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SCENTAREA LIMITED

BLYTHE PARK, CRESSWELL, STOKE-ON-TRENT

PRELIMINARY PHASE I AND II GEO-ENVIRONMENTAL ASSESSMENT

MAY 2017

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SCENTAREA LTD

BLYTHE PARK, CRESSWELL, STOKE-ON-TRENT

PRELIMINARY PHASE I AND II GEO-ENVIRONMENTAL ASSESSMENT

MAY 2017

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DRAWINGS

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ST15807-003	Site Investigation Locations and Known Recorded Services	Not to Scale
ST15807-007	Preliminary Development Constraints (Western Area)	1:1,000
ST15807-008	Preliminary Development Constraints (Eastern Area)	1:1,000

1 EXECUTIVE SUMMARY

1.1 The site is located at National Grid Ref. 397810, 338960 (Blythe Park) and comprises two areas of predominantly agricultural land with areas of hardstanding, a dance studio and cable detection training ground. It is proposed to carry out residential development of the western area and commercial development of the eastern area. A new road will be constructed running through Blythe Business Park. The overall site area is approximately 15.12 hectares. A summary of pertinent information relating to the site is provided in Table 1 below.

TABLE 1: Summary of Intrusive Ground Investigation

Category	Summary
Present and past site use.	Both development areas have predominately been used for agriculture apart from the north eastern area of the western development area which contains a dance studio and area of hardstanding, used currently for car parking and material storage. The proposed interconnecting roadway runs through Blythe Business Park, the historic site of Blythe Colour Works. A presumed infilled river channel (old course of the River Blithe) cuts across both areas.
Ground Conditions	**Made Ground** Evidence of made ground was identified at seven locations across both development areas and along the proposed roadway. Made ground generally comprised of clayey silty sand and/or gravel with medium to high cobble content. The gravel and cobble components comprise, in varying quantities across the site and at different depths, ceramic fragments, brick, concrete, building stone, slag, mudstone, sandstone and quartzite. TP10, WS08, WS11 and WS12 were found to contain made ground associated Blythe Business Park. TP26 contained made ground likely to be associated with a historical tank/associated structures. Reworked natural deposits were found along locations inferred as the old route of the River Blithe. **Superficial** The natural superficial deposits can be broadly split into three units as follows: • Topsoil comprising brown clayey silty gravelly sand / soft brown silty sandy gravelly clay with inclusions of rootlets; • Reddish to orangeish brown slightly clayey slightly silty sand and gravel with low to high cobble content (River Terrace deposits); • Soft to firm grey to brown mottled orange silty sandy gravelly clay (Devensian Till). **Solid** Mercia Mudstone was encountered in one windowless sample borehole from a depth of 3.6m. The mudstone was recorded as fully weathered to partially weathered. **Groundwater** Shallow groundwater was encountered at several borehole and trial pit locations at depths varying from 0.20m to 3.50m bgl.

TABLE 1: Summary of Intrusive Ground Investigation	
Category	**Summary**
Tier 1 Contaminated Land Risk Assessment	
Human Health	The results of the chemical analysis were screened against Generic Assessment Criteria (GAC) for residential land use (including plant uptake) and commercial end uses. • No exceedances were found within the eastern development area for a commercial end use; and • Exceedances of dibenzo(ah)anthracene (TP26) and lead and cadmium (TP10) were identified within the western development area, both within made ground deposits. At least 600mm clean cover is required across all made ground deposits found within the western (residential) area. No remedial measures are required for the eastern (commercial) area from a soil contamination perspective.
Controlled Waters	Although exceedances of PAH and inorganic compounds were detected across both development areas, it is considered the site represents a low risk to controlled waters and no further actions are required.
Ground Gas	Based upon the gas monitoring undertaken to date, gas precaution measures for carbon dioxide will be required. No methane was detected. Remedial options will be Characteristic Situation 2/Amber 1 for the eastern and western areas, respectively.
Geotechnical Assessment	
Underground Obstructions	No underground obstructions were encountered during the site investigation, apart from clay field drainage pipes in several trial pits. Remnant foundations may be present where limited historical structures have been present and those associated with the dance studio. Several services are known to cross both development areas, including a high pressure gas main within the eastern development area. Special considerations and easements must be adhered to in relation to the High Pressure Gas Main in terms of future development.
Allowable Bearing Pressure (ABP) and Foundation Options	The natural superficial deposits across both development areas are deemed to be suitable as a founding horizon subject to some processing including drying and sorting. The shallow groundwater indicates that some dewatering will be necessary. In addition, excavations in the granular soils are likely to be unstable. • An Allowable Bearing Capacity of 250kPa may be assumed for the natural superficial deposits within the eastern development area. This is based upon a square pad foundation solution at 0.75m depth. • An Allowable Bearing Capacity of 125kPa may be assumed for the natural superficial deposits within the western development area. This is based upon a shallow 0.6m wide strip foundation at 0.75m depth. Foundation may have to be deepened in the vicinity of the existing dance studio.
Soak-Away Drainage	Due to the groundwater levels identified along with permeabilities attained at the site, soak-away drainage is not considered feasible.

1.2 The executive summary forms part of the overall report and should not be considered in isolation.

2 INTRODUCTION

Instructions

2.1 This report is prepared in accordance with written instructions from Mark Harris of Scentarea limited dated 9 December 2016. This follows an initial proposal dated 28 October 2016 and a revised proposal dated 6 March 2017 by Wardell Armstrong to conduct a Geo-Environmental Assessment.

Site Location

2.2 The site is located at approximately National Grid Ref. 397810, 338960, south of the A50 in Cresswell, the location of which is shown on the attached Drawing No. ST15807-001. The site is approximately 15.12 hectares split into two development areas (east and west), both of which are agricultural land used for the cultivation of crops (predominately barley). The western area also contains one building (currently used as a dance studio) and rough grassland used as a cable detection facility. An area of hardstanding is found to the south east of the dance studio, found to be occupied by storage containers and discarded materials including timber, bricks, tyres, machinery and lubricants. An old disused and overgrown track/roadway runs parallel to the River Blithe along the northern boundary. A proposed roadway interconnects these two areas, running through the centre of the current location of Blythe Business Park which has a variety of commercial and industrial units. For the purpose of this report, it is included within the eastern development area.

2.3 The eastern development area is bounded by the River Blithe to the north, Blythe Business Park to the west, a drainage ditch and tree line to the east with the southern boundary not being physically demarcated and cuts across an agricultural field.

2.4 The western development area is bounded by the River Blithe and Blythe Business Park to the north, Sandon Road and Sandon Close to the west, Blythe Business Park to the east and Rookery Crescent to the south. The outer perimeter of this area is bounded by trees and hedgerows.

Scope and Objectives

2.5 This report, which is based on a desk study and ground investigation, provides an assessment of the prevailing ground conditions associated with the proposed development, development constraints and foundation options. The objectives of the geo-environmental investigation are to:

- Review historical plans, geology, hydrogeology, site sensitivity, mining records and any local authority information available in order to complete a Desk Study in line with the Environment Agency (EA) document Model Procedures for the Management of Contaminated Land (Contaminated Land Report 11 (CLR11));
- Undertake a preliminary stage of investigation and analysis to provide an overview of environmental issues identified;
- Assess the implications of any potential environmental risks, liabilities and development constraints associated with the site in relation to the future use of the site and in relation to off-site receptors;
- Assess the geotechnical information and provide preliminary recommendations in relation to foundations and floor slabs; and
- Provide recommendations regarding future works required.

2.6 The interpretation of the ground conditions provided in this report is based on extrapolation of ground conditions from individual site investigation locations. Whilst these have been designed to allow sufficient coverage for reasonable extrapolation, the potential for unexpected ground conditions in areas between site investigation locations and within safety standoff areas to known services cannot be discounted.

Proposed Site Use

2.7 It is proposed that the site will be split into two development areas. The eastern area is to be developed for a commercial end use while the western area is to be developed for a residential end use. A roadway will interconnect these two areas, running though the centre of Blythe Business Park. An Illustrative Layout Plan for the proposed development is shown in Appendix 1.

3 SITE HISTORY AND CURRENT LAND USE

Data Sources

3.1 The history of the site and the surrounding land has been investigated by consultation with a range of archive sources. The topographical and environmental data is based primarily on an Envirocheck report prepared by the Landmark Information Group and dated 6 January 2014 (Appendix 2). The Envirocheck Report was previously obtained by Wardell Armstrong in 2014 for a Ground Conditions Chapter of an Environmental Statement of the site. The boundary used within the LIG report was produced for an alternative site boundary (to include the entrance to Blythe Business Park) and as such, approximate distances defined within this report may be under/overestimated.

3.2 In addition, the following sources of information have been used and referenced for and review:

- Wardell Armstrong Report Ref. NL07510/001 – Addendum to Validation Report on Construction Quality Assurance for Remediation of Areas 1, 2 and 3 and Associated Site Information, dated September 2013;
- Wardell Armstrong Report Ref. ST13776 – Ground Conditions Chapter, Environmental Statement, Blythe Business Park, Staffordshire, July 2014;
- Rogers Geotechnical Services Ltd Report No J1505/09/E – Factual Report on a Site Investigation at Blythe Park Power Station, Draycott on the Moors, Staffordshire, dated January 2010;
- Staffordshire County Council Ref CLR_BCW_PSI – Contaminated Land Report, Scoping Proposal, dated 16 October 2009;
- Staffordshire County Council Ref ENV04_2014_BP – Environmental Information Regulations (2004) request, dated 17 March 2013;
- Utilities Connections Management Limited Ref W117 – Utility Connections Report at Blythe Business Park, off Sandon Road, Cresswell, Stoke-On-Trent, ST11 9RD, dated 15 August 2014;
- Wardell Armstrong in-house records; and
- Internet searches.

Site History

3.3 Historic maps provided in the LIG report have been used to identify previous land uses, including any significant potentially contaminative uses. Where other features that may have an effect on development of the site have been identified, they are described.

3.4 Table 2 (below) summarises the history of the site and its immediate vicinity from 1880 to the present day.

TABLE 2: Summary of Land Use

Date	Site Land Use	Adjacent Land Use
1880-1888	Both development areas are both currently large fields with footpaths crossing both. The old course of the River Blithe crosses the eastern area trending east-west.	The Uttoxeter Branch runs parallel to the north of both areas, with a train station and Stoke-On-Trent Junction box located beside Sandon Road, which runs parallel to the west boundary of the western area. There is also to the north Whiting Mill, Station farm, St Mary's Chapel and some residential units within 250m of the site boundary, with an old gravel pit c.400m to the north. A Colour Mill is also located in-between both areas (c.50m), along the River Blythe/Mill Race, Rookery Farm (c.200m) and Leesehouses (c.350m) are located to the south. The River Blithe also runs to the north of the site.
1901	The old course of the River Blithe running through the eastern area and a small part in the western area is now marked as 'marshy ground' and is no longer known as the course of the river.	To the north, the Cheadle Branch line now operates and connects to the renamed North Staffordshire Railway line.
1924	A 'spring' is marked in the south east corner of the eastern area.	The colour mill has expanded. Whiting Mill no longer marked.
1937	No significant change	Residential construction of properties along Sandon Road and to the north has occurred since 1924. There has been the construction of a pumping station to the north east of the western area. The Colour Mill is now called Blythe Colour works and has further expanded westwards, with several marked tanks across its site. A cricket ground to the north is now shown. There is also a possible unmarked tank west of the western area along with a filter bed.

TABLE 2: Summary of Land Use		
Date	**Site Land Use**	**Adjacent Land Use**
1943-1950	A tank is located in the south east corner of the western area with several small associated structures.	Bolero Camp Cresswell was established during the war housing US troops, south of the western area (c.150-200m) who used the Blythe Colour works. Colour works expand.
1954-1955	No significant change	No significant change
1957-1971	Track now runs through western area trending east-west.	New properties have been established along Sandon Road with the unmarked tank now no longer there. Properties also built along Sandon Close and Rookery Crescent. Blythe Colour works are now labelled as 'works' and several new industrial units have now appeared. Large above surface pipeline which goes underground located west of western area.
1978-1984	A field boundary now exists within the western area.	No significant change.
1987-1989	Blythe Business Park expands into east corner of western area, altering internal field boundary. Dance studio building is now built within the western area.	Construction of A50 to the north. Pumping station decreasing in size.
1994-Present day	Tank no longer marked in western area.	No significant change.

Current Site Use

3.5 A site walkover was conducted on 31 January 2017. Two Wardell Armstrong representatives were present. At the time of the visit, the field in the eastern area had recently been sown with barley, with the field in the western area remaining as a large grass field. The building within the western area was still for use as a dance studio with the rough grass around the centre being used for cable detection training. The area of hardstanding adjacent to the building was occupied by storage containers, cars and lorry trailers, along with discarded materials including:

- Timber;
- Bricks;
- Tyres;
- Machinery; and
- Lubricants.

3.6 The route of the proposed interconnecting road between the two areas runs through the centre of Blythe Business Park, which contains a variety of industrial and commercial units and warehouses. Towards the west boundary of the eastern area where the roadway would enter through, there is an area of disused (partly temporarily fenced) hardstanding with building debris and materials left on the surface.

3.7 The eastern area was very wet underfoot and included areas of standing water, particularly in the east of the eastern area. Nevertheless the walkover had been carried out during a wet period of weather.

3.8 No evidence of Japanese Knotweed, Himalayan Balsam and Giant Hogweed was identified during the walkover, although it was carried out during January and therefore it is recommended that an ecological survey is undertaken to prove/disprove this.

Services

3.9 A specialist Utility Connections Report was undertaken for Wardell Armstrong by Utilities Connections Management Limited in 2014 for a previous site assessment. This report highlighted known services and potential diversions / disconnections /proposed utility routes.

3.10 From the above information, the following key services were identified:

Eastern development area

- A Local High Pressure (HP) Gas Main (National Grid Ref MIL WICH-HULME 113000050) cuts through the field, trending north-south. The presence of this gas main is noted by the HP gas main pole.

Western development area

- A Local Medium Pressure (MP) Gas Main cuts through the top of the field and passes north of the dance studio, trending north west to south east. The gas pipe terminates at a Gas Meter House along the route of the proposed roadway;
- A MP Gas Main (63mm) runs along the western boundary beside/underneath the footpath;

- A Local Low Pressure (LP) Gas Main (300mm) runs along the western boundary beside/under the footpath;
- Overhead Low Voltage (LV) power line along the southern boundary;
- BT Openreach connections (underground and overhead) run to the location of the dance studio trending north to south, with an additional connection running perpendicular to this. An additional section of BT connections is located along the footpath along the western boundary;
- A 100mm Ductile Iron (DI) water main runs alongside the western boundary within/beside the footpath;
- A series of foul/combined sewers cross the development area from local residential housing and local area. The main sewer, the Blithe Valley Sewer runs from west to east across the north of the area, with a pipe diameter of 900mm; and
- A Storm sewer crosses the area, south west to north east trending from local residential housing.

3.11 No private services running inside of Blythe Business Park were identified within the plans attained from the client, apart from the services mentioned above. Evidence of the presence of private services were observed around the business park.

Asbestos

3.12 The Health and Safety at Work Act, the Control of Asbestos Regulations and the Construction (Design and Management) Regulations impose duties upon employers, site owners, their agents and contractors in respect of hazardous materials including asbestos. Other health and safety and welfare regulations place duties on Employers to undertake appropriate risk assessments. This could include the commissioning of surveys, identification and management of hazardous materials including any proposals for remedial work.

3.13 A site walkover survey has been completed. However, the walkover survey does not constitute an asbestos survey and not all areas of the site may have been visited or made available for inspection.

3.14 Asbestos was not identified on site during the initial site walkover, although an inspection of the dance studio was not undertaken. Given the age of the building, the likelihood of the asbestos being utilised within the construction is possible and it is recommended that a full asbestos survey should be carried out of the Dance Studio to confirm this.

4 GEOLOGICAL AND HYDROGEOLOGICAL SETTING

Geology

4.1 The assessment of the geology of the site is based on the published geological mapping sheets (Sheet No.124, Ashbourne, Solid and Drift Geology, 1: 50,000 scale) supplemented by the geological memoir, topographical plans, and the boreholes contained within the Rogers Geotechnical Services Ltd Report (Appendix 3). Online data from the BGS has also been reviewed. A summary of relevant geological information is provided below in Table 3.

TABLE 3: Summary of Relevant Geological Data

Strata	Description
Made ground	Made ground deposits are recorded to exist within Blythe Business Park, consisting of material thought to have been associated with Blythe Colour Works, historical debris and demolition arisings.
Natural superficial deposits	The majority of the site is underlain by river terrace deposits consisting of sand and gravel. The south western corner of the western area is underlain by Devensian Till.
Solid strata	The site is underlain by the Tarporley Siltstone Formation (siltstone, mudstone and sandstone) in the north of both development areas and the Mercia Mudstone Group in the south of both development areas.
Geological structure	An inferred geological fault runs through the western area trending east to west. The local dip direction generally is 8 degrees south west.
Natural cavities	No record.
Landslides	The BGS indicate no mass movement within the local area. They therefore record the potential for landslides as very low.
Ground stability	British Geological Information Services indicate a very low potential for ground collapse, a moderate potential for compressible ground stability hazards, no dissolution hazards, very low potential for landslide stability, low running sand hazards, a very low potential for shrinkage/swelling potential located within the site boundary. These are determined to be the same within or up to 250m of the site boundary.

Hydrogeology

4.2 Hydrogeological information has been obtained from a review of:

- Envirocheck report;
- Groundwater Protection Policy and Groundwater Vulnerability maps published by the EA;
- Hydrogeological maps published by the BGS;
- Groundwater Protection: Policy and Practice (EA, 2006); and

- EA interactive aquifer designation map.

4.3 This information indicates the site to be underlain by superficial deposits which are classified as a Secondary A Aquifer (river terrace deposits) and Unproductive Strata (till). The underlying solid strata are both classified as a Secondary B Aquifer.

4.4 Secondary A aquifers are generally fractured or potentially fractured formations and do not have a high primary permeability. Although not producing large quantities of water for abstraction, they are important for local supplies and may supply base flow to rivers.

4.5 Secondary B aquifers are generally regarded as containing limited quantities of groundwater. Groundwater flow through such rocks, although imperceptible, does take place and needs to be considered in assessing the risk associated with persistent pollutants.

4.6 Unproductive Strata have low permeability and have negligible significance for water supply or river base flow.

4.7 There are four groundwater abstraction licences within 250m distance of the site. The three closest are located 244m north west of the site (NGR: 397400, 339500) and are operated by Severn Trent Water Limited, to abstract an unknown quantity of water per year from three boreholes within the Tarporley Siltstone Formation for potable water supply. A Source Protection Zone is centred across this abstraction, with the northern section of the western area within Source Protection Zone II (Outer Protection Area).

4.8 The northern section of the eastern area lies within Source Protection Zone III (Total Catchment).

4.9 The remainder of the site does not lie within a source protection zone.

Soil Vulnerability Classification – Leaching Potential

4.10 The soil vulnerability classification groups the many different soil types of England and Wales into three soil vulnerability classes and six sub-classes. Each is based on the

physical and chemical properties of the soil, which affect the downward passage of water and contaminants. This classification is not applied to soil above non-aquifers. Soil information for urban areas is based on fewer observations than elsewhere. A worst case vulnerability is therefore assumed until proved otherwise.

4.11 The soil has a high leaching potential (H1) as they readily transmit liquid discharges because the materials are either shallow, or susceptible to rapid flow directly to rock, gravel or groundwater.

Hydrology

4.12 The nearest graded surface watercourse is the River Blithe, which runs parallel to the northern boundary of both development areas. The EA has given the River Blithe a General Quality Assessment (Chemistry) rating of A (very good). This has been updated in 2015 under the water framework directive and assessed as "Good" for chemistry and "Poor for Biology". There is a local ungraded water feature (stream) that runs along the eastern development area's western boundary, and another stream which used to be recorded as the old course of the River Blithe running perpendicular to the eastern boundary.

4.13 The EA maintains national flood maps based on ground levels, predicted flood levels, information on flood defences and local knowledge. The flood maps show the predicted likelihood of flooding in an area in the context of current and also the proposed land use considered in development planning.

4.14 For existing land use purposes, the likelihood of flooding is classed as very low, low, medium or high based on the EA map entitled Risk of Flooding from Rivers and Sea. The two development areas lie within;

Eastern development area

- Medium to high risk along the northern part of the area; and
- Low to high along the western boundary.

Western development area

- Medium to high risk around the dance studio and area of hardstanding in the north east corner of the area.

4.15 A separate Flood Risk Assessment is undertaken for the site and reference should be made to this specific report regarding the flooding issues.

4.16 There are four surface water abstraction licences within 1km of the site. They are all located on the adjacent Blythe Business Park (NGR 397600, 339100) and are operated by Johnson Matthey PLC whom are licensed to abstract an unknown quantity of surface water per year for non-evaporative cooling and process water.

5 ENVIRONMENTAL SETTING AND CONSULTATIONS

Statutory Sources

5.1 Information from various statutory sources has been summarised from the Envirocheck report (Appendix 2) and prepared specifically for this site. The results from a site visit have also been considered as part of this assessment.

Contaminated Land Register Entries and Notices

5.2 No contaminated land entry or notice have been identified within 1km of the site.

Waste Management

5.3 Information supplied has indicated the presence of two landfills adjacent to the site (along the interconnecting roadway and bounding both the eastern and western development areas) with five landfills within 500m of the site boundary. Three of these are recorded EA historic landfill sites, with no other records of other types of waste management/landfill sites located within 1km of the site. All types of recorded landfills within 500m of the site is shown in Table 4.

5.4 The landfill which is located between the eastern and western areas (Landfill Reference EAHLD28839) is recorded to contain waste including inert, industrial, commercial, special waste and liquid sludge, with the licence holder being Blythe Colours Limited. This operated from 31 December 1948 until 27 March 1992. No additional information is held about the other adjacent landfill.

5.5 Wardell Armstrong investigated the landfill as a part of the wider Blythe Business Park assessment in 1998 (discussed in detail in Section 6). The subsequent report found that, due to the significant levels of contamination detected within the landfill, further remedial options were required.

5.6 Wardell Armstrong were re-instructed in 2005 and produced a revised risk assessment and updated remedial options strategy in 2007. These were subsequently approved by the EA and Staffordshire Moorlands District Council (SMDC) in 2007 and 2008 respectively. The main area of remediation was undertaken within landfil with the instalment of an engineered clay cap to further prevent leaching of contaminants into

the surrounding area, following the criteria of a Construction Quality Assurance (CQA) Plan. The cap was engineered to the following specifications and tested before, during and after application as per the CQA plan:

- Permeability <1x10^{-9} m/s (BS1377: 1990: Part 6);
- Clay content (0.002mm) >10% (BS1377: 1990: Part 2);
- Plasticity index >10% and <65% (BS1377: 1990: Part 2);
- Liquid limit <90% (BS1377: 1990: Part 2);
- Air voids <5% on compacted engineering clay.

5.7 Wardell Armstrong undertook a four-year programme of water monitoring and site walkover visits of the landfill, agreed with SMDC for Scentarea Limited and Johnson Matthey Investments Ltd, ending in July 2013. The results of this programme are reviewed and discussed in Report Ref NL07510/001/V0.1.

5.8 Nine visits were undertaken between April 2010 and July 2013, with visits being quarterly in the first year, twice per year for the second and third years and once during the fourth year.

5.9 Four samples were obtained at each location and analysed using standard suite tests for surface water. Testing was undertaken by Alcontrol Testing Laboratories (now ALS UK) who were Mcerts accredited. All results were compared to Environment Agency Water Quality Standards for England and Wales (EQS) or United Kingdom Drinking Water Standards (UKDWS) or Surface Water Abstraction Limit (SWAL).

5.10 Results found that there were increases and decreases of nickel, chromium, arsenic copper, lead, selenium and zinc. None of the levels exceeded the EQS/UKDWS/SWAL standards (at time of analysis).

5.11 Monitoring results were communicated with the EA and SMDC from all visits conducted, with these agencies stating that the remediation had worked to satisfactory standards upon receipt of the final report within letters Ref. WLDB 623 and Ref.CLR_BP_V2 respectively.

TABLE 4: Recorded Landfill Sites	
Location	**Details**
BGS Recorded Landfill Site Site Name: Blythe Colours Ltd Grid Ref: 397774, 338967 Distance from Site: 0m	Site Location: Cresswell, Stoke-on-Trent, Staffordshire Waste Type: Unknown Licence Status: Unknown
Historical Landfill Site Licence Holder: Blythe Colours Ltd Site Name: Blythe Colours Ltd Grid Ref: 397787, 338951 Distance from Site: 0m	Site Location: Cresswell, Stoke-on-Trent, Staffordshire Reference Number: EAHLD28839 First Input Date: 31 December 1948 Last Input Date: 27 March 1992 Specified Waste: Inert, industrial, commercial, special waste and liquid sludge.
Historical Landfill Site Licence Holder: Not supplied Site Name: The Paddock Grid Ref: 397655, 339161 Distance from Site: 10m	Site Location: Sandon Road, Cresswell, Staffordshire Reference Number: EAHLD28922 First Input Date: Not supplied Last Input date: Not supplied Specified Waste: Unknown
Registered Landfill sites Licence Holder: Blythe Colours Ltd Grid Ref: 397700, 338900 Distance from Site: 69m	Site Location: South of River Blithe, Cresswell, Blythe Bridge, Stoke-on-Trent, Staffordshire Reference Number: 1/D/77/0061 (B14) Authority: Environment Agency – Midlands Region, Upper Trent Area Site Category: Landfill Input Rate: Less than 10,000 tonnes per year Source: Produced on site Status: Licence lapsed/cancelled/defunct/not applicable/surrendered cancelled
Local Authority Recorded Landfill Sites Grid Ref: 397280, 339000 Distance from Site: 93m	Site Location: The Paddock, Sandon Road, Cresswell Reference Number: 26 Authority: Staffordshire County Council, Waste Management Types of Waste: Saggers Date of Closure: Not supplied
Historical Landfill Site Licence Holder: Not supplied Site Name: Land Near Isaac Walton Farm Grid Ref: 397765, 339378 Distance from Site: 173m	Site Location: Cresswell, Staffordshire Reference Number: EAHLD28838 First Input Date: Not supplied Last Input Date: Not supplied Specified Waste: Unknown
Local Authority Recorded Landfill Sites Grid Ref: 397754, 339592 Distance from site: 361m	Site Location: Land Near Isaac Walton Farm, Cresswell Reference Number: 58 Authority: Staffordshire County Council, Waste Management Types of Waste: Not supplied Date of Closure: Not supplied

Radon

5.12 Radon can be a hazard within built developments and especially within enclosed or confined spaces. The Health Protection Agency and British Geological Survey document "Indicative Atlas of Radon in England and Wales" (2007) provides a summary of the number of homes in a given area above the “Action Level” for radon. Although the radon atlas relates directly to measurements taken from homes or dwellings, it is also relevant to employers assessing risks for enclosed underground and ground floor work places.

5.13 The BRE document "Radon: guidance on protective measures for new buildings" (2015) provides guidance for reducing the concentration of radon in new buildings and a two stage procedure using accompanying maps needed to determine the level of protection for a given site.

5.14 These documents have been consulted and the site is shown to lie in an area where no protection against radon is needed should development of residential dwellings or new structures of similar form of construction and compartmentation occur.

Environmental Issues

5.15 The EA data via the Envirocheck report records the following environmental issues at or within the vicinity of the site:

- 1 category three (minor) pollution incidents to controlled waters within 0.50km (Table 5);
- 5 discharge consents within 0.50km (Table 6);
- 3 Local Authority Pollution Prevention Controls within 0.50km (Table 7);
- 9 Integrated Pollution Controls within 0.50km (Table 8); and
- 3 Integrated Pollution Prevention and Control within 0.50km (Table 9).

TABLE 5: Pollution Incidents to Controlled Waters

Incident	Details
Property Type: Fire Water Grid Ref: 397790, 339020 Distance from Site: 8m	Reference: 2700507 Pollutant: Miscellaneous – Foam Incident Date: 3rd June 1996 Note: Other adverse effects; Blythe; Foaming over weir Incident Severity: Cat 3 – minor

TABLE 6: Discharge Consents	
Consent	**Details**
Operator: Cookson Matthey Ceramics & Materials Ltd Grid Ref: 397600, 339000 Distance from Site: 0m	Location: Johnson Matthey Plc, Cresswell, Stoke-on-Trent, Staffordshire, ST11 9RD Discharge Reference: T/06/02795/T Effective Date: 26th August 1970 Revocation Date: 9th November 1999 Type: Trade discharge – Process water Receiving Water: River Blithe Status: Pre National River Authority Legislation where issue date <01/09/1989
Operator: Cookson Matthey Ceramics & Materials Ltd Grid Ref: 397600, 339000 Distance from Site: 0m	Location: Johnson Matthey Plc, Cresswell, Stoke-on-Trent, Staffordshire, ST11 9RD Discharge Reference: T/06/02795/T Effective Date: 10th November 1999 Revocation Date: 3rd December 2001 Type: Trade discharge – Process water Receiving Water: River Blithe Status: Revoked (Water Resources Act 1991, Section 88 & Schedule 10 as amended by Environment Act 1995)
Operator: Cookson Matthey Ceramics & Materials Ltd Grid Ref: 397900, 339000 Distance from Site: 25m	Location: Johnson Matthey Plc, Cresswell, Stoke-on-Trent, Staffordshire, ST11 9RD Discharge Reference: T/06/02795/T Effective Date: 26th August 1970 Revocation Date: 9th November 1999 Type: Trade discharge – Process water Receiving Water: River Blithe Status: Pre National River Authority Legislation where issue date <01/09/1989
Operator: Johnson Matthey Plc Grid Ref: 397900, 339000 Distance from Site: 25m	Location: Johnson Matthey Plc, Cresswell, Stoke-on-Trent, Staffordshire, ST11 9RD Discharge Reference: Ai1973 Effective Date: 9th August 1993 Revocation Date: Not supplied Type: Trade effluent discharge – Site drainage Receiving Water: Not supplied Status: Post National River Authority Legislation where issue date >31/08/1989
Operator: Mrs M F Sloan Grid Ref: 397100, 338600 Distance from Site: 442m	Location: Meadow Croft, Sandon Road, Cresswell, Stoke-on-Trent, Staffordshire Discharge Reference: 3/28/06/1521/1 Supplied Date: 16th October 1970 Revocation Date: Not supplied Type: Sewage effluent Receiving Water: Not supplied Status: Not supplied

TABLE 7: Local Authority Pollution Prevention Controls	
Operator and Location	**Details**
Operator: Goonvean Ceramic Products Grid Ref: 397660, 339177 Distance from Site: 1m	Location: Unit 6 Blythe Park, Cresswell, Stoke-on-Trent, Staffordshire, ST11 9RD Permit Reference: PPC/GC/1/001 Date: 1st March 2001 Authority: Staffordshire Moorlands District Council, Environmental Health Department Description: PG3/17 China and ball clay processes including the spray drying of ceramics Status: authorised revoked
Operator: Technico Grid Ref: 397800, 339000 Distance from Site: 9m	Location: Unit 14 Blythe Park, Cresswell, Stoke-on-Trent, Staffordshire, ST11 9RD Permit Reference: P100-6/44 Date: Not supplied Authority: Staffordshire Moorlands District Council, Environmental Health Department Description: PG6/44 Manufacture of coating materials Status: Permitted
Operator: Technico Surface Coatings Ltd Grid Ref: 397743, 339088 Distance from Site: 66m	Location: Unit 14 Blythe Park, Cresswell, Stoke-on-Trent, Staffordshire, ST11 9RD Permit Reference: P100-6/44 Date: 17th February 2010 Authority: Staffordshire Moorlands District Council, Environmental Health Department Description: PG6/44 Manufacture of coating materials Status: Permitted

TABLE 8: Integrated Pollution Controls	
Operator and Location	**Details**
Operator: Johnson Matthey Plc Grid Ref: 397663, 339174 Distance from Site: 0m	Location: Cresswell, Blythe Bridge, Stoke-on-Trent, Staffordshire, ST11 9RD Permit Reference: Bi1650 Effective Date: 27th June 2000 Description: 4.5 A (H) Inorganic Chemical Processes within the Chemical Industry Status: Revoked – Now IPPC
Operator: Johnson Matthey Plc Grid Ref: 397658, 339178 Distance from Site: 3m	Location: Main Building, Cresswell, Stoke-on-Trent, ST11 9RD Permit Reference: Bi1668 Effective Date: 27th June 2000 Description: 3.5 A Glass manufacture and production within the mineral industry Status: Revoked – Now IPPC

TABLE 8: Integrated Pollution Controls	
Operator and Location	**Details**
Operator: Johnson Matthey Plc Grid Ref: 397658, 339178 Distance from Site: 3m	Location: Main Building, Cresswell, Stoke-on-Trent, ST11 9RD Permit Reference: BC5873 Effective Date: 24th November 1998 Description: 3.5 A Glass manufacture and production within the mineral industry Status: Authorisation superseded by a substantial or non-substantial variation superseded
Operator: Johnson Matthey Plc Grid Ref: 397658, 339178 Distance from Site: 3m	Location: Main Building, Cresswell, Stoke-on-Trent, ST11 9RD Permit Reference: AI1973 Effective Date: 5th August 1993 Description: 3.5 A Glass manufacture and production within the mineral industry Status: Authorisation superseded by a substantial or non-substantial variation superseded
Operator: Cookson Matthey Ceramics & Materials Ltd Grid Ref: 397505, 339300 Distance from Site: 23m	Location: Main Building, Cresswell, Stoke-on-Trent, ST11 9RD Permit Reference: AR6380 Effective Date: 17th May 1995 Description: 4.5 A (H) Inorganic Chemical Processes within the Chemical Industry Status: Application has met the requirements for authorisation (but not yet authorised)
Operator: Johnson Matthey Plc Grid Ref: 397718, 339081 Distance from Site: 50m	Location: P O Box 4, Main Building, Cresswell, Stoke-on-Trent, ST11 9RD Permit Reference: AP8390 Effective Date: 30th January 1995 Description: 4.5 A (H) Inorganic Chemical Processes within the Chemical Industry Status: Authorisation superseded by a substantial or non-substantial variation superseded
Operator: Johnson Matthey Plc Grid Ref: 397723, 339081 Distance from Site: 52m	Location: P O Box 4, Main Building, Cresswell, Stoke-on-Trent, ST11 9RD Permit Reference: AO1908 Effective Date: 1st December 1994 Description: 4.5 A (H) Inorganic Chemical Processes within the Chemical Industry Status: Authorisation superseded by a substantial or non-substantial variation superseded
Operator: Johnson Matthey Plc Grid Ref: 397723, 339086 Distance from Site: 56m	Location: Cresswell, Stoke-on-Trent, ST11 9RD Permit Reference: BD0834 Effective Date: 24th November 1998 Description: 4.5 A (H) Inorganic Chemical Processes within the Chemical Industry Status: Authorisation superseded by a substantial or non-substantial variation superseded

TABLE 8: Integrated Pollution Controls	
Operator and Location	**Details**
Operator: Johnson Matthey Ceramics and Materials Ltd (Dissolved) Grid Ref: 397718, 339091 Distance from Site: 59m	Location: Cresswell Frit, Glaze and Colour Works, Main Building, Cresswell, Stoke-on-Trent, ST11 9RD Permit Reference: ZP3638LP Effective Date: 29th June 2009 Description: 4.3 A (F) Acid Processes within the Chemical Industry Status: Authorisation revoked

TABLE 9: Integrated Pollution Prevention and Controls	
Operator	**Details**
Operator: Johnson Matthey Plc Grid Ref: 397573, 339228 Distance from Site: 28m	Permit Reference: ZP3638LP Effective Date: 29th June 2009 Description: Inorganic Chemicals 4.2 A(1)(D) and glass and fibre 3.3 A(1)(B) Status: Superseded by variations
Operator: Johnson Matthey Plc Grid Ref: 397700, 338980 Distance from Site: 48m	Permit Reference: KP3630NR Effective Date: 28th May 2013 Description: Inorganic Chemicals 4.2 A(1)(V) Status: Effective
Operator: Johnson Matthey Plc Grid Ref: 397700, 338980 Distance from Site: 48m	Permit Reference: CP3837UC Effective Date: 21st December 2007 Description: Inorganic Chemicals 4.2 A(1)(D) and glass and glass fibre 3.3 A(1)(B) Status: Superseded by variations
Operator: Johnson Matthey Plc Grid Ref: 397721, 339090 Distance from Site: 59m	Permit Reference: Bs9741ij Effective Date: 31st March 2003 Description: Inorganic Chemicals 4.2 A(1)(D) and glass and glass fibre 3.3 A(1)(B) Status: Superseded by variations

6 PREVIOUS SITE INVESTIGATION

Blythe Business Park and Landfill

6.1 Wardell Armstrong has historically been involved with adjacent Blythe Business Park as detailed within Wardell Armstrong Report Ref.NL07510/J01. A desk study was prepared in 1997 at the request of Cookson Matthey Ceramics and Materials Ltd, entitled "Phase 1 Environmental Assessment of Blythe Colour Works, Cresswell, Stoke-on-Trent, Staffordshire" to provide an initial site assessment and any environmental liability that the site may have. Due to the potential for contamination due to landfill materials associated with Blythe Colour Works, a site investigation was proposed.

6.2 Site investigation works followed in 1998 as instructed by Johnson Matthey Ceramic Materials Division, identifying areas of potential contamination across the business park as found within Wardell Armstrong Report titled "Environmental Site Investigation Interpretative Report" dated July 1998. The investigation involved 6 boreholes, 20 trial pits and 3 probe holes. Gas and groundwater monitoring wells were also installed within all boreholes drilled. Samples were also collected for laboratory geochemical testing. From the analysis of the results gained, the site was split into four contamination areas as shown on Drawing No.NL07510/115. The areas are described as follows:

- Area 1 – Former waste disposal site (landfill) situated in-between the two development areas as operated by Blythe Colour Works;
- Area 2 – Area of hardstanding in the extreme eastern area of Blythe Business Park bounded by the river and railway line containing roadways, hard core surfaced ground and buildings;
- Area 3 – Area directly behind building 29 of Blythe Business Park consisting of roadways, loading areas and grass;
- Area 4 – The rest of the site across Blythe Business park including roadways, grass, hard core, car parks and buildings.

6.3 Potential remediation strategies were outlined and submitted to the client and to the EA and SMDC. After correspondence with the EA and SMDC with regards to issues arising from the above site investigation, additional intrusive work was undertaken involving deep rotary boreholes in area 1 and 20 dynamic probe holes in areas 2, 3 and 4. The subsequent report found that due to the significant levels of contamination detected across the site in areas 1-3, further remedial options and boundaries to these areas had

to be selected. However, due to a lapse in time, planning permission had to be reapplied for M J Barrett Ltd in 2000 to undertake these works.

6.4 Wardell Armstrong produced a revised risk assessment and updated remedial options strategy in 2007. These were subsequently approved by the EA and SMDC in 2007 and 2008 respectively. Areas 1 to 3 were subjected remediation, details of area 1 (landfill) remediation was discussed in Section 5. Both areas 2 and 3 were remediated with impermeable macadam (black top) surfacing which is now used as car parking in both areas. Surface water attenuation tanks were also installed along with suitable surface drainage. Designs for these were both approved by the EA. To ensure that the remedial works were effective across all areas, Wardell Armstrong proposed future monitoring for up to 4 years including the taking of water samples and walkover inspections. Full details about the above remediation and subsequent monitoring can be found within Wardell Armstrong Report Ref.NL07510/J01 and Ref.NL07510/001/VO.1.

Blythe Park Power Station

6.5 Consideration was given to the construction of a power station at the site. An intrusive investigation was undertaken by Rogers Geotechnical Services Ltd (RGS) on behalf of M J Barrett Ltd in November 2009. Parsons Brincherhoff acted as a consultant for these works. The report is present in Appendix 3.

6.6 Correspondence prior to the undertaking of the investigation with Staffordshire Moorlands (Ref: CLR_BCW_PSI, Appendix 4) advised that the site investigation target the old course of the River Blithe (thought to be infilled) due to its potential to be pathway from the landfill located between the two development areas under review within this report. Materials possibly contained within the landfill is known to be radioactive and hazardous to human health. There is also a possibility that materials used to infill the river channel could also be the same material.

6.7 The investigation was instructed primarily for the retrieval of samples for contamination testing while gaining additional information in relation to the underlying geology of the site. This included the undertaking of three cable percussive boreholes (SA1-SA3) to a maximum depth of 7.55m below ground level (bgl) and three trial pits (TP1-TP3) along the western boundary of the eastern area. Gas and groundwater monitoring wells were

installed to 4.00m bgl within SA1-SA3. All locations were within the designated area of set a side around the large agricultural field.

6.8 Three groundwater samples were sent to Chemtest, a UKAS accredited laboratory for analysis. Results of the testing without any interpretation was provided in the report to Scentarea Ltd and Parsons Brincherhoff. Therefore, the data provided in the report was reviewed against relevant published screening values (EQS UKDWS) by Wardell Armstrong in April 2017. Comments on exceedances are as follows:

- Exceedance of nickel found at SA1 and SA2; and
- Isolated exceedance of chromium found at SA2.

6.9 Although the RGS logs suggest that disturbed samples were attained during the site works, no soil contamination results were provided with the RGS report. No information was provided in relation to gas and groundwater monitoring from the installed wells.

6.10 Across the borehole and trial pit locations, a range of made ground, Lower River Terrace deposits (natural superficial deposits) and Mercia Mudstone was recorded. A summary of the geology encountered is found in Table 10 below:

TABLE 10: Summary of Encountered Geology

Strata Type	Depths From (m bgl)	Depths To (m bgl)	Thickness (m)
Made Ground (reworked terrace gravels)*	Ground Level	0.80-1.90	0.80-1.90
Lower River Terrace Deposits (Natural Superficial Deposits)*	0.40-1.40	2.60-5.90	1.40-5.45
Mercia Mudstone*	3.50-5.90	6.85-7.55+	1.65-3.35+
* Where encountered			

6.11 Made ground deposits were recorded as reworked river terrace gravels consisting of yellow/orange brown silty sandy gravel and/or clay with cobbles in various concentrations. Gravels and cobbles generally comprised of sandstone and quartzite.

6.12 Lower River Terrace Deposits were generally recorded as brown sandy gravel with cobbles in various concentrations. Gravel and cobbles generally comprised of sandstone, quartzite, greywacke, mudstone, siltstone, limestone, chert and conglomerates. Uncorrected SPT 'N' values ranged from 13 to 37.

6.13 Mercia Mudstone was only recorded within the cable percussive boreholes (SA1-SA3). It was found to be highly weathered mudstone (clay) containing lithorelicts of mudstone. The mudstone was found to be classified as Mercia Mudstone grade IVA under the weathering grades as defined in the BGS document "Engineering geology of British rocks and soils. Mudstones of the Mercia Mudstone Group" RR/01/02. Uncorrected SPT 'N' values ranged from 22 to 70.

7 CONCEPTUAL SITE MODEL

7.1 Conclusions are drawn from the preceding information in terms of potential sources of contamination, possible receptors that may be affected by any sources of contamination and the pathways that exist between source and receptor. This basic risk assessment allows identification of the suitability of the site for its current and future use and evaluation of any potential environmental liability that may attach to the site. The issues can be broadly addressed as follows: land contamination, groundwater contamination, surface water contamination, ground gases and air pollution.

Sources

7.2 The land use history has identified the following potentially significant sources of contamination both on the site and adjacent to the site (off-site).

On-site

7.3 Using available historical maps, both development areas have been predominately used for agriculture with localised areas of development.

7.4 The only feature identified within the eastern development area was the infilling/diversion of the old course of the River Blithe. The RGS investigation report suggested that this channel may have been infilled with reworked river terrace gravels, however, it has also been suggested that waste from the adjacent colour works may have used to infilled this feature. Therefore, the infill material is a potential source of contamination, the contaminants of concern are discussed in Section 7.6.

7.5 The western area has had development within its north eastern corner, with a building constructed in the 1980s (now used as a dance studio) with an area of hardstanding for the storage of materials and parking. A tank with some small associated structures was also recorded on historical maps in the south east corner, the contents of the tank are unknown.

Off Site

7.6 In-between the two development areas and along the route of the interconnecting roadway is Blythe Business Park, which has been historically active. Blythe Colour works manufactured a range of colour products for various purposes, primarily for the ceramics industry. They used a range of harmful and radioactive materials which is thought to have included heavy/toxic metals (arsenic, boron, cadmium, lead, antimony, chromium, nickel and cobalt), uranium oxide, turpentine oil and naphtha (solvents).

7.7 During the war, it is known that the US Army used tetrachloride's (e.g. tetrachloroethene and tetrachloroethane) as a dry cleaning chemical/solvent for chemical impregnation of clothing to provide protection against chemical attack. This was undertaken within the site of Blythe Colour Works.

7.8 Materials associated with the above were deposited within the landfill situated in between the two area. As discussed in Section 5, this landfill has been subject to remediation (capping) and validation monitoring of surface waters. Although the landfill still represents a potential source of contamination to the site via groundwater, it is considered a low to moderate risk to the remedial works undertaken.

7.9 Commercial and industrial units are now situated across the area known as Blythe Colour Works (now known as Blythe Business Park), undertaking a range of processes including engineering, car repairs, metal and paint manufacturing, industrial cladding and catalytic converter manufacturing.

Contaminants of Concern

7.10 The main associated contaminants as described within NHBS R&D publication 66:2008 Volume 2 entitled "Guidance for the safe development of housing on land affected by contamination" for the highlighted industrial past and findings from previous site investigations are as follows:

- Metals (antimony, arsenic, cadmium, cobalt, chromium, copper, lead, nickel, zinc);
- Organic compounds and chemicals including hydrocarbons such as diesel and oil (total petroleum hydrocarbons, TPHs), polycyclic aromatic

hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), phenols, herbicides. This also covers volatile organic compounds (VOCs);

- Inorganic compounds including mercury, selenium, vanadium, boron;
- Asbestos including white, brown and blue types;
- Sulphates, chlorides (including tetrachlorides) and sulphides;
- Acids including sulphuric acid;
- Alkalis including sodium hydroxide;
- Ground gases including carbon dioxide and methane;
- Uranium Oxide;
- Solvents.

Pathways

7.11 In order for a risk to be present, a viable pathway must exist between the potential contamination source and receptor. The level of risk posed by a potential contaminant source is therefore largely dependent on the viability of pathways.

7.12 Humans may be exposed to contamination via: ingestion of soil; ingestion of indoor dust/fibres; dermal contact with soil; dermal contact with indoor dust/fibres; ingestion of vegetables grown on site; ingestion of soil on vegetables growing on site; inhalation of fugitive soil dust/fibres; inhalation of fugitive indoor dust/fibres; inhalation of vapours outdoors or inhalation of vapours indoors. These pathways are considered viable for both construction workers and future site users. However, it is expected that construction workers will be equipped with appropriate PPE, follow appropriate safe working procedures and spend a relatively short period of time on site, thereby largely mitigating potential effects on them.

7.13 Contaminants contained within near surface soils can be leached and transmitted to groundwater via percolation. They may also reach surface water bodies via overland flow and/or through flows/shallow groundwater flow. The likelihood of this occurring is largely dependent on the permeability of the local geology. With regard to the superficial geology, the Lower River Terrace deposits (sands and gravels) recorded across the majority of the site are considered to exhibit a moderate to high permeability. However, the glacial till consists of low permeability clays. The nearest surface water feature is the River Blithe, therefore the transmission of contamination from the site to surface water bodies via overland flow is considered low to moderate

The site's underlying solid geology comprises Mercia Mudstone and Tarporley Siltstone Formation, which are both categorised by the Envirocheck Report to have low productivity. However, the potable groundwater abstraction located 244m to the north of the site indicates that these strata are locally used.

7.14 Ground gas/vapours may accumulate in enclosed spaces following migration through permeable strata. Again, given that permeability of the drift geology is expected to be moderate to high, there is a high potential that gas could migrate.

Receptors

7.15 The critical receptors in relation to human health are considered to be construction workers during site redevelopment and future site users. Based on the worst case scenario of an acute risk to human health from any of the contaminant sources identified above, the potential severity of effects is considered to be low to moderate.

7.16 Controlled waters are considered legal contaminant receptors. The definition of controlled waters includes groundwater, rivers, lakes and ponds. The nearest surface water feature is the River Blithe, located on the northern boundary of both development areas. Therefore, the potential severity of effects is considered to be moderate.

7.17 The sources, pathways and receptors provided above have been assessed using Table 11, below, which is generally based on guidance within CIRIA C552 "*Contaminated Land Risk Assessment A Guide to Good Practice*" (2001). The outcome of this assessment is summarised in Table 12, which provides CSM based on the current understanding of the site. This includes a classification of the level of risk associated with each source-pathway-receptor linkage.

TABLE 11: Risk Assessment Matrix				
		Receptor Sensitivity		
		Low	**Medium**	**High**
Contaminant Source (Potential Severity of Contamination)	**Low**	Low	Low to Moderate	Moderate
	Moderate	Low to Moderate	Moderate	Moderate to High
	High	Moderate	Moderate to High	High
Notes Where either contaminant source or receptor sensitivity is considered to be negligible, a classification of "very low" risk is used by default. The classification of "high", "moderate" or "low" is made based on qualitative judgement. Discussion of the risk classification assigned in the CSM is provided below.				

7.18 The conceptual site model presented in Table 12 details an initial assessment of all potential pollutant linkages.

TABLE 12: Conceptual Site Model			
SOURCE (CONTAMINANT)	**PATHWAY**	**RECEPTOR**	**RISK**
Made ground on site associated with historical use (including Blythe Colour Works)	1. Inhalation. 2. Dermal contact. 3. Ingestion. 4. Surface runoff. 5. Groundwater migration. 6. Direct contact (aggressive attack). 7. Gas migration.	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Moderate
Gas generation from potential isolated areas of made ground on site	1. Gas migration.	1. Current occupiers. 2. Future occupiers. 3. Construction workers.	Low to moderate
Unknown contents of historic tank within western development area.	1. Inhalation. 2. Dermal contact. 3. Ingestion. 4. Surface runoff. 5. Groundwater migration. 6. Direct contact (aggressive attack).	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Moderate

TABLE 12: Conceptual Site Model			
SOURCE (CONTAMINANT)	**PATHWAY**	**RECEPTOR**	**RISK**
Unknown material used for infilling the old course of the River Blithe (eastern development area)	1. Inhalation. 2. Dermal contact. 3. Ingestion. 4. Surface runoff. 5. Groundwater migration. 6. Direct contact (aggressive attack). 7. Gas migration.	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Moderate
Off site Surrounding Commercial and Industrial uses within Blythe Business Park. (wide range of potential contaminants).	1. Inhalation. 2. Dermal contact. 3. Ingestion. 4. Surface runoff. 5. Groundwater migration.	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Low to moderate
Historic landfill with hazardous and potentially radioactive waste	1. Inhalation. 2. Dermal contact. 3. Ingestion. 4. Surface runoff. 5. Groundwater migration. 6. Direct contact (aggressive attack).	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Moderate

8 SITE INVESTIGATION

Introduction and Rationale

8.1 A site investigation was carried out at the site between 21 February and 3 March 2017, with subsequent gas and groundwater monitoring and laboratory testing. The aims of the investigation were to provide preliminary information on the prevailing ground conditions across the entire site.

8.2 The site investigation comprised a combination of trial pits and windowless sampling boreholes and/or dynamic probes (super heavy) tests (DPSH). Selected windowless sampling boreholes had standpipes installed and/or in-situ variable head permeability tests undertaken. Soil samples were taken for geotechnical and geochemical laboratory testing. A rationale for the location of these investigations are summarised in Table 13 below. The investigation locations are shown on Drawing No.ST15807-003.

TABLE 13:
Summary of Ground Investigation

Development area	Location Hole	Potential Source/Rationale	Type	Maximum Depth (m bgl)
Western	WS01	Field/proving superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample and DPSH	6.00
	WS02	Field/proving superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample and DPSH	6.00
	WS03	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample and DPSH	6.00
	WS04	Field/proving superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample	5.45
	WS05	Field/proving superficial and bedrock depths/foundation design/ baseline conditions/permeability	Windowless Sample, DPSH and in-situ variable head permeability test	6.00
	WS06	Field/proving superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample and DPSH	5.00
	WS07	Field/proving superficial and bedrock depths/foundation design/ baseline conditions/permeability	Windowless Sample, DPSH and in-situ variable head permeability test	6.00

TABLE 13: Summary of Ground Investigation				
Development area	**Location Hole**	**Potential Source/Rationale**	**Type**	**Maximum Depth (m bgl)**
	WS08	Filed/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample	3.00
	WS09	Field/proving superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample	5.45
	WS10	Blythe Business Park and historic use/proving mad ground, superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample and DPSH	6.00
Roadway (Eastern area)	WS11	Blythe Business Park and historic use/proving made ground deposits, superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample	3.00
	WS12	Blythe Business Park and historic use/proving made ground deposits, superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample and DPSH	6.00
Eastern	WS13	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample and DPSH	6.00
	WS14	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample and DPSH	6.00
	WS15	Proving route and material of potentially infilled channel/superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample and in-situ variable head permeability test	3.00
	WS16	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample	5.45
	WS17	Field/proving superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample	3.00
	WS18	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample	5.45
	WS19	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample	3.45
	WS20	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample	3.00
	WS21	Field/proving superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample	3.00
	WS22	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	DPSH	6.00
	WS23	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	DPSH	6.00
	WS24	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample	3.00
	WS25	Proving route and material of potentially infilled channel and field/superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample and in-situ variable head permeability test	3.00

TABLE 13: Summary of Ground Investigation				
Development area	**Location Hole**	**Potential Source/Rationale**	**Type**	**Maximum Depth (m bgl)**
	WS26	Field/proving superficial and bedrock depths/foundation design/ baseline conditions	Windowless Sample	3.00
	WS27	Field/proving superficial and bedrock depths /groundwater and ground gas monitoring/ foundation design/ baseline conditions	Windowless Sample and in-situ variable head permeability test	3.00
Western	TP01	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.70
	TP02	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.50
	TP03	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.00
	TP04	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.90
	TP05	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	1.30
	TP06	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.70
	TP07	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	3.00
	TP08	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.70
	TP09	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	3.00
	TP10	Blythe Business Park/Infilled river channel and historic use/proving made ground and superficial depths/baseline conditions	Trial pit	1.00
Eastern	TP11	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	1.70
	TP12	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.20
	TP13	Proving route and material of potentially infilled channel and field/superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.90
	TP14	Proving route and material of potentially infilled channel and field/superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.10
	TP15	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	1.80
	TP16	Proving route and material of potentially infilled channel and field/superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.40
	TP17	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.20
	TP18	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.10
	TP19	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	1.90
	TP20	Proving route and material of potentially infilled channel and field/superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.20

TABLE 13: Summary of Ground Investigation				
Development area	**Location Hole**	**Potential Source/Rationale**	**Type**	**Maximum Depth (m bgl)**
	TP21	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	1.90
	TP22	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.00
	TP23	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	2.00
	TP24	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	1.80
	TP25	Field/proving superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	1.90
Western	TP26	Tank and field/proving made ground and superficial depth/baseline conditions	Trial pit	1.00
Eastern	TP27	Proving route and material of potentially infilled channel and field/superficial and bedrock depths/ foundation design/ baseline conditions	Trial pit	1.10

8.3 Windowless sampling, DPSH and in-situ variable head permeability tests were carried out by Strata Renewables, a specialist site investigation contractor, supervised by Wardell Armstrong. Trial pits were conducted using an excavator supplied by Scentarea Limited, supervised by Wardell Armstrong.

8.4 All investigation locations were marked out by GPS prior to the site investigation commencing. These were then cleared of services by a specialist service clearance contractor, Avoin Maa.

Trial Pits

8.5 Twenty-seven trial pits (TP01-TP27) were excavated to provide a wide spread coverage into the ground conditions found across the site. The pits were excavated to depths of 3.00m bgl using a 7 tonne tracked excavator. The arisings were logged by a geologist from Wardell Armstrong, with the logs presented in Appendix 5. Soil samples were taken from the arisings to be later analysed for geotechnical and geochemical properties.

8.6 Trial pits TP13, TP14, TP16, TP20 and TP27 were extended laterally to produce trial trenches up to 28.00m long to identify the old course of the River Blithe. Owing to the presence of a gas main, TP10 was excavated as a hand dug pit to 1.00m bgl.

Dynamic Sampling

8.7 Twenty-seven dynamic samples boreholes (WS01-WS27) were drilled to depths between 3.00 and 5.45m bgl, where refusal was encountered. Where twelve windowless samples were terminated at shallow depth, these were extended with DPSH tests to 6.00m bgl. In-situ Standard Penetration Tests (SPT) were carried out at 1.00m intervals throughout the boreholes. Samples were also collected for subsequent geochemical testing.

8.8 The boreholes were situated to give a general spread across the site, with WS15 and WS25 targeting the route of the potentially infilled old course of the River Blithe and WS12 for the potential location of a bridge abutment. The arisings were logged by a Wardell Armstrong representative with detailed logs of the boreholes along with DPSH results presented as Appendix 6.

8.9 Gas and groundwater monitoring standpipes were installed in eleven selected locations (WS15, WS17, WS21, WS25 and WS27 in eastern area and WS01, WS02, WS04, WS06, WS09, WS10, in western area) with a response area from 1.00m bgl to the base of the borehole, to examine gas migration from landfill located within Blythe Business Park.

Radiological Screening

8.10 To determine if radioactive material (uranium oxide)was present in the infilled river channel (eastern area), a specialist radiological consultant (Radman Associates) monitored trial pit arisings with handheld monitors (Georadis RT-30 NaI scintillation detector and Mini 900 EP15 GM detector) for gamma and alpha/beta emitting radionuclides. The radiological screening was undertaken during the excavation of TP13. TP14, TP16 and TP20. A report was issued by Radman Associates stating the finding and is presented in Appendix 7.

In-Situ Variable Head Permeability Tests

8.11 In-situ variable head permeability tests (falling head tests) were undertaken within WS05, WS07, WS15, WS25 and WS27. The falling head tests were carried out in general accordance with CIRIA 211 with the boreholes filled with water and the water level was then monitored for a period of time.

Gas and Groundwater Monitoring

8.12 Following the intrusive phase of site works, four gas and groundwater monitoring visits was undertaken between 21 March and 12 April 2017, undertaken by Wardell Armstrong.

8.13 The standpipes were all monitored for concentrations of methane (CH_4), carbon dioxide (CO_2), hydrogen sulphide (H_2S), carbon monoxide (CO) and Oxygen (O_2) using a calibrated and MCERTS accredited hand-held gas analyser (GFM 436). Gas flow and atmospheric pressure were also measured. Gas measurements were recorded for a minimum of sixty seconds at each location, at which point the maximum and steady concentration of CH_4 and CO_2 together with the lowest concentration of O_2 were recorded.

8.14 Groundwater monitoring was undertaken using an electronic dip meter to record the depth to groundwater. The results of the groundwater and gas monitoring visit are presented in Appendix 8.

Laboratory Testing

Geotechnical Testing

8.15 Seventeen samples were scheduled for a range tests including moisture content, atterburg limits, particle size distribution and heavy compaction testing. The samples were sent to Strata Renewables laboratory and the results are presented as Appendix 9.

Geochemical Testing

8.16 Soil samples destined for chemical analysis were collected at regular intervals in appropriate sampling containers. All samples were subsequently stored in cooled boxes prior to submission to an analytical laboratory. The samples were collected using appropriate PPE and sampling equipment that was cleaned at each sampling location.

8.17 Samples were obtained from a range of depths to allow each material type identified by the site investigation to be tested. The samples were sent to Alcontrol Laboratories, a UKAS accredited laboratory. Thirty-six samples were scheduled for

chemical testing. Samples were tested for a range of contaminants including metals, asbestos, cyanide, speciated petroleum hydrocarbons ('TPH-CWG' method), polycyclic aromatic hydrocarbons, pH, phenols, sulphate and sulphur. Seven samples were subjected to a Pesticides/Herbicides suite, five samples were subjected to chlorides (soluble) and four samples subjected to Volatile Organic Compounds (VOCs). The results are presented as Appendix 10.

8.18 Eight groundwater samples were obtained and subjected to metals, TPH-CWG, PAH, phenols, pH and cyanide, VOCs analysis was also undertaken on three of the samples. The results are presented as Appendix 11.

Site Investigation Results

Geology

8.19 The geology as encountered within the Wardell Armstrong trial pits and dynamic sampling is summarised below in Table 14 and was found to comprise of made ground and natural superficial deposits.

Table 14: Summary of Encountered Geology

Strata Type	Depths From (m bgl)	Depths To (m bgl)	Thickness (m)
Made Ground*	Ground Level	0.70-1.10	0.70-1.10
Natural Superficial Deposits	Ground Level – 0.70	3.60 to 5.45+	5.45+
Solid Deposits*	3.60	5.45+	5.45+
* Where encountered.			

Made Ground

8.20 Made ground was encountered at TP10, TP14, TP26, TP27, WS08, WS11 and WS12 to an observed maximum of 1.10m bgl. The thickest made ground was found at TP27 along the old course of the River Blithe within the eastern development area and WS12 within Blythe Industrial Park. Made ground was recorded mainly within Blythe Business Park (TP10, WS08, WS11 and WS12). The exception for this was found within an area of past historic use (TP26) associated with an old tank and associated structures within the western development area and the potential course of the old River Blithe (TP14 and TP27).

8.21 Made ground within the Business Park generally comprised a clayey silty sand and/or gravel with medium to high cobble content. The gravel and cobble components comprise, in varying quantities across the site and at different depths, ceramic fragments, brick, concrete, building stone, slag, mudstone, sandstone and quartzite.

8.22 Made ground was found to a depth of only 0.80m bgl within the area of the historical tank (TP26) within the western development area, comprising concrete, building stone and slabs of 0.40m by 0.45m.

8.23 TP27 and TP14 were located along the possible route of the old course of the River Blithe, both contained reworked natural sand and gravel deposits. TP27 contained reworked natural silty clayey sand and gravel which had a slight organic odour. TP14 contained the similar reworked material however, with rare occurrences of slag/clinker.

8.24 The radiological readings of the trial pit arisings along the inferred infilled route of the River Blithe were comparable to background, indicating the absence of any significant radiological contamination with the locations monitored.

Natural Superficial Deposits

8.25 Natural Superficial Deposits were encountered at all site investigation locations, with the exception of TP10 which was a hand dug pit to 1.00m bgl, which terminated in made ground.

8.26 Where encountered, the natural superficial deposits were found directly at the surface or directly underlying the made ground at depths of between ground surface and 1.10m bgl. The superficial deposits were encountered at thickness 5.45m (maximum borehole depth) with the base only being recorded in WS16 at 3.60m bgl.

8.27 The natural superficial deposits generally comprise of three units:

- Topsoil – Typically grass or crop over brown clayey silty gravelly sand/soft brown silty sandy gravelly clay with inclusions of rootlets. The thickness of the topsoil was encountered between 0.30m and 0.75m;

- Reddish to orangeish brown slightly clayey slightly silty sand and gravel with low to high cobble content (River Terrace deposits). The concentrations of these elements were found to vary across the site; and
- Soft to firm grey to brown mottled orange silty sandy gravelly clay (Devensian Till) up to 2.10m thick. Encountered in the western development area.

8.28 Uncorrected SPT "N" values from within the natural superficial deposits range from 2 to 40, generally increasing with depth.

8.29 Atterburg limits testing was undertaken on two clay samples. The liquid limit was found to range between 21-26%, plastic limit range of 12-16% and a plasticity index of 9-10%. The modified plasticity index ranged from 4.4-5.4%. A third test was undertaken on a sand and gravel sample, which was reported to be non-plastic.

8.30 Table 15 below summaries the geotechnical properties of the natural superficial deposits.

TABLE 15:
Summary of Geotechnical Properties of Natural Superficial Deposits

Property	Minimum		Maximum		No. Tests	
	Eastern area	Western area	Eastern area	Western area	Eastern area	Western area
Uncorrected SPT "N" Value	2	8	40	31	38	30
Corrected N60 Values	2	9	53	43	38	30
Moisture Content (%)	-	15.3	-	22.4	0	3
Optimum Moisture Content (%)	5.8	5.2	7.6	8	2	2
Maximum Dry Density – 4.5kg (Mg/m^3)	2.103	2.082	2.144	2.107	2	2
Liquid Limit (%)	-	21	-	26	0	3
Plastic Limit (%)	-	12	-	16	0	3
Plasticity Index	-	9	-	10	0	3
% Passing 0.425mm	-	46	-	51	0	2
Modified Plasticity Index	-	4.41	-	5.40	0	2
Bulk Density (Mg/m^3)	2.136	2.195	2.324	2.462	2	2
Uniformity coefficient	63.30	6.67	158.30	500.00	2	4

- No test conducted

Solid Deposits

8.31 Mercia Mudstone was encountered in WS16 only from a depth of 3.6m. Utilising the Weathering Schemes presented in the CIRIA C570; Engineering in Mercia Mudstone, the mudstone was recorded as fully weathered Grade IVb through to partially weathered Grade III. Fully weathered Grade IVb mudstone was recorded as stiff reddish brown mottled grey slightly sandy clay. Partially weathered Grade IVa mudstone was recorded as stiff reddish brown mottled grey clay. Partially weathered Grade III mudstone was recorded as very stiff reddish brown slightly sandy clay with some fine to coarse gravel of lithorelics.

Hydrogeology

8.32 The boreholes were dipped across all monitoring visits. In total, five visits were undertaken by a WA technician over a 5-week period between 16 March and 12 April 2017.

8.33 Water levels were found to fluctuate across the site with the exclusion of WS02, which was dry across all visits. Excluding WS01, average water depths varied from 0.34m to 4.11m bgl.

8.34 The monitoring results are given in Appendix 8 and summarised in Table 16 below:

TABLE 16:
Summary of Groundwater Monitoring

Development area	Borehole	Minimum water depth (m bgl)	Maximum water depth (m bgl)	Average Water level (m AOD)	Depth of Well (m bgl)
Western	WS01	DRY	DRY	DRY	3.30
	WS02	0.90	1.51	1.33	3.00
	WS04	4.15	DRY	4.11	4.40
	WS06	1.19	1.90	1.41	2.20
	WS09	2.80	3.50	3.18	4.50
	WS10	0.25	0.43	0.34	2.10
Eastern	WS15	1.56	1.78	1.67	2.32
	WS17	0.57	DRY	0.37	1.80
	WS21	0.82	1.12	0.99	2.21
	WS25	0.20	1.99	0.58	3.79
	WS27	0.42	0.83	0.68	2.11

8.35 Five locations were selected for falling head tests to measure permeability of underlying strata. WS13, WS25 and WS27 were undertaken within the eastern development area whilst WS05 and WS07 was undertaken in the western development area (WS10 could not be undertaken due to constant high water levels).

8.36 Due to the slow rate of tests conducted on WS07 and WS25, no permeability could be calculated. Across the other locations, permeability results varied from $2.38x10^{-5}$ to $4.27x10^{-7}$, with higher permeabilities obtained within the eastern area.

8.37 The falling head results are given in Appendix 12 and summarised in Table 17 below:

Table 17: Falling Head test results

Development area	Borehole Location	Depth of water at beginning (m bgl)	Depth of water at end (m bgl)	Calculated permeability	Test time undertaken (mins)
Western	WS05	0	0.9	$4.27x10^{-7}$	30
	WS07	0	0.4	-	30
Eastern	WS15	0	1.00	$1.02x10^{-6}$	30
	WS25	0	0.06	-	30
	WS27	0	0.21	$2.38x10^{-5}$	30

- Permeability unable to be calculated

Subterranean gas

8.38 Gas monitoring was undertaken four times within eleven windowless sample boreholes over a 4-week period between 21 March and 12 April 2017.

8.39 Carbon dioxide was detected across all boreholes with a maximum concentration of 6.00% v/v. Slightly higher concentrations were recorded across the western development area.

8.40 No methane, carbon monoxide or hydrogen sulphide was detected across any visits.

8.41 The monitoring results are provided in Appendix 8 and summarised in Table 18 below:

TABLE 18: Summary of Ground Gas Monitoring Results						
Development area	**Borehole**	**Carbon Dioxide Maximum Concentration (% v/v)**	**Methane Maximum Concentration (% v/v)**	**Oxygen Minimum Concentration (% v/v)**	**Maximum Flow (l/s)**	**Gas Screening Value (CO2) (l/s)**
Western	WS01	4.30	0.00	19.90	3.00	0.129
	WS02	3.60	0.00	19.80	0.00	0.00
	WS04	5.80	0.00	19.60	-0.40	0.00
	WS06	6.00	0.00	20.00	0.00	0.00
	WS09	1.70	0.00	20.60	0.00	0.00
	WS10	0.90	0.00	20.00	1.30	0.0117
Eastern	WS15	3.40	0.00	19.60	-0.10	0.00
	WS17	4.10	0.00	20.60	3.10	0.1271
	WS21	2.20	0.00	20.60	0.00	0.00
	WS25	2.00	0.00	20.80	0.20	0.004
	WS27	2.00	0.00	20.60	0.00	0.00
	Maximum	**6.00**	**0.00**	**20.80**	**3.00**	**0.129**
	Minimum	**0.90**	**0.00**	**19.60**	**-0.40**	**0.00**

Soil Contamination

8.42 The results were compared with the relevant screening values (S4UL, C4SL) for a commercial end use for the eastern development area and residential end use for the western development area. The full results are provided in Appendix 10. A summary of the results are presented in Table 19 and Table 20, below.

Eastern Area

8.43 From examination of the results, no exceedances of contaminants were recorded from the eastern development area. The radiological readings of the trial pit arisings along the inferred infilled route of the River Blithe were comparable to background, indicating the absence of any significant radiological contamination with the locations monitored.

TABLE 19:
Summary of Soil Contamination Test Results for the Eastern Development Area (Commercial End Use)

Determinand	Number of Samples	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Assessment Criteria (mg/kg)	Assessment Criteria Source	No. of Exceedances
Asbestos	15	-	-	ND	N/A	-
Cyanide (total)	15	<1	1.01	50	*	-
Phenols (total monohydric)	15	<0.035	<0.035	760	S4UL**	-
METALS						
Arsenic	15	2.17	60.2	640	S4UL**	-
Cadmium	15	<0.02	1.27	190	S4UL**	-
Chromium	15	<9	12.6	8600	S4UL**	-
Chromium VI	14	<0.6	<0.6	33	S4UL**	-
Copper	15	<1.4	19.5	68000	S4UL**	-
Lead	15	3.92	45.9	2300	C4SL***	-
Mercury	15	<0.14	<0.14	11000	S4UL**	-
Nickel	15	1.39	23	980	S4UL**	-
Selenium	15	<1	1.29	12000	S4UL**	-
Zinc	15	3.48	86.1	730000	S4UL**	-
TPH						
Benzene	15	<0.01	<0.01	27	S4UL**	-
Toluene	15	<0.002	<0.002	56000	S4UL**	-
Ethylbenzene	15	<0.003	<0.003	5700	S4UL**	-
m,p-Xylene	15	<0.006	<0.006	5900	S4UL**	-
o-Xylene	15	<0.003	<0.003	6600	S4UL**	-
Aliphatics >C5-C6	15	<0.01	<0.01	3200	S4UL**	-
Aliphatics >C6-C8	15	<0.01	<0.01	7800	S4UL**	-
Aliphatics >C8-C10	15	<0.01	0.0116	2000	S4UL**	-
Aliphatics >C10-C12	15	<0.01	<0.01	9700	S4UL**	-
Aliphatics >C12-C16	15	<0.1	0.385	59000	S4UL**	-
Aliphatics >C16-C21	15	<0.1	2.57	1600000	S4UL**	-
Aliphatics >C35-44	15	<0.1	29.9	1600000	S4UL**	-
Aromatics >C5-C7	15	<0.01	<0.01	26000	S4UL**	-
Aromatics >C7-C8	15	<0.01	<0.01	56000	S4UL**	-
Aromatics >C8-C10	15	<0.01	<0.01	3500	S4UL**	-
Aromatics >C10-C12	15	<0.01	<0.01	16000	S4UL**	-
Aromatics >C12-C16	15	<0.1	0.209	36000	S4UL**	-
Aromatics >C16-C21	15	<0.1	3.75	28000	S4UL**	-
Aromatics >C21-C35	15	<0.1	138	28000	S4UL**	-
Aromatics >C35-C44	15	<0.1	27.4	28000	S4UL**	-
Aromatics >C40-C44	15	<0.1	8.82	28000	S4UL**	-
PAH						

TABLE 19:
Summary of Soil Contamination Test Results for the Eastern Development Area (Commercial End Use)

Determinand	Number of Samples	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Assessment Criteria (mg/kg)	Assessment Criteria Source	No. of Exceedances
Acenapthene	15	<0.008	<0.008	84000	S4UL**	-
Acenapthylene	15	<0.012	0.11	83000	S4UL**	-
Anthracene	15	<0.016	<0.016	520000	S4UL**	-
Benz(a)Anthracene	15	<0.014	0.0447	170	S4UL**	-
Benzo(a)Pyrene	15	<0.015	0.0358	35	S4UL**	-
Benzo(b)Fluoranthene	15	<0.015	0.071	44	S4UL**	-
Benzo(ghi)Perylene	15	<0.024	0.0434	3900	S4UL**	-
Benzo(k)Fluoranthene	15	<0.014	0.0204	1200	S4UL**	-
Chrysene	15	<0.01	0.0303	350	S4UL**	-
Dibenzo(ah)Anthracene	15	<0.023	<0.023	3.5	S4UL**	-
Fluoranthene	15	<0.017	0.0519	23000	S4UL**	-
Fluorene	15	<0.01	<0.01	63000	S4UL**	-
Indeno(123-cd)Pyrene	15	<0.018	0.0331	500	S4UL**	-
Naphthalene	15	<0.009	0.00992	190	S4UL**	-
Phenanthrene	15	<0.015	0.0657	22000	S4UL**	-
Pyrene	15	<0.015	0.0425	54000	S4UL**	-

Notes
* No SGV or S4UL is available for cyanide. Accordingly, a criterion of 50mg/kg has been adopted based on UK legislation concerning allowable concentrations of hydrogen cyanide in food (Flavourings in Food Regulations, 1992).
** S4UL = The LQM/CIEH S4UL's for Human Health Risk Assessment, published by Land Quality Press (2014), based upon the assumption of 1% soil organic matter.
*** Neither an SGV nor a S4UL is available for lead. Lead formerly had a published SGV, which was withdrawn (along with all other pre-August 2008 SGVs) as part updates to the Contaminated Land Exposure Assessment methodology (CLEA) in August 2008. A screening level of 2300mg/kg for lead is proposed based upon the Category 4 Screening Level.
ND: Not detected.
N/A: Not applicable.

Western Area

8.44 Referring to Table 20 below, the results of the direct comparison show that screening values have been exceeded for the following determinands:

- Isolated exceedance of Dibenzo(ah)Anthracene found at TP26;
- Isolated exceedance of lead and cadmium found at TP10.

Table 20:
Summary of Soil Contamination Test Results for the Western Development Area (Residential with plant uptake End Use)

Determinand	Number of Samples	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Assessment Criteria (mg/kg)	Assessment Criteria Source	No. of Exceedances
Asbestos	10	-	-	ND	N/A	-
Cyanide (total)	10	<1	<1	50	*	-
Phenols (total monohydric)	10	<0.035	<0.035	280	S4UL**	-
METALS						
Arsenic	10	4.36	15.7	37	S4UL**	-
Cadmium	10	0.0446	28.9	11	S4UL**	1
Chromium	10	<0.9	85	910	S4UL**	-
Chromium VI	10	<0.6	<0.6	6	S4UL**	-
Copper	10	6.3	68.1	2400	S4UL**	-
Lead	10	9.99	382	200	C4SL****	1
Mercury	10	<0.14	0.298	40	S4UL**	-
Nickel	10	8.56	24.4	180	S4UL**	-
Selenium	10	<1	6.26	250	S4UL**	-
Zinc	10	17.6	1160	3700	S4UL**	-
TPH						
Benzene	10	<0.01	<0.01	0.087	S4UL**	-
Toluene	10	<0.002	<0.002	130	S4UL**	-
Ethylbenzene	10	<0.003	<0.003	47	S4UL**	-
m,p-Xylene	10	<0.006	<0.006	56	S4UL**	-
o-Xylene	10	<0.003	<0.003	60	S4UL**	-
Aliphatics >C5-C6	10	<0.01	<0.01	42	S4UL**	-
Aliphatics >C6-C8	10	<0.01	<0.01	100	S4UL**	-
Aliphatics >C8-C10	10	<0.01	<0.01	27	S4UL**	-
Aliphatics >C10-C12	10	<0.01	<0.01	130	S4UL**	-
Aliphatics >C12-C16	10	<0.1	2.89	1100	S4UL**	-
Aliphatics >C16-C21	10	<0.1	1.34	0	S4UL**	-
Aliphatics >C35-44	10	<0.1	2.53	65000	S4UL**	-
Aromatics >C5-C7	10	<0.01	<0.01	70	S4UL**	-
Aromatics >C7-C8	10	<0.01	<0.01	130	S4UL**	-
Aromatics >C8-C10	10	<0.01	<0.01	34	S4UL**	-
Aromatics >C10-C12	10	<0.01	<0.01	74	S4UL**	-
Aromatics >C12-C16	10	<0.1	0.498	140	S4UL**	-
Aromatics >C16-C21	10	<0.1	7.02	260	S4UL**	-
Aromatics >C21-C35	10	<0.1	39.3	1100	S4UL**	-
Aromatics >C35-C44	10	<0.1	12.6	1100	S4UL**	-
Aromatics >C40-C44	10	<0.1	4.36	1600	S4UL**	-
PAH						

Table 20:
Summary of Soil Contamination Test Results for the Western Development Area (Residential with plant uptake End Use)

Determinand	Number of Samples	Minimum Concentration (mg/kg)	Maximum Concentration (mg/kg)	Assessment Criteria (mg/kg)	Assessment Criteria Source	No. of Exceedances
Acenapthene	10	<0.008	0.0604	210	S4UL**	-
Acenapthylene	10	<0.012	0.0299	170	S4UL**	-
Anthracene	10	<0.016	0.157	2400	S4UL**	-
Benz(a)Anthracene	10	<0.014	1.23	7.2	S4UL**	-
Benzo(a)Pyrene	10	<0.015	1.7	2.2	S4UL**	-
Benzo(b)Fluoranthene	10	<0.015	2.14	2.6	S4UL**	-
Benzo(ghi)Perylene	10	<0.024	1.18	320	S4UL**	-
Benzo(k)Fluoranthene	10	<0.014	0.638	77	S4UL**	-
Chrysene	10	<0.01	0.967	15	S4UL**	-
Dibenzo(ah)Anthracene	10	<0.023	0.247	0.24	S4UL**	1
Fluoranthene	10	<0.017	1.87	280	S4UL**	-
Fluorene	10	<0.01	0.0331	170	S4UL**	-
Indeno(123-cd)Pyrene	10	<0.018	0.989	27	S4UL**	-
Naphthalene	10	<0.009	0.108	2.3	S4UL**	-

Notes
* No SGV or S4UL is available for cyanide. Accordingly, a criterion of 50mg/kg has been adopted based on UK legislation concerning allowable concentrations of hydrogen cyanide in food (Flavourings in Food Regulations, 1992).
** S4UL = The LQM/CIEH S4UL's for Human Health Risk Assessment, published by Land Quality Press (2014), based upon the assumption of 1% soil organic matter.
*** Neither an SGV nor a S4UL is available for lead. Lead formerly had a published SGV, which was withdrawn (along with all other pre-August 2008 SGVs) as part updates to the Contaminated Land Exposure Assessment methodology (CLEA) in August 2008. A screening level of 2300mg/kg for lead is proposed based upon the Category 4 Screening Level.
ND: Not detected.
N/A: Not applicable.

Water Contamination

8.45 Eight groundwater samples were submitted for laboratory analysis. Samples were obtained across the site with WS15, WS17, WS21 and WS25 from the eastern area and WS01, WS02, WS06, WS09 and WS10 from the western area. The samples were collected using a submersible electric pump and purged until levels of pH, EC and temperature had stabilised. The results are provided in Appendix 11. Results have been reviewed against relevant published screening values (EQS, UKDWS) and summarised for each development area, presented in Table 21 and Table 22 below.

Eastern Area

8.46 Referring to Table 21 below, the results of the direct comparison show that screening values have been exceeded for the following determinands:

- Isolated exceedance of cadmium, chromium, copper and nickel at WS17;
- Isolated exceedance of sulphate at WS15;
- Isolated exceedances of aliphatic >C16-C21, aromatic >EC12-16 and >EC16-21, fluorene and anthracene at WS15;
- Exceedance of benzo(a)pyrene, fluoranthene, sum of Benzo(b)fluoranthene and Benzo(k)fluoranthene and sum of Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene at both WS15 and WS25. Both of these locations are located on/near to the recorded old course of the River Blithe; and
- Exceedance of aliphatic >C21-C35 and aromatic >EC21-EC35 at WS15, WS17 and WS25.

TABLE 21:
Summary of Groundwater Quality Test Results for the eastern development area (µg/l)

Determinand	Number of Samples	Minimum Concentration	Maximum concentration	Assessment Criteria**	Assessment Criteria Source	Number of exceedances
Alkalinity, Total as CaC03	4	32	245	NS	NS	-
Arsenic	4	<0.51	3.08	50	WFD[1]	-
Cadmium	4	0.106	1.06	0.2	WFD[1]	1
Chromium	4	<1.2	4.78	4.7	WFD[4]	1
Copper	4	<0.85	57.7	10	WFD[1]	1
Total Cyanide	4	<0.05	<0.05	1	WFD[4]	-
Lead	4	<0.1	1.31	7.2	WFD[1]	-
Mercury	4	<0.01	0.0248	0.075	WFD[3]	-
Nickel	4	3.2	28.7	15	WFD[5]	1
pH Value	4	6.13	7.29	NS	NS	-
Selenium	4	<0.81	2.99	10	WFD[1]	-
Sulphate (Soluble)	4	33.6	232	188,000	WFD[1]	1
Aliphatics >C16-C21	4	<10	306	300	WHO[2]	1
Aliphatics >C21-C35	4	199	4010	300	WHO[2]	3
Aromatics >EC12-EC16	4	<10	118	100	WHO[2]	1
Aromatics >EC16-EC21	4	13	279	90	WHO[2]	1
Aromatics >EC21-EC35	4	54	3330	90	WHO[2]	3

TABLE 21:
Summary of Groundwater Quality Test Results for the eastern development area (µg/l)

Determinand	Number of Samples	Minimum Concentration	Maximum concentration	Assessment Criteria**	Assessment Criteria Source	Number of exceedances
Phenols Total Monohydric	4	<0.016	<0.016	7.5	WFD[1]	-
Naphthalene	4	<0.1	0.6	2.4	WFD[1]	-
Benzo(a)pyrene	4	<0.009	0.657	0.075	WFD[5]	2
Anthracene	4	<0.015	0.104	0.1	WFD[1]	1
Fluorene	4	<0.014	0.74	0.1	WFD[1]	1
Fluoranthene	4	<0.017	0.889	0.1	WFD[1]	2
PAH: Sum of Benzo(b)fluoranthene and Benzo(k)fluoranthene	4	<0.023	1.364	0.03	WFD[4]	2
PAH: Sum of Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene	4	<0.016	0.952	0.002	WFD[4]	2

NS = No assessment criterion

[1] Groundwater impacts on surface water minimum threshold value – Water Framework Directive 2016

[2] WHO Guidelines for Drinking-water Quality - 2011

[3] Groundwater Drinking Water Protected Areas – Water Framework Directive 2016

[4] Inland Surface Waters for Aquatic life – Water Framework Directive 2016

[5] UK Drinking Water Standards (Water Quality Regs) – Consumers tap 2016

Western Area

8.47 Referring to Table 22 below, the results of the direct comparison show that screening values have been exceeded for the following determinands:

- Isolated exceedances of aliphatic >C21-C35, aromatic >EC16-EC21 and fluorine at WS02;
- Exceedances of cadmium and nickel at WS02 and WS06;
- Exceedances of Benzo(a)pyrene at WS02, WS09 and WS10;
- Exceedances of fluoranthene, sum of Benzo(b)fluoranthene and Benzo(k)fluoranthene and sum of Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene at all borehole locations.

TABLE 22:
Summary of Groundwater Quality Test Results for the western development area (µg/l)

Determinand	Number of Samples	Minimum Concentration	Maximum concentration	Assessment Criteria**	Assessment Criteria Source	Number of exceedances
Alkalinity, Total as CaC03	4	200	380	NS	NS	-
Arsenic	4	0.532	0.795	7.5	WFD[1]	-
Cadmium	4	0.0929	0.488	0.2	WFD[1]	2
Chromium	4	<1.2	<1.2	4.7	WFD[4]	-
Copper	4	0.984	3.64	10	WFD[1]	-
Total Cyanide	4	<0.05	<0.05	1	WFD[4]	-
Lead	4	<0.1	<0.1	7.2	WFD[1]	-
Mercury	4	<0.01	0.0379	0.075	WFD[3]	-
Nickel	4	0.761	32.8	15	WFD[5]	2
pH Value	4	6.96	7.55	NS	NS	-
Selenium	4	1.41	2.18	10	WFD[1]	-
Sulphate (Soluble)	4	8.1	90.9	188,000	WFD[1]	-
Aliphatics >C16-C21	4	<10	<10	300	WHO[2]	-
Aliphatics >C21-C35	4	149	1580	300	WHO[2]	1
Aromatics >EC12-EC16	4	<10	<10	100	WHO[2]	-
Aromatics >EC16-EC21	4	<10	139	90	WHO[2]	1
Aromatics >EC21-EC35	4	51	1290	90	WHO[2]	1
Phenols Total Monohydric	4	<0.016	<0.016	7.5	WFD[1]	-
Naphthalene	4	<0.1	<0.1	2.4	WFD[1]	-
Benzo(a)pyrene	4	0.0658	0.12	0.075	WFD[5]	3
Anthracene	4	0.0391	0.0483	0.1	WFD[1]	-
Fluorene	4	<0.014	0.149	0.1	WFD[1]	1
Fluoranthene	4	0.121	0.359	0.1	WFD[1]	4
PAH: Sum of Benzo(b)fluoranthene and Benzo(k)fluoranthene	4	0.1616	0.421	0.03	WFD[4]	4
PAH: Sum of Benzo(g,h,i)perylene and Indeno(1,2,3-cd)pyrene	4	0.1431	0.32	0.002	WFD[4]	4

NS = No assessment criterion
[1] Groundwater impacts on surface water minimum threshold value – Water Framework Directive 2016
[2] WHO Guidelines for Drinking-water Quality - 2011
[3] Groundwater Drinking Water Protected Areas – Water Framework Directive 2016
[4] Inland Surface Waters for Aquatic life – Water Framework Directive 2016
[5] UK Drinking Water Standards (Water Quality Regs) – Consumers tap 2016

9 ASSESSMENT, RECOMMENDATIONS AND DEVELOPMENT CONSTRAINTS

Introduction

9.1 An assessment of the geotechnical, contaminated land ground conditions and the likely development constraints for the site is provided in the following sections.

Surface and Below Ground Structures

9.2 There are currently no above ground structures within the eastern development area. The western area currently contains a dance studio building with associated soft landscaping area, a large area of hardstanding used for car parking and stockpiling/storage of a variety of materials. An old disused track runs parallel to the River Blithe in the north of the development area. The rest of the development area is currently used for agricultural purposes. Below ground structures (i.e. foundations and services) associated with the dance studio will be present beneath or within the immediate vicinity of the dance studio.

9.3 In addition, remnant historic structures (small floor slabs) are present in the southern part of the eastern area. Any below ground obstructions will require to be removed part of the redevelopment work.

9.4 Along the route of the proposed roadway, there is currently an existing road which provides access to adjacent commercial and industrial units. It is anticipated that possible below structures will be located within this existing road.

Underground Services

9.5 From service plans obtained from the client, there are a range of services located across both development areas. All future development within the site should have due regard to the location of the underground services. Additional unrecorded services may also be present.

Eastern Area

9.6 Within the eastern area, the only known service is the presence of a Local High Pressure (HP) Gas main, trending north-south through the centre of the field. From the UCML Utility Connections Report (Report Ref W117), a development standoff

(typically 14.00m easement guideline distance) will be required from this. Consultation with National Grid will have to be undertaken to confirm the distance of the easement from HP main. No additional services are allowed to run within the easement from the HP main but may cross above or below with at least 600mm clearance after correspondence with National Grid has taken place.

Western Area

9.7 Local Medium Pressure (MP) and Local Low Pressure (LP) gas mains also run through/bound the site. The UCML Report suggests that diversion works could be negotiated with National Grid. Additional correspondence will be required for the MP gas main as this runs into the centre of Blythe Business Park.

9.8 Overhead Low Voltage (LV) power line runs along the southern boundary, presumably supplying local properties. BT Openreach connections area located running to the dance studio from Blythe Business Park with an additional line (appearing unconnected) running parallel.

9.9 A series of foul/combined and storm sewers cross the development area from local residential housing and the local area. A main sewer, the 'Blithe Valley Sewer' is located from west to east across the northern part of the area with the pipe up to 900mm diameter, at unknown depth.

9.10 It is understood, anecdotally, that a series of electrical cables are present in the grass surrounding the dance studio which are used for cable detection training purposes.

Interconnecting roadway

9.11 No private service plans were provided for locations within Blythe Business Park, however, it is anticipated that services will be present with the roadway and investigation into these will have to be undertaken.

Topography

9.12 The topographical level of the eastern and western areas is shown on Drawing No. ST15807-007 and ST15807-008, respectively. The eastern area is generally flat, sloping very gently downwards towards the River Blithe to the north. Site levels vary

from 156.36m AOD along the southern boundary to 152.94m AOD. It is considered that only minor regrading works will be required to established a suitable construction level.

9.13 The western area slopes downwards to the north from c.164.00m AOD to c.155.60m AOD. Given the presence of the slope, it is likely that earthworks would be required to create a suitable development platform before construction could begin. This would involve the remove of material and flattening of slopes to a suitable gradient

9.14 Along the proposed route of the interconnecting roadway (not shown on the above drawings), the site is relatively flat with levels varying between 154.00m and 157.00m AOD.

Old Course of River Blithe

9.15 From assessment of historical maps, the River Blithe used to run through the centre of the eastern area (trending east to west) and just clips the north east corner of the western area.

9.16 The river appears to have been infilled between 1888 and 1901 with unknown materials. It was then recorded to be marshy ground with a spring marked within the south eastern corner of the eastern development area. During the site investigation several locations (TP13, TP14, TP16, TP20, TP27, WS15 and WS25) were marked (via GPS) to target the potential infilled river channel using a 'best fit' location for the river channel. No locations were undertaken at the recorded location of the former river channel in the western area due to the presence of services with the exception of a single hand dug pit (TP10) which was carried out in the general vicinity where services allowed.

9.17 Arisings from the trial pits along the 'best fit' locations were examined by a radiological consultant in case of encountering radioactive material associated with Blythe Colour Works. No radioactive material was encountered (Appendix 7).

9.18 No obvious signs of significant made ground were identified in any of the site investigations which were carried out along the recorded route of the old river channel, including the long linear trenches. It is possible that the natural materials excavated to form the new route of the river were used to backfill the old river channel, hence the evidence of potential reworked material.

9.19 Consideration should be given to the positioning of structures over the former course of the River Blithe as the strength characteristics of soils in this area may vary.

Near Surface Soils and Construction

9.20 The investigation works undertaken to date are suitable for an assessment of the development constraints and the likely suitable foundation types. It may be necessary for further investigation to be carried out in order to develop specific development proposals for the wider site area. At present, it is understood that the development of the site will involve the construction of commercial units (eastern development area) and residential units (western area) with associated infrastructure.

Foundations

9.21 Natural superficial deposits were encountered in all of the site investigation locations at a thickness of up to 5.45m+ bgl. The natural superficial deposits are predominately medium dense sand and gravel across the entire site apart from glacial till observed within the western area, meaning it could be used as a founding horizon subject to some processing.

9.22 It is presumed that further made ground is located within Blythe Business Park including the north east corner of the western development area where the current Dance Studio and area of hardstanding is located. It is presumed that the material would not be suitable for use as a founding horizon.

9.23 The anticipated bearing capacity and foundation types are outlined below for each development area:

- It is anticipated that an allowable bearing capacity of 250kPa may be assumed for the natural superficial deposits within the eastern development area. This is based upon a square pad foundation solution at 0.75m depth.

- It is anticipated that an allowable bearing capacity of 125kPa utilising a 0.6m wide shallow strip foundation at 0.75m depth may be assumed within the natural superficial deposits within the western development area. These foundations may have to deepened within the vicinity of the dance studio due below ground obstructions.

9.24 The above solutions and calculated bearing capacities will require confirmation and reassessment based on the detailed design of any structures in both development areas. In order to minimise the potential for differential settlement, foundations should be designed to bear on uniform strata. This is particularly important in the area of the potentially infilled former river channel and it is imperative that foundations are not formed in the backfill material which could lead to differential settlement issues.

9.25 Cohesive soils have been encountered within the western area at likely foundation depths with modified plasticity indexes of 4.41%-5.4% and therefore should be considered to be of low volume change potential as per Chapter 4.1 in NHBC 2011 "Land quality – Managing Ground Conditions". These plasticity indexes calculated are only based on two atterburg limit tests, undertaken on cohesive materials within the western area. Therefore, additional testing will be required to confirm these parameters before foundation design in undertaken.

9.26 Deeper foundations and heave precautions may be required where in close proximity to trees. A detailed tree survey will need to be undertaken to ensure correct foundation types and required depths are calculated, prior to construction taking place.

9.27 It should be noted that the compaction test results indicate that the natural sand and gravel deposits are naturally wet of their optimum and would require some form of drying or mixing prior if they are to be re-used in regrading/earthworks.

Floor slabs

9.28 The selection of the type of floor slab will be dependent upon various factors such as proposed finish levels compared to present levels, the type of building to be

constructed, ground conditions, construction preferences and external factors such as the presence of trees. However, it is considered that ground bearing slabs could be utilised on both areas.

9.29 In areas where made ground or reworked material is thicker than 600mm floor slabs will need to be suspended.

9.30 Groundwater was observed in the majority of the trial pits and windowless samples. Where it was encountered, it occurred as an influx of water or running sands. Therefore, there will be a requirement for dewatering of excavations should water be found at shallow depths.

Excavations

9.31 Observations made during the site investigation suggest that the excavations will have stability issues once water is encountered. Excavations sides should be made stable by either undertaking a reduced level dig, benching or battering of excavation sides or provision of trench support as appropriate. Conventional mechanical excavation should be achievable to the depths required for construction works <1.00m.

9.32 Rockhead of the Mercia Mudstone has been identified at a minimum depth of c.3.60m. Whilst this is unlikely to comprise a constraint, if it is necessary to carry out deeper excavations (e.g. deep drains), the rock may require specialist digging techniques. Additional care should be taken in the south east corner of the eastern development area where a historic spring was located.

Groundwater

9.33 The results of the groundwater monitoring show that groundwater level at the site is relatively high and the groundwater is at a depth whereby soakaways may not be viable. Other drainage options should be utilised, with final designs and suitable options should be undertaken and reviewed by a qualified drainage specialist.

Slopes

9.34 Whilst it is unknown from the current development proposals, if slopes are to be cut into the natural superficial deposits, especially within the western area, then it is recommended that a detailed assessment is made of the material at the locations of

any proposed slope to determine safe slope angles and the composition of any support needed.

Roads, Hardstanding and Parking Areas

9.35 The made ground deposits mainly found within Blythe Business Park may require improvement works as outlined above in the foundations section before roads and hardstanding can be constructed. The level of improvement will require further assessment once the detailed design and loading are known for the roads and hardstanding areas. However, it is probable that some degree of excavating and re-compaction will be required in order to provide a suitable and uniform formation.

9.36 The natural superficial deposits found across both development areas is thought to be suitable for the construction of roads and hardstanding. It is possible that a degree of excavating and re-compaction will be required to provide a suitable and uniform formation.

9.37 The underlying clays should be regarded as frost susceptible and as such should not be included within the upper 450mm of pavement construction.

Concrete

9.38 Water soluble sulphate determination was undertaken on 25 samples and 8 water samples in order to assess the concrete class detailed in the 2001 publication by the Building Research Establishment Special Digest 1 “Concrete in aggressive ground” (Parts 1 to 4) and which provides guidance, inter alia, on the appropriate cement type, minimum cement content and maximum free water/cement ratio under various sulphate concentrations.

9.39 The sulphate chemical results are summarised in Table 19 below.

TABLE 19: Summary of Sulphate Results				
Property	**No. Samples**		**Range of Results**	
	Eastern Development Area	Western Development Area	Eastern Development Area	Western Development Area
Soil water soluble sulphate in 2:1 preparation (g/l)	16	9	<0.004-0.0535	<0.004-0.0453
Soil pH	16	9	5.27-8.13	6.57-8.2
Groundwater Sulphate (mg/l)	4	4	33.6-232	8.1-90.9
Groundwater pH	4	4	6.13-7.29	6.96-7.55

9.40 From the data available for the site, a design sulphate class of DS-1 and an aggressive chemical environment for concrete (ACEC) site classification of AC-2 should be used for the eastern development area and AC-1 for the western development area.

9.41 The designer of any in ground concrete structures will need to undertake additional sulphate/sulphide sampling and testing to confirm this prior to construction.

Soil and Water Contamination

9.42 Chemical exceedances within soil samples tested were only recorded within made ground at TP26 and TP10 on the western area. Topsoil and the natural drift strata elsewhere were recorded to be suitable for their proposed end use.

9.43 Where made ground deposits were encountered or could be encountered during future development of the western area, a 600mm layer of 'clean cover' should be applied to garden and landscape areas to remove the pathway to these contaminants. The extent of this will need to be further confirmed with additional geochemical samples taken across the site where made ground was encountered.

9.44 With regards to water contamination results, exceedances were found at all locations tested. For the western area, no identifiable source of these contaminants was determined. Therefore, the levels found are likely to be associated with background levels found locally.

9.45 For the eastern area however, exceedances appeared mainly to occur within the southern half of the site, including along the old course of the River Blithe. Elevated levels here could be associated with the transmission of contaminants from the large

area of landfill found in-between both areas. As the eastern area is down gradient to this, it is therefore likely this is the source. Exceedances of contaminants in both these development areas are thought to be minimal, requiring no further remedial action.

Ground Gas

9.46 An assessment has been made in line with guidance contained in the following documents:

- CIRIA C665 'Assessing risks posed by hazardous ground gases to buildings';
- NHBC 'Guidance on evaluation of development proposals on sites where methane and carbon dioxide are present'. (This document assesses the risk of gases based on a "Traffic Light" system ranging from green (no gas precautions required) to red (development precluded).

9.47 In accordance with the methodology outlined with the CIRIA publication C665, Wardell Armstrong has utilised the results of the ground gas monitoring visits to calculate a Gas Screening Value (GSV). The maximum GSV calculated for methane was 0.001l/hr and for carbon dioxide was 0.1271l/hr.

9.48 The GSV has been compared to the criteria outlined within CIRIA C665 or the NHBC to determine the level of risk to the proposed development and to ensure the appropriate remedial options are incorporated into any future building design in this area.

Eastern Area

9.49 Based on the results obtained thus far it would be prudent to classify the site under Characteristic Situation 2 in accordance with guidance in the CIRIA publication "C665 Assessing risks posed by hazardous ground gases to buildings".

9.50 This classification recommends any commercial or industrial buildings on site will require some form of gas protection, depending on the type of floor slab used as outlined below:

- Cast in-situ floor slab (either suspended, non-suspended or raft) – minimum of a 1200 g damp proof membrane;

- Beam and block or pre-cast concrete slab – minimum of a 2000 g damp proof/reinforced gas membrane.

9.51 The above options could be used with underfloor venting or pressurisation to increase the level of gas protection if required. All joints and penetrations should be sealed.

Western Area

9.52 The calculated GSVs would put the site into the "Amber 1" category under the NHBC traffic light system for a Situation B development. Situation B applies to all low rise residential development with a minimum 150mm ventilated sub floor void. All residential properties within this area identified as "low risk" will require some form of gas protection including the use of a gas membrane, as prescribed in BRE 414. Ventilation of the sub-floor void should be designed to provide a minimum of one complete volume change per 24 hours.

Water supply pipes

9.53 The chemical composition of the soils and groundwater has been assessed in accordance with the recommendations of UKWIR publication *'Guidance for the Selection of Water Supply Pipes to be Used in Brownfield Sites'* to determine the likely specification of water supply pipes to be used in the future development. Even though the site is not deemed to be 'brownfield', the application of the UKWIR publication is deemed suitable to greenfield sites which may have been affected by contamination.

9.54 From the examination of contamination testing undertaken, it is expected that the use of standard polyethylene pipes could be used across both development areas. The presence of slightly elevated levels of TPH and PAH within the near surface soils may affect the suitability for the installation of water supply pipes, as these contaminants could possibly permeate through standard polyethylene pipes, meaning that a barrier pipe may be required. Ground conditions may also be considered corrosive to wrapped steel pipes (pH <7), meaning that ductile iron or copper pipes may be required.

9.55 Once the route of the water supply pipes for the development is known, a further investigation should be undertaken along the proposed routes to determine the chemical suitability of the ground into which the future pipe will be placed, along with the type of pipe required.

10 REVISED CONCEPTUAL SITE MODEL

10.1 The conceptual site model presented in section 7.0 Is reviewed after the undertaking of the site investigation and subsequent contamination testing. Table 23 below, details a revised assessment of all potential pollutant linkages currently identified on site.

TABLE 12: Conceptual Site Model

SOURCE (CONTAMINANT)	PATHWAY	RECEPTOR	RISK
Made ground on site associated with historical use (including Blythe Colour Works)	1. Inhalation. 2. Dermal contact. 3. Ingestion. 4. Surface runoff. 5. Groundwater migration. 6. Direct contact (aggressive attack). 7. Gas migration.	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Low to Moderate
Gas generation from potential isolated areas of made ground on site	1. Gas migration.	1. Current occupiers. 2. Future occupiers. 3. Construction workers.	Low
Contents of historic tank within western development area.	1. Inhalation. 2. Dermal contact. 3. Ingestion. 4. Surface runoff. 5. Groundwater migration. 6. Direct contact (aggressive attack).	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Moderate
Unknown material used for infilling the old course of the River Blithe (eastern development area)	1. Inhalation. 2. Dermal contact. 3. Ingestion. 4. Surface runoff. 5. Groundwater migration. 6. Direct contact (aggressive attack). 7. Gas migration.	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Low

TABLE 12: Conceptual Site Model			
SOURCE (CONTAMINANT)	**PATHWAY**	**RECEPTOR**	**RISK**
Surrounding Commercial and Industrial uses within Blythe Business Park. (wide range of potential contaminants).	6. Inhalation. 7. Dermal contact. 8. Ingestion. 9. Surface runoff. 10. Groundwater migration.	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Low
Historic landfill with hazardous and potentially radioactive waste	1. Inhalation. 2. Dermal contact. 3. Ingestion. 4. Surface runoff. 5. Groundwater migration. 6. Direct contact (aggressive attack).	1. Current occupiers. 2. Future occupiers. 3. Construction workers. 4. Groundwater. 5. Surface water. 6. Subsurface building materials and plastic service pipes. 7. Flora and Fauna.	Low to Moderate

11 CONCLUSIONS AND RECOMMENDATIONS

11.1 A site investigation has been conducted on two development areas located at Blythe Business Park in Cresswell, Stoke-on-Trent. This was undertaken to determine the nature of the prevailing ground conditions and to evaluate the ground related constraints to the development of both sites. Historical uses and the results from the site investigation have been considered during this report. These potential constraints include soil and water contamination, gas migration, groundwater, unknown ground conditions and made ground deposits. The western area will be developed for residential end use and the eastern area will be developed for commercial business units.

11.2 From the thirty-six soil samples analysed, two samples of made ground failed to comply with residential with plant uptake end use threshold values for the western development area. These two sampling positions were in locations which had previously been built on. At least a 600mm layer of 'clean cover' should be used within areas containing or thought to contain made ground deposits. The majority of the western area was not underlain by made ground and these areas will not require any remedial work. All samples analysed for the eastern area complied with the threshold values for a commercial end use and hence required no remedial work.

11.3 Trial pits located in the infilled channel recorded reworked natural deposits. It is considered possible that the river channel was entirely infilled with reworked natural deposits, possibly generated during the excavation of the new course of the River Blithe. The radiological readings of the trial pit arisings along the inferred infilled route of the River Blithe were comparable to background, indicating the absence of any significant radiological contamination with the locations monitored.

11.4 No asbestos was recorded across either development area. However, an asbestos survey should be undertaken at the dance studio building to ascertain the risk from this building.

11.5 Eight samples of groundwater were obtained and analysed for a range of commonly occurring contaminants. When compared with standard guideline values, it was found that several the contaminants marginally exceeded the threshold values. Whilst

exceedances of contaminants were recorded in both development areas, these are thought to be minimal and as such, requiring no further remedial action.

11.6 Based upon the gas monitoring undertaken to date, gas precaution measures for carbon dioxide will be required. No methane was detected. Remedial options will be Characteristic Situation 2/Amber 1 for the eastern and western areas, respectively.

11.7 It is anticipated that an allowable bearing capacity of 250kPa may be assumed for the natural superficial deposits within the eastern development area. This is based upon a square pad foundation solution at 0.75m depth.

11.8 It is anticipated that an allowable bearing capacity of 125kPa utilising a 0.6m wide shallow strip foundation at 0.75m depth may be assumed within the natural superficial deposits within the western development area. These foundations may have to be deepened within the vicinity of the dance studio due below ground obstructions.

11.9 The presence of shallow groundwater in combination with poor permeability of underlying soils deem the use of soak-away drainage as unviable.

11.10 Shallow groundwater has been identified and therefore it is probable that excavations may require dewatering. In addition, due to the predominantly granular soils, it is likely that excavations would collapse, particularly if left open for any extended period of time, and therefore would require support.

11.11 Across the areas proposed for development, several known services exist. This includes high and medium pressure gas mains, foul/combined sewers and storm drains. Care should be taken when developing near these, especially in relation to the high pressure gas main running through the eastern development area. Liaison with the appropriate authorities and companies must therefore be undertaken prior to any development. Additional information must also be gained with relation to any private services that run near/along the route of the proposed roadway within Blythe Business Park.

11.12 The site may need to be regraded in parts to provide a suitable development platform.

11.13 It has been identified that the site has several constraints to development associated with previous site uses and also the natural ground conditions. Nevertheless, it is not considered that any of these constraints are insurmountable with the use of appropriate remedial and engineering techniques.