GEO-ENVIRONMENTAL ASSESSMENT - REST OF SITE
BOWBURN ESTATE
DURHAM, NORTHUMBERLAND
CITRUS DURHAM LTD.
GEA-18582Q-16-311
AUGUST 2016

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AN idom GROUP COMPANY

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Document Revisions

Rev	Date	Author	Approved	Issued	Remarks

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GEO-ENVIRONMENTAL ASSESSMENT - REST OF SITE

A Geo-Environmental Assessment was requested by Citrus Durham Ltd. The purpose of the assessment was to identify any contaminative or geotechnical issues associated with current and former land uses at *Bowburn Estate, Durham, Northumberland* which might impact on the site's redevelopment.

SITE DETAILS	
Approximate site area	65 ha
Current/previous use	Peat Edge Farm with fields used for livestock pasture and arable crop growth.
Proposed use	Phased developments of industrial/commercial and retail units, low-rise office blocks with hardstanding, footpaths, access roads and car parking. Limited areas of soft landscaped public open spaces are also proposed.
PHASE 1 NON-INTRUSIVE INVESTIGATION	
Expected geology	Made ground overlying superficial deposits of glacial till
Groundwater	The superficial glacial deposits are classified as unproductive strata. The Pennine Middle Coal Measures bedrock is classified as a Secondary 'A' aquifer. There are no groundwater abstractions within 1 km of the site. The site is not located within a SPZ.
Surface water	The Bowburn Beck is located adjacent to the western boundary of the Phase 2 Residential Area site. According to the EA flood risk data the Bowburn Beck is associated with a 'Zone 2' and a 'Zone 3' floodplain. The site does not benefit from flood defence protection. The closest surface water abstraction is approximately 2.6 km to the south of the site.
Other	The site lies within a Nitrate Vulnerable Zone.
PHASE 2 EXPLORATORY INVESTIGATION	
Ground Conditions	Made ground identified in the south and northwest of the site with topsoil to a maximum depth of 0.60 m bgl overlying glacial till (base not proven).
Contamination	No significant contamination of the soils or groundwater has been identified.
Geotechnical issues	Soft clays / variable ground conditions across most of the site.
RECOMMENDATIONS	
Geotechnical	Shallow pad footings considered feasible, alternatively piles could be considered.
Remediation	The soils, excluding the made ground, are considered to be clean and suitable for re-use in landscaped areas. Made ground may be suitable for re-use as general fill providing geotechnical criteria are met.
Waste classification	Chemical testing suggests a non-hazardous classification for the soils. WAC testing has not been carried out. Natural arisings (except topsoil) would be classed as inert waste without the requirement for WAC testing.
Re-use of site-won materials	It may be possible to re-use site-won soils provided the reported criteria are met. Production of a *Materials Management Plan* under the industry *CL:AIRE Code of Practice on the Definition of Waste* represents a robust method of demonstrating that proposed re-use of materials meets the criteria.

SECTION 1 INTRODUCTION

1.1 Citrus Durham Ltd. (**Citrus**) proposes to develop an area of land located Bowburn for commercial/industrial development purposes. The proposed development forms part of the Bowburn Estate and comprises phased developments of industrial/commercial and retail units, low-rise office blocks with hardstanding, footpaths, access roads and car parking. Limited areas of soft landscaped public open spaces are also proposed. Idom Merebrook Limited (**Merebrook**) has been commissioned by Citrus to undertake preliminary site investigation works and to advise on the geo-environmental implications of the redevelopment of the site for the proposed end use.

1.2 The objectives of the investigation are to:

i. Assess surface and sub-surface ground conditions present at the site;

ii. Identify hazards associated with ground contamination which may place constraints on the site and the proposed development;

iii. Evaluate the risks associated with any identified hazards;

iv. Provide preliminary recommendations for the mitigation of any significant risks identified; and

v. Provide preliminary geotechnical recommendations.

1.3 A Phase 2b ground investigation has been undertaken for the site. This is supplemental to a Phase 1 (non-intrusive) and a Phase 2a (preliminary intrusive) investigation carried out by Merebrook in April 2014 and reported in GEA-18582-14-114 Revision b. This is reproduced in Appendix 2 and the key findings are summarised in Section 2.

1.4 Phase 2 Geo-environmental assessment reports have been completed for the Phase 1 Residential Area (GEA-18582q-16-286), Phase 2 Residential Area (GEA-18582q-16-310) and the Entrance Hub (GEA-18582q-16-302) and should be read in conjunction with this report.

1.5 This report presents the findings of the geo-environmental investigation for the rest of the Bowburn Estate development and provides an interpretation of the geo-environmental conditions that exist at the site. The contaminative status of the site and the implications with respect to development have been interpreted in accordance with the current government guidance on source-pathway-receptor risk assessment. This report uses a Tier 1 risk assessment to ascribe a conservative qualitative appraisal of the hazards associated with the site.

1.6 This report has been prepared for Citrus for the sole purpose described above and no extended duty of care to any third party is implied or offered. Third parties

making reference to the report should consult Citrus and Merebrook as to the extent to which the findings may be appropriate for their use.

SECTION 2 PHASE 1 (NON-INTRUSIVE INVESTIGATION)

2.1 INTRODUCTION

2.1.1 The non-intrusive investigation has been conducted with reference to information contained within the Merebrook Geo-environmental Assessment report reference GEA-18582-14-114b dated April 2014, a copy of which is included in Appendix 2, and the documents and sources detailed in table 1 below:

Table 1: Published Data and Information Sources

SOURCE DATA
BGS 1:50,000 Series Geological Sheet 286
BGS Geology of Britain 1:50,000 online maps
Radon: guidance on protection measures for new dwellings
Environment Agency (EA) online data maps

2.1.2 The above published sources are all authoritative and it is believed that they are reasonably reliable. However, independent verification of the information supplied has not necessarily been carried out and Merebrook cannot be held liable for inaccuracies or deficiencies in the information.

2.2 SITE LOCATION AND SETTING

2.2.1 The subject site investigated here forms the larger part of the Bowburn Estate development and includes phased developments of commercial, industrial and retail areas.

2.2.2 The site is located approximately 5 km to the south east of Durham City and is bounded to the north by the village of Bowburn. The A688 forms the eastern boundary to the site with the A1(M) Junction 61 Durham Services located adjacent to the northeastern site boundary. The Bowburn Sewage Treatment Works is located in the west of the site and is accessed via minor road running east – west through the site off the A688. The western boundary to the site comprises the disused Leamside railway line and the southern boundary comprises the Tursdale Business Centre. The Bowburn Beck river runs approximately north – south through the northern half of the site before heading southwest towards the sewage treatment works and finally towards the west and off site. Peat Edge Farm and its associated buildings are located in the northeast of the site.

2.2.3 The portion of the site that this report is concerned with comprises an area of approximately 65 ha is centred on NGR $^{4}30420$, $^{5}37070$. The site is indicated on drawing 18582q-304-001, presented in Appendix 1 of this report.

2.2.4 The site is dominated by grassland separated into field parcels that are bounded by hedgerows and fences. The fences were generally found to be in poor state of repair with livestock moving freely between fields. The southern and northwestern fields were being used for arable crop growth.

2.2.5 A site walkover did not indicate the presence of any invasive species.

2.2.6 The topography of the site is generally even, sloping from the north gently down towards the southwest and from the northwest towards the southeast. A topographical survey of the site indicates that the site levels vary between approximately 97 m Above Ordnance Datum (AOD) and approximately 75 m AOD.

2.2.7 Surrounding land uses include farmland used for pasture and arable crops, the sewage treatment works to the southwest and Bowburn South Industrial Estate.

2.3 PREVIOUS INVESTIGATIONS

2.3.1 Merebrook carried out an intrusive ground investigation within the wider context of the site in April 2014. The scope of works comprised:

i. Five windowless sampler boreholes (MWS01 to MWS05) to a maximum depth of 5.0 metres below ground level (m bgl); and

ii. Twelve machine excavated trial pits (MTP01 to MTP12) to a maximum depth of 4.4 m bgl.

2.3.2 The key findings of the investigation were as follows:

i. The ground conditions comprised made ground in the south of the site adjacent to the Tursdale Business Park, in the northwest of the site in association with a significant thickness of colliery spoil and in the east of the site in association with the Peat Edge Farm buildings overlying cohesive and granular glacial till;

ii. Shallow groundwater was encountered within granular deposits;

iii. No significant contamination of the soils was identified;

iv. No significant contamination of the groundwater was identified;

v. One round of gas monitoring identified a generally negligible gassing regime however, positive ground gas flow recorded in MWS04 near the farm buildings indicated a Gas Screening Value (GSV) of 0.09 l hr^{-1} meaning gas protection measures are recommended in the vicinity; and

vi. Evidence of acid mine drainage was observed off site leading towards the Bowburn Beck.

2.4 PRELIMINARY CONCEPTUAL SITE MODEL AND RISK ASSESSMENT

2.4.1 From the Phase 1 assessment and the preliminary geo-environmental assessment carried out by Merebrook in April 2014, a site conceptual model and risk assessment have been produced using the framework established in Part 2A of the *Environmental Protection Act 1990* and detailed in Contaminated Land Report *CLR11 - Model Procedures for the Management of Land Contamination*.

2.4.2 Risk from contamination has been assessed using the source-pathway-receptor and pollutant linkage methodology, whereby a risk can only exist if all elements of: source, pathway and receptor, are present.

2.4.3 Potential Sources

i. Potential for heavy metals, polyaromatic hydrocarbons (PAH), petroleum hydrocarbons, asbestos, soil gas/vapour and groundwater contamination associated with made ground and the sites former uses;

ii. Potential for contaminants arising from the fuel service station to the east of the site, the farmyard to the north, the sewage treatment works to the west and the tile works depicted on the historic maps;

iii. Potential for contaminants associated with the colliery spoil depicted to the west of the site in the historical maps.

2.4.4 Potential Pathways

i. Direct contact;

ii. Ingestion and inhalation of contaminated soil and dust/vapours;

iii. Vertical migration to underlying Secondary Aquifer; and

iv. Horizontal migration to the Bowburn Beck.

2.4.5 Potential Receptors

i. Human health (future users and construction workers);

ii. Potable water (permeation of supply pipes);

iii. Adjacent land; and

iv. Controlled waters (underlying aquifer and Bowburn Beck).

2.4.6 Following the Phase 1 assessment and the Phase 2a ground investigation carried out in April 2014 an updated preliminary site conceptual model has been produced which is presented as Table 2 and identifies the potential pollutant linkages. These

have been used to inform the Phase 2 intrusive investigation presented in the subsequent sections.

Table 2: Preliminary Conceptual Model

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	**PATHWAYS**	**RECEPTORS**	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (current users)	**Low risk identified** No significant widespread contamination identified and limited potential for exposure.
	Ingestion and inhalation of contaminated soil and dust	Human health (current users)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (future residents and construction workers)	**Likely low risk but potential for localised moderate risk** No significant widespread contamination identified site wide but potential for localised contamination not yet identified.
	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	
Asbestos (made ground)	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	**Likely low risk but potential for localised moderate risk** Existing farm buildings contain suspected asbestos containing materials. No asbestos identified in limited soils sampling but potential for localised asbestos at the surface and in the upper soil profile.
Contamination (all forms)	Vertical migration to aquifer	Controlled waters	**Low risk identified** No significant widespread contamination identified. Significant aquitard protecting the underlying aquifer.
Contamination (all forms)	Horizontal migration to surface water	Controlled waters	**Low to moderate risk identified** No evidence of current impact from site on surface water quality in Bowburn Beck. There is evidence of acid mine drainage/leaching from colliery spoil, however; this is likely from an off-site source.
Hydrocarbons	Direct contact	Plastic water pipes	**Low / Moderate risk identified** No hydrocarbon contamination identified, however; utility company may require upgraded pipes due to made ground.
Hazardous Gas/Vapours In soil	Ingress into buildings and voids	Human health (future residents and construction workers)	**Likely low risk but subject to further assessment** Preliminary monitoring has not identified significant quantities of hazardous gas. Not likely to present a significant constraint but further assessment required.

SECTION 3 SITE INVESTIGATION RATIONALE

3.1.1 A site investigation rationale has been devised in accordance with the findings of the Phase 1 assessment, Phase2a ground investigation and the resultant preliminary conceptual site model and risk assessment. Priority contaminants

were identified as heavy metals, polyaromatic hydrocarbons (PAH), petroleum hydrocarbons and asbestos.

3.1.2 Intrusive sampling locations were chosen on the basis of providing broad spatial coverage of the site and in areas of possible made ground.

3.2 SITE INVESTIGATION METHODS

3.2.1 An intrusive investigation was carried out by Merebrook between the 6th and 17th June 2016 and comprised the following scope of work:

i. Eight cable percussion borehole (MBH102, MBH104, MBH107 and MBH109 to MBH113) to 25 metres below ground level (m bgl); and

ii. Thirteen machine-dug trial holes (MTP102 to MTP104, MTP107, MTP109 to MTP116 and CBR1 to CBR3) to a maximum depth of 5 m bgl.

3.2.2 Exploratory hole locations are indicated on drawing 18582q-304-001 in Appendix 1. Logging of exploratory holes was undertaken by a Merebrook Officer. Exploratory hole logs are contained in Appendix 3.

3.2.3 Light cable percussion equipment was used to advance the boreholes. Standard Penetration Tests (SPTs) were performed at approximate 1 metre intervals. The tests involved driving a steel cone tipped series of rods into the ground over a distance of 450 mm using the repeated blows of a 63.5 kg weight allowed to free fall over a distance of 760 mm. The total number of blows required for the final 300 mm penetration (the 'N' value) is recorded on the window sample logs.

3.2.4 Monitoring standpipes were installed in MBH107, MBH112 and MBH113 with the slotted pipe forming a response zone within the glacial till. A monitoring standpipe was installed in MBH111 with the slotted pipe forming a response zone within the colliery spoil made ground.

3.2.5 The trial pits were excavated using a Volvo EX98 tracked excavator.

3.2.6 Representative soil samples were taken from various depths and strata to assess the contaminative status of the site. Soil samples were submitted to an MCERTS/ UKAS accredited laboratory for chemical analysis of a broad suite of potential contaminants. The results are provided in Appendix 4.

3.2.7 A programme of geotechnical laboratory testing was performed on selected soil samples obtained from the boreholes, comprising classification and strength tests. Chemical testing was also undertaken to assess the aggressiveness of the ground with respect to buried concrete. The results are provided in Appendix 5.

SECTION 4 GROUND CONDITIONS

4.1 SURFACE GROUND CONDITIONS

4.1.1 The site comprises dominantly grassland used as pasture for livestock and fields of arable crops.

4.2 SUB-SURFACE GROUND CONDITIONS

4.2.1 The results of the investigation indicate the site is underlain by made ground in the northwest of the site coinciding with the colliery spoil and Glacial Till. This is consistent with the published geological record.

4.2.2 A summary of the ground conditions encountered is presented in Table 3, whilst a more detailed assessment of the strata is contained in the following sections of the report.

Table 3: Summary of Sub-surface Ground Conditions

STRATA	DEPTH TO TOP RANGE (m bgl)	THICKNESS RANGE (m)
Topsoil	0.00	0.15 – 0.60
Made Ground	0.00	5.00
Superficial Glacial Till	0.15 – 5.00	>24.85 (base not proven)

4.2.3 Topsoil

4.2.3.1 The topsoil comprised a soft to firm dark brown, slightly desiccated, slightly sandy, slightly gravelly clay with abundant rootlets. The gravels comprised predominantly fine to coarse, angular and subangular sandstone and flint with occasional fine and medium, subangular brick fragments.

4.2.3.2 There was no visual or olfactory evidence of contamination.

4.2.3.3 There was no evidence of groundwater within the stratum.

4.2.4 Made Ground

4.2.4.1 Made ground was only encountered in MBH111 and MTP111 which was located in the northwest of the site and coinciding with the colliery spoil. The made ground comprised dominantly granular deposits of black and reddish pink slightly clayey gravels and cobbles of ash, coal, brick and sandstone.

4.2.4.2 There was no visual or olfactory evidence of gross contamination.

4.2.4.3 Perched groundwater was identified within the made ground in MTP111.

4.2.4.4 SPTs performed within the made ground recorded 'N' values ranging between 9 and 12 indicating loose to medium dense conditions.

4.2.5 **Natural Ground – Superficial Glacial Till**

4.2.5.1 The glacial till was encountered in all of the exploratory holes and comprised cohesive and granular deposits. It formed an upper glaciofluvial complex and a lower consolidated boulder clay.

4.2.5.2 The upper glaciofluvial sediments were composed of variably brown, greyish brown and reddish brown silty, slightly sandy clay. Occasional thin laminations were observed as well as partings of pale grey, black or red sand.

4.2.5.3 A lower unit of boulder clay comprised consolidated, stiff, fissured dark brown, slightly sandy, slightly gravelly clay with frequent lenses of pale grey fine and medium grained sand. The gravels were variably fine to coarse size with occasional cobbles, angular to subrounded and composed dominantly of sandstone with coal and flint. The contact between the strata was observed within the cable percussion boreholes between 10.0 m and 18.0 m bgl.

4.2.5.4 The granular deposits were located in the shallow soils and comprised fine and medium grained sands that were brown, grey and yellowish brown in colour. The most widespread unit comprised a yellowish brown speckled black fine and medium grained sand. The black specks were sand size and fine gravel size coal fragments. A lens of orangish brown and brown, slightly clayey, sandy gravel of coal, platy sandstone and rare igneous and metamorphic rocks was observed within MTP103 and MTP104 between 3.0 m and 4.2 m bgl.

4.2.5.5 There was no visual or olfactory evidence of contamination

4.2.5.6 Shallow groundwater was observed within the gravels bed in MTP103 and MTP104. Groundwater was also observed within sand horizons in the trial pits CBR1, CBR2, MTP114, MTP115 and MTP116 between 1.7 m and 3.35 m bgl. The groundwater mixed with the sand to form a slurry that led to sidewall instability in the excavations and forced their premature closure.

4.2.5.7 Atterberg limit tests carried out on fourteen samples of clay indicate that the soil can be classified as clay of predominantly low and intermediate plasticity. The plasticity index of the soil was found to range between 10 and 31 %, and in accordance with NHBC guidelines, this soil is of low and medium volume change potential. Moisture contents were also determined and ranged from 13 to 33 %.

4.2.5.8 Triaxial tests were performed on twenty-seven undisturbed samples of clay obtained from depths of between 1.2 and 21.5 m bgl in the boreholes. The tests revealed undrained shear strengths ranging from 15 to 287 kN/m². These results are indicative of ground conditions ranging from very soft (very low strength) to very stiff (very high strength). It is possible that low strength values obtained at significant depths are due to sample disturbance.

4.2.5.9 Consolidation tests were carried out on five undisturbed samples of clay obtained from depths of between 2.0 and 4.8 m bgl in the boreholes. The tests revealed values of between 0.232 and 0.523 m²/MN for the coefficient of volume compressibility (Mv) at pressures of between 50 and 100 kN/m² indicative of a soil of medium and high compressibility.

4.2.5.10 SPTs performed within the upper cohesive glaciofluvial till deposits recorded 'N' values ranging between 1 and 28. The 'N' values generally increased with depth. SPTs performed within the lower cohesive boulder clay glacial till deposits recorded 'N' values ranging between 11 and > 50. 'N' values generally increased with depth. One SPT performed within the granular glacial till deposits recorded and 'N' value of 16 which indicates medium dense conditions.

SECTION 5 PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

5.1 GENERAL

5.1.1 The proposed development comprises phases of industrial/commercial and retail units (labelled DC1 to DC6), low-rise office blocks with hardstanding, footpaths, access roads and car parking. Limited areas of soft landscaped public open spaces are also proposed.

5.1.2 It is understood that levels will change in the areas designated for commercial units. In the southern part of the site Unit DC1 will see up to 5 m of fill beneath the southeast corner, whilst Unit DC2 will see 3 m of fill in the northwest corner and 3 m of cut in the southeast corner. For Units DC3 and DC4 up to 4 m of fill is proposed towards the western edge of each building, whilst up to 4 m of cut is proposed towards the eastern edge of each building. In the north western area of the site Unit DC5 will see up to 9 m of cut towards the northern corner of the building, whilst levels will remain relatively unaltered beneath Unit DC6.

5.1.3 The ground investigation encountered ground conditions consisting of limited thicknesses of topsoil overlying superficial deposits of Glacial Till. Made ground comprising colliery spoil (5.0 m thick) was encountered in the north western area beneath unit DC5. SPTs revealed the cohesive superficial deposits to be soft and firm (low and medium strength) in nature, becoming stiff (high strength) with depth.

5.2 FOUNDATIONS

5.2.1 It is indicated that existing made ground in the north-west will be substantially removed by proposed cutting. Nevertheless the footprints of commercial units will straddle areas of cut and fill.

5.2.2 Based on the ground conditions encountered, natural glacial strata should be able to support anticipated loads on pad footings for the large commercial units. For clay soils of medium volume change potential, footings should be founded at a minimum depth of 0.9 m bgl. Footings may need to be locally deepened where

new building footprints are situated within the zone of influence of any existing or proposed trees, in accordance with NHBC guidelines.

5.2.3 As a preliminary guide allowable bearing pressures (ABPs) should be limited to 65 kN/m² for 1.0 x 1.0 square pad footings founded within borderline soft / firm clay. It is recommended at this stage that a single foundation solution be adopted for each unit. Where units are located in both cut and fill, the variation in foundation depths required to reach competent soils will need to be assessed to ensure that pad construction remains feasible. Further testing and assessment would be required to determine whether engineered fill would support pad loads within tolerable levels of settlement.

5.2.4 For the proposed pub-restaurant situated adjacent to the A688 and Durham Services, traditional strip / trench footings are considered likely to suitable based on the ground conditions encountered to date. Allowable bearing pressures of 100 kN/m² will be achievable for strip footings up to 1 m wide founded within firm (medium strength) clay.

5.2.5 Alternatively, consideration should be given to a piled foundation solution. It is envisaged that either driven or bored / Continuous Flight Auger (CFA) piles could be adopted at the site. Driven piles could possibly be utilised as they have the advantage that no arisings are generated, however, the effects of noise / vibrations are likely to be an issue given the proximity of the existing commercial development.

5.2.6 The advantage of using bored / CFA piles is the low noise / vibration of the system, however, arisings are generated by bored / CFA piles. Piles would need to be taken through the upper weak superficial deposits to found within the underlying competent superficial clay. Consideration of piling, which it is understood may be limited by mining restrictions to 15 m depth, are discussed below.

5.2.7 It is recommended that the advice of a specialist contractor be sought in order to determine the most appropriate / cost effective system and to advise on pile diameters, depths and safe working capacity. A guide to safe working loads for individual bored / CFA piles of varying length and diameter is presented in the table below. Pile calculations have been based on assessing skin friction and end bearing resistance in the undisturbed natural strata. No allowance has been made at this stage for any potential drag down (negative skin friction). This should be assessed and allowed for by the designer.

5.2.8 The calculations assume piles of 12 and 15 m length penetrating into the stiff natural clay, whilst no contribution from any existing fill or soft clay has been allowed for. A factor of safety of 2.5 has been applied to the calculated ultimate capacities. Greater safe working capacities would be achievable if piles were taken to greater depth thereby benefiting from increased skin friction contribution and possible greater end bearing resistance. As discussed, these values are for guidance purposes only and should be verified by a specialist contractor. In

addition, the safe working loads given are for individual isolated piles. The group effect should be assessed during the design stage.

Table 4: Safe Working Capacities for bored / CFA Piles

Pile Diameter (mm)	Pile Length (m)	Safe Working Capacity (kN)
300	12	75
	15	120
450	12	125
	15	200
600	12	185
	15	290

5.2.9 Due consideration will need to be given to the adoption of a pile testing programme at the site. It is usual practice to carry out load and integrity tests on a proportion of the installed working piles in order to verify acceptability of the design loads. A specialist piling contractor may recommend that a load test be carried out on at least one sacrificial pile installed in advance of the works. The sacrificial pile/piles should not form part of the permanent works and should be tested to failure in order to assess ultimate capacity.

5.2.10 It is recommended that further more detailed investigation is undertaken in order to provide a better understanding of the ground conditions and to zone the site in terms of foundation requirements.

5.3 EXCAVATIONS AND GROUNDWATER

5.3.1 Based on the ground conditions observed at the site, any shallow excavations have the potential to become unstable in the short term, therefore, if man-entry is required, excavations should be supported by shoring or otherwise battered back to a safe angle in order to protect the workforce from possible collapse.

5.3.2 Groundwater was encountered during the intrusive investigation in the majority of locations at depths of between 1.6 and 4.5 m bgl. In view of this, it is considered possible that groundwater ingress will occur in shallow excavations, therefore, provision for dewatering during the construction period should be considered.

5.4 FLOOR SLABS

5.4.1 In order to construct ground bearing floor slabs for the commercial units the upper natural soils will need to be removed and replaced with suitable compacted

granular material placed to an engineered specification. Consideration may also be given to the use of lime-cement stabilisation to create more competent formations – subject to specialist contactor assessment of the suitability of site soils. This will need to be evaluated further when detailed floor designs, (loads, acceptable settlements and gradients) are available. A suspended floor slab should be adopted for the pub restaurant.

5.5 SLOPE STABILITY

5.5.1 Based on the current cut and fill proposals up to 9 m of cut will be carried out beneath the footprint of Unit DC5. This is likely to result in slopes being formed around the northern and north western sides of the new building. The upper part of the slopes are likely to be constructed within made ground (colliery spoil), whilst natural cohesive soils will be present in the lower part of the slopes. Slope gradients of 1V:3H are considered to be appropriate in these materials, whilst some form of erosion control geotextile and / or new planting should be considered in order to ensure the long term stability of the slopes. It would be prudent to undertake a detailed slope stability assessment for the cut slopes.

5.6 BURIED CONCRETE

5.6.1 Recommendations given in BRE Special Digest 1:2005 *"Concrete in aggressive ground"* have been followed in order to give recommendations with respect to buried concrete.

5.6.2 Water soluble sulphate analysis was carried out on thirty-one soil samples obtained from depths of between 0.0 and 21.5 m bgl with soil pH determination also carried out on these samples. Water soluble sulphate contents typically ranged between <0.01 and 0.42 g/l. In accordance with BRE guidelines the characteristic value is calculated by determining the mean of the highest 20 % of results. In this case the characteristic value is 0.17 g/l. On this basis the Design Sulphate Class is DS-1.

5.6.3 The pH values in the soil samples varied between 6.1 and 8.5. The mean of the lowest 20 % of values is 6.5 which represents the characteristic value. Mobile groundwater conditions have been assumed and on this basis the Aggressive Chemical Environment for Concrete (ACEC) class for the site is AC-1^{d}.

5.7 ROADS AND PAVED AREAS

5.7.1 For preliminary design purposes it is recommended that a California Bearing Ratio (CBR) value of 2 % is assumed for the natural clay. Once the positions of proposed roads and areas of hardstanding have been finalised, *in situ* testing could be undertaken to determine an appropriate design CBR value.

5.8 SOAKAWAYS

5.8.1 The ground investigation has revealed the presence of natural cohesive soils across the site which are not considered to be suitable for the use of shallow soakaways.

SECTION 6 ENVIRONMENTAL ASSESSMENT

6.1 SOIL QUALITY

6.1.1 A total of thirty soil samples from the 2014 and 2016 ground investigations were submitted to the laboratory for chemical analysis, including nine samples from natural ground and twenty-one samples from made ground/topsoil. The laboratory chemical analysis certificates are contained in Appendix 4. The results of the analysis are summarised in Table 5.

6.1.2 An initial screening exercise has been undertaken whereby contaminant concentrations recorded in soils have been assessed against *Suitable for Use Levels* (S4ULs) published in 2015 by LQM/CIEH[1]. These precautionary screening levels are designed to be representative of minimal risk to human health in a number of land use scenarios. In this report S4ULs have been selected for a commercial land use and assuming a soil organic matter of 2.5 %. For lead the DEFRA Category 4 Screening Level[2] has been used as this is based on updated toxicological data and a low risk to human health.

6.1.3 An additional set of phytotoxin screening levels have been adopted from 'The Code of Agricultural Practice for the Protection of Soil' Ministry of Agriculture, Fisheries and Food (MAFF), 1993, which are protective of healthy plant growth.

Table 5: Summary of Soils Chemical Analysis Results

CONTAMINANT	UNITS	MAX	MEAN	No of Tests	SCREENING LEVEL (SL)	No > SL*
HUMAN HEALTH RISK ASSESSMENT						
Asbestos in soil	-	nd	nd	11	Detected	0
pH	-	8.4	7.34	30	5 – 9	0
Arsenic	$mg.kg^{-1}$	36	11.16	30	640	0
Cadmium	$mg.kg^{-1}$	2.3	0.67	30	190	0
Chromium (total)	$mg.kg^{-1}$	74	36.63	30	8600	0
Hexavalent Chromium	$mg.kg^{-1}$	< 1.0	< 1.0	30	33	0
Lead	$mg.kg^{-1}$	160	51.37	30	2300	0
Mercury	$mg.kg^{-1}$	0.39	0.09	30	1100	0

[1] Nathanail, C. P., McCaffrey, C., Gillett, A. G., Ogden, R. C. and Nathanail, J. F. 2015. The LQM/CIEH S4ULs for Human Health Risk Assessment. Land Quality Press, Nottingham. Copyright Land Quality Management Limited reproduced with permission; Publication Number S4UL3100. All rights reserved. Includes August 2015 nickel update.

[2] SP1010 *Development of Category 4 Screening Levels Main Report* (Dec 2013) and SP1010 *Policy Companion Document* (Mar 2014).

CONTAMINANT	UNITS	MAX	MEAN	No of Tests	SCREENING LEVEL (SL)	No > SL*
HUMAN HEALTH RISK ASSESSMENT						
Nickel	$mg.kg^{-1}$	52	29.63	30	980	0
Selenium	$mg.kg^{-1}$	4.2	1.35	30	12000	0
TPH Aliphatic >EC_5 - EC_6	$mg.kg^{-1}$	0.01	< 0.01	30	12000	0
TPH Aliphatic >EC_6 - EC_8	$mg.kg^{-1}$	0.02	< 0.01	30	40000	0
TPH Aliphatic >EC_8 - EC_{10}	$mg.kg^{-1}$	0.01	< 0.01	30	11000	0
TPH Aliphatic >EC_{10} - EC_{12}	$mg.kg^{-1}$	1.5	< 1.5	30	47000	0
TPH Aliphatic >EC_{12} - EC_{16}	$mg.kg^{-1}$	1.9	1.26	30	90000	0
TPH Aliphatic >EC_{16} - EC_{21}	$mg.kg^{-1}$	7.2	2.08	30	1800000	0
TPH Aliphatic >EC_{21} - EC_{35}	$mg.kg^{-1}$	26	5.38	30	1800000	0
TPH Aromatic >EC_5 - EC_7	$mg.kg^{-1}$	0.01	< 0.01	30	86000	0
TPH Aromatic >EC_7 - EC_8	$mg.kg^{-1}$	0.01	< 0.01	30	180000	0
TPH Aromatic >EC_8 - EC_{10}	$mg.kg^{-1}$	0.23	< 0.01	30	17000	0
TPH Aromatic >EC_{10} - EC_{12}	$mg.kg^{-1}$	0.9	< 0.9	30	34000	0
TPH Aromatic >EC_{12} - EC_{16}	$mg.kg^{-1}$	1.5	0.56	30	38000	0
TPH Aromatic >EC_{16} - EC_{21}	$mg.kg^{-1}$	5.7	1.07	30	28000	0
TPH Aromatic >EC_{21} - EC_{35}	$mg.kg^{-1}$	22	3.52	30	28000	0
Benzene	$mg.kg^{-1}$	< 0.01	< 0.01	30	90	0
Toluene	$mg.kg^{-1}$	< 0.01	< 0.01	30	27000	0
Ethylbenzene	$mg.kg^{-1}$	< 0.01	< 0.01	30	180000	0
Xylene	$mg.kg^{-1}$	< 0.01	< 0.01	30	30000	0
Acenaphthene	$mg.kg^{-1}$	0.38	0.28	30	100000	0
Acenaphthylene	$mg.kg^{-1}$	< 0.03	< 0.03	30	100000	0
Anthracene	$mg.kg^{-1}$	0.08	0.05	30	540000	0
Benz(a)anthracene	$mg.kg^{-1}$	0.24	0.12	30	180	0
Benzo(a)pyrene	$mg.kg^{-1}$	0.23	0.05	30	36	0
Benzo(b)fluoranthene	$mg.kg^{-1}$	0.37	0.14	30	45	0
Benzo(ghi)perylene	$mg.kg^{-1}$	0.11	0.09	30	4000	0
Benzo(k)fluoranthene	$mg.kg^{-1}$	0.17	0.11	30	1200	0
Chrysene	$mg.kg^{-1}$	0.28	0.14	30	350	0
Dibenz(ah)anthracene	$mg.kg^{-1}$	0.04	0.04	30	3.6	0
Fluoranthene	$mg.kg^{-1}$	0.53	0.22	30	23000	0
Fluorene	$mg.kg^{-1}$	0.18	0.13	30	71000	0
Indeno(123-cd)pyrene	$mg.kg^{-1}$	0.18	0.09	30	510	0
Naphthalene	$mg.kg^{-1}$	0.08	0.03	30	1100	0
Phenanthrene	$mg.kg^{-1}$	0.34	0.16	30	23000	0
Pyrene	$mg.kg^{-1}$	0.45	0.23	30	54000	0
Phenol	$mg.kg^{-1}$	2.3	0.60	30	1300	0
PHYTOTOXICITY RISK ASSESSMENT						
	Units	**Max**	**Mean**	**No of Test**	**Screening Level (SL)**	**No > SL**
Copper	$mg.kg^{-1}$	110	32.67	30	200	0
Nickel	$mg.kg^{-1}$	52	29.63	30	110	0

CONTAMINANT	UNITS	MAX	MEAN	No of Tests	SCREENING LEVEL (SL)	No > SL*
HUMAN HEALTH RISK ASSESSMENT						
Zinc	$mg.kg^{-1}$	330	103.63	30	300	0

Notes: * Number of samples exceeding screening level nd = not detected

6.1.4 **Zootoxic Metals (harmful to human health)**

6.1.4.1 There are no exceedances for zootoxic metals.

6.1.5 **Phytotoxic Metals (harmful to plant health)**

6.1.5.1 There are no exceedances for phytotoxic metals.

6.1.6 **Organic Contaminants**

6.1.6.1 There are no exceedances for organic contaminants.

6.1.7 **Inorganic Contaminants**

6.1.7.1 There are no exceedances for inorganic contaminants.

6.1.8 **Summary**

6.1.8.1 No significant contamination has been identified in the made ground.

6.1.8.2 No significant contamination has been found in natural ground.

6.2 **GROUNDWATER**

6.2.1 Groundwater level monitoring and sampling was undertaken on two occasions. The water level monitoring results are summarised below in Table 6.

Table 6: Summary of Groundwater Levels

Well	Response Zone (m)	Response Stratum	Depth to water (m)	Date
MBH104	1.0 – 10.0	Glacial Till	0.20*	28/06/2016
MBH111	1.0 – 5.0	Made Ground	2.84	28/06/2016
MBH112	1.0 – 10.0	Glacial Till	2.75	27/06/2016
MBH113	2.9 – 4.1	Glacial Till	3.85	27/06/2016
MWS02	0.5 – 1.5	Made Ground	1.41	14/04/2014
MWS03	0.8 – 3.8	Glacial Till	1.74	14/04/2014
MWS04	0.5 – 2.5	Glacial Till	0.38*	14/04/2014
MWS05	0.5 – 1.5	Made Ground	0.57	14/04/2014

* Response zone is submerged

6.2.1.2 Groundwater samples were not collected from the monitoring standpipe installations during the 2014 ground investigation.

6.2.1.3 Samples were collected from MBH104, MBH11 and MBH112 in June 2016 and were submitted to the laboratory for analysis of a broad contamination suite. Screening levels for groundwater have been derived from the Maximum Allowable Concentrations (MAC) in the Water Supply (Water Quality) Regulations 2010 where prescribed, or for those determinands not included, the 1989 regulations. The laboratory chemical analysis certificate is contained in Appendix 6 and groundwater level data is contained in Appendix 7. A summary of groundwater contaminant concentrations is contained in Table 7.

6.2.1.4 The samples collected from MBH104 and MBH112 were derived from perched pockets within granular horizons in the Glacial Till. The sample collected from MBH104 was derived from perched water within the made ground colliery spoil.

Table 7: Summary of Groundwater Chemical Analysis Results

CONTAMINANT	UNITS	GLACIAL TILL		COLLIERY SPOIL		SCREEN LEVEL (SL)	>SL*
		MAX	MEAN	MAX	MEAN		
pH	-	7.8	7.28	6.9	6.9	6.5**	0
Arsenic	$\mu g.l^{-1}$	1.8	1.80	0.35	0.35	10	0
Cadmium	$\mu g.l^{-1}$	0.03	0.03	0.09	0.09	5	0
Chromium (total)	$\mu g.l^{-1}$	< 0.25	< 0.25	< 0.25	< 0.25	50	0
Copper	$\mu g.l^{-1}$	2.9	2.75	3.9	3.9	2000	0
Lead	$\mu g.l^{-1}$	0.13	0.11	0.37	0.37	10	0
Mercury	$\mu g.l^{-1}$	< 0.01	< 0.01	< 0.01	< 0.01	1	0
Nickel	$\mu g.l^{-1}$	4.6	4.05	12	12	20	0
Selenium	$\mu g.l^{-1}$	0.69	0.56	4.7	4.7	10	0
Zinc	$\mu g.l^{-1}$	19	17.50	67	67	5000	0
Cyanide	$\mu g.l^{-1}$	< 40	< 40	< 40	< 40	50	0
Sulphate	$mg.l^{-1}$	350	235.00	1900	1900	250	0
TPH	$\mu g.l^{-1}$	< 10	< 10	< 10	< 10	10	0
BTEX	$\mu g.l^{-1}$	< 1.0	< 1.0	< 1.0	< 1.0	-	0
PAH (total)	$\mu g.l^{-1}$	< 0.07	< 0.01	<0.07	<0.07	-	0
PAH****	$\mu g.l^{-1}$	< 0.1	< 0.1	<0.1	<0.1	0.1	0
Benzo(a)pyrene	$\mu g.l^{-1}$	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0
Naphthalene	$\mu g.l^{-1}$	< 0.01	< 0.01	< 0.01	< 0.01	-	0
Phenols	$\mu g.l^{-1}$	< 0.50	< 0.50	< 0.50	< 0.50	0.5	0

Notes: * Samples exceeding screen level

** Minimum value applies (i.e. most acid)

*** Not detected above screening level

**** sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene & indeno(1,2,3-cd)pyrene

6.2.2 No significant contamination has been detected in the groundwater samples.

6.2.3 In addition to the samples collected from the exploratory holes, water samples were collected from the Bowburn Beck and submitted to the laboratory for analysis of a broad contamination suite. Screening levels for groundwater have been derived from the Maximum Allowable Concentrations (MAC) in the Water Supply (Water Quality) Regulations 2010 where prescribed, or for those determinands not included, the 1989 Regulations. The laboratory chemical analysis certificates are contained in Appendix 6. A summary of groundwater contaminant concentrations comparing samples collected in 2014 and 2016 against the screening level is contained in Table 8.

Table 8: Summary of Bowburn Beck Water Chemical Analysis

CONTAMINANT	UNITS	APRIL 2014		JUNE 2016		SCREEN LEVEL (SL)	>SL*
		MAX	MEAN	MAX	MEAN		
pH	-	8	7.97	7.8	7.50	6.5**	0
Arsenic	$\mu g.l^{-1}$	0.65	0.59	0.86	0.68	10	0
Cadmium	$\mu g.l^{-1}$	0.08	0.07	0.1	0.10	5	0
Chromium (total)	$\mu g.l^{-1}$	0.43	0.36	0.37	0.34	50	0
Copper	$\mu g.l^{-1}$	7.5	5.57	4.7	3.65	2000	0
Lead	$\mu g.l^{-1}$	1.2	0.97	0.73	0.50	10	0
Mercury	$\mu g.l^{-1}$	< 0.01	< 0.01	< 0.01	< 0.01	1	0
Nickel	$\mu g.l^{-1}$	3.6	3.40	3	3.00	20	0
Selenium	$\mu g.l^{-1}$	1.7	1.40	1.7	1.20	10	0
Zinc	$\mu g.l^{-1}$	68.5	60.63	49	33.50	5000	0
Cyanide	$\mu g.l^{-1}$	< 40	< 40	< 40	< 40	50	0
Sulphate	$mg.l^{-1}$	540	443.33	220	200.00	250	0
TPH	$\mu g.l^{-1}$	< 10	< 10	< 10	< 10	10	0
BTEX	$\mu g.l^{-1}$	< 1.0	< 1.0	< 1.0	< 1.0	-	0
PAH (total)	$\mu g.l^{-1}$	0.11	< 0.1	<0.07	<0.07	-	0
PAH****	$\mu g.l^{-1}$	< 0.1	< 0.1	<0.1	<0.1	0.1	0
Benzo(a)pyrene	$\mu g.l^{-1}$	< 0.01	< 0.01	< 0.01	< 0.01	0.01	0
Naphthalene	$\mu g.l^{-1}$	< 0.01	< 0.01	< 0.01	< 0.01	-	0
Phenols	$\mu g.l^{-1}$	< 0.50	< 0.50	< 0.50	< 0.50	0.5	0

Notes: * Samples exceeding screen level
** Minimum value applies (i.e. most acid)
*** Not detected above screening level
**** sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene & indeno(1,2,3-cd)pyrene

6.2.4 No contamination has been detected in the water samples collected from the Bowburn Beck.

6.3 HAZARDOUS GAS

6.3.1 Gas monitoring has been undertaken on two occasions. The first round took place on the 14th April 2014. The second round took place on the 27th June 2016 measuring levels within the recently installed cable percussion boreholes only. Levels of methane, carbon dioxide and oxygen were recorded in each standpipe, together with associated parameters including borehole flow and ambient air pressure. The results of these gas monitoring rounds are contained in Appendix 7.

6.3.2 Monitoring of exploratory holes installed within the colliery spoil, MBHH111 (2016) and MWS05 (2014) were undertaken at barometric pressures ranging between 1003 mb and 1015 mb. Positive flow was not detected. During the monitoring round methane (CH_4) was not detected, carbon dioxide (CO_2) was detected to a maximum of 10.7 % by volume (% v/v) with a corresponding depleted oxygen concentration of 5.9 % v/v.

6.3.3 Monitoring of exploratory holes installed within the rest of the site, MBH104 and MBH112 (2016) and MWS02, and MWS03 (2014) were undertaken at barometric pressures ranging between 1004 mb and 1015 mb. The response zones for MBH104 and MWS104 were submerged meaning the data cannot be used for interpretation.

6.3.4 Positive flow was not detected. During the monitoring round methane (CH_4) was not detected, carbon dioxide (CO_2) was detected to a maximum of 2.3 % by volume (% v/v) with a corresponding depleted oxygen concentration of 14.7 % v/v. Neither carbon monoxide (CO) nor hydrogen sulphide (H_2S) were detected.

6.4 WASTE CLASSIFICATION, OFF-SITE DISPOSAL OR RE-USE

6.4.1 Waste Considerations

6.4.1.1 Contaminant concentrations in the soil samples suggest a non-hazardous classification

6.4.1.2 Asbestos was not detected within the soil samples and no visible fragments were observed during the ground investigation. It is advised (for information) that soils containing visible asbestos are considered as mixed wastes and can attract a hazardous waste classification.

6.4.1.3 Natural as-dug arisings (excluding topsoil) could be classed as inert waste without the requirement for WAC testing.

6.4.2 WAC testing has not been carried out.

6.4.2.1 Materials, including waste soils which are not to be retained on site, should be removed and disposed of in accordance with all relevant statues including the *Environmental Protection Act 1990*, *The Controlled Waste Regulations 2012* as amended, *The Waste Regulations 2011* as amended, *The List of Wastes Regulations 2005* as amended, *The Hazardous Waste Regulations 2005* as

amended, *The Waste Management Regulations 2006* and *The Environmental Permitting Regulations 2010* as amended.

6.4.2.2 It is a requirement of these regulations that waste sent to landfill should have been subject to measures to reduce the amount of waste, reduce harmful or hazardous properties and facilitate recycling. These requirements may be satisfied by measures such as segregation and screening of wastes to recover suitable fill and material for crushing, segregation of inert materials and putrescible wastes.

6.4.3 Re-use Considerations

6.4.3.1 The development proposals require the re-contouring of the site levels. It may be possible to re-use site-won soils provided the following criteria are met:

i. Use of the material will not create an unacceptable risk of pollution to the environment or harm to human health;

ii. The material must be chemically and geotechnically suitable without further treatment;

iii. There must be certainty of use within the scheme; and

iv. Material should only be used in the quantity necessary for that use.

6.4.3.2 Provided these criteria are met, the re-use of site-won materials is unlikely to be deemed a waste activity. Production of a *Materials Management Plan* under the industry *CL:AIRE Code of Practice on the Definition of Waste* represents a robust method of demonstrating that proposed re-use of materials meets the criteria.

SECTION 7 RISK ASSESSMENT

7.1 The potential sources of contamination at the site and the implications with respect to development have been interpreted in accordance with the current government guidance on source-pathway-receptor risk assessment.

7.2 The investigations demonstrate that the former uses of the site have not resulted in any significant chemical contamination. Elevated carbon dioxide gas has been detected within gas monitoring pipes in colliery spoil made ground. These materials are considered for their potential to act as sources for a number of pollutant linkages.

7.3 The potential impacts of contamination sources have been considered with respect to the following receptors:

i. The general public and present site users,

ii. Users of future development,

iii. Groundwater,

iv. Surface water,

v. Construction workers,

vi. Adjacent land, and

vii. Infrastructure.

7.4 In each case the existence of a pollutant linkage requires a pathway by which the receptor could be exposed to the source. A qualitative assessment of risk is thus considered in the first instance with respect to the site in its current condition and is summarised in the sections below.

7.5 **The general public and present site users**

7.5.1 The site is used for grazing livestock and arable farming. Access to the general public is precluded.

7.5.2 No significant risks have been identified on the site.

7.6 **Future users of the development**

7.6.1 Soil contamination (chemical)

7.6.1.1 No significant risks are considered to be posed to future users on the site.

7.6.2 Asbestos

7.6.2.1 Asbestos was not detected on the site and no significant risks are considered to be posed to future users.

7.6.3 Hazardous Soil Gas/Vapours – Colliery Spoil (including hydrocarbon vapours/radon)

7.6.3.1 BS8485 (2015) and CIRIA 665 guidance have been followed to assess the recorded soil gas and flow conditions. Calculations are presented in Appendix 8 which suggest that the Gas Screening Value (GSV) for the site is <0.01 l hr^{-1}.

7.6.3.2 According to the Modified Wilson & Card system which is suitable for this site, the elevated carbon dioxide concentration detected in MBH111 corresponds to a classification of Characteristic Situation 2. Normally, this would trigger consideration if implementing the following mitigation measures:

- Reinforced concrete cast in situ floor slab (suspended, non-suspended or raft) with at least 1200 g DPM^2 and underfloor venting; and
- All joints and penetrations sealed; or
- Beam and block or pre-cast concrete and 2000 g DPM/ reinforced gas membrane and underfloor venting; and,

- All joints and penetrations sealed.

7.6.3.3 The source of the ground gas may be resulting from the biodegradation of organic material within the made ground. However due to the proposed re-contouring the gas source materials and resulting gas risk regime will be substantially altered. This could result in short-term increases in carbon dioxide generation in made ground disturbed, moved and placed, although long term, it is anticipated the worse gas regime identified to date would diminish. In addition, it is likely that the risk of ingress and accumulation into the large internal areas in the commercial units would be low. At this stage consideration should be given to including protection measures to enclosed ground floor spaces in fill areas. However, it is recommended that plot specific monitoring and risk assessment be undertaken to confirm final mitigation details.

7.6.4 Hazardous Soil Gas/Vapours – Unfilled areas in rest of Site (including hydrocarbon vapours/radon)

7.6.4.1 BS8485 (2015) and CIRIA 665 guidance have been followed to assess the recorded soil gas and flow conditions. Calculations are presented in Appendix 8 which suggest that the Gas Screening Value (GSV) for the site is < 0.01 l hr^{-1} which according to the Modified Wilson & Card system corresponds to classification of Characteristic Situation 1 meaning no gas protection measures are required.

7.6.4.2 The site does not lie within a radon affected area as defined by the Health Protection Agency (less than 1 % of houses are above the action level). Guidance issued by the Buildings Research Establishment (BRE-211) indicates that no radon protection measures are necessary.

7.6.4.3 The reported results are based upon one round of gas monitoring. Additional monitoring rounds may be required.

7.7 **Controlled waters**

7.7.1 No significant contamination has been identified within the soil or water samples analysed.

7.7.2 As no contamination was found in the soils the potential for leaching of contamination into controlled waters is considered to be low.

7.8 **Construction workers**

7.8.1 Potentially, construction workers are initially at the greatest risk from exposure to hazardous contamination due to excavation works and during the handling of materials including imported soils. No significant contamination was identified in the soils and there is a limited thickness of made ground on the site.

7.8.2 The risk to construction workers is considered to be low from soil contamination.

7.8.3 There is a risk of accumulation of carbon dioxide gas to hazardous levels within deep excavations and sub-floor voids and chambers.

7.9 **Adjacent land**

7.9.1 No significant contamination has been identified on site and the risk to adjacent land from site-derived contamination is considered to be low.

7.9.2 There is no evidence of the migration of contamination from adjacent land to the subject site.

7.10 **Infrastructure**

7.10.1 The risks to plants from site-derived contamination is considered to be low as phytotoxic contamination was not observed. The cosmetic appearance and composition of the topsoil indicates it should be suitable to reuse in domestic gardens and public open spaces subject to confirmation of nutrient status.

7.10.2 Limited contamination with the potential to permeate polymeric services has been identified by this investigation, however it is recommended that the utility provider is consulted with respect to their requirements for water supply pipes.

7.10.3 Utility companies apply strict guideline levels on use of polymeric pipes and may consider all made ground unsuitable for typical plastic pipe materials to be used.

SECTION 8 UPDATED CONCEPTUAL MODEL

8.1 Following completion of phases 1, 2a and 2 of the investigation and a qualitative risk assessment, the conceptual model for the site, with relation to pollutant linkages, has been updated. The revised model is presented in Table 9 below.

Table 9: Revised Conceptual Model

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	**PATHWAYS**	**RECEPTORS**	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (current users)	**Low risk identified** No significant contamination identified on the site. Site is used for pasture and crops and is not accessible to the general public.
	Ingestion and inhalation of contaminated soil and dust	Human health (current users)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (future users and construction workers)	**Low risk identified** No significant contamination identified on site.
	Ingestion and inhalation of contaminated soil and dust	Human health (future users and construction workers)	
Asbestos (made ground)	Ingestion and inhalation of contaminated soil and dust	Human health (future residents and construction workers)	**Low risk identified** Asbestos was not detected

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	**PATHWAYS**	**RECEPTORS**	
Contamination (all forms)	Vertical migration to aquifer	Controlled waters	**Low risk identified** No contamination was identified in the soil samples. Superficial glacial till deposits are classified as unproductive strata. The ground investigations found water bearing granular deposits to be truncated and discontinuous. Site has a thick unsaturated zone above the Secondary 'A' aquifer.
	Horizontal migration to surface water	Controlled waters	**Low risk identified** No contamination identified in the soil samples to affect the Bowburn Beck 260 m to the west.
Hydrocarbons	Direct contact	Plastic water pipes	**Low risk identified** Hydrocarbon contamination was not encountered.
Hazardous Gas/Vapours In soil	Ingress into buildings and voids	Human health (future residents and construction workers)	**Low-Moderate risk identified** Initial monitoring suggests the portions of the site in the vicinity of the colliery is classified as Characteristic Situation 2 (Modified Wilson & Card) and some protective measures are recommended. This will change due to proposed cut & fill works. Further monitoring assessment required. The rest of the site is classified as Characteristic Situation 1 and no protective measures are recommended. Risk of carbon dioxide gas in deep trenches, excavations and voids
Adjacent Land	Horizontal migration to subject site	Subject site	**Low risk identified** No evidence of off-site contamination impacting site.

SECTION 9 PRELIMINARY REMEDIATION STRATEGY

9.1 The proposed development comprises a series of industrial/commercial and retail units with low-rise office blocks, hardstanding, access roads, car parking and limited soft landscaped public open spaces.

9.2 No significant contamination of the soils or groundwater has been identified on site and no significant risks have been identified.

9.3 The area of the site in the vicinity of the colliery spoil is classified as Characteristic Situation 2 (Modified Wilson & Card) and some gas protection measures are recommended, on the basis of the current gas regime. A further gas risk assessment is recommended to assess the gas risk when site reprofiling is undertaken. The rest of the site has a negligible gassing regime and is not in an area where radon protection is required. However, as the monitoring standpipe in MWS04 was submerged, there is no data for the gassing regime beneath the farm

yard and buildings. Post demolition investigations with the installation of monitoring standpipes is recommended.

9.4 No specific soil remediation is required.

9.5 Above ground tanks have been identified in the farm building complex. Following the decommissioning and removal of these tanks and all associated pipework during the development works, the soils should be investigated to determine their contaminative status. Any further tanks identified on site during the development works should also be investigated.

9.6 Given the character and composition of the soils on site they are considered clean and suitable for use in private gardens and soft landscaped areas subject to further visual inspection and confirmation of nutrient status.

9.7 If the quantities of soil for re-use are insufficient on site and material is imported for the formation of landscaped areas, they should be obtained from a validated source. The validation should incorporate an assessment of the provenance of the material and chemical analysis.

9.8 Potential risks for construction workers from contamination of the soils is considered to be low however; appropriate Health and Safety procedures will ensure that risks to operatives at the site are further minimised. Operatives should not be allowed to eat, drink or smoke on site except in designated areas and should be required to wash all exposed skin at the end of each shift. Operatives should be required to report any observations of suspect material.

9.9 It is recommended that this report is submitted to the regulators (Local Authority EHO and Planners, Environment Agency Planning Liaison and NHBC) for approval prior to commencement of the works.

9.10 Any observations of ground conditions atypical of those already described should be reported to Merebrook immediately so that an assessment of appropriate action can be made.

SECTION 10 CONCLUSIONS

10.1 The site is underlain by a thin veneer of topsoil overlying superficial cohesive and granular Glacial Till. The Pennine Middle Coal Measures bedrock was not encountered during the ground investigation. Significant thicknesses of made ground were identified in the northwest of the site coinciding with spoil waste from the nearby disused colliery and in the extreme south of the site that are associated with the adjacent Tursdale Business Centre.

10.2 No significant contamination of the groundwater or soils has been identified and no specific remediation is required.

10.3 The made ground soils within the colliery spoil and south of the site are unlikely to be suitable for reuse as subsoil in private gardens or public open space landscaping. The soils are clean and considered suitable for re-use in domestic gardens and communal soft landscaped areas. However, site-won topsoil should be subject to additional visual inspection and its nutrient status established prior to use.

10.4 Initial ground gas monitoring suggests a low risk gassing regime in existing fill areas and negligible gas risk elsewhere. Further assessment may allow this risk rating to be revised.

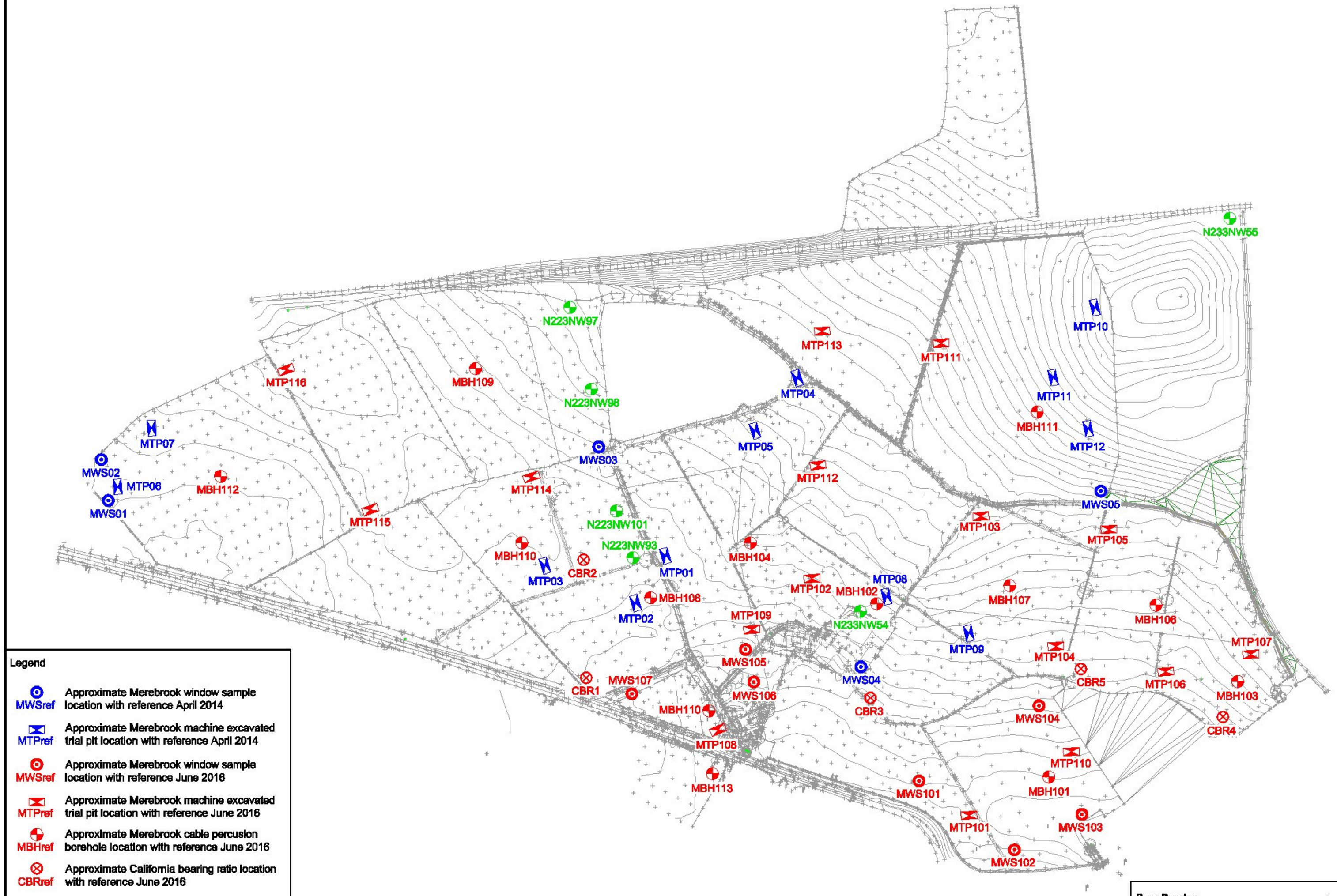
10.5 Any soils that require to be imported to site for use in landscaped areas should be obtained from a validated source.

10.6 For the purposes of waste, the soils are considered to be non-hazardous. Natural as-dug arisings (excluding topsoil) could be classed as inert waste without the requirement for WAC testing. WAC testing has not been carried out. This would be a requirement in order to assess whether non-hazardous arisings are suitable for disposal at an inert landfill.

10.7 The development proposals require the re-contouring of the site levels. It may be possible to re-use site-won soils provided the reported criteria are met.

10.8 Shallow pad footings are considered feasible for the large commercial units where depths of fill permit, whilst as an alternative, piled foundations could be adopted across the site in general. Traditional strip / trench footings are likely to be suitable for the pub restaurant situated adjacent to the A688 and Durham Services. Suspended floor slabs will be required for the pub restaurant, whilst ground bearing floor slabs will be required for the commercial units. Buried concrete classes DS-1 and AC-1^{d} will apply for this site.

APPENDIX 1 ▪ Drawings



Legend

MWSref	Approximate Merebrook window sample location with reference April 2014
MTPref	Approximate Merebrook machine excavated trial pit location with reference April 2014
MWSref	Approximate Merebrook window sample location with reference June 2016
MTPref	Approximate Merebrook machine excavated trial pit location with reference June 2016
MBHref	Approximate Merebrook cable percusion borehole location with reference June 2016
CBRref	Approximate California bearing ratio location with reference June 2016
ref	Approximate historical borehole location with reference

Base Drawing	-	DATE19-07-2016	REV -
		D.M.S. C.B.	R.G.
Issue Details		Dwn Chd	App'd

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Dwg Title: Site Investigation Locations

Job No. 18582q	Dwg No. 18582q-304-001	Revision -
Scale NTS	Date July 2016	Frame Dimensions mm (A3) 400 x 280
Drawn D.M.S.	Checked C.B.	Approved R.G.

APPENDIX 2 ▪ GEA-18582-14-114b

all together better

PRELIMINARY GEO-ENVIRONMENTAL ASSESSMENT
ACORN BUSINESS PARK
DURHAM
GUERNSEY PROPERTY INVESTMENTS LIMITED
GEA-18582-14-114
APRIL 2014

AN idom GROUP COMPANY

merebrook consulting

PRELIMINARY GEO-ENVIRONMENTAL
ASSESSMENT
ACORN BUSINESS PARK
DURHAM
GUERNSEY PROPERTY INVESTMENTS LIMITED
GEA-18582-14-114
APRIL 2014

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SECTION 1 INTRODUCTION

1.1 BRIEF

1.1.1 Idom Merebrook Limited (Merebrook) has been commissioned by Guernsey Property Investments Limited to prepare a Preliminary Geo-environmental Assessment for a site at Acorn Business Park, Durham.

1.1.2 The proposed development is understood to be mixed residential and commercial.

1.2 OBJECTIVES

1.2.1 The objectives of the Preliminary Geo-environmental Assessment are to:

i. Undertake a site walkover;

ii. Review the historical and current land uses associated with the site and assess the potential for ground contamination;

iii. Review the environmental setting of the site and assess the sensitivity of the surrounding environment to any potential contamination;

iv. Review potential sources of contamination on/or adjacent to the site;

v. Assess surface and sub-surface ground conditions present at the site;

vi. Identify hazards associated with ground contamination which may place constraints on the site and the proposed development;

vii. Evaluate the risks associated with any identified hazards;

viii. Provide preliminary recommendations for the mitigation of any significant risks or potential liabilities identified; and

ix. Provide preliminary geotechnical recommendations

1.2.2 The contaminative status of the site and the implications with respect to any future development has been interpreted in accordance with the current published guidance on source-pathway-receptor risk assessment.

1.3 LIMITATIONS

1.3.1 This report has been prepared for Guernsey Property Investments Limited for the sole purpose described above and no extended duty of care to any third party is implied or offered. Third parties making reference to the report should consult Guernsey Property Investments Limited and Merebrook as to the extent to which the findings may be appropriate for their use.

SECTION 2 SITE SETTING AND LAND USE

2.1 SITE LOCATION

2.1.1 The site is located close to the city of Durham.

2.1.2 The site occupies an area of approximately 76 hectares and is located at National Grid Reference 430765, 537425.

2.1.3 The site is situated to the west of junction 61 of the A1 (M). To the north is Bowburn, comprising residential and industrial land use. To the south of site is farmland and Tursdale Business Park. To the west of site are a sewage works, disused railway line and farm land. The site is shown on the Site Location Plan in Appendix 1.

2.2 SITE DESCRIPTION AND SITE WALKOVER SURVEY

2.2.1 A site walkover was undertaken by a Merebrook representative on 1 April 2014.

2.2.2 A sketch plan is contained in Appendix 1 identifying points of interest encountered during the walkover.

2.2.3 The site was comprised of undulating fields, some of which were grassed and others were cropped with oilseed rape. The fields were demarcated by hedgerows and dilapidated wooden fences. Four small areas of waterlogged low-lying land (labelled 1 to 4 on the site walkover plan presented in Appendix 1) were encountered to the south, the middle of site, the west beyond the railway line and the far north.

2.2.4 Vegetation along the northern boundary comprised bushes and trees, with an area of woodland (mainly conifers with some deciduous trees around the edges). The western boundary (along the railway) and the eastern boundary were vegetated with bushes and small trees. Coniferous woodland, with some deciduous trees along the edges, was encountered along the southern part of the western boundary.

2.2.5 The railway starts level with site in the northwest corner and proceeds south onto a high embankment, reaching its highest point adjacent to the sewage works, then becomes more level to the south.

2.2.6 The following areas of potential contamination were identified by the walkover:

i. An area of woodland in the northwestern portion of the site rises from the northern boundary and evidence of colliery spoil was observed at the surface (No. 5 on the site walkover plan) and on land immediately north of the site boundary. Colliery spoil was also observed in the steep bank adjacent to the eastern half of the northern boundary (No.6 on the walkover plan).

ii. Bright orange staining was observed in the stream running adjacent to the disused railway along the western boundary in the northwestern portion of the site (No. 7 on the walkover plan).

iii. Plastic and metal fuel/oil drums were encountered in Peat Edge Farm yard (No. 8 on the walkover plan). Potential asbestos containing cement sheets were associated with farm buildings (No.9 on the walkover plan) and a slurry tank (No.10 on the walkover plan) was identified.

iv. Colliery spoil was observed at the surface in the southern corner of the site (encroaching from a wooded area where colliery spoil exists) (No.11 on the walkover plan).

v. Fly-tipped materials were observed at location No's.12 and 13 on the walkover plan.

2.3 SITE HISTORY

2.3.1 The site history, based on a review of the historic and current maps, dating from 1857 to present is summarised below. Potentially contaminative land uses are shown in bold. Copies of the maps used in this review are provided in Appendix 2.

Table 1: Summary of the key features shown on historic maps

Data Source	Site / Surroundings
County Series 1857 (1:2,500 scale), (1:10,560 scale)	The site was formed of several fields some of which were delineated by hedgerows. Bowburn Beck crosses the site from the northeast. Towards the middle of the site was a well. Properties were identified on site known as Peat Edge (which included a well) and Crow Trees. **Crow Trees Tile Works** was identified towards the middle of the site. The **North Eastern railway line** bisected the northwestern section of the site.
	A property known as Low Peat Edge adjoined the site to the northeast and included a well. The **North Eastern railway line** was identified running parallel to the eastern site boundary. A road and electric telegraph were present, adjoining the site to the east. An **old mine shaft** was present approximately 300 m to the north of site.
Country Series 1895-1898 (1: 2,500 scale), (1: 10,560 scale)	The **Crow Tile Works** was shown as disused. Two buildings were present to the south of site. Two possible ponds were present close to the tile works.
	A **Sand Pit** and **Tursdale Colliery** were present (approximately 100m and 250m respectively) to the south of site. Land adjoining the site to the southeast (associated with Cornforth Moor House) and running off site was shown as a marsh. A **smithy** was present approximately 100m to the east of site.

Data Source	Site / Surroundings
County Series 1923 (1: 2,500 scale), (1:10,560 scale)	A **sewage works** was identified in the far north of site. The former **tile works** and lakes are no longer present.
	Bowburn Colliery was present approximately 250m to the north of site and included buildings and a reservoir. Two reservoirs were present at **Tursdale Colliery** approximately 200 and 250m south of site. **Workings/spoil heaps** were present adjoining the site to the south.
County Series 1939 (1: 2,500 scale), (1:10,560 scale)	A raised area of **spoil** (assumed to be **mine waste**) was present in the northwest of site. A pond was identified close to the eastern site boundary.
	Bowburn had undergone significant expansion in the north of site with a railway spur to **Bowburn Colliery** and aerial cable approximately 100m to the north of site. A **gravel pit** was present approximately 500m to the north west. A **sewage works** was present adjoining the site in the west.
Provisional 1951 (1:1,250 scale), (1:10,560 scale)	Playing fields were present in the far south of site. The pond previously identified close to the eastern boundary was no longer present.
	A new **railway** spur was present 400m to the southwest. A **cemetery** was present approximately 400m to the northwest. **Bowburn Hall Farm** was present approximately 300m to the north of site.
Provisional 1964-1966 (1:1,250 scale), (1:10,000 scale)	The **colliery spoil heap** remains on site but includes two **ponds**.
	Bowburn underwent further expansion. **Mines** were present approximately 100m and 300m north of site and 300m south of site. The **smithy** was no longer present. An unspecified **works** was present approximately 200m to the northwest. **Cornforth Moor Farm** was present approximately 250m to the east of site.
National Grid 1977 (1:1,250 scale), (1:10,000 scale)	The **colliery spoil** in the northwest was identified as a wooded hill.
	The **sewage works** adjoining the site in the west had undergone significant expansion and was identified as sewage disposal works. A **motorway** with associated cuttings and spur roads was present adjoining the site in the east. A **deport** and **warehouse** were present approximately 250m to the northeast. **Bowburn Mine/Colliery** was no longer present having been replaced by **Bowburn Industrial Estate** which adjoins the site in the north. **Tursdale Colliery** to the south of site was present as a Training Centre. The workings that adjoined the site in the south were no longer shown but a small drain was present approximately 20m to the south of site.

Data Source	Site / Surroundings
National Grid 1992 (1:10,000 scale)	No evidence of land use change on site.
	Broom Hill Farm was present approximately 550m to the southwest. A **pumping station** adjoined the site to the northeast. The training centre in the south was present as **Tursdale Works.**
2002 (1:1,250 scale), (1:10,000 scale)	No evidence of land use change on site.
	A pond was present within a service area approximately 50m east of site. A further pond was identified approximately 50m to the southeast of site.
2012 (1:1,250 scale), (1:10,000 scale)	No evidence of land use change on site.
	The **railway line** to the west was shown as disused.

2.3.2 In summary, a review of historic mapping from the 1850s to present shows that the site has been subject to several potentially contaminative land uses including a tile works, a sewage works, disposal of colliery spoil and railway uses.

2.4 STATUTORY REGISTER SEARCHES

2.4.1 Potentially significant environmental issues have been investigated within relevant distances of the site, based on the database of records supplied by Groundsure as well as a review of Environment Agency information. These relate to the following searches:

i. Water discharge or pollution incidents within 250m of the site;

ii. Statutory authorisations within 50m of the site;

iii. Trade directory entries of possible contaminative use within 250m of the site; and

iv. Environmental Permits, Incidents and Registers within 250m of the site.

2.4.2 The environmental search information is summarised in Table 2 below.

Table 2: Summary of the environmental setting of the site

Environmental Category	Description
Water discharge or pollution incidents within 250m	There is one historic record of a discharge consent located on site relating to discharge from Bowburn Colliery to the Bowburn Beck, however this was revoked in 1990. There are eight discharge consents relating to discharge from the adjacent sewage works to the Bowburn Beck, of which one remains active.

Environmental Category	Description
	A further three active discharge consents are identified within 50m of the site for sewage discharges into Bowburn Beck. There are three pollution incidents recorded on site. The latest incident occurred in 2013 relating to crude sewage being released, which resulted in a major impact to water quality and significant impact to land apparently to the north of Peat Edge Farm. Two further pollution incidents were recorded in 2002, concerning the release of raw sewage, which resulted in a minor impact to water quality. These are in connection with the adjoining Bowburn Bridge sewage pumping station on the northeast corner of the site. One pollution incident was identified within 250m of the site. The incident occurred in 2003 and relates to the release of phenols and creosote, which resulted in a minor impact to land. The release relates to a location 110m to the north of site and is considered unlikely to be of significance to the site.
Waste management sites within 250m	There are no records of historic or operational landfill sites within 500m of the site. There are no registered waste management facilities on the site. Tonks Recycling on Tursdale Industrial Estate is described as a Household, Commercial and Industrial Waste Transfer Station located 149m to the south of site.
Statutory authorisations within 50m	The Bowburn Sewage Treatment Works adjoining the west of the site is subject to a List 2 Dangerous Substance Inventory Status although is inactive.
Trade directory entries of possible contaminative use within 50m	Potentially contaminative activities/industries include the sewage works adjoining the west of the site and the pumping station on the northeastern boundary. On site, tanks are listed associated with Peat Edge Farm. Off site, industries within 50 m include a vehicle parts and accessories operation to the northwest. The closest electricity substation is located 6m to the northwest of the site.
Special protection or conservation areas within 50m	None
Other relevant issues	The site lies within a Coal Mining Area

2.5 AIR QUALITY

2.5.1 The site does not lie within a designated Air Quality Management Area (AQMA) according to Department for Environment, Food and Rural Affairs (DEFRA).

SECTION 3 GEOLOGY, HYDROGEOLOGY AND HYDROLOGY

3.1 GEOLOGY

3.1.1 The British Geological Survey Map No. 27 and the BGS online geology viewer show that the site is underlain by superficial deposits of glacial till and boulder clay with a narrow spur of alluvium encountered in the west along the Bowburn Beck, comprising clay, silt, sand and gravel. The underlying sedimentary bedrock strata comprises Pennine Middle Coal Measures Formation (mudstone, siltstone and sandstone) with an igneous intrusion comprising a Late Carboniferous Tholeitic Dyke (quartz micro gabbro).

3.1.2 There are records of twenty eight historical surface ground working features on and adjacent to site (dated between 1857 and 1992). These include a sewage works (north), collieries (north and south), refuse heaps (north and south), filter beds (west), unspecified ground workings (south), sewage disposal works (west), ponds (north and east) and cuttings (southwest and northwest).

3.1.3 A further thirty six historical surface ground workings are located within 250m of the site. These include collieries, a gravel pit (33m to the west), refuse heaps, reservoirs (174m south and 171m northwest) and sewage works (adjoining the site to the west).

3.1.4 Groundsure records indicate that there are five historic underground working features on site. The features are described as collieries and are located in the south and north/northwest, dating between 1923 and 1940. Mine workings are discussed in greater detail in Section 3.6, as more detailed records have been obtained as part of this review.

3.1.5 A further ten records relate to historic underground features within 500m of the site. The features include collieries, mines and shafts dating between 1857 and 1967.

3.1.6 Records from seven historic British Geological Survey (BGS) borehole logs located on site at grid references NZ23NE35, NZ23NE55, NZ33NW54, NZ33NW98, NZ33NW97, NZ33NW101 and NZ33NW93 dated between 1885 and 1955 have been obtained (provided in Appendix 3).

3.1.7 Borehole records show the underlying geology consists of soil (presumed topsoil) to 0.3mbgl, clay/boulder clay to 31.4mbgl, sandstone proved to 46mbgl and a coal seam proved to 47mbgl.

3.1.8 The Groundsure report indicates that the site lies within an area of very low susceptibility to shrink – swell clays. Risks from landslides, soluble rocks, collapsible rocks and running sand were classified as negligible to low.

3.1.9 Risk from compressible ground was classified as moderate therefore there is potential for compressibility constraints. It is advisable to avoid large differential loadings of the ground.

3.1.10 Records held by the Coal Authority indicate that the site is within a coal mining area (the search area is within 75m of the site). There is a low to moderate subsidence hazard relating to shallow mining on site. Mine workings are discussed in greater detail in Section 3.6 as more detailed records have been obtained as part of this review.

3.2 HYDROGEOLOGY

3.2.1 The online Environment Agency maps indicate that the spur of alluvium associated with the Bowburn Beck is classified as a Secondary A Aquifer. Secondary A Aquifers are classified as 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.

3.2.2 The superficial deposits of Glacial till are classified as unproductive strata. These are deposits with low permeability that have negligible significance for water supply or river base flow.

3.2.3 The bedrock geology beneath the site associated with the Coal Measures formation is classified as a Secondary A Aquifer. A Secondary B Aquifer is associated with the igneous dyke that crosses the site from east to west.

3.2.4 There are no groundwater abstractions within 1 km of the site. The site is not located within a groundwater Source Protection Zone (SPZ). There are no groundwater Source Protection Zones within 2 km of the site.

3.3 HYDROLOGY AND FLOOD RISK

3.3.1 Bowburn Beck crosses the site in the north, as it crosses the site it goes from a tertiary to secondary river and is partially culverted. The river flows westwards and joins Tursdale Beck 311m to the west (which flows in a southerly direction). Waterways adjoin the site to the west, northeast and south.

3.3.2 A location on Bowburn Beck 174m east of site has been evaluated for biological quality. Records from 2005 to 2009 rate the water way as bad (grade E).

3.3.3 The closest surface water abstraction licence is located 1.1 km to the south of site. The abstraction is for general farming and domestic uses and is from Coxhoe Beck.

3.3.4 According to the Environment Agency flood risk data, The Bowburn Beck is associated with a ‘Zone 2’ and a ‘Zone ‘3 floodplain designation in the west of the site. Environment Agency Zone 2 floodplains estimate the annual probability of flooding as between 1 in 1000 (0.1%) and 1 in 100 (1%) from rivers and between 1 in 1000 (0.1%) and 1 in 200 (0.5%) from the sea. Zone 3 shows the extent of a river flood with a 1 in 100 (1%) or greater chance of occurring in any year or a sea flood with a 1 in 200 (0.5%) or greater chance of occurring in any year.

3.4 RADON GAS

3.4.1 With reference to the BRE Report 211: 2001, the site is not shown to lie within a Radon Affected Area as defined by the Health Protection Agency. Guidance issued by the Buildings Research Establishment (BRE-211) indicates that no radon protection measures are necessary at the site.

3.5 ECOLOGY

3.5.1 Information from environmental and ecological datasets was obtained from a review of the MAGIC (Multi-Agency Geographic Information for the Countryside) web-site and the Groundsure report. The data assessed indicates that there are no Sites of Special Scientific Interest (SSSI), National Nature Reserves (NNR), Local Nature Reserve (LNR), Special Areas of Conservation (SAC), Special Protection Areas (SPA), Ramsar sites, World Heritage Sites, Environmentally Sensitive Areas, National Parks or Areas of Outstanding Natural Beauty (AONB) within 500m of the site.

3.5.2 However, Hett Wood is designated as an ancient woodland and is located 819m to the west of site. Adjoining the site to the west is a deciduous woodland Biodiversity Action Plan (BAP) priority habitat and a National Inventory of Woodland and Trees designated site adjoins to the south.

3.5.3 The site lies within a Nitrate Vulnerable Zone.

3.6 COAL MINING

3.6.1 Records obtained from the Coal Authority (Appendix 4) indicate that the site is in the likely zone of influence from four seams of coal at 60 to 190mbgl, which were last worked in 1967. It is considered that any movement from these coal workings should have ceased by now.

3.6.2 It is considered likely that coal outcrops at or close to the surface on site and this may have been worked in the past.

3.6.3 The site is not in the likely zone of influence of current underground coal workings. Furthermore, the site is not in an area were the Coal Authority is determining or has granted a licence to remove underground deposits of coal.

3.6.4 The site has not been identified as at risk of subsidence under section 46 of the Coal Mining Subsidence Act 1991.

3.6.5 Records available to the Coal Mining Authority do not indicate any known coal mine entries on site or within 20m of the site boundary.

3.6.6 Records indicate that the site does not lie within the boundary of a historic open cast mine. Furthermore, the site is not within 200m of an operational opencast mine or 800m proposed opencast mine.

SECTION 4 CONCEPTUAL SITE MODEL & PRELIMINARY RISK ASSESSMENT

4.1 REGULATORY CONTEXT

4.1.1 A Conceptual Site Model (CSM) and environmental risk assessment have been constructed using the framework established in Part IIA of the Environmental Protection Act (EPA) 1990 and detailed in Contaminated Land Report CLR11 - Model Procedures for the Management of Land Contamination.

4.1.2 Risk from contamination has been assessed using the source-pathway-receptor and pollutant linkage methodology, also known as the CSM, based on the relationship between the identified sources and receptors. Under the Part IIA framework, a risk can only exist if the following three components of a pollutant linkage are present:

i. A source of contamination or a substance capable of causing harm;

ii. A pathway by which the contaminant can reach the receptor; and

iii. A receptor that could be adversely affected by the contaminant.

4.1.3 The potential sources, pathways and receptors identified at the Acorn Business Park site are summarised in the following sections.

4.2 POTENTIAL SOURCES

4.2.1 The potential sources identified on the site and its surroundings include:

4.2.1.1 On site:

i. Made Ground which may be present as a result of the historical developments on the site. The chemical quality of the Made Ground is unknown; however historic previous land use as workings/pits, sewage works, refuse heaps/landfills, railway, tile works, former mining activity and tanks may have given rise to contamination of this material. Potential contaminants within the ground include localised heavy metals, polyaromatic hydrocarbons, biological contamination and possible asbestos from demolition of former farm structures. Asbestos containing materials may be present within the existing structures;

ii. Fuel/oil drums were encountered during the site walkover and any leakage from such may have given rise to localised contamination with hydrocarbons;

iii. Fly-tipped materials were observed during the walkover and may be associated with localised contamination;

iv. The infilling of ponds, former workings and refuse heaps could be a source of ground gas. The potential for hazardous gas arising from coal bearing strata should also be considered.

4.2.1.2 Off site:

i. Historic surrounding land uses such as the sewage disposal works, general works, collieries, workings/pits and refuse heaps could have given rise to contamination from a range of contaminants including metals, hydrocarbons, and localised polychlorinated biphenyls (PCBs) from the substation.

ii. Depending on the origin of any Made Ground (if present) off site, this stratum could also be a source of ground gas. The potential for hazardous gas arising from coal bearing strata should also be considered.

4.3 RECEPTORS

4.3.1 The potential impacts of contamination sources have been considered with respect to the following site specific receptors:

i. The general public and present site users;

ii. Demolition/construction workers;

iii. Occupants of any future development – commercial and residential scenarios;

iv. Groundwater in the strata;

v. Surface water courses;

vi. Adjacent land; and

vii. Infrastructure.

4.4 PATHWAYS

4.4.1 The potential pathways for contaminant exposure at the site include direct contact, inhalation, leaching and lateral/vertical migration, as well as gaseous and vapour flow pathways.

4.4.2 The site is underlain by relatively impermeable glacial clay, which overlies the Secondary B Aquifer of the Coal Measures. BGS logs indicate there is likely to be approximately 31m of clay/boulder clay. As such it is anticipated that any lateral or vertical migration of contamination through this stratum would be significantly restricted. It is acknowledged that there is a spur of more permeable alluvium associated with the western extent of the Bowburn Beck, however this is limited in area and does not coincide with the main historic contaminative land uses.

4.5 POLLUTANT LINKAGE RISK RATINGS

4.5.1 The existence of a pollutant linkage requires a pathway by which the receptor could be exposed to the source. A qualitative assessment of risk is thus considered with regard to the potential re-development scenario which includes areas of residential and commercial land use.

4.5.2 **The general public and present site users**

4.5.2.1 The degree of contamination at the site is expected to be relatively low level and is considered unlikely to present any significant risks to current users and the general public.

4.5.3 **Demolition and Construction Workers**

4.5.3.1 Ground workers are initially at the greatest risk from exposure to any hazardous contamination due to clearance and excavation works and during the handling of excavation arisings.

4.5.3.2 The risk to construction workers is assessed as Low/Moderate. However, this can be mitigated to Low if dust levels are kept within statutory limits and appropriate health and safety procedures are adhered to during the site clearance phase and any subsequent works.

4.5.4 **End users in the commercial re-development:**

4.5.4.1 The majority of the site would be covered by structures and hard standing with minimal areas of soft landscaping. These hard surfaces effectively restrict pollutant linkage pathways between any subsurface contaminants and the general public and future users of the site. The risk to future site users of the commercial development and the general public are considered to be Low.

4.5.4.2 There is potential for hazardous soil gas to impact the development as a result of ingress to structures. In the absence of monitoring data, this risk is ascribed as moderate.

4.5.5 **End users in the residential re-development:**

4.5.5.1 The conceptual site model for a residential land use scenario is notably different from that above. In a residential development, the sensitivity of end receptors, exposure frequency, exposure duration and type of active pollutant linkages are more prevalent. The likelihood of both communal and private gardens, as well as landscaped areas, is greater in a residential setting. Assuming this is the case, the pollutant linkage pathways between any subsurface contaminants and the end users, become more significant. As such, the risk to future site users of a residential development is considered likely to be Low/Moderate.

4.5.5.2 In the absence of information on the site's ground gas regime, the risk to end users in both land use scenarios (commercial and residential) from ground gases is

considered to be Moderate. It is noted infilled ponds, workings, former collieries and refuse heaps/landfills provide significant opportunity for ground gas generation.

4.5.6 **Groundwater**

4.5.6.1 Previous investigations have encountered approximately 31m of clay over the coal formation. The clay will retard and restrict the lateral and vertical mobilisation of potential contaminants into the deep aquifer. The superficial deposits on site are classified as Secondary A Aquifers, but it should be noted that no abstractions take place within 2km of the site. The risk to groundwater is therefore considered to be Low.

4.5.7 **Surface Waters**

4.5.7.1 The Bowburn Beck is the main surface water body on the site and has historically been associated with poor water quality although this may be representative of historic industry in the wider area. There is however considered to be potential for site-derived contamination to impact water quality and the risk is ascribed as moderate in the absence of further information.

4.5.7.2 Orange staining was noted in a stream running outside the north western boundary of the site. A parallel stream within the site boundary did not exhibit any staining. Given that no on site impact was observed, it is considered most likely that this is the result of mine drainage from the main colliery off-site.

4.5.8 **Adjacent Land**

4.5.8.1 The proposed development site is underlain by relatively impermeable Clay and generally it is not considered that the site presents a significant risk to adjacent land. However, run-off and leaching of contaminants from colliery spoil and potentially also drainage of mine workings are considered to have the potential to impact adjacent surface waters. There is also potential for off-site sources of hazardous soil gas which might impact the development.

4.5.9 **Infrastructure**

4.5.9.1 The presence of made ground may necessitate the allowance for upgraded water supply pipes.

4.6 PRELIMINARY CONCEPTUAL SITE MODEL

4.6.1 From the Phase 1 assessment a preliminary site conceptual model has been produced as Table 3 which summarises the potential pollutant linkages.

Table 3: Preliminary Conceptual Model

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	**PATHWAYS**	**RECEPTORS**	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (current users)	**Low risk identified** Potential for made ground which can contain elevated metals and hydrocarbons, however limited potential for exposure.
	Ingestion and inhalation of contaminated soil and dust	Human health (current users)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (demolition and construction workers)	**Low risk identified** Potential for made ground which can contain elevated metals and hydrocarbons however mitigated by standard precautions.
	Ingestion and inhalation of contaminated soil and dust	Human health (demolition and construction workers)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (Future commercial development occupants)	**Low risk identified** Potential for made ground which can contain elevated metals and hydrocarbons however limited potential for exposure.
	Ingestion and inhalation of contaminated soil and dust	Human health (Future commercial development occupants)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (Future residential development occupants)	**Low/Moderate risk identified** Potential for made ground which can contain elevated metals and hydrocarbons. Exposure likely.
	Ingestion and inhalation of contaminated soil and dust	Human health (Future residential development occupants)	
Asbestos (made ground)	Ingestion and inhalation of contaminated soil and dust	Human health	**Low/Moderate risk** Existing farm buildings contain suspected asbestos containing materials. Potential for localised asbestos at the surface and in the upper soil profile.
Contamination (all forms)	Vertical migration to aquifer	Controlled waters	**Low risk identified** Any contamination likely to be low level. Significant aquitard protecting the underlying aquifer.
Contamination (all forms)	Horizontal migration to surface water	Controlled waters	**Moderate** Risk to Bowburn Beck likely to be moderate. Evidence of acid mine drainage/leaching from colliery spoil (likely to be off site source, however).
Hydrocarbons	Direct contact	Plastic water pipes	**Moderate risk identified** Cannot rule out presence of hydrocarbon contamination at this stage.

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	**PATHWAYS**	**RECEPTORS**	
Hazardous Gas/Vapours In soil	Ingress into buildings and voids	Human health (future residents and construction workers)	**Moderate risk identified** Potential for made ground which could act as source of hazardous gas. Cannot rule out fuel spillages as source of vapours. Potential for coal gas.

4.7 DESK STUDY CONCLUSIONS

4.7.1 On the basis of desk study and site walkover information sources, a conceptual model has been produced which highlights the following potential contamination risks:

i. Potential for risks to human health from ground contamination in the case of future sensitive land uses, such as for residential purposes;

ii. Likely risks to localised surface waters from drainage and leaching from colliery spoil and possibly mine drainage;

iii. Potential requirement for upgraded water supply pipes and part of the development infrastructure;

iv. Potential for hazardous soils gas to impact both residential and commercial forms of built development.

SECTION 5 RATIONALE FOR PRELIMINARY SITE INVESTIGATION

5.1 INTRODUCTION

5.1.1 A preliminary site investigation rationale has been devised in accordance with the findings of the Phase 1 investigation and the resultant preliminary conceptual site model and risk assessment.

5.1.2 The preliminary site investigation has been designed to address the following broad issues with the purpose of identifying key development constraints and environmental liabilities associated with the purchase and development of the site:

i. To investigate the presence of Made Ground and chemical or gaseous contamination by means of intrusive investigation of the subsurface with a programme of chemical testing and gas monitoring. The scope of works includes targeted sampling of soils around the farm, the old tile works, land adjacent to the sewage works and colliery spoil.

ii. To investigate the extent of colliery spoil on the northern and southern parts of the site;

iii. To assess shallow groundwater and surface water quality.

5.1.3 Other items which will require detailed assessment in due course include:

i. Asbestos survey of existing buildings which are to be demolished or refurbished;

ii. Further detailed site investigation for geotechnical purposes. There is evidence to suggest that colliery spoil was deposited in two localised areas on site. Mine workings could potentially have extended onto the north of the site. Information from the Coal Authority indicates that as closure of the workings was in the 1960s there is a low potential for further settlement. The geotechnical properties and stability of the spoil heaps are currently unknown and should be assessed by means of detailed intrusive investigation. The potential for geotechnical and engineering constraints associated with underground coal mining and the deposit of spoil should be investigated further.

iii. Should the development proposals require re-contouring of the site levels, there is considered to be potential for movement and re-use of materials on site to achieve the required landform, provided certain conditions could be met. It is recommended that this should be done through a Materials Management Plan under the *CL:AIRE Code of Practice on the Definition of Waste* in order to minimise waste disposal costs. As such, intrusive investigation and characterisation of the site soil resource would be required at an early stage.

5.2 SITE INVESTIGATION METHODS

5.2.1 An intrusive investigation was carried out by Merebrook on 9-11 April 2014 and comprised the following scope of work:

i. Five shallow windowless sample probe holes (MWS01 to MWS05) to a depth of 5 m bgl; and

ii. Twelve machine-dug trial holes (MTP01 to MTP12) to a depth of 4.4 m bgl.

iii. Water sampling from the Bowburn Beck at the upstream (northern) boundary, mid-point and the downstream (western) boundary of the site.

5.2.2 Exploratory hole locations are indicated on drawing 18582-304-001 in Appendix 1. Logging of exploratory holes was undertaken by a Merebrook Officer. Exploratory hole logs are contained in Appendix 5.

5.2.3 A tracked windowless sampling rig was used to advance MWS01-05. This comprised a rig-mounted drop hammer to drive a hollow steel barrel into the ground. The barrel is recovered along with a removable plastic sleeve, which lines the barrel and holds a core of soil which is retracted for logging and sampling. SPTs were performed at approximate 1 m intervals in all windowless sample holes.

5.2.4 Four of the probe holes were installed with monitoring wells as follows:

i. MWS02 response zone 0.5 – 1.5 m in made ground;

ii. MWS03 response zone 0.8 – 3.8 m in natural drift strata;

iii. MWS04 response zone 0.5 – 2.5 m predominantly in natural drift strata; and

iv. MWS05 response zone 0.5 – 1.5 m in made ground.

5.2.5 Representative soil samples were taken from various depths and strata to assess the contaminative status of the site. Soil samples were submitted to an MCERTS/ UKAS accredited laboratory for chemical analysis of a broad suite of potential contaminants including heavy metals, hydrocarbons, polyaromatic hydrocarbons and asbestos. The results are provided in Appendix 6.

SECTION 6 GROUND CONDITIONS

6.1 SUB-SURFACE GROUND CONDITIONS

6.1.1 A summary of the ground conditions across the majority of the site is presented in Table 4, whilst a more detailed assessment of the strata is contained in the following sections of the report.

Table 4: Summary of Sub-surface Ground Conditions - majority of site

STRATA	DEPTH TO TOP RANGE (m bgl)	THICKNESS RANGE (m)
Made Ground	0.0	0.0 – 0.6 m
Topsoil Present to east of sewage works	0.0	0.0 – 0.4 m
Drift Site-wide predominantly clay, with water bearing sand horizons to the east of the sewage works	0.2 – 0.6 m	Depth not proven

6.1.2 The northern and southern tips of the site are affected by colliery spoil and ground conditions are summarised in Table 5 below.

Table 5: Summary of ground Conditions – Colliery Spoil

STRATA	DEPTH TO TOP RANGE (m bgl)	THICKNESS RANGE (m)
Made Ground – Colliery Spoil	0.0	North: 2.4 - > 4.1 m South: 0.6-2.3 m
Drift Clay	North: 2.4 - > 4.1 m South: 0.6-2.3 m	Depth not proven

6.1.3 Topsoil

6.1.3.1 Topsoil was recorded in a subset of trial holes to the east of the sewage works and comprised firm dark brown silty clay with no visual or olfactory evidence of contamination.

6.1.4 Made Ground

6.1.4.1 Made ground (excluding the areas affected by colliery spoil) was generally limited in thickness to approximately 0.3 m and was typically cohesive with inclusions of brick. However thicker granular made ground (MWS04) was recorded in the vicinity of Peat Edge Farm with inclusions of ash, coal, gravel and brick.

6.1.4.2 Made ground in the northern area of colliery spoil (MTP10-12 & MWS05) was locally in excess of 4 m thick and comprised clayey and sandy gravel and gravelly clay with coal, mudstone and brick. Frequent cobbles and boulders of mudstone were noted.

6.1.4.3 Made ground in the southern area of colliery spoil was up to 2.3 m thick and comprised ashy sandy gravel of coal, brick, mudstone and clinker.

6.1.4.4 Perched water was encountered locally during drilling in made ground as follows:

i. At the interface between made ground (colliery spoil) and natural underlying clay at 2.3 m bgl in MWS02 on the southern tip of the site. Trial holes MTP6 and MTP7 located nearby did not encounter perched water in the made ground colliery spoil.

ii. At 2.1 m in made ground comprising colliery spoil in MWS05 on the north of the site. Trial holes MTP10, MTP11 and MTP12 located nearby did not encounter perched water in the made ground colliery spoil.

6.1.4.5 SPTs undertaken within granular made ground revealed 'N' values ranging from 2 to 11, indicating the presence of very loose to medium dense ground conditions.

6.1.5 Natural Ground

6.1.5.1 Natural ground consistent with descriptions of glacial till was predominantly cohesive and comprised finely laminated variably soft to stiff clay. More sandy strata were encountered in the centre of the site. No visual or olfactory evidence of contamination was encountered in natural ground.

6.1.5.2 Perched groundwater was recorded in the drift deposits on the centre of the site at depths of 2-3 m bgl where sandy strata were encountered. Field data does not suggest the presence of a site-wide continuous water body within the drift deposits, rather the water is more likely to be present as perched discontinuous lenses.

6.1.5.3 SPTs performed in natural cohesive soils recorded 'N' values in the range 1 to 11, indicating the presence of extremely low strength (very soft) to medium strength

(firm) ground conditions. Locally, SPTs carried out within sand or gravel revealed 'N' values in the range 1 to 12, indicative of very loose to medium dense ground conditions.

SECTION 7 PRELIMINARY GEOTECHNICAL RECOMMENDATIONS

7.1 FOUNDATIONS

7.1.1 The proposed development is believed to comprise a mixture of residential and commercial buildings.

7.1.2 As discussed in Section 6.1 the recent ground investigation has found significant thicknesses of made ground in areas associated with former land uses, whilst in other areas significant thicknesses of soft / loose natural soils were revealed. Preliminary recommendations with regards to foundation options are given below for the areas targeted by the ground investigation:

i. North western area - traditional shallow spread foundations will not be suitable due to the presence of significant thicknesses of colliery spoil. Alternative solutions, such as ground improvement or piles, will be required;

ii. Area surrounding existing farm - traditional shallow spread foundations are unlikely to be suitable due to the presence of soft / loose natural soils. Piles are likely to be the most appropriate solution in this area;

iii. Area surrounding sewage works – traditional shallow spread foundations are unlikely to be suitable due to the presence of soft / loose natural soils. Piles are likely to be the most appropriate solution;

iv. Area of former brickworks – traditional shallow spread foundations are considered to be feasible founding within firm or stiff cohesive soils, with NHBC guidance being considered where trees are present; and

v. Southernmost area – traditional shallow spread foundations are unlikely to be suitable due to the presence of soft / loose natural soils beneath made ground. Piles are likely to be the most appropriate solution.

7.1.3 Across remaining parts of the site, which as yet have not been investigated, traditional shallow spread foundations are considered likely to be feasible for low-rise structures providing that competent natural soils are present at shallow depth. NHBC guidance will need to be followed for structures located in the zone of influence of existing or proposed trees. Ground improvement or piles will need to be considered for areas of deep made ground or weak natural soils.

7.1.4 Although an initial review does not indicate a significant risk of mine subsidence, detailed coal mining records will need to be consulted further in order to determine whether underground workings extend beneath the site. In particular, for the

northern and southern areas, and whether foundations will need to take into account the presence of any workings.

7.2 EXCAVATIONS AND GROUNDWATER

7.2.1 Based on the ground conditions observed at the site, any shallow excavations have the potential to become unstable in the short term. If man-entry is required, all excavations should be supported by shoring or otherwise battered back to a safe angle in order to protect the workforce from possible collapse.

7.2.2 Groundwater was encountered in six locations at depths ranging from 1.9 to 3.0 m bgl. In view of this, it is considered likely that groundwater ingress will occur in shallow excavations, therefore, provision for dewatering during the construction period should be considered.

7.3 FLOOR SLABS

7.3.1 In view of the presence of made ground and / or shrinkable natural soils encountered in the areas investigated to date, it is recommended that suspended floor slabs are adopted for the proposed development.

7.4 BURIED CONCRETE

7.4.1 Recommendations given in BRE Special Digest 1:2005 *"Concrete in aggressive ground"* have been followed in order to give recommendations with respect to buried concrete.

7.4.2 Water soluble sulphate analysis was carried out on twenty soil samples obtained from depths of between 0.1 and 1.0 m bgl with soil pH determination also carried out on these samples. Water soluble sulphate contents ranged between 0.015 and 1.8 g/l. In accordance with BRE guidelines the characteristic value is calculated by determining the mean of the highest 20 % of results. In this case the characteristic value is 0.67 g/l. On this basis the Design Sulphate Class is DS-2.

7.4.3 The pH values in the soil samples varied between 6.0 and 8.4. The mean of the lowest 20 % of values is 6.7 which represents the characteristic value. Mobile groundwater conditions have been assumed and on this basis the Aggressive Chemical Environment for Concrete (ACEC) class for the site is AC-2.

7.5 ROADS AND PAVED AREAS

7.5.1 In the absence of *in situ* test data, it is recommended that for preliminary design purposes, a California Bearing Ratio (CBR) value of < 2 % is assumed for made ground and natural cohesive soils at shallow depth.

7.6 SOAKAWAYS

7.6.1 The areas investigated to date have either revealed the presence of significant thicknesses of made ground or predominantly cohesive natural soils. Based on

these finding, it is considered unlikely at this stage that shallow soakaways will be feasible for the proposed development, however, further intrusive investigations may reveal areas which could be considered suitable for surface water drainage.

SECTION 8 ENVIRONMENTAL ASSESSMENT

8.1 SOIL QUALITY

8.1.1 A total of 20 soil samples were submitted to the laboratory for chemical analysis, including three samples from topsoil, fourteen samples from made ground and three samples from underlying natural strata. The laboratory chemical analysis certificates are contained in Appendix 6. The results of the analysis are summarised in Table 6.

8.1.2 An initial screening exercise has been undertaken whereby contaminant concentrations recorded in soils have been assessed against Environment Agency published Soil Guideline Values (where available) for a residential setting where the possibility of consumption of homegrown produce exists. This is the most sensitive land use with regard to land contamination. Where SGVs are not available, Generic Acceptance Criteria published by CIEH/LQM in 2009 have been used assuming soil organic matter of 1 %. For the contaminant lead, the SGV of 450 $mg.kg^{-1}$ has been withdrawn. However work has been carried out by others using the Society of Environmental Geochemistry and Health (SEGH) equation as a basis for the SGV with an amended blood lead target, delta value and a reduced geometric mean of blood lead concentrations in young children (based on a decrease in environmental exposures over time). This work has generated a range of values, in which 450 $mg.kg^{-1}$ sits. Until such time as definitive guidance is issued, use of the previous SGV is not considered unreasonable when compared against the range of sensitivity modelling results, and is suitably protective of human health.

8.1.3 For any contaminants that exceed the conservative residential screening level, a second screening exercise has been carried out comparing the contaminant concentration with a less conservative commercial land use screening criterion from the above reference sources.

8.1.4 An additional set of phytotoxin screening levels have been adopted from 'The Code of Agricultural Practice for the Protection of Soil' Ministry of Agriculture, Fisheries and Food (MAFF), 1993, which are protective of healthy plant growth.

Table 6: Summary of Soils Chemical Analysis Results

CONTAMINANT	UNITS	MAX	No of Tests	RESIDENTIAL SCREENING LEVEL (SL1)	No > SL1*	COMMERICAL SCREENING LEVEL (SL2)	No > SL2*
HUMAN HEALTH RISK ASSESSMENT							
Asbestos in soil	-	nd	7	Detected	0	-	-

CONTAMINANT	UNITS	MAX	No of Tests	RESIDENTIAL SCREENING LEVEL (SL1)	No > SL1*	COMMERICAL SCREENING LEVEL (SL2)	No > SL2*
HUMAN HEALTH RISK ASSESSMENT							
pH	-	6.0-8.4 range	20	5 (min)	0	-	-
Arsenic	$mg.kg^{-1}$	36	20	**32**	1	640	0
Cadmium	$mg.kg^{-1}$	2.3	20	**10**	0	-	-
Chromium (total)	$mg.kg^{-1}$	74	20	*627*	0	-	-
Hexavalent Chromium	$mg.kg^{-1}$	<1.0	20	*4.3*	0	-	-
Lead	$mg.kg^{-1}$	160	20	450	0	-	-
Mercury	$mg.kg^{-1}$	0.4	20	**170**	0	-	-
Nickel	$mg.kg^{-1}$	52	20	**130**	0	-	-
Selenium	$mg.kg^{-1}$	3.9	20	**350**	0	-	-
Cyanide	$mg.kg^{-1}$	0.3	20	**-**	-	-	-
TPH Aliphatic >EC_5 - EC_6	$mg.kg^{-1}$	<0.01	20	*30*	0	-	-
TPH Aliphatic >EC_6 - EC_8	$mg.kg^{-1}$	<0.01	20	*73*	0	-	-
TPH Aliphatic >EC_8 - EC_{10}	$mg.kg^{-1}$	<0.01	20	*19*	0	-	-
TPH Aliphatic >EC_{10} - EC_{12}	$mg.kg^{-1}$	<1.5	20	*93*	0	-	-
TPH Aliphatic >EC_{12} - EC_{16}	$mg.kg^{-1}$	1.9	20	*740*	0	-	-
TPH Aliphatic >EC_{16} - EC_{21}	$mg.kg^{-1}$	7.2	20	*45000*	0	-	-
TPH Aliphatic >EC_{21} - EC_{35}	$mg.kg^{-1}$	26	20	*45000*	0	-	-
TPH Aromatic >EC_5 - EC_7	$mg.kg^{-1}$	<0.01	20	*65*	0	-	-
TPH Aromatic >EC_7 - EC_8	$mg.kg^{-1}$	<0.01	20	*120*	0	-	-
TPH Aromatic >EC_8 - EC_{10}	$mg.kg^{-1}$	<0.01	20	*27*	0	-	-
TPH Aromatic >EC_{10} - EC_{12}	$mg.kg^{-1}$	<0.9	20	*69*	0	-	-
TPH Aromatic >EC_{12} - EC_{16}	$mg.kg^{-1}$	1.5	20	*140*	0	-	-
TPH Aromatic >EC_{16} - EC_{21}	$mg.kg^{-1}$	5.7	20	*250*	0	-	-
TPH Aromatic >EC_{21} - EC_{35}	$mg.kg^{-1}$	22	20	*890*	0	-	-
Benzo(a)pyrene	$mg.kg^{-1}$	0.23	20	*0.83*	0	-	-
Naphthalene	$mg.kg^{-1}$	0.08	20	*1.5*	0	-	-
Phenols	$mg.kg^{-1}$	1.1	20	**420**	0	-	-
PHYTOTOXICITY RISK ASSESSMENT							
	Units	**Max**	**No of Test**	**Screening Level (SL)**	**No > SL**		
Copper	$mg.kg^{-1}$	110	20	200	0	-	-
Nickel	$mg.kg^{-1}$	52	20	110	0	-	-
Zinc	$mg.kg^{-1}$	330	20	300	1	-	-

Notes: * Number of samples exceeding screening level nd = not detected
Bold Values relate to EA Published Soil Guideline Values
Italic Values relate to CIEH/LQM 2nd edition GACs assuming 1% SOM

8.1.5 Zootoxic Metals (harmful to human health)

8.1.5.1 Of the broad suite of zootoxic heavy metals tested, a single sample marginally exceeded the conservative residential screening level for arsenic. The results are not indicative of widespread contamination of made ground with heavy metals.

Preliminary indications are that heavy metals are unlikely to form a significant development constraint for either a sensitive residential end use, or a commercial end use.

8.1.6 **Phytotoxic Metals (harmful to plant health)**

8.1.6.1 A single near surface soil sample was found to contain a marginally elevated zinc concentration. Overall, preliminary indications are that phytotoxic heavy metals are unlikely to inhibit healthy plant growth in future landscaped areas at the site.

8.1.7 **Organic Contaminants**

8.1.7.1 Soils were tested for a broad suite of organic contaminants including total petroleum hydrocarbons, polyaromatic hydrocarbons and phenols and none were found in excess of sensitive residential screening levels. Preliminary indications are that organic contaminants are unlikely to be widespread at the site.

8.1.8 **Inorganic Contaminants**

8.1.8.1 No asbestos fibres were detected in the made ground soil samples tested.

8.1.9 **Summary**

8.1.9.1 Results from the preliminary investigation have not highlighted significant soil contamination at the site. Given the size of the site, coupled with the low investigation density, it is possible that localised areas of contamination have not been identified, however early results do not suggest widespread contamination with the potential to form a significant development constraint.

8.2 **SURFACE WATER**

8.2.1 Surface water sampling was undertaken from the Bowburn Beck at the following positions:

i. Upstream close to the northern site boundary;

ii. Midpoint of Bowburn Beck to the northwest of Peat Edge Farm;

iii. Downstream close to the boundary with the sewage works.

8.2.2 The samples were submitted to the laboratory for analysis of a typical contamination suite. Screening levels for surface water have been derived from the Environmental Quality Standards (EQS); Maximum Allowable Concentration (MAC) where available, otherwise Annual Average (AA). Additional screening levels have been applied for pH, derived from the Surface Waters Regulations 1994, and arsenic, derived from the Surface Waters Regulations 1997 and 1998. These are considered to provide a suitably conservative screening tool. The laboratory chemical analysis certificate is contained in Appendix 7. A summary of surface water contaminant concentrations is contained in Table 7.

Table 7: Summary of Surface Water Chemical Analysis Results

CONTAMINANT	UNITS	Max	SCREEN LEVEL (SL)	>SL*
pH	-	8.0	6.0-9.0	x
Arsenic	$\mu g.l^{-1}$	0.65	50	x
Cadmium	$\mu g.l^{-1}$	0.08	0.45	x
Lead	$\mu g.l^{-1}$	1.2	7.2	x
Mercury	$\mu g.l^{-1}$	<0.01	0.07	x
Nickel	$\mu g.l^{-1}$	3.6	20	x
Benzo(a)pyrene	$\mu g.l^{-1}$	<0.05	0.1	x
Naphthalene	$\mu g.l^{-1}$	<0.06	2.4	x
Phenols	$mg.l^{-1}$	<0.05	-	-

Notes: * Samples exceeding screen level
** Minimum value applies (i.e. most acid)
*** Not detected above screening level

8.2.3 The analysis of water samples taken from Bowburn Beck passing through the site indicates the watercourse is not impacted with significant metallic or organic contamination. The results also indicate that the site is not having a significant impact on surface water quality.

8.3 GROUNDWATER

8.3.1 Groundwater level monitoring was undertaken from four monitoring wells on 14 April 2014. Resting waters levels were recorded at relatively shallow depth from 0.38 m to 1.74 m bgl representing perched water in the made ground and in the upper layers of drift deposits.

8.4 HAZARDOUS GAS

8.4.1 A preliminary round of gas monitoring was undertaken from four monitoring wells on 14 April 2014.

8.4.2 Levels of methane, carbon dioxide and oxygen were recorded in each standpipe, together with associated parameters including borehole flow and ambient air pressure. The results of the gas monitoring round are contained in Appendix 8. Data from MWS04 has been excluded from assessment as the standpipe was waterlogged and gas data is therefore considered unrepresentative.

8.4.3 The monitoring round was undertaken at barometric pressures of 1015 with is approximately average. Positive gas flow and methane were not detected. Carbon dioxide (CO_2) was detected to a maximum of 3.4 % v/v and oxygen concentrations were slightly depleted.

8.4.4 Preliminary indications are that hazardous soil gas is unlikely to form a major development constraint at the site, although the potential for low level gas to be revealed by additional monitoring should be recognised.

8.5 WASTE CLASSIFICATION AND OFF-SITE DISPOSAL

8.5.1 Preliminary chemical data suggests that site soils would be non-hazardous with regard to waste classification.

8.5.2 Should the development proposals require re-contouring of the site levels, there is considered to be potential for movement and re-use of materials on site to achieve the required landform, provided certain conditions could be met. It is recommended that this should be done through a Materials management Plan under the *CL:AIRE Code of Practice on the Definition of Waste* in order to minimise waste disposal costs. As such, intrusive investigation and characterisation of the site soil resource would be required at an early stage.

8.5.3 It is also relevant to note that the organic matter content of the soils is relatively high (average 7 % soil organic matter (SOM) which is equivalent to approximately 4 % total organic carbon (TOC)). The TOC limit for inert landfill is 3 % and as such, made ground soils are unlikely to be eligible for disposal at inert landfill. It would likely be preferable to design the development platform to achieve a cut/fill balance so that materials can be retained on site.

8.5.4 Natural as-dug arisings (excluding topsoil) could be classed as inert waste without the requirement for WAC testing.

8.5.5 Materials, including waste soils which are not to be retained on site, should be removed and disposed of in accordance with all relevant statues including the *Environmental Protection Act 1990*, *The Controlled Waste Regulations 2012* as amended, *The Waste Regulations 2011* as amended, *The List of Wastes Regulations 2005* as amended, *The Hazardous Waste Regulations 2005* as amended, *The Waste Management Regulations 2006* and *The Environmental Permitting Regulations 2010* as amended.

8.5.6 It is a requirement of these regulations that waste sent to landfill should have been subject to measures to reduce the amount of waste, reduce harmful or hazardous properties and facilitate recycling. These requirements may be satisfied by measures such as segregation and screening of wastes to recover suitable fill and material for crushing, segregation of inert materials and putrescible wastes.

SECTION 9 RISK ASSESSMENT

9.1 The potential sources of contamination at the site and the implications with respect to development have been interpreted in accordance with the current government guidance on source-pathway-receptor risk assessment.

9.2 The investigations demonstrate that the former uses of the site have not resulted in significant ground or ground gas contamination sources.

9.3 The potential impacts of contamination sources have been considered with respect to the following receptors:

i. The general public and present site users,

ii. Residents of future development,

iii. Groundwater,

iv. Surface water,

v. Construction workers,

vi. Adjacent land, and

vii. Infrastructure.

9.4 In each case the existence of a pollutant linkage requires a pathway by which the receptor could be exposed to the source. A qualitative assessment of risk is thus considered in the first instance with respect to the site in its current condition and is summarised in the sections below.

9.1.1 **The general public and present site users**

9.1.1.1 Preliminary investigations suggest that the degree of contamination at the site is Low. Such low level contamination is considered unlikely to present any significant risks to current users and the general public.

9.1.2 **Demolition and Construction Workers**

9.1.2.1 Ground workers are initially at the greatest risk from exposure to any hazardous contamination due to clearance and excavation works and during the handling of excavation arisings.

9.1.2.2 The risk to construction workers is assessed as Low given the low levels of contamination. Standard health and safety procedures should be adhered to during the site clearance phase and any subsequent works.

9.1.3 **End users in the commercial re-development:**

9.1.3.1 Given the low levels of contamination identified by the preliminary investigation and the minimal nature of exposure to soils in this development scenario due to the presence of buildings/hardstanding with minimal areas of soft landscaping, the risk to future site users of the commercial development is considered to be Low.

9.1.3.2 Preliminary gas monitoring would suggest that there is not a significant issue with hazardous ground gas at the site and the risk of ingress to structures is likely to be

Low. However, additional detailed investigation and monitoring would be required to confirm that this is the case.

9.1.4 **End users in the residential re-development:**

9.1.4.1 The conceptual site model for a residential land use scenario is notably different from that above. In a residential development, the sensitivity of end receptors, exposure frequency and exposure duration are greater due to the inclusion of communal and private gardens, as well as landscaped areas. Assuming this is the case, the pollutant linkage pathways between any subsurface contaminants and the end users, become more significant. Given the apparent lack of a widespread contaminant source, the risk to future site users of a residential development from soil contamination is considered likely to be Low. Nevertheless the potential exists for a Moderate risk in any localised areas of contamination not yet identified.

9.1.4.2 Preliminary gas monitoring would suggest that there is not a significant issue with hazardous ground gas at the site and the risk of ingress to structures is likely to be low. However, additional detailed investigation and monitoring would be required to confirm that this is the case.

9.1.5 **Groundwater**

9.1.5.1 The current investigation has not highlighted the presence of widespread soil contamination. The superficial deposits on site are classified as Secondary A Aquifers however investigations suggest that water within these deposits is perched and discontinuous. Previous investigations have encountered approximately 31m of drift clay over the Coal Measures aquifer. The clay will retard and restrict the lateral and vertical mobilisation of any contaminants into the deep aquifer. The risk to groundwater is therefore considered to be Low.

9.1.6 **Surface Waters**

9.1.6.1 The Bowburn Beck is the main surface water body on the site and has historically been associated with poor water quality, although this may be representative of historic industry in the wider area. The results from samples obtained from the Beck do not indicate that site-derived contamination is currently impacting water quality and the risk is therefore ascribed as Low.

9.1.6.2 Orange staining was noted in a stream running outside the north western boundary of the site. A parallel stream within the site boundary did not exhibit any staining. Given that no on site impact was observed, it is considered most likely that this is the result of mine drainage from the main colliery off-site.

9.1.7 Adjacent Land

9.1.7.1 The proposed development site is underlain by relatively impermeable Clay and generally it is not considered that the site presents a significant risk to adjacent land. However, run-off and leaching of contaminants from colliery spoil and potentially also drainage of mine workings are considered to have the potential to impact adjacent surface waters, although samples taken from Bowburn Beck do not indicate an impact from the site. There is also potential for off-site sources of hazardous soil gas which might impact the development.

9.1.8 Infrastructure

9.1.8.1 The presence of made ground may necessitate the allowance for upgraded water supply pipes.

SECTION 10 UPDATED CONCEPTUAL MODEL

10.1 Following completion of phases 1 and 2 of the investigation and a qualitative risk assessment, the conceptual model for the site, with relation to pollutant linkages, has been updated. The revised model is presented in Table 8 below.

Table 8: Revised Conceptual Model

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	**PATHWAYS**	**RECEPTORS**	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (current users)	**Low risk identified** No significant widespread contamination identified and limited potential for exposure.
	Ingestion and inhalation of contaminated soil and dust	Human health (current users)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (demolition and construction workers)	**Low risk identified** No significant widespread contamination identified.
	Ingestion and inhalation of contaminated soil and dust	Human health (demolition and construction workers)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (Future commercial development occupants)	**Low risk identified** No significant widespread contamination identified and limited potential for exposure.
	Ingestion and inhalation of contaminated soil and dust	Human health (Future commercial development occupants)	
Heavy metals and hydrocarbons (made ground)	Contact with contaminated soil	Human health (Future residential development occupants)	**Likely Low Risk but Potential for Localised Moderate Risk** No significant widespread contamination identified site-wide but potential for localised contamination, not yet identified.
	Ingestion and inhalation of contaminated soil and dust	Human health (Future residential development occupants)	

POSSIBLE POLLUTANT LINKAGE			RISK CHARACTERISATION
POTENTIAL SOURCES	**PATHWAYS**	**RECEPTORS**	
Asbestos (made ground)	Ingestion and inhalation of contaminated soil and dust	Human health	**Likely Low Risk but Potential for Localised Moderate risk** Existing farm buildings contain suspected asbestos containing materials. No asbestos identified in limited soils sampling, but potential for localised asbestos at the surface and in the upper soil profile.
Contamination (all forms)	Vertical migration to aquifer	Controlled waters	**Low risk identified** No significant widespread contamination identified. Significant aquitard protecting the underlying aquifer.
Contamination (all forms)	Horizontal migration to surface water	Controlled waters	**Low to Moderate** No evidence of current impact from site on surface water quality in Bowburn Beck. There is evidence of acid mine drainage/leaching from colliery spoil; however, this is likely to be from an offsite source.
Hydrocarbons	Direct contact	Plastic water pipes	**Low / Moderate risk identified** No hydrocarbon contamination identified, however utility company may require upgraded pipes due to made ground.
Hazardous Gas/Vapours In soil	Ingress into buildings and voids	Human health (future residents and construction workers)	**Likely Low risk but subject to further assessment** Preliminary monitoring has not identified significant quantities of hazardous ground gas. Not likely to present a significant constraint but further assessment required.

SECTION 11 DISCUSSION

11.1 Preliminary investigations have identified significant thicknesses of made ground comprising colliery waste on the northern and southern tips of the site which is likely to form a localised geotechnical constraint to development. Made ground on the remainder of the site is limited in thickness and is unlikely to form a significant constraint. Likely foundation options in areas of deep made ground and / or areas of soft / loose natural soils will include ground improvement and piles, whilst traditional shallow spread foundations are considered to be feasible where firm and stiff natural clay soils are present at shallow depth.

11.2 Preliminary investigations have not identified significant ground contamination in the made ground or the natural ground although it is recognised that the investigation density is low at this stage. It is unlikely that soil contamination will require any site-wide remedial action, however it may be prudent to allow for limited clean capping in a proportion of proposed soft landscaped/garden areas in

the event that more detailed investigations encounter pockets of localised contamination (for example around Peat Edge Farm).

11.3 Preliminary hazardous gas monitoring has not identified significant quantities of ground gas and therefore early indications are that the new development is unlikely to require gas protection measures to be incorporated into the floor structures. However additional monitoring would be required to substantiate this position. It is possible that additional monitoring could identify slightly higher gas concentrations, however it is consider that at worst, basic gas protection measures would be likely to mitigate any risk, if present. Such basic measures would be unlikely to form a significant abnormal cost to development.

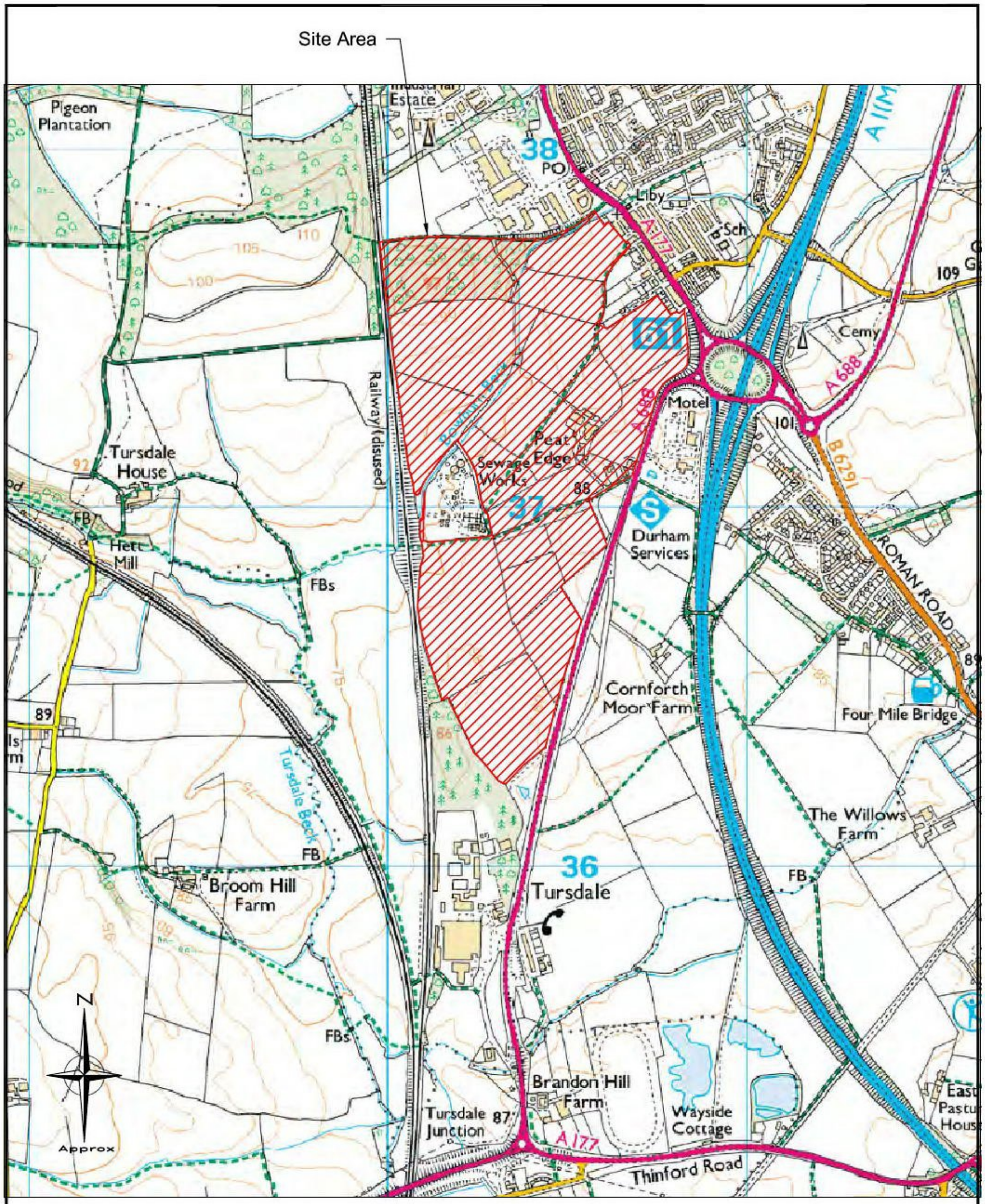
11.4 The results of analysis on samples taken from Bowburn Beck do not indicate significant contamination or an impact from the site itself. There is visual evidence of acid mine drainage/leaching from colliery spoil impacting on a watercourse/drain to the west of the site. This stream is located off-site, and a parallel stream within the site boundary is not impacted. This is considered evidence of an off-site source of contamination.

11.5 It is recommended that existing buildings which are to be demolished or refurbished be subject to an appropriate asbestos survey.

11.6 Desk study and site investigation has identified colliery spoil deposits in two localised areas on site. Mine workings could potentially have extended onto the north of the site. Information from the Coal Authority indicates that as closure of the workings was in the 1960s there is a low potential for further settlement. Coal mining records have been consulted and indicate that the risk from subsidence is likely to be low. However, more detailed records should be checked at the design stage.

11.1.1 Should the development proposals require re-contouring of the site levels, there is considered to be potential for movement and re-use of materials on site to achieve the required landform, provided certain conditions could be met. It is recommended that this should be done through a Materials management Plan under the *CL:AIRE Code of Practice on the Definition of Waste* in order to minimise waste disposal costs. As such, detailed intrusive investigation and characterisation of the site soil resource would be required at an early stage.

APPENDIX 1 ▪ Drawings



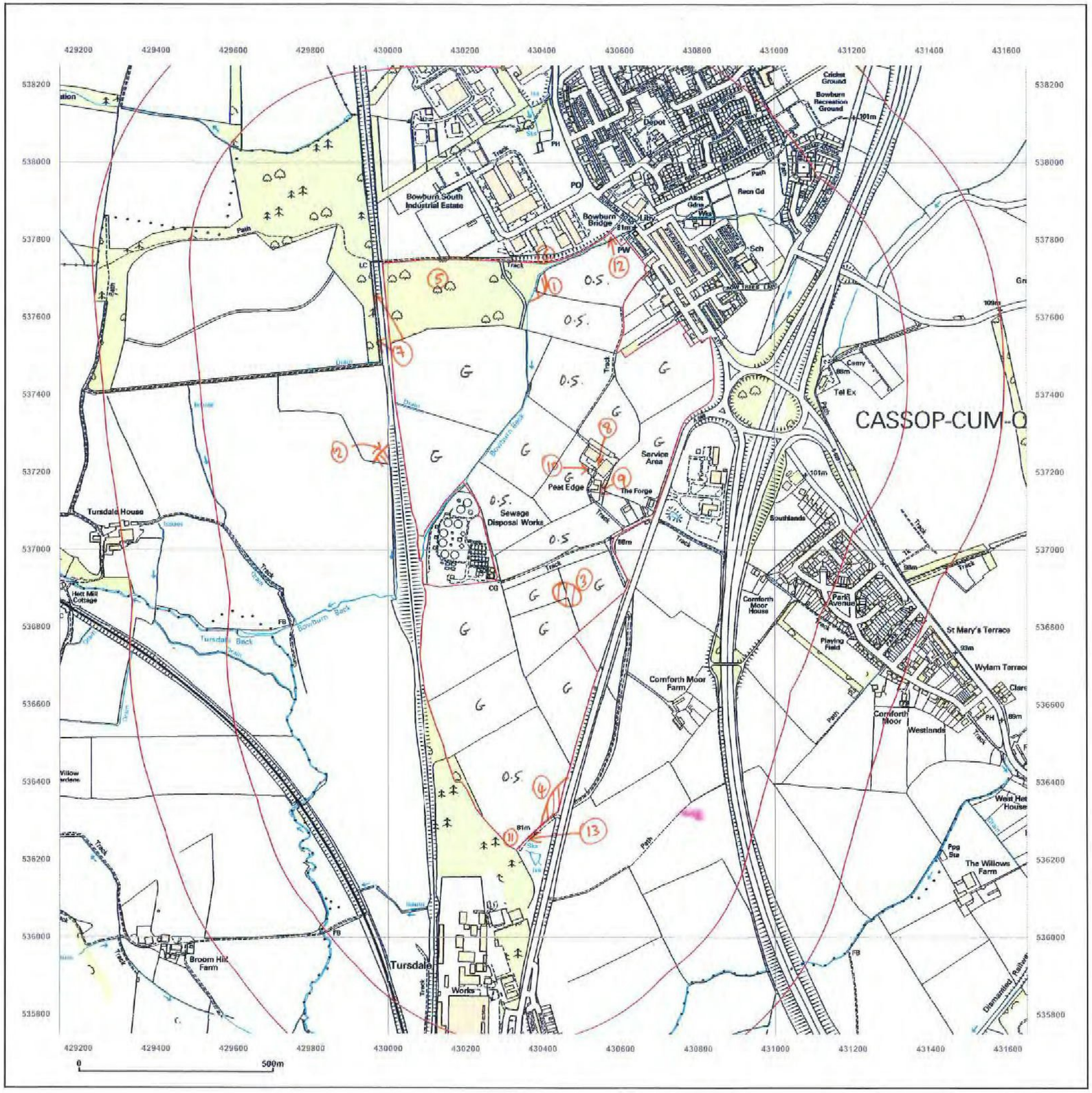
Revision Details	Dwn	Chd	App'd
Based on a scanned image.	04/04/14		-
	RH	LB	-

merebrook consulting
AN idom GROUP COMPANY

Guernsey Property Investment Ltd
Acorn Business Park, Durham
Site Location Plan

Job No.	Dwg No.	Revision
18582	001/001	-
Scale	**Date**	**Frame Dimensions mm**
N.T.S.	April 2014	(A4) 250x181
Drawn	**Checked**	**Approved**
RH	LB	-

G- Grass
O.S. - Oilseed Rape



GroundSure
ENVIRONMENTAL INSIGHT

Site Details:

ACORN BUSINESS
PARK,DURHAM, DL5 6HP

Client Ref: 14-S274-FDO-MER00806
Report Ref: HMD-154-1359846
Grid Ref: 430400, 537000

Map Name: 1:10,000 Raster
Map date: 2002
Scale: 1:10,000
Printed at: 1:10,000

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2002

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T: 08444 159000
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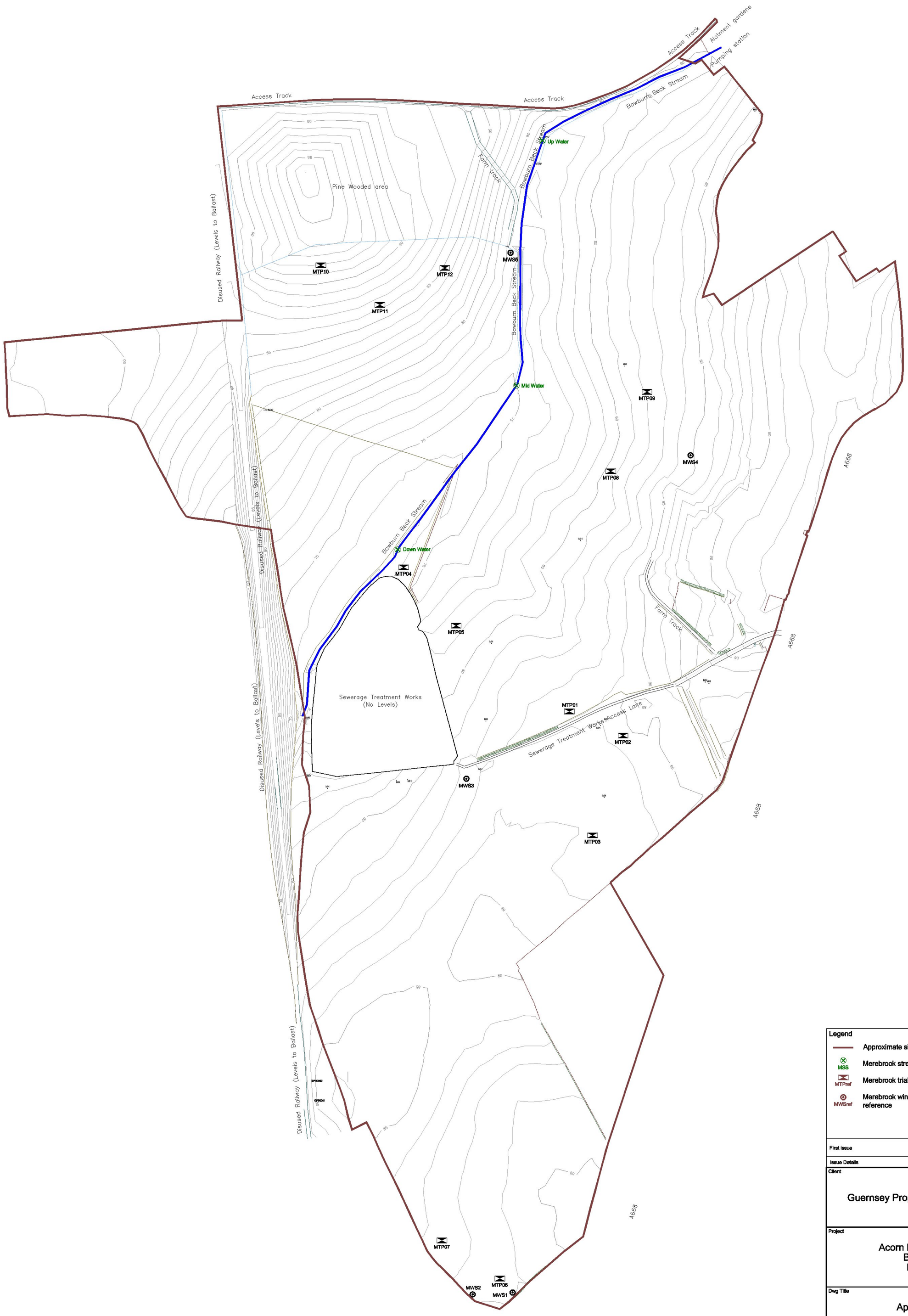
Production date: 25 March 2014

To view map legend click here *Legend*

N

Approx



Legend

- Approximate site boundary
- MSS — Merebrook stream samples
- MTPref — Merebrook trial pit with location reference
- MWSref — Merebrook window sample with location reference

Issue Details	Dwn	Chd	App'd
First issue	RH	SJ	SJ
	22-04-14		-

Client

Guernsey Property Investments Ltd

Project

Acorn Business Park
Bowburn,
Durham

Dwg Title

Approximate

Site Investigation Locations

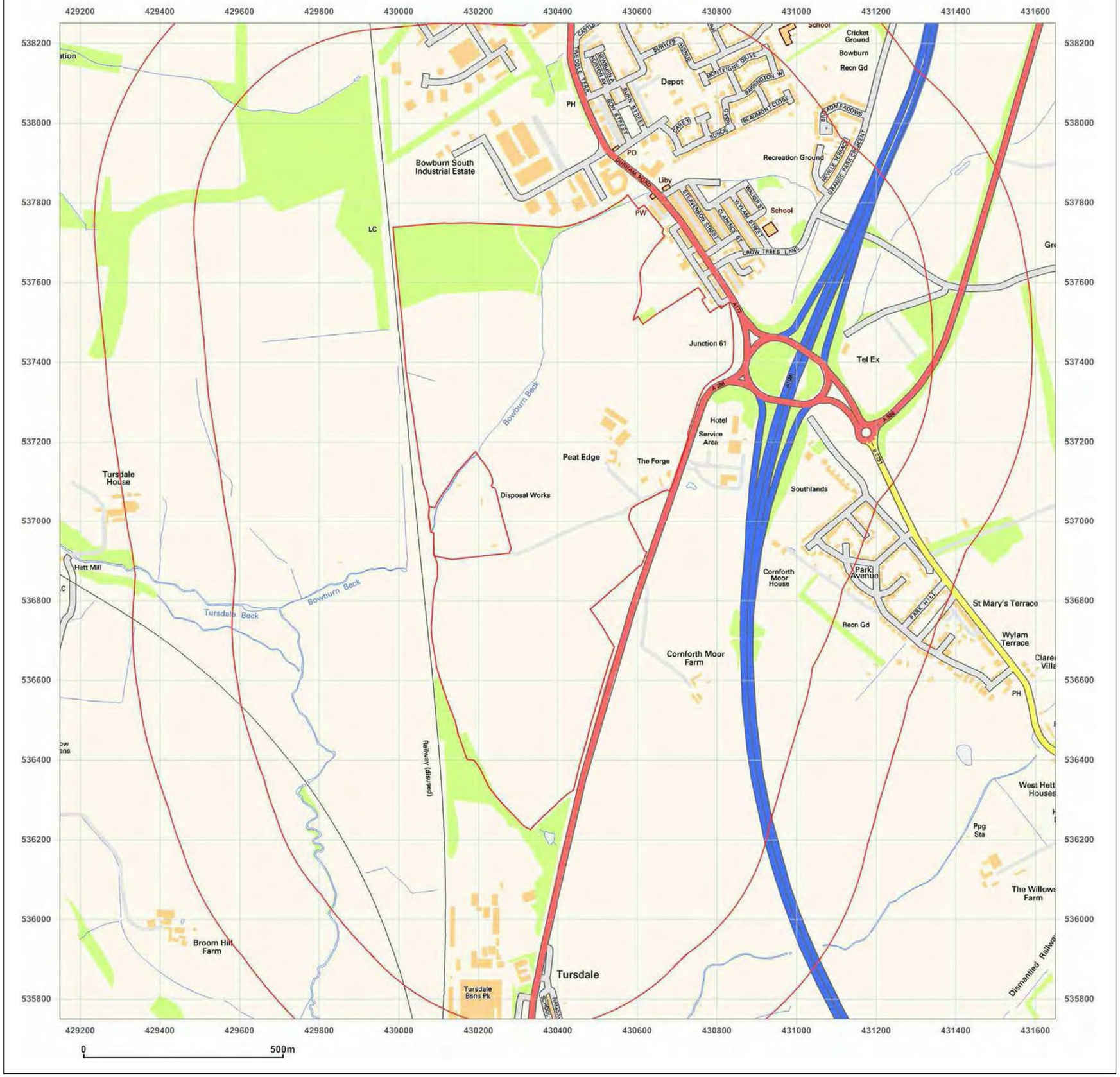
Job No.	Dwg No.	Revision
18582	304-001	-
Scale: 1:2500	Date: April 2014	Frame Dimensions mm: (A1) 791 x 544
Drawn: RH	Checked: SJ	Approved: SJ

London
Kent
Derby
Cardiff
Manchester

idom merebrook

East Mill, Bridgefoot, Belper, Derbyshire, England. DE56 2UA
tel +44(0)1773 829988 fax +44(0)1773 828383 email info@merebrook.co.uk

APPENDIX 2 ▪ Historic Plans



GroundSure
ENVIRONMENTAL INSIGHT

Site Details:

ACORN BUSINESS
PARK,DURHAM, DL5 6HP

Client Ref: 14-S274-FDO-MER00806
Report Ref: HMD-154-1359846
Grid Ref: 430400, 537000

Map Name: National Grid

Map date: **2012**

Scale: 1:10,000

Printed at: 1:10,000

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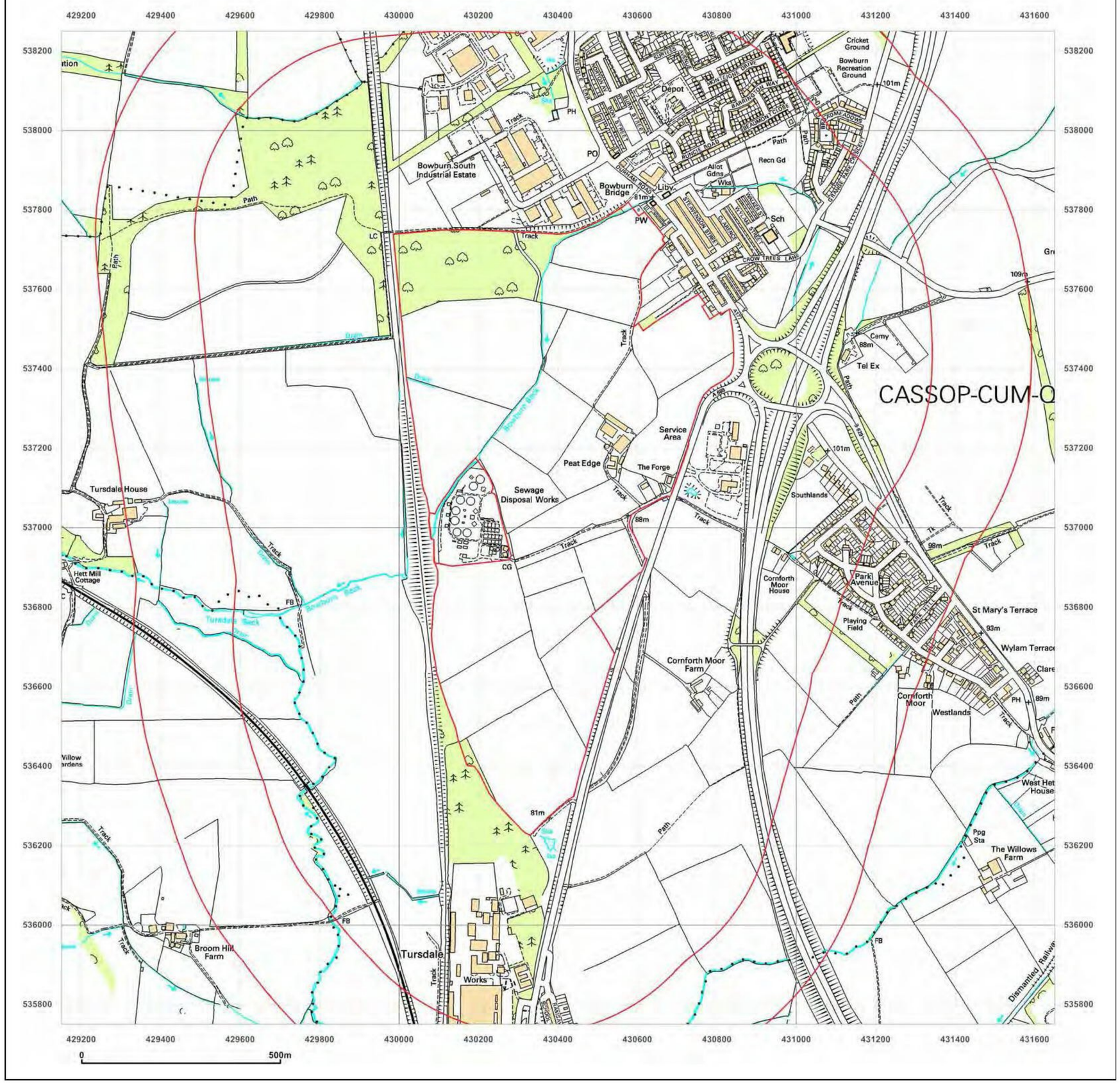

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Site Details:

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Client Ref: 14-S274-FDO-MER00806
Report Ref: HMD-154-1359846
Grid Ref: 430400, 537000

Map Name: 1:10,000 Raster

Map date: **2002**

Scale: 1:10,000

Printed at: 1:10,000

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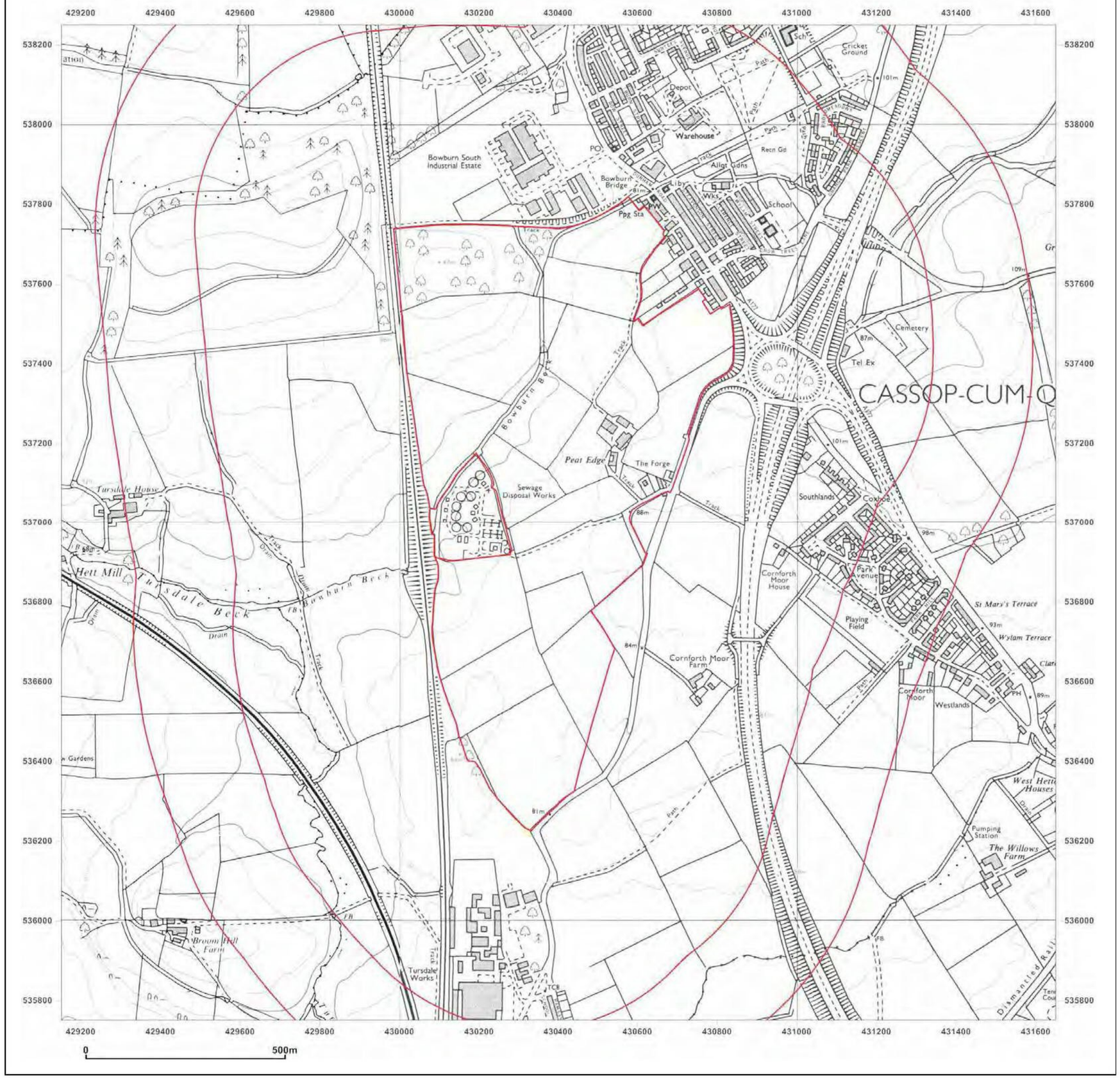

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PARK,DURHAM, DL5 6HP

Client Ref: 14-S274-FDO-MER00806
Report Ref: HMD-154-1359846
Grid Ref: 430400, 537000

Map Name: National Grid

Map date: **1992**

Scale: 1:10,000

Printed at: 1:10,000

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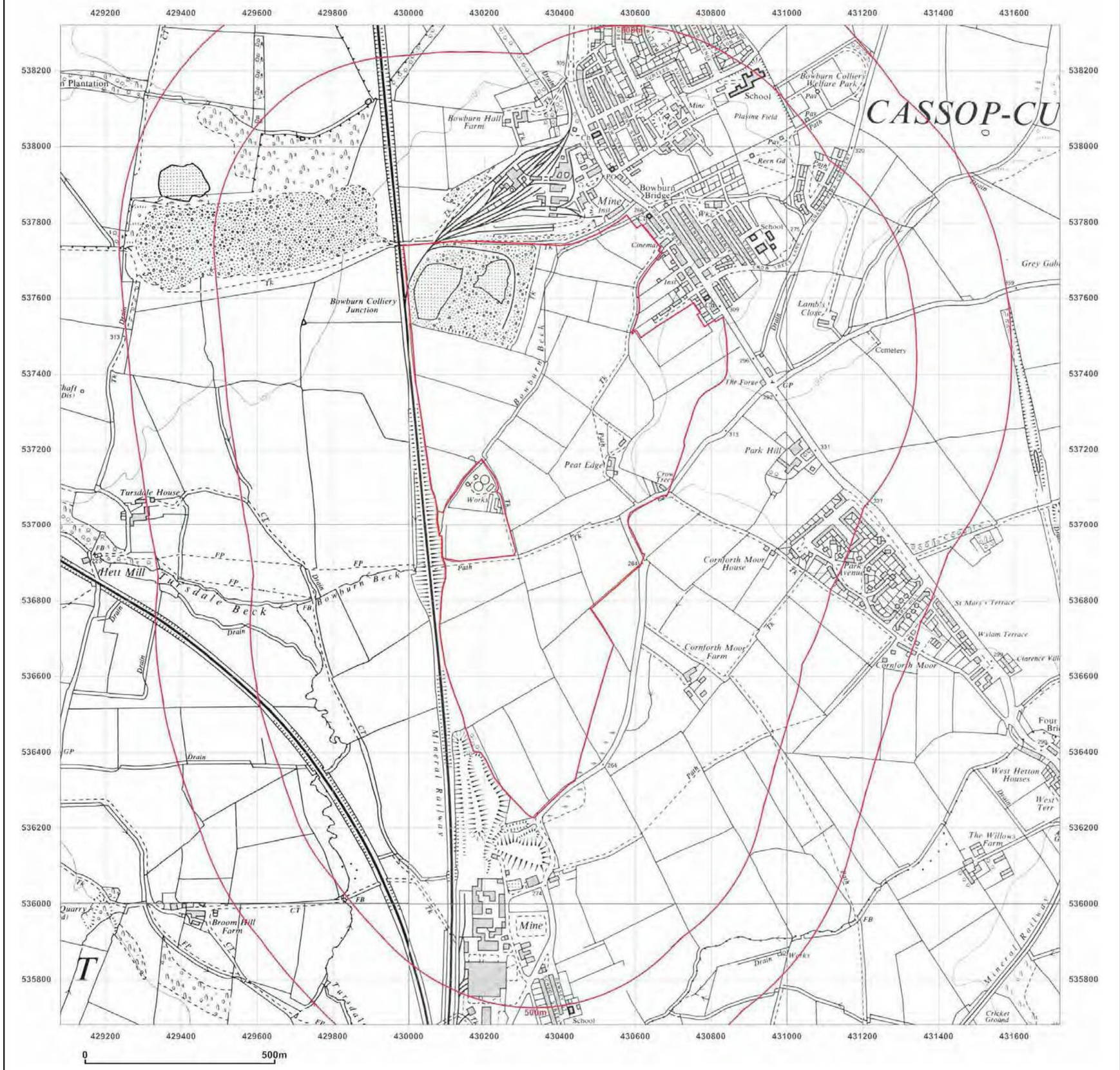

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Site Details:

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Client Ref: 14-S274-FDO-MER00806
Report Ref: HMD-154-1359846
Grid Ref: 430400, 537000

Map Name: Provisional

Map date: **1964-1966**

Scale: 1:10,560

Printed at: 1:10,560

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Surveyed 1966	Surveyed 1967
Revised 1966	Revised 1967
Edition N/A	Edition N/A
Copyright N/A	Copyright N/A
Levelled N/A	Levelled N/A

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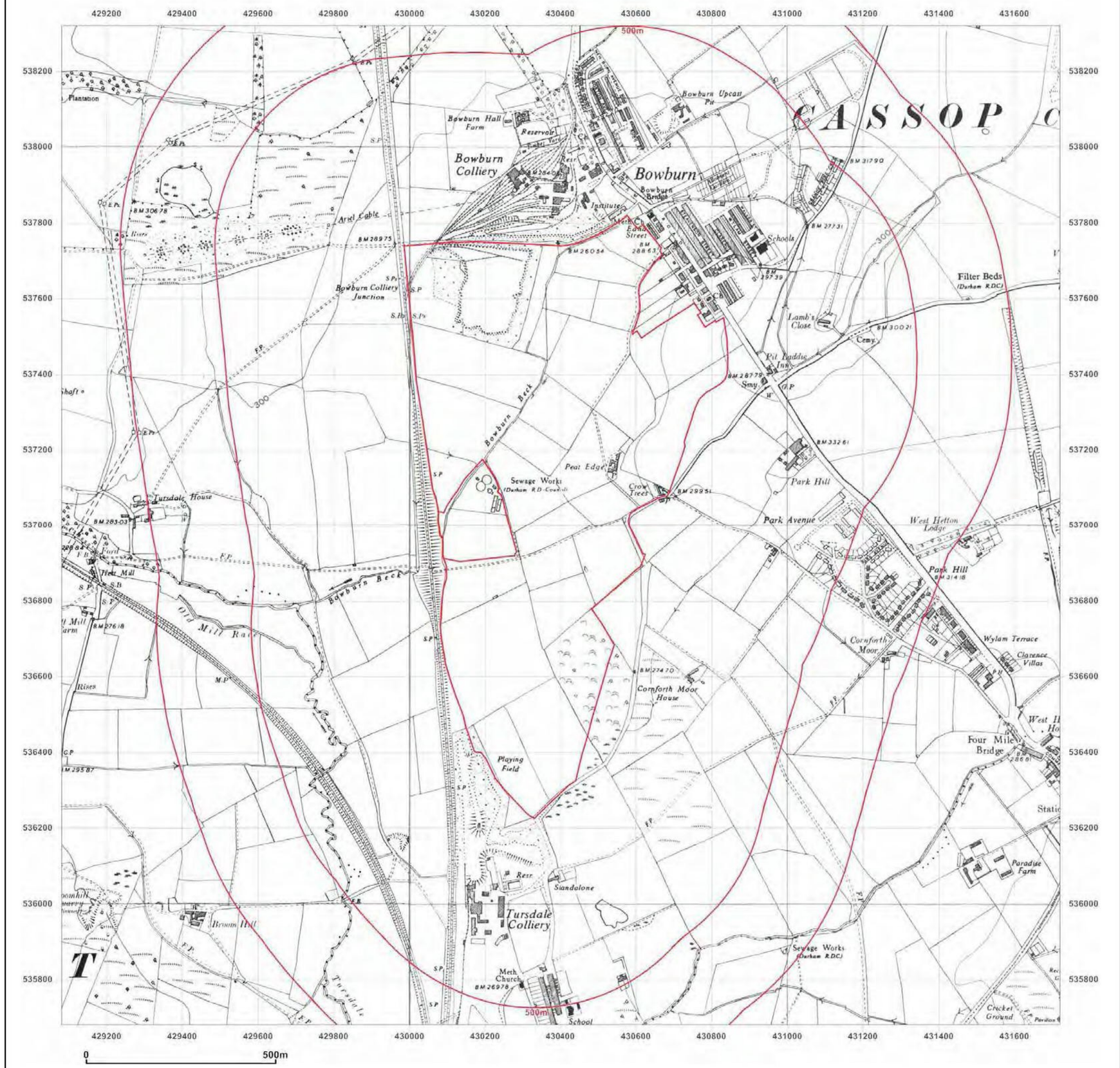

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Site Details:

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Report Ref: HMD-154-1359846
Grid Ref: 430400, 537000

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Map date: **1951**

Scale: 1:10,560

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Surveyed N/A
Revised 1951
Edition N/A
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Surveyed 1940
Revised 1940
Edition N/A
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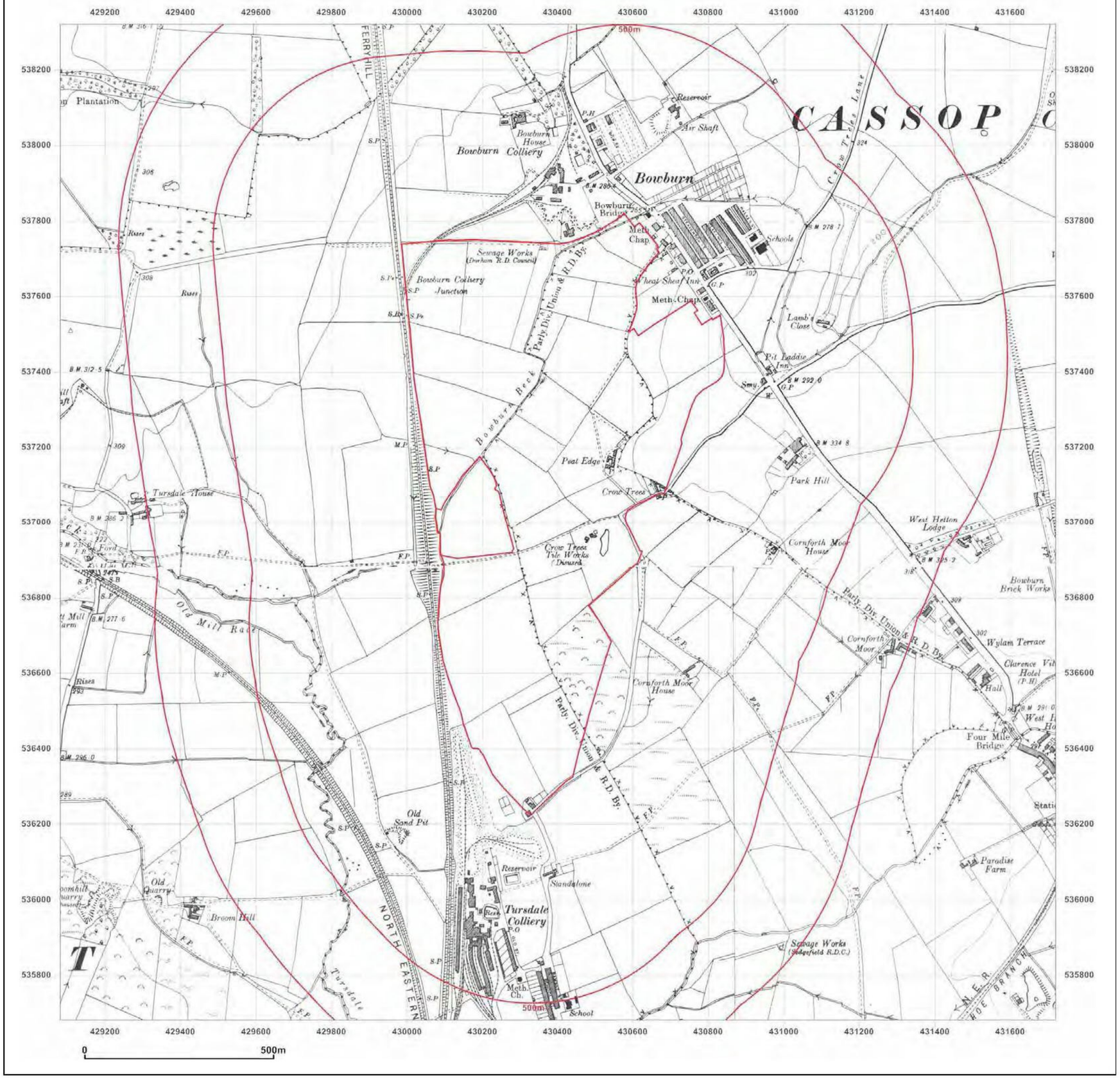

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ENVIRONMENTAL INSIGHT

Site Details:

ACORN BUSINESS
PARK,DURHAM, DL5 6HP

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Report Ref: HMD-154-1359846
Grid Ref: 430400, 537000

Map Name: County Series

Map date: **1923**

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Printed at: 1:10,560

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Surveyed 1857
Revised 1923
Edition N/A
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Surveyed 1857
Revised 1923
Edition N/A
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Surveyed 1857
Revised 1923
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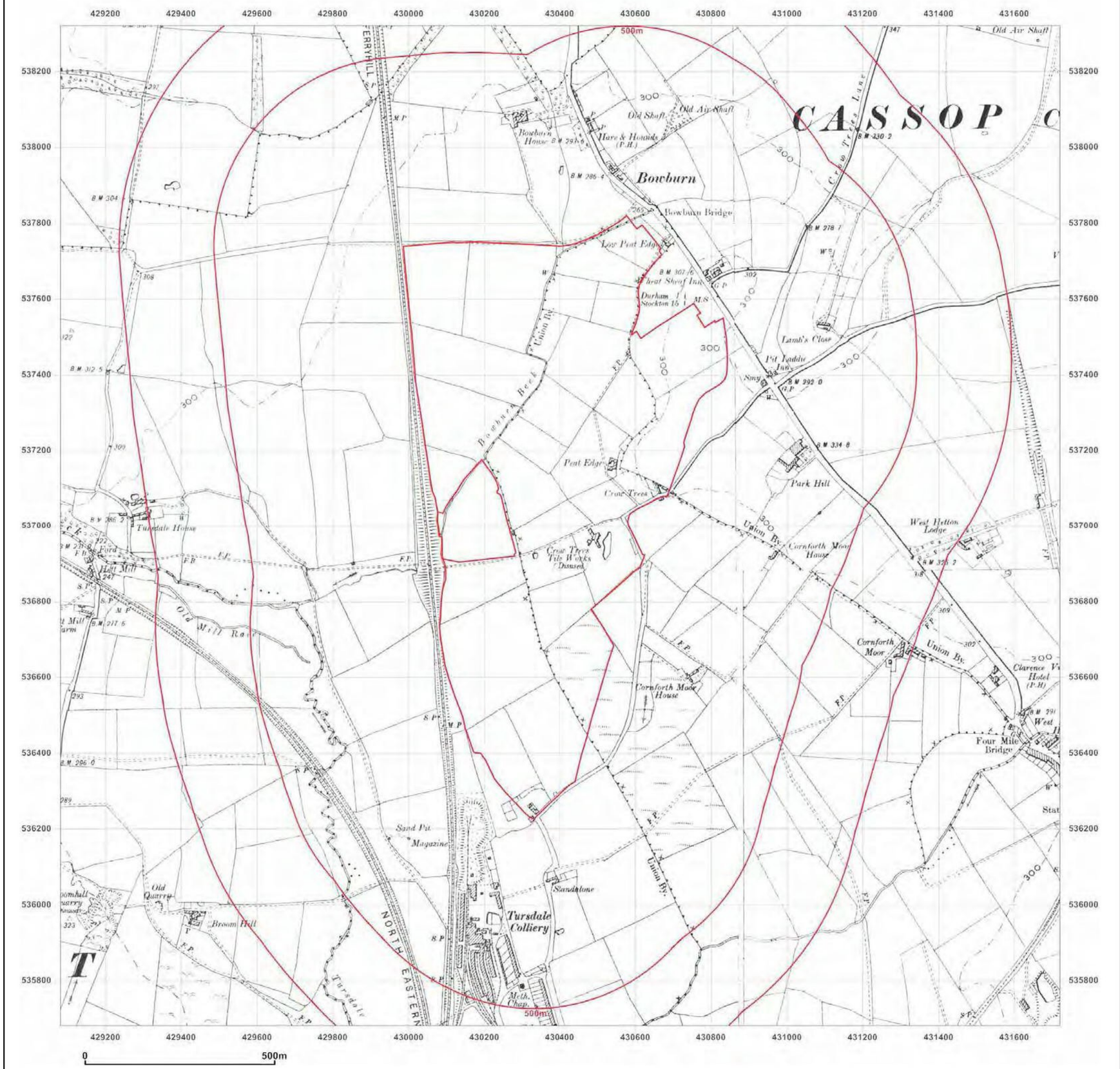

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ENVIRONMENTAL INSIGHT

Site Details:

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PARK,DURHAM, DL5 6HP

Client Ref: 14-S274-FDO-MER00806
Report Ref: HMD-154-1359846
Grid Ref: 430400, 537000

Map Name: County Series

Map date: **1895-1898**

Scale: 1:10,560

Printed at: 1:10,560

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Surveyed 1857
Revised 1895
Edition N/A
Copyright N/A
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Surveyed 1857
Revised 1898
Edition N/A
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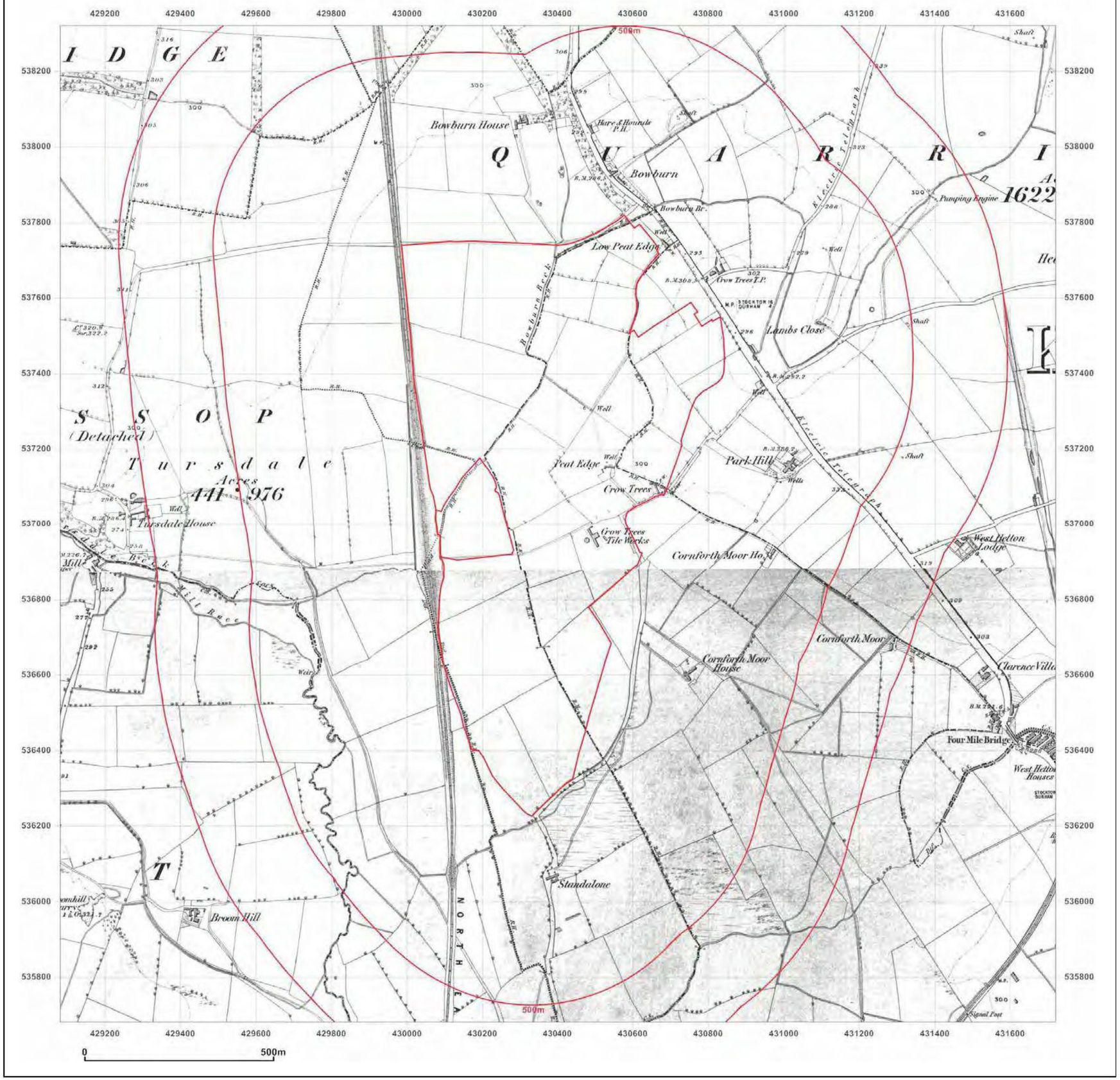

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Client Ref: 14-S274-FDO-MER00806
Report Ref: HMD-154-1359846
Grid Ref: 430400, 537000

Map Name: County Series

Map date: **1857**

Scale: 1:10,560

Printed at: 1:10,560

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APPENDIX 3 ▪ BGS Borehole Logs

NZ/23/NE/

SECTION OF Bowburn Surface Borehole (No.23 on site) 25 Feet East of Leaside Branch Railway and 330 Feet North of Bowburn Junction

6 incl
Regist
G
D.

Exact Site

Lat. 54°-44'-01.2" N

Long. 1°-32'-03.1" W

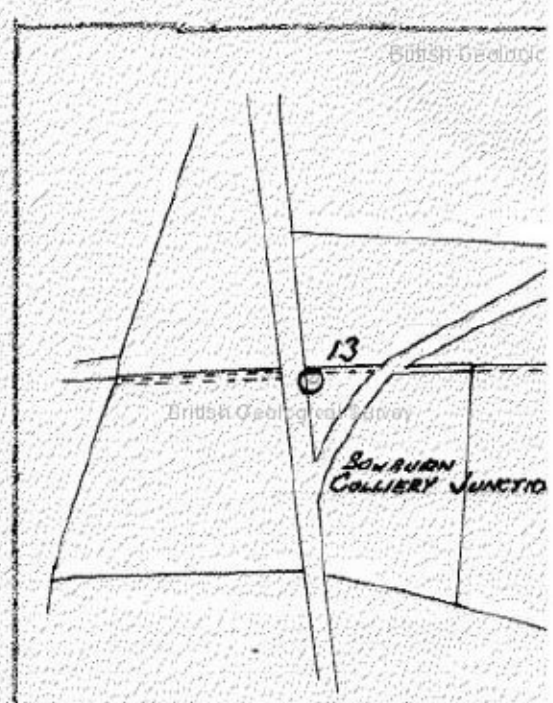
Level at which bore ~~shaft~~ ~~drift~~ commenced relative to O.D. + 288.13

Date of sinking or boring Commenced 24.3.55 Completed 12.4.55

Sinker or Borer N.C.B.

One Inch Geological Map 103 N.E. (New Series Sheet 27)

Six Inch Map (County and Quarter Sheet) Durham NZ 23 NE



Scale 6" to 1

Geologist's Notes	NATURE OF STRATA Borer's Journal		THICKNESS Feet	In.	Fe
	Strong Light Brown Boulder Clay (good)		112	0	11
	Sand		3	0	11
	Soft Sandy Clay		35	0	1
	Strong Boulder Clay	+ 108.63	29	6	17
	Grey Shale		4	6	18
	Grey Sandstone		6	0	19
	Grey Shale		3	0	19
	Grey Sandstone with coal pipings		30	0	22
	Blue Shale		1	10	22
	COAL (Low Main)	+ 60.63	2	8	22
	Seggar (Into)		2	6	23
	Bottom of Borehole	+ 53.13			

NZ/33/NW/101 104

SECTION OF Bowburn Surface Borehole No.9 on site apprex 900 ft South West of Peat Edge and 240ft West of No.1 Borehole (S.M.5)

6 inch Registe

D.1

Exact Site

Lat. 54°-43'-35.0"

Long. 1°-31'-43.0"

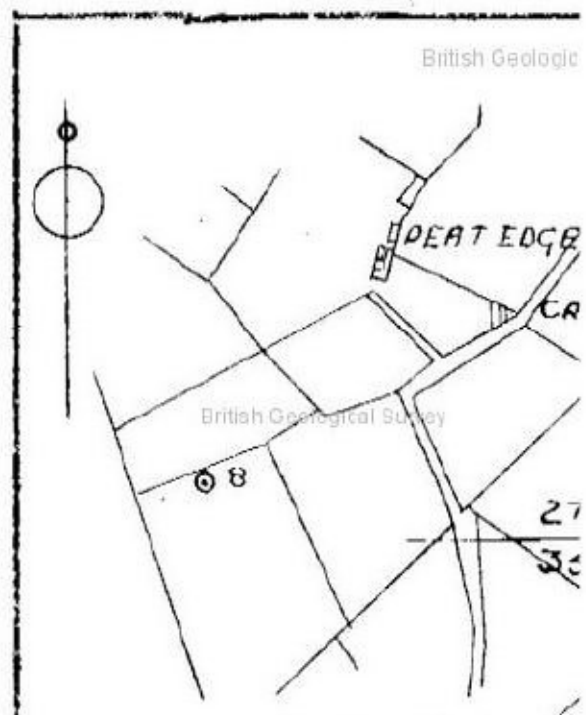
Level at which ~~shaft~~ bore ~~drift~~ commenced relative to O.D. + 272.66

	Commenced	Completed
Date of sinking or boring	3.11.54	4.11.54

Sinker or Borer N.C.B.

One Inch Geological Map 103N.E. (New Series Sheet 27)

Six Inch Map (County and Quarter Sheet) Durham 27 S.W. NZ/33/NW



Scale 6" to 1

Geologist's Notes	NATURE OF STRATA Borer's Journal		THICKNESS Feet	THICKNESS In.	D Fee
	Soil		1	0	1
	Soft Sandy Clay		27	0	2
	Strong Boulder Clay		79	0	10
	Heavily Bouldered Clay	+ 151.91	13	9	12
	Broken Sandstone (Into)		4	3	12
	Bottom of Borehole	+ 147.66			

NZ33NW/54 NZ/33/NW

(68/4028) Wt. 74179/81 8000 2/49 [illegible] St., Ltd. [illegible]

82 51
32

SECTION OF Boring in Vale Pit, Crawcrook, from the bottom of the Main Seam.

Surface Level ~~~ 100'

Communicated by B.G.S. 2626

Date of boring or sinking 1865 Borer

One-inch Map 27 Six-inch Map (County and Half-Quarter Sheet) Durham 27 SE NZ/33/N

	Thickness.			Depth from	
	Fathoms.	feet.	ins.	Fathoms.	f
Soil		1	3		
Metal pipe	3	2	0	3	
Grey metal stone, with post pebbles.	3	2	0	6	
White post, with a little water near bottom.	4	4	0	11	
Grey metal stone, with coarse pebbles.	2	0	0	15	
Coarse metal, mixed with coal		2	4	13	
Grey metal stone, with post pebbles.	6	1	5	20	
White post	5	5	3	26	
Grey post mixed with coal			6	26	
Coarse, very coarse (Low Main)		2	6	26	
Grey metal, into.			4	26	