M42 Junction 6 Improvement
Scheme Number TR010027
Volume 6
6.3 Environmental Statement
Appendix 10.1 Ground Investigation Report

Regulation 5(2)(a)

Planning Act 2008

Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

January 2019

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

M42 Junction 6 Improvement

Development Consent Order 202[ ]

6.3 Environmental Statement
Appendix 10.1 Ground Investigation Report

Regulation Number	Regulation 5(2)(a)
Planning Inspectorate Scheme Reference	TR010027
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Subject	M42 J6 Improvements Ground Investigation Report: Ground Contamination Assessment		
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1. Introduction

1.1 General

The M42 is a strategic route between Bromsgrove in Worcestershire and Ashby-de-la-Zouch in Leicestershire. The M42 carries significant volumes of traffic around the Birmingham area with the M42 Junction 6 forming connections between the national motorway network and the A45 Coventry Road providing access to Birmingham to the west and Coventry to the east. The Scheme comprises the improvement of Junction 6 of the M42 to help alleviate current congestion problems which would unlock additional investment and further economic growth for the area. The improvements will also enhance the accessibility to key assets within the area as well as ensuring the access to the proposed HS2 station is not compromised.

This purpose of this technical note is to:

- Outline the baseline geo-environmental ground conditions anticipated across the area of the Scheme;
- Produce a Conceptual Site Model (CSM) using information compiled as part of the baseline assessment in order to define the plausible contaminant source, pathways and receptor linkages that could be present associated with the Scheme;
- Produce a Generic Quantitative Risk Assessment (GQRA) of the potential significance of contaminants of potential concern (CoPC) concentrations detected in soil, soil leachate and groundwater associated with the Scheme, utilising Generic Assessment Criteria (GAC) that are considered to be protective of human health and controlled waters receptors; and
- Present a Ground Gas and HazWaste assessment.

The baseline and CSM sections of this technical note develop upon and Preliminary Sources Study Report (PSSR) Addendum (January 2017), assimilating and providing interpretation on historical information and new information gathered since the preparation of the addendum.

This document has been prepared for internal review by the AECOM project team and for the purposes of being collated as part of AECOM's 'Ground Investigation Report' (GIR) currently being prepared.

Where reference is made to the current alignment/assessment, this relates to the Scheme alignment considered as part of this assessment undertaken 13th September 2018.

2. Method and Limitations

Section 3 of this document comprises a summary of the geo-environmental baseline information available from the Environmental Statement (ES) relative to the Scheme and associated Red Line Boundary (RLB) available at the time of writing.

The baseline information presented in the ES has been collated by making reference to the following data sources. The information obtained has formed the geo-environmental baseline against which potential geo-environmental impacts associated with the Scheme have been assessed. The baseline information does not account for the 2018 ground investigation undertaken:

- British Geological Survey (BGS);
- Department for Environment, Food and Rural Affairs (DEFRA);
- Environment Agency;
- Landmark 'Envirocheck' Report (referenced 141548789_1_1);
- Natural England;
- Solihull Metropolitan Borough Council;
- Warwickshire County Council;
- Warwickshire Geological Conservation Group (WGCG);
- Site Walkover information (undertaken by AECOM on 14 to 15 September 2017 in support of proposed ground investigation);

The ES considers a 'study area'; this includes the Scheme (defined as the area within the Order Limits) and an additional distance of 250m extending from the Scheme. This area is considered appropriate for the consideration of historical and current potentially contaminative land uses and it aligns with established industry practice for defining land contamination study areas for Environmental Impact Assessments (EIA). This area is hereinafter referred to as the 'geology study area'.

It should be noted that the study area was extended to 500m from the Scheme for groundwater, surface water and potable water abstractions (hereinafter referred to as the extended study area).

The baseline information also references a summary of additional pertinent desk study information received after the preparation of the PSSR Addendum in January 2017, and not currently included within the ES. This summary note is presented as a separate technical note, titled Additional Geo-environmental Baseline Information and referenced HE551485-ACM-SGT-ZZ_SW_ZZ_ZZ-TN-GE-0002.

The baseline information provided in this document has been collated to form the basis of the CSM, updated from that presented as part of the PSSR Addendum. The CSM has then formed the basis of the ground contamination assessment reported in this note.

This assessment presented in this note is based on the Scheme alignment available at the time of assessment (dated 13th September 2018, drawing reference: HE551485-ACM-HGN-M42_GEN_ZZ_ZZ-DR-CH-0014).

3 Baseline Conditions

3.1 Geology

The British Geological Survey (BGS) 1:50,000 scale solid and drift geological maps (Birmingham Sheet 168) and the BGS GeoIndex digital mapping, together with information provided from previous ground investigation reports, as described within the PSSR, have been used to describe the geology in the area of the Scheme.

Made Ground and superficial deposits are present within the study area. Superficial deposits are sparse but where encountered are anticipated to comprise alluvium, glaciofluvial and river terrace deposits. The bedrock geology underlying the study area is the Mercia Mudstone Group.

3.1.1 Made Ground

Made Ground is anticipated to be present to the west of the M42 Junction 6, and the north of the A45 associated with Birmingham International Airport and with some areas further north along the M42. There are also areas of infilled ground, notably adjacent east of the Scheme, south of the A45, between the M42 Junction 6 and Stonebridge Island to the east, and further north near to Birmingham Business Park.

Based on publically available BGS boreholes, historical ground investigation boreholes records and BGS mapping, the Made Ground can be categorised into various types, with the main descriptions including:

- Embankment construction material associated with the existing M42 motorway;
- Worked ground (i.e. areas where ground has been cut away such as quarries) ;
- Infilled ground (i.e. areas where ground has been cut away then wholly or partially backfilled); and
- Areas of undifferentiated Made Ground (i.e. areas which have been built up above natural ground level by man-made deposits).

The thickness of the embankment construction material varies from between 1.2m and 6.0m based on historical ground investigation data. The material is a mixture of granular and cohesive deposits with concrete, brick and rubble being the typical constituents. A number of boreholes encountered material considered to be former road surface layers and road sub-base.

No information is available in relation to the depth, thickness or composition of the worked or infilled ground. This is likely to be variable and specific to individual features. Worked ground is associated with former clay and sand extraction pits that are located in the grassland surrounding Bickenhill and it is also indicated to be associated with road and railway cuttings. A large number of localised infilled ground relates to infilling of former ponds.

Areas of undifferentiated Made Ground have been encountered during historical ground investigations in the area. Undifferentiated Made Ground represents areas which have been built up above natural ground level (but excluding embankment

construction materials which are considered separately). This includes spoil heaps and areas of major construction (such as the National Exhibition Centre (NEC)), and it comprises both granular and cohesive materials. Up to 7.1m of undifferentiated Made Ground has been encountered during historical ground investigations, with the thickest material encountered located around the area of the Clock Interchange.

Areas of Made Ground are located immediately north-west and north-east of Junction 6, occupying the area between the M42 and the eastbound A45. According to historical studies, infilled ground is encountered associated with landfills, former mineral workings and localised former ponds. Worked ground is found where the ground has been cut away but not infilled, including the M42 earthworks cuttings.

3.1.2 Superficial Deposits

Superficial deposits are shown on the BGS geological maps to be absent across the majority of the Scheme. Localised outcrops of alluvium deposits (clay, silt, sand and gravel) associated with the Shadow Brook and Low Brook intersect the Scheme on the M42 and Coventry Road. Glaciofluvial deposits are present outcropping in patches across the central part of the Scheme north of Shadow Brook Lane with wider expanses south of Hampton Lane Farm and to the north of the M42 Junction 6. The southern part of the study area, the area between Friday Lane and Henwood Lane, variably comprises alluvium, river terrace deposits and glaciofluvial deposits.

Where encountered during historical ground investigations, the alluvium referred to comprises of a mixture of clays, silts, sands and gravels with rare layers of peat and varying in thickness from 1.80m to 3.55m. Glaciofluvial material, where encountered, was found to comprise typically sand and gravels (occasionally clay or silt with granular secondary constituents) and varying in thickness from 2.10m to 10.80m.

3.1.3 Bedrock Geology

The Scheme is entirely underlain by the Mercia Mudstone Group comprising Sidmouth Mudstone Formation, Branscombe Mudstone Formation and Arden Sandstone Formation. These are sedimentary bedrock formed in the Triassic Period. Most parts of the Arden Sandstone Formation are recorded as sandstone, siltstone and mudstone. However, in some cases, notably an outcrop near to the southern part of the Scheme in between the village of Catherine De Barnes and the M42, the strata is recorded as mudstone only.

The Mercia Mudstone Group was found to be present along the entire site investigated during historical studies. However, no boreholes encountered material considered to be non-weathered Mercia Mudstone (Zone 1) within the study area, with up to approximately 10m to 15m of fully/partially weathered material being encountered. The Arden Sandstone Formation was proven up to 20m in thickness.

3.1.4 Sensitive Sites

There are no geological Sites of Special Scientific Interest (SSSI) within the Scheme or within the geology study area.

3.2 Mining and Mineral Resources

3.2.1 Mining

The Scheme is not in an area that might be affected by coal mining. There are also no known hazards in relation to non-coal mining areas.

According to the PSSR, a review of the Mining and Instability West Midlands Report indicates no significant mining has taken place in the area considered by the PSSR and that the underlying strata are not coal bearing.

3.2.2 Mineral Resources

There are two BGS Recorded Mineral Sites within the geology study area detailed as follows:

1. Arden Landfill

   Also known as Jackson's Landfill and the location of Arden Brickworks detailed above. This is located approximately 230m from the Scheme south of the A45 between the M42 Junction 6 and Stonebridge Island to the east. It was a dormant opencast site for which the commodity is recorded as common clay and shale. Based on information provided by SMBC there has recently been a recommencement of activity at the site both with infilling of the old void area, plus new clay extraction activity in the last 2 – 3 years. The old mineral consents were consolidated in the Review of Old Mineral Posessions (ROMP) 1997, and a further review of the consolidated set of minerals conditions has since been postponed for a further 15 years. Additionally, other past uses included the base for a demolition company, open storage for civils contractors, plus as Materials Recovery Facility (MRF) and related activities. The MRF operation is currently the subject of a 10 year temporary consent which expires in ~September 2019. The mineral extraction is authorised to 2042. Additionally, SMBC commented that a Regionally Important Geological Site designation applies to part of the site, although this designation will be lost as the long term restoration plan is for infilling and restoration of the whole minerals site to agriculture.

2. Middle Bickenhill Brick Works

   Located approximately 70m from the Scheme, and also south of the A45 between the M42 Junction 6 and Stonebridge Island to the east. This is a ceased opencast site for which the commodity is recorded as common clay and shale.

According to the PSSR, the BGS memoir for BGS Sheet 168 states that Jackson's Brick Pit (600m east of Junction 6 – at approximate national grid reference 420638, 282588) is the site of a former clay extraction pit within the Mercia Mudstone Group. The memoir also indicates the possibility for localised bell pits, associated with historical extraction of the Mercia Mudstone Group for agricultural use, to be present within the area considered by historical studies. It is noted that no information regarding the location of such pits is available. Although no definitive evidence is available, it is highlighted that it is possible that small ponds within areas of

glaciofluvial deposits and Mercia Mudstone represent former sand and gravel, and clay extraction pits, respectively.

The Solihull Metropolitan Borough Council (SMBC) Local Plan Review Proposals Map (November 2016) and Warwickshire County Council (WCC) Warwickshire Minerals Plan Publication Consultation (December 2016) identify a Mineral Safeguarding Area (MSA) for sand and gravel aggregate within the study area. The footprint of this MSA covers the area east of the M42 and west of the A452.

The area of MSA land to the east of the NEC and M42 is identified as an MSA in the current adopted development plan (the Solihull Local Plan 2013) and remains the current policy designation. This is maintained in the emerging Local Plan Review. The site is the subject of two major planning permissions for sand and gravel extraction, one of which was implemented some time ago but recently became the subject of a Stop Notice by HS2 Limited, which caused the mineral extraction to cease on 1st December 2017, (Places Directorate, Solihull MBC).

BGS GeoIndex website shows that the majority of the Scheme (i.e. the south of Park Farm on the A452) lies within a sand and gravel Mineral Assessment Area, with SMBC listed as the Mineral Planning Authority for the majority of the Scheme and surrounds (WCC in the far north-east). One Mineral Planning Permissions (point) is recorded as an active site for common clay and shale south of the A45 between the M42 Junction 6 and Stonebridge Island to the east, and this relates to the aforementioned landfill/brickworks site.

3.3 Soil Chemistry

Historical studies report on the natural background concentrations for certain heavy metals as follows:

a) Arsenic (<15 mg/kg)
b) Cadmium (<1.8 mg/kg)
c) Chromium (20-90 mg/kg)
d) Lead (<150 mg/kg) and
e) Nickel (15-30 mg/kg).

No further information on this is presented as part of the Envirocheck Report (2017).

3.4 Hydrogeology

The superficial deposits (alluvium, river terrace and glaciofluvial) underlying the Scheme are classified by the Environment Agency as Secondary A aquifers.

The underlying bedrock including the Sidmouth Mudstone and Branscombe Mudstone Formations are classified as Secondary 'B' aquifers. The Arden Sandstone Formation bedrock is classed as a Secondary 'A' aquifer, with the exception of areas where it is recorded as mudstone only (such as the outcrop near to the southern part of the Scheme in between Catherine De Barnes and the M42), where it is classed as Secondary 'B'.

There are no groundwater source protection zones (SPZ) within 500m of the Scheme. The groundwater vulnerability zones around the area of the Scheme are mainly minor aquifers, with high vulnerability and minor aquifer with low vulnerability.

The borehole records from the historical ground investigations associated with the development of the M42 motorway provide groundwater level data in the area adjacent to the M42 J6. In summary, areas of shallow groundwater generally coincide with areas of granular made ground, granular alluvium and glaciofluvial deposits. In some cases multiple strikes are recorded within an exploratory hole, where water bearing granular stratum is confined by cohesive material of very low permeability.

According to the review of the historical ground investigation data, groundwater was generally encountered within 10m of the ground surface, with the bulk of groundwater strikes encountered between 1m and 8m of the ground surface. There are no obvious trends identified in groundwater levels with regards to locations within the study area considered as part of historical studies. However, it should be noted that the historical ground investigation data considered dates back to the 1970s and 1980s and so groundwater conditions may have since changed.

The Envirocheck Report (2017) indicates that there is one groundwater abstraction license located within the boundary of the Scheme, with a further 10 groundwater abstraction licenses located outside, but within the extended study area (i.e. 500m of the Scheme). A summary of the groundwater abstraction license details is provided in Table 3.2.

Table 3.2. Groundwater abstractions within the extended study area

License Holder	License Number	Type of Use	Location
Birmingham Corporation (Warren Farm)	03/28/11/0079	General Farming And Domestic	Present within the Scheme approximately 200m north of the M42 Junction 6 southbound off-slip road
[redacted]	03/28/11/0020	General Farming And Domestic	115m east of the Scheme and approximately 350m west of Chester Road
Melbick Nurseries Limited	03/28/11/0081	Horticulture And Nurseries: General Use (Medium Loss) – deep well	196m east of the Scheme, off Chester Road (A452)
Melbick Nurseries Limited	03/28/11/0081	Horticulture And Nurseries: General Use (Medium Loss) – shallow well	196m east of the Scheme, off Chester Road A452 (southbound)
Melbick Nurseries Limited	03/28/11/0081	Horticulture And Nurseries: General Use (Medium Loss) – shallow well	204m east of the Scheme, off Chester Road A452 (northbound)
[redacted]	03/28/11/0020	General Farming And Domestic	204m east of the Scheme, off Chester Road A452 (northbound)
[redacted]	03/28/11/0065	General Farming And Domestic	286m east of the Scheme, off the A446 westbound approach to the A446/A452 interchange
Wyevale Garden	Md/028/0011/006	Horticulture And Nurseries: Spray	310m east of the Scheme off the Chester

License Holder	License Number	Type of Use	Location
Centres G&L Limited		Irrigation - Direct	Road A452 (southbound)
The Garden & Leisure Group Limited	Md/028/0011/006	Horticulture And Nurseries: Spray Irrigation - Direct	310m east of the Scheme off Chester Road A452 (southbound)
Whale Tankers Ltd	03/28/11/0131	Other Industrial/Commercial/Public Services: Process Water	442m west of the southern extent of the Scheme where the M42 crosses Henwood Lane
[redacted]	03/28/12/0014	General Farming And Domestic	461m north-west of the northern extent of the Scheme. Approximately 200m west of the M42 Junction 7 off-slip road.

Two discharge consents are recorded (Envirocheck Report, 2017) within the Scheme, detailed as follows:

- Sewage Discharges (W05) - Final/Treated Effluent - Not Water Company (domestic/farm buildings) - Discharge to Soakaway/underlying strata – 12 March 1971. Situated adjacent to Shadowbrook Lane in the central-eastern area of the scheme, assumed to be related to the adjacent 'Heath Farm' (C01);
- Sewage Treatment Works (W07) - Final Effluent - Discharge to River Blythe - Issued: 12th May 1969. However, as this is noted as being situated at 'Warren Farm', a former farm not evident on plans after the early 1980s during the construction of the M42, it is assumed this discharge consent is now defunct.

A further discharge consent is recorded to be just outside of the study area but within 50m of the proposed alignment, with details as follows:

- Sewage Discharges (W41) - Pumping Station - Discharge to Holywell Brook Tributary - Issued: 11th January 1991. Situated adjacent to Bickenhill Lane on the periphery of Trinity Park, north of the A45.

3.5 Hydrology

Three main surface water bodies cross the Scheme, all flowing generally from west to east. These comprise:

a) Hollywell Brook (northern part of the Scheme, north of M42 Junction 6);

b) River Blythe (far southern part of the Scheme); and

c) Shadow Brook (central part of the scheme, north of the B4102 Solihull Road and south of M42 Junction 6).

Several minor drains and small unlabelled ponds are located within and around the Scheme. In addition, the Grand Union Canal, Low Brook, Pendigo Lake and Coleshill Pool are all within 250m of the Scheme in the south/south west, central area, north and far north, respectively.

Based on the Envirocheck Report (2017) no surface water abstractions are located within the Scheme. One surface water abstraction is within the Scheme study area and is located approximately 400m east of the Scheme, adjacent to Holywell Brook.

It relates to a license held by Packington Estate Enterprises Limited and listed as ‘Mineral Products: Make-Up Or Top Up Water’.

The River Blythe and Coleshill and Bannerly Pools (the most westerly of which, Coleshill Pool, is located adjacent east of the M42 in the far north of the Scheme) are both surface water receptors which are designated as SSSI. The extended study area is also located within a surface water Nitrate Vulnerable Zone, whilst much of the Scheme is within a Protected Drinking Water Surface Water Safeguard Zone.

According to the Envirocheck Report (2017), three pollution incidents are recorded within the Scheme. All were Category 3, minor incidents:

1. Grand Union Canal; Large Amount Of Rubbish Fridges etc. - 6th April 1999, Receptor: Grand Union Canal;
2. Amenity Affected; Septic Tank Overflowing To Brook - 19th July 1996, Receptor: River Blythe Catchment; and
3. 10 Litres Foam To Water; Foam type unknown; Cause of incident: Fire - 2nd December 1997, Receptor: Watercourse - River Blythe Catchment.

There are twelve (12) further pollution incidents recorded within the extended study area.

There are twenty-one (21) discharge consents recorded (Envirocheck Report, 2017) within the extended study area, four of which are within the Scheme. Seven of the discharge consents are granted to Severn Trent for sewage discharges, with the remaining granted mainly to domestic properties (including farm houses) and trade companies. The receiving waters for these discharge consents include tributaries of River Blythe, Eastcote, Low, Bannerly, Shadow, Ravenshaw and Hollywell Brooks.

The Substantiated Pollution Incident Register records within the Scheme a Water Impact Category 1 Major Incident caused by "Oils or Other Organic Products" according to the Envirocheck Report (2017). The incident occurred on 14th December 2003 and was also a Land Impact Category 3 - Minor Incident. The incident was recorded as being located on the M42 carriageway, north of Friday Lane and south of Solihull Road. No further Substantiated Pollution Incident Register records are located within the extended study area.

There are no Local Authority Pollution Prevention Control records present within the Scheme, the nearest being situated approximately 22 m from the scheme, relating to the crushing of material (aggregate processing). Seven (7) further Local Authority Pollution Prevention Control records are situated within the extended study area. One Integrated Pollution Prevention and Control record is present within the extended study area, situated approximately 141 m from the Scheme and relates to the disposal or recovery of hazardous waste with a capacity exceeding 10 tonnes per day involving biological treatment.

3.6 Sensitive Land Use

Bickenhill Meadows, which is represented by two distinct areas around the central part of the Scheme with the nearest area being adjacent west, is a SSSI and an ecological receptor. As previously stated, the River Blythe and Coleshill and Bannerly

Pools are also designated as SSSI, whilst the extended study area is also located within a surface water Nitrate Vulnerable Zone and much of the Scheme is within a Protected Drinking Water Surface Water Safeguard Zone.

3.7 Land Use, Regulated Activities and Potential Contaminative Sources

Data obtained from the available sources have been reviewed to identify current and historical potential contaminative land uses. A summary of the key areas of potentially contaminated land within the geology study area (split by those within the Scheme, and those within 250 m of the Scheme) is presented in Tables 3.3 and Table 3.4.

These tables exclude regulated landfills and other waste disposal features (evidence of non-regulated wastes disposal is included), as well as other regulated activities, which are presented separately. The tables also exclude railways and roads. These potential sources intercept the Scheme but as a result of their linear construction they span both the Scheme and the overall study area. Details of the key roads and railway land associated with the study area are therefore presented separately in Table 3.5.

Made Ground (anthropogenic material) associated with construction and development is also a potential source of contamination but as it is widespread it is not included within the tables below.

A figure showing the potential current and historical contaminative land uses is presented as Drawing 1. Each source has been designated a reference using the following convention:

- CXX – Current Land Use
- HXX – Historical Land Use
- LXX – Landfills and Other Waste Features
- WXX – Discharge Consents

Table 3.3 - Summary of Potential Sources of Contamination within the Scheme[1]

Land Use Type	Number	Potential Sources within the Scheme[2]	
		Date	Land Use
Airports	1	Current Land Use	Birmingham International Airport (C57)
Car Parks	6	Current Land Use	NEC/Airport Overspill car park (C18) NEC Eastern (C19) NEC SE 1 (C20) NEC Southern Carpark (C21) NEC Central (C22) NEC SE 2 (C29)
Depots	1	Current Land Use	DHL Stonebridge Trailer Park (Logistics Depot) (C02)
Electricity Substation	1	Current Land Use	Substation associated with The National Motorcycle

Land Use Type	Number	Potential Sources within the Scheme[2]	
		Date	Land Use
			Museum (C55)
	3	1886 to 2006 1886 to 1955 1888 to 1999	Cottage Farm (H19) Warren Farm (H20) Myrtle Cottage Farm (H25)
	3	Current Land Use	Hampton Lane Farm (C35) Church Farm (C41) Long Acre Farm (C58)
Industrial	1	1979 to 1991	A. Arnall Garage Services (H24)
Sewage Works	1	Current Land Use	Sewage Pumping Station (Clock Lane) (C45)
Fly Tipping	Two areas of fly-tipped material (C14, C15) were observed during a site walkover (undertaken on the 14 and 15 September 2017) in the wooded area adjacent to the M42 off the B4102 comprising used tyres and brick rubble.		

[1] Excluding roads/railways and landfills/waste, presented in tables 3.5 and 3.6 respectively.
[2] Where reference is made to dates, the feature has been identified from the Envirocheck Report (2017) historical land use maps, unless otherwise stated. Where no reference is made to dates, the feature has been identified from the Envirocheck Report (2017) datasheets and available current mapping, unless otherwise stated.

With regards to the pits and ponds it should be noted that there are various historical pits and ponds; (some of which have been infilled) which are present within the study area. However, there is not considered to be any potentially significant historical pits or ponds that may give rise to potential source of contamination within the Scheme.

Table 3.4 - Summary of Potential Sources of Contamination within 250 m of the Scheme[1]

Land use type	Number	Potential sources within 250m of the Scheme[2, 3]	
		Date	Land use
Brick Works	1	1904 to 1999	Old Arden Brickworks (H21)
Car Parks	9	Current Land Use	Airport/Train station car park (C16) Airport/Train station expanded car park (C17) NEC Centre South (C23) NEC SW (C24) NEC West - Genting Arena (C25) NEC NE 1 (C26) NEC NE 2 (C27) NEC North (C28) NEC E5 Car park (C46)
Depots	4	1980 to 1992 1980 to 1994 1993 to 1999 1993 to 1999	Unnamed ‘Depot’ (H16) Unnamed ‘Depot’ (H27) Unnamed ‘Depot’ (H29) Croggers Road Service Depot (H35)
Electricity Substation	4	Current Land Use	Unnamed Substations (C49, C50, C51, C54)
Farms	4	1955 to 1999 1888 to 1965 1888 to 1967 1962 to 1999	Oak Farm (H11) Hurdle Hall (H14) Common Farm Cottage (H30) Brackenlands Farm (H31)

Land use type	Number	Potential sources within 250m of the Scheme[2, 3]	
		Date	**Land use**
	10	Current Land Use	Heath Farm (C01) Home Farm (C05) Nursery Cottages (C06) Common Farm (C07) Walford Hall Farm (C36) Woodhouse Farm (C37) Grange Farm (C38) Glebe Farm (C40) Hazel Farm (C43) Yew Tree Farm (C44)
Petrol Filling Stations	1	1937 – 1999	Fina Petrol Station (H36)
	1	Current Land Use	Bickenhill Service Station (C30)
Industrial	12	Historical – Unknown	Sand, Gravel & Other Aggregates - Lafarge Aggregates (H01) Salvage Dealers - Motor Salvage (UK) Ltd (H02) Crane Hire, Sales & Service - Dewsbury & Proud (H03) Cement Manufacturers & Distributors – Tarmac (H04) Medical Equipment Manufacturers - Ferraris Group Plc (H05) Telecommunications Equipment & Systems - Detewe Ltd (H06) Freight Forwarders- Now Cargo Ltd (H07) Freight Forwarders- First Port Shipping (H08) Pottery Manufacturers & Suppliers – Denby (H09) Concrete & Mortar Ready Mixed - Lafarge Aggregates Ltd (H10) Incol Pressworks Ltd (H34) Anne's Pantry (H37)
	2	Current Land Use	Office Furniture & Equipment; Central Design Services (C03) Commercial Cleaning Services - J M Ellis Holdings Ltd (C04) Bath Resurfacing - Alscot Bathroom Company (C08) Floor Cleaning & Polishing Equipment - Manufacturers & Distributors – Koalaflor (C09) Cement Manufacturers & Distributors – Tarmac (C11) Crane Hire, Sales & Service - N M T Crane Hire (C12) Catering Equipment – Procook (C13) Chris Morgan-Cettler (C31) Furniture Manufacturers - Home & Office - Oaktree Frames (C32) Car Accessories Manufacturers - Trekkers Ltd (C33) Lingerie & Hosiery Manufacturers & Wholesalers - Scala Agenturen Ltd (C34) Warehouse (Fujitsu) - Part of Birmingham Business Park (C53)

Land use type	Number	Potential sources within 250m of the Scheme[2, 3]	
		Date	Land use
Nurseries (Horticulture)	1	1954 - 1996	Glasshouses, Church Lane (H23)
	2	Current Land Use	Braceys Nurseries and Garden Centre (C39) Melbicks Garden Centre (C59)
Ponds	2	Current Land Use	Pendigo Lake (man-made) (C47) Coleshill Pool (C52)
Quarries	1	Current Land Use	Current Mineral Extraction to north-east of scheme (C48)
Railway Stations	1	Current Land Use	Birmingham International Railway Station (C10)
Refuse Tips	1	Historical – Unknown	Un-named refuse tip in former Old Arden Brickworks (H26)
Sewage Works	2	1887 – 1982 1953 – 1980	Sewage Farm Solihull RDC (H12) Sewage Works for Meriden R.D.C. (H18)
	1	Current Land Use	STW Barton (C42)
Tanks	2	1980 – 1992 1904 – 1999	Tanks associated with Depot at same location (H17) Tanks associated with Old Arden Brickworks (H22)
Works	3	1904 – 1999 1954 – 1999 1961 – 1999 1937 – 1999	Unnamed Works Building (H13) Scaffolding Factory (H15) Unnamed Works Building (H28) Unnamed Works Building (H38)

[1] Excluding roads/railways and landfills/waste, presented in tables 3.5 and 3.6 respectively.
[2] Where reference is made to dates, the feature has been identified from the Envirocheck Report (2017) historical land use maps, unless otherwise stated. Where no reference is made to dates, the feature has been identified from the Envirocheck Report (2017) datasheets and available current mapping, unless otherwise stated.
[3] The area between the Scheme and within 250m of the Scheme.

Table 3.5 - Summary of Potential Sources of Contamination (Roads and Railways) within the Geology Study Area

Land Use	Description
Roads[1]	The M42 (which trends approximately north to south). Road network associated with the NEC and surrounds, east of Bickenhill noted from mid-late 1970s. The A45 trends approximately west to east.
Railways	The London and North Western Railway 1886 to present oriented north-west to south-east, east of Bickenhill (crosses the Scheme in between the Clock Lane Interchange and the M42 Junction 6). Currently known as Birmingham Loop (C56). The Midland Railway at the eastern extent of the Scheme close to the M42 Junction 6 from 1886 (H32). Dismantled by 1970. A mineral railway associated with the Old Arden Brickworks is present between 1954 and 1961 (H33).

[1] Roads not assigned reference and so are not polygonised on Drawing 1.

A summary of the landfills and other waste features identified from the Envirocheck Report (2017) to be within, and within 250m of, the Scheme is presented in Table 3.6. Waste types accepted were noted to be wide-ranging. These are considered to represent additional key potential areas of contamination.

Table 3.6 - Summary of landfills and other waste features within the geology study area

Land use type	Waste features within the Scheme		Waste features within 250m of the Scheme[1]	
	Number	Land use	Number	Land use
BGS Recorded Landfills	1	Church Farm (L28)	3	Walford Hall Farm (L27) Jacksons Brickworks (L29) Denbigh Spinney (L30)
Historic Landfills	4	Glebe Farm (L10) Castle Hills Farm (L11) Bickenhill Lane (L12) Site Corner Clock Lane (L15)	13	Jacksons Brickworks (L13, L16) Shadowbrook Lane (L14) Windbridge Nurseries (L17) Friday Lane (L31, L33, L34) Walford Hall Farm (L32) Opposite Church Farm (L35) Hargrave Farm (L36, L37) Rear of Jacksons Brickworks (L38) Brackenlands Farm (L39)
Licensed Waste Management Facilities	-	-	5	Sita - Jackson Brickworks (L43) Enterprise Managed Services Ltd - Household Waste Amenity Sites (L44) Eastcote Nurseries - Friday Lane Landfill Site (L42, L45, L46)
Local Authority Recorded Landfill	2	Mercon Construction (L18) Castlehill Farm (L19)	5	Friday Lane (L20, L21, L40) Shadow Brook Lane (L22) Jacksons Brickworks (L23)
Infilled Pond	-	-	2	Spinney Pool (L52) Coleshill Pool (L53)
Registered Landfill Sites	2	'Mercon Construction Ltd - Landfill' (L24) 'Sheridan Contractors – Landfill ' (L25)	6	B J O'Reilly & Sons Ltd (L26) Bulldog Demolition Ltd (L41) Eastcote Nurseries (Solihull) Ltd (L47) BM Fisher (L48) Licence Holder: West Midlands Excavation (L49) Rawlins Brothers (L50)
Other Pits/Quarries/ Tips/Waste	9	Tip - mainly builders waste (L03) Contractors unsuitable tip (L04) Agricultural waste dump (L05) Previous agricultural waste dump (L06) Pit infilled with waste (L07) Contractors unsuitable tip (L08) Infilled Ground - Pit partially backfilled with domestic refuse (L09) Old Marl Pit (L55) Backfilled Borrow Pit (L57)	4	Opencast - Arden Landfill (L01) Opencast - Middle Bickenhill Brick Works (L02) Refuse Tip, Church Farm (L51) Quarry mentioned in PSSR review at these coordinates. Due to detailed mapping not going back far enough AECOM is not able to corroborate this information in the historical review (L54)

Land use type	Waste features within the Scheme		Waste features within 250m of the Scheme[1]	
	Number	Land use	Number	Land use

[1] The area between the Scheme boundary and within 250m of the Scheme boundary

Those sources which are bisected by the proposed design alignment, and hence considered to present a higher risk based on excavation potential during construction, are summarised in Table 3.7.

Table 3.7 - Summary of Selected Key Sources Bisected by the Proposed Design Alignment

Site Reference	Historical Land Use	Current Land Use	Additional Information
L10, L18, L28, L24	1988 to 1989 Church Farm/ Glebe Farm Landfill	Vacant/Over-grown	Operated by Mercon Construction Small (equal to or greater than 10,000 and less than 25,000 tonnes per year) Authorised waste: clean hardcore, naturally occurring sands, gravels, clays, subsoil, topsoil SMBC[1] documents SL588 and 028, dated 6th July 1988 and 5th August 1991 respectively, detail licences to deposit waste. A handwritten note states 'possibly contaminated – ashes?'. Pertinent points of licence: – No materials other than topsoil, subsoil, and builders rubble to be deposited – 30 loads per day – The operator should protect the water course running along western boundary – The depth of any layer shall not exceed 1.5m after compaction
L11, L19	1977 to 1979 Castle Hills Farm Landfill	Open field, with small portion bisecting adjacent Gaelic Sports Facility	Operated by Bulldog Demolition Deposited waste included Inert Waste SMBC[1] documents SL42 and 023, dated 17/02/77 and 02/08/91 respectively, detail licences to deposit waste. A handwritten note states 'possibly contaminated – ashes?'. Pertinent points of licence: – Only builders rubble and excavated soil – 150 loads per day – Depth must not exceed 9 feet – No materials tipped within 5m of the perimeter of the site
H19	1887 – 2001 Cottage Farm	Field adjacent to existing A45	No further information – historical farm identified from mapping, potential for Made Ground
H20	1888 – 1965 Warren Farm	Field adjacent to existing M42	No further information – historical farm identified from mapping prior to construction of M42, potential for Made Ground
C14, C15	Undeveloped Land	Fly-tipped areas	Fly-tipped areas of tyres and demolition rubble identified during site survey
C18, C19, C20, C29,	Agricultural Land	Car Parks associated with the N.E.C.	No further information - potential for considerable Made Ground
L56	Made Ground	Varied	Made Ground (from PSSR Geo-hazard Plans)
L04, L08	Refuse Tips	Field adjacent to existing	'Contractors Unsuitable Tip' (from PSSR

Site Reference	Historical Land Use	Current Land Use	Additional Information
		M42	source data)
-[2]	Varied	Roads	M42, A45 and existing road network associated with the NEC and surrounds east of Bickenhill noted from mid-late 1970s.

[1] Documents obtained from Solihull Metropolitan Borough Council.
[2] No Reference.

3.8 Unexploded Ordnance (UXO)

An Unexploded Ordnance (UXO) Desk Study and Risk Assessment was undertaken by Zetica Ltd (September 2017). The boundary used in the Zetica report is a polygon which broadly incorporates the alignment route of the scheme considered as part of this assessment. Based on this boundary, no records have been found indicating that the scheme alignment was bombed and no other significant sources of UXO hazard have been identified. The UXO plans for the northern and southern parts of the scheme alignment area are classified as having a “low” UXO hazard level.

3.9 Additional desk study information

Additional baseline information was received after the preparation of the Preliminary Sources Study Addendum. Additional pertinent desk study information associated with this is presented as a separate technical note, referenced HE551485-ACM-SGT-ZZ_SW_ZZ_ZZ-TN-GE-0002 and summarised in Section 3 of the AECOM 2018 Ground Investigation Report.

4. Conceptual Site Model

4.1 Introduction

To assess the potential geo-environmental impacts associated with the Scheme, a risk assessment has been undertaken using the source-pathway-receptor approach, promoted by DEFRA and the Environment Agency. For there to be an identifiable risk, not only must there be contaminants present on, or near to, the Scheme (source) i.e. contaminated ground or groundwater, but also there must be a receptor and a pathway which allows the source to impact on the receptor. All three elements must be present to form a contaminant linkage before there can be a potential risk to specific receptors.

The term 'pollutant linkage' indicates that all three elements (i.e. a contaminant; a pathway; and, a receptor) have been identified. The term 'significant contaminant linkage' means a plausible contaminant linkage that gives rise to a level of risk sufficient to justify a site or a piece of land being determined as 'Contaminated Land' in accordance with the definition in Part 2A of the Environmental Protection Act 1991. This defines contaminated land as:-

'any land which appears to the local authority in whose area it is situated to be in such a condition by reason of substances in, on, or under the land, that:

> (a) significant harm is being caused or there is significant possibility of such harm being caused; or
>
> (b) significant pollution of controlled waters is being caused, or there is a significant possibility of such pollution being caused

Initially a qualitative assessment is undertaken as a screening exercise to identify plausible contaminant linkages, which potentially pose a risk to an identified receptor.

In order to identify whether the Scheme conditions could pose a risk to human health or to Controlled Waters, a CSM has been developed based on a review of the baseline conditions. The CSM identifies the main sources, pathways and receptors associated with the Scheme, enabling a qualitative Preliminary Risk Assessment (PRA) to be produced.

The CSM is then used as the basis for a quantitative risk assessment. This considers the level of risk associated with the potential presence of identified ground and/or groundwater contamination. This approach is consistent with Contaminated Land Report (CLR) 11 'Model Procedures for the Management of Land Contamination' (2004).

4.2 Sources

A figure showing the potential sources of contamination identified during the baseline review within the extended study area is presented as Drawing 1.

The rationale for screening the potential sources of contamination considered the inclusion of features typically:

- Within the Scheme alignment considered as part of this current assessment;
- Up to 50 m from the Scheme alignment for sources where ground gas potential is perceived to be low; and
- Up to 250 m from the Scheme alignment for notable potential ground gas generating sources.

More distal sources have also been included as they were considered to represent a relatively high risk.

The CSM may therefore need to be re-visited should there be any significant variations from this assumption (for example should there be any significant route alterations or if any construction compounds/activities are proposed to be substantially offset from the Scheme alignment). These features are summarised in Table 4.1 below.

In addition to the features identified in Table 4.1, the following wider/linear features are also considered to be potential sources of contamination:

- Anthropogenic Material: widespread and variable both within/around the Scheme, but notably near the NEC, on the boundary of the Scheme alignment (adjacent to Junction 6 of the M42); and
- Roads: including notably the M42 which trends approximately north to south and the A45 which trends approximately west to east.

A plan portraying the identified potential sources of contamination is presented as Drawing 2.

Table 4.1 – Potential Sources of Contamination

Reference (From Drawing 1)	Feature Classification	Record Type	Name and or Description	Approximate Distance from the Scheme Alignment (m)
C18	Current Land Use	Car Park	NEC/Airport overspill car park (Car Park 6)	0
C19	Current Land Use	Car Park	NEC Eastern	0
C20	Current Land Use	Car Park	NEC SE 1	0
C29	Current Land Use	Car Park	NEC SE 2	0
H20	Historical Land Use	Farm	Warren Farm	0
L04 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Contractors unsuitable tip	0 [B]
L10, L18, L24, L28	Potential Gassing Feature	Historic Landfill	Glebe Farm waste included Inert Waste	0 [B]
L11, L19	Potential Gassing Feature	Historic Landfill	Castle Hills Farm -deposited waste included Inert Waste	0 [B]
L08 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Contractors unsuitable tip	0 [B]
L57	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Backfilled borrow pit (from HS2 source data)	0 [B]
C41	Current Land Use	Farm	Church Farm	1
C15	Current Land Use	Fly Tipping	Fly-tipped material comprising used tyres	1
L15	Potential Gassing Feature	Historic Landfill	Site Corner Clock Lane	3 [B]
C21	Current Land Use	Car Park	NEC Southern car park	3
L08 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Contractors unsuitable tip	6 [B]

Reference (From Drawing 1)	Feature Classification	Record Type	Name and or Description	Approximate Distance from the Scheme Alignment (m)
C02	Current Land Use	Depot	DHL Stonebridge Trailer Park	6
H25	Historical Land Use	Farm	Myrtle Cottage Farm	6
L35	Potential Gassing Feature	Historic Landfill	Opposite Church Farm - deposited waste included Industrial, Commercial and Household Waste	6 [B]
H32	Historical Land Use	Railway	Disused Railway - Midland Railway	7
L09 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Infilled ground - pit partially backfilled with domestic refuse	7 [B]
W07	Discharge Consents	Discharge Consents	Sewage Treatment Works - final effluent - discharge to River Blythe Issued: 12th May 1969	8
C45	Current Land Use	Sewage Works	Sewage Pumping Station (Clock Lane)	9
H24	Historical Land Use	Garage	A.Arnall Garage Services	9
C14	Current Land Use	Fly Tipping	Fly-tipped material comprising used tyres and demolition rubble	12
L09 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Infilled ground - Pit partially backfilled with domestic refuse	12 [B]
L12, L25	Potential Gassing Feature	Historic Landfill	Bickenhill Lane - feposited waste included Inert Waste	14 [B]
C27	Current Land Use	Car Park	NEC NE 2	15
C28	Current Land Use	Car Park	NEC North	15
C40	Current Land Use	Farm	Glebe Farm	20

Reference (From Drawing 1)	Feature Classification	Record Type	Name and or Description	Approximate Distance from the Scheme Alignment (m)
C16	Current Land Use	Car Park	Airport/Train Station car park	22
C57	Current Land Use	Airport	Birmingham International Airport	22
C58	Current Land Use	Farm	Longacre Farm	23
C35	Current Land Use	Farm	Hampton Lane Farm	26
C39	Current Land Use	Nursery (Horticulture)	Braceys Nurseries and Garden Centre	27
L17, L49	Potential Gassing Feature	Historic Landfill	Windbridge Nurseries - deposited waste included Inert Waste	30 [B]
W41	Discharge Consents	Discharge Consents	Sewage Discharges - Pumping Station - discharge to Holywell Brook Tributary - Issued: 11th January 1991	30
H19	Historical Land Use	Farm	Cottage Farm	37
L51	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Refuse Tip, Church Farm	46 [B]
H29	Historical Land Use	Depot	Depot	47
C30	Current Land Use	Fuel Filling Station	Esso Fuel Filling Station	47
C56	Current Land Use	Railway	London and North Western Railway / Birmingham Loop	48
L44	Potential Gassing Feature	Licensed Waste Management Facilities (Location)	Enterprise Managed Services Ltd - Household Waste Amenity Sites	53 [B]
L04 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Contractors unsuitable tip	73 [B]
L54	Potential Gassing Feature	Quarry	Quarry	76 [B]

Reference (From Drawing 1)	Feature Classification	Record Type	Name and or Description	Approximate Distance from the Scheme Alignment (m)
H18	Historical Land Use	Sewage Works	Sewage Works for Meriden R.D.C.	77 [C]
C42	Current Land Use	Sewage Works	STW Barston - Birmingham Tame and Rea Drainage Board	78 [C]
C48	Current Land Use	Quarry	Current mineral extraction	89 [C]
L05 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Agricultural waste dump	94 [B]
L41	Potential Gassing Feature	Registered Landfill Sites	Bulldog Demolition Ltd: excavated natural materials , hardcore and rubble	96 [B]
L06 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Previous agricultural waste dump	100 [B]
L02	Potential Gassing Feature	Quarry	Mercia Mudstone Group, common clay and shale - opencast - Middle Bickenhill Brick Works	103 [B]
L05 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Agricultural waste dump	108 [B]
L27, L32	Potential Gassing Feature	BGS Recorded Landfill	Walford Hall Farm - BGS Recorded Landfill - ,	117 [B]
L06 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Previous agricultural waste dump	119 [B]
L55	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Old marl pit	134 [B]
L01, L13, L16, L23, L43	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Mercia Mudstone Group; common clay and shale - opencast - Arden Landfill	178 [B]
L29, L38	Potential Gassing Feature	BGS Recorded Landfill	Jacksons Brickworks - BGS Recorded Landfill Site	199 [B]

Reference (From Drawing 1)	Feature Classification	Record Type	Name and or Description	Approximate Distance from the Scheme Alignment (m)
L07 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Pit infilled with waste	212 [B]
L07 [A]	Potential Gassing Feature	Other Pits/Quarries/ Tips/Waste	Pit infilled with waste	223 [B]
L36, L37	Potential Gassing Feature	Historic Landfill	Hargrave Farm - deposited waste included Inert Waste	224 [B]
L14	Potential Gassing Feature	Historic Landfill	Shadowbrook Lane - deposited waste included Inert Waste	233 [B]

[A] In some cases the co-ordinates presented in the PSSR for the features L03 to L09 (inclusive) did not always align with the associated polygons on Drawing 1. The polygons are considered more likely to represent the accurate feature footprint, however for completeness and to provide a clear reference back to the PSSR source data, the features for L03 to L09 (inclusive) have been plotted based on both the polygons and coordinates provided in the PSSR. Hence, there are two references for each record.

[B] Notable potential ground gas generating sources.

[C] Although outside of 50m from alignment, added based significance of potential source.

4.3 Pathways

The human health exposure pathways that have been considered based on the proposed road scheme and landscaping end use are listed below:

- Dermal contact with soil, dust and groundwater;
- Ingestion of soil, dust and groundwater;
- Inhalation of dust;
- Inhalation of vapours (from soils and groundwater) in confined spaces; and
- Inhalation of ground-gas in confined spaces.

The potential controlled waters pathways considered are as follows:

- Vertical and lateral migration of leachate through the unsaturated soils to groundwater;
- Vertical and lateral groundwater migration; and
- Surface water run-off.

4.4 Receptors

The principal receptors which could be affected by either contamination on-site or off-site which is created or affected by construction and/or operation of the Scheme comprise:

- Human health: construction and maintenance workers, offsite receptors and future road/site users;
- Controlled Waters: groundwater, surface water features and water abstractions;
- Construction materials: existing and new concrete and structures associated with the highway;
- Sensitive sites (including ecological receptors and soil/geological resource receptors);
- Surrounding land uses: agricultural land; and
- Property.

High sensitivity human receptors comprise nearby residents, workers in, and visitors to, commercial properties, and members of the public accessing areas of open space and any adjacent community facilities. Construction workers also represent additional high sensitivity human receptors during the construction phase only. Road users by their very nature are transient and are therefore considered to represent a lower risk, although laybys may provide areas for longer stay visits to the site.

The primary (i.e. most sensitive) surface water receptors that have been identified include the moderately sensitive Hollywell Brook and the Shadow Brook as these both bisect separate areas of the Scheme alignment. Other surface water receptors include minor drains and small unlabelled ponds, the River Blythe, the Grand Union Canal, Low Brook, Pendigo Lake and Coleshill Pool, all located within 1 km of the Scheme. It should be noted that both the Holywell Brook and the Shadow Brook are

tributaries of the River Blythe, which itself is a tributary of the River Tame. The Envirocheck records the River Blythe to be of 'River Quality B'.

One surface water abstraction has been identified within 1km of the site, 400m east of the Scheme adjacent to Holywell Brook. It relates to a license held by Packington Estate Enterprises Limited and listed as 'Mineral Products: Make-Up Or Top Up Water'. The extended study area is also located within a surface water Nitrate Vulnerable Zone, whilst much of the Scheme is within a Protected Drinking Water Surface Water Safeguard Zone.

Groundwater receptors include the Secondary 'A' aquifers associated with both the superficial deposits and the Secondary A and Secondary B aquifers associated with the bedrock geology. There are ten groundwater abstractions recorded within 500 m of the scheme. The nearest permit relates to an abstraction associated with the historical 'Warren Farm' (H20). As this is a former farm (not evident on plans after the early 1980s during the construction of the M42), it is assumed the abstraction is now defunct. The closest active abstraction is considered to be a well situated at 'Common Farm', located approximately 280 m from the Scheme alignment for 'General Farming and Domestic' uses, and is assumed to be abstracting from the underlying Secondary 'A' Aquifer in the glaciofluvial deposits. There are no potable groundwater abstractions or groundwater SPZs within 500 m of the Scheme.

Although Secondary 'A' Aquifers are present in the study area within the glaciofluvial and alluvial deposits, and occasional bands of the Arden Sandstone within the Mercia Mudstone Group, it is considered that the units of these stratum are not substantial within the area of the Scheme, with limited lateral extent and limted thickness. Although there is a 'general farming and domestic' groundwater abstraction situated approximately 280 m to the north of the proposed alignment, the controlled waters in the Secondary 'A' Aquifer of the glaciofluvial deposits in the north of the site are considered to be of low sensitivity given the historic land-use in the area of landfilling/industry and also the nature of the abstraction.

Several areas of ecological sensitivity have been identified within 1km of the Scheme, including the River Blythe, Bickenhill Meadow, Coleshill Pool and Bannerly Pool, all designated as SSSI's considered to be of moderate sensitivity to contamination.

Property receptors comprise residential and commercial properties, agricultural crops, livestock and infrastructure such as below ground utilities, considered to be low sensitivity receptors.

Plans showing the potential receptors to contamination with the extent of the Scheme are presented as Drawings 3 and 4.

4.5 Additional Information

No significant additional sources, pathways or receptors over and above those recorded as part of the baseline desk study information were identified during the 2018 ground investigation. An updated geo-hazards constraints plan presenting the most significant baseline information, as well as constraints identified during the

ground investigation such as any additional areas of made ground, is presented as part of the GIR.

4.6 Preliminary Risk Assessment

4.6.1 Risk Assessment Principles

Current good practice recommends that the determination of hazards due to contaminated land is based on the principle of risk assessment, as outlined in the Environment Agency guidance on Model Procedures for the Management of Land Contamination.

For a risk to be present, there must be a viable pollutant linkage; i.e. a mechanism whereby a source impacts on a sensitive receptor via a pathway. The potential pollutant linkages that have been identified for this site are presented below.

Assessments of risks associated with each of these pollutant linkages are discussed in the following sections.

Using criteria broadly based on those presented in EA, Chartered Institute of Environmental Health (CIEH) and National House Building Council (NHBC) R&D Publication 66 'Guidance for the Safe Development of Housing on Land Affected by Contamination' (2008), the magnitude of the risk associated with potential contamination at the site has been assessed. To do this an estimate is made of:

- the magnitude of the potential consequence (i.e. severity);
- the magnitude of probability (i.e. likelihood).

4.6.2 Severity of Risk

The severity of risk is classified according to the criteria in Table 4.2.

Table 4.2 – Severity of Risk

Severity	Definition and Examples
Severe	Highly elevated concentrations that are likely to result in "significant harm" to human health as defined by the EPA 1990, Part 2A, if exposure occurs. Equivalent to EA Category 1 pollution incident including persistent and/or extensive effects on water quality; leading to closure of a potable abstraction point; major impact on amenity value or major damage to agriculture or commerce, e.g. highly elevated concentrations of contaminants in groundwater close to a sensitive abstraction. Major damage to aquatic or other ecosystems, which is likely to result in a substantial adverse change in its functioning or harm to a species of special interest that endangers the long-term maintenance of the population, e.g. major fish kill from large spillage on site. Catastrophic damage to crops, buildings or property, e.g. explosion to buildings.
Medium	Elevated concentrations which could result in "significant harm" to human health as defined by the EPA 1990, Part 2A if exposure occurs. Equivalent to EA Category 2 pollution incident including significant effect on water quality; notification required to abstractors; reduction in amenity value or significant damage to agriculture or commerce. Significant damage to aquatic or other ecosystems, which may result in a substantial adverse change in its functioning or harm to a species of special interest that may endanger the long-term maintenance of the population. Significant damage to crops, buildings or property e.g. damage to foundations rendering it unsafe or ingress of contaminants through plastic, potable water pipes.

Severity	Definition and Examples
Mild	Exposure to human health unlikely to lead to "significant harm". Exposure could lead to slight short-term effects e.g. mild skin rash. Equivalent to EA Category 3 pollution incident including minimal or short lived effect on water quality; marginal effect on amenity value, agriculture or commerce. Minor or short lived damage to aquatic or other ecosystems, which is unlikely to result in a substantial adverse change in its functioning or harm to a species of special interest that would endanger the long-term maintenance of the population. Minor damage to crops, buildings or property e.g. spalling concrete.
Minor	No measurable effect on humans. Equivalent to insubstantial pollution incident with no observed effect on water quality or ecosystems. Repairable effects of damage to buildings, structures and services, e.g. loss of plants in a landscaping scheme

Adapted from EA, Chartered Institute of Environmental Health (CIEH) and National House Building Council (NHBC) R&D Publication 66 'Guidance for the Safe Development of Housing on Land Affected by Contamination' (2008), Annex 4

4.6.3 Likelihood of risk occurrence

The probability of the risk occurring is classified according to the criteria in Table 4.3.

Table 4.2 – Likelihood of risk occurrence

Likelihood	Explanation
High	Pollutant linkage may be present that appears very likely in the short-term and risk is almost certain to occur in the long term, or there is evidence of harm to the receptor.
Likely	Pollutant linkage may be present, and it is probable that the risk will occur over the long term.
Low	Pollutant linkage may be present and there is a possibility of the risk occurring, although there is no certainty that it will do so.
Unlikely	Pollutant linkage may be present but the circumstances under which harm would occur even in the long-term are improbable.

Adapted from EA, Chartered Institute of Environmental Health (CIEH) and National House Building Council (NHBC) R&D Publication 66 'Guidance for the Safe Development of Housing on Land Affected by Contamination' (2008), Annex 4

4.6.4 Risk based on comparison of likelihood and severity

An overall evaluation of the level of risk is gained from a comparison of the severity and probability, as shown in Table 4.4.

Table 4.4 – Risk based on comparison of likelihood and severity

		Severity			
		High	**Medium**	**Mild**	**Minor**
Probability	**High**	Very High	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low	Moderate	Moderate/Low	Low	Very Low
	Unlikely	Moderate/Low	Low	Very Low	Very Low

Adapted from EA, Chartered Institute of Environmental Health (CIEH) and National House Building Council (NHBC) R&D Publication 66 'Guidance for the Safe Development of Housing on Land Affected by Contamination' (2008), Annex 4

4.6.5 Preliminary Risk Evaluation

In accordance with the risk assessment principles outlined above, a preliminary evaluation of the potential risks associated with the identified sources at the site to the various potential receptors is discussed and presented in this section below. The level of risk is determined based on the current condition of the site (i.e. the effects of mitigation measures are not included). Mitigation is then proposed based on the significance of the risk. In some cases a degree of mitigation is assumed as part of legislative requirements or standard construction practice. This is acknowledged where these assumptions are made.

Receptor	Contaminant Linkage	Severity	Likelihood	Risk
Human Health; *Future Site Users*	*Direct contact/ingestion of contaminants within Made Ground/soils, together with soil derived dust and groundwater*	*Mild*	*Low*	Low
	Inhalation of organic vapours from Made Ground/soils, soil derived dust, and groundwater	*Mild*	*Unlikely*	Very Low
	Ground Gas inhalation, Explosion Risk	*Mild*	*Unlikely*	Very Low
Human Health; *Construction / maintenance / ground workers*	*Direct contact / ingestion of contaminants within Made Ground / soils, together with soil derived dust and groundwater*	*Mild*	*Unlikely*	Very Low [A]
	Inhalation of organic vapours from Made Ground / soils, soil derived dust, and groundwater	*Mild*	*Unlikely*	Very Low [A]
	Ground Gas inhalation	*Mild*	*Unlikely*	Very Low [A]
Human Health; *Current and future offsite residents and visitors*	*Inhalation of organic vapours from Made Ground / soils, and groundwater generated from the site*	*Mild*	*Unlikely*	Very Low
	Inhalation of wind-blown contaminated soil derived dusts generated from the site	*Mild*	*Unlikely*	Very Low
Controlled Waters; *Groundwater in Secondary 'A' and 'B' Aquifers*	*Impact to groundwater within alluvium, glaciofluvial deposits, Mercia Mudstone Group and Arden Sandstone from contaminated soil/leachate in Made Ground/soils*	*Medium*	*Unlikely*	Low
Controlled Waters: *Surface Waters (Holywell Brook, Shadow Brook)*	*Impact to surface water from migration of contaminated groundwater*	*Medium*	*Low*	Moderate/low
Future Development Infrastructure	*Aggressive attack through direct contact with natural ground or contaminants within Made Ground / soils, leachate and groundwater*	*Mild*	*Low*	Low

Receptor	Contaminant Linkage	Severity	Likelihood	Risk
	Ground gas accumulation and potential explosion risk	*Mild*	*Unlikely*	Very Low
Ecological Receptors *(River Blythe, Bickenhill Meadow, Coleshill Pool and Bannerly Pool SSSI's)*	*Impact to SSSI from migration of contaminated surface water and groundwater*	*Mild*	*Unlikely*	Very Low

[A] Whilst the risk has been assessed as 'very low', this assumes the preparation of a construction management and health and safety plan including the use of PPE in accordance with statutory health and safety requirements.

5. Laboratory Testing and Monitoring

5.1 Soils

In order to assess the significance of the soils associated with the potential sources of contamination identified, a total of 129 soil samples were submitted for chemical testing. These were recovered from 105 exploratory locations between 14th February and 21st June 2018. Soil samples were submitted for UKAS and MCERTS accredited (where applicable) environmental laboratory analysis Concept Life Sciences (CLS) laboratories for a number of chemicals of potential concern (CoPC). These CoPC were identified based on the current/historical land use identified associated with the area of the Scheme and are listed in Table 5.1. Soil samples were obtained from a range of depths and geological material types, extending from between surface level and 10.30 metres below ground level (m bgl).

Table 5.1 – Soil and soil leachate chemical testing suite and analysis

Suite of CoPC	Number of Samples Tested	
	Made Ground	Natural Stratum
Soil Suite (E) (Metals/metalloids; cyanides; sulphates; nitrates; sulphurs and sulphides; pH; soil organic matter (SOM); speciated and total polycyclic aromatic hydrocarbons (PAHs);	45	63
Soil Suite (F) (Benzene, toluene, ethylbenzene and xylene (BTEX); and Total Petroleum Hydrocarbons (TPH) criteria working ground (CWG banding)	18	8
Soil Suite (I) (Asbestos screen plus asbestos quantification if asbestos fibres identified from screen)	20	-

Suite of CoPC	Number of Samples Tested	
	Made Ground	Natural Stratum
Leachate Suite (J) (BS EN 12457, 2:1 ratio) (Metals/metalloids; cyanides; pH; ammonia; ammoniacal nitrogen; sulphate; nitrate and nitrite; speciated and total PAHs; hardness and total organic carbon (TOC)	19	13
Leachate Suite (Waste Acceptance Criteria (WAC)) (BS EN 12457, 2:1 ratio) (Metals/metalloids; cyanides; pH; ammonia; ammoniacal nitrogen; sulphate; nitrate and nitrite; phenols; hardness and dissolved organic carbon (DOC)	2	2
Leachate Suite (Additional) (BS EN 12457, 2:1 ratio) (TPH (speciated) CWG aliphatic/aromatic split, BTEX)	1	-

The results of the laboratory testing of soil and soil leachate samples identified concentrations of CoPC above respective method detection limits and the significance of these are discussed in Sections 6.2 and 6.3.

5.2 Groundwater and Ground Gas

In order to assess the potential for groundwater to have been impacted upon from the potential sources of contamination and any associated impacted soils, and the potential for there to be a ground gas generation potential at selected key locations, a total of eight monitoring visits have been undertaken to date. All of the visits comprised groundwater level gauging, with two of the visits including ground gas monitoring and one of the visits including groundwater sampling. The visits were undertaken between February and July 2018, and details of activities undertaken at each visit are summarised in Table 5.2:

Table 5.2 – Groundwater and ground gas monitoring and groundwater sampling summary

Visit	Number of Boreholes		
	Groundwater Level Gauging	Gas Monitoring	Groundwater Sampling
Round 1 (February)	9	0	0
Round 2 (March)	24	0	0
Round 3 (March)	26	0	0
Round 4 (April)	29	12	0
Round 5 (May)	34	13	4
Round 6 (June)	12	0	0

Visit	Number of Boreholes		
	Groundwater Level Gauging	Gas Monitoring	Groundwater Sampling
Round 7 (July)	59	0	0
Round 8 (July)	7	0	0

Groundwater was encountered in fifty-one of the sixty-one boreholes that were gauged, and recorded at depths of between 0.47 m bgl and 11.67 m bgl.

During the monitoring visit in May 2018, six standpipes were targeted for groundwater sampling with the samples retrieved submitted for laboratory testing. Groundwater (when encountered) was purged, sampled and tested, with six samples successfully obtained (although only four results were included as part of the factual report). A full summary of the groundwater level monitoring data is presented in Section 6.3.1. The groundwater samples were submitted to CLS laboratories for environmental laboratory analysis (UKAS and MCERTS accredited laboratory testing (where applicable)) for a suite of CoPC, that were considered relevant to the historical and current land uses identified in relation to the area of the Scheme. These are listed in Table 5.3.

Table 5.3 – Groundwater chemical testing suite and analysis

Suite of CoPC	Number of Samples Tested
Groundwater suite (K) (Metals/metalloids; cyanides; pH; ammonia; ammoniacal nitrogen; sulphate; nitrate and nitrite; speciated and total PAHs; TOC; hardness; total phenols)	4
Groundwater suite (L) (TPH CWG banding; BTEX)	4
Groundwater suite (M) (Volatile and Semi Volatile Organic Compounds (VOC and SVOC))	4

The results of the laboratory testing of groundwater samples identified concentrations of CoPC above respective method detection limits and the significance of these are discussed in Section 6.3. The results of the ground gas monitoring are discussed in Section 6.4.

Ground gas monitoring was also undertaken during the monitoring visits; a summary and assessment of the ground gas monitoring data is also presented in Section 6.4.

6. Generic Quantitative Risk Assessment

6.1 Methodology

The ground investigation undertaken by SOCOTEC, on behalf of Interserve Construction Ltd and for Highways England, is detailed in report referenced Report No E8005-18 and dated August 2018. This report provides preliminary information on ground conditions and includes details on the soil and groundwater samples obtained and scheduled for chemical analysis. The findings of the ground investigation and chemical analysis completed, have been used as the basis for a Generic Qualitative Risk Assessment (GQRA), which aims to quantify the potential significance of any risks identified associated with the CSM and provides information to refine the CSM.

The CSM identifies potential source-pathway-receptor pollutant linkages that, consistent with the staged approach advocated by CLR11[1], require further assessment.

An assessment of the potential significance of CoPC concentrations detected in soil, soil leachate and groundwater during the ground investigation has been undertaken against Generic Assessment Criteria (GAC) that are intended to be protective of human health and controlled waters receptors.

The GAC provide a conservative means of initial assessment and provide the basis for screening out CoPC that do not warrant further consideration or action (i.e. the level of risk associated with the CoPC is minimal/negligible and not of concern).

Risks to human health have been primarily been assessed in accordance with the Contaminated Land Exposure Assessment CLEA methodology[2].

Risks to controlled waters have been assessed using a tiered approach based on that described in the EA's Remedial Targets Methodology (RTM)[3].

The results of the laboratory analyses are presented in Tables 1, 2 and 3, appended to this note.

6.2 Human Health

6.2.1 Assumptions and Criteria Used

Soil GAC have been published for numerous contaminants by both regulatory and industry recognised bodies. Where GAC have not been published, AECOM has derived its own GAC values using industry recommended and accepted methods.

GAC have been derived for several land use scenarios including residential with plant uptake (with private gardens), residential without plant uptake (no private gardens), commercial/industrial, allotments, public open space (parks) and public open space

[1] Environment Agency, (2004). CLR11: Model Procedures for the Management of Land Contamination.

[2] Environment Agency (2009) Updated technical background to the CLEA model, Science Report, SC050021/SR3

[3] Environment Agency, (2006). Remedial Targets Methodology. Hydrogeological Risk Assessment for Land Contamination.

(residential). GAC have been selected that are appropriate for a commercial/industrial end use. The selection of these criteria is considered to be conservative given the proposed development is a road scheme and given the potential exposure pathways to human receptors during both construction and operation of the Scheme.

It is acknowledged that the exposure assumptions for the adopted human health GAC under a commercial/industrial use are not fully representative of the exposure scenario for a highway scheme. The former assumes the critical receptor to be a female worker, working daily at the site aged 16 to 65.Users of the Scheme will be unlikely to regularly come into contact with contaminated soil and/or soil-derived dust or vapour on the assumption that the facility will be hard-surfaced and their use of the Scheme transient. There will also not be any enclosed structures. Therefore, the commercial/industrial human health GAC used in this assessment are viewed to be a conservative first screen. It is noted that the commercial/industrial human health GAC are not based on any aesthetic consideration of soil quality, nor suitability for plant health (re: any proposed landscaping), nor suitability for subsurface utilities.

The following hierarchy has been adopted in selecting the appropriate GAC to use for the CoPC to screen as part of this assessment:

- LQM/CIEH Suitable 4 Use Levels (2014). Commercial. Inorganic.
- LQM/CIEH Suitable 4 Use Levels (2014). Commercial. 1% SOM.
- EIC/AGS/CL:AIRE GAC. Commercial/Industrial, Sandy Loam, 1% SOM
- AECOM GAC, modified EIC. Commercial/Industrial, Sandy Loam, 1% SOM
- Defra (2014) SP1010: Development of Category 4 Screening Levels for Assessment of Land Contamination -Policy Companion Document, December 2014. Commercial. 1% SOM.
- US Environmental Protection Agency, Regional Screening Levels, Nov 2017. Industrial (no vapours)

Human health GAC include the following assumptions:

- CoPC are present in the top 1 m of ground and there is a viable pathway to the surface;
- Tested soil during the ground investigation has a mean soil organic matter (SOM) content of 1.90% based on laboratory analysis of 108 samples. Using the conversion factor of 0.58, an average total organic carbon (TOC) content of 1.10%, has been calculated; as such, the GAC relating to TOC >0.58% to <1.45% have been used; and
- Soils are deemed to be most representative of a ‘sandy loam’.

6.2.1.1 Comparison of Human Health GAC against Soil Results

Screening of laboratory soil testing data indicates that all of the individual CoPC tested were reported at a concentration below their respective human health GAC, with the exception of chromium (III+VI), the total of trivalent (III) and hexavalent (VI) chromium.

As a published GAC for total chromium (III+VI) is not available, the GAC for hexavalent chromium (VI) of 33mg/kg has been used as a conservative assessment, compared with the GAC for trivalent chromium (III) of 8600mg/kg. However, given that all samples tested recorded hexavalent chromium below the 1 mg/kg detection limit, it is considered appropriate to screen the total chromium data against the GAC for trivalent chromium of 8600mg/kg; when doing this all samples pass the GAC.

20 soil samples (all Made Ground) were submitted for an asbestos screen. Asbestos, reported by the laboratory as chrysotile asbestos ,was detected in one sample of Made Ground recovered at 1.0 m bgl in trial pit TP701-17. Quantification analysis on this sample is currently underway in order to assess the risk posed. It should be noted that TP701-17 was undertaken in the location of potentially infilled land, identified as a 'Contractors unsuitable tip' from the PSSR data. Low/sporadic levels of asbestos in Made Ground is reasonably common when crushed demolition rubble is a constituent of the Made Ground, given the history of asbestos use in building construction in the UK.

6.2.1.2 Comparison of Human Health GAC against Soil Results

Screening of laboratory soil testing data indicates that all of the individual CoPC tested were reported at a concentration below their respective human health GAC, with the exception of chromium (III+VI), the total of trivalent (III) and hexavalent (VI) chromium.

As a published GAC for total chromium (III+VI) is not available, the GAC for hexavalent chromium (VI) of 33mg/kg has been used as a conservative assessment, compared with the GAC for trivalent chromium (III) of 8600mg/kg. However, given that all samples tested recorded hexavalent chromium below the 1 mg/kg detection limit, it is considered appropriate to screen the total chromium data against the GAC for trivalent chromium of 8600mg/kg; when doing this all samples pass the GAC.

20 soil samples (all Made Ground) were submitted for an asbestos screen. Asbestos, reported by the laboratory as chrysotile asbestos ,was detected in one sample of Made Ground recovered at 1.0 m bgl in trial pit TP701-17. Quantification analysis on this sample is currently underway in order to assess the risk posed. It should be noted that TP701-17 was undertaken in the location of potentially infilled land, identified as a 'Contractors unsuitable tip' from the PSSR data. Low/sporadic levels of asbestos in Made Ground is reasonably common when crushed demolition rubble is a constituent of the Made Ground, given the history of asbestos use in building construction in the UK.

6.3 Controlled Waters

6.3.1 Assumptions and Criteria Used

Soil leachate data and groundwater data have been screened against Controlled Waters GAC that are designed to be protective of surface water within the local surface water network, and protective of groundwater resources within the underlying aquifer. Controlled Waters GAC were derived based on the following:

- The surface water courses of the Hollywell Brook and the Shadow Brook both bisect the alignment of the Scheme. COPC originating from the Scheme area could enter these water bodies and pose a risk to the surface water network in the area. It should be noted that both water courses flow in an easterly direction and are tributaries of the River Blythe, itself a tributary of the River Tame.

- Although Secondary 'A' Aquifers are present in the area in the form of glaciofluvial and alluvial deposits, and occasional bands of the Arden Sandstone within the Mercia Mudstone Group, there are no groundwater SPZs within 500 m of the Scheme. There are also no sensitive potable groundwater abstractions are recorded within 500 m of the Scheme, whilst. An abstraction for 'general farming and domestic' use is situated 280 m north of the proposed alignment, assumed to be within the Secondary 'A' Aquifer of the glaciofluvial deposits. However, the overall sensitivity of the aquifer in the area of the scheme is deemed to be low given the historical land use and widespread landfilling and also the nature of the abstraction. Furthermore, given that the majority of the site area is underlain by bedrock of the Mercia Mudstone, a designated Secondary 'B' Aquifer, the sensitivity of the groundwater associated with the Scheme is deemed to be relatively low overall. Given the proximity of the surface water courses and sensitivity of the groundwater bodies within the Scheme Area, the Secondary Aquifers are considered to be more important as potential pathways to the above surface water bodies than as receptors.
- Controlled Waters GAC selected for soils and groundwater are primarily Environmental Quality Standards (EQS) for protection of the surface water, and England & Wales Drinking Water Standards (DWS) for aquifer protection. However, these are not published for certain determinands, and so in the absence of an EQS or DWS, reference has been made to the following in order of preference:

  <u>EQS (freshwater) Criteria:</u>

  - The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 – Annual Average (AA)-Environmental Quality Standard (EQS) Inland;
  - The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 – Maximum Acceptable Concentration (MAC)-EQS Inland;
  - The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015 – Freshwater Standards;
  - The Water Environment (River Basin Management Planning etc.) (Miscellaneous Amendments) (Scotland) Regulations 2015. Scottish SI 2015 No. 211. AA-EQS Inland;
  - The Water Environment (River Basin Management Planning etc.) (Miscellaneous Amendments) (Scotland) Regulations 2015. Scottish SI 2015 No. 211. MAC-EQS Inland;

- Scottish Environmental Protection Agency (SEPA) - Supporting Guidance (WAT-SG-53) Environmental Quality Standards for Discharges to Surface Waters. v6. Dec 2015. Fresh EQS – AA;
- Scottish Environmental Protection Agency - Supporting Guidance (WAT-SG-53) Environmental Quality Standards for Discharges to Surface Waters. v6. Dec 2015. Fresh EQS – MAC;
- The Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015. AA-EQS Inland;
- The Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015. MAC-EQS Inland;
- The Water Framework Directive (Classification, Priority Substances and Shellfish Waters) Regulations (Northern Ireland) 2015 - Freshwater Standards;
- European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2015. S.I. No. 386 of 2015. Ireland - AA-EQS Inland;
- European Union Environmental Objectives (Surface Waters) (Amendment) Regulations 2015. S.I. No. 386 of 2015. Ireland - MAC-EQS Inland; and
- Predicted No Effect Concentration (PNEC) derived for EU REACH registration dossiers – Freshwater.

DWS Criteria:

- Water, England & Wales - Water Supply (Water Quality) Regulations, 2016 No. 614;
- Guidelines for Drinking-water Quality (4th Edition inc. the First Addendum). World Health Organisation. 2017;
- World Health Organisation (WHO), Petroleum Products in Drinking-water. Background document for development of WHO Guidelines for Drinking-water Quality WHO/SDE/WSH/05.08/123, 2008;
- Drinking Water Guidelines Calculated using WHO Methodology;
- US Environmental Protection Agency, Risk Screening Levels, May 2016. Tap water; and
- Draft health protective concentration from California Environmental Protection Agency (1999) Ethanol in Gasoline.

- At this stage, the Holywell Brook and the Shadow Brook have been assessed as the key potential Controlled Waters receptors, and both soil leachate and groundwater data have been screened against EQS.
- Although groundwater is being considered as a potential pathway, these water bodies are Secondary Aquifers. Data have also been screened against DWS to provide a benchmark against which the current status/quality of the

groundwater beneath the area of the Scheme can be compared against, rather than to assess its quality for potential potable use.

6.3.1.1 Comparison of Controlled Waters GAC against Soil Leachate Analysis Results

Following the screening of laboratory soil leachate testing data against EQS and DWS GAC, the tables below (Tables 6.1 to 6.4) presents those CoPC concentrations found in Made Ground and natural soil samples that exceed their respective GAC.

Table 6.1 – Made Ground soil leachate concentrations exceeding EQS

Determinand	GAC Value (EQS) (µg/l)	Concentration (µg/l)	Location	Depth (m bgl)
Metal / Metalloids				
Lead	1.2	3.2 1.6	BH808-17 BH920-17	2.60 0.60
Mercury	0.07	0.08	BH924-17	3.50
Nickel	4	6	BH810-17	1.80
Cadmium	0.08	0.13 0.25 0.10	BH924-17 TP700-17 TP701-17	3.50 0.70 3.00
Copper	1	15 exceedances Minimum - 1.2 Maximum - 17	Various (Max TP700-17, BH804-17)	0.25 – 4.20
Zinc	10.9	13 37	BH808-17 TP700-17	2.60 0.70
PAHs				
Benzo(a)pyrene	0.00017	8 exceedances Minimum - 0.2 Maximum - 1100	Various (Max - BH220-17)	0.25 – 4.20
Naphthalene	2	22 10 12	BH219-17 BH220-17 BH802-17	4.20 4.20 0.45
Anthracene	0.1	7 exceedances Minimum - 0.18 Maximum - 660	Various (Max - BH220-17)	0.25 – 4.20
Benzo(g,h,i)perylene	0.0082	8 exceedances Minimum - 0.02 Maximum - 490	Various (Max - BH220-17)	0.25 – 4.20
Fluoranthene	0.0063	14 exceedances Minimum - 0.01 Maximum – 2700	Various (Max - BH220-17)	0.25 – 7.50

Determinand	GAC Value (EQS) (µg/l)	Concentration (µg/l)	Location	Depth (m bgl)
Inorganics				
Sulphate	400	650 1600	BH810-17 BH924-17	1.80 3.50
Fluoride	1	1.6	TP700-17	0.70

Table 6.2 – Natural soil leachate concentrations exceeding EQS

Determinand	GAC Value (EQS) (µg/l)	Concentration (µg/l)	Location	Depth (m bgl)
Metal / Metalloids				
Copper	1	10 exceedances Minimum - 1.3 Maximum - 21	Various (Max BH804-17)	0.30 – 6.40
Zinc	10.9	17 24	BH413-17 BH813-17	1.2 2.80
Chromium (Trivalent)	4.7	43	BH211-17	0.30
PAHs				
Benzo(a)pyrene	0.00017	2.3 0.01 0.06	BH211-17 BH813-17 BH901-17	0.30 2.80 0.50
Naphthalene	2	24	BH211-17	0.30
Anthracene	0.1	1.1	BH211-17	0.30
Benzo(g,h,i)perylene	0.0082	1.4 0.01 0.01 0.05	BH211-17 BH616B-17 BH813-17 BH901-17	0.30 2.40 2.80 0.50
Fluoranthene	0.0063	9 exceedances Minimum - 0.01 Maximum – 4.6	Various (Max - BH211-17)	0.50 – 7.50

Table 6.3 – Made Ground soil leachate concentrations exceeding DWS

CoPC	GAC Value (DWS) (µg/l)	Concentration (µg/l)	Location	Depth (m bgl)
Metal / Metalloids				
Iron	200	860	BH802-17	0.45

CoPC	GAC Value (DWS) (µg/l)	Concentration (µg/l)	Location	Depth (m bgl)
		380	BH813-17	0.90
		560	BH920-17	0.60
Arsenic	10	15	BH808-17	2.60
		29	BH923-17	0.60
PAHs				
Benzo(a)pyrene	0.001	7 exceedances Minimum – 0.2 Maximum - 1100	Various (Max - BH220-17)	0.25 – 4.50
Dibenzo(a,h)anthracene	0.07	6 exceedances Minimum - 0.1 Maximum - 150	Various (Max - BH220-17)	0.30 – 4.20
Benzo(a)anthracene	3.5	270	BH219-17	4.20
		1400	BH220-17	4.20
Acenaphthene	18	170	BH219-17	4.20
		960	BH220-17	4.20
Phenanthrene	4	590	BH219-17	4.20
		880	BH220-17	4.20
Fluorene	12	190	BH219-17	4.20
		770	BH220-17	4.20
Pyrene	9	460	BH219-17	4.20
		1200	BH220-17	4.20
Acenaphthylene	18	240	BH220-17	4.20
Chrysene	7	190	BH219-17	4.20
		960	BH220-17	4.20
PAHs (sum of 4)[1]	0.1	7 exceedances Minimum - 0.3 Maximum - 1070	Various (Max - BH220-17)	0.25 – 4.50
Inorganics				
Sulphate	250	650	BH810-17	1.80
		1600	BH924-17	3.50
Fluoride	0.8	1.6	TP700-17	0.70

1. Applies to sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene and indeno(123-cd)pyrene

Table 6.4 – Natural soil leachate concentrations exceeding DWS

CoPC	GAC Value (DWS) (µg/l)	Concentration (µg/l)	Location	Depth (m bgl)

CoPC	GAC Value (DWS) (µg/l)	Concentration (µg/l)	Location	Depth (m bgl)
Metal / Metalloids				
Iron	200	650	BH813-17	2.80
		300	BH921-17	1.50
		320	BH922-17	4.80
Arsenic	10	17	BH924-17	7.50
		39	TP701-17	3.00
PAHs				
Benzo(a)pyrene	0.001	2.3	BH211-17	0.30
		0.06	BH901-17	0.50
Dibenzo(a,h)anthracene	0.07	0.3	BH211-17	0.30
PAHs (sum of 4)[1]	0.1	2.7	BH211-17	0.30
		0.11	BH901-17	0.50

1. Applies to sum of benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(ghi)perylene and indeno(123-cd)pyrene

6.3.1.2 Comparison of Controlled Water GAC against Groundwater Analysis Results

Following the screening of groundwater testing data against EQS and DWS Controlled Waters GAC, the tables below (Tables 6.5 to 6.6) present those CoPC concentrations exceeding their respective GAC.

Table 6.5 – Groundwater concentrations exceeding EQS

Determinand	GAC Value (EQS) (µg/l)	Concentration (µg/l)	Location
Metal / Metalloids			
Copper	1	2.4	BH229-17
		3.0	BH806-17
		1.9	BH605-17
PAHs			
Fluoranthene	0.0063	0.01	BH806-17

Table 6.6 – Groundwater concentrations exceeding DWS

Determinand	GAC Value (DWS) (µg/l)	Concentration (µg/l)	Location
Inorganics			
Nitrate (as NO3-)	50	71	BH605-17

6.3.1.3 Risk Evaluation

Risk to Surface Water

Soil leachate concentrations of selected metals/metalloids, other inorganics PAHs exceeding respective EQS GAC have been recorded in Made Ground and natural deposits across the investigated area. In summary:

- concentrations of metals/ metalloids in soil leachate are the same order of magnitude as EQS, with the exception of copper and chromium (trivalent) which have been recorded up to an order of magnitude above the EQS; and
- concentrations of anthracene, benzo(a)pyrene, benzo(g,h,i)perylene, and fluoranthene have been recorded several orders of magnitude above the EQS, with concentrations of naphthalene recorded one order of magnitude above the EQS.
- concentrations of sulphate have been recorded up to an order of magnitude above the EQS, whilst a marginal exceedance of fluoride has been recorded.

Groundwater concentrations of selected metals/metalloids and PAHs exceeding respective EQS GAC have been recorded. In summary:

- concentrations of copper in groundwater are the same order of magnitude as EQS; and
- concentrations of fluoranthene have been recorded an order of magnitude above the EQS in one sample.

The maximum detected metal concentrations in the soils tested, which are leachable at concentrations greater than the EQS (lead, mercury, nickel, cadmium, copper, zinc and chromium (trivalent)) are also recorded at higher levels compared to literature background topsoil values for the surrounding area (as shown in the table below). However, average metal concentrations in the soils tested are broadly comparable to the background values from the literature.

Table 6.7 - Observed metal / metalloid soil concentrations which exceeded soils leachate EQS versus background soil concentrations

Metal / Metalloid	Minimum Observed	Maximum Observed	Average Observed	Background [A]	Background [B]
Cadmium	<1	3	0.59	0.278	<1.8
Copper	3	430	47	17.1 – 37.3	-
Chromium	3	430	28	36.0 – 46.1	20 - 90
Lead	3	490	30	13.6 – 43.9	<150
Nickel	4	150	24	8.66 – 15.7	15 - 30
Mercury [C]	<1	2	0.51	-	-
Zinc	9	720	93	57.0 – 76.0	-

[A] *Background topsoil concentrations were obtained from United Kingdom Soils Observatory http://www.ukso.org/mapViewer.html, accessed on 21 August 2018.*

[B] *Natural background soil concentrations collated from historical studies outlined in the Envirocheck report (2017).*

[C] *Background topsoil concentrations for Mercury not available.*

Note: all concentrations are given in mg/kg.

Based on the information from the GQRA and the current CSM, a potential pathway exists for CoPC from the soils associated with the Scheme to migrate to the identified surface water receptors of the Holywell Brook and the Shadow Brook.

Leachable concentrations of metals, PAHs and other inorganics have been detected in numerous samples. The five metals that recorded exceeded leachate concentrations above the GAC have all been recorded in soil up to an order of magnitude above the natural background concentrations. However, average metal concentrations in the soils tested are broadly comparable to the published background values. Furthermore, the average observed metal concentrations in Made Ground samples tested from across the scheme are broadly comparable to the average observed metal concentrations within the natural deposits tested. This suggests that detected metal concentrations, at least in part, are representative of background levels.

Exceedances of five PAH determinands have been recorded at least one order of magnitude higher than the EQS with highly elevated leachable concentrations recorded in two samples obtained from 4.20m bgl in two adjacent boreholes BH219-17 and BH220-17, both advanced adjacent to Solihull Road into the embankment taking the carriageway over the existing M42. Furthermore, concentrations of sulphate have been recorded up to an order of magnitude above the EQS, whilst a marginal exceedance of fluoride has been recorded.

The only exceedances of EQS GAC recorded in groundwater were for copper and fluoranthene. This suggests that CoPC leaching and migration from soils to surface waters is not as great as the laboratory leaching test results imply. However, as only four groundwater samples have been tested to date, from a single monitoring event, the dataset does not provide sufficient coverage to assess seasonal variations CoPC concentrations. Collection of data over successive monitoring events would allow a better assessment of the risk of CoPC migrating to surface water in the area in sufficient concentrations to present a risk to the surface water network. Therefore, further groundwater monitoring and sampling followed by further assessment of detected CoPC concentrations is recommended.

Although further groundwater data will be required to provide an robust risk assessment, as a preliminary assessment it is considered that there is potential for the identified leachable concentrations of PAH's to migrate to the identified surface water receptors, however, the risk for this is deemed to be low at this stage due to the proximity of soils with elevated levels of CoPC to surface waters and limited evidence of CoPC reaching groundwater. Specifically:

- From the analyses undertaken in the boreholes advanced nearby Holywell Brook (BH810-17, BH811-17, BH813-17, BH814-17, BH816-17, BH901-17, BH902-17, BH922-17, BH923-17, BH924-17, TP700-17, TP701-17), leachable concentrations of metals, PAHs and inorganics exceeding the EQS have been recorded within variable granular and cohesive Made Ground, glaciofluvial deposits and alluvial deposits. However, given that metals have been assessed as being within background levels, and none of the identified PAH exceedances

are more than one order of magnitude higher than that of the EQS, the risk to controlled surface waters in Holywell brook is considered to be low.

- From the analyses undertaken in the boreholes advanced nearby Shadow Brook, (BH219-17, BH220-17, BH400-17), leachable concentrations of PAHs and inorganics exceeding the EQS have been recorded within variable granular and cohesive Made Ground, and in the cohesive glaciofluvial and mudstone deposits. None of the exceedances recorded in BH400-17 were more than an order of magnitude above the EQS, however, highly elevated leachable concentrations of PAHs have been identified in BH219-17 and BH220-17 at a depth of 4.20m bgl, over four orders of magnitudes higher than the EQS in the case of the concentration of benzo(g,h,i)perylene recorded in BH220-17 (490µg/kg compared to an EQS of 0.0082µg/kg). The PAH-17 total for the two leachate samples were recorded to be 3,500µg/kg and 15,000µg/kg in BH219-17 and BH220-17 respectively, indicating elevated concentrations of PAHs within the material in at this depth in this area. Furthermore, the material recorded from 4.00m to 4.70m in BH219-17 was noted to exhibit a 'strong odour'. Both BH219-17 and BH220-17 were advanced through an engineered embankment built in order to carry the B4102 Solihull Road over the existing M42. These exceedances are considered to be localised to the Made Ground materials at the base of the engineered embankment above the natural Mercia Mudstone deposits, recorded at a depth of between 5.20m and 5.30m bgl in the two boreholes. Given the cohesive nature of the deposits beneath the recorded exceedances, the fact there was no groundwater strike in either borehole to a maximum penetrated depth of 30.50m, and that these boreholes are situated approximately 280m from Shadow Brook, the potential for PAHs to mobilise into the groundwater and migrate laterally into the controlled surface water course is considered to be very low. This assessment, however, will need to be checked by obtaining groundwater samples from standpipes installed into the ground in the area between these exceedances, the alignment, and the identified surface water receptor, namely BH233-17 and BH234-17.

Furthermore, the risks are considered to be low, given that:

- the Scheme traverses an area of former landfills, mineral extraction and other former and current industrial uses which may already have impacted upon the quality of the groundwater and the surface water receptors;
- The additional covering of the surface in hardstanding as part of the Scheme will reduce the infiltration pathway reducing the potential for soils above the groundwater level to leach in to groundwater below, thus limiting the migration pathway.

Although the risks to surface waters have been initially identified to be low, it is considered that further groundwater monitoring and sampling would provide a more robust assessment of the risk posed to surface waters, notably Shadow Brook and Holywell Brook.

Risk to Groundwater

Soil leachate concentrations of iron and arsenic have been recorded to exceed the respective DWS GAC, with all of the recorded exceeded concentrations of both iron and arsenic being the same order of magnitude as the DWS GAC.

The metal concentrations identified in soils which are leachable at concentrations greater than the DWS (only arsenic; the presence of iron in soils was not analysed) are generally similar to background topsoil values for the surrounding area with a small number of outliers marginally above the background value (as shown in Table 5.8 below). As the leachable concentrations are within the same order of magnitude as the DWS GAC and were not identified within groundwater at concentrations which exceeded the DWS GAC, the risk from the metals within the soils associated with the Scheme to the groundwater below is considered to be low.

Table 6.8 - Observed metal / metalloid soil concentrations which exceeded soils leachate DWS versus background soil concentrations

Metal / Metalloid	Minimum Observed	Maximum Observed	Average Observed	Background*
Arsenic	<2	36	5.8	6.09 – 8.76

** Background topsoil concentrations were obtained from United Kingdom Soils Observatory http://www.ukso.org/mapViewer.html, accessed on 3rd September 2018.*

Note: all concentrations are given in mg/kg.

Soil leachate concentrations of numerous PAH determinands have been recorded to exceed the respective DWS GAC, with several of the exceedances recorded at a number of orders of magnitude above the DWS, primarily within the Made Ground samples tested from BH219-17 and BH220-17. Five further Made Ground samples (from boreholes BH400-17, BH406-17, BH802-17, BH804-17 and BH813-17) have recorded exceedances of PAHs, with benzo(a)pyrene recorded up to several orders of magnitude above the DWS in all five samples.

Two samples from natural deposits (from boreholes BH211-17 and BH901-17) recorded leachate PAH concentrations above the DWS. However, the concentrations recorded within BH211-17 were recorded within a sample taken from 0.30 m bgl, 0.05 m below the surface hardstanding; as such, this is considered to be a potentially anomalous result influenced by debris from Made Ground above. The exceedances recorded within the sample from BH901-17 are marginal, with both benzo(a)pyrene and PAHs (sum of 4) recorded within the same order of magnitude as the DWS. Furthermore, this sample was also obtained from the top of the natural deposits directly underneath a layer of Made Ground, possibly influencing the concentrations recorded.

Screening of the four groundwater samples against the respective DWS GAC indicated only one exceedance for nitrate, recorded at a concentration of 71 mg/kg compared to the DWS of 50 mg/kg. None of the DWS for the TPH, BTEX, PAH, metal or other inorganic/organic determinands detected were exceeded in the four tested samples.

Given the results of the soil leachate testing undertaken, the potential for CoPC to migrate in sufficient concentrations to impact groundwater in the Secondary 'A' Aquifer in the glaciofluvial deposits is considered to be low. The two closest soil leachate results to the groundwater abstraction at Common Farm are from BH920-

17, and BH921-17, situated 490m and 590m away respectively. The only exceedances of DWS were from samples from these wells were for iron, within both the Made Ground and natural deposits, both within a magnitude of the GAC. Furthermore, given that the ground levels in the area fall down to the level of Holywell Brook, from 98.62 mAOD (metres above ordnance datum) at the position of BH811-17 to 88.17 mAOD at the position of BH814-17, the anticipated direction of groundwater flow would carry potential mobile contaminants in the opposite direction, away from the position of the identified abstraction.

However, only four groundwater samples from across the Scheme area have been tested during the ground investigation to date, with the sample retrieved from BH806-17 adjacent to the existing J6 M42/A45 roundabout the closest to the abstraction at Common Farm, approximately 1.40km to the south. Given the granular nature of the glaciofluvial deposits in the northern part of the scheme, and the presence of a groundwater abstraction assumed to be from this unit approximately 280 m north of the proposed alignment, this preliminary assessment should be revisited after further groundwater monitoring and sampling has been undertaken, particularly from standpipes installed in the glaciofluvial deposits within the northern part of the scheme, north of Holywell Brook. This would allow assessment of risks to this receptor. Additionally repeat monitoring events will allow seasonal variations in CoPC in groundwater to be assessed.

At this stage, it should also be noted that the DWS GAC values assume a potential potable use and are therefore conservative given the lack of use of the aquifer for potable water supply. The additional covering of the surface in hardstanding as part of the Scheme will also reduce the infiltration pathway reducing the potential for soils above the groundwater level to leach into the groundwater below.

6.4 Additional Data from 2018 HS2 Investigation

Further to the ground contamination assessment undertaken, the results of the soil, soil leachate and surface water analysis associated with the additional 2018 HS2 ground investigation data summarised in the additional geo-environmental baseline information technical note (ref. HE551485-ACM-SGT-ZZ_SW_ZZ_ZZ-TN-GE-0002) have been compared to the adopted GAC discussed earlier in this technical note.

It should be noted that the information from HS2 was obtained by AECOM in July 2018, after the ground investigation for the M42 scheme had been completed.

6.4.1 Area A

Screening of laboratory soil testing data indicates that all of the individual CoPC tested were reported at a concentration below their respective human health GAC. One of the four samples recorded a positive detection of chrysotile asbestos fibres, however, subsequent quantification analysis of the sample revealed <0.001% of the total mass was determined to be asbestos fibres.

Copper was recorded above the EQS in two of the five soil leachate analyses, albeit only minor exceedances within the same order of magnitude as the GAC. No other metals were recorded above the EQS GAC.

All three surface water samples recorded copper concentrations above the EQS, although only marginal exceedances above the EQS. No other metals were recorded above the EQS GAC. Three PAH determinands (benzo(a)pyrene, benzo(g,h,i)perylene and fluoranthene) were recorded above the GAC in two of the three tested samples (ML156-SW007 and ML156-SW009), each a number of order of magnitudes above the EQS. ML 156-SW008 recorded one exceedance of the EQS for fluoranthene, two orders of magnitude above the EQS. None of the concentrations of TPH, VOC or SVOC were recorded above the laboratory limit of detection. It should be noted that SW007 and SW008 were obtained from the western and eastern side of Pendigo Lake respectively, whilst SW009 was obtained from Holywell Brook approximately 140m before it flows beneath the carriageway of the M42 motorway.

6.4.2 Area B

Screening of laboratory soil testing data indicates that all of the individual CoPC tested were reported at a concentration below their respective human health GAC. Furthermore, none of the three samples screened for asbestos recorded a positive detection for asbestos fibres.

Copper and lead were recorded above the EQS in both of the soil leachate analyses undertaken, although again only minor exceedances within the same order of magnitude as the GAC. No other metals were recorded above the EQS GAC.

Both surface water samples recorded copper, chromium (III) and zinc concentrations above the EQS, although only marginal exceedances above the EQS within one order of magnitude. Iron was recorded an order of magnitude above the EQS in ML156-SW006, with no other metals were recorded above the EQS GAC. Four separate PAH determinands (anthracene, benzo(a)pyrene, benzo(g,h,i)perylene and fluoranthene) were recorded above the GAC in the sample referenced ML156-SW006, all a number of magnitudes above the EQS. Minor concentrations of TPH were recorded in the same sample, with no detections above the laboratory limit recorded in ML156-SW005. None of the concentrations of VOC or SVOC were recorded above the laboratory limit of detection in either sample.

It should be noted that ML 156-SW005 and ML 156-SW006 were obtained from Holywell Brook approximately 350m and 250m to the west of the M42 respectively, after the brook has flowed under the carriageway.

6.4.3 Summary

The assessment of the 2018 HS2 data does not present any significantly different outcomes to those identified as part of AECOM's 2018 ground investigation contamination assessment and as such no additional recommendations over and above those already stated are considered applicable.

Given that comparable concentrations of PAHs exceeding the EQS have been recorded both upstream and downstream of the M42 crossing the Holywell Brook, it is considered that this further reinforces that the concentrations recorded are representative of background concentrations within the soil and groundwater in the area of the Scheme.

6.5 Assessment of Additional Data from 2012/2013 A45 Bridge Widening Investigation

Further to the ground contamination assessment undertaken for the above scheme, the recorded concentrations of leachable determinands were deemed to be low and only slightly exceeded the applied water quality standards. It was therefore considered that there was a low potential risk to controlled waters.

The findings of this assessment are further reviewed in the aforementioned additional desk study information technical note.

7. Assessment of Ground Gases

The potential for ground gases migrating from the underlying Made Ground and adjacent areas of landfill is considered unlikely to pose a risk to end users of the Scheme due to there being no plausible pathway for these gases to accumulate within confined spaces given the absence of any structures or confined spaces. However, further hazards associated with ground gas relate to risk to construction workers during the construction phase and maintenance workers during the operational phase e.g. where entry into excavations, manholes and service ducts is required. The assessment presented here focuses on occupational exposure risks only.

Table 7.1 below shows a summary of the ground gas data from the two monitoring rounds undertaken to date at the time of writing. The first round of monitoring was undertaken between 24th April and 26th April 2018, with the second undertaken between 11th May and 17th May 2018. Twelve boreholes were monitored on the first round, with the same twelve monitored on the second round as well as BH415-17, bringing the total to 13. An 18-month ground gas monitoring programme is yet to commence, during which monitoring of the all 37 ground gas monitoring standpipes installed as part of the investigation will be undertaken.

Table 7.1 – Ground gas monitoring data

Location	Dates	Gas flow Rate (l/hr)		Methane (% v/v)		Carbon dioxide (% v/v)		Oxygen (% v/v)		Peak CO (ppm)	Peak H2S (ppm)
		Start	End	Peak	Steady	Peak	Steady	Low	Steady		
BH207-17	24/04/2018	0.0	0.0	ND	ND	ND	ND	21.5	21.5	1.8	ND
	11/05/2018	-0.1	-0.1	ND	ND	1.7	1.7	17.5	17.5	ND	ND
BH211-17	24/04/2018	0.0	0.0	ND	ND	2.9	2.9	13.7	13.7	ND	ND
	14/05/2018	0.0	0.0	ND	ND	0.4	0.4	19.4	19.4	1.4	ND
BH229-17	24/04/2018	0.0	0.0	ND	ND	ND	ND	21.7	21.7	ND	ND
	14/05/2018	0.0	0.0	ND	ND	1.1	1.1	21.3	21.3	1.1	ND
BH230-17	24/04/2018	0.0	0.0	ND	ND	ND	ND	21.7	21.7	2.7	ND

Location	Dates	Gas flow Rate (l/hr)		Methane (% v/v)		Carbon dioxide (% v/v)		Oxygen (% v/v)		Peak CO (ppm)	Peak H2S (ppm)
		Start	End	Peak	Steady	Peak	Steady	Low	Steady		
	14/05/2018	0.0	0.0	ND	ND	1.0	1.0	20.4	20.4	3.4	ND
BH231-17	26/04/2018	0.0	0.0	ND	ND	0.8	0.8	21.1	21.1	ND	ND
	14/05/2018	0.1	0.1	ND	ND	1.1	1.1	20.8	20.8	ND	ND
BH232-17	24/04/2018	0.0	0.0	ND	ND	ND	ND	21.7	21.7	ND	ND
	14/05/2018	0.0	0.0	ND	ND	3.8	3.8	3.0	3.0	ND	ND
BH400-17	24/04/2018	0.0	0.0	ND	ND	ND	ND	21.6	21.6	ND	ND
	14/05/2018	0.0	0.0	ND	ND	0.1	0.1	21.1	21.1	ND	ND
BH401-17	24/04/2018	0.0	0.0	ND	ND	0.2	0.1	20.8	21.2	ND	ND
	14/05/2018	0.0	0.0	ND	ND	1.3	0.4	18.0	20.0	ND	ND
BH408-17	24/04/2018	0.0	0.0	ND	ND	ND	ND	21.8	21.8	ND	ND
	15/05/2018	0.0	0.0	ND	ND	1.4	1.4	19.3	19.3	6.0	ND
BH415-17	14/05/2018	0.0	0.0	ND	ND	0.5	0.5	14.6	14.6	ND	ND
BH605-17	24/04/2018	0.0	0.0	ND	ND	1.0	0.4	15.9	18.1	ND	ND
	15/05/2018	0.1	0.0	ND	ND	ND	ND	21.4	21.7	ND	ND
BH806-17	26/04/2018	0.2	0.2	ND	ND	2.6	2.2	10.1	11.5	ND	ND
	16/05/2018	0.0	0.0	ND	ND	3.5	3.5	5.1	5.1	ND	ND
BH810-17	26/04/2018	0.0	0.0	ND	ND	17.0	16.0	1.7	1.7	ND	ND
	17/05/2018	0.0	0.0	ND	ND	18.0	18.0	ND	ND	ND	ND

1. ND – Not Detected

Methane

The greatest hazards posed by methane are those of fire and explosion. The limits of flammability, i.e. the Lower Explosion Limit (LEL) and Upper Explosion Limit (UEL), are 5% v/v and 15% v/v respectively. Where methane concentrations are encountered between these two ranges there is the possibility of ignition/explosion. However, it is important to note that where methane is outside of this range, i.e. above, safety shouldn't be assumed as further dilution can occur bringing it back to within explosive limits.

Where monitored, none of the installations had concentrations of methane within the 5% to 15% v/v range. Maximum methane (% v/v) concentrations within each of the wells were recorded below the detection limit of the monitoring equipment on all occasions.

For methane, the threshold for toxicity by asphyxiation is considered to be 30% (v/v) (8 hour long term Occupational Exposure Limit (OEL). The results show that the concentrations of methane (% v/v) recorded, do not exceed this limit.

Ventilation in confined spaces is required at concentrations greater than 0.25% (v/v). This should be monitored on site during construction activities. Where entry into excavations is unavoidable the activity should comply with confined space legislation.

Oxygen

Table 7.2 below summarises the physiological effects of an oxygen deficient atmosphere (CIRIA Report 149)

Table 7.2 – Physiological effects of an oxygen deficient atmosphere

Oxygen % (vol./vol.)	Physiological Effects
19 - 21	Normal range of concentration in the atmospheric air
17	Faster deeper breathing, slight impairment of judgment
10 - 16	Initial signs of anoxia leading to emotional upsets, abnormal fatigue upon exertion
6 - 10	Nausea, vomiting, unconsciousness; collapse may occur
<6	Convulsions, gasping respiration, death

Oxygen concentrations have been recorded below normal range in all exploratory holes except BH229-17, BH230-17, BH231-17, BH400-17and BH408-17, which may (if exposed) result in faster deeper breathing and slight impairment of judgement. Oxygen concentrations have been recorded within the 10 to 16% v/v range in the standpipes installed in BH211-17 and BH415-17, which may (if exposed) result in initial signs of anoxia leading to emotional upsets and abnormal fatigue upon exertion. Concentrations of under 6% have been recorded in three of the exploratory holes (BH232-17, BH806-17, BH810-17), whereby the exposure could result in convulsions, gasping respiration or death. Where entry into excavations is unavoidable the activity should comply with confined space legislation.

Carbon Dioxide

For carbon dioxide there is no risk of flammability, however, there is a risk of asphyxiation and as such there are toxicity limits of 0.5% (v/v) for an 8 hour long term Occupational Exposure Limit (OEL) and 1.5% (v/v) for a 10 minute Occupational Exposure Limit (OEL).

Most of the installations monitored recorded peak (and steady) carbon dioxide concentrations which exceeded the 0.5% v/v limit, with numerous also exceeding the 1.5% v/v limit on at least one of the two monitoring visits undertaken. Peak concentrations of carbon dioxide ranged from 0.1% v/v (BH400-17) to 18.0% (BH810-17), with steady state concentrations ranging from the same values, with the minimum steady state of 0.1% v/v recorded in BH401-17 as well as BH400-17. .

A potential risk of asphyxiation would exist if concentrations exceeding the toxicity limits were identified within confined spaces. It is recommended that confined space legislation be adhered to where entry into excavations by site workers is unavoidable.

Hydrogen Sulphide

Peak hydrogen sulphide concentrations were recorded at concentrations below the detection limit of the monitoring equipment on all occasions monitored.

Carbon Monoxide

Peak carbon monoxide concentrations were detected above the detection limit of the monitoring equipment on six occasions in BH207-17, BH211-17, BH229-17, BH230-17 and BH408-17, with concentrations ranging from 1.1 ppm in BH229-17 to 6.0 ppm in BH408-17). It is recommended that the potential for carbon monoxide to be present is assessed as part of any construction health and safety phase plan.

8 HazWaste Assessment

A preliminary waste classification has been undertaken on the soils sampled during the ground investigation. This assessment is indicative only, and only relevant in the event that the soils are excavated with a view to being disposed of off-site as waste during construction. For a material to be waste there must be an intention to discard such materials. If the material under consideration is not intended to be discarded as waste, then the following assessment does not apply; instead risk-based criteria for re-use as part of the development should be adopted and consideration given to adopting a materials management plan and the Definition of Waste: Development Industry Code of Practice or it may be necessary to consider an exemption or permitting approach.

The samples have been classified in accordance with Technical Guidance WM3 (Version 1.1), published by the Environment Agency in May 2018. This should be considered an indicative assessment also because the classification of soils destined for disposal should be based on representative sampling of the soils specifically identified for disposal.

The following steps have been undertaken to classify the soils sampled:

- Setting of an initial European Waste Catalogue (EWC) code (transposed into UK legislation as the List of Wastes Regulations). This is based on our current understanding of the soils present at the site that may require disposal;
- Review of the chemical composition of the soils based on the Conceptual Site Model developed for the site, and the laboratory analysis completed on samples recovered from ground investigation;
- Comparison of reported concentrations of dangerous substances in the waste against threshold levels for hazardous and non-hazardous waste classifications; and
- Proposal of final classification.

The waste classification was carried out using HazWasteOnline™, which is a licensed online software package that provides an accurate and auditable tool for the classification of waste materials such as contaminated soils, filter cakes, sludge residues and wastes from organic processes. The software follows the WM3 guidance and European regulations and lets the user focus on what is in the waste that is driving the classification. This can help in designing treatment and disposal strategies.

European Waste Catalogue Code (List of Wastes Regulations)

Soils potentially requiring excavation and that may be considered for off-site disposal are considered to align with ‘Construction and Demolition Wastes (Including Excavated Soil from Contaminated Sites)’ which has waste code 17.

From this code, the sub-code 17 05 04 (soil and stones other than those mentioned in 17 05 03) and its hazardous mirror entry 17 05 03 (soil and stones containing

dangerous substances) are selected as the most appropriate waste categories for further classification.

Determination of Waste Classification

HazWasteOnline™ uses the solid waste analysis from sample testing to classify materials as '*Hazardous*' or '*Non Hazardous*' (in accordance with Environment Agency WM3 Technical Guidance). The tool also sometimes refers to a '*Potentially Hazardous*' classification, which is unique to HazWasteOnline™. A '*Potentially Hazardous*' classification is normally identified where a hazardous property could be present simply because a determinand is detected in a sample; i.e. there is no threshold other than its presence or absence. By identifying this as '*Potentially Hazardous*' this enables the assessor to consider this further and, where appropriate, include further justification as to why the sample should be adopted as either '*Hazardous*' or '*Non Hazardous*'.

For some analytes (primarily inorganics), the laboratory analysis does not identify the compound present in the waste but instead reports the individual species that make up that component, such as cations and anions. Environment Agency (2018) WM3 guidance states that if it is not possible to ascertain which substances might be present based on the process/activity that produced the waste, the most conservative classification should therefore be initially assumed for each component and the waste assessed accordingly.

In the UK, some laboratories report their analytical results for solids on a dry weight basis i.e. the concentration of the substance in the sample after any moisture has been driven off. If the moisture content is known HazWasteOnline™ allows assessors to select an option to adjust the chemical concentrations to take account of moisture in the samples; which effectively dilutes the chemical concentration in the soil mass. Where metal (loids) are the primary contaminant the methodology can take into account specific mineralogy which may affect toxicity and the outcome of the assessment.

Laboratory soil chemical data provided from the soil samples have been considered in this preliminary and indicative assessment. The output generated from HazWasteOnline™ is appended to this Technical Note. The soil samples recovered have been segregated into Made Ground/Topsoil (46 samples), Natural Superficial Deposits (26) and Mudstone (from the Mercia Mudstone Group) (36 samples).

Waste Classification and Assessment

As part of the assessment, AECOM has assumed the following (where applicable) for all groups of samples within the Made Ground/Topsoil, Natural Superficial Deposits and Mudstone sets of samples:

- Total Petroleum Hydrocarbons (TPH). A judgement was taken to overrule a '*Potentially Hazardous*' classification on selected samples due to the Hazardous Property HP3(i) '*Flammable*'. This was triggered due to the presence of Total Petroleum Hydrocarbons and the potential identified for flammable liquids; for which there is no threshold other than presence or

absence. This was discounted as this is a solid waste without a free draining liquid phase and with no evidence of free product. This adjustment removed the '*Potentially Hazardous*' classification.

For the assessment of the Made Ground/Topsoil group of samples the following additional assumption was taken (where applicable):

- Mercury Difulminate: This is a default assumption made by the screening tool in that the prevalent form of Mercury within soils will be Mercury Difulminate. Mercury Difulminate is typically associated with the manufacture and use of explosive materials and associated residues. The CSM for the scheme area does not suggest that the use or manufacture of explosives has happened historically. This has therefore been modified to the second most conservative mercury association; mercury dichloride.

All samples within the Natural Superficial Deposits and Mudstone sample groups were reported to be 'Non Hazardous' in the event that they were earmarked for waste disposal.

Within the Made Ground/Topsoil sample group, two samples of the forty-six screened returned a 'Hazardous' classification; one sample (TP700-17 at 0.7m depth) for zinc chromate and copper sulphate (H14 Ecotoxic) and one sample (BH219-17 at 4.2m) for total petroleum hydrocarbons (HP7 Carcinogenic and HP11 Mutagenic). The following additional judgements were applied in light of these two 'Hazardous' results:

- Zinc Chromate: The screening tool assumes, as a default worst case assumption, that zinc would take the form of zinc chromate. However, upon review there is no evidence of chromium VI in the soil samples (all reported below detection limit) and so zinc chromate is considered unlikely to be the prevalent form of zinc in soil at the scheme site. The default association has therefore been reduced to zinc sulphate as the next most conservative form of zinc. However, this did not alter the Hazardous classification.

The CSM was also reviewed to check that the sources identified at the scheme site support the judgements taken in this assessment. The CSM was also reviewed to check that there was no reasonable justification to modify the assumed zinc sulphate and copper sulphate associations any further. The sample from TP700-17 at 0.7m depth is from within a field and close to an historical farm. Zinc chromate can be associated with weed killers and copper sulphate, pesticides and weed killers. Given the land uses associated with where the sample was taken, there was deemed to be insufficient grounds to amend any of the assumptions further. The sample from BH219-17 at 4.2 m depth is from embankment fill adjacent to the Solihull Road and M42.

In conclusion all samples were reported to be 'Non Hazardous', except for BH219-17 at 4.2m depth (Made Ground) and BH700-17 at 0.7 m depth (Made Ground/Topsoil) which were determined to be Hazardous.

In the event that soils are generated for waste disposal during construction, further testing and classification would be required based on the actual soils excavated and

segregated for disposal. Any sampling undertaken should be representative and follow the guidance provided in Appendix D of WM3.

9 Conclusions and Recommendations

The results of the human health GQRA suggests that the CoPC identified in soil are not likely to impact on the health of future human receptors (based on the proposed end use as a highways scheme).

Leachable concentrations of metals, PAHs and other inorganics have been detected in numerous soil samples, however, the detected metal concentrations are considered to be representative of background levels.

Exceedances of several PAH determinands have been recorded at least one order of magnitude higher than the GAC with highly elevated leachable concentrations recorded locally. However, only marginal exceedances of the GAC were recorded in groundwater, suggesting that CoPC leaching and migration from soils to surface waters is not as great as the laboratory leaching test results imply. However, as only four groundwater samples have been tested to date, from a single monitoring event, the dataset does not provide sufficient coverage to assess seasonal variations CoPC concentrations. Collection of data over successive monitoring events would allow a better assessment of the risk of CoPC migrating to surface water in the area in sufficient concentrations to present a risk to the surface water network. Therefore, further groundwater monitoring and sampling followed by further assessment of detected CoPC concentrations is recommended.

Although further groundwater data will be required to provide a robust risk assessment, as a preliminary assessment it is considered that there is potential for the identified leachable concentrations of PAHs to migrate to the identified surface water receptors, however, the risk for this is deemed to be low at this stage due to the proximity of soils with elevated levels of CoPC to surface waters and limited evidence of CoPC reaching groundwater.

The potential for CoPC to migrate in sufficient concentrations to impact groundwater in the Secondary ‘A’ Aquifer in the glaciofluvial deposits to the north of the scheme is considered to be low. However, as only four groundwater samples from across the Scheme area have been tested during the ground investigation to date, and further to the above, this preliminary assessment should be revisited after further groundwater monitoring and sampling has been undertaken, particularly from standpipes installed in the glaciofluvial deposits within the northern part of the scheme, north of Holywell Brook.

All samples analysed in the HazWaste assessment were reported to be ‘Non Hazardous’, except for BH219-17 at 4.2m depth (Made Ground) and BH700-17 at 0.7 m depth (Made Ground/Topsoil) which were determined to be Hazardous. In the event that soils are generated for waste disposal during construction, further testing and classification would be required based on the actual soils excavated and segregated for disposal. Any sampling undertaken should be representative and follow the guidance provided in Appendix D of WM3.