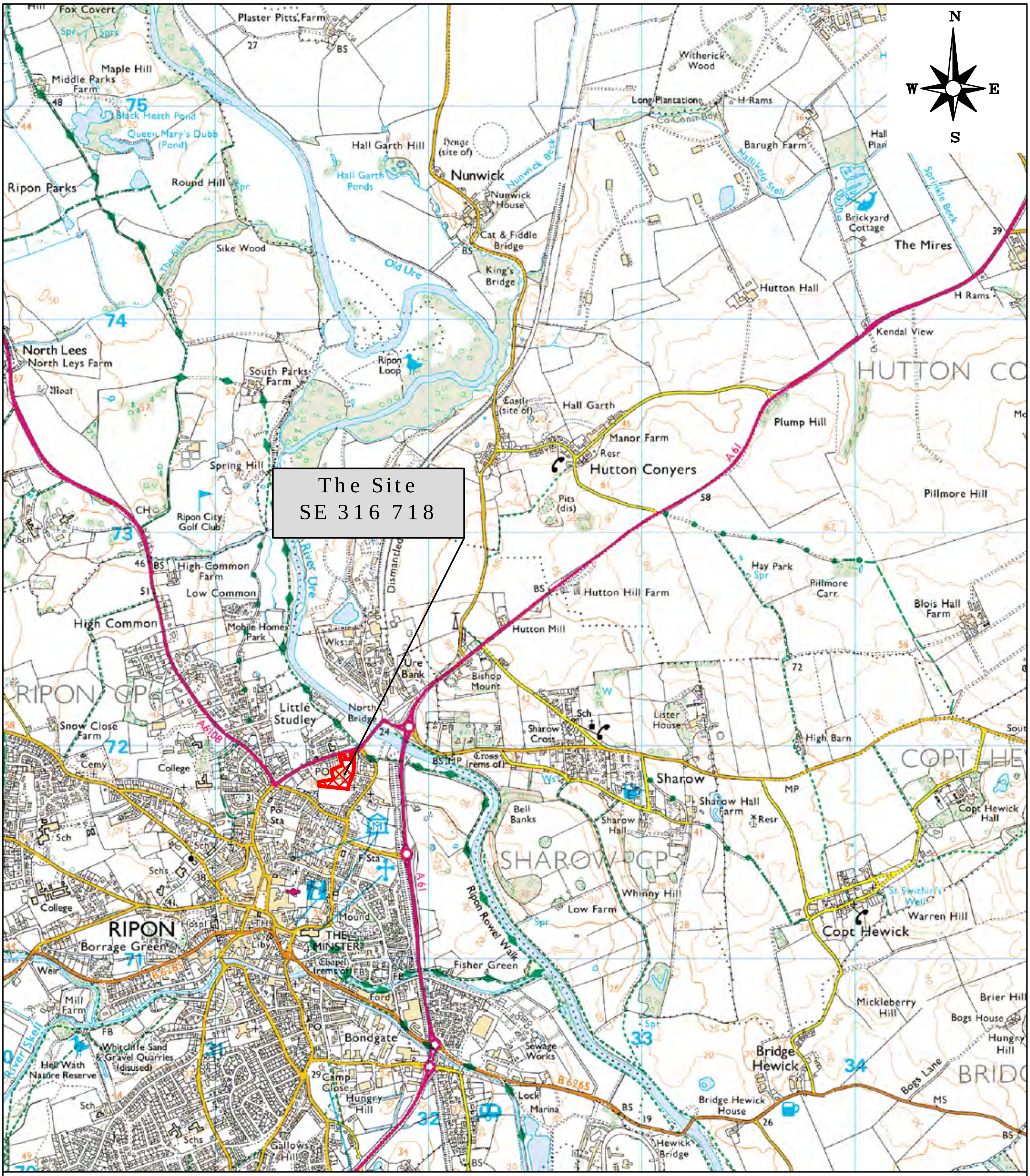
i *Harries CR, Witherington PJ and McEntee JM (1995). Interpreting measurements of gas in the ground. CIRIA Report 151*
ii *CIRIA (2006) – Assessing risks posed by hazardous ground gases to buildings.*
iii *Wilson SA and Card GB (February 1999). Reliability and Risk in Gas Protection Design. Ground Engineering.*
iv *Boyle & Witherington (2006) – 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*
v *Wilson SA and Card GB (February 1999). Reliability and Risk in Gas Protection Design. Ground Engineering.*

Appendix B

Drawings



LITHOS CONSULTING info@lithos.co.uk www.lithos.co.uk Tel 01937 545330	CLIENT RIPON FARMERS LIVESTOCK MART CO LTD	JOB TITLE RIPON AUCTION MART	DRAWING TITLE SITE LOCATION PLAN	DRAWN: ASw CHECKED: REG STATUS: FOR COMMENT ☐ FOR APPROVAL ☐ SCALE: 1:25,000 SHEET: A4	DATE: 04 03 2016 DATE: 08 03 2016 DRAFT ☐ FINAL ☑ DRAWING NO. 2376/1 REVISION

NOTES

REPRODUCED MS ARCHITECTS DRAWING 1082/1.9, DATED MAY 2016

REV.	DESCRIPTION	DATE
A	REVISED ARCHITECTS LAYOUT	18/05/2016

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CLIENT

RIPON FARMERS LIVESTOCK MART CO LTD

JOB TITLE

RIPON AUCTION MART

DRAWING TITLE

PROPOSED SITE LAYOUT

DRAWN	DATE	STATUS
ASw	04 03 2016	FOR COMMENT ☐ / FOR APPROVAL ☐
CHECKED	DATE	DRAFT ☐
REG	08 03 2016	FINAL ☑

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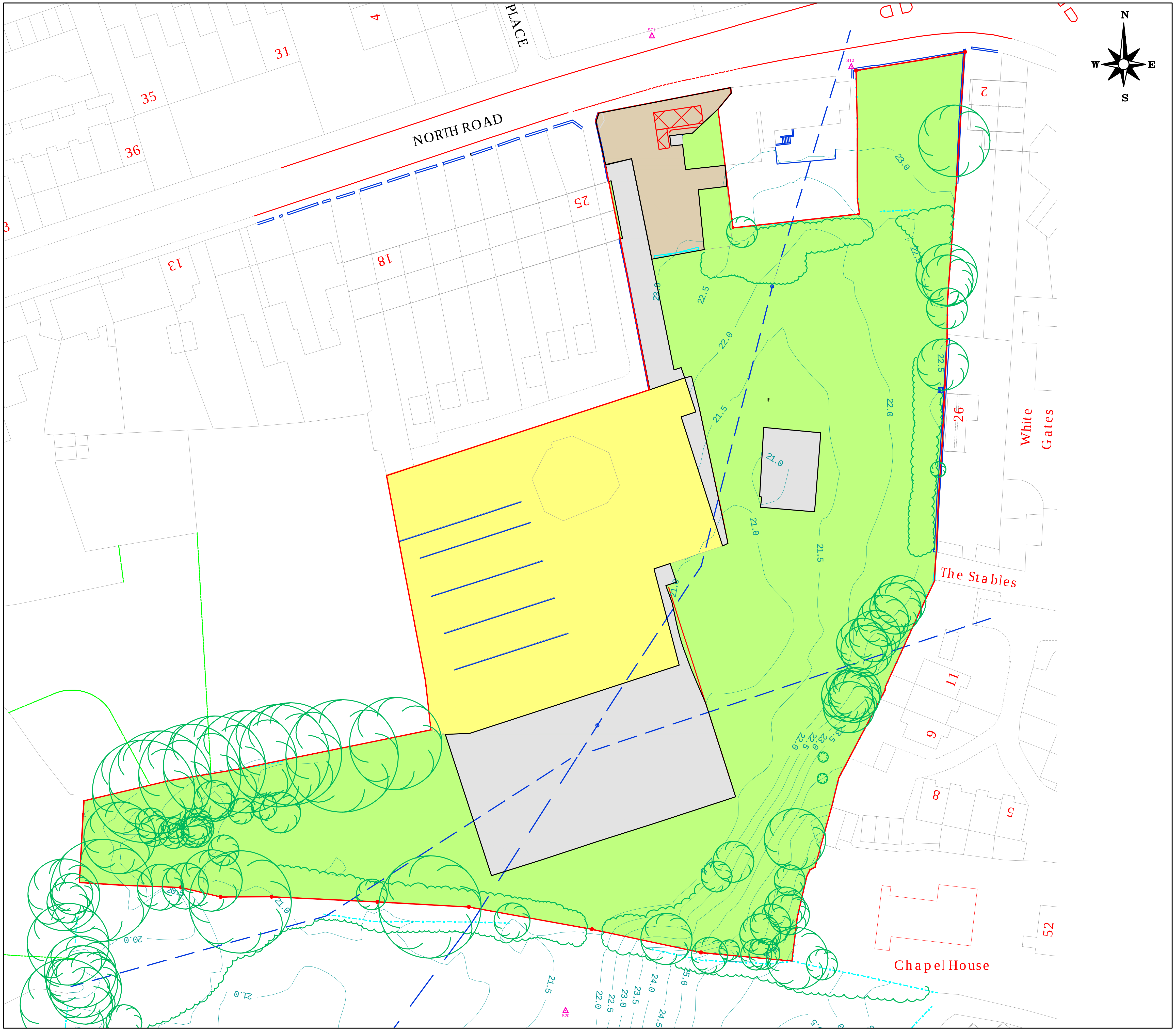

NOTES

GRASS & OVERGROWN AREAS

BUILDING

TARMAC HARDSTAND

CONCRETE HARDSTAND

FUEL STORAGE TANKS

APPROXIMATE SITE BOUNDARY

APPROXIMATE LINE OF SEWERS

REV.	DESCRIPTION	DATE

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RIPON AUCTION MART

DRAWING TITLE

SITE FEATURES

DRAWN	DATE	STATUS
ASw	04 03 2016	FOR COMMENT ☐
		FOR APPROVAL ☐
CHECKED	DATE	DRAFT ☐
REG	08 03 2016	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
1:750	A3	2376/3	

NOTES

APPROXIMATE SITE BOUNDARY

LOCATION & ORIENTATION OF PHOTOGRAPH

REV.	DESCRIPTION	DATE

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JOB TITLE

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DRAWING TITLE

SITE PHOTOGRAPHS

DRAWN	DATE	STATUS
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CHECKED	DATE	
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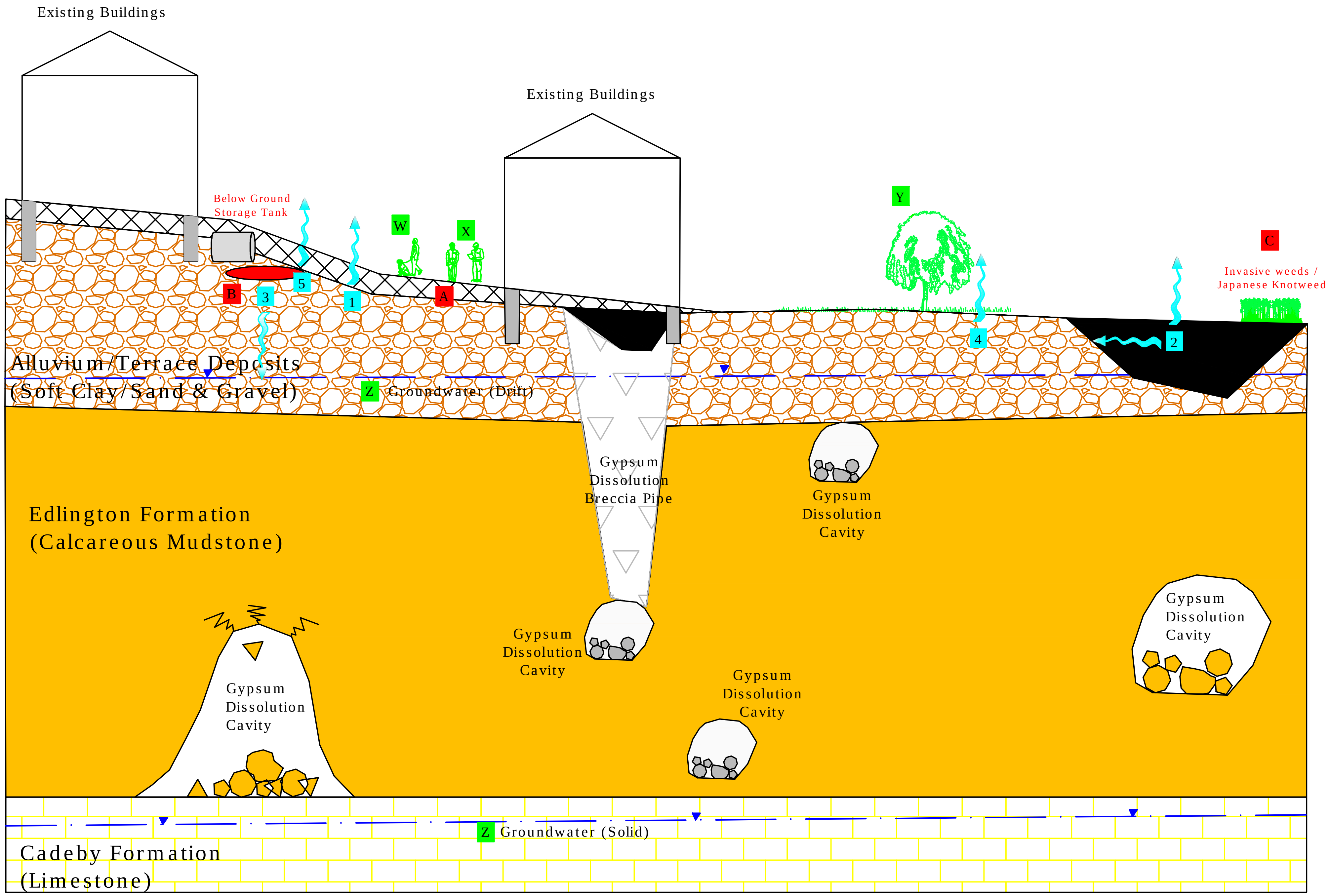

KEY
Made ground
Peat
Alluvium/Terrace Deposits
Edlington Formation (Mudstone)
Cadeby Formation (Limestone)

SOURCES	
A	Made Ground
B	Below Ground Fuel Tank Leakage/Spillage
C	Invasive Plants

PATHWAYS	
1	Dermal Contact/Ingestion/Inhalation
2	Hazardous Gas Migration
3	Leaching of Mobile Contaminants
4	Uptake by Plants
5	Volatilisation of Organic Contaminants

RECEPTORS	
W	End Users (Residents)
X	Site Workers
Y	Vegetation
Z	Controlled Waters (Ground)

NOTES

REV.	DESCRIPTION	DATE

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JOB TITLE
RIPON AUCTION MART

DRAWING TITLE
PRELIMINARY CONCEPTUAL SITE MODEL

DRAWN	DATE	STATUS
ASw	04 03 2016	FOR COMMENT ☐ FOR APPROVAL ☐
CHECKED	DATE	DRAFT ☐
REG	08 03 2016	FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
Not to scale	A3	2376/5	

NOTES

Lithos Investigations 2011/2012

Trial Pit Location (May 2011)
Borehole Location (May 2011)

Borehole Location (November 2011)
Trial Pit Location (December 2011)

Borehole Location (February 2012)
Trial Pit Location (February 2012)

REV.	DESCRIPTION	DATE

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JOB TITLE

RIPON AUCTION MART

DRAWING TITLE

EXPLORATORY HOLE LOCATIONS

DRAWN	DATE	STATUS
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CHECKED	DATE	DRAFT ☐
REG	08 03 2016	FINAL ☑

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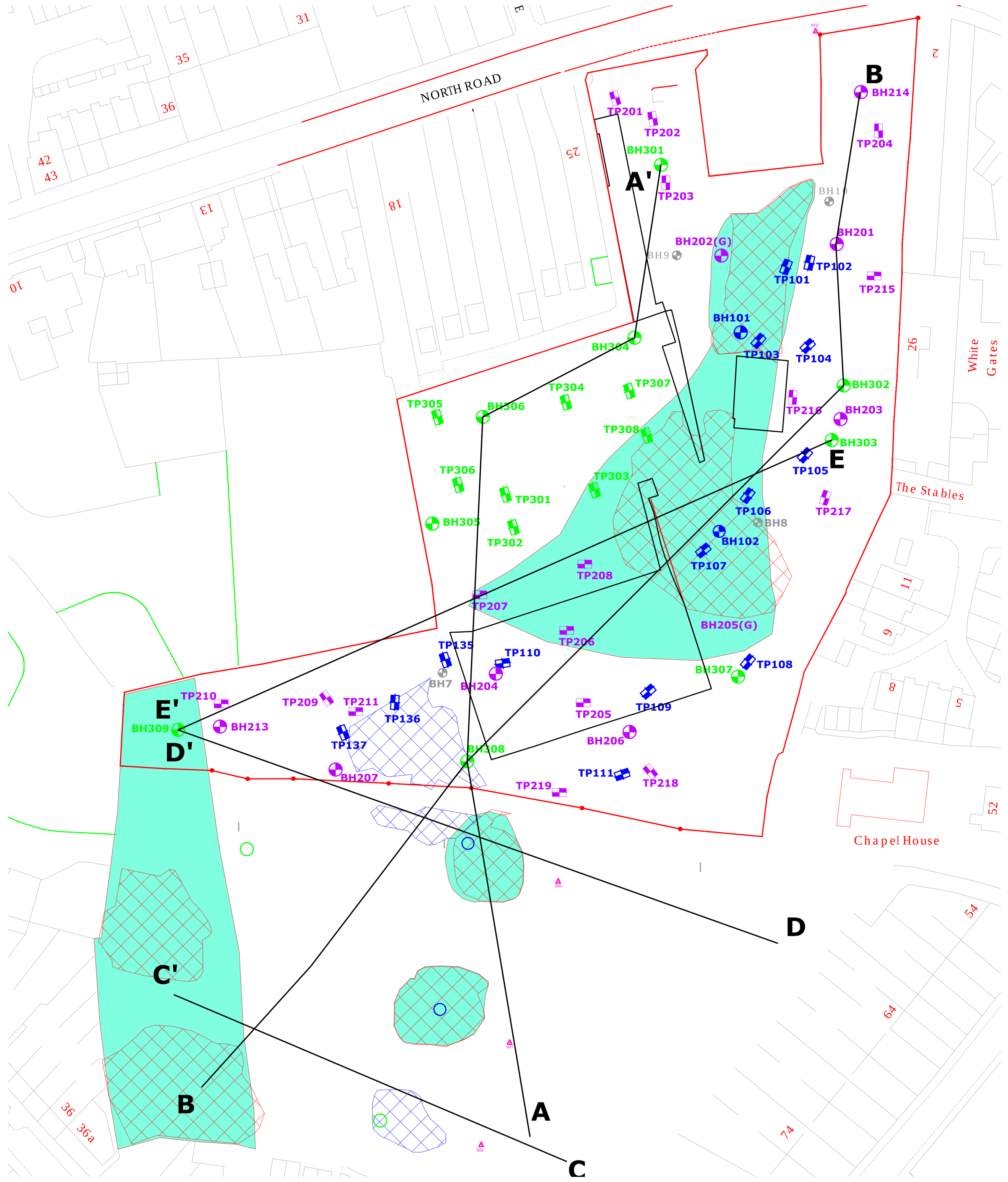
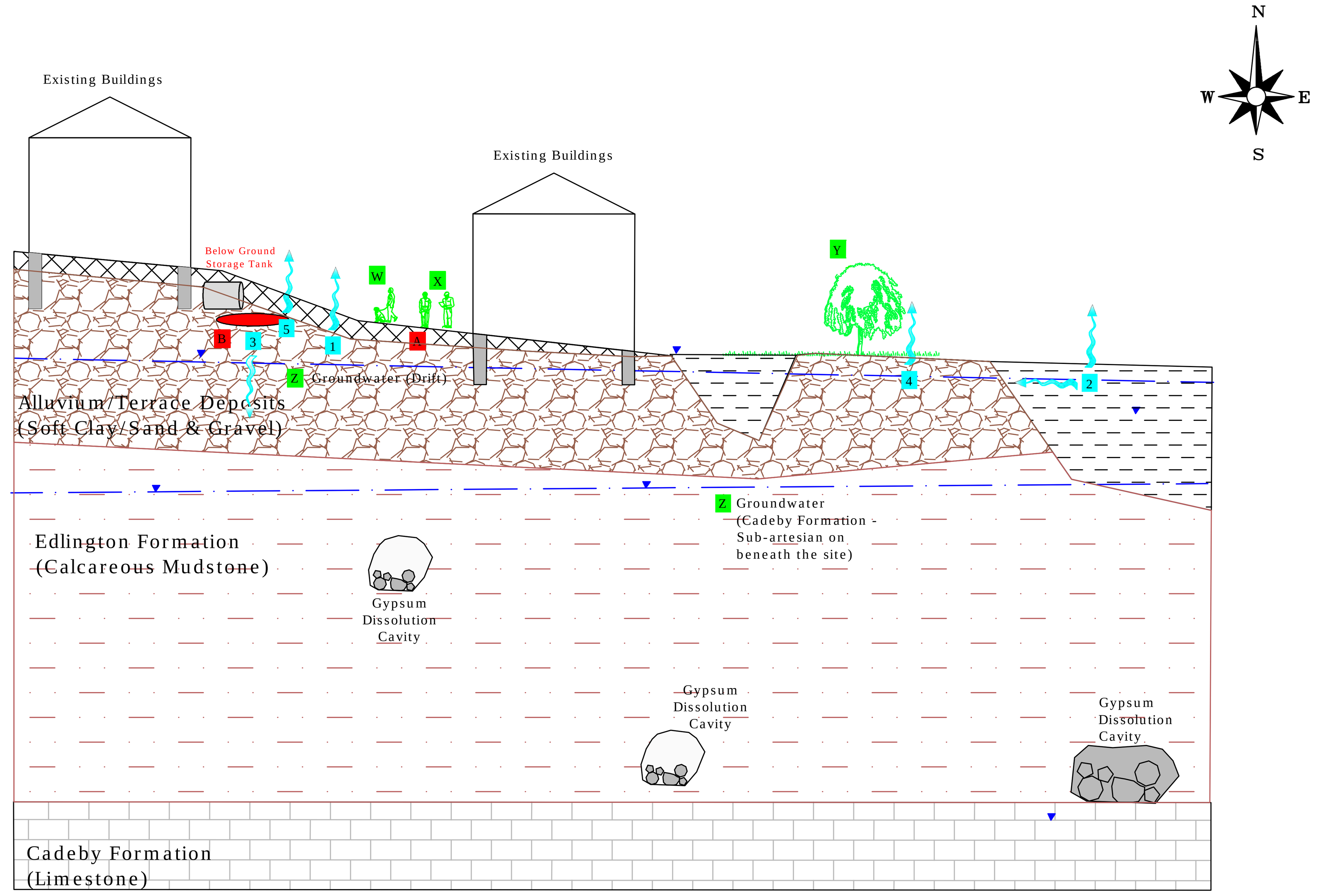




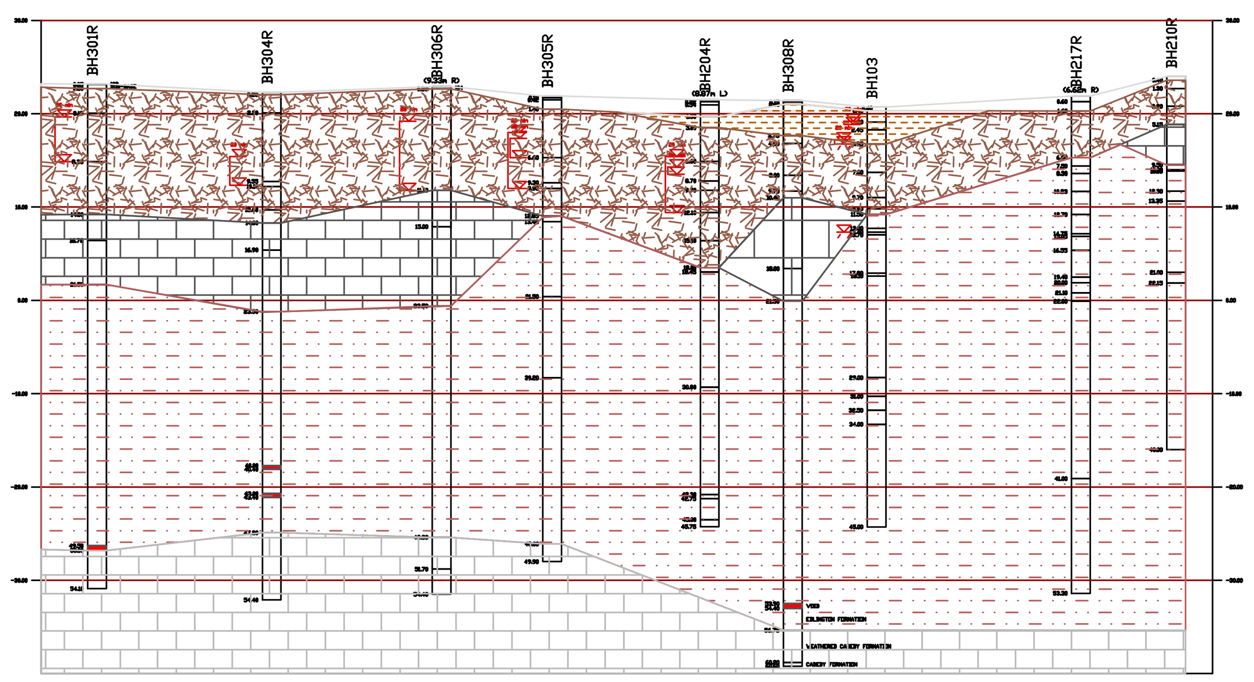
KEY
Made ground
Lacustrine Deposits
Glaciofluvial Sheet Deposits
Edlington Formation (Mudstone)
Cadeby Formation (Limestone)

SOURCES	
A	Made Ground
B	Below Ground Fuel Tank Leakage/Spillage
C	Invasive Plants

PATHWAYS	
1	Dermal Contact/Ingestion/Inhalation
2	Hazardous Gas Migration
3	Leaching of Mobile Contaminants
4	Uptake by Plants
5	Volatilisation of Organic Contaminants

RECEPTORS	
W	End Users (Residents)
X	Site Workers
Y	Vegetation
Z	Controlled Waters (Ground)

CROSS-SECTION A-A'



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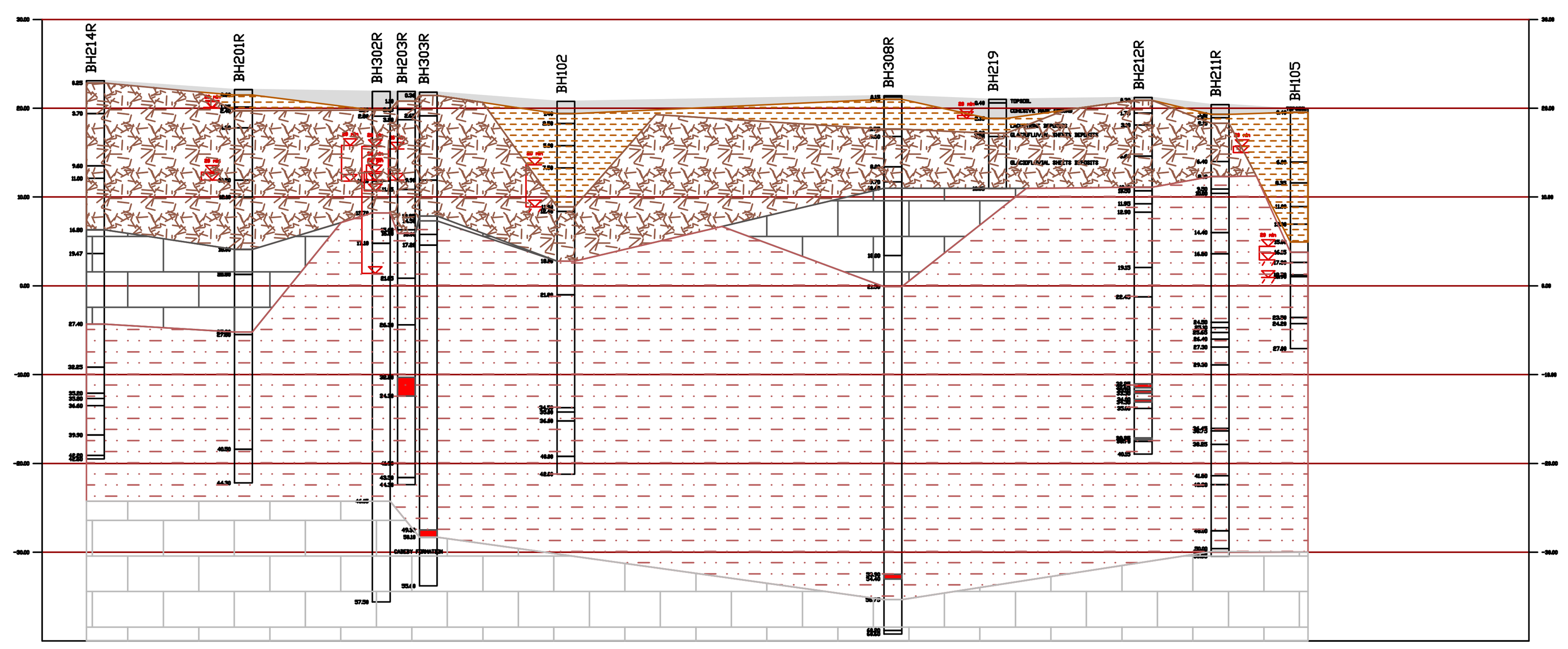

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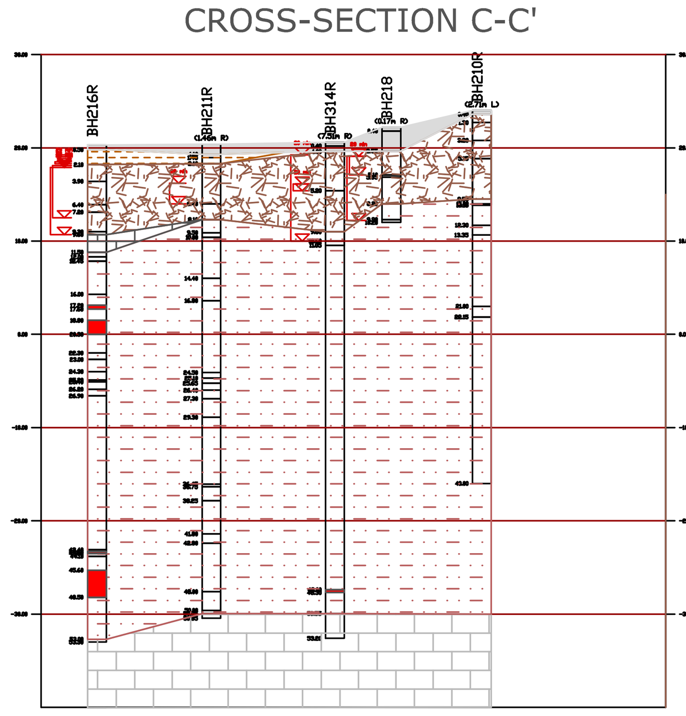

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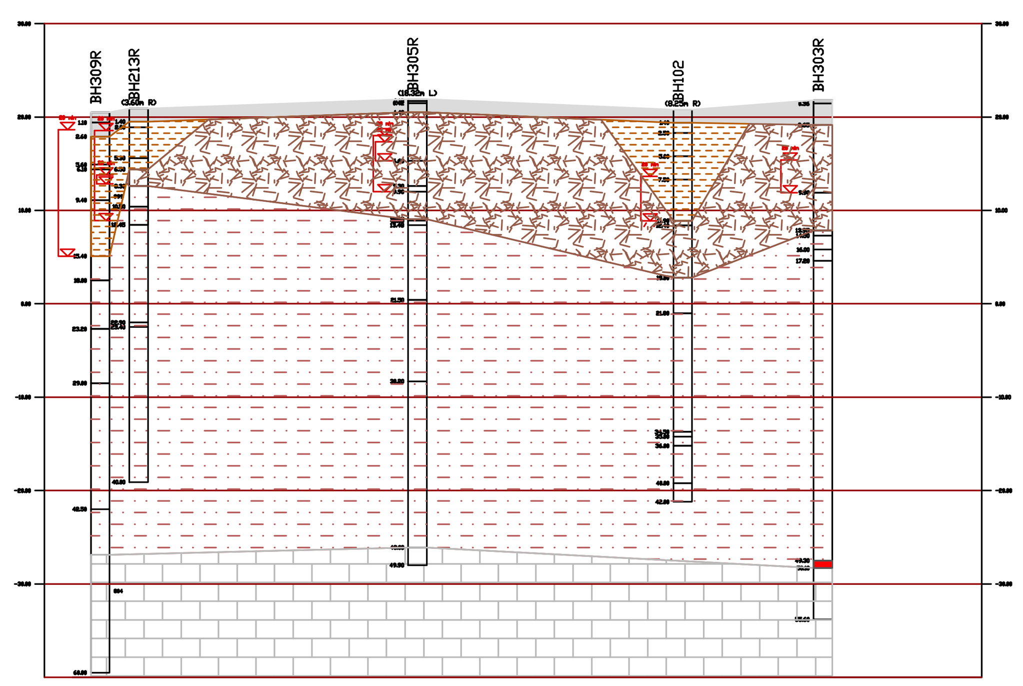

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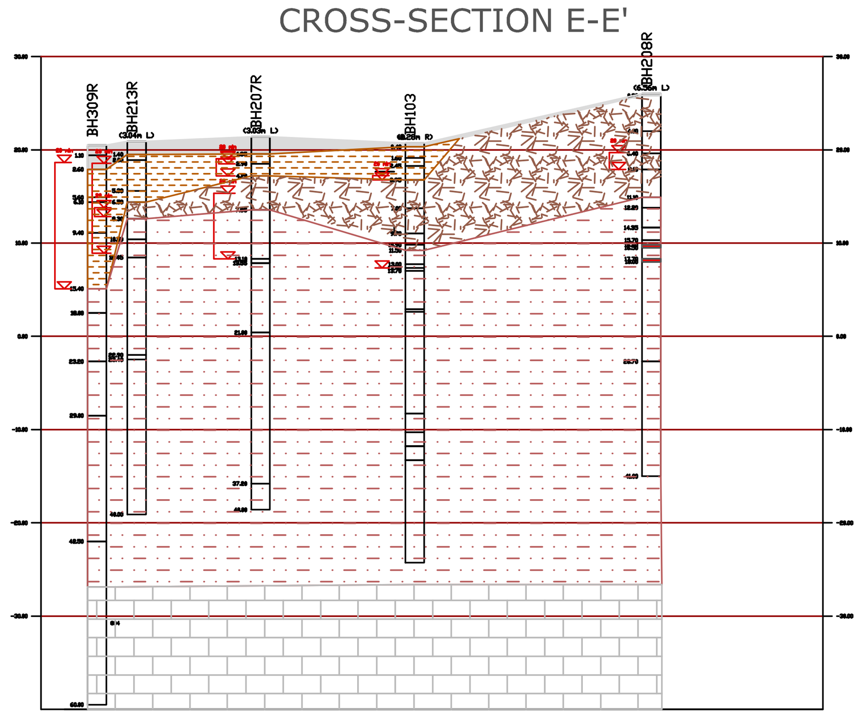

NOTES

Geophysical Anomaly Soft Ground

Geophysical Anomaly Brick/Tile fragments

Historical gypsum dissolution hollow in-filled with Lacustrine Deposits; extent initially defined by geophysical survey and confirmed by intrusive site investigation.

A — A Line of Geological Cross-Section

Cavity (void) encountered within borehole - see cross-sections

REV.	DESCRIPTION	DATE

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Tel 01937 545330

CLIENT
RIPON FARMERS LIVESTOCK MART CO LTD

JOB TITLE
RIPON AUCTION MART

DRAWING TITLE
REVISED CSM & GEOLOGICAL CROSS-SECTIONS

DRAWN	DATE	STATUS
ASw	04 03 2016	FOR COMMENT ☐ / FOR APPROVAL ☐
CHECKED	DATE	
REG	08 03 2016	DRAFT ☐ / FINAL ☑

SCALE	SHEET	DRAWING NO.	REVISION
NTS	A1	2376/7	

Appendix C

Commission

003/2376/REG

27th January 2016

Mr C Fordy
Strutt & Parker
Princes House
13 Princes Square
Harrogate
HG1 1LW

LITHOS CONSULTING

Registered in England 07068066

Parkhill
Wetherby
West Yorkshire
LS22 5DZ

T *01937 545 330*

www.lithos.co.uk

Dear Chris

Ripon Auction Mart

Further to recent discussion, please find below our proposal for preparing a new geoenvironmental appraisal report for the above site.

It is understood that your clients are intending to develop the site with about 34 Park Homes or Log Cabins, with a private estate roadway. The Park Homes will be prefabricated units, and sit on concrete pads, with access to mains water, electricity and drainage.

As discussed, whilst issues associated with gypsum dissolution are now considered to render the site unsuitable for a conventional residential development, a Park Homes/Log Cabin scheme is considered feasible. This is primarily because in the event of a subsidence event the home/cabin could simply to be craned-off and placed in a new location (cf conventional brick-built house, which would likely require demolition in the event of subsidence). Of course, this might still result in perception and conveyancing issues if your client intended to sell, rather than rent, the homes/cabins.

We will make use of Lithos data originally commissioned by Ben Bailey Homes and presented in Report 1249/3C, dated November 2012, and write the Report in the context of a proposed Park Homes/Log Cabin scheme. Our Report will be in a format familiar to Harrogate BC, and therefore suitable for submission in support of a planning application.

It is anticipated that a final report will be available within 4 weeks of receiving your written instruction to proceed. Our lump sum fee for provision of this report is **£*** ** plus VAT.

This work will be undertaken in accordance with our Standard Terms and Conditions, a copy of which are enclosed.

It is hoped the above is sufficient for your present needs. However, should you require any further information, please contact the undersigned.

Yours sincerely

Mark Perrin
Director
for and on behalf of
LITHOS CONSULTING LIMITED

Terms and Conditions for the Appointment of Lithos Consulting Limited

DEFINITIONS AND INTERPRETATION

1.1 In this Agreement, unless the context otherwise requires, the following words and expressions have the following meanings:

"Agreement" shall mean these Terms (entitled "Terms and Conditions for the Appointment of Lithos Consulting"), the Proposal, any document recording the Client's unequivocal acceptance of the Proposal and any other documents or parts of other documents expressly referred to in any of the foregoing:

"Client" shall mean the party for whom the Services are being provided by Lithos;

"Documents" shall mean all documents of any kind and includes plans, drawings, reports, programmes, specifications, Bills of Quantities, calculations, letters, e-mails, faxes, memoranda, films and photographs (including negatives), or any other form of record prepared or provided or received by, or on behalf of Lithos, and whether in paper form or stored electronically or on disk, or otherwise;

"Lithos" shall mean Lithos Consulting Limited whose registered office is at Parkhill, Walton Road, Wetherby, West Yorkshire, LS22 5DZ.

"Intellectual Property" includes all rights to, and any interests in, any patents, designs, trade marks, copyright, know-how, trade secrets and any other proprietary rights or forms of intellectual property (protectable by registration or not) in respect of any technology, concept, idea, data, programme or other software (including source and object codes), specification, plan, drawing, schedule, minutes, correspondence, scheme, programme, design, system, process logo, mark, style, or other matter or thing, existing or conceived, used, developed or produced by any person;

"Parties" shall mean the Client and Lithos

"Project" shall mean the project described in the Proposal and any enquiry from the Client on which Lithos has based its Proposal;

"Proposal" means the offer document prepared by Lithos in response to an enquiry or otherwise, in connection with the proposed provision of the Services;

"Services" means the work and services relating to the Project to be provided by Lithos pursuant to the Agreement and as set out in the Proposal and shall include any additions or amendments thereto made in accordance with these Terms;

"Terms" means these terms entitled "Lithos Consulting Terms of Appointment".

1.2 Words importing the singular only shall also include the plural and vice versa, where the context requires.

1.3 Words importing persons or parties shall include firms, corporations and any organisation having legal capacity and vice versa, where the context requires; and words importing a particular gender include all genders.

1.4 The sub-headings to the clauses of these Terms are for convenience only and shall not affect the construction of the Agreement.

1.5 A reference to legislation includes that legislation as from time to time amended, re-enacted or substituted and any Orders in Council, orders, rules, regulations, schemes, warrants, by-laws, directives or codes of practice issued under any such legislation.

1.6 In the event of conflict between the documents forming part of the Agreement, the Proposal shall prevail, followed by the Terms.

2 APPOINTMENT

2.1 The Client agrees to engage Lithos and Lithos agrees to provide the Services in accordance with the provisions of the Agreement.

3 OBLIGATIONS OF LITHOS

3.1 Lithos shall perform the Services using the reasonable standard of skill and care normally exercised by similar professional Environmental firms in performing similar services under similar conditions.

3.2 Lithos shall use all reasonable endeavours to perform the Services in accordance with all relevant environmental and safety legislation.

4 OBLIGATIONS OF THE CLIENT

4.1 Throughout the period of this Agreement the Client shall afford to Lithos or procure the affording to Lithos of access to any site where access is required for the performance of the Services.

4.2 The Client accepts responsibility for ensuring that Lithos is notified in writing of all special site and/or plant conditions, including without prejudice to the generality of the foregoing, the existence and precise location of all underground services, cables, pipes, drains or underground buildings, constructions or any hazards known or suspected by the Client, which the Client shall clearly mark on the ground or identify on accurate location plans supplied to Lithos prior to the commencement of the Services. The Client shall also inform Lithos in writing of any relevant operating procedures including any site safe operating procedures and any other regulations relevant to the carrying out of the Services. The Client shall indemnify Lithos against all costs, claims, demands and expenses arising as a result of any non-disclosure in this respect, including but not limited to indemnification against any action brought by the owner of the land or otherwise.

4.3 If the Client discovers any conflict, defect or other fault in the information or designs provided by Lithos pursuant to the Agreement, he will advise Lithos in writing of such defect, conflict or other fault and Lithos shall have the right to rectify the same or where necessary, to design the solution for rectification of any works carried out by others pursuant the conflicting, defective or in any other way faulty information or designs.

5 INTELLECTUAL PROPERTY

5.1 The copyright in all Intellectual Property prepared by or on behalf of Lithos in connection with the Project for delivery to the Client shall remain vested in Lithos.

5.2 The Client shall have a non-exclusive licence to copy and use such Intellectual Property for purposes directly related to the Project. Such licence shall enable the Client to copy and use the Intellectual Property but solely for its own purposes in connection with the Project and such use shall not include any licence to reproduce any conceptual designs or professional opinions contained therein nor shall it include any license to amend any drawing, design or other Intellectual Property produced by Lithos.

5.3 Should the Client wish to use such Intellectual Property in connection with any other works or for any other purpose not directly related to the Project or wish to pass any Intellectual Property to any third party, it must obtain the prior written consent of Lithos. The giving of such consent shall be at the discretion of Lithos and shall be upon such terms as may be required by Lithos. Lithos shall not be liable for the use by any person of such Intellectual Property for any purpose other than that for which the same were prepared by or on behalf of Lithos.

5.4 Ownership of any proposals submitted to the Client that are not subsequently confirmed as part of the Services to be provided for the Client remain with Lithos and such proposals must not be used as the basis for any future work undertaken by the Client or a third party and no liability can be accepted howsoever arising from such proposals.

5.5 In the event of the Client being in default of payment of any fees or other amounts due, Lithos may suspend further use of the licence on giving 2 days' notice of the intention to do so. Use of the licence may be resumed on receipt of the outstanding amounts.

6 TITLE

6.1 Lithos shall transfer only such title or rights in respect of the Documents as it has, and if any part is purchased from a third party Lithos shall transfer only such title or rights as that party had and has transferred to Lithos.

6.2 Title in the Documents shall remain with and shall not pass to the Client until the amount due under the invoice(s) (including interest and costs) has been paid in full.

6.3 Until title passes, the Client shall hold the Documents as bailee for Lithos and shall store or mark them so that they can at all times be identified as the property of Lithos.

6.4 At any time before title passes (save and except where payment is not due), but only after prior consultation with the Client, Lithos may without any liability to the Client repossess and use or sell all or any of part of the Documents and by doing so terminate the right of the Client to use, sell or otherwise deal in the Documents.

6.5 Lithos may maintain an action for the price of the Documents notwithstanding that title in them has not passed to the Client.

7 CONFIDENTIALITY

7.1 Lithos undertakes not to divulge or disclose to any third party without the written consent of the Client information which is designated confidential by the Client or which can reasonably be considered to be confidential and arises during the performance of the Services unless required to do so by law or necessary in the proper performance of its duties in relation to the Project, or in order to make full frank and proper disclosure to its insurers or intended insurers, or to obtain legal or accounting advice.

7.2 Subject to the above, Lithos shall be permitted to use information related to the Services it provides in connection with the Project for the purposes of marketing its services and in proposals for work of a similar type.

8 THIRD PARTIES

8.1 The Agreement or any part thereof or any benefit or interest thereunder may not be assigned by the Client without the prior written consent of Lithos. The giving of such consent shall be at the discretion of Lithos and Lithos will only agree to an assignment on its terms and in return for payment of a fee by the Client to Lithos to cover Lithos's legal and other costs associated with any assignment.

8.2 The Agreement shall not confer and shall not purport to confer on any third party any benefit or any right to enforce any term of this Agreement for the purposes of the Contracts (Rights of Third Parties) Act 1999 or otherwise.

8.3 Lithos will consider and may consent to any request from the Client for Lithos to enter a collateral warranty with a third party with regard to the Services provided under the Agreement. The giving of such consent shall be at the discretion of Lithos and Lithos will only enter a collateral warranty on its terms and in return for payment of a fee by the Client to Lithos to cover Lithos's legal and other costs associated with any collateral warranty.

9 INSURANCE

9.1 Lithos warrants to the Client that there is in force a policy of Professional Indemnity insurance covering its liabilities for negligence under this Agreement, with a limit of indemnity of £5,000,000 (FIVE MILLION POUNDS) any one claim, save for pollution and contamination claims and asbestos claims both of which carry £2,000,000 (TWO MILLION) in the aggregate cover. This policy is annually renewable and whilst renewal is not automatic, Lithos agrees to use reasonable endeavours to maintain such insurance at all times until six years from the date of the completion (or termination) of the Services under the Agreement, provided such insurance is available at commercially reasonable rates having regard, inter alia, to premiums required and policy terms obtainable.

9.2 If for any period such insurance is not available at commercially reasonable rates, Lithos shall forthwith inform the Client and shall obtain in respect of such period such reduced level of Professional Indemnity insurance as is available and as would be fair and reasonable in the circumstances for Lithos to obtain.

10 LIMITATIONS ON LIABILITY

10.1 Unless otherwise agreed in writing, Lithos's liability under or in connection with the Agreement whether in contract, tort, negligence, breach of statutory duty or otherwise (other than in respect of personal injury or death) shall be limited to and shall not exceed the lesser of either five million pounds in the aggregate (unless it is a pollution, contamination or asbestos claim in which case it is two million pounds in the aggregate) or 10 times the total value of invoices issued to the Client for consultancy work instructed under the Agreement.

10.2 No action or proceedings under or in respect of the Agreement whether in contract, tort, negligence, under statute or otherwise shall be commenced against Lithos after the expiry of a period of six years from the date of the completion (or termination) of the Services under the Agreement.

10.3 Whilst Lithos will scan all potential exploratory locations with a Cable Avoidance Tool, Lithos shall not be liable for any damage to underground services, cables, pipes, drains or underground buildings, constructions and the like which were either not marked on site or for which accurate plans were not provided.

10.4 Lithos shall not be liable for the cost of rectifying any defect, conflict or other fault in the information or designs provided by Lithos or for the cost of designing a solution for and rectifying any subsequent works carried out by others pursuant to the conflicting, defective or in any other way faulty information or designs, unless Lithos has been advised in writing of the same by the Client and has been given the opportunity to rectify the same or where necessary, to design the solution for rectification of any subsequent works carried out by others pursuant to the same.

11 PAYMENT

11.1 Invoices for services rendered will be submitted for payment in accordance with the Proposal.

11.2 The due date for payment is the date of the invoice and the final date for payment is 28 days from the date of the invoice.

11.3 If the Client disputes the amount included for payment in an invoice a written notice must be served on Lithos by the Client not later than 14 days before the final date for payment. If no notice is given the amount due shall be the amount stated in the invoice.

11.4 In the event of failure on the part of the Client to pay any monies in accordance with the foregoing payment provisions, Lithos will be entitled to charge interest on any monies owed to it by the Client, such interest to be at a rate of 8% above the base rate of a clearing bank from time to time calculated from the final date for payment to the date of actual payment on a compound basis.

12 DELAY

12.1 Lithos will comply with any timescale agreed for completion of the Services unless delayed or prevented by circumstances beyond its reasonable control and in the event of any such circumstances arising Lithos undertakes to complete the Services within a reasonable period, but will not be liable to the Client for any delay as a result.

13 TERMINATION

13.1 The Agreement may be determined by either party in the event of the other making a composition or arrangement with its creditors, becoming bankrupt, or being a company, making a proposal for a voluntary arrangement for a composition of debts, or has a provisional liquidator appointed, or has a winding-up order made, or passes a resolution for voluntary winding-up (except for the purposes of a bona fide scheme of amalgamation or reconstruction), or has an administrator or an administrative receiver appointed to the whole or any part of its assets. Notice of determination must be given to the party which is insolvent by the other party.

13.2 If for any reason the performance of the Services by Lithos is suspended for a period in excess of three calendar months then Lithos shall be entitled to determine its appointment in respect of the Services by seven days written notice to the Client.

13.3 If the Client shall fail to pay in full any sum due under the terms of the Agreement by the final date for payment for that sum and no effective notice of intention to withhold payment has been issued, Lithos may serve written notice on the Client demanding payment within 14 days of such notice. If the Client shall fail to comply with such notice, Lithos shall be entitled to terminate its employment under the Agreement forthwith.

13.4 Any determination of the appointment of Lithos howsoever caused shall be without prejudice to the right of Lithos to require payment for all services performed up to the date of such determination including but not limited to payment of a fair and reasonable proportion of any figure identified in the Proposal or otherwise for fees in respect of a particular service which Lithos has started, but not completed.

14 NOTICES

14.1 Any notice provided for in the Agreement shall be in writing and shall be deemed to be properly given if delivered by hand or sent by first class post to the address of the relevant party as may have been notified by each party to the other or, in the absence of notification, to the address of Lithos set out above or to the registered address of the Client.

14.2 Such notice shall be deemed to have been received on the day of delivery if delivered by hand or on the second working day after the day of posting if sent by first class post.

15 ENTIRE AGREEMENT

15.1 The Agreement constitutes the complete and entire agreement between the Client and Lithos with respect to the Services and supersedes any prior oral and/or written warranties, terms, conditions, communications and representations, whether express or implied and any claim against Lithos in respect of the Services can only be made in contract under the provisions of the Agreement and not otherwise under the law or tort or otherwise.

15.2 No amendments, modifications or variation of the Agreement shall be valid unless made in writing and agreed to by both the Client and Lithos; such agreement must be recorded in writing by at least one of the Parties.

15.3 Lithos will not be bound by any standard or printed terms or conditions furnished by the Client in any of its documents unless Lithos specifically states in writing separately from such documents that it intends such terms and conditions to apply.

16 DISPUTES AND GOVERNING LAW

16.1 The Agreement shall be governed by and construed in accordance with English law and the Parties irrevocably and unconditionally submit to the jurisdiction of the English Courts.

16.2 Where the Housing Grants, Construction and Regeneration Act 1996 applies, any dispute between the Parties may be referred to adjudication in accordance with The Scheme for Construction Contracts Regulations 1998 or any amendment or modification thereof being in force at the time of the dispute, as applicable to England, Wales, Scotland and Northern Ireland.

Reg

Subject: FW: Ripon Auction Mart

From: Chris Fordy [mailto:Chris.Fordy@struttandparker.com]
Sent: 01 March 2016 16:08
To: Reg
Cc: mark@msarchitects.biz; hugh@greensit.co.uk; ben.smith@avanthomes.co.uk
Subject: RE: Ripon Auction Mart

Dear Reg,

Re: Geo technical/Ground Surveys - Land at Ripon Auction Mart, North Road, Ripon

Further to our discussion on Friday, I apologise for the confusion with confirmation of instructions, but I can confirm that I have agreement from my Clients, Ripon Farmers Livestock Mart Co Ltd, to agree your fee quote, as set out in your letter dated 27th January 2016.

I believe that Avant Homes have now been paid by my Clients for the release/assignmenrt of the relevant survey data and reports you had previously prepared on their behalf for this site, and I hope that you will now have authority to provide this information, with necessary warranties etc for my Clients.

I look forward to hearing from you as to when you can prepare the requisite supporting informtion for our proposed planning application.

If you have any queries about what is required and the format of the scheme, please can you speak with Mark Sturgis at MS Architects in Ripon. Tel: 01765 692022

Yours,

Christopher Fordy BSc MRICS
Consultant

Princes House
13 Princes Square
Harrogate
HG1 1LW

Email: chris.fordy@struttandparker.com
Mobile: 07809 202 300

From: Reg [Reg@lithosconsulting.co.uk]
Sent: 27 January 2016 16:22
To: Chris Fordy
Subject: Ripon Auction Mart

Chris

Proposal as promised.

Regards

Mark Perrin
Lithos Consulting Ltd
M 07703 396635
DD 01937 545 331
www.lithos.co.uk

From: Chris Fordy [mailto:Chris.Fordy@struttandparker.com]
Sent: 25 January 2016 20:27

To: Reg
Cc: ben.smith@avanthomes.co.uk; hugh@greensit.co.uk; mark@msarchitects.biz
Subject: Ripon Auction Mart

Dear Reg,

Re: Geo technical/Ground Surveys - Land at Ripon Auction Mart, North Road, Ripon

I refer to our most recent discussions regarding the above matter.

As you are aware, my clients, The Ripon Farmers Livestock Mart Co Ltd have agreed to make a payment of £*** to Avant Homes, to facilitate the assignment/use of their geotechnical surveys and associated reports, which I understand you were commissioned to prepare for them at the time they were seeking to purchase the above site during 2014/15.

We have not been supplied with any copies of this work, or the basis of the findings, but we understand there was extensive on site intrusive survey work carried out, including trial pits, boreholes and micro sensitivity analysis, such that you were able to give a full and detailed analysis of the underlying ground conditions, and existence/whereabouts of gypsum. This data was submitted in support of the Avant (Ben Bailey) application to develop the site for housing.

I understand your concerns generally about the underlying ground conditions in this area of Ripon, and the problems associated with gypsum. You have explained that your advice and recommendations relating to developing this particular site for standard housing has changed, and you would not be willing to support such a use, other than potentially in very specific areas, and using carefully designed re-enforced foundations.

As you know, my clients have accepted that position, regretfully, and are now seeking to progress a planning application to develop the site for either Park Homes/Log Cabins. The proposal will envisage installation of an estate roadway, which would be private, and hence not built to an adoptable standard, off which there will be served approx 34 plots in a landscaped setting. The Park Homes will be prefabricated units, which will sit on a concrete pad, with access to mains water, electric and drainage.

There are a number of very similar Park Homes sites in Ripon, including a site just to the North of this. You may also want to take a quick look at the link below for various manufacturers in this sector so you can see the type of product we have in mind. The key is, these can be moved on and off site relatively easily, they are substantially lighter than a standard house, and therefore the load bearing attributes will be less of an issue in the vent of underlying voids in the sub-strata.

http://www.parkhome-living.co.uk/park-home-manufacturers

I have attached a proposed site layout plan, together with a site showing our clients landownership. Please note that the previous Ben Bailey development included land to the south, which is in separate ownership, and will no longer form part of this proposal.

Can you please let me know what your costs will be to prepare the necessary supporting ground investigation supporting evidence we will require to accompany this planning application, and confirmation that you are willing and able to offer the technical support we will require to achieve a positive outcome, given your extensive knowledge of this particular site.

Many thanks,

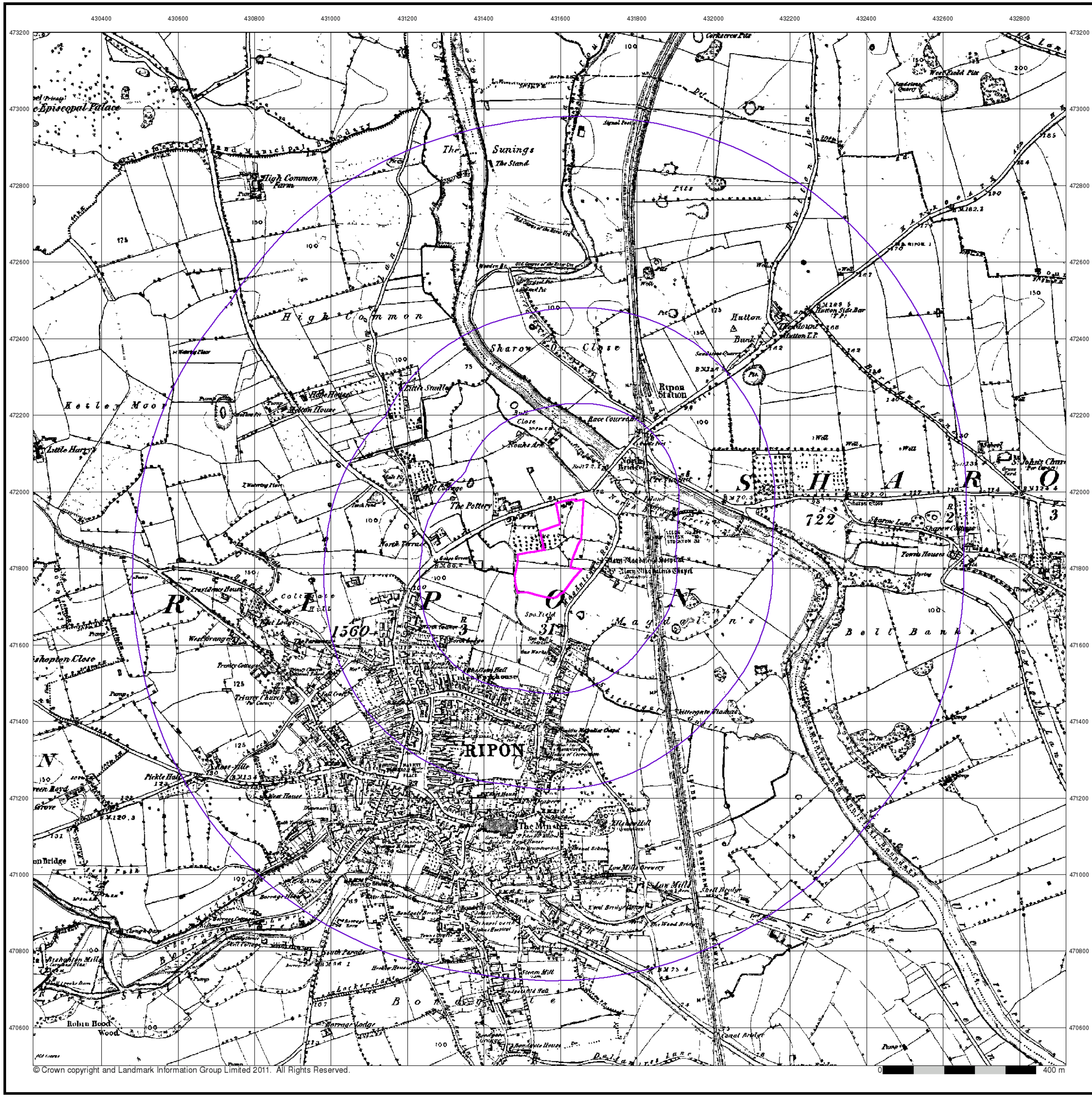
Christopher Fordy BSc MRICS
Consultant

Princes House
13 Princes Square
Harrogate
HG1 1LW

Email: chris.fordy@struttandparker.com
Mobile: 07809 202 300

Appendix D

Historical OS plans



LITHOS CONSULTING

Yorkshire

Published 1856

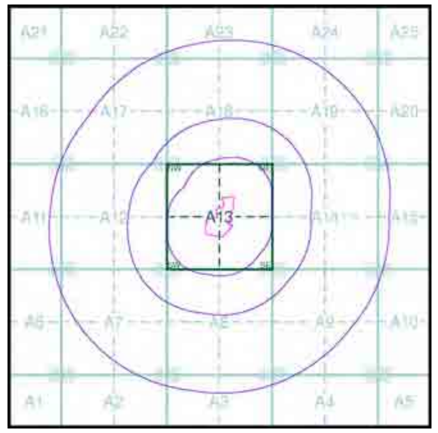
Source map scale - 1:10,560

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas; these maps were used to update the 1:10,560 maps. The published date given therefore is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas. In the late 1940`s, a Provisional Edition was produced, which updated the 1:10,560 mapping from a number of sources. The maps appear unfinished - with all military camps and other strategic sites removed. These maps were initially overprinted with the National Grid. In 1970, the first 1:10,000 maps were produced using the Transverse Mercator Projection. The revision process continued until recently, with new editions appearing every 10 years or so for urban areas.

Map Name(s) and Date(s)

11900
1856
1:10,560

Historical Map - Slice A



Order Details

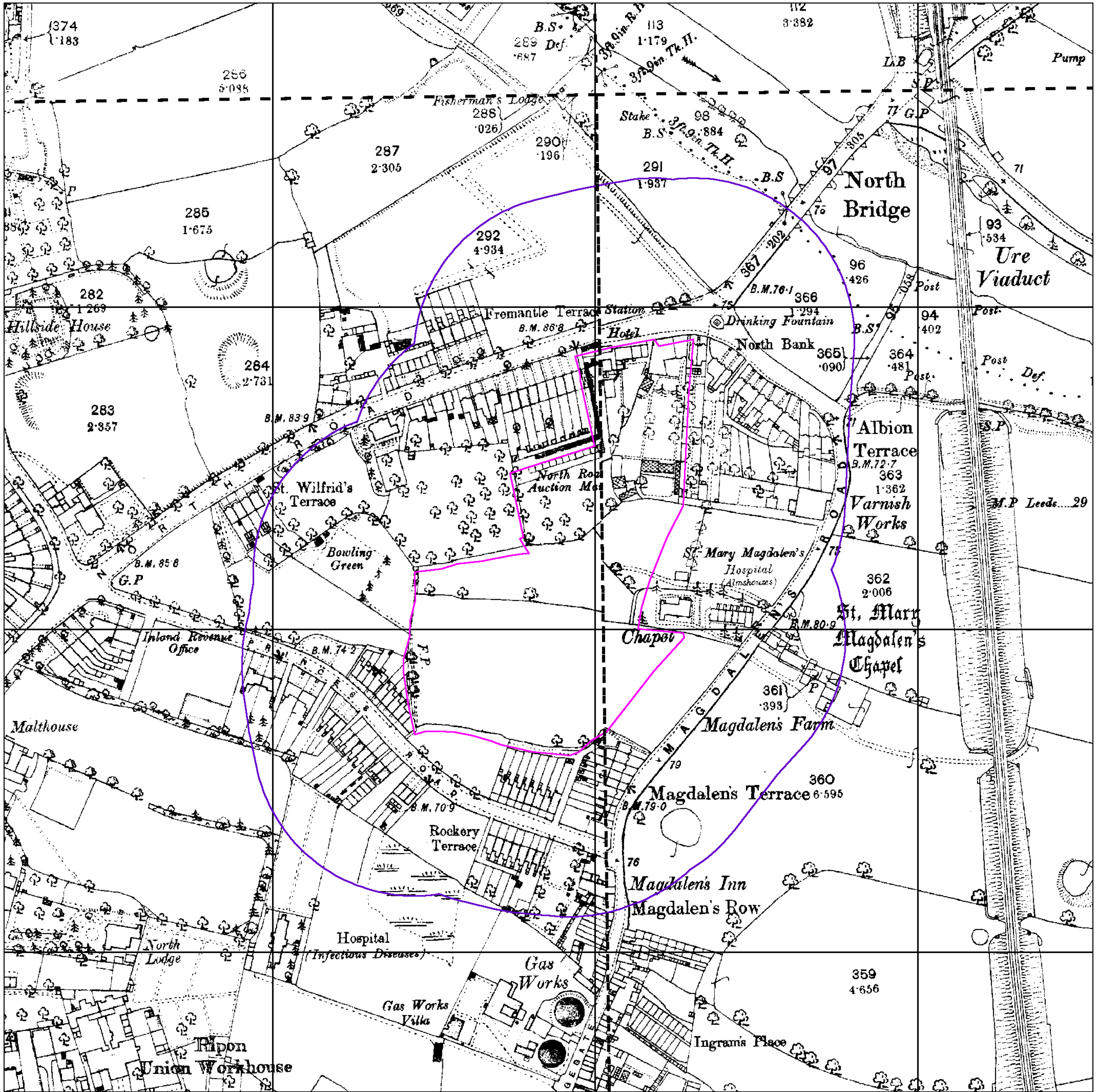
Order Number: 36467960_1_1
Customer Ref: PO6140/1249/RJH
National Grid Reference: 431580, 471850
Slice: A
Site Area (Ha): 2.7
Search Buffer (m): 1000

Site Details

Ripon Farmers Live-Stock Mart Co Ltd, The Auction Mart, North Road, RIPON, North Yorkshire, HG4 1JP

Landmark Information Group

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



0 100 m

LITHOS CONSULTING

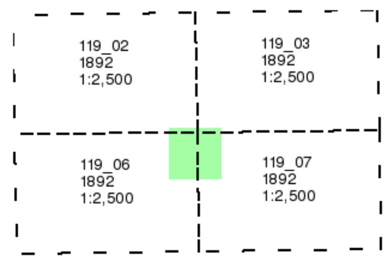
Yorkshire

Published 1892

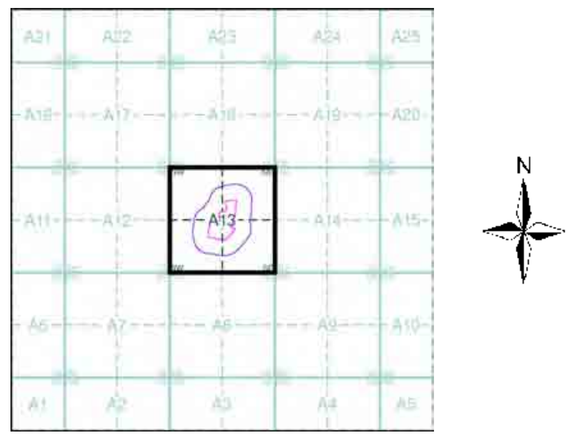
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

Order Number:	36467960_1_1
Customer Ref:	PO6140/1249/RJH
National Grid Reference:	431580, 471850
Slice:	A
Site Area (Ha):	2.7
Search Buffer (m):	100

Site Details

Ripon Farmers Live-Stock Mart Co Ltd, The Auction Mart, North Road, RIPON, North Yorkshire, HG4 1JP

Landmark Information Group

Tel:	0844 844 9952
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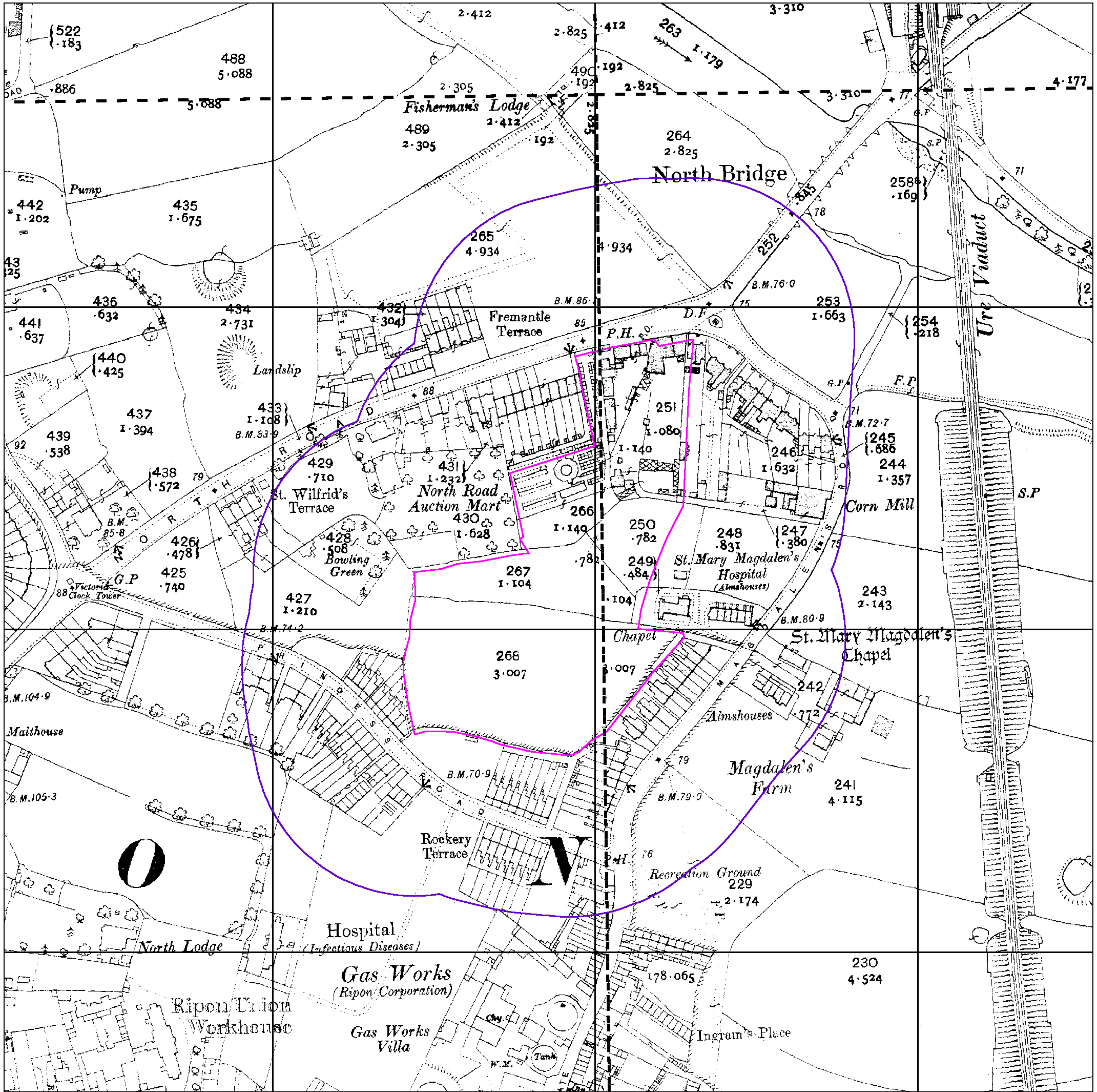


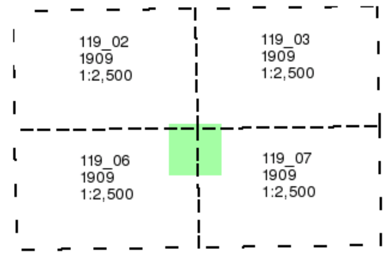
Yorkshire

Published 1909

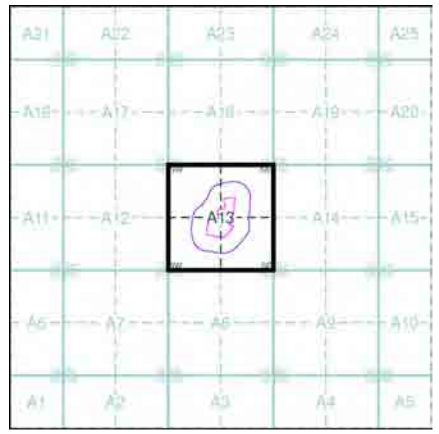
Source map scale - 1:2,500

The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)



Historical Map - Segment A13



Order Details

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Slice:	A
Site Area (Ha):	2.7
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Site Details

Ripon Farmers Live-Stock Mart Co Ltd, The Auction Mart, North Road, RIPON, North Yorkshire, HG4 1JP

Tel: 0844 844 9952
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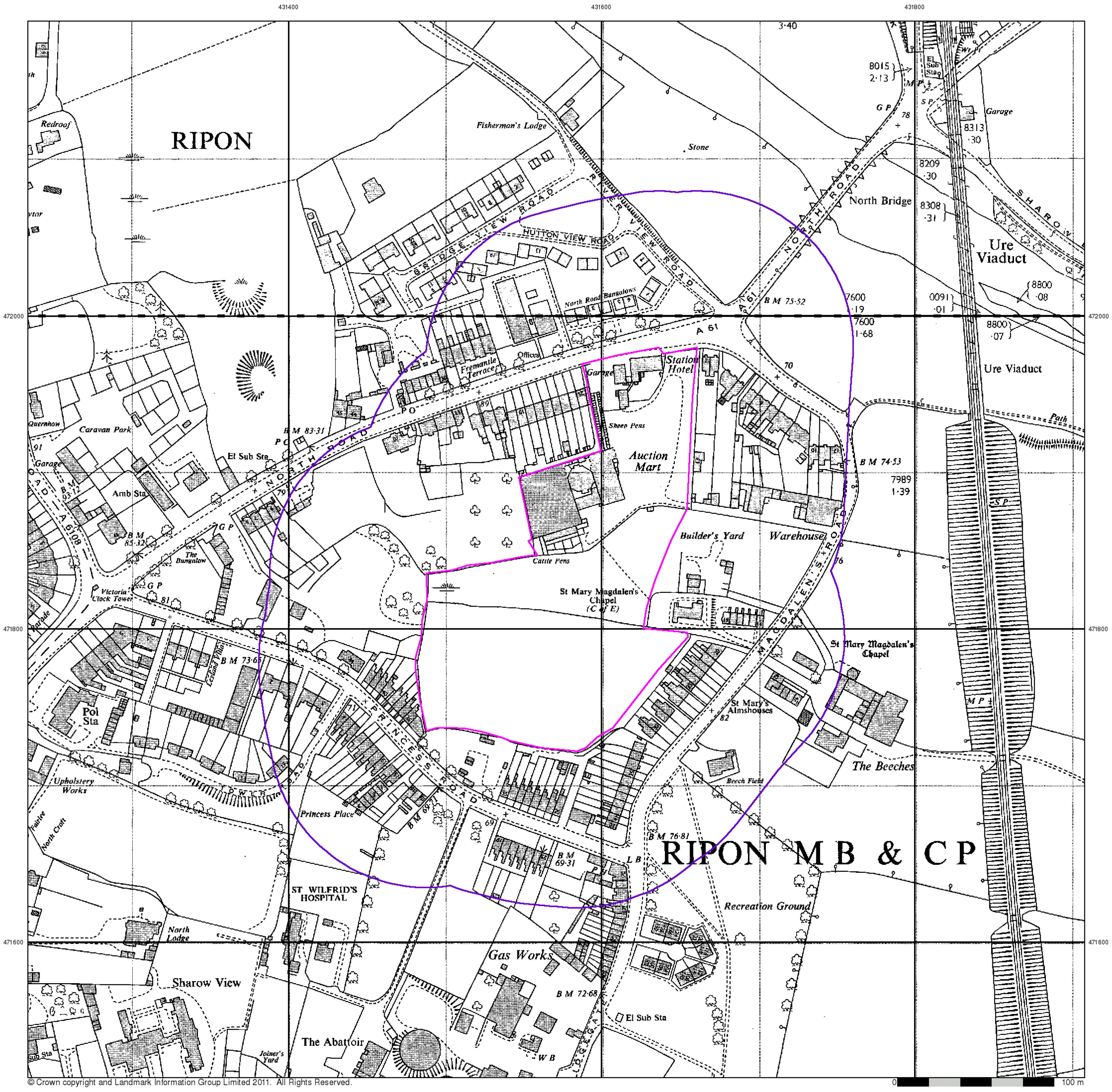


LITHOS CONSULTING

Ordnance Survey Plan

Published 1968

Source map scale - 1:2,500

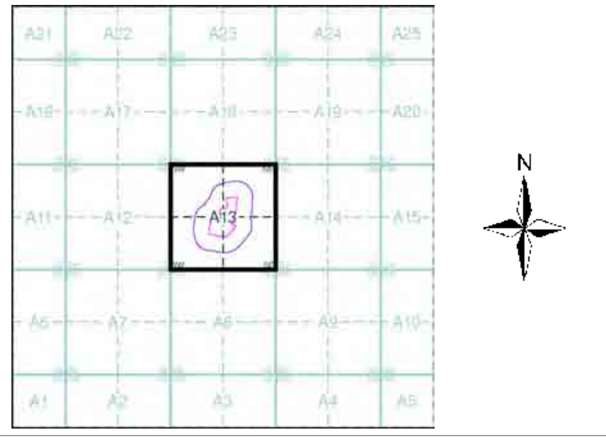
The historical maps shown were reproduced from maps predominantly held at the scale adopted for England, Wales and Scotland in the 1840`s. In 1854 the 1:2,500 scale was adopted for mapping urban areas and by 1896 it covered the whole of what were considered to be the cultivated parts of Great Britain. The published date given below is often some years later than the surveyed date. Before 1938, all OS maps were based on the Cassini Projection, with independent surveys of a single county or group of counties, giving rise to significant inaccuracies in outlying areas.

Map Name(s) and Date(s)

SE3172
1968
1:2,500

SE3171
1968
1:2,500

Historical Map - Segment A13



Order Details

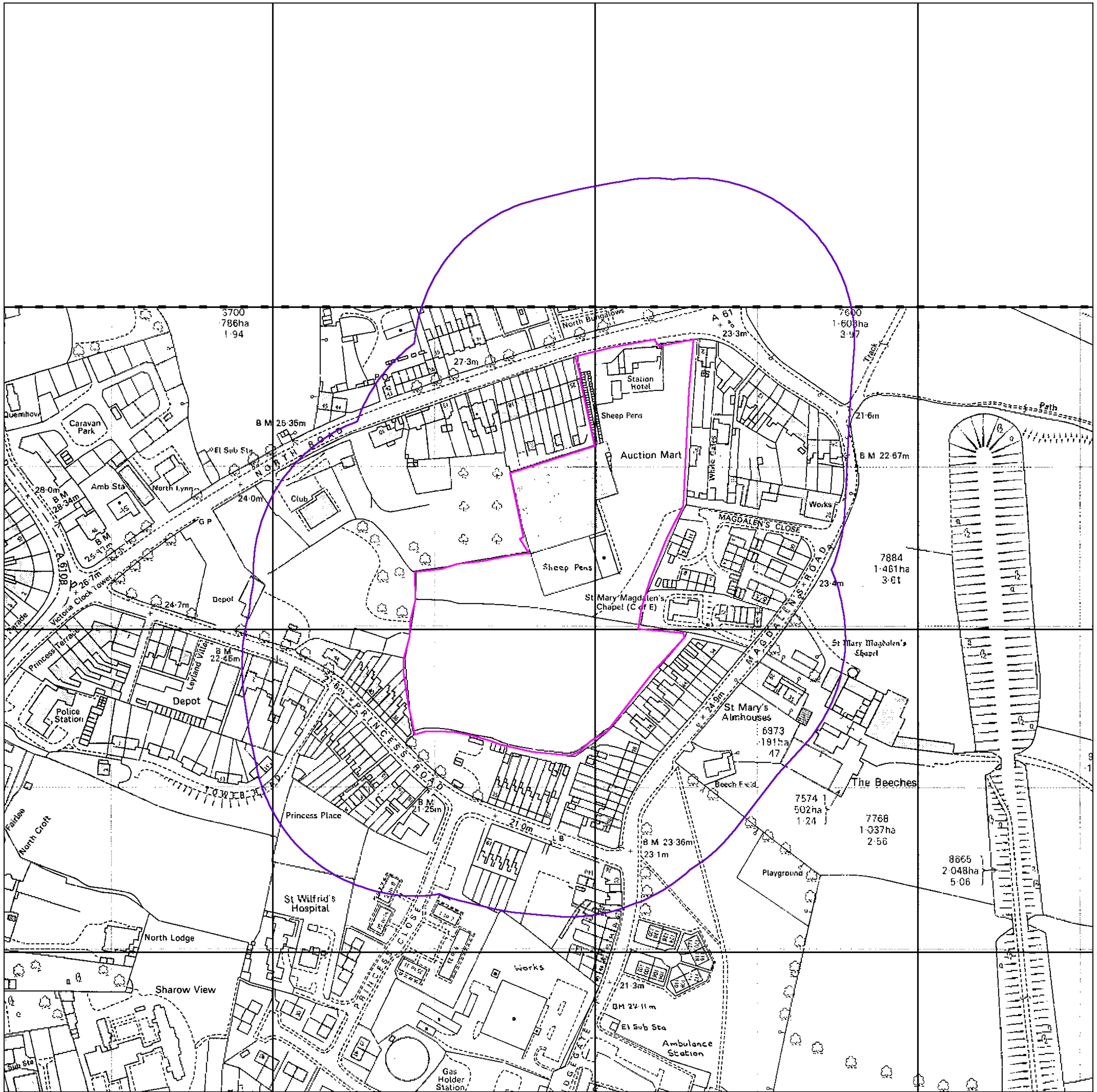
Order Number: 36467960_1_1
Customer Ref: PO6140/1249/RJH
National Grid Reference: 431580, 471850
Slice: A
Site Area (Ha): 2.7
Search Buffer (m): 100

Site Details

Ripon Farmers Live-Stock Mart Co Ltd, The Auction Mart, North Road, RIPON, North Yorkshire, HG4 1JP

Landmark Information Group

Tel: 0844 844 9952
Fax: 0844 844 9951
Web: www.envirocheck.co.uk



0 100 m

LITHOS CONSULTING

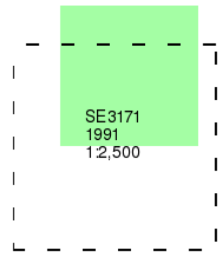
Additional SIMs

Published 1991

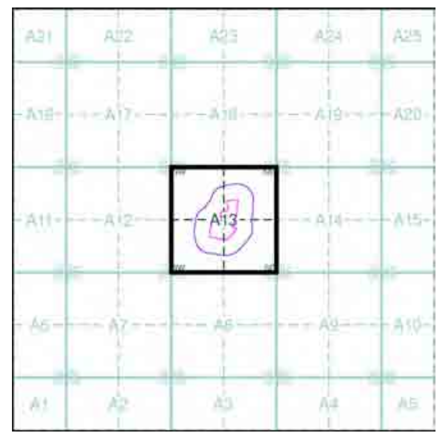
Source map scale - 1:2,500

The SIM cards (Ordnance Survey's `Survey of Information on Microfilm') are further, minor editions of mapping which were produced and published in between the main editions as an area was updated. They date from 1947 to 1994, and contain detailed information on buildings, roads and land-use. These maps were produced at both 1:2,500 and 1:1,250 scales.

Map Name(s) and Date(s)



Historical Map - Segment A13



N

Order Details

Order Number:	36467960_1_1
Customer Ref:	PO6140/1249/RJH
National Grid Reference:	431580, 471850
Slice:	A
Site Area (Ha):	2.7
Search Buffer (m):	100

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