Gardner Garages Ltd.

City Service Station, Hereford

Flood Risk Assessment

881904-R1(01)-FRA

THE QUEEN'S AWARDS FOR ENTERPRISE: INTERNATIONAL TRADE 2015

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RSK GENERAL NOTES

Project No.: 881904-R1(01)-FRA

Site: City Service Station, Hereford

Title: Flood Risk Assessment

Client: Gardner Garages Ltd.

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Status: Draft

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Where field investigations have been carried out, these have been restricted to a level of detail required to achieve the stated objectives of the work.

This work has been undertaken in accordance with the quality management system of RSK LDE Ltd.

CONTENTS

1 INTRODUCTION

1.1 Context

RSK Land and Development Engineering Ltd (RSK) was commissioned to carry out a Flood Risk Assessment (FRA) for Gardner Garages (the 'client'). The assessment is in support of the detailed planning submission for the commercial development at City Service Station, Hereford (the 'site').

The assessment has been prepared in accordance with the National Planning Policy Framework (NPPF)[1] and its accompanying Planning Practice Guidance[2], the Interim Code of Practice for Sustainable Drainage[3], BS 8533-2011 Assessing and Managing Flood Risk in Development Code of Practice[4], BS 8582:2013 Code of practice for surface water management for development sites[5] and the Non-statutory technical standards for sustainable drainage systems[6], with site-specific advice from the Environment Agency (EA), the Lead Local Flood Authority (LLFA), the Local Planning Authority (LPA), the architect and the client.

The NPPF sets out the criteria for development and flood risk by stating that inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere.

The key definitions within the PPG are:

- "Flood risk" is a combination of the probability and the potential consequences of flooding from all sources – including from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems, and from reservoirs, canals and lakes and other artificial sources; and
- "Areas at risk of flooding" means areas at risk from all sources of flooding. For fluvial (river) and sea flooding, this is principally land within Flood Zones 2 and 3. It can also include an area within Flood Zone 1 which the EA has notified the local planning authority as having critical drainage problems.

For this site, the key aspects that require the assessment are:

- The EA's indicative flood zone map shows that the site is located within Flood Zone 2.

[1] Communities and Local Government, 'National Planning Policy Framework', February 2019.

[2] Communities and Local Government, 'Planning Practice Guidance - Flood Risk and Coastal Change, ID 7', March 2014. http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

[3] DEFRA, 'Interim Code of Practice for Sustainable Drainage Systems' National SUDS Working Group, July 2004.

[4] BSI, 'BS 8533-2011 Assessing and managing flood risk in development Code of practice', October 2011.

[5] BSI, 'BS 8582:2013 Code of practice for surface water management for development sites', November 2013.

[6] DEFRA, 'Sustainable Drainage Systems - Non-statutory technical standards for sustainable drainage systems', March 2015.

1.2 Scope of work

A key element of project development is to prepare a FRA to establish the flood risk associated with the proposed development and to propose suitable mitigation, if required, to reduce the risk to a more acceptable level.

The scope of work relating to a FRA is based on the guidance provided in Section 14 of the NPPF[1] and its accompanying Planning Practice Guidance.

A site-specific FRA must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall. The scope of this assessment therefore comprises the following elements:

- To review architect plans, planning information and other studies to determine existing site conditions;
- To obtain information on the hydrology and hydrological regime in and around the site;
- To obtain the views of the EA/LLFA including scope, location and impacts;
- To determine the extent of new flooding provision and the influence on the site;
- To assess the impact on the site from climate change effects and anticipated increases in rainfall over a 60 year period for a commercial use;
- To review site surface water drainage based on the proposed layout and, if necessary, to determine the extent of infrastructure required; and
- To prepare a report including calculations and summaries of the source information and elements reviewed.

Reliance has been placed on factual and anecdotal data obtained from the sources identified. RSK cannot be held responsible for the scope of work, or any omissions, misrepresentation, errors or inaccuracies with the supplied information. New information, revised practices or changes in legislation may necessitate the re-interpretation of the report, in whole or in part.

The comments given in this report and opinions expressed are subject to RSK Group Service Constraints provided in **Appendix A**.

2 SITE DESCRIPTION

2.1 Existing site

2.1.1 Location

Site Name and Address: City Service Station, 40 Commercial Road, Hereford, Herefordshire, HR1 2BG

Site National Grid Reference: (E) 351507; (N) 240352

The site is approximately 0.15Ha in size and is located within the north-east of Hereford city centre. The site is currently an active fuel filling station and can be accessed from Commercial Road. The site is comprised of four fuel pumps beneath a forecourt canopy, a forecourt shop, a car washing facility, car parking and an interceptor tank.

Table 2.1: Site setting

Direction	Characteristic
North	To the north is a supermarket car park containing a trolley station which is directly adjacent to the boundary.
East	To the east is a supermarket car park containing a trolley station which is directly adjacent to the boundary.
South	Directly adjacent to the south-eastern site boundary is Commercial Road.
West	A Hotel / Pub is adjoining to the south-western site boundary, fronting onto Commercial Road. Directly to the north-west of the site is a supermarket car park.

Figure 2.1 shows a site location map.

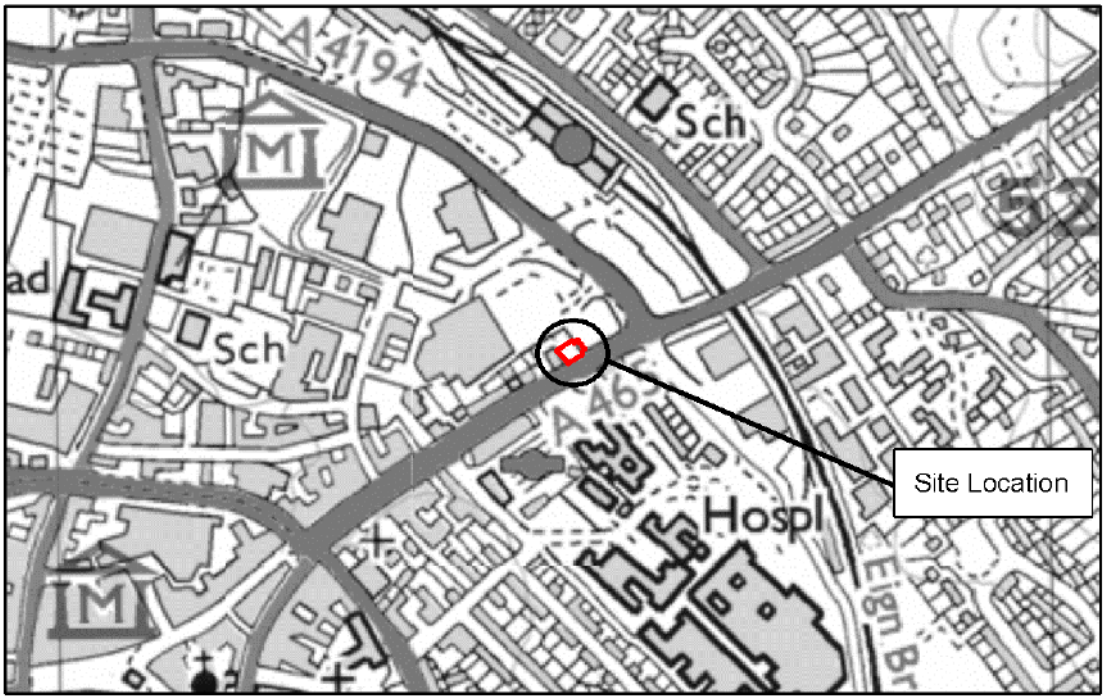


Figure 2.1: Site location map

2.1.2 Land use and topography

The existing site is currently comprised of a commercial property and hardstanding ground, and therefore the site can be described as being brownfield.

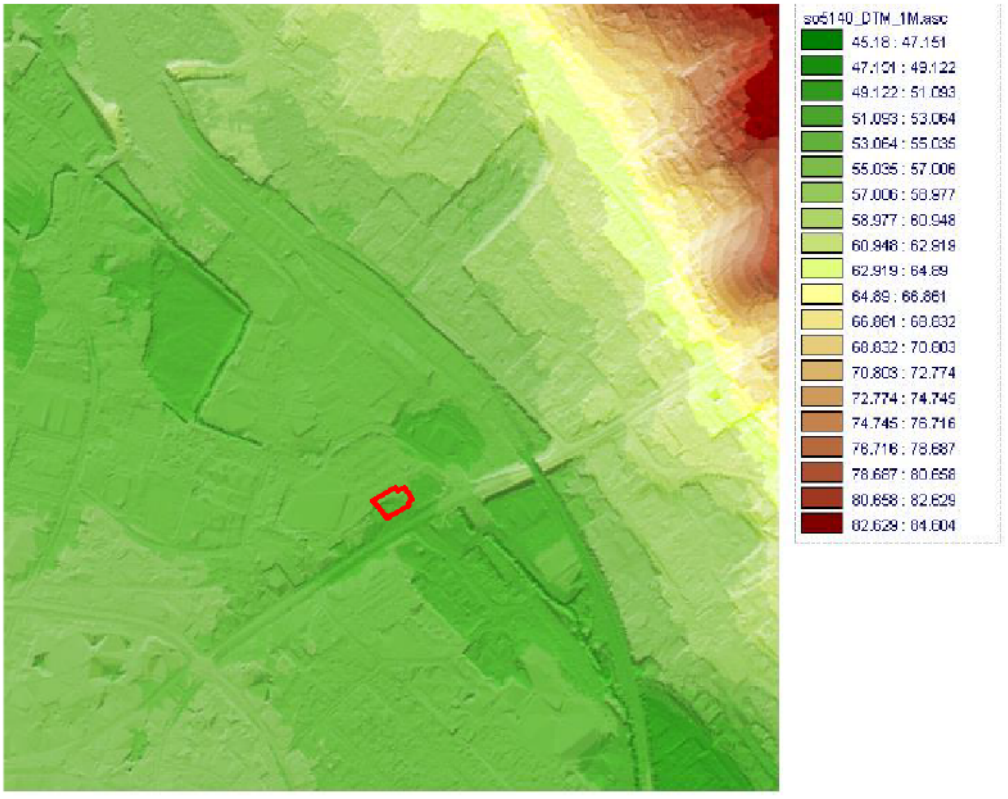


Figure 2.2: LIDAR data map

Using LIDAR data provided by DEFRA[7], shown in Figure 2.2, the site is shown to be at an approximate level of 52.80m Above Ordnance Datum (mAOD). From this LIDAR data, it can be assumed that the site naturally falls south-eastwards towards Commercial Road, which is at a lower elevation to that of the site being approximately 52.50mAOD. There is a slight fall from Commercial Road to Stonebow Road in a south-easterly direction

2.1.3 Hydrology

Eign Brook is located approximately 100m north-east of the site and can be descried as being an 'Ordinary Watercourse'. The watercourse is culverted beneath the supermarket car park to the north of the site. It conveys flows in a southernly direction for approximately 1.4km to eventually discharge into the River Wye.

2.1.4 Geology

2.1.4.1 Desk Study

Based on the British Geological Survey[8] online mapping for the area, the site exhibits the following geology:

- Superficial Geology: Alluvium - Clay, Silt, Sand and Gravel. Superficial Deposits formed up to 2 million years ago in the Quaternary Period. Local environment previously dominated by rivers (U).
- Base rock Geology: Raglan Mudstone Formation - Siltstone and Mudstone, Interbedded. Sedimentary Bedrock formed approximately 419 to 424 million years ago in the Silurian Period. Local environment previously dominated by rivers.

BGS Borehole data records were searched for nearby borehole logs that may give relevant information regarding the on-site geology. On-site, one record was found within the western site corner, BGS Reference (SO54SW13). Within this borehole, stratum was defined as being 2.1mbgl (metres below ground level) of Gravel underlain with 165.4mbgl of red Clay. No Groundwater was observed within the borehole.

There were no further records available within the surrounding vicinity of the site.

An assessment of the potential impact of the ongoing fuel station site use on the shallow soils was undertaken by RSK Environment Ltd for the site (report ref: 314262 L02 (01)), of which three borehole logs were included within the report, as shown within **Appendix B**.

These borehole logs showed Made Ground to depths of 2.1mbgl, underlain with Glaciofluvial deposits. Within these boreholes, water was struck between depths of 2.00m to 4.10m.

2.1.5 Hydrogeology

Hydrogeological information was obtained from the online Magic Maps service. These maps indicate that the site is underlain by a Secondary A bedrock aquifer. These can be defined as 'permeable strata capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers'.

[7] DEFRA Survey Data Download, available at https://environment.data.gov.uk/DefraDataDownload/?Mode=survey
[8] British Geological Survey online mapping, available at http://mapapps.bgs.ac.uk/geologyofbritain/home.html?location=&gobBtn=go.

The maps also indicate that the site is underlain by a 'Secondary A' superficial aquifer. These can be defined as 'permeable strata capable of supporting water supplies at a local rather than strategic scale and in some cases forming an important source of base flow to rivers'.

The site is not located within a Groundwater Source Protection Zone (SPZ). The nearest SPZ is a Zone II- Outer Protection Zone located approximately 2.6km north-west of the site.

2.2 Development proposals

The proposed development is for a commercial end use.

The approximate land uses of the proposed site are summarised in Table 2.2 below.

Table 2.2: Proposed site land uses

Land use	Area (Ha)	Percentage
Impermeable	0.15	100%
Permeable	0	0%
Total	0.15	100%

The proposed site plans are shown in **Appendix C**.

3 LEGISLATION, POLICY AND GUIDANCE

3.1 National policy

Table 3.1: National legislation and policy context

Legislation	Key provisions
National Planning Policy Framework (2019)	The aims of planning policy on development and flood risk are to ensure that flood risk is taken into account at all stages in the planning process to avoid inappropriate development in areas at risk of flooding, and to direct development away from areas at highest risk. Where new development is, exceptionally, necessary in such areas, policy aims to make it safe without increasing flood risk elsewhere and where possible, reducing flood risk overall.
Planning Practice Guidance (2014)	The NPPF is supported by an online Planning Practice Guidance, which provide additional guidance on flood risk.
Flood and Water Management Act 2010[9]	The Flood and Water Management Act (FWMA) aims to implement the findings of the 2007 Pitt Review and co-ordinate control of drainage and flood issues. There are a number of increased responsibilities within the Act that affect adoption of SuDS features and the role of the EA to expand on the mapping data they provide. The implementation of SuDS features has many beneficial impacts on the treatment of surface water during remediation works.
Water Resources Act 1991[10]	Section 24 – The EA is empowered under this Act to maintain and improve the quality of 'controlled' waters Section 85 – It is an offence to cause or knowingly permit pollution of controlled waters Section 88 – Discharge consents are required for discharges to controlled waters
Water Framework Directive (2000)[11]	The Water Framework Directive (WFD) requires all inland and coastal waters to reach 'good' chemical and biological status by 2015. Flood risk management is unlikely to have a significant impact on chemical water quality except where maintenance works disturb sediment (such as de-silting) or where pollutants are mobilised from contaminated land by floodwaters. The main impact of the WFD on flood risk management, both now and in the future, relates to the ecological quality of water bodies. Channel works, such as straightening and deepening, or flood risk management schemes that modify geomorphological processes can change river morphology. The WFD aims to protect conservation sites identified by the EC Habitats Directive and

[9] Flood and Water Management Act, 2010
[10] Water Resources Act, 1991
[11] EU Water Framework Directive, 2000

Legislation	Key provisions
	Birds Directive that have water-related features, by designating them as 'protected sites'.

3.2 Local policy

Table 3.2: Local policy legislation and policy context

Legislation	Key provisions
Herefordshire Local Plan Core Strategy 2011-2031 Herefordshire Council[12] Adopted October 2015	'**Policy SD3 – Sustainable water management and water resources** Measures for sustainable water management will be required to be an integral element of new development in order to reduce flood risk; to avoid an adverse impact on water quantity; to protect and enhance groundwater resources and to provide opportunities to enhance biodiversity, health and recreation. This will be achieved by ensuring that: 1. Development proposals are located in accordance with the Sequential Test and Exception Tests (where appropriate) and have regard to the Strategic Flood Risk Assessment (SFRA) 2009 for Herefordshire; 2. Development is designed to be safe, taking into account the lifetime of the development and the need to adapt to climate change by setting appropriate floor levels, providing safe pedestrian and vehicular access, where appropriate, implementing a flood evacuation management plan and avoiding areas identified as being subject to Rapid Inundation from a breach of a Flood Defence; 3. Where flooding is identified as an issue, new development should reduce flood risk through the inclusion of flood storage compensation measures or provide similar betterment to enhance the local flood risk regime; 4. Development will not result in the loss of open watercourse and culverts should be opened up where possible to improve drainage and flood flows. Proposals involving the creation of new culverts (unless essential to the provision of access) will not be permitted; 5. Development includes appropriate sustainable drainage systems (SuDS) to manage surface water appropriate to the hydrological setting of the site. Development should not result in an increase in runoff and should aim to achieve a reduction in the existing runoff rate and volumes, where possible; 6. Water conservation and efficiency measures are included in all new developments, specifically:

[12] Herefordshire Local Plan Core Strategy 2011-2031, Herefordshire Council, October 2015

Legislation	Key provisions
	• residential development should achieve Housing - Optional Technical Standards - Water efficiency standards. At the time of adoption, the published water efficiency standards were 110 litres/person/ day; or • non-residential developments in excess of 1,000 m2 gross floorspace to achieve the equivalent of BREEAM 3 credits for water consumption as a minimum; 7. The separation of foul and surface water on new developments is maximised; 8. Development proposals do not lead to deterioration of EU Water Framework Directive water body status; 9. Development should not cause an unacceptable risk to the availability or quality of water resources; and 10. In particular, proposals do not adversely affect water quality, either directly through unacceptable pollution of surface water or groundwater, or indirectly through overloading of Wastewater Treatment Works. Development proposals should help to conserve and enhance watercourses and riverside habitats, where necessary through management and mitigation measures for the improvement and/or enhancement of water quality and habitat of the aquatic environment. Proposals which are specifically aimed at the sustainable management of the water environment will in particular be encouraged, including where they are required to support business needs such as for agriculture. Innovative measures such as water harvesting, winter water storage and active land use management will also be supported. In all instances it should be demonstrated that there will be no significant adverse landscape, biodiversity or visual impact.' '**Policy SD4 - Wastewater treatment and river water quality** Development should not undermine the achievement of water quality targets for rivers within the county, in particular through the treatment of wastewater. In the first instance developments should seek to connect to the existing mains wastewater infrastructure network. Where this option would result in nutrient levels exceeding conservation objectives targets, in particular additional phosphate loading within a SAC designated river, then proposals will need to fully mitigate the adverse effects of wastewater discharges into rivers caused by the development. This may involve: • Incorporating measures to achieve water efficiency and/or a reduction in surface water discharge to the mains sewer network, minimising the capacity required to accommodate the proposal, in accordance with policy SD3; • Phasing or delaying development until further capacity is available; • The use of developer contributions/community infrastructure levy funds to contribute to improvements to waste water treatment works or other appropriate

Legislation	Key provisions
	measures to release capacity to accommodate new development; • In the case of development which might lead to nutrient levels exceeding the limits for the target conservation objectives within a SAC river, planning permission will only be granted where it can be demonstrated that there will be no adverse effect on the integrity of the SAC in view of the site's conservation objectives; and • Where the nutrient levels set for conservation objectives are already exceeded, new development should not compromise the ability to reduce levels to those which are defined as favourable for the site. Where evidence is submitted to the local planning authority to indicate connection to the wastewater infrastructure network is not practical, alternative foul drainage options should be considered in the following order: • Provision of or connection to a package sewage treatment works (discharging to watercourse or soakaway); • Septic tank (discharging to soakaway). With either of these non-mains alternatives, proposals should be accompanied by the following: • • Information to demonstrate there will be no likely significant effect on the water quality, in particular of designated national and European sites, especially the River Wye SAC and the River Clun SAC; or • Where there will be a likely significant effect upon a SAC river, information to enable the council, in its role as a competent authority, to ascertain that the development will have no adverse effect on the integrity of the SAC; • In relation to water courses with national or European nature conservation designations, the inclusion of measures achieving the highest standard of water quality discharge to the natural drainage system including provision for monitoring. The use of cesspools will only be considered in exceptional circumstances and where it can be demonstrated that sufficient precautionary measures will ensure no adverse effect upon natural drainage water quality objectives.'

3.3 Area guidance

Table 3.3: Area Guidance

Study	Overview of key provisions and policies
SFRA: Herefordshire Strategic Flood	The principle aim of the SFRA was to map all forms of flood risk in order to provide an evidence base to locate new development. It also aims to provide appropriate policies for the management of

Study	Overview of key provisions and policies
Risk Assessment Level 1 Final Report[13] 2019	flood risk and identify the level of detail required for site-specific FRAs. The SFRA contains information and maps detailing flood sources and risks. Information relevant to the site is detailed in Section 4 of this report. 'The large number of natural springs located throughout Herefordshire and that form many of the country's ordinary watercourses indicates that groundwater emergence can be common.' There are no Environment Agency historic records of groundwater flooding within Hereford, whilst there are limited records of groundwater within Herefordshire. No historic surface water flooding records were located on-site or near to the site.
PFRA: Herefordshire Preliminary Flood Risk Assessment[14] 2011	Preliminary Flood Risk Assessments (PFRAs) are produced by Lead Local Flood Authorities (LLFAs) in England and Wales. A Preliminary Flood Risk Assessment (PFRA) is the first part of the planning cycle for flood risk management as set out in the Flood Risk Regulations (2009), which implement the requirements of the European (EU) Floods Directive (2007). The EU Floods Directive aims to provide a consistent approach to managing flooding across Europe. The PFRA is organised and produced by the LLFA (in this case Herefordshire Council). The PFRA considers local sources of flooding that the LLFA is responsible for: ordinary watercourses, surface water, groundwater and sewers where flooding is wholly or partially caused by rainwater or other precipitation entering or affecting the system. Information is gathered from existing sources on past floods and flood models to identify Flood Risk Areas. The PFRA includes the national guidance issued by Defra and WAG which sets out the criteria used for defining significant flood risk and the Flood Risk Areas. In developing the methodology for assessing flood risk, threshold levels were defined for the key Flood Risk Indicators as follows: • Number of People > 200, • Non-Residential Properties > 20, • Critical Infrastructure > 1 This process resulted in maps of 'Hotspots' or places above the thresholds, defined where 1 km grid squares meet the significance level set for at least one of the key Flood Risk Indicators shown above. The site is located within one of these hotspots.
CFMP: River Severn Catchment Flood Management Plan[15] 2009	Catchment Flood Management Plans (CFMP) give an overview of the flood risk from inland sources across each river catchment and recommend ways of managing those risks now and over the next 50-100 years. The EA is responsible for producing CFMPs. The site falls within the 'Lower Severn Corridor & Leadon Catchment' sub-catchment and the policy applicable to this site is Policy Option 2 which states "Areas of low to moderate flood risk where we can generally reduce existing flood risk management actions".

[13] Herefordshire Strategic Flood Risk Assessment Level 1 Final Report, WSP, April 2019
[14] Herefordshire Preliminary Flood Risk Assessment, Preliminary Assessment Report, JBA Consulting, May 2011
[15] River Severn Catchment Flood Management Plan, Summary Report, Environmental Agency, December 2009

Study	Overview of key provisions and policies
	There is an intended focus here on reducing dependence on raised flood defences and surface water becoming a growing problem within the sub-catchment. The CFMP provides the following key proposed actions: • Encourage rural and urban best practices in land-use and in land-management to restore more sustainable natural floodplains and to reduce run-off; • Raise awareness of flooding among the public and key partners, allowing them to be better prepared. Encourage them all to increase the resilience and resistance of vulnerable buildings, infrastructure and businesses; • Ensure floodplains are not inappropriately developed; • Review how effective and sustainable flood defences are; and • Seek opportunities to improve watercourses where it would benefit fisheries (especially salmon.) Consider the impact of flood risk management activities on SSSIs.

3.4 Site-specific consultation

As part of this assessment, the following authorities have been contacted to obtain relevant data/guidance and establish key site constraints:

Table 3.4: Key site-specific consultations

Consultee	Date	Enquiry	Appendix
Environment Agency (EA)	August 2019	Product data Pre-application enquiry	**Appendix D**
Herefordshire Council (Lead Local Flood Authority)	November 2019	Product data	**Appendix E**

Key findings are referred to in the relevant part of Section 4 and full details are contained in the relevant appendices.

4 SOURCES OF FLOOD RISK

4.1 Criteria

In accordance with the NPPF[1] and advice from the EA, a prediction of the flood sources and levels is required along with the effects of climate change from the present for the design life of the development (in this case assumed to be 60 years).

Changes to climate change guidance in February 2016 indicate that increased allowances in peak river flow and rainfall intensity should now be incorporated within any assessment. The appropriate allowance for peak river flow is based on the location of the site within the country, the lifetime of development, the relevant flood zone and the vulnerability of the proposed end use.

The flood risk elements that need to be considered for any site are defined in BS 8533 as the "Forms of Flooding" and are listed as:

- Flooding from rivers (fluvial flood risk);
- Flooding from the sea (tidal flood risk);
- Flooding from the land;
- Flooding from groundwater;
- Flooding from sewers (sewer and drain exceedance, pumping station failure etc); and
- Flooding from reservoirs, canals and other artificial structures.

The following section reviews each of these in respect of the subject site.

4.2 Flooding from rivers (fluvial flood risk)

4.2.1 Main river

The EA Flood Zone mapping study for England is available on their website at: https://flood-map-for-planning.service.gov.uk.

The latest Environment Agency published flood zone map (Figure 4.1), taking into account the presence of flood defences, shows the site to be located within Flood Zone 2 (representing land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding). Without the local flood defences, land and property in this flood zone would have a high probability of flooding, indicating a '**moderate**' risk of flooding, according to the Environment Agency maps.

In December 2013, the EA released an additional form of mapping 'Risk of Flooding from Rivers and Sea', which is available at:

https://flood-warning-information.service.gov.uk/long-term-flood-risk

The latest 'Risk of Flooding from Rivers and Sea' flood map (Figure 4.2), which shows the Environment Agency's assessment of the likelihood of flooding from rivers and the sea at any location and is based on the presence and effect of all flood defences, predicted flood levels, and ground levels, indicates that the site is considered to be at '**low-moderate**' risk of flooding.

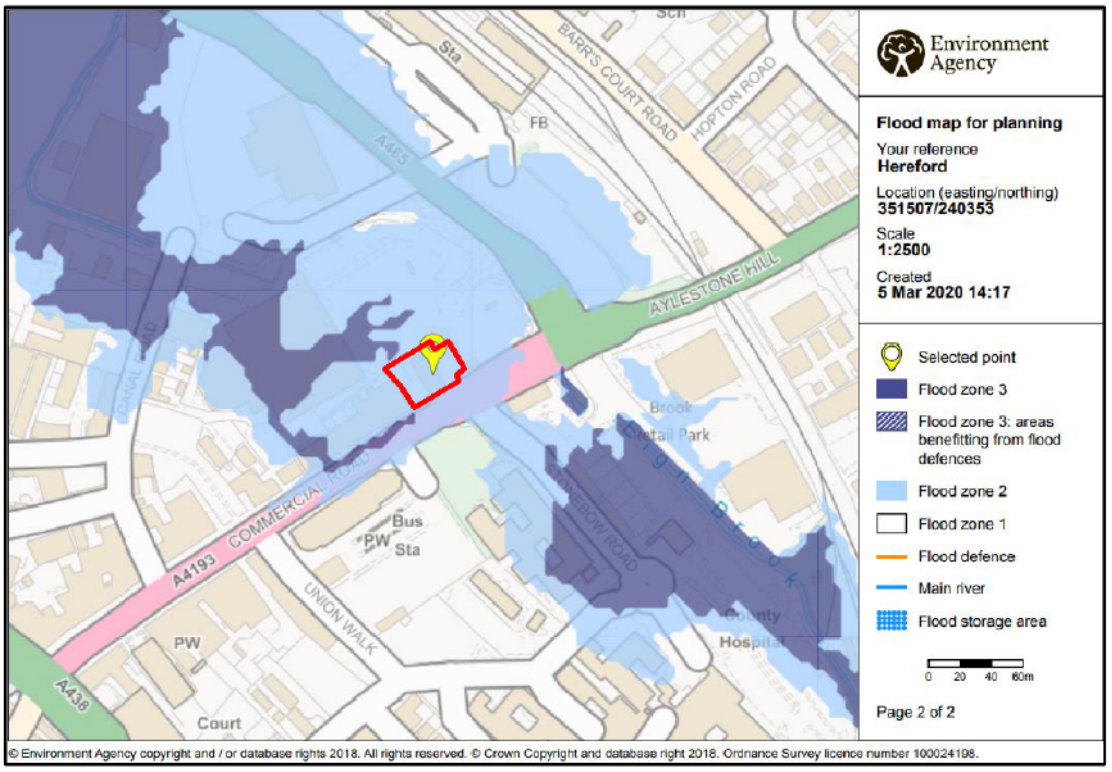


Figure 4.1: Environment Agency 'Flood map for planning' (accessed March 2020)

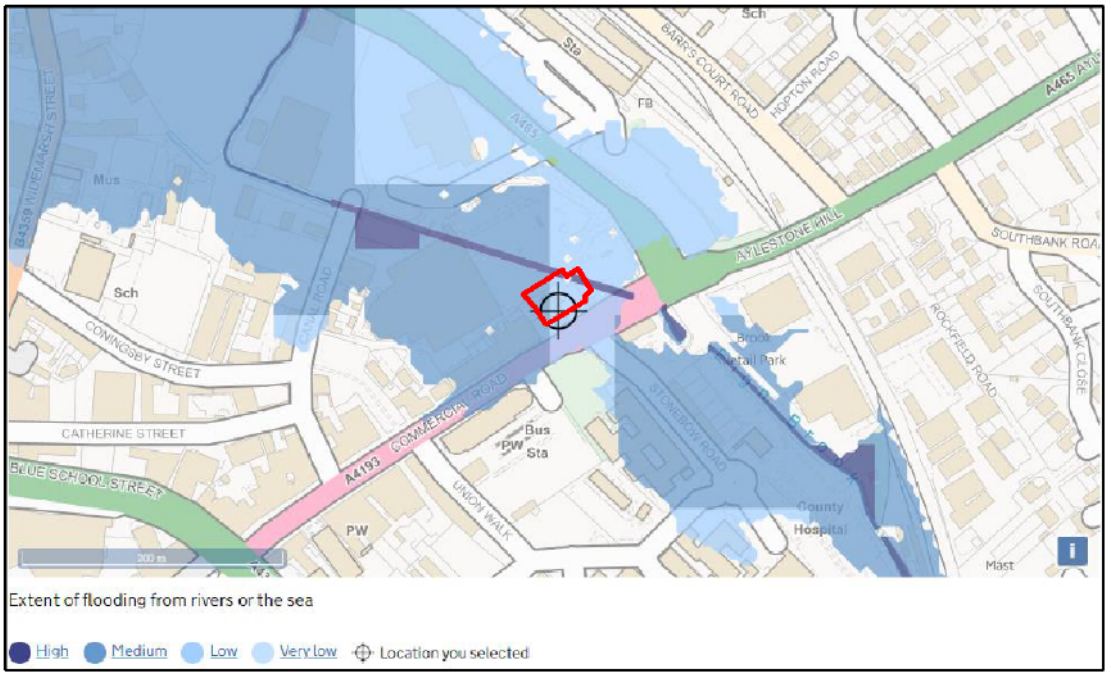


Figure 4.2: Environment Agency 'Flood risk from rivers or the sea' map (accessed March 2020)

The site is considered to be at risk of flooding from fluvial sources from Eign Brook. Fluvial levels have been supplied by Herefordshire Council within the vicinity of the site (**Appendix E**) based on hydraulic model analysis.

The fluvial analysis is contained within **Table 4.1**.

Table 4.1: Fluvial Level – Yazor Brook / Widemarsh Brook Hydraulic Model

Node	Modelled Flood Levels				
	1 in 20	1 in 100	1 in 100 +30% cc	1 in 100 +70% cc	1 in 1000
EB1408	51.94	52.26	52.68	52.81	52.81
Node	**Modelled Residual Risk Flood Levels**				
	1 in 20	1 in 100	1 in 100 +30% cc	1 in 100 +70% cc	1 in 1000
EB1408	52.61	52.77	52.84	52.87	52.87

The site is at risk of fluvial flooding from a modelled defended 1 in 100 year return period plus 75% climate change flood event and a 1 in 1000 year flood event, of which the maximum level for both events is 52.81mAOD, with the on-site ground level being approximately 5.80mAOD, according to available LIDAR data.

The site is at risk from a modelled residual risk 1 in 100 year return period plus 30% climate change flood event, of which the maximum level is 52.84mAOD. The site is also at risk from a modelled residual risk 1 in 100 year return period plus 70% climate change flood event and a 1 in 1000 year flood event, of which the maximum level for both events is 52.87mAOD.

4.2.2 Climate change

Fluvial flooding is likely to increase as a result of climate change. A greater intensity and frequency of precipitation is likely to raise river levels and increase the likelihood of a river overtopping its banks. Climate change guidance for river modelling was updated by the EA in February 2016. The impact upon the developable area of the site is significant given its location within Flood Zone 2, which can be mitigated against.

4.3 Flooding from the sea (tidal flood risk)

The site is not considered to be at risk from tidal flooding due to its inland location, indicating a '**low**' risk of flooding.

4.3.1 Climate change

Climate change is not considered to result in an increased risk of tidal flooding to the site.

4.4 Flooding from the land (overland pluvial flood risk)

If intense rain is unable to soak into the ground or be carried through manmade drainage systems, for a variety of reasons, it can run off over the surface causing localised floods before reaching a river or other watercourse.

Generally, where there is impermeable surfacing or where the ground infiltration capacity is exceeded, surface water runoff can occur. Excess surface water flows from the site are believed to drain naturally to the local water features, either by overland flow or through infiltration.

The EA's surface water flood map (Figure 4.3) shows the site is at a very low risk from pluvial flooding. Although, there is a localised section of low surface water flood risk existing within the eastern site corner, which is currently used for car parking purposes.

A surface water flow path of low-high risk is located along Commercial Road of which the site fronts onto. This flow path is conveyed in a north-easterly direction towards the junction where Commercial Road intersects Stonebow Road, to then continue flowing in a south-easterly direction along Stonebow Road, away from the site.

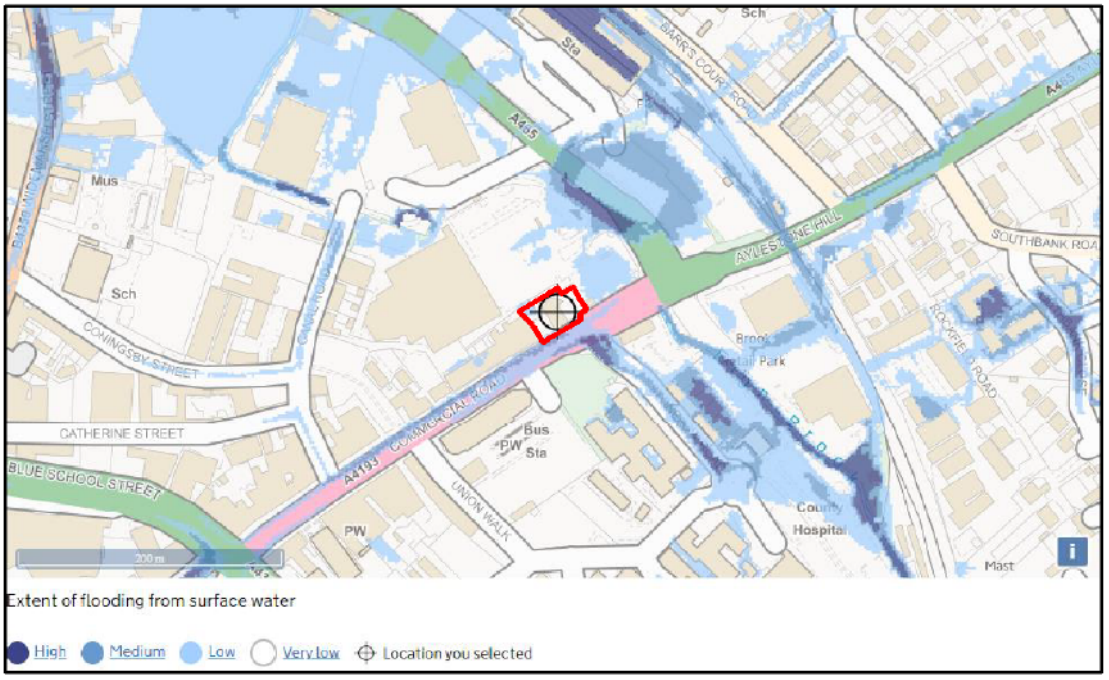


Figure 4.3: Environment Agency 'Flood risk from surface water' map (accessed March 2020)

LIDAR data, detailed in Section 2, shows that surface water runoff will be flowing south-eastwards away from the site, to follow the natural falls of the area. The proposed development is not likely to generate significant quantities of on-site surface water runoff.

The risk of surface water flooding at the site is considered to be **low**.

4.4.1 Climate change

Surface water flooding is likely to increase as a result of climate change in a similar ratio to fluvial flooding. Increased intensity and frequency of precipitation is likely to lead to reduced infiltration and increased overland flow. Climate change guidance for rainfall intensity has recently been updated by the EA in late February 2016. The change in flood risk from climate change is negligible.

4.5 Flooding from groundwater

Groundwater flooding tends to occur after much longer periods of sustained high rainfall. Higher rainfall means more water will infiltrate into the ground and cause the water table to rise above normal levels. Groundwater tends to flow from areas where the ground level is high, to areas where the ground level is low. In low-lying areas the water table is usually at shallower depths anyway, but during very wet periods, with all the additional groundwater flowing towards these areas, the water table can rise up to the surface causing groundwater flooding.

From the British Geological Survey Borehole records discussed in Section 2, it is understood that within on-site borehole records, groundwater levels indicate there to be no high groundwater present on-site, whilst within the surrounding vicinity of the site there are no borehole records to indicate high groundwater is present.

Within the site-specific report (ref: 314262 L02 (01)), water was struck within the boreholes between depths of 2.00m to 4.10m.

From the above and due to the sporadic nature of groundwater flooding, the design of the development and no knowledge of groundwater emergence at the site, it is unlikely that groundwater flooding would affect the development.

Whilst groundwater flooding is sporadic in nature, due to the design of the development (i.e. underground fuel tanks), there is potential that groundwater flooding could impact on the site. Mitigation should be provided to ensure that any subterranean infrastructure is protected against groundwater flow (Section 10).

The resultant groundwater flood risk is considered to be **low-moderate**.

4.5.1 Climate change

Climate change could increase the risk of groundwater flooding as a result of increased precipitation filtering into the groundwater body. If winter rainfall becomes more frequent and heavier, groundwater levels may increase. Higher winter recharge may however be balanced by lower recharge during the predicted hotter and drier summers. This is less likely to cause a significant change to flood risk than from other sources, since groundwater flow is not as confined. It is probable that any locally perched aquifers may be more affected, but these are likely to be isolated. The change in flood risk is likely to be low.

4.6 Flooding from sewers

Flooding from artificial drainage systems occurs when flow entering a system, such as an urban storm water drainage system, exceeds its conveyance capacity, the system becomes blocked or it cannot discharge due to a high water level in the receiving watercourse. A sewer flood is often caused by surface water drains discharging into the combined sewer systems; sewer capacity is exceeded in large rainfall events causing the backing up of floodwaters within properties or discharging through manholes.

Most adopted surface water drainage networks are designed to the criteria set out in Sewers for Adoption[16]. One of the design parameters is that sewer systems be designed

[16] WRC, 'Sewers for Adoption' 7th Edition, August 2012

such that no flooding of any part of the site occurs in a 1 in 30 year rainfall event. By definition a 1 in 100 year event would exceed the capacity of the surrounding sewer network as well as any proposed drainage.

When exceeded, the surcharged pipe work could lead to flooding from backed up manholes and gully connections. This could lead to immediate flooding within highways surrounding the site. As described above, surface water would most likely follow the topography of the area and flow away from the site along Stonebow Road.

Sewer details have been referenced from sewer record plans obtained from Welsh Water (included in **Appendix F**). The plans indicate the following network of sewers around the site:

- Surface water;
  - A 450mm public surface water sewer runs beneath the A465 to the north-east of the site, where it conveys flow south to eventually discharge into Eign Brook where it is culverted beneath Commercial Road.
- Combined water;
  - A 1125 x 750mm combined sewer runs beneath Commercial Road, conveying flow north-east and eventually south-east beneath Stonebow Road, away from the site.
  - A 375mm public combined sewer runs beneath the A465 to the north-east of the site, which conveys flow south-east, and eventually south away from the site.

There is a public combined sewer located on-site, according to Welsh Water public sewer records. The head of the run is located beneath properties to the south-west of the site and conveys flow north-east to a manhole on-site, of which is located within the western site corner. Flow is then conveyed south-east within a 150mm pipe to join the combined water sewer beneath Commercial Road.

Development has the potential to cause an increase in impermeable area, an associated increase in surface water runoff rates and volumes, and a consequent potential increase in downstream flood risk due to overloading of sewers, watercourses, culverts and other drainage infrastructure. For this proposed development, there is to be no increase in impermeable area and therefore no increase in off-site flows or volumes.

The resultant sewer flood risk is considered to be **low**.

4.6.1 Climate change

The impact of climate change is likely to be negative regarding flooding from sewers. Increased rainfall and more frequent flooding put existing sewer and drainage systems under additional pressure resulting in the potential for more frequent surcharging and potential flooding. This would increase the frequency of local sewer flooding but would not be significant in terms of the proposed development.

4.7 Other sources of flooding

4.7.1 Reservoirs

Flood events can occur from a sudden release of large volumes of water from reservoirs, canals and artificial structures.

The EA reservoir flood map (reproduced as Figure 4.4) shows the largest area that might be flooded if a reservoir were to fail and release the water it holds. Since this is a prediction of a worst-case scenario, it is unlikely that any actual flood would be this large. According to the EA Reservoir flood maps the site is at risk of flooding from reservoirs.

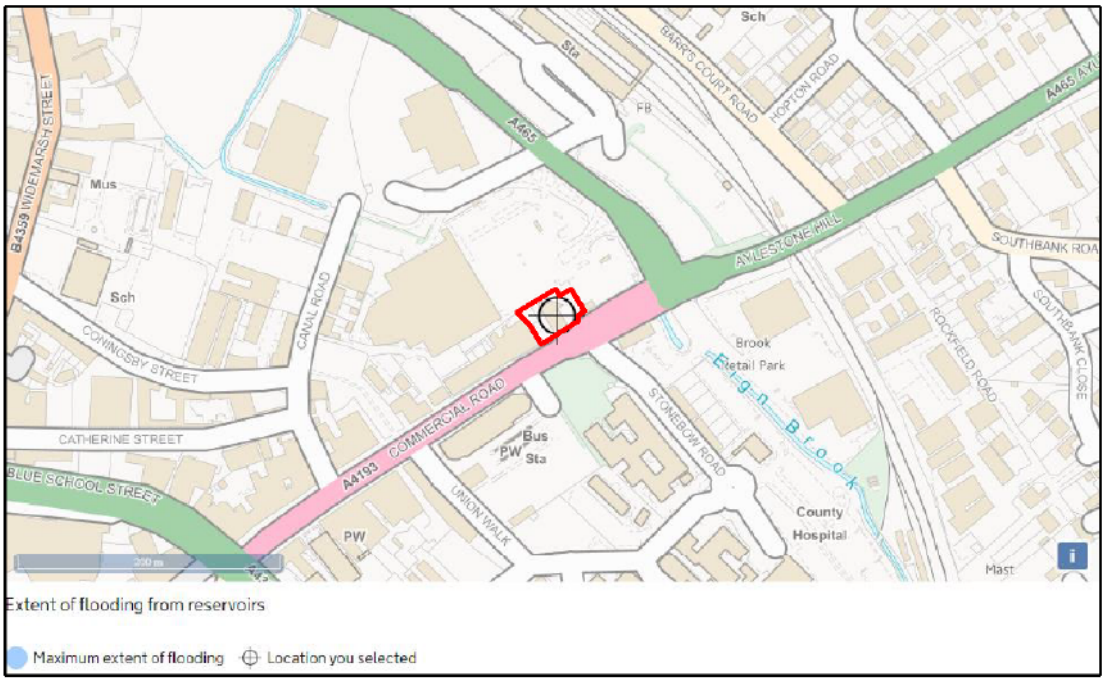


Figure 4.4: Environment Agency 'Flood risk from reservoirs' map (accessed March 2020)

Reservoir flooding is also extremely unlikely. There has been no loss of life in the UK from reservoir flooding since 1925. Since then reservoir safety legislation has been introduced to ensure reservoirs are maintained.

The resultant flood risk is considered to be **very low**.

Reservoirs can be managed over time, controlling inflow/outflow of water and therefore there is the capacity to control the effects of climate change. Increased rainfall has the potential to increase base flow, but this should be minimal. It is unlikely that there will be a substantial change to the risk of flooding for this site.

4.7.2 Canals

There are no Canal & River Trust owned canals within the vicinity of the site.

As a result, the risk to the site from this source is considered low.

4.7.3 Blockages of artificial drainage systems

There is a possibility that flooding may result due to culverts and/or sewers being blocked by debris or structural failure. This can cause water to backup and result in localised flooding, as well as placing areas with lower ground levels at risk.

Eign Brook is culverted beneath the supermarket car park and Commercial Road approximately 170m north-west of the site. The culvert opens approximately 60m east of the site. Due to the distance of this culvert from the site, it is unlikely pose as a significant risk to the site in terms of flooding.

The risk of flooding from artificial drainage systems is considered to be **low**.

Climate change is unlikely to affect the flooding risk to the site from such blockages.

5 FLOOD MITIGATION MEASURES

5.1 Overview

The developable area lies within Flood Zone 2 and therefore flood mitigation has been considered.

5.2 Overland flood flow

No further overland flow control measures are proposed as all surface water runoff up to the 1 in 100 year climate change storm will be discharged via existing connections with no increase in flow or volume as a result of the development.

There are no existing overland flood flow paths on-site.

5.3 Finished floor levels

As this site will be affected by fluvial flooding, freeboard levels will need to be incorporated into the finished floor levels of the design. Low lying areas that could lead to ponding of surface flows will be avoided by careful design of finished levels. As the development is for commercial end use and is hence less vulnerable with a shorter lifespan, it is acceptable to set finished floor levels 600mm above the 1 in 100 year plus 30% climate change flood event.

Floor levels of the kiosk should be set 600mm above the 1 in 100 year plus 30% climate change flood event (52.68mAOD). This would make the finished floor levels of the kiosk set at 53.28mAOD, being 480mm above the existing floor levels and 470mm above the 1 in 100 year plus 70% climate change levels.

5.4 Safe access/egress

For extreme events outside the 1 in 100 year climate change flood extent, it is considered appropriate that site users should be able to safely escape to an area within Flood Zone 1 (i.e. above the 1 in 1000 year flood level). In this case the route should be through a walk of approximately 130m in a south-westerly direction along Commercial Road, until the junction to access Union Walk is reached. Generally, vehicles can pass through water depths of up to 300mm and as such vehicular access/egress should be feasible during a flood event.

5.5 Flood management

The Environment Agency provides a free flood warning service for many areas at risk of flooding from rivers and the sea. In some parts of England, the Environment Agency may be able to provide warnings when flooding is possible. The Environment Agency free flood warning service can provide advance notice of flooding and can provide time to prepare for a potential flood event.

The main means by which flood risks will be managed is through the Environment Agency's flood warning dissemination plan. This makes arrangements for warnings to be provided within this Council's area, including individual warnings to high-risk properties.

Flood Warning and Flood Alert Areas can be viewed on the Environment Agency website. The Environment Agency issue flood warnings to homes and businesses when flooding to properties is expected. Upon receipt of a flood warning, occupants should take immediate action. The Environment Agency also issue flood alerts when flooding to low lying land and roads is expected. Flood alerts cover larger areas than flood warnings and are issued more frequently. Upon receipt of an alert, occupants should be prepared for flooding and to take action. Flood warnings and flood alerts are signed up to separately, however when signing up for flood warnings homes and businesses must agree to receive flood alerts.

All managers and staff should sign up to receive flood warnings. When a flood warning is in place, it is recommended that the outside bar area is not to be used.

5.6 Environmental Permit/Ordinary watercourse easement and consents

Under the Water Resources Act 1991 and associated byelaws, works in, over, under or adjacent to main rivers require the consent of the EA and works in, over, under or adjacent to ordinary watercourses will require IDB, Local Authority or LLFA consent. This is to ensure that they neither interfere with the IDB/EA/LPA/LLFA's work nor adversely affect the environment, fisheries, wildlife and flood defence in the locality.

No watercourses are located within the vicinity of the site, so consent from the EA/LLFA will not be needed for any works on-site concerning proximity to a watercourse, along with the requirement for specific easements for watercourses.

5.7 Groundwater

Due to the potential groundwater flood risk at the site it is recommended that groundwater monitoring is undertaken and suitable mitigation included to anchor any underground tanks if required.

6 PLANNING CONTEXT

6.1 Application of planning policy

Section 14 of the NPPF includes measures specifically dealing with development planning and flood risk using a sequential characterisation of risk based on planning zones and the EA Flood Map. The main study requirement is to identify the flood zones and vulnerability classification relevant to the proposed development, based on an assessment of current and future conditions.

6.2 Land use vulnerability

Planning Practice Guidance (PPG) includes a list of appropriate land uses in each flood zone dependent on vulnerability to flooding. In applying the Sequential Test, reference is made to Table 6.1 below, reproduced from Table 3 of PPG.

Table 6.1: Flood risk vulnerability and flood zone 'compatibility'

Flood Risk Vulnerability Classification		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	Zone 1	Appropriate	Appropriate	Appropriate	Appropriate	Appropriate
	Zone 2	Appropriate	Appropriate	Exception Test Required	Appropriate	**Appropriate**
	Zone 3a	Exception Test Required	Appropriate	Should not be permitted	Exception Test Required	Appropriate
	Zone 3b functional floodplain	Exception Test Required	Appropriate	Should not be permitted	Should not be permitted	Should not be permitted

With reference to Table 2 of the PPG, the proposed development, based on its use as a service, is classed as 'Less Vulnerable'. This classification of development is appropriate for areas within Flood Zone 2 and therefore appropriate for the subject site.

6.3 Sequential Test

The Sequential Test is required to assess flood risk and the PPG recommends that the test be applied at all stages of the planning process to direct new development to areas with the lowest probability of flooding (Flood Zone 1).

The site is located within Flood Zone 2 and passes the Sequential Test; therefore, there is no requirement for the Exception Test to be satisfied.

7 SURFACE WATER DRAINAGE ASSESSMENT

7.1 Scope

As development will be located in Flood Zone 2 and it is less than 1ha in size, the EA requires such development to focus on the management of surface water run-off. This section discusses the potential quantitative effects of the development on both the risk of surface water flooding on-site and elsewhere within the catchment, as well as the type of potential SuDS features that could be incorporated as part of the masterplan.

In accordance with the Defra Non-Statutory Technical Standards, the surface water drainage strategy should seek to implement a SuDS hierarchy that aspires to achieve reductions in surface water runoff rates to greenfield rates. Where a reduction to the greenfield rate is not practicable, the proposed surface water drainage strategy should not exceed the existing runoff rate.

In addition, Building Regulations Part H[17] requires that the first choice of surface water disposal should be to discharge to an adequate soakaway or infiltration system, where practicable. If this is not reasonably practicable then discharge should be to a watercourse, the least favourable option being to a sewer (surface water before combined). Infiltration techniques should therefore be applied wherever they are appropriate.

7.2 Pre-development situation

The development of the proposals will only result in a negligible change in impermeable area from the existing scenario. Following development, it is likely that the site is likely to communicate with the existing drainage system for the service station (via appropriate pollution control measures), and discharge to the combined sewers on-site. Therefore, soakaways or other infiltration based SuDS will not be incorporated into the drainage design and discharge from the site will utilise existing connections.

[17] HM Government (2010 with 2013 amendments), 'The Building Regulations 2010: Approved Document H - Drainage and Waste Disposal (2002 Edition incorporating 2010 amendments)'

8 CONCLUSIONS AND RECOMMENDATIONS

This FRA complies with the NPPF and Planning Practice Guidance and demonstrates that flood risk from all sources has been considered in the proposed development. It is also consistent with the Local Planning Authority requirements with regard to flood risk.

The proposed development site lies in an area designated by the EA as a Flood Zone 2 and is outlined to have between a 1 in 100 and 1 in 1,000 (1%>0.1%) annual probability of river flooding, in any year.

NPPF sets out a Sequential Test, which states that preference should be given to development located within Flood Zone 1. This flood risk assessment demonstrates that the requirements of the Sequential Test have been met, with the location of the site within Flood Zone 2 and 'Less Vulnerable' classification of the development.

This flood risk assessment has considered multiple sources of flooding and concluded the following:

Table 8.1: Flood risk summary

Source	Level of risk	Mitigation
Fluvial	Low-Moderate	The proposed development will remain in Flood Zone 2.
Tidal	Low	The proposed development will remain in Flood Zone 2.
Surface water	Low	The site will remain unaffected by surface water flooding.
Groundwater	Low-Moderate	On-site water was struck between depths of 2.00m to 4.10m.
Sewers	Low	There is no known risk from existing sewers and there is to be no increase in off-site flows or volumes from the development.
Artificial sources	Low	The culverted Eign Brook to the east of the site is not considered to pose a risk to the site if kept clear of debris.

The site should not be at risk from a 1 in 100 year plus 30% climate change fluvial flood event with the proposed finished floor levels of the kiosk being 600mm above the existing flood event level. The finished floor levels of the kiosk should be set at a minimum of 53.28mAOD.

It is recommended that the managers and staff sign up to the Environmental Agency's flood warning system, to be notified in advance of any flooding events to provide time to prepare for a potential flood event.

The proposals will follow best practice regarding site drainage to ensure that any surface water runoff from the development is managed, ensuring flood risk is not increased elsewhere. The proposed development will not increase the impermeable area on-site though it is likely that the surface water drainage from the service station will communicate with the existing drainage network at the establishment.

Overall, taking into account the above points, the development of the site should not be precluded on flood risk grounds.

APPENDIX A
RSK GROUP SERVICE CONSTRAINTS

1. This report and the drainage design carried out in connection with the report (together the "Services") were compiled and carried out by RSK LDE Ltd (RSK) for Gardner Garages Ltd. (the "client") in accordance with the terms of a contract between RSK and the "client". The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable civil engineer at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.

2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.

3. Unless otherwise agreed in writing, the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.

4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.

5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.

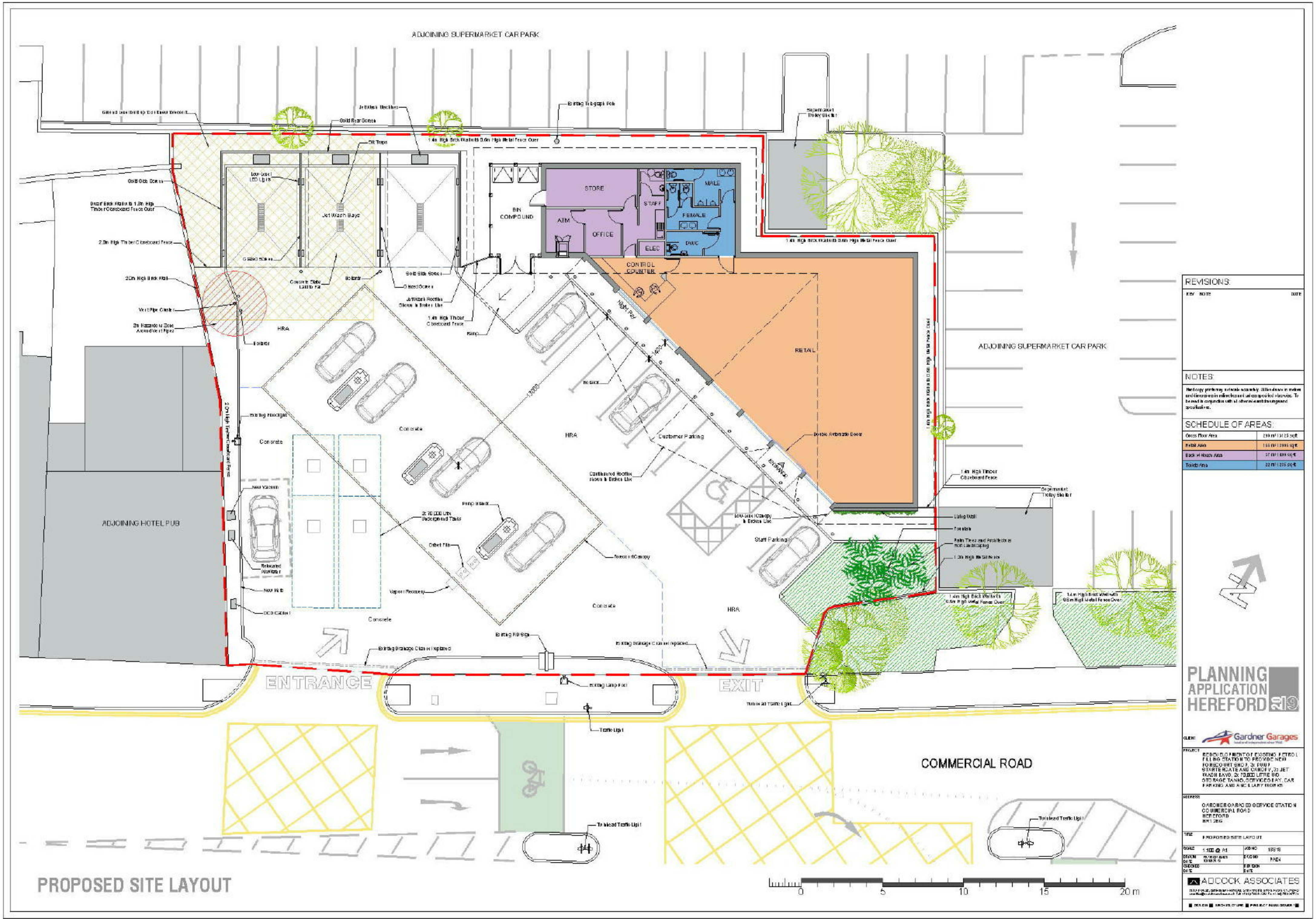
6. The observations and conclusions described in this report are based solely upon the Services, which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.

7. The Services are based upon RSK's observations of existing physical conditions at the site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

8. The phase II or intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition, chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information,] and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (boreholes, trial pits etc) annotated on site plans are not drawn to scale but are centred over the appropriate location. Such features should not be used for setting out and should be considered indicative only.

APPENDIX B
PROPOSED SITE LAYOUT


ADJOINING SUPERMARKET CAR PARK
STORE
STAFF
MALE
FEMALE
DWC
ATM
OFFICE
ELEC
BIN COMPOUND
CONTROL COUNTER
RETAIL
Jet Wash Bays
HRA
Concrete
Customer Parking
Staff Parking
ADJOINING SUPERMARKET CAR PARK
ADJOINING HOTEL PUB
ENTRANCE
EXIT
COMMERCIAL ROAD
PROPOSED SITE LAYOUT
REVISIONS:
NOTES:
SCHEDULE OF AREAS:
Gross Floor Area
Retail Area
Back of House Area
Toilets Area
PLANNING APPLICATION HEREFORD 2019
CLIENT
Gardner Garages
PROJECT
REDEVELOPMENT OF EXISTING PETROL FILLING STATION TO PROVIDE NEW FORECOURT SHOP, 3x PUMP STARTERGATE AND CANOPY, 3x JET WASH BAYS, 2x 70,000 LITRE U/G STORAGE TANKS, SERVICES BAY, CAR PARKING AND ANCILLARY WORKS
ADDRESS
GARDNER GARAGES SERVICE STATION
COMMERCIAL ROAD
HEREFORD
TITLE
PROPOSED SITE LAYOUT
SCALE
1:100 @ A1
ADCOCK ASSOCIATES
0
5
10
15
20 m

APPENDIX C
REPORT REF: 314262 L02 (01)

Our Ref: 314262 L02/CL

04th December 2018

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Abbey Park Industrial Estate
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UK

Telephone: +44 (0)1794 329276
www.rsk.co.uk

Gardner Garages Ltd

Lansdown Road

Cheltenham

Gloucestershire

GL50 2JA

Attention of: Clive Gardner

Dear Clive

RE: CITY SERVICE STATION, 40 COMMERCIAL ROAD, HEREFORD, HR1 2BG

1. BACKGROUND

RSK Environment Limited (RSK) was commissioned by Gardner Garages (the 'Client') to carry out an initial assessment on the potential impact of the ongoing fuel station site use on the shallow soils at the aforementioned site. A plan showing the site area is included as **Figure 1**. The purpose of the assessment was to examine the site with regards to providing an indication as to the current condition of the site with respect to the risks it may pose to sensitive receptors/the environment and as part of the pre-purchase due diligence process.

The subject site is approximately 0.15 hectares in area and is currently an active fuel filling station. The site is broadly rectangular in shape with maximum dimensions in the order of 45m northeast to southwest and 30m north-west to south-east. There are 4 pumps spilt across two pump islands beneath a forecourt canopy fronting onto Commercial Road to the immediate southeast. Car parking is present along the north-eastern and south-western ends of the site, whilst a shop and car wash occupy the north-western half. An interceptor tank is located within the western portion.

With reference to historic mapping data the site and surrounding area is shown to be a wool and leather works (northwest) and a garage/engineering works (northeast). The wool and leather works are no longer indicated on historic maps after 1975. An historic tank farm was located within the south western portion of the site with vent stacks within the northeast portion. Information received from the Petroleum officer indicates that in early 2003 evidence was detected of a potential forecourt collapse caused by an underground void. The information provided indicated that historically the petrol station was built on the site of a former wool and leather factory. Early drawings showed that an old "pit" was present when the factory was constructed and the factory made use of this old "pit"

and, subsequently, built it up using more modern bricks. This was evident as the bottom half of the pit was constructed of a sandstone material and the top half a more modern orange brickwork. It was suggested that the pit could have been used as a tanning/soaking pit.

It appeared that the pit was capped off using railway sleepers or similar which over the years rotted and collapsed. To rectify this issue, it is believed the pit was infilled with a foamed mix of sand/cement and, subsequent line tests for integrity, proved satisfactory. It was further noted that if the pit was used as a tanning/soaking tank there was high possibility that others could be adjacent/near to it. A ground penetrating radar was advised but no evidence of any results can be found. It is presumed by the petroleum officer that no further pits were detected.

The published geological map indicates that the site is underlain by bedrock comprising Carboniferous Period interbedded siltstone and mudstone of the Raglan Mudstone Formation. Superficial deposits are shown to comprise Alluvium (clay, silt, sand and gravel) to the north-east and Glaciofluvial Sheet Deposits (sand and gravel) to the south-west; the site is shown to lie on or close to the boundary between the two. The Glaciofluvial Sheet Deposits have been shown to be dense to very dense.

Historical online borehole data indicates that the superficial material may be in the region of a few metres in thickness and granular in nature. It is anticipated that any groundwater present would be within this stratum over the underlying solid geology, anticipated at a depth greater than 3 m.

The DEFRA Magic Maps website indicates the site is not located within a Groundwater Source Protection Zone; the superficial deposits and bedrock geology are both classified as Secondary A aquifers.

Eign Brook is located some 58 m southeast of the site and flows south southeast towards the River Wye, some 850m south-southwest of the site.

1.1 Limitations

The comments given in this report and the opinions expressed are based on the ground conditions encountered during the site works and on the results of tests made in the field.

However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of Made Ground not detected or the thickness and quality of Made Ground across the site may be variable.

Numerous underground services and obstructions were encountered during both phases of investigation and utility clearance exercise, as such suitable locations for safe investigation were severely limited with a number of attempted holes meeting buried structures in excess of 2.0m depth.

This report is subject to the RSK Service Constraints presented in **Appendix A**.

2 SUMMARY OF WORKS

RSK undertook 5 dynamic sampling holes, designated WS1, WS2, WS2a WS3 and WS4, on the 26th October 2018. Three (WS2, WS2a and WS3) of the exploratory holes refused within dense gravel deposits during the hand digging of the pits with WS1 and WS4 refusing within dense gravels at depth during windowless sampling. Due to ground conditions, the investigation was not able to be completed to install boreholes into groundwater beneath the site.

Subsequently to the above, RSK reattended site between the 19th and 20th of November to commence 3No boreholes using a tracked geo205 to a provisional depth of 5 - 6m.

The depths of the exploratory holes and the reason for their termination are summarised in Table 1 below.

Table 1 Summary of borehole termination depths

Exploratory hole	Termination depth (m)	Reason for termination
WS1	3.00	Refusal of drilling rig due to dense/very dense ground
WS2	0.90	Concrete obstruction
WS2a	0.90	Concrete obstruction
WS3	0.55	Membrane and concrete obstruction
WS4	2.00	Refusal of drilling rig due to dense/very dense ground
BH1	1.10	Refusal within hand pit due to very dense sand and gravel
BH1a	6.00	Depth of investigation achieved
BH2	6.00	Depth of investigation achieved
BH4	2.10	Concrete obstruction

Disturbed soil samples and samples of the groundwater were taken from the exploratory holes for laboratory analysis. The approximate locations of the exploratory holes are given within **Figure 2**.

The descriptions of the strata encountered, list of samples taken, field observations of soil and groundwater and the results of vane shear tests are included on the exploratory hole records presented in **Appendix B**.

3 GROUND CONDITIONS

The RSK investigation identified a covering of Made Ground followed by Glaciofluvial deposits. Within BH2 the top of the weathered bedrock was encountered at a depth of 5.50m. The exploratory hole logs and other site work records are presented in **Appendix B**.

Detailed strata descriptions are outlined below.

Made Ground: Encountered at all exploratory hole positions, beneath the concrete and hardstanding, to a maximum depth 3.00 m, comprised both granular and cohesive portions.

The granular portion consists of greyish brown to reddish brown and noted as black, clayey. gravelly sand with rare cobbles. The gravel fraction contains subrounded to angular brick, clinker, concrete with timber fragments.

The cohesive made ground generally comprised greyish brown sandy, gravelly clay, with the gravel fraction containing subrounded to angular limestone, brick and concrete.

Hydrocarbon odour and staining was noted sporadically across the site within the made ground deposits

Glaciofluvial Deposits: Encountered beneath the made ground between depths of 2.1 m and 6.0 m described as a reddish/greyish brown gravelly sand.

Raglan Mudstone Formation: Encountered in BH2 only at a depth of 5.50m depth described as a stiff to very stiff reddish brown slightly gravelly clay.

3.1 Gas Monitoring

The maximum results from the recent RSK investigation are presented in **Table 2.**

The range of atmospheric pressure over the 2 monitoring rounds completed was 997-1014 mbar and this was recorded to be falling at the time of 2 rounds.

Table 2 Summary of RSK (2018) ground gas monitoring results

Borehole	Response zone/ stratum	Number of monitoring visits	Methane (%)	Carbon dioxide (%)	Oxygen (%)	Flow rate (l/hr)	Water level (m b TOC)	Atmospheric pressure (mbar)
BH1	GF	2	0	1.2	16.8	0	2.67	997 -1014
BH2	GF	2	0	3.1	18.6	0	3.39	
WS1	GF	2	0	2.4	16.1	0.2	Dry	
WS4	MG	2	0	1.4	20.4	0	1.26	
Note: *MG – Made Ground, GF – Glaciofluvial* *Maximum gas concentrations and flows are presented in this table.*								

The results of the initial ground gas monitoring programme has detected no methane, a maximum carbon dioxide concentration of 3.1%v/v and lowest oxygen concentration 16.1%, over a monitoring period with atmospheric pressure conditions varying between 997 and 1014mbar.

- Methane GSV (0 l/hr) = methane concentration (0 % v/v) x flow rate (0.2 l/hr)

- Carbon Dioxide GSV (0.006 l/hr) = carbon dioxide concentration (3.1 % v/v) x flow rate (0.2 l/hr).

Based on the GSVs derived and the method for determining the CS presented within Table 2 of BS8485, the site has been characterised as CS1.

The Gas monitoring results are presented within **Appendix C**.

3.2 Groundwater

Groundwater was encountered within the Glaciofluvial deposits during the drilling of boreholes BH1A and BH2 and window sample WS4.

Subsequent groundwater monitoring encountered a resting groundwater level at depths ranging between 1.26 m bgl within WS4 in the southern portion of the site and 3.51 m within BH2 in the northern portion, is summarised in **Table 3** below.

Table 3 Groundwater results during investigation

Exploratory hole location	Stratum	Groundwater level during monitoring period m bgl (mOD)	
		09/11/18	22/11/18
BH1	Glaciofluvial	-	2.94
BH2	Glaciofluvial	-	3.51
WS1	Glaciofluvial	DRY	-
WS4	Made Ground	1.26	1.58

It can be inferred from the above table that the general groundwater table lies within the Glaciofluvial Deposits. Generally, groundwater is expect to flow in a southeast direction towards Widemarsh Brook. It should be noted that groundwater levels might fluctuate for a number of reasons including seasonal variations. Ongoing monitoring would be required to establish both the full range of conditions and any trends in groundwater levels.

The Groundwater monitoring results are presented within **Appendix C**.

3.3 Visual/olfactory evidence of soil and groundwater contamination

Visual evidence of contamination was encountered in the form of hydrocarbon staining and odours recorded locally throughout the site. On-site PID screening of disturbed samples indicated concentrations of volatile organic compounds (VOCs) of below detection limits with the exception of WS4 at 1.6 m and 2.0 m which recorded readings of 33.0 and 4.0 ppm respectively..

In addition to the above, a strong hydrocarbon odour and black staining was noted within the made ground in WS4 at 1.6 m bgl.

The boreholes were analysed for product using an interface meter and found no detectable product on the surface of the groundwater.

Representative groundwater samples were collected where applicable and scheduled for appropriate analysis.

4 LABORATORY RESULTS

The testing was carried out to assess the levels of contamination within the made ground and natural soils beneath the site with regard to potential risk posed to end users in the context of ongoing use as a filling station and the underlying Secondary aquifer. Testing was undertaken by a UKAS accredited laboratory.

4.1 Soils testing

Soil testing undertaken is summarised in Table 4 below:

Table 4 Summary of chemical testing of soil samples

Stratum	Tests undertaken	No. of tests
Made ground	Speciated TPH, Speciated PAH, metals (As, Cd, Cr, Cu, Hg, Pb, Ni, Se, Zn) and pH	9
	Asbestos screening and ID	9
	TPH, PAH, BTEX and MTBE	9
	VOC and SVOC	9
	Total Organic Carbon (TOC)	9

The comparison of the laboratory results to the applicable RSK human health GAC for a commercial end use indicates that measured concentrations listed above are not found to be in excess of the GAC for a commercial end use.

Asbestos was detected within one of the four samples tested (WS2 at 0.60 m) identified as Chrysotile and Crocidolite.

The results of the laboratory testing are presented within **Appendix D**.

The RSK GAC's for commercial end use are presented in **Appendix E**.

4.2 Groundwater testing

Groundwater testing undertaken is summarised in Table 5 below:

Table 5 Summary of chemical testing of groundwater samples

Stratum	Tests undertaken	No. of tests
Made ground	Speciated TPH, Speciated PAH, metals (As, Cd, Cr, Cu, Hg, Pb, Ni, Se, Zn) and pH	1
	alkanlinity, calcium, DOC	1
	TPH, PAH, BTEX and MTBE	1
	Fuel Oxygenates (ETBE, DIPE, TBA, TAME, ethanol)	1
	Total Organic Carbon (TOC)	1
Glaciofluvial and Raglan Mudstone Formation	Speciated TPH, Speciated PAH, metals (As, Cd, Cr, Cu, Hg, Pb, Ni, Se, Zn) and pH	2
	alkanlinity, calcium, DOC	2
	TPH, PAH, BTEX and MTBE	2
	Fuel Oxygenates (ETBE, DIPE, TBA, TAME, ethanol)	2
	Total Organic Carbon (TOC)	2

Based on the testing carried, no exceedances with regards to the RSK Human Health GrAC for commercial end use have been recorded. Further comparison of the laboratory results to the UK drinking water standards and EQS for freshwater indicates one marginal exceedance has been identified for Cadmium, with a maximum concentration of 9.5.

5 CONCLUSIONS AND RECOMMENDATIONS

Based upon the investigation and subsequent testing carried out at the site, the following comments are made with respect to the site.

- Ground conditions comprise variable made ground extending up to >2.0 m bgl, over water bearing Glaciofluvial Deposits;
- The main potential source of contamination at the site derives from the sites use historically as a wool and leather works, a garage and its current use as a petrol station. Testing of the soils at the site has not identified any exceedances with regards to Human Health GAC's for a continued commercial end use. Furthermore, hardstanding is present across the site, therefore no direct contact pollutant linkages are present with regards to Human Health;
- PID readings at the site ranged between non-detect and 33 ppm. This is not considered to be significant with respect to the current and continued site use;
- Asbestos has been identified below the concrete slab/hardstanding at the site. It is our understanding that no development will be occurring at the site and that the slab/hardstanding will remain in situ, therefore the risks associated with asbestos are

considered very low. Should future in ground works be planned, the future contractor should be made aware to enable them to plan their works accordingly;

- Laboratory testing of the Groundwater underlying the site shows no exceedances of the GAC's, with one marginal exceedance of the EQS for Cadmium recorded within WS4. This is not considered to be significant and therefore a very low risk to human health and controlled waters are anticipated;

Based on the initial investigations undertaken and the results obtained, it is considered that the site is unlikely to pose a significant risk to human health or controlled water receptors. This is based on its current use and setting; should any aspect be altered (for example disturbance of hard landscaping) this assessment will need to be reconsidered. Given the history of the site, degree of subsurface obstructions present and absence of a monitoring point directly down hydraulic gradient of the tanks, it is always possible that impacted soils and groundwater exist outside of the extents of this investigation.

We trust that the above meets with your current requirements, but please do not hesitate to contact the undersigned if you require further information or you have any queries.

Yours sincerely
For RSK Environment Limited

[redacted]

Craig Lewis
Senior Geoenvironmental Consultant

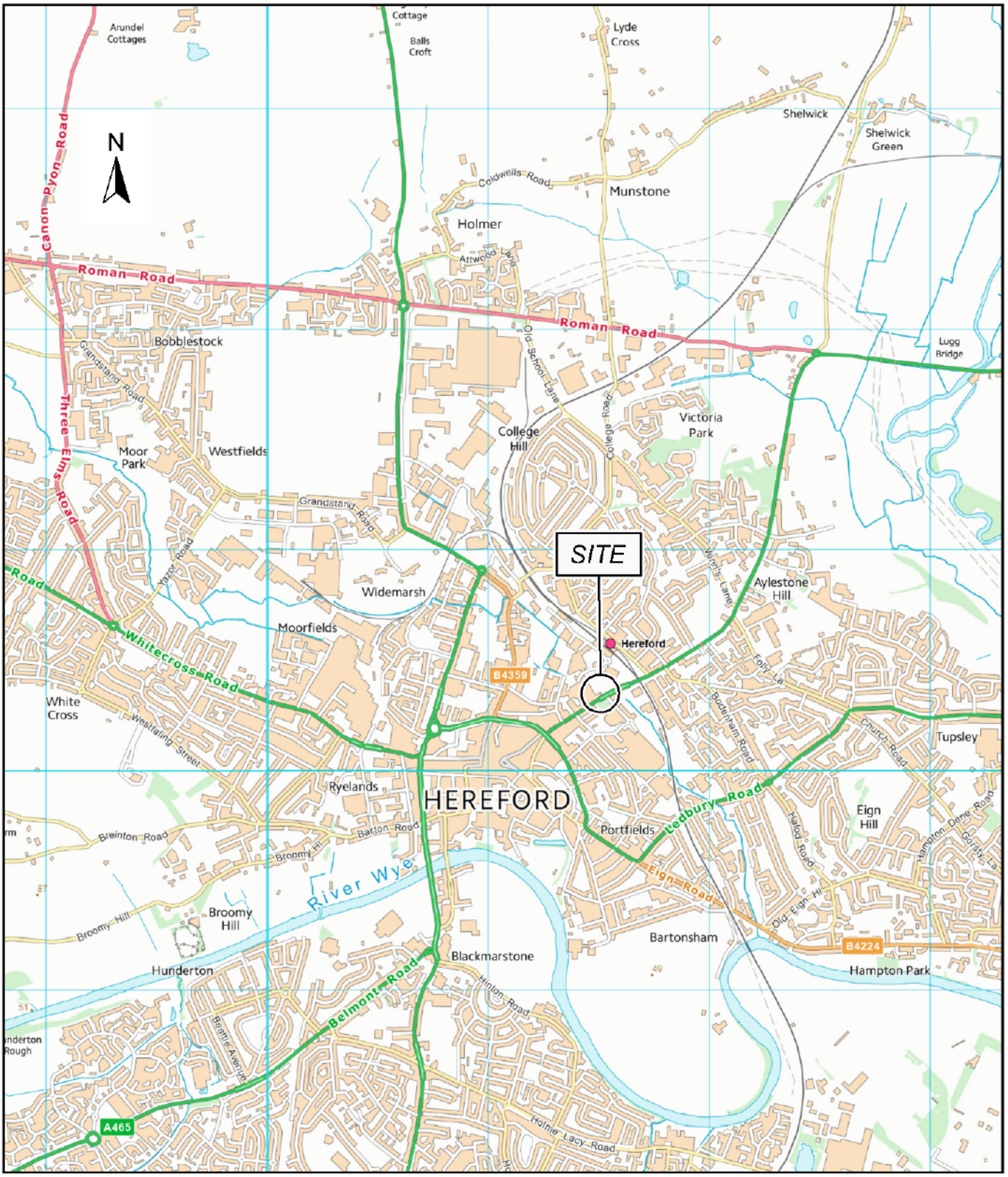
[redacted]

Jeremy Leach
Associate Director

Enc.

Figure 1	Site Location plan
Figure 2	Exploratory Hole Location Plan
Appendix A	Service constraints
Appendix B	Exploratory hole records
Appendix C	Gas and Groundwater Monitoring results
Appendix D	Laboratory Test Results
Appendix E	RSK Generic Assessment Criteria - Commercial

FIGURES



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Client: Gardner Garages

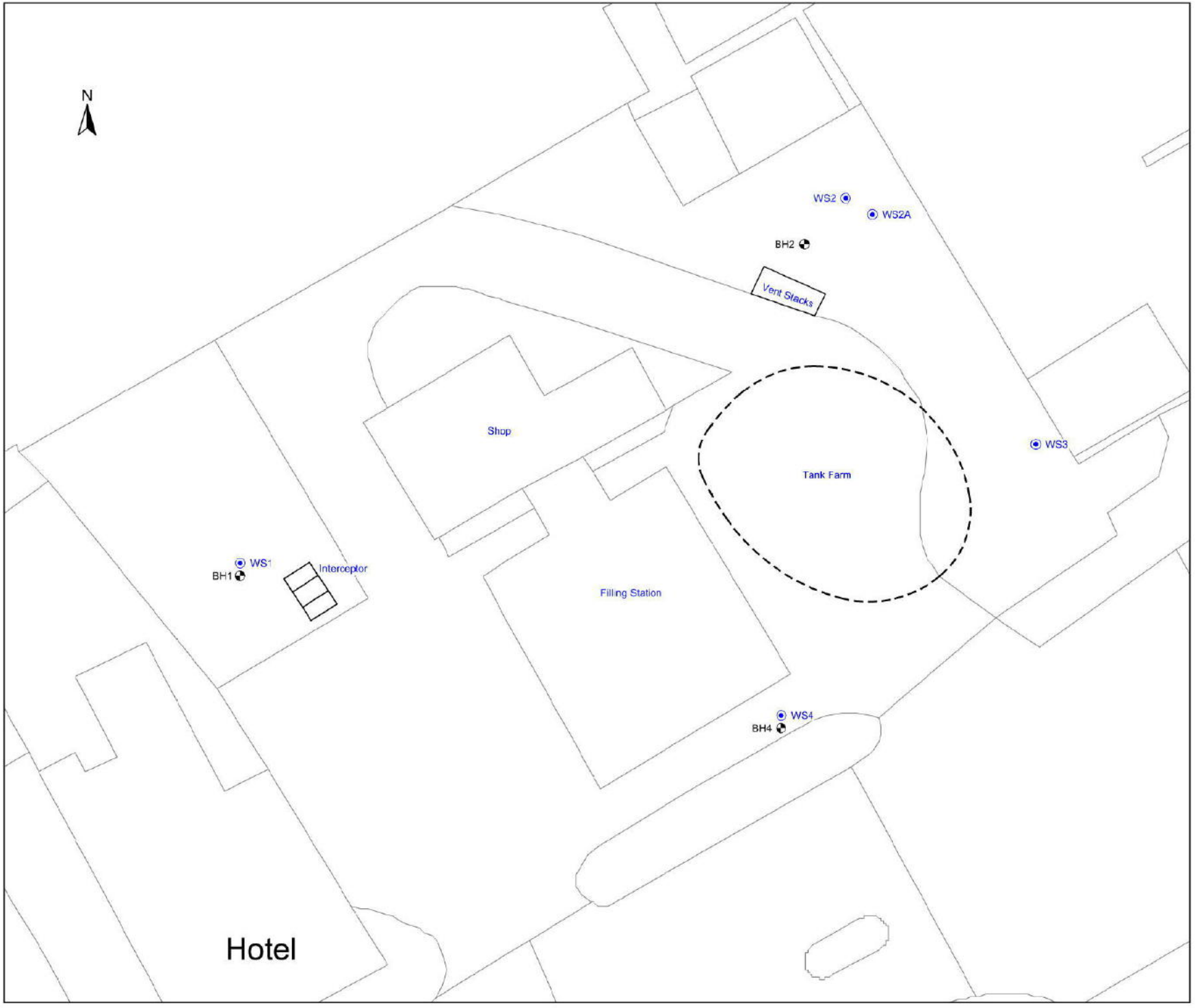
Project Title: Gardner Garage, Hereford

Drawing Title: SITE LOCATION MAP

Rev	Drawn	Date	Checked	Date	Approved	Date
00	MW	30.11.18	CL	30.11.18	-	-

Dimensions	Scale	Original Size
m	1:25,000	A4

Project Number	Grid Ref	Scale Bar	Drawing Number
314262	SO 515 403	0 250 500 750 1,000m	FIGURE 1



LEGEND

- Borehole Location
- Window Sample Location
- Approximate Area of Historic Areas

Rev.	Date	Amendment	Drawn	Chkd.	Appd.
00	30.11.2018	-	MW	CL	-

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Project Title: Gardner Garage, Hereford

Drawing Title: Exploratory Hole Location Plan

Drawn	Date	Checked	Date	Approved	Date
MW	30.11.18	CL	30.11.18	-	-

Dimensions	Scale	Original Size
m	NTS	A3

Project Number	Drawing Number
314262	Figure 2

Drawing File	Rev
314262 - Fig 2 - rev 00 - EHLP	00

APPENDIX A
SERVICE CONSTRAINTS

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK Environment Limited (RSK) for Gardner Garages (the "Client") in accordance with the terms of a contract between RSK and the "client".. The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.

2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.

3. Unless otherwise agreed in writing the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. **Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.**

4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK 's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date of this report, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.

5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.

6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.

7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walk-over survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walk-over survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.

8. The intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information], and it should not be inferred that other chemical species are not present.

9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site. Features (boreholes, trial pits etc) annotated on site plans are not drawn to scale but are centred over the approximate location. Such features should not be used for setting out and should be considered indicative only.

APPENDIX B
EXPLORATORY HOLE LOGS

BOREHOLE LOG

Contract:	Client:	Borehole:
City Service Station	**Gardner Garages Ltd**	**BH1**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
314262	**11.19.18**	**---**	**---**	**1** of **1**
	End: **11.19.18**			

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
0.50-0.70 0.50		ES PID	0.0ppm			MADE GROUND: Asphalt.	0.10	
						MADE GROUND: Coarse angular limestone GRAVEL with low limestone cobble content. Sub-base.	0.30	
						MADE GROUND: Dark black gravelly fine to coarse SAND with low cobble content and occasional brick. Gravel is fine to coarse of sandstone becoming black coarse SAND at 0.50m depth.	(0.80)	
						Borehole terminated at 1.10m depth.	1.10	

Boring Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth

Chiselling / Slow Progress		
From	To	Duration (hh:mm)

General Remarks

1. GPR service scan.
2. HP to 1.10m depth.
3. End of hole at 1.10m depth.
4. Backfilled with bentonite.

All dimensions in metres | Scale: **1:50**

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Cable percussion	**Comacchio GEO 205**	**DSUK**	**RNewberry**	

BOREHOLE LOG

Contract:	Client:	Borehole:
City Service Station	**Gardner Garages Ltd**	**BH1A**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
314262	**10.26.18** End: **11.20.18**	**---**	**---**	**1** of **1**

Samples and In-situ Tests				Water	Backfill & Instru-mentation	Description of Strata	Depth (Thick ness)	Material Graphic Legend
Depth	No	Type	Results					
						MADE GROUND: Asphalt	0.29	
						MADE GROUND: Concrete	0.33	
						MADE GROUND: Yellowish brown very gravelly medium to coarse SAND. Gravel is sub-angular to sub-rounded fine to coarse frequent brick and concrete with rare clinker and glass.	0.40 (0.60) 1.00	
						MADE GROUND: Reddish brown very sandy sub-angular to sub-rounded fine to coarse GRAVEL with a low cobble content. Sand is medium to coarse. Gravel of frequent brick and limestone. Rare brick cobbles.	1.20 (0.90)	
						MADE GROUND: Degraded wood across base of pit with black staining and moderate hydrocarbon odour.	2.10	
						Between 1.2 and 2 m core run, little recovery. Soils recovered comprise wood fragments, with brick cobble stuck in base of barrel		
						Reddish brown very gravelly coarse SAND. Gravel of sub-angular to sub-rounded fine to coarse mudstone, sandstone and quartzite. (GLACIOFLUVIAL DEPOSITS)	(0.90) 3.00	
3.20-3.40 3.20		ES PID	0.0ppm	≈		Reddish brown very gravelly fine to coarse SAND with a low cobble content. Gravel is fine to coarse sandstone, siltstone and quartzite. Becoming reddish brown sand and gravel. (GLACIOFLUVIAL DEPOSITS)	(3.00)	
5.10-5.30 5.10		ES PID	0.0ppm				6.00	
						Borehole terminated at 6.00m depth.		

Boring Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth

Chiselling / Slow Progress		
From	To	Duration (hh:mm)

General Remarks

1. GPR service scan.
2. Groundwater encountered at 3.60m depth.
3. End of hole at 6.00m depth.
4. Installed with 2.00m of plain pipe and 4.00m of slotted pipe.

All dimensions in metres | Scale: **1:50**

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Cable percussion	**Comacchio GEO 205**	**DSUK**	**RNewberry**	AGS

BOREHOLE LOG

Contract:	Client:	Borehole:
City Service Station	Gardner Garages Ltd	BH2

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
314262	11.19.18	---	---	1 of 1
	End: 11.19.18			

Samples and In-situ Tests				Water	Backfill & Instru-mentation	Description of Strata	Depth (Thick ness)	Material Graphic Legend
Depth	No	Type	Results					
						MADE GROUND: Asphalt.	0.10	
0.40-0.60 0.40		ES PID	0.0ppm			MADE GROUND: Reddish brown clayey gravelly fine to coarse SAND. Gravel is fine to coarse angular to subrounded of frequent slate, sandstone and mudstone and occasional brick and metal wire. . . . at 0.70m brick structure.	(0.80) 0.90	
						MADE GROUND: Brown slightly slightly gravelly sandy CLAY. Gravel is fine to coarse subangular to subrounded mudstone, sandstone and rare slate.	1.30	
1.20-1.40 1.20		ES PID	0.0ppm			Firm dark brown sandy gravelly CLAY with low sandstone cobble content. Gravel is subangular to subrounded of sandstone and rare quartzite. (GLACIOFLUVIAL DEPOSITS)	(1.30)	
							2.60	
2.80-3.00 2.80		ES PID	0.0ppm			Greyish brown gravelly fine to coarse SAND. Gravel is fine to coarse subangular to subrounded sandstone. Becoming reddish brown below 3.30m depth. (GLACIOFLUVIAL DEPOSITS)	(2.90)	
							5.50	
5.20-5.40 5.20		ES PID	0.0ppm			Stiff to very stiff reddish brown slightly gravelly CLAY. (RAGLAN MUDSTONE FORMATION)	(0.50)	
							6.00	
						Borehole terminated at 6.00m depth.		

Boring Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth

Chiselling / Slow Progress		
From	To	Duration (hh:mm)

General Remarks

1. GPR service scan.
2. HP to 1.20m depth.
3. Groundwater encountered at 4.10m depth.
4. Installed with 2.00m of plain pipe and 4.00m f slotted pipe.
5. End of hole at 6.00m depth.

All dimensions in metres | Scale: 1:50

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Cable percussion	Comacchio GEO 205	DSUK	RNewberry	

BOREHOLE LOG

Contract:	Client:	Borehole:
City Service Station	Gardner Garages Ltd	BH4

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
314262	11.20.18	---	---	1 of 1
	End: 11.20.18			

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
0.50-0.70 0.50		ES PID	0.0ppm			MADE GROUND: Asphalt.	0.07	
						MADE GROUND: Concrete.	0.20	
						MADE GROUND: Greyish brown very gravelly fine to coarse SAND. Gravel is fine to coarse angular to subrounded ofslate, sandstone and mudstone and rare glass and metal wire.	(0.60) 0.80	
1.10-1.30 1.10		ES PID	0.0ppm			MADE GROUND: Brown slightly sandy gravelly CLAY. Gravel is fine to coarse of sandstone, mudstone and occasional slate and brick fragments with rare quartzite fragments.	(1.30)	
				≈			2.10	
						Borehole terminated at 2.10m depth on concrete obstruction.		

Boring Progress and Water Observations					
Date	Time	Borehole Depth	Casing Depth	Borehole Diameter (mm)	Water Depth

Chiselling / Slow Progress		
From	To	Duration (hh:mm)

General Remarks

1. HP to 1.20m depth.
2. Groundwater encountered at 2.00m depth.
3. End of hole at 2.10m depth on concrete.
4. Backfilled with bentonite.

All dimensions in metres | Scale: 1:50

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Cable percussion	Comacchio GEO 205	DSUK	RNewberry	AGS

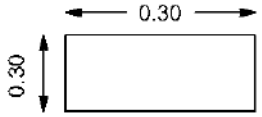
TRIAL PIT LOG

Contract:	Client:	Trial Pit:
City Service Station	Gardner Garages Ltd	WS2

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
314262	10.26.18	---	---	1 of 1
	End: 10.26.18			

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						MADE GROUND: Asphalt.	0.07	
						MADE GROUND: Reddish brown very sandy GRAVEL. Sand is coarse. Gravel of sub-angular to angular fine to coarse limestone scalpings (type 1).	0.20	
						MADE GROUND: Greyish brown gravelly very sandy CLAY. Sand is medium. Gravel of sub-angular to sub-rounded fine to coarse brick, slate, sandstone and rare concrete. Localised pockets of sand.	(0.70)	
						. . . at 0.8m boulder sized breeze block (>200mm)	0.90	
						Terminated at 0.90 m bgl due to refusal on concrete		

Plan (Not to Scale)



General Remarks

1. Scanned with GPR and CAT/Genny.
2. No groundwater encountered
3. Concrete obstruction encountered at 0.9 m bgl during hand excavation
4. Backfilled with arisings and concrete plug upon completion.

All dimensions in metres | Scale: 1:25

Method Used:	Plant Used:	Logged By:	Checked By:
Hand dug	Hand tools	HBovenizer	

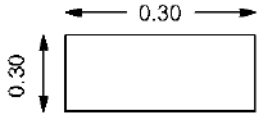
TRIAL PIT LOG

Contract:	Client:	Trial Pit:
City Service Station	Gardner Garages Ltd	WS2A

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
314262	10.26.18	---	---	1 of 1
	End: 10.26.18			

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						MADE GROUND: Asphalt.	0.07	
						MADE GROUND: Reddish brown very sandy GRAVEL. Sand is coarse. Gravel of sub-angular to angular fine to coarse limestone scalpings (type 1).	0.20	
0.40		PID	0.0ppm			MADE GROUND: Greyish brown gravelly very sandy CLAY. Sand is medium. Gravel of sub-angular to sub-rounded fine to coarse brick, slate sandstone and rare concrete. Localised pockets of sand.	(0.70)	
0.60		ES	1xT 1xJ 1xV					
0.80		PID	0.0ppm				0.90	
						Terminated at 0.90 m bgl due to refusal on concrete		

Plan (Not to Scale)



General Remarks

1. Scanned with GPR and CAT/Genny.
2. No groundwater encountered
3. Concrete obstruction encountered at 0.9 m bgl during hand excavation
4. Backfilled with arisings and concrete plug upon completion.

All dimensions in metres | Scale: 1:25

Method Used:	Plant Used:	Logged By:	Checked By:
Hand dug	Hand tools	HBovenizer	

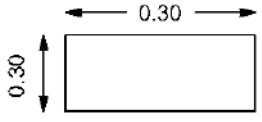
TRIAL PIT LOG

Contract:	Client:	Trial Pit:
City Service Station	Gardner Garages Ltd	WS3

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
314262	10.26.18	---	---	1 of 1
	End: 10.26.18			

Samples and In-situ Tests				Water	Backfill	Description of Strata	Depth (Thickness)	Material Graphic Legend
Depth	No	Type	Results					
						MADE GROUND: Asphalt.	0.07	
						MADE GROUND: Reddish brown very sandy GRAVEL. Sand is coarse. Gravel of sub-angular to angular fine to coarse limestone scalpings (type 1).	0.15	
0.40 0.40		ES PID	1xT 1xJ 1xV 0.0ppm			MADE GROUND: Greyish brown gravelly very sandy CLAY. Sand is medium. Gravel of sub-angular to sub-rounded fine to coarse brick, slate, sandstone and rare concrete. Localised pockets of sand.	(0.40)	
						Terminated at 0.55 m bgl due to refusal on membrane over concrete	0.55	

Plan (Not to Scale)



General Remarks

1. Scanned with GPR and CAT/Genny.
2. No groundwater encountered
3. Concrete obstruction encountered at 0.55 m bgl during hand excavation
4. Backfilled with arisings and concrete plug upon completion.

All dimensions in metres | Scale: 1:25

Method Used:	Plant Used:	Logged By:	Checked By:
Hand dug	Hand tools	HBovenizer	

WINDOW SAMPLE LOG

Contract:	Client:	Window Sample:
City Service Station	**Gardner Garages Ltd**	**WS1**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
314262	**10.26.18** End: **10.26.18**	**---**	**---**	**1** of **1**

Progress	Samples / Tests				Water	Backfill & Instru-mentation	Description of Strata	Depth (Thick ness)	Material Graphic Legend
Window Run	Depth	No	Type	Results					
							MADE GROUND: Asphalt.	0.10	
	0.10		PID	0.0ppm			MADE GROUND: Reddish brown very sandy sub-angular to sub-rounded fine to coarse GRAVEL with low cobble content. Sand is medium to coarse. Gravel of brick and limestone. Rare brick cobble.	0.29	
							MADE GROUND: Concrete.	0.33	
	0.60		ES	1xT 1xJ 1xV			MADE GROUND: Yellow brown very gravelly SAND. Sand is medium to coarse. Gravel of sub-angular to sub-rounded fine to coarse brick and concrete, with rare glass. Rare clinker	(0.67)	
	0.60		PID	0.0ppm			. . . from 0.6m, cobbles of brick, concrete and breeze blocks.	1.00	
							. . . from 0.6 m becoming black/ashy		
	1.10		PID	20.0ppm			MADE GROUND: Degraded wood across base of pit with black staining, with hydrocarbon odour.	1.20	
							. . . at 1.0 m to 1.2 m, degraded wood across base of pit, black staining, with hydrocarbon odour.		
							Between 1.2 and 2 m core run, little recovery. Soils recovered comprise wood fragments, with brick cobble stuck in base of barrel.	(0.90)	
	2.00		ES	1xT 1xJ 1xV			. . . from 2 m pocket of foul lime and becoming more clayey, with fine clinker gravel (at top of core run 2 m to 3 m)	2.10	
	2.00		PID	0.0ppm			Reddish brown very gravelly coarse SAND. Gravel of sub-angular to sub-rounded fine to coarse mudstone, sandstone and quartzite.		
	2.50		PID	0.0ppm			(GLACIOFLUVIAL DEPOSITS)	(0.90)	
							. . . at 2.6 m cobble of sandstone		
								3.00	
	3.00		ES	1xT 1xJ 1xV			. . . at 3.0 m becoming damp		
	3.00		PID	0.0ppm			Terminated at 3.00 m bgl, due to refusal of drilling barrel.		

Drilling Progress and Water Observations					
Date	Time	Borehole Depth (m)	Casing Depth (m)	Borehole Diameter (mm)	Water Depth (m)

General Remarks

1. Scanned with GPR and CAT/Genny. Hand dug pit to 1.2 m bgl
2. No groundwater encountered
3. Installed with gas and groundwater monitoring pipe, with response zone between 2 m and 3 m bgl

All dimensions in metres | Scale: **1:25**

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Inspection pit + Tracked window sampling	**Archway Competitor**	**???**	**HBovenizer**	

WINDOW SAMPLE LOG

Contract:	Client:	Window Sample:
City Service Station	**Gardner Garages Ltd**	**WS4**

Contract Ref:	Start:	Ground Level:	Co-ordinates:	Sheet:
314262	**10.26.18**	**---**	**---**	**1** of **1**
	End: **10.26.18**			

Progress	Samples / Tests				Water	Backfill & Instrumentation	Description of Strata	Depth (Thickness)	Material Graphic Legend
Window Run	Depth	No	Type	Results					
							MADE GROUND: Asphalt	0.08	
							MADE GROUND: Concrete	0.19	
							MADE GROUND: Reddish brown very sandy GRAVEL. Gravel of angular to sub-angular fine to coarse limestone scalpings.	0.40	
	0.50		PID	0.0ppm			MADE GROUND: Reddish brown sandy very gravelly CLAY. Sand is medium. Gravel of angular to sub-rounded brick and quartzite with rare concrete.	(0.50)	
	0.60		ES	1xT 1xJ 1xV				0.90	
	1.20		ES	1xT 1xJ 1xV			MADE GROUND: Reddish brown slighty gravelly sandy CLAY. Sand is medium. Gravel of sub-angular to sub-rounded fine to medium quartzite and mudstone with rare brick.		
	1.20		PID	0.0ppm				(1.10)	
	1.60		ES	1xT 1xJ 1xV			. . . between 1.6 m and 1.7 m, black staining and hydrocarbon odour.		
	1.60		PID	33.0ppm			. . . from 1.7 m hydrocarbon odour lessenign toward base of borehole		
							. . . at 1.95 m, possibly into top of sands and gravels (glacial till)	2.00	
	2.00		ES	1xT 1xJ 1xV			Terminated at 2.00 m bgl, due to refusal of drilling barrel.		
	2.00		PID	4.0ppm					

Drilling Progress and Water Observations					
Date	Time	Borehole Depth (m)	Casing Depth (m)	Borehole Diameter (mm)	Water Depth (m)

General Remarks

1. Scanned with GPR and CAT/Genny. Hand dug pit to 1.2 m bgl
2. No groundwater encountered
3. Installed with gas and groundwater monitoring pipe, with response zone between 1 m and 2 m bgl

All dimensions in metres | Scale: **1:25**

Method Used:	Plant Used:	Drilled By:	Logged By:	Checked By:
Inspection pit + Tracked window sampling	**Archway Competitor**	**???**	**HBovenizer**	

APPENDIX C
GAS AND GROUNDWATER MONITORING RESULTS

IN-SITU GAS MONITORING RESULTS

[Pressures]	Previous	During	Start	End	Equipment Used & Remarks
Round 1	Constant	Constant	997	997	Weather: Overcast + Ground: Dry + Wind: Light + Air Temp: 10DegC
Round 2	-	Rising	1013	1014	Weather: Clear + Ground: Dry + Wind: None + Air Temp: 4DegC

Exploratory Position ID	Pipe ref	Pipe diameter (mm)	Monitoring Round	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)
BH1	#REF!	#REF!	2	NDA	---	No Installation	22/11/2018 10:21:00	1014	1014	$0.0_{(I)}$	-	-	-	-	-	-	-
BH1	#REF!	#REF!	2		---	No Installation	60 secs	-	-	$0.0_{(SS)}$	-	-	-	-	-	-	-
BH1	#REF!	#REF!	2 (2)	NDA	---	No Installation	22/11/2018 10:23:00	-	-	-	-	0.1	0.0	20.9	3.4	0	0
BH1	#REF!	#REF!	2 (2)		---	No Installation	15 secs	-	-	-	-	1.1	0.0	19.7	-	158	0
BH1	#REF!	#REF!	2 (2)		---	No Installation	30 secs	-	-	-	-	1.1	0.0	17.8	-	232	0
BH1	#REF!	#REF!	2 (2)		---	No Installation	60 secs	-	-	-	-	1.1	0.0	17.2	-	212	0
BH1	#REF!	#REF!	2 (2)		---	No Installation	90 secs	-	-	-	-	1.1	0.0	17.1	-	193	0
BH1	#REF!	#REF!	2 (2)		---	No Installation	120 secs	-	-	-	-	1.1	0.0	17.1	-	179	0
BH1	#REF!	#REF!	2 (2)		---	No Installation	180 secs	-	-	-	-	1.1	0.0	17.1	-	163	0
BH1	#REF!	#REF!	2 (2)		---	No Installation	240 secs	-	-	-	-	1.1	0.0	17.1	-	161	0
BH1	#REF!	#REF!	2 (2)		---	No Installation	300 secs	-	-	-	-	1.2	0.0	17.0	-	168	0
BH1	#REF!	#REF!	2 (2)		---	No Installation	360 secs	-	-	-	-	1.2	0.0	17.0	-	181	1
BH1	#REF!	#REF!	2 (2)		---	No Installation	420 secs	-	-	-	-	1.2	0.0	16.9	-	195	1
BH1	#REF!	#REF!	2 (2)		---	No Installation	480 secs	-	-	-	-	1.2	0.0	16.8	-	210	1
BH1	#REF!	#REF!	2 (2)		---	No Installation	540 secs	-	-	-	-	1.2	0.0	16.8	-	223	1
BH1	#REF!	#REF!	2 (2)		---	No Installation	600 secs	-	-	-	-	1.2	0.0	16.8	-	223	1
BH1	#REF!	#REF!	2 (3)	NDA	5.48	No Installation	22/11/2018 10:34:00	-	-	-	2.67	-	-	-	-	-	-

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

RSK Environment Ltd
The Old School
Stillhouse Lane
Bedminster
Bristol BS3 4EB

Compiled By	Date	Checked By	Date	Contract Ref:
[redacted]	26/11/18			314262

Contract: **City Service Station**

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IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Pipe ref	Pipe diameter (mm)	Monitoring Round	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)
BH2	1	50	2	6.00	---	2.00 to 6.00	22/11/2018 09:11:00	1014	1014	$0.0_{(I)}$	-	-	-	-	-	-	-
BH2	1	50	2		---	2.00 to 6.00	60 secs	-	-	$0.0_{(SS)}$	-	-	-	-	-	-	-
BH2	1	50	2 (2)	6.00	---	2.00 to 6.00	22/11/2018 09:13:00	-	-	-	-	0.1	0.0	20.9	0.5	0	0
BH2	1	50	2 (2)		---	2.00 to 6.00	15 secs	-	-	-	-	2.9	0.0	20.5	-	0	0
BH2	1	50	2 (2)		---	2.00 to 6.00	30 secs	-	-	-	-	2.9	0.0	19.1	-	1	0
BH2	1	50	2 (2)		---	2.00 to 6.00	60 secs	-	-	-	-	3.0	0.0	18.8	-	1	0
BH2	1	50	2 (2)		---	2.00 to 6.00	90 secs	-	-	-	-	3.0	0.0	18.8	-	0	0
BH2	1	50	2 (2)		---	2.00 to 6.00	120 secs	-	-	-	-	3.0	0.0	18.8	-	0	0
BH2	1	50	2 (2)		---	2.00 to 6.00	180 secs	-	-	-	-	3.0	0.0	18.7	-	0	0
BH2	1	50	2 (2)		---	2.00 to 6.00	240 secs	-	-	-	-	3.0	0.0	18.7	-	0	0
BH2	1	50	2 (2)		---	2.00 to 6.00	300 secs	-	-	-	-	3.1	0.0	18.6	-	0	0
BH2	1	50	2 (3)	6.00	5.58	2.00 to 6.00	22/11/2018 09:19:00	-	-	-	3.39	-	-	-	-	-	-
WS1	1	50	1	3.00	---	2.00 to 3.00	09/11/2018 08:38:00	997	997	$0.1_{(I)}$	-	-	-	-	-	-	-
WS1	1	50	1		---	2.00 to 3.00	60 secs	-	-	$0.2_{(SS)}$	-	-	-	-	-	-	-
WS1	1	50	1 (2)	3.00	---	2.00 to 3.00	09/11/2018 08:40:00	-	-	-	-	0.1	0.0	20.9	0.3	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	15 secs	-	-	-	-	1.0	0.0	19.4	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	30 secs	-	-	-	-	0.9	0.0	19.0	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	60 secs	-	-	-	-	1.0	0.0	18.7	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	90 secs	-	-	-	-	0.9	0.0	18.9	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	120 secs	-	-	-	-	0.9	0.0	18.9	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	180 secs	-	-	-	-	1.1	0.0	18.5	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	240 secs	-	-	-	-	1.2	0.0	18.3	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	300 secs	-	-	-	-	1.4	0.0	18.0	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	360 secs	-	-	-	-	1.5	0.0	17.6	-	0	0

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Pipe ref	Pipe diameter (mm)	Monitoring Round	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)
WS1	1	50	1 (2)		---	2.00 to 3.00	420 secs	-	-	-	-	1.7	0.0	17.4	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	480 secs	-	-	-	-	2.0	0.0	16.6	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	540 secs	-	-	-	-	2.2	0.0	16.4	-	0	0
WS1	1	50	1 (2)		---	2.00 to 3.00	600 secs	-	-	-	-	2.4	0.0	16.1	-	0	0
WS1	1	50	1 (3)	3.00	2.60	2.00 to 3.00	09/11/2018 08:51:00	-	-	-	DRY	-	-	-	-	-	-
WS4	1	50	1	2.00	---	1.00 to 2.00	09/11/2018 07:52:00	997	997	$0.0_{(I)}$	-	-	-	-	-	-	-
WS4	1	50	1		---	1.00 to 2.00	60 secs	-	-	$0.0_{(SS)}$	-	-	-	-	-	-	-
WS4	1	50	1 (2)	2.00	---	1.00 to 2.00	09/11/2018 07:54:00	-	-	-	-	0.1	0.0	21.0	0.5	0	0
WS4	1	50	1 (2)		---	1.00 to 2.00	15 secs	-	-	-	-	1.2	0.0	20.5	-	0	0
WS4	1	50	1 (2)		---	1.00 to 2.00	30 secs	-	-	-	-	1.2	0.0	20.2	-	0	0
WS4	1	50	1 (2)		---	1.00 to 2.00	60 secs	-	-	-	-	1.2	0.0	20.2	-	0	0
WS4	1	50	1 (2)		---	1.00 to 2.00	90 secs	-	-	-	-	1.2	0.0	20.2	-	0	0
WS4	1	50	1 (2)		---	1.00 to 2.00	120 secs	-	-	-	-	1.2	0.0	20.2	-	0	0
WS4	1	50	1 (2)		---	1.00 to 2.00	180 secs	-	-	-	-	1.2	0.0	20.1	-	0	0
WS4	1	50	1 (2)		---	1.00 to 2.00	240 secs	-	-	-	-	1.2	0.0	20.2	-	0	0
WS4	1	50	1 (2)		---	1.00 to 2.00	300 secs	-	-	-	-	1.2	0.0	20.2	-	0	0
WS4	1	50	1 (3)	2.00	1.79	1.00 to 2.00	09/11/2018 08:00:00	-	-	-	1.26	-	-	-	-	-	-
WS4	1	50	2	2.00	---	1.00 to 2.00	22/11/2018 08:13:00	1013	1013	$0.0_{(I)}$	-	-	-	-	-	-	-
WS4	1	50	2		---	1.00 to 2.00	60 secs	-	-	$0.0_{(SS)}$	-	-	-	-	-	-	-
WS4	1	50	2 (2)	2.00	---	1.00 to 2.00	22/11/2018 08:15:00	-	-	-	-	0.1	0.0	21.0	0.1	0	0
WS4	1	50	2 (2)		---	1.00 to 2.00	15 secs	-	-	-	-	1.4	0.0	20.8	-	0	0
WS4	1	50	2 (2)		---	1.00 to 2.00	30 secs	-	-	-	-	1.4	0.0	20.5	-	0	0
WS4	1	50	2 (2)		---	1.00 to 2.00	60 secs	-	-	-	-	1.4	0.0	20.4	-	0	0
WS4	1	50	2 (2)		---	1.00 to 2.00	90 secs	-	-	-	-	1.4	0.0	20.4	-	0	0

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

RSK Environment Ltd
The Old School
Stillhouse Lane
Bedminster
Bristol BS3 4EB

Compiled By	Date	Checked By	Date	Contract Ref:
[redacted]	26/11/18			314262

Contract: **City Service Station**

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IN-SITU GAS MONITORING RESULTS

Exploratory Position ID	Pipe ref	Pipe diameter (mm)	Monitoring Round	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring (elapsed time)	Borehole Pressure (mb)	Atmos Pressure (mb)	Gas Flow (l/hr)	Water Depth (mbgl)	Carbon Dioxide (% / vol)	Methane (% / vol)	Oxygen (% / vol)	PID (ppm)	Carbon Monoxide (ppm)	Hydrogen Sulphide (ppm)
WS4	1	50	2 (2)		---	1.00 to 2.00	120 secs	-	-	-	-	1.4	0.0	20.5	-	0	0
WS4	1	50	2 (2)		---	1.00 to 2.00	180 secs	-	-	-	-	1.4	0.0	20.5	-	0	0
WS4	1	50	2 (2)		---	1.00 to 2.00	240 secs	-	-	-	-	1.3	0.0	20.6	-	0	0
WS4	1	50	2 (2)		---	1.00 to 2.00	300 secs	-	-	-	-	1.3	0.0	20.6	-	0	0
WS4	1	50	2 (3)	2.00	1.78	1.00 to 2.00	22/11/2018 08:21:00	-	-	-	1.57	-	-	-	-	-	-

Key: I = Initial, P = Peak, SS = Steady State. Note: LEL = Lower Explosive Limit = 5% v/v.

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Compiled By	Date	Checked By	Date	Contract Ref:
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Contract: **City Service Station**

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IN-SITU WATER MONITORING RESULTS

	Weather	Ground Conditions	Wind Conditions	Air Temperature (°C)	Equipment Used & Remarks
Round 1	Overcast	Dry	Light	10	
Round 2	Clear	Dry	None	4	

Exploratory Position ID	Pipe Ref	Pipe Diameter	Monitoring Round / Test Number	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring	Water Depth (mbgl)	pH	Redox (mV)	Conduc-tivity (uS/cm)	Temp-erature (°C)	Dissolved Oxygen (mg/l)	Remarks
BH1	1	NDA	2 / 1	NDA	5.75	NDA to NDA	22/11/2018 10:40	2.94	7.26	207	1245	7.2	2.5	
BH1	1	NDA	2 / 1				22/11/2018 10:43	2.94	7.04	269	1204	10.8	0.8	
BH1	1	NDA	2 / 1				22/11/2018 10:46	2.94	6.95	266	1189	12.2	0.5	
BH1	1	NDA	2 / 1				22/11/2018 10:49	2.94	6.89	259	1177	12.9	0.4	
BH1	1	NDA	2 / 1				22/11/2018 10:52	2.94	6.85	259	1176	13.0	0.3	
BH2	1	50	2 / 1	6.00	5.70	2.00 to 6.00	22/11/2018 09:31	3.51	6.91	167	1787	7.6	5.4	
BH2	1	50	2 / 1				22/11/2018 09:34	3.51	6.79	163	1753	9.0	3.4	
BH2	1	50	2 / 1				22/11/2018 09:37	3.51	6.74	162	1743	9.5	1.9	
BH2	1	50	2 / 1				22/11/2018 09:40	3.51	6.72	158	1741	10.0	1.2	
BH2	1	50	2 / 1				22/11/2018 09:43	3.51	6.73	157	1727	10.2	0.9	
BH2	1	50	2 / 1				22/11/2018 09:46	3.51	6.72	155	1731	10.3	0.8	
BH2	1	50	2 / 1				22/11/2018 09:49	3.51	6.70	156	1731	10.4	0.7	
WS1	1	50	1 / 1	3.00	2.61	2.00 to 3.00	09/11/2018 12:00	DRY	---	---	---	---	---	
WS4	1	50	1 / 1	2.00	1.79	1.00 to 2.00	09/11/2018 08:10	1.26	---	---	---	---	---	
WS4	1	50	1 / 1				09/11/2018 08:14	1.45	8.64	301	1949	12.4	6.2	General Remarks: 1L glass filled 3/4. Insufficient water. No odour.

Key: NDA denotes 'no data available'.

RSK Environment Ltd
The Old School
Stillhouse Lane
Bedminster
Bristol BS3 4EB

Compiled By	Date	Checked By	Date	Contract Ref:
[redacted]	26/11/18			314262

Contract: **City Service Station**

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IN-SITU WATER MONITORING RESULTS

Exploratory Position ID	Pipe ref	Pipe Diameter	Monitoring Round / Test Number	Reported Installation Depth (m)	Measured Installation Depth (mbgl)	Response Zone	Date & Time of Monitoring	Water Depth (mbgl)	pH	Redox (mV)	Conduc-tivity (uS/cm)	Temp-erature (°C)	Dissolved Oxygen (mg/l)	Remarks
														Clear.
WS4	1	50	2 / 1	2.00	1.79	1.00 to 2.00	22/11/2018 08:44	1.58	6.47	266	2483	7.2	7.2	
WS4	1	50	2 / 1				22/11/2018 08:47	1.58	6.50	262	2532	6.9	4.5	
WS4	1	50	2 / 1				22/11/2018 08:50	1.58	6.60	257	2459	8.3	4.3	
WS4	1	50	2 / 1				22/11/2018 08:53	1.58	6.53	256	2447	8.7	3.0	
WS4	1	50	2 / 1				22/11/2018 08:56	1.58	6.58	255	2429	9.1	3.3	

Key: NDA denotes 'no data available'.

RSK Environment Ltd
The Old School
Stillhouse Lane
Bedminster
Bristol BS3 4EB

Compiled By	Date	Checked By	Date	Contract Ref:
[redacted]	26/11/18			314262

Contract: **City Service Station**

Page: **2** of **2**

APPENDIX D
LABORATORY TEST RESULTS

Chemtest
The right chemistry to deliver results
Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

UKAS TESTING
2183

Final Report

Report No.:	18-37075-1
Initial Date of Issue:	04-Dec-2018
Client	RSK Environmental Ltd - Bristol
Client Address:	The Old School Stillhouse Lane Bedminster Bristol BS3 4EB
Contact(s):	Jeremy Leach
Project	314262 City Service Station

Quotation No.:		**Date Received:**	26-Nov-2018
Order No.:	PO285975	**Date Instructed:**	26-Nov-2018
No. of Samples:	3		
Turnaround (Wkdays):	5	**Results Due:**	30-Nov-2018
Date Approved:	04-Dec-2018		

Approved By:

[redacted]

Details: Glynn Harvey, Laboratory Manager

Chemtest
The right chemistry to deliver results

Results - Water

Project: 314262 City Service Station

Client: RSK Environmental Ltd - Bristol					Chemtest Job No.:	18-37075	18-37075	18-37075
Quotation No.:					Chemtest Sample ID.:	730850	730851	730852
					Sample Location:	BH1	BH2	WS4
					Sample Type:	WATER	WATER	WATER
					Top Depth (m):	3.935	4.510	1.750
					Bottom Depth (m):	5.750	5.700	1.890
					Date Sampled:	22-Nov-2018	22-Nov-2018	22-Nov-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
pH	U	1010		N/A		8.1	8.1	8.3
Alkalinity (Total)	U	1220	mg/l	10		370	440	490
Calcium	U	1415	mg/l	5.0		150	190	190
Arsenic (Dissolved)	U	1450	µg/l	1.0		2.1	2.8	14
Boron (Dissolved)	U	1450	µg/l	20		78	130	350
Cadmium (Dissolved)	U	1450	µg/l	0.080		< 0.080	< 0.080	9.5
Chromium (Dissolved)	U	1450	µg/l	1.0		1.4	3.9	9.0
Copper (Dissolved)	U	1450	µg/l	1.0		3.4	3.0	11
Mercury (Dissolved)	U	1450	µg/l	0.50		< 0.50	< 0.50	< 0.50
Nickel (Dissolved)	U	1450	µg/l	1.0		1.8	14	7.5
Lead (Dissolved)	U	1450	µg/l	1.0		< 1.0	3.5	1.7
Selenium (Dissolved)	U	1450	µg/l	1.0		1.3	1.1	3.7
Zinc (Dissolved)	U	1450	µg/l	1.0		7.4	8.8	22
Chromium (Hexavalent)	U	1490	µg/l	20		< 20	< 20	< 20
Dissolved Organic Carbon	U	1610	mg/l	2.0		8.2	10	14
Aliphatic TPH >C5-C6	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aliphatic TPH >C6-C8	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aliphatic TPH >C8-C10	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aliphatic TPH >C10-C12	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aliphatic TPH >C12-C16	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aliphatic TPH >C16-C21	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aliphatic TPH >C21-C35	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aliphatic TPH >C35-C44	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Total Aliphatic Hydrocarbons	N	1675	µg/l	5.0		< 5.0	< 5.0	[C] < 5.0
Aromatic TPH >C5-C7	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aromatic TPH >C7-C8	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aromatic TPH >C8-C10	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aromatic TPH >C10-C12	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aromatic TPH >C12-C16	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aromatic TPH >C16-C21	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aromatic TPH >C21-C35	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Aromatic TPH >C35-C44	N	1675	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Total Aromatic Hydrocarbons	N	1675	µg/l	5.0		< 5.0	< 5.0	[C] < 5.0
Total Petroleum Hydrocarbons	N	1675	µg/l	10		< 10	< 10	[C] < 10
Naphthalene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Acenaphthylene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Acenaphthene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Fluorene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10

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Results - Water

Project: 314262 City Service Station

Client: RSK Environmental Ltd - Bristol					Chemtest Job No.:	18-37075	18-37075	18-37075
Quotation No.:					Chemtest Sample ID.:	730850	730851	730852
					Sample Location:	BH1	BH2	WS4
					Sample Type:	WATER	WATER	WATER
					Top Depth (m):	3.935	4.510	1.750
					Bottom Depth (m):	5.750	5.700	1.890
					Date Sampled:	22-Nov-2018	22-Nov-2018	22-Nov-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Phenanthrene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Anthracene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Fluoranthene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Pyrene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Benzo[a]anthracene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Chrysene	N	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Benzo[b]fluoranthene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Benzo[k]fluoranthene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Benzo[a]pyrene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Indeno(1,2,3-c,d)Pyrene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Dibenz(a,h)Anthracene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Benzo[g,h,i]perylene	U	1700	µg/l	0.10		< 0.10	< 0.10	[C] < 0.10
Total Of 16 PAH's	U	1700	µg/l	2.0		< 2.0	< 2.0	[C] < 2.0
Dichlorodifluoromethane	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
Chloromethane	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
Vinyl Chloride	N	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
Bromomethane	U	1760	µg/l	5.0		< 5.0	< 5.0	< 5.0
Chloroethane	U	1760	µg/l	2.0		< 2.0	< 2.0	< 2.0
Trichlorofluoromethane	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
1,1-Dichloroethene	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
Trans 1,2-Dichloroethene	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
1,1-Dichloroethane	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
cis 1,2-Dichloroethene	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
Bromochloromethane	U	1760	µg/l	5.0		< 5.0	< 5.0	< 5.0
Trichloromethane	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
1,1,1-Trichloroethane	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
Tetrachloromethane	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
1,1-Dichloropropene	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
Benzene	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
1,2-Dichloroethane	U	1760	µg/l	2.0		< 2.0	< 2.0	< 2.0
Trichloroethene	N	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
1,2-Dichloropropane	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
Dibromomethane	U	1760	µg/l	10		< 10	< 10	< 10
Bromodichloromethane	U	1760	µg/l	5.0		< 5.0	< 5.0	< 5.0
cis-1,3-Dichloropropene	N	1760	µg/l	10		< 10	< 10	< 10
Toluene	U	1760	µg/l	1.0		< 1.0	< 1.0	< 1.0
Trans-1,3-Dichloropropene	N	1760	µg/l	10		< 10	< 10	< 10
1,1,2-Trichloroethane	U	1760	µg/l	10		< 10	< 10	< 10

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Results - Water

Project: 314262 City Service Station

Client: RSK Environmental Ltd - Bristol		Chemtest Job No.:			18-37075	18-37075	18-37075
Quotation No.:		Chemtest Sample ID.:			730850	730851	730852
		Sample Location:			BH1	BH2	WS4
		Sample Type:			WATER	WATER	WATER
		Top Depth (m):			3.935	4.510	1.750
		Bottom Depth (m):			5.750	5.700	1.890
		Date Sampled:			22-Nov-2018	22-Nov-2018	22-Nov-2018
Determinand	**Accred.**	**SOP**	**Units**	**LOD**			
Tetrachloroethene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,3-Dichloropropane	U	1760	µg/l	2.0	< 2.0	< 2.0	< 2.0
Dibromochloromethane	U	1760	µg/l	10	< 10	< 10	< 10
1,2-Dibromoethane	U	1760	µg/l	5.0	< 5.0	< 5.0	< 5.0
Chlorobenzene	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,1,1,2-Tetrachloroethane	U	1760	µg/l	2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
o-Xylene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Styrene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Tribromomethane	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Bromobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2,3-Trichloropropane	N	1760	µg/l	50	< 50	< 50	< 50
N-Propylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
2-Chlorotoluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
4-Chlorotoluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Tert-Butylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Sec-Butylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,3-Dichlorobenzene	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
4-Isopropyltoluene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
N-Butylbenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2-Dibromo-3-Chloropropane	U	1760	µg/l	50	< 50	< 50	< 50
1,2,4-Trichlorobenzene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Hexachlorobutadiene	U	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
1,2,3-Trichlorobenzene	U	1760	µg/l	2.0	< 2.0	< 2.0	< 2.0
Ethyl Tert-Butyl Ether	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
Methyl Tert-Butyl Ether	N	1760	µg/l	1.0	< 1.0	< 1.0	< 1.0
TAME	N	1760	µg/l	10.0	< 10	< 10	< 10
Isopropylether	N	1760	µg/l	10	< 10	< 10	< 10
T-Butanol	N	1780	µg/l	0.10	< 0.10	< 0.10	< 0.10
2-Methylnaphthalene	N	1790	µg/l	0.50	< 0.50	< 0.50	< 0.50
VOC TIC	N	1760	µg/l	N/A	None Detected	None Detected	None Detected

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Deviations

In accordance with UKAS Policy on Deviating Samples TPS 63. Chemtest have a procedure to ensure 'upon receipt of each sample a competent laboratory shall assess whether the sample is suitable with regard to the requested test(s)'. This policy and the respective holding times applied, can be supplied upon request.The reason a sample is declared as deviating is detailed below. Where applicable the analysis remains UKAS/MCERTs accredited but the results may be compromised.

Sample:	Sample Ref:	Sample ID:	Sample Location:	Sampled Date:	Deviation Code(s):	Containers Received:
730852			WS4	22-Nov-2018	C	EPA Vial 40ml
730852			WS4	22-Nov-2018	C	Plastic Bottle 250ml

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Test Methods

SOP	Title	Parameters included	Method summary
1010	pH Value of Waters	pH	pH Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1415	Cations in Waters by ICP-MS	Sodium; Potassium; Calcium; Magnesium	Direct determination by inductively coupled plasma - mass spectrometry (ICP-MS).
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1490	Hexavalent Chromium in Waters	Chromium [VI]	Automated colorimetric analysis by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1675	TPH Aliphatic/Aromatic split in Waters by GC-FID(cf. Texas Method 1006 / TPH CWG)	Aliphatics: >C5–C6, >C6–C8, >C8– C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Pentane extraction / GCxGC FID detection
1700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Waters by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Pentane extraction / GC FID detection
1760	Volatile Organic Compounds (VOCs) in Waters by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics. (cf. USEPA Method 8260)	Automated headspace gas chromatographic (GC) analysis of water samples with mass spectrometric (MS) detection of volatile organic compounds.
1780	Alcohols	Alcohols	GCMS detection
1790	Semi-Volatile Organic Compounds (SVOCs) in Waters by GC-MS	Semi-volatile organic compounds	Solvent extraction / GCMS detection

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Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

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Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
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Email: info@chemtest.com

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Final Report

Report No.:	18-33975-1
Initial Date of Issue:	15-Nov-2018
Client	RSK Environmental Ltd - Bristol
Client Address:	The Old School Stillhouse Lane Bedminster Bristol BS3 4EB
Contact(s):	Hannah Bovenizer
Project	314262 - City Service Station

Quotation No.:		**Date Received:**	31-Oct-2018
Order No.:	P0285975	**Date Instructed:**	31-Oct-2018
No. of Samples:	6		
Turnaround (Wkdays):	9	**Results Due:**	12-Nov-2018
Date Approved:	15-Nov-2018		

Approved By:

[redacted]

Details: Glynn Harvey, Laboratory Manager

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Results - Soil

Project: 314262 - City Service Station

Client: RSK Environmental Ltd - Bristol			Chemtest Job No.:		18-33975	18-33975	18-33975	18-33975	18-33975	18-33975
Quotation No.:			Chemtest Sample ID.:		717091	717093	717095	717096	717098	717099
Order No.: P0285975			Client Sample Ref.:		ES	ES	ES	ES	ES	ES
			Sample Location:		WS1	WS1	WS4	WS4	WS2A	WS3
			Sample Type:		SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
			Top Depth (m):		0.60	3.00	1.20	1.60	0.60	0.40
			Date Sampled:		26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018
			Asbestos Lab:		COVENTRY		COVENTRY		COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**						
ACM Type	U	2192		N/A	-		-		Cement\fibre clumps	-
Asbestos Identification	U	2192	%	0.001	No Asbestos Detected		No Asbestos Detected		Chrysotile Crocidolite	No Asbestos Detected
Moisture	N	2030	%	0.020		5.4	14	19	7.6	13
pH	U	2010		N/A		8.9	8.5		8.6	8.9
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40		< 0.40	0.61		0.70	0.88
Arsenic	U	2450	mg/kg	1.0		14	15		15	26
Cadmium	U	2450	mg/kg	0.10		0.95	0.26		0.31	0.75
Chromium	U	2450	mg/kg	1.0		18	16		21	32
Copper	U	2450	mg/kg	0.50		12	28		37	69
Mercury	U	2450	mg/kg	0.10		< 0.10	0.71		0.50	0.49
Nickel	U	2450	mg/kg	0.50		24	25		29	56
Lead	U	2450	mg/kg	0.50		13	100		89	130
Selenium	U	2450	mg/kg	0.20		< 0.20	< 0.20		< 0.20	< 0.20
Zinc	U	2450	mg/kg	0.50		30	40		80	140
Chromium (Hexavalent)	N	2490	mg/kg	0.50		< 0.50	< 0.50		< 0.50	< 0.50
Total Organic Carbon	U	2625	%	0.20		< 0.20	0.93	1.5	1.1	
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0	
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0	
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0	< 1.0	2.4	< 1.0	
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0	< 1.0	13	< 1.0	
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0	< 1.0	56	< 1.0	
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0	< 1.0	78	< 1.0	
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0	< 1.0	61	96	
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0	
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0	< 5.0	210	96	
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0	
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0	
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0	
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0	
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0		< 1.0	< 1.0	5.8	< 1.0	
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0		< 1.0	< 1.0	18	4.1	
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0		< 1.0	< 1.0	47	71	
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0	
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0		< 5.0	< 5.0	71	75	
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0		< 10	< 10	280	170	

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Results - Soil

Project: 314262 - City Service Station

Client: RSK Environmental Ltd - Bristol					Chemtest Job No.:	18-33975	18-33975	18-33975	18-33975	18-33975	18-33975
Quotation No.:					Chemtest Sample ID.:	717091	717093	717095	717096	717098	717099
Order No.: P0285975					Client Sample Ref.:	ES	ES	ES	ES	ES	ES
					Sample Location:	WS1	WS1	WS4	WS4	WS2A	WS3
					Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
					Top Depth (m):	0.60	3.00	1.20	1.60	0.60	0.40
					Date Sampled:	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018
					Asbestos Lab:	COVENTRY		COVENTRY		COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**							
Dichlorodifluoromethane	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Chloromethane	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Vinyl Chloride	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Bromomethane	U	2760	µg/kg	20		< 20	< 20	< 20	< 20		
Chloroethane	N	2760	µg/kg	2.0		< 2.0	< 2.0	< 2.0	< 2.0		
Trichlorofluoromethane	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,1-Dichloroethene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Trans 1,2-Dichloroethene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,1-Dichloroethane	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
cis 1,2-Dichloroethene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Bromochloromethane	N	2760	µg/kg	5.0		< 5.0	< 5.0	< 5.0	< 5.0		
Trichloromethane	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,1,1-Trichloroethane	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Tetrachloromethane	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,1-Dichloropropene	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Benzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,2-Dichloroethane	U	2760	µg/kg	2.0		< 2.0	< 2.0	< 2.0	< 2.0		
Trichloroethene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,2-Dichloropropane	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Dibromomethane	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Bromodichloromethane	U	2760	µg/kg	5.0		< 5.0	< 5.0	< 5.0	< 5.0		
cis-1,3-Dichloropropene	N	2760	µg/kg	10		< 10	< 10	< 10	< 10		
Toluene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Trans-1,3-Dichloropropene	N	2760	µg/kg	10		< 10	< 10	< 10	< 10		
1,1,2-Trichloroethane	U	2760	µg/kg	10		< 10	< 10	< 10	< 10		
Tetrachloroethene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,3-Dichloropropane	N	2760	µg/kg	2.0		< 2.0	< 2.0	< 2.0	< 2.0		
Dibromochloromethane	N	2760	µg/kg	10		< 10	< 10	< 10	< 10		
1,2-Dibromoethane	U	2760	µg/kg	5.0		< 5.0	< 5.0	< 5.0	< 5.0		
Chlorobenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,1,1,2-Tetrachloroethane	U	2760	µg/kg	2.0		< 2.0	< 2.0	< 2.0	< 2.0		
Ethylbenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
m & p-Xylene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
o-Xylene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Styrene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Tribromomethane	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Isopropylbenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		

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Results - Soil

Project: 314262 - City Service Station

Client: RSK Environmental Ltd - Bristol					Chemtest Job No.:	18-33975	18-33975	18-33975	18-33975	18-33975	18-33975
Quotation No.:					Chemtest Sample ID.:	717091	717093	717095	717096	717098	717099
Order No.: P0285975					Client Sample Ref.:	ES	ES	ES	ES	ES	ES
					Sample Location:	WS1	WS1	WS4	WS4	WS2A	WS3
					Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
					Top Depth (m):	0.60	3.00	1.20	1.60	0.60	0.40
					Date Sampled:	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018
					Asbestos Lab:	COVENTRY		COVENTRY		COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**							
Bromobenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,2,3-Trichloropropane	N	2760	µg/kg	50		< 50	< 50	< 50	< 50		
N-Propylbenzene	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
2-Chlorotoluene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,3,5-Trimethylbenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
4-Chlorotoluene	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Tert-Butylbenzene	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,2,4-Trimethylbenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Sec-Butylbenzene	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,3-Dichlorobenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
4-Isopropyltoluene	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,4-Dichlorobenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
N-Butylbenzene	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,2-Dichlorobenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,2-Dibromo-3-Chloropropane	N	2760	µg/kg	50		< 50	< 50	< 50	< 50		
1,2,4-Trichlorobenzene	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Hexachlorobutadiene	N	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
1,2,3-Trichlorobenzene	N	2760	µg/kg	2.0		< 2.0	< 2.0	< 2.0	< 2.0		
Ethyl Tert-Butyl Ether	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
Methyl Tert-Butyl Ether	U	2760	µg/kg	1.0		< 1.0	< 1.0	< 1.0	< 1.0		
TAME	N	2760	µg/kg	10.0		< 10	< 10	< 10	< 10		
Ethanol	N		mg/kg	10		< 10	< 10	< 10	< 10		
2-Methylnaphthalene	U	2790	mg/kg	0.50		< 0.50	< 0.50	< 0.50	< 0.50		
Naphthalene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	< 0.10		
Acenaphthylene	N	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	< 0.10		
Acenaphthene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	< 0.10		
Fluorene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	< 0.10		
Phenanthrene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	0.20		
Anthracene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	< 0.10		
Fluoranthene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	0.55		
Pyrene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	0.49		
Benzo[a]anthracene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	0.10		
Chrysene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	0.12		
Benzo[b]fluoranthene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	0.11		
Benzo[k]fluoranthene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	< 0.10		
Benzo[a]pyrene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	< 0.10		
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10		< 0.10	< 0.10	< 0.10	< 0.10		

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Results - Soil

Project: 314262 - City Service Station

Client: RSK Environmental Ltd - Bristol					**Chemtest Job No.:**	18-33975	18-33975	18-33975	18-33975	18-33975	18-33975
Quotation No.:					**Chemtest Sample ID.:**	717091	717093	717095	717096	717098	717099
Order No.: P0285975					Client Sample Ref.:	ES	ES	ES	ES	ES	ES
					Sample Location:	WS1	WS1	WS4	WS4	WS2A	WS3
					Sample Type:	SOIL	SOIL	SOIL	SOIL	SOIL	SOIL
					Top Depth (m):	0.60	3.00	1.20	1.60	0.60	0.40
					Date Sampled:	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018	26-Oct-2018
					Asbestos Lab:	COVENTRY		COVENTRY		COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**							
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10			< 0.10	< 0.10	< 0.10	< 0.10	
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10			< 0.10	< 0.10	< 0.10	< 0.10	
Total Of 16 PAH's	N	2800	mg/kg	2.0			< 2.0	< 2.0	< 2.0	< 2.0	
VOC TIC	N	2760	µg/kg	N/A			None Detected	None Detected	None Detected	None Detected	

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Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2192	Asbestos	Asbestos	Polarised light microscopy / Gravimetry
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2790	Semi-Volatile Organic Compounds (SVOCs) in Soils by GC-MS	Semi-volatile organic compounds(cf. USEPA Method 8270)	Acetone/Hexane extraction / GC-MS
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS

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Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
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SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

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Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

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Final Report

Report No.:	18-34883-1
Initial Date of Issue:	16-Nov-2018
Client	RSK Environmental Ltd - Bristol
Client Address:	The Old School Stillhouse Lane Bedminster Bristol BS3 4EB
Contact(s):	Hannah Bovenizer
Project	314262 City Service Station
Quotation No.:	
Order No.:	PO285975
No. of Samples:	1
Turnaround (Wkdays):	5
Date Approved:	16-Nov-2018
Approved By:	

Date Received:	08-Nov-2018
Date Instructed:	08-Nov-2018
Results Due:	14-Nov-2018

[redacted]

Details: Robert Monk, Technical Manager

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Results - Single Stage WAC

Project: 314262 City Service Station

					Landfill Waste Acceptance Criteria Limits		
Chemtest Job No:	18-34883						
Chemtest Sample ID:	721156						
Sample Ref:							
Sample ID:							
Sample Location:	WS4						
Top Depth(m):	1.20						
Bottom Depth(m):							
Sampling Date:	26-Oct-2018						
Determinand	**SOP**	**Accred.**	**Units**		**Inert Waste Landfill**	**Stable, Non-reactive hazardous waste in non-hazardous Landfill**	**Hazardous Waste Landfill**
Total Organic Carbon	2625	U	%	0.96	3	5	6
Loss On Ignition	2610	U	%	1.8	--	--	10
Total BTEX	2760	U	mg/kg	< 0.010	6	--	--
Total PCBs (7 Congeners)	2815	U	mg/kg	< 0.10	1	--	--
TPH Total WAC (Mineral Oil)	2670	U	mg/kg	< 10	500	--	--
Total (Of 17) PAH's	2700	N	mg/kg	< 2.0	100	--	--
pH	2010	U		8.6	--	>6	--
Acid Neutralisation Capacity	2015	N	mol/kg	0.046	--	To evaluate	To evaluate
Eluate Analysis			**10:1 Eluate mg/l**	**10:1 Eluate mg/kg**	**Limit values for compliance leaching test using BS EN 12457 at L/S 10 l/kg**		
Arsenic	1450	U	0.0053	0.053	0.5	2	25
Barium	1450	U	0.0036	< 0.50	20	100	300
Cadmium	1450	U	< 0.00010	< 0.010	0.04	1	5
Chromium	1450	U	< 0.0010	< 0.050	0.5	10	70
Copper	1450	U	0.0017	< 0.050	2	50	100
Mercury	1450	U	< 0.00050	< 0.0050	0.01	0.2	2
Molybdenum	1450	U	0.0060	0.060	0.5	10	30
Nickel	1450	U	< 0.0010	< 0.050	0.4	10	40
Lead	1450	U	< 0.0010	< 0.010	0.5	10	50
Antimony	1450	U	0.0013	0.013	0.06	0.7	5
Selenium	1450	U	< 0.0010	< 0.010	0.1	0.5	7
Zinc	1450	U	< 0.0010	< 0.50	4	50	200
Chloride	1220	U	8.5	85	800	15000	25000
Fluoride	1220	U	0.12	1.2	10	150	500
Sulphate	1220	U	4.1	41	1000	20000	50000
Total Dissolved Solids	1020	N	98	970	4000	60000	100000
Phenol Index	1920	U	< 0.030	< 0.30	1	-	-
Dissolved Organic Carbon	1610	U	7.2	72	500	800	1000

Solid Information	
Dry mass of test portion/kg	0.090
Moisture (%)	13

Waste Acceptance Criteria

Landfill WAC analysis (specifically leaching test results) must not be used for hazardous waste classification purposes. This analysis is only applicable for hazardous waste landfill acceptance and does not give any indication as to whether a waste may be hazardous or non-hazardous.

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Test Methods

SOP	Title	Parameters included	Method summary
1020	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Electrical Conductivity and Total Dissolved Solids (TDS) in Waters	Conductivity Meter
1220	Anions, Alkalinity & Ammonium in Waters	Fluoride; Chloride; Nitrite; Nitrate; Total; Oxidisable Nitrogen (TON); Sulfate; Phosphate; Alkalinity; Ammonium	Automated colorimetric analysis using 'Aquakem 600' Discrete Analyser.
1450	Metals in Waters by ICP-MS	Metals, including: Antimony; Arsenic; Barium; Beryllium; Boron; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Tin; Vanadium; Zinc	Filtration of samples followed by direct determination by inductively coupled plasma mass spectrometry (ICP-MS).
1610	Total/Dissolved Organic Carbon in Waters	Organic Carbon	TOC Analyser using Catalytic Oxidation
1920	Phenols in Waters by HPLC	Phenolic compounds including: Phenol, Cresols, Xylenols, Trimethylphenols Note: Chlorophenols are excluded.	Determination by High Performance Liquid Chromatography (HPLC) using electrochemical detection.
2010	pH Value of Soils	pH	pH Meter
2015	Acid Neutralisation Capacity	Acid Reserve	Titration
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2610	Loss on Ignition	loss on ignition (LOI)	Determination of the proportion by mass that is lost from a soil by ignition at 550°C.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2670	Total Petroleum Hydrocarbons (TPH) in Soils by GC-FID	TPH (C6–C40); optional carbon banding, e.g. 3-band – GRO, DRO & LRO*TPH C8–C40	Dichloromethane extraction / GC-FID
2700	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-FID	Acenaphthene; Acenaphthylene; Anthracene; Benzo[a]Anthracene; Benzo[a]Pyrene; Benzo[b]Fluoranthene; Benzo[ghi]Perylene; Benzo[k]Fluoranthene; Chrysene; Dibenz[ah]Anthracene; Fluoranthene; Fluorene; Indeno[123cd]Pyrene; Naphthalene; Phenanthrene; Pyrene	Dichloromethane extraction / GC-FID
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2815	Polychlorinated Biphenyls (PCB) ICES7Congeners in Soils by GC-MS	ICES7 PCB congeners	Acetone/Hexane extraction / GC-MS
640	Characterisation of Waste (Leaching)	Waste material including soil, sludges and granular waste	ComplianceTest for Leaching of Granular Waste Material and Sludge

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customerservices@chemtest.com

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Chemtest Ltd.
Depot Road
Newmarket
CB8 0AL
Tel: 01638 606070
Email: info@chemtest.com

Interim Report

Report No.: 18-36755-0

Initial Date of Issue:

Client RSK Environmental Ltd - Bristol

Client Address: The Old School
Stillhouse Lane
Bedminster
Bristol
BS3 4EB

Contact(s): Jeremy Leach
Hannah Bovenizer

Project 314262 City Service Station

Quotation No.:

Date Received: 22-Nov-2018

Order No.: PO285975

Date Instructed: 22-Nov-2018

No. of Samples: 4

Turnaround (Wkdays): 5

Results Due: 28-Nov-2018

Date Approved:

Approved By:

Details:

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Results - Soil

Project: 314262 City Service Station

Client: RSK Environmental Ltd - Bristol				Chemtest Job No.:	18-36755	18-36755	18-36755	18-36755
Quotation No.:				Chemtest Sample ID.:	729547	729551	729554	729556
				Sample Location:	BH1	BH2	BH4	Skip 1
				Sample Type:	SOIL	SOIL	SOIL	SOIL
				Top Depth (m):	0.50	1.20	0.50	
				Bottom Depth (m):	0.70	1.40	0.70	
				Date Sampled:	19-Nov-2018	19-Nov-2018	20-Nov-2018	20-Nov-2018
				Asbestos Lab:	COVENTRY	COVENTRY	COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
ACM Type	U	2192		N/A	-	-	-	-
Asbestos Identification	U	2192	%	0.001	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected	No Asbestos Detected
Moisture	N	2030	%	0.020	17	14	5.0	14
pH	U	2010		N/A	9.3	7.9	9.3	8.5
Boron (Hot Water Soluble)	U	2120	mg/kg	0.40	0.57	0.77	0.53	0.74
Arsenic	U	2450	mg/kg	1.0	28	7.9	14	14
Cadmium	U	2450	mg/kg	0.10	0.15	0.21	0.15	0.20
Chromium	U	2450	mg/kg	1.0	12	20	15	13
Copper	U	2450	mg/kg	0.50	45	18	11	15
Mercury	U	2450	mg/kg	0.10	0.36	0.26	< 0.10	0.29
Nickel	U	2450	mg/kg	0.50	27	24	18	20
Lead	U	2450	mg/kg	0.50	100	54	15	47
Selenium	U	2450	mg/kg	0.20	< 0.20	0.21	< 0.20	< 0.20
Zinc	U	2450	mg/kg	0.50	90	57	28	24
Chromium (Hexavalent)	N	2490	mg/kg	0.50	< 0.50	< 0.50	< 0.50	< 0.50
Fraction of Organic Carbon	U	2625		0.0010	0.094	0.0077	0.021	0.015
Aliphatic TPH >C5-C6	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C6-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C12-C16	U	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C16-C21	U	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aliphatic TPH >C21-C35	U	2680	mg/kg	1.0	27	< 1.0	7.2	< 1.0
Aliphatic TPH >C35-C44	N	2680	mg/kg	1.0	35	< 1.0	< 1.0	< 1.0
Total Aliphatic Hydrocarbons	N	2680	mg/kg	5.0	62	< 5.0	7.2	< 5.0
Aromatic TPH >C5-C7	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C7-C8	N	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C8-C10	U	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C10-C12	U	2680	mg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Aromatic TPH >C12-C16	U	2680	mg/kg	1.0	16	< 1.0	< 1.0	< 1.0
Aromatic TPH >C16-C21	U	2680	mg/kg	1.0	250	< 1.0	< 1.0	< 1.0
Aromatic TPH >C21-C35	U	2680	mg/kg	1.0	2000	< 1.0	28	< 1.0
Aromatic TPH >C35-C44	N	2680	mg/kg	1.0	300	< 1.0	< 1.0	< 1.0
Total Aromatic Hydrocarbons	N	2680	mg/kg	5.0	2500	< 5.0	28	< 5.0
Total Petroleum Hydrocarbons	N	2680	mg/kg	10.0	2600	< 10	35	< 10
Dichlorodifluoromethane	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0

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Results - Soil

Project: 314262 City Service Station

Client: RSK Environmental Ltd - Bristol			Chemtest Job No.:		18-36755	18-36755	18-36755	18-36755
Quotation No.:			Chemtest Sample ID.:		729547	729551	729554	729556
			Sample Location:		BH1	BH2	BH4	Skip 1
			Sample Type:		SOIL	SOIL	SOIL	SOIL
			Top Depth (m):		0.50	1.20	0.50	
			Bottom Depth (m):		0.70	1.40	0.70	
			Date Sampled:		19-Nov-2018	19-Nov-2018	20-Nov-2018	20-Nov-2018
			Asbestos Lab:		COVENTRY	COVENTRY	COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Chloromethane	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Vinyl Chloride	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Bromomethane	U	2760	µg/kg	20	< 20	< 20	< 20	< 20
Chloroethane	N	2760	µg/kg	2.0	< 2.0	< 2.0	< 2.0	< 2.0
Trichlorofluoromethane	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trans 1,2-Dichloroethene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloroethane	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
cis 1,2-Dichloroethene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Bromochloromethane	N	2760	µg/kg	5.0	< 5.0	< 5.0	< 5.0	< 5.0
Trichloromethane	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1,1-Trichloroethane	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tetrachloromethane	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1-Dichloropropene	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Benzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichloroethane	U	2760	µg/kg	2.0	< 2.0	< 2.0	< 2.0	< 2.0
Trichloroethene	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichloropropane	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Dibromomethane	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Bromodichloromethane	U	2760	µg/kg	5.0	< 5.0	< 5.0	< 5.0	< 5.0
cis-1,3-Dichloropropene	N	2760	µg/kg	10	< 10	< 10	< 10	< 10
Toluene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Trans-1,3-Dichloropropene	N	2760	µg/kg	10	< 10	< 10	< 10	< 10
1,1,2-Trichloroethane	U	2760	µg/kg	10	< 10	< 10	< 10	< 10
Tetrachloroethene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3-Dichloropropane	N	2760	µg/kg	2.0	< 2.0	< 2.0	< 2.0	< 2.0
Dibromochloromethane	N	2760	µg/kg	10	< 10	< 10	< 10	< 10
1,2-Dibromoethane	U	2760	µg/kg	5.0	< 5.0	< 5.0	< 5.0	< 5.0
Chlorobenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,1,1,2-Tetrachloroethane	U	2760	µg/kg	2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethylbenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
m & p-Xylene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
o-Xylene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Styrene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tribromomethane	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Isopropylbenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Bromobenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0

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Results - Soil

Project: 314262 City Service Station

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Quotation No.:			Chemtest Sample ID.:		729547	729551	729554	729556
			Sample Location:		BH1	BH2	BH4	Skip 1
			Sample Type:		SOIL	SOIL	SOIL	SOIL
			Top Depth (m):		0.50	1.20	0.50	
			Bottom Depth (m):		0.70	1.40	0.70	
			Date Sampled:		19-Nov-2018	19-Nov-2018	20-Nov-2018	20-Nov-2018
			Asbestos Lab:		COVENTRY	COVENTRY	COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
1,2,3-Trichloropropane	N	2760	µg/kg	50	< 50	< 50	< 50	< 50
N-Propylbenzene	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
2-Chlorotoluene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3,5-Trimethylbenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
4-Chlorotoluene	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Tert-Butylbenzene	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,4-Trimethylbenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Sec-Butylbenzene	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,3-Dichlorobenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
4-Isopropyltoluene	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,4-Dichlorobenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
N-Butylbenzene	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dichlorobenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2-Dibromo-3-Chloropropane	N	2760	µg/kg	50	< 50	< 50	< 50	< 50
1,2,4-Trichlorobenzene	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Hexachlorobutadiene	N	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
1,2,3-Trichlorobenzene	N	2760	µg/kg	2.0	< 2.0	< 2.0	< 2.0	< 2.0
Ethyl Tert-Butyl Ether	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
Methyl Tert-Butyl Ether	U	2760	µg/kg	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TAME	N	2760	µg/kg	10.0	< 10	< 10	< 10	< 10
Ethanol	N		mg/kg	10	< 10	< 10	< 10	< 10
2-Methylnaphthalene	U	2790	mg/kg	0.50	< 0.50	< 0.50	< 0.50	< 0.50
Naphthalene	U	2800	mg/kg	0.10	0.49	< 0.10	< 0.10	< 0.10
Acenaphthylene	N	2800	mg/kg	0.10	0.48	< 0.10	< 0.10	< 0.10
Acenaphthene	U	2800	mg/kg	0.10	3.6	< 0.10	< 0.10	< 0.10
Fluorene	U	2800	mg/kg	0.10	3.1	< 0.10	< 0.10	< 0.10
Phenanthrene	U	2800	mg/kg	0.10	30	0.29	0.13	< 0.10
Anthracene	U	2800	mg/kg	0.10	7.0	< 0.10	< 0.10	< 0.10
Fluoranthene	U	2800	mg/kg	0.10	51	0.41	0.38	< 0.10
Pyrene	U	2800	mg/kg	0.10	37	0.40	0.42	0.12
Benzo[a]anthracene	U	2800	mg/kg	0.10	28	0.11	0.19	< 0.10
Chrysene	U	2800	mg/kg	0.10	33	0.11	0.27	< 0.10
Benzo[b]fluoranthene	U	2800	mg/kg	0.10	37	< 0.10	0.32	< 0.10
Benzo[k]fluoranthene	U	2800	mg/kg	0.10	15	< 0.10	0.11	< 0.10
Benzo[a]pyrene	U	2800	mg/kg	0.10	21	< 0.10	0.18	< 0.10
Indeno(1,2,3-c,d)Pyrene	U	2800	mg/kg	0.10	16	< 0.10	0.12	< 0.10
Dibenz(a,h)Anthracene	N	2800	mg/kg	0.10	4.6	< 0.10	< 0.10	< 0.10

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Results - Soil

Project: 314262 City Service Station

Client: RSK Environmental Ltd - Bristol			Chemtest Job No.:		18-36755	18-36755	18-36755	18-36755
Quotation No.:			Chemtest Sample ID.:		729547	729551	729554	729556
			Sample Location:		BH1	BH2	BH4	Skip 1
			Sample Type:		SOIL	SOIL	SOIL	SOIL
			Top Depth (m):		0.50	1.20	0.50	
			Bottom Depth (m):		0.70	1.40	0.70	
			Date Sampled:		19-Nov-2018	19-Nov-2018	20-Nov-2018	20-Nov-2018
			Asbestos Lab:		COVENTRY	COVENTRY	COVENTRY	COVENTRY
Determinand	**Accred.**	**SOP**	**Units**	**LOD**				
Benzo[g,h,i]perylene	U	2800	mg/kg	0.10	15	< 0.10	< 0.10	< 0.10
Total Of 16 PAH's	N	2800	mg/kg	2.0	300	< 2.0	2.1	< 2.0
T-Butanol	N	2765	µg/kg	10	To Follow	To Follow	To Follow	To Follow
VOC TIC	N	2760	µg/kg	N/A	None Detected	None Detected	None Detected	None Detected

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Test Methods

SOP	Title	Parameters included	Method summary
2010	pH Value of Soils	pH	pH Meter
2030	Moisture and Stone Content of Soils(Requirement of MCERTS)	Moisture content	Determination of moisture content of soil as a percentage of its as received mass obtained at <37°C.
2120	Water Soluble Boron, Sulphate, Magnesium & Chromium	Boron; Sulphate; Magnesium; Chromium	Aqueous extraction / ICP-OES
2192	Asbestos	Asbestos	Polarised light microscopy / Gravimetry
2450	Acid Soluble Metals in Soils	Metals, including: Arsenic; Barium; Beryllium; Cadmium; Chromium; Cobalt; Copper; Lead; Manganese; Mercury; Molybdenum; Nickel; Selenium; Vanadium; Zinc	Acid digestion followed by determination of metals in extract by ICP-MS.
2490	Hexavalent Chromium in Soils	Chromium [VI]	Soil extracts are prepared by extracting dried and ground soil samples into boiling water. Chromium [VI] is determined by 'Aquakem 600' Discrete Analyser using 1,5-diphenylcarbazide.
2625	Total Organic Carbon in Soils	Total organic Carbon (TOC)	Determined by high temperature combustion under oxygen, using an Eltra elemental analyser.
2680	TPH A/A Split	Aliphatics: >C5–C6, >C6–C8,>C8–C10, >C10–C12, >C12–C16, >C16–C21, >C21–C35, >C35– C44Aromatics: >C5–C7, >C7–C8, >C8– C10, >C10–C12, >C12–C16, >C16– C21, >C21– C35, >C35– C44	Dichloromethane extraction / GCxGC FID detection
2760	Volatile Organic Compounds (VOCs) in Soils by Headspace GC-MS	Volatile organic compounds, including BTEX and halogenated Aliphatic/Aromatics.(cf. USEPA Method 8260)*please refer to UKAS schedule	Automated headspace gas chromatographic (GC) analysis of a soil sample, as received, with mass spectrometric (MS) detection of volatile organic compounds.
2790	Semi-Volatile Organic Compounds (SVOCs) in Soils by GC-MS	Semi-volatile organic compounds(cf. USEPA Method 8270)	Acetone/Hexane extraction / GC-MS
2800	Speciated Polynuclear Aromatic Hydrocarbons (PAH) in Soil by GC-MS	Acenaphthene*; Acenaphthylene; Anthracene*; Benzo[a]Anthracene*; Benzo[a]Pyrene*; Benzo[b]Fluoranthene*; Benzo[ghi]Perylene*; Benzo[k]Fluoranthene; Chrysene*; Dibenz[ah]Anthracene; Fluoranthene*; Fluorene*; Indeno[123cd]Pyrene*; Naphthalene*; Phenanthrene*; Pyrene*	Dichloromethane extraction / GC-MS

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Report Information

Key

U	UKAS accredited
M	MCERTS and UKAS accredited
N	Unaccredited
S	This analysis has been subcontracted to a UKAS accredited laboratory that is accredited for this analysis
SN	This analysis has been subcontracted to a UKAS accredited laboratory that is not accredited for this analysis
T	This analysis has been subcontracted to an unaccredited laboratory
I/S	Insufficient Sample
U/S	Unsuitable Sample
N/E	not evaluated
<	"less than"
>	"greater than"

Comments or interpretations are beyond the scope of UKAS accreditation
The results relate only to the items tested
Uncertainty of measurement for the determinands tested are available upon request
None of the results in this report have been recovery corrected
All results are expressed on a dry weight basis
The following tests were analysed on samples as received and the results subsequently corrected to a dry weight basis TPH, BTEX, VOCs, SVOCs, PCBs, Phenols
For all other tests the samples were dried at < 37°C prior to analysis
All Asbestos testing is performed at the indicated laboratory
Issue numbers are sequential starting with 1 all subsequent reports are incremented by 1

Sample Deviation Codes

A - Date of sampling not supplied
B - Sample age exceeds stability time (sampling to extraction)
C - Sample not received in appropriate containers
D - Broken Container
E - Insufficient Sample (Applies to LOI in Trommel Fines Only)

Sample Retention and Disposal

All soil samples will be retained for a period of 45 days from the date of receipt
All water samples will be retained for 14 days from the date of receipt
Charges may apply to extended sample storage

If you require extended retention of samples, please email your requirements to:
customerservices@chemtest.com

APPENDIX E
RSK GENERIC ASSESSMENT CRITERIA - COMMERCIAL

GENERIC ASSESSMENT CRITERIA FOR CONTROLLED WATERS

Protection of the water environment

The water environment in the United Kingdom is protected under a number of regulatory regimes. The relevant environmental regulator is consulted where there may be a risk that pollution of 'controlled waters' may occur or may have occurred in the past.

The term 'controlled waters' refers to coastal waters, inland freshwaters and groundwater. The EU Water Framework Directive (WFD) (2000/60/EC) is implemented via domestic regulations and guidance, covering aspects of groundwater and surface water protection as well as drinking water supply policy. Domestic legislation and guidance will vary across the United Kingdom. Therefore, the relevant legislation for England, Wales, Northern Ireland and Scotland should be reviewed, alongside guidance provided by the Environment Agency (EA), Natural Resource Wales (NRW), the Scottish Environmental Protection Agency (SEPA) or the Northern Ireland Environment Agency (NIEA), as appropriate.

The main objectives of the protection and remediation of groundwater under threat from land contamination are set out within "The Environment Agency's approach to groundwater protection", version 1.0 (March 2017)[1] and the associated guidance "Land contamination groundwater compliance points: quantitative risk assessments (March 2017)[1a] that have replaced the previous guidance document "Groundwater Principles and Practice (GP3)". When assessing risks to groundwater, the following need to be considered:

- Where pollutants have not yet entered groundwater, all necessary and reasonable measures must be taken to:
    - ***prevent*** *the input of* ***hazardous*** *substances into groundwater (see description of hazardous substances below)*
    - ***limit*** *the entry of other (non-hazardous) pollutants into groundwater to avoid pollution, deterioration in the status of groundwater bodies and to prevent sustained, upward trends in pollutant concentrations in groundwater.*
- Where pollutants have already entered groundwater, the priority is to take all necessary and reasonable measures to:
    - ***minimise*** *further entry of "contaminants" where there is a defined source*
    - ***limit the pollution*** *of groundwater or any effect on the status of the groundwater body from the future expansion of the 'plume', if necessary, by actively reducing its extent.*

Within the context of groundwater risk assessments on sites affected by land contamination, "reasonable" means feasible without involving disproportionate costs. What costs are "disproportionate" depends on site-specific circumstances, which may include:

- Considerations of technical feasibility such as identified by the remedial options appraisal, this may be due to the distribution or nature of the contamination and the available remedial methods to treat the identified contamination;
- Sustainability considerations.

DEFINITIONS AND SUBSTANCE CLASSIFICATIONS

Risks to surface waters:

When assessing risks to surface waters, the following list of definitions should be understood:

Priority substances (PS) are harmful substances originally identified under the Water Framework Directive (WFD) 2000/60/EC as substances 'presenting a significant risk to or via the aquatic environment' at a European level. Member States are required to incorporate the identified **PS** into their country-wide monitoring programmes. There are currently 33 **PS** defined within the Priority Substances Directive (2013/39/EU; Annex 1), with a further 12 additional substances due to come into force from 22 December 2018. Directive 2013/39/EU has been transposed into domestic legislation for England and Wales by The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

Under the umbrella of **PS**, there is a sub-set of substances identified as being "hazardous", and these are referred to as **Priority hazardous substances (PHS).** The list of **PHS** is defined at EU level within the Priority Substances Directive (2013/39/EU). The WFD defines hazardous substances as 'substances (or groups of substances) that are toxic, persistent and liable to bio-accumulate, and other substances or groups of substances that give rise to an equivalent level of concern.' There are currently 15 **PHS**, with a further 6 additional substances due to come into force from 22 December 2018.

There is also another group of substances defined at EU level and which are referred to as **other pollutants (OP)** in Directive 2013/39/EU**.** These are additional substances which although not **priority substances**, have EQS which are identical to those laid down in the legislation which applied prior to 13 January 2009 (Directive 2008/105/EU). The **OP** are listed along with the **priority substance (PS)** within the Priority Substances Directive (2013/39/EU),and their associated EQS are also listed therein. There are 6 **OP** defined within the Priority Substances Directive (2013/39/EU).

In addition to the EU level substances, there are also a group of pollutants defined at a Member State level, referred to as **Specific pollutants (SP)**. These substances are pollutants which are released in significant quantities into water bodies in each of the individual European Member States. Under the WFD, Member States are required to set their own EQS for these substances. An indicative list of **SP** is given in Annex VIII of the WFD. Many of the substances categorised as **SP** in the UK were formerly List 2 substances under the old Groundwater Directive (80/68/EEC). The **SP** are defined within Part 2 (Table 1) of The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

Risks to groundwater:

When assessing risks to groundwater, the following definitions should be understood:

Under the requirements of the Groundwater Daughter Directive (2006/118/EU), the UK has published a list of substances it considers to be **hazardous substances** with respect to groundwater. In their advisory capacity to the government, this list has been derived by the UK Joint Agencies Groundwater Directive Advisory Group (JAGDAG), of which the Environment Agency is a member. The JAGDAG list of **hazardous substances** was published in January 2017 and the Environment Agency will use the updated list of hazardous substances from this date for all new activities that may lead to the discharge of hazardous substances to groundwater. The list is extensive and can be found in full at:

https://www.wfduk.org/stakeholders/jagdag

Selecting the appropriate assessment criteria

When assessing the risks to controlled waters, various assessment criteria apply, depending on the nature of the assessment and the conceptual site model.

Where a surface water body is involved, then Environmental Quality Standards (EQS) are the relevant assessment criteria as they are designed to be protective of surface water ecology.

Where a public water supply or a Principal aquifer is involved, then the standards defined in The Water Supply (Water Quality) Regulations[2] are the primary source of assessment criteria. The Private Water Supplies Regulations[3] may also be applicable in some cases. For instances where there are no UK assessment criteria, then the World Health Organisation (WHO) drinking water guidelines[4] may be used.

This appendix presents the generic assessment criteria (GAC) that RSK considers suitable for assessing risks to controlled waters for our most commonly encountered determinants. A full list of EQS for England and Wales are included in The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.

The RSK GAC for controlled waters are presented in **Table 1** and **Table 2**. In line with the Environment Agency's Remedial Targets Methodology, the GAC for controlled waters are termed 'target concentrations'.

The appropriate target concentrations should be selected with consideration to:

- the site conceptual model (i.e. the receptor at potential risk);
- whether the substance is already present in groundwater at the site;
- whether or not the substance is classified as a priority hazardous substance under the Priority Substances Directive (2013/39/EC) (see above), or as a hazardous substance according to the current list of JAGDAG determinations[5]; and
- background concentrations in the aquifer (if applicable).

It is important to remember that the WFD and Environment Agency guidance[1 & 1a] support a sustainable, risk-based approach be applied to groundwater contamination. Exceedance of any target concentration does not necessarily imply that an unacceptable risk exists or that remediation is inevitably required.

Target concentrations shaded in green are statutory values	Target concentrations shaded in orange are non-statutory values

Note: Units µg/l throughout (unless otherwise stated)

Table 1: Target concentrations for controlled waters (excluding TPH CWG fractions)

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors[5]	Surface water receptors[6]		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Metals & other inorganics						
Hazardous substance	Specific pollutant	Arsenic	-	10[2]	50[8a]	25[8a]
Non-hazardous pollutant	Priority substance	Cadmium	0.1[7]	5[2]	≤0.08, 0.08, 0.09, 0.15, 0.25 [8b]	0.2[8a]
(Not determined)	-	Chromium (total)	-	50[2]	Sum values for chromium III and VI	
(None	Specific pollutant	Chromium (III)	-	Use value for total chromium	4.7[8a]	-
Hazardous substance	Specific pollutant	Chromium (VI)			3.4[8a]	0.6[8a]

Substance classification		Determinant	Target concentrations (µg/l)			
			Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
Groundwater receptors[5]	Surface water receptors[6]				Freshwater	Transitional (estuaries) and coastal waters
(Not determined)	Specific pollutant	Copper	-	2,000[2]	1 bioavailable[6a]	3.76 dissolved, where DOC ≤1mg/l[6a]
						3.76µg/l + (2.677µg/l x ((DOC/2) – 0.5µg/l)) dissolved, where DOC >1mg/l[6a]
Hazardous substance	Priority substance	Lead	-	10[2]	1.2 bioavailable[6a]	1.3[6a]
Hazardous substance	**Priority hazardous substance**	Mercury	0.01[7]	1[2]	0.07[6c]	0.07[6c]
Non-hazardous pollutant	Priority substance	Nickel	-	20[2]	4.0 bioavailable[6a]	8.6[6a]
Non-hazardous pollutant	-	Selenium	-	10[2]	-	-
Non-hazardous pollutant	Specific pollutant	Zinc	-	3,000[3]	10.9 bioavailable[6a]	6.8 dissolved [6a]
None	Specific pollutant	Iron	-	200[2]	1000[6a]*1	1000[6a])*1
None	Specific pollutant	Manganese	-	50[2] (0.05mg/l)	123 bioavailable[6a] (0.123mg/l)	-
(Not determined)	-	Aluminium	-	200[2]	-	-

Substance classification		Determinant	Target concentrations (µg/l)			
			Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
Groundwater receptors[5]	Surface water receptors[6]				Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	**Priority hazardous substance**	Tributyltin compounds (Tributyltin-cation)	0.001[7]	-	0.0002[6a]	0.0002[6a]
(Not determined)	-	Sodium	-	200,000[2] (200 mg/l)	-	-
Non-hazardous pollutant	Specific pollutant	Cyanide (Hydrogen cyanide)	-	50[2] (0.05 mg/l)	1[6a] (0.001 mg/l)	1[6a] (0.001 mg/l)
Non-hazardous pollutant	-	Total ammonia[$] (ammonium (as NH_4^+) plus ammonia (NH_3)	-	500[2] (0.5 mg/l)	300[6f] (0.3 mg/l)	-
Non-hazardous pollutant	Specific pollutant	Ammonia un-ionised (NH_3)	-	-	-	21[6a] (0.021 mg/l)
Non-hazardous pollutant	Specific pollutant	Chlorine	-	-	2[6a] (0.002 mg/l)	10[6d] (0.01 mg/l)
(Not determined)	-	Chloride	-	250,000[2] (250 mg/l)	-	-
(Not determined)	-	Sulphate	-	250,000[2] (250 mg/l)	-	-
(Not determined)	-	Nitrate (as NO_3)	-	50,000[2] (50 mg/l)	-	-
(Not determined)	-	Nitrite (as NO_2)	-	500[2] (0.5 mg/l)	10[9] (0.01 mg/l)	-

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors[5]	Surface water receptors[6]		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
Volatile organic compounds (VOC)						
Non-hazardous pollutant	Other pollutant	Tetrachloroethene (tetrachloroethylene; PCE)	0.1[7]	10[2] sum of TCE and PCE	10[6a]	10[6a]
Hazardous substance	Other pollutant	Trichloroethene (trichloroethylene; TCE)	0.1[7]		10[6a]	10[6a]
None	Specific pollutant	Tetrachloroethane	-	-	140[6a]	-
Hazardous substance	Other pollutant	Carbon tetrachloride (tetrachloromethane)	0.1[7]	3.0[2]	12[6a]	12[6a]
Non-hazardous pollutant	Priority substance	1,2-Dichloroethane	1.0[7]	3.0[2]	10[6a]	10[6a]
Non-hazardous pollutant	-	1,2-Dichloroethene (DCE)	-	50.0[4]	-	-
Hazardous substance	-	Vinyl chloride (chloroethene)	-	0.5[2]	-	-
Non-hazardous pollutant	Priority substance	Dichloromethane	-	20[4]	20[6a]	20[6a]
Non-hazardous pollutant	Priority substance	Trichlorobenzenes	0.01[7]	-	0.4[6a]	0.4[(6a)]
(Not determined)	-	Trihalomethanes	-	100[2a]	-	-

Substance classification		Determinant	Target concentrations (µg/l)			
			Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
Groundwater receptors[5]	Surface water receptors[6]				Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Priority substance	Trichloromethane (Chloroform)	0.1[7]	(see "Trihalomethanes" above)	2.5[6a]	2.5[6a]
Non-hazardous pollutant	**Priority hazardous substance**	Di(2-ethylhexyl) phthalate (bis(2-ethylhexyl) phthalate, DEHP)	-	8[4]	1.3[6a]	1.3[6a]
None	Specific pollutant	Benzyl butyl phthalate	-	-	7.5[6a]	0.75[6e]
Hazardous substance	**Priority hazardous substance**	Hexachlorobutadiene	0.005[7]	0.6[4]	0.6[6c]	0.6[6c]
Semi-volatile organic compounds (SVOC)						
(Not determined)	-	Acenaphthylene (C12-C16)	-	-	5.8[10]	
Hazardous substance	**Priority hazardous substance**	Anthracene (C16-C21)	-	-	0.1[6a]	0.1[6a]
Non-hazardous pollutant	Priority substance	Naphthalene (C10-C12)	-	-	2[6a]	2[6a]

Substance classification		Determinant	Target concentrations (µg/l)			
			Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
Groundwater receptors[5]	Surface water receptors[6]				Freshwater	Transitional (estuaries) and coastal waters
Hazardous substance	Priority substance	Fluoranthene (C21-C35)	-	-	0.0063[6a]	0.0063[6a]
Hazardous substance(s)	**Priority hazardous substance(s)**	Benzo(a)pyrene (C21-C35)	-	0.01[2]	0.00017[6a]	0.00017[6a]
		Benzo(b)fluoranthene (C21-C35)	-	0.1[2] sum of the concentration of the four specified compounds	No EQS for these substances. B(a)P should be used as the indicator compound instead.	
		Benzo(k)fluoranthene (C21-C35)	-			
		Benzo(g,h,i)perylene (C21-C35)	-			
		Indeno(1,2,3-cd) pyrene (C21-C35)	-			
Non-hazardous pollutant	Specific pollutant	Phenol		-	7.7[6a]	7.7[6a]
Hazardous substance	Specific pollutant	2,4-Dichlorophenol	0.1[7]	-	4.2[6a]	0.42[6a]
Hazardous substance	Priority substance	Pentachloro-phenol (PCP)	0.1[7]	9[4]	0.4[6a]	0.4[6a]

Substance classification		Determinant	Target concentrations (µg/l)			
					EQS or best equivalent	
Groundwater receptors[5]	Surface water receptors[6]		Minimum reporting value	UK drinking water standard (or best equivalent)	Freshwater	Transitional (estuaries) and coastal waters
Petroleum hydrocarbons						
Hazardous substance	-	Total petroleum hydrocarbons	-	See Table 2 for individual (non-statutory) TPH CWG fractions with respect to drinking water receptors	See individual risk driving compounds (i.e. BTEX and PAH) for specific EQS	
Hazardous substance	Priority substance	Benzene (C5-C7)	1[7]	1[2]	10[6a]	8[6a]
Hazardous substance	Specific pollutant	Toluene (C7-C8)	4[7]	700[4]	74[6a]	74[6a]
Hazardous substance	-	Ethylbenzene (C8-C9)	-	300[4]	-	-
(Not determined)	-	Xylenes (C8-C10)	3[7]	500[4]	30[11]	-
Non-hazardous pollutant	-	Methyl tertiary butyl ether (MTBE)	-	15[12]	-	
Pesticides, fungicides, insecticides and herbicides						
Hazardous substance(s)	Other pollutant (Cyclodiene	Aldrin	0.003[7]	0.03[2]	0.01[6a] (sum of all four)	0.005[6a] (sum of all four)
		Dieldrin	0.003[7]	0.03[2]		

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors[5]	Surface water receptors[6]		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters
	pesticides)	Endrin	0.003[7]	0.1[2b]		
		Isodrin*[2]	0.003[7]	0.1[2b]		
Hazardous substance	Other pollutant	DDT (total)	0.002[7]	1[4]	0.025[6a]	0.025[6a]
(Not determined) – assume to be Hazardous Substance	-	Total pesticides	-	0.5[2]	-	-
(Not determined) - assume to be Hazardous Substance	-	Other individual pesticides	-	0.1[2]		
Hazardous substance	Specific pollutant	Carbendazim	-	-	0.15[6a]	-
Hazardous substance	Specific pollutant	Chlorothalonil	-	-	0.035[6a]	-
Hazardous substance	Specific pollutant (until 22/12/18, after which it becomes a Priority substance)	Cypermethrin	-	-	0.0001[6a] From 22/12/18: 8.0E-5[6a]	0.0001[6a] From 22/12/18: 8.0E-6[6a]
Hazardous substance	Specific pollutant	Dimethoate	0.01[7]	-	0.48[6a]	0.48[6a]

Substance classification		Determinant	Target concentrations (µg/l)			
			Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
Groundwater receptors[5]	Surface water receptors[6]				Freshwater	Transitional (estuaries) and coastal waters
(Not determined)	Specific pollutant	Glyphosate	-	-	196[6a]	196[6a]
Hazardous substance	Specific pollutant	Linuron		-	0.5[6a]	0.5[6a]
Non-hazardous pollutant	Specific pollutant	Mecoprop	0.04[7]	-	18[6a]	18[6a]
Non-hazardous pollutant	Specific pollutant	Methiocarb	-	-	0.01[6a]	-
Non-hazardous pollutant	Specific pollutant	Pendimethalin	-	20[4]	0.3[6a]	-
Hazardous substance	Specific pollutant	Permethrin	0.001[7]	-	0.001[6a]	0.0002[6a]
Hazardous substance	Priority substance	Alachlor	-	20[4]	0.3[6a]	0.3[6a]
Hazardous substance	Priority substance	Atrazine	0.03[7]	100[4]	0.6[6a]	0.6[6a]
Hazardous substance	Priority substance	Diuron	-	-	0.2[6a]	0.2[6a]
Hazardous substance	**Priority hazardous substance**	Endosulphan	0.005[7]	-	0.005[6a]	0.0005[6a]

Substance classification		Determinant	Target concentrations (µg/l)			
			Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
Groundwater receptors[5]	Surface water receptors[6]				Freshwater	Transitional (estuaries) and coastal waters
Non-hazardous pollutant	Priority substance	Isoproturon	-	9[4]	0.3[6a]	0.3[6a]
Hazardous substance	Priority substance	Simazine	0.03[7]	2[4]	1[6a]	1[6a]
Hazardous substance	**Priority hazardous substance**	Trifluralin	0.01[7]	20[4]	0.03[6a]	0.03[6a]
(Not determined)	From 22/12/18: Priority substance	Dichlorovos	-	-	From 22/12/18: 6.0E-4[6a]	From 22/12/18: 6.0E-5[6a]
Hazardous substance	From 22/12/18: Priority substance	Heptachlor and heptachlor epoxide	-	0.03[2]	From 22/12/18: 2.0E-7[6a]	From 22/12/18: 1.0E-08[6a]
Miscellaneous						
None	Specific pollutant	Triclosan (antibacterial agent)	-	-	0.1[6a]	0.1[6a]
Hazardous substance	**From 22/12/18: Priority hazardous substance**	Perfluoro-octane sulfonic acid (and its derivatives) (PFOS)	-	-	From 22/12/18: 6.5E-4[6a]	From 22/12/18: 1.3E-4[6a]
Hazardous substance	**From 22/12/18: Priority hazardous substance**	Hexabromo cyclododecane (HBCDD)	-	-	From 22/12/18: 0.0016[6a]	From 22/12/18: 0.0008[6a]

Substance classification		Determinant	Target concentrations (µg/l)			
Groundwater receptors[5]	Surface water receptors[6]		Minimum reporting value	UK drinking water standard (or best equivalent)	EQS or best equivalent	
					Freshwater	Transitional (estuaries) and coastal waters

Notes:

'-' A target concentration is not available.

$Please note that total ammonia (NH_4^+ and NH_3) is equivalent to ammoniacal nitrogen in laboratory reports

*1 Please note that although iron is listed in the 2015 Direction as 1.000 µg/l, the EQS remains at 1mg/l in Scotland and it is assumed this is an error and should read either 1,000 or 1000µg/l.

*2 Please note that although Isodrin is not listed in name within the group of "Cyclodiene pesticides" in Table 1 of Schedule 3 Part 3 of the 2015 Direction[6], the CAS number for Isodrin (465-73-6) **is** listed and therefore it is assumed that it has been missed off the named list of substances.

*3 Total petroleum hydrocarbons is used for consistency, but is an analytical method-defined measurement for a mixture of hydrocarbons subject to environmental analysis[11].

"Bioavailable" in relation to copper, zinc, nickel and manganese (but not lead) is the generic EQSbioavailable[6a] derived from the Metal Bioavailability Assessment Tool (M-BAT) developed by the Water Framework Directive UK Technical Advisory Group (WFDTAG). Exceedance of this value should prompt a site-specific assessment using the M-BAT with pH, DOC and Ca to derive a site-specific EQS termed the $PNEC_{dissolved}$. http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat.

For zinc, if there is an exceedance of the EQSbioavailable in an initial GQRA, Tier 2 required that the EQS for zinc should also have the ambient background concentration of zinc added as well

Table 2: World Health Organization (WHO) guide values for TPH CWG fractions in drinking water[13] (as referenced in CL:AIRE, 2017[11])

TPH CWG fraction	WHO guide value for drinking water[13] (µg/l)
Aliphatic fractions:	
Aliphatic EC5-EC6	15,000
Aliphatic >EC6-EC8	15,000
Aliphatic >EC8-EC10	300
Aliphatic >EC10-EC12	300
Aliphatic >EC12-EC16	300
Aliphatic >EC16-EC21	-
Aliphatic >EC21-EC35	-
Aromatic fractions:	
Aromatic EC5-EC6	10 (benzene)
Aromatic >EC6-EC8	700 (toluene)
Aromatic >EC8-EC10	300 (ethyl benzene) 500 (xylenes)
Aromatic >EC10-EC12	90
Aromatic >EC12-EC16	90
Aromatic >EC16-EC21	90
Aromatic >EC21-EC35	90
Reference: World Health Organisation (WHO), 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality. WHO/SDE/WSH/05.08/123. World Health Organisation, Geneva[13].	

References

1. Environment Agency (2017), 'The Environment Agency's approach to groundwater protection', version 1.0, March 2017 (formerly contained within GP3) [accessed 29 March 2017]. https://www.gov.uk/government/collections/groundwater-protection

1a. Environment Agency (2017), 'Land contamination groundwater compliance points: quantitative risk assessments', March 2017 (formerly contained within GP3) [accessed 29 March 2017]. https://www.gov.uk/government/collections/groundwater-protection

2. The Water Supply (Water Quality) Regulations 2016 (SI 2016/619)
    2a. Sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane
    2b. Standard applies to individual pesticides except aldrin, dieldrin, heptachlor and heptachlor epoxide, for which a separate standard is defined.
3. The Private Water Supplies (England) Regulations 2016. SI 2016 / 618
4. WHO (2011), *Guidelines for drinking-water quality*, 4th edn
5. JAGDAG hazard substance determinations: This list contains substances that are determined to be hazardous substances or non-hazardous pollutants for the purposes of the groundwater directive 2006/118/EC. The absence of an assessment or substance from the list means an assessment has not been done yet and is presented as 'Not yet determined'; if a substance has been assessed but does not fall into either category it is presented as 'None'. For further details on how substances are assessed, see the Joint Agencies Groundwater Directive Advisory Group (JAGDAG) 'Methodology for the determination of hazardous substances in groundwater for the purposes of the groundwater directive 2006/118/EC' which is available from the JAGDAG website. The methodology is a UK –wide framework that sets criteria for how to assess whether a substance is a hazardous substances in groundwater. The list of substances can be found at:

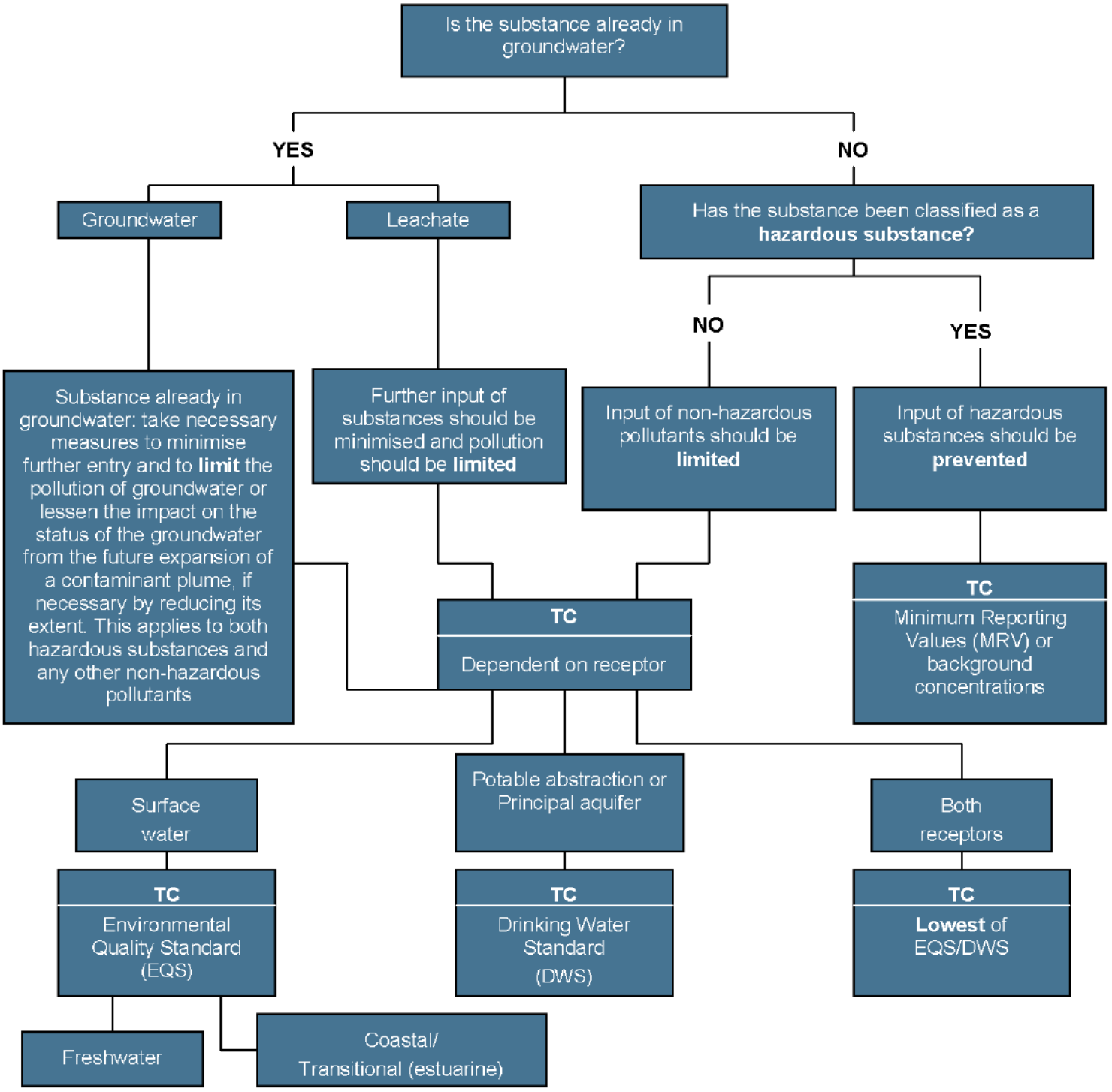
    https://www.wfduk.org/stakeholders/jagdag

6. The Water Framework Directive (Standards and Classification) Directions (England and Wales) 2015.
    6a. The EQS for these substances are based on a "long term mean" or an "annual average (AA)" EQS.
    6b. For cadmium and its compounds the EQS values vary depending on the hardness of the water as specified in five class categories (Class 1: < 40 mg CaCO3/l, Class 2: 40 to < 50 mg CaCO3/l, Class 3: 50 to < 100 mg CaCO3/l, Class 4: 100 to < 200 mg CaCO3/l and Class 5: ≥ 200 mg CaCO3/l).
    6c. The EQS for Mercury and hexachlorobutadiene are based on a "maximum acceptable concentration (MAC)" EQS in absence of an "annual average (AA)" EQS.
    6d. The EQS for chlorine in saltwater is based on the 95th percentile concentration of total residual oxidant, which refers to the sum of all oxidising agents existing in water, expressed as available chlorine.
    6e. The recommended saltwater standard is derived using a safety factor of 100. Where the standard is failed, it is recommended that supporting evidence of ecological damage should be obtained before committing to expensive action.
    6f. EQS for total ammonia is as per Schedule 3, Part 1, Table 7 of of the above directions. EQS applies to river types 1, 2 and 4 and 6 (namely upland and low alkalinity). The EQS for a lowland and high alkalinity rivers (types 3, 5 and 7) is 600µg/l (0.6mg/l).

Additional information on the Metal Bioavailability Assessment Tool (M-BAT) is available at http://www.wfduk.org/resources/rivers-lakes-metal-bioavailability-assessment-tool-m-bat

7. Minimum reporting values listed at https://www.gov.uk/government/publications/values-for-groundwater-risk-assessments/hazardous-substances-to-groundwater-minimum-reporting-values (updated 13 January 2017; accessed 29 March 2017). Note target concentration for xylenes is 3 µg/l each for o-xylene and m/p xylene as it may not be possible to separate m- and p-xylene; 135 tcb, 124 tcb, 123 tcb each to 0.01 µg/l)
8. The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations 1996 (as amended). SI 1996 / 3001
9. Council Directive on the Quality of Fresh Waters Needing Protection or Improvement in Order to Support Fish Life (Freshwater Fish Directive) (78/659/EEC)
10. WRc plc (2002), R&D Technical Report P45.
11. CL:AIRE, 2017. Petroleum Hydrocarbons in Groundwater: Guidance on assessing petroleum hydrocarbons using existing hydrogeological risk assessment methodologies. V1.1.
12. Drinking Water Inspectorate (London, UK). Environmental Information Request on MTBE in drinking water. Ref. DWI 1/10/18; dated 28 November 2006. Value is based on the odour threshold for MTBE, which is lower than a health-based guideline value
13. World Health Organisation (WHO), 2008. Petroleum products in drinking-water. Background document for development of WHO guidelines for drinking water quality. WHO/SDE/WSH/05.08/123. World Health Organisation, Geneva. [accessed 29 March 2017] http://www.who.int/water_sanitation_health/dwq/chemicals/petroleumproducts_2add_june2008.pdf

FLOW CHART TO ASSIST WITH SELECTION OF TARGET CONCENTRATIONS



TC = Target concentration

When leachate is being assessed the 'compliance point' is the groundwater body. Therefore dilution within the groundwater body may be applied with caution before comparing with the TC.

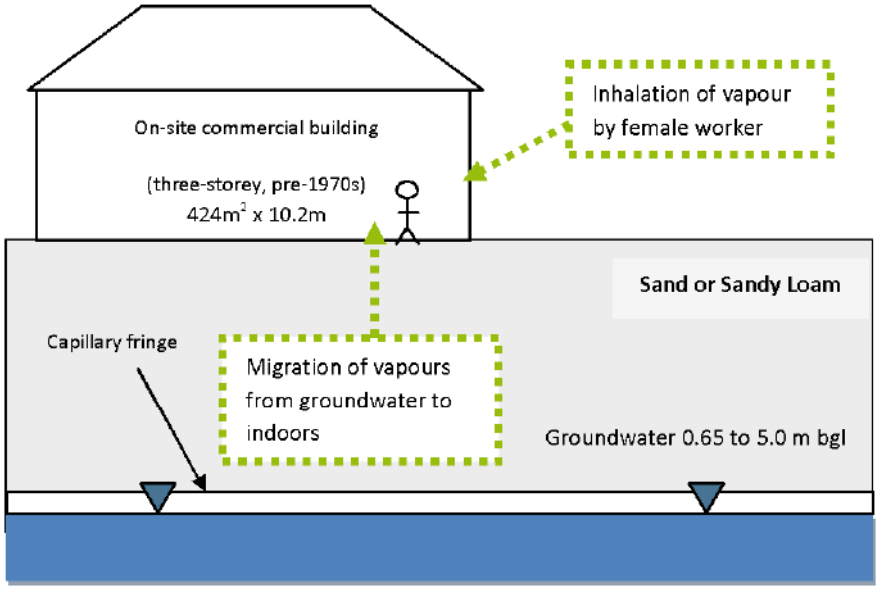
When directly assessing a receptor, e.g., a river, the appropriate TC should be selected.

Generic groundwater assessment criteria (GrAC) for human health: commercial scenario (adult receptor)

Background

Volatile organic compounds (VOC) in groundwater have the potential to pose risks to residential site end users via indoor and outdoor inhalation exposure. Due to significant dilution effects in outdoor air, inhalation risk is dominated by indoor exposure. The GrAC conceptual site model (CSM) is shown in Figure 1 (not to scale).

Figure 1: GrAC conceptual model for a generic commercial scenario



RSK GrAC derivation

Model selection

The Society for Brownfield Risk Assessment (SoBRA) published a set of generic assessment criteria for assessing vapour risk to human health from volatile contaminants in groundwater in February 2017[(1)]. The criteria were developed for a list of common VOC using the Environment Agency Contaminated Land Exposure Assessment (CLEA) tool[(2)] based on a sand soil type and a groundwater depth of 0.65 m below foundation base level. The CLEA tool is not designed to directly model VOC in groundwater and the SoBRA generic criteria are recognised as being conservative since calculations in CLEA are based on three-phase partitioning in the unsaturated zone between soil, soil vapour and soil moisture, with the latter taken by SoBRA as a groundwater equivalent. This method does not take account of the presence of a semi-saturated capillary fringe above the water table, which will serve to provide some mitigation to vertical soil vapour migration.

RSK GrAC are calculated using the RBCA Toolkit for Chemical Releases (version 2.6) with the Johnson and Ettinger model, based on the CSM in Figure 1 for a pre-1970 three storey office

building (as defined in SR3[3], Table 4.21) and which allows consideration of a capillary fringe. The capillary fringe is the subsurface layer in which groundwater seeps up from a water table by capillary action to partially fill soil pores.

The RBCA model was used in preference to the Environment Agency Contaminated Land Exposure Assessment (CLEA) tool[2], as the CLEA tool is not designed to directly model VOC in groundwater and does not take account of the presence of a semi-saturated capillary zone.

Conceptual model

In accordance with SR3[3], the commercial scenario considers risks to an adult female worker who works from the age of 16 to 65 years. It should be noted that this end use is not suitable for a workplace nursery (where children will be present for an extended period of time) but may be appropriate for a sports centre or shopping centre where children are present but for limited periods of time.

The pollutant linkage considered in production of the GrAC is the volatilisation of compounds from groundwater and subsequent vapour inhalation by the identified receptor while indoors. Figure 1 illustrates this linkage. Although the outdoor air inhalation pathway is also valid, this contributes little to the overall risks owing to the dilution in outdoor air. RBCA does not take account of the presence of non-aqueous phase chemicals but highlights when the assessment criterion exceeds the solubility limit of the pure compound.

Input selection – chemical and toxicological parameters

Key parameters used in the RBCA model are listed and justified in Table 1. The most up-to-date published chemical and toxicological data was obtained from EA Report SC050021/SR7[2], the EA TOX[5] reports, and published by Nathanial et al.,[6], as appropriate. Toxicological and specific chemical parameters for 1,2,4-trimethylbenzene and methyl tertiary-butyl ether (MTBE) were obtained from the CL:AIRE Soil Generic Assessment Criteria report[7].

The toxicological input parameters are associated with minimal risk, rather than low risk.

For petroleum hydrocarbon fractions, aromatic hydrocarbons C5–C8 were not modelled, as this range comprises benzene (>EC5-EC7) and toluene (>EC7-EC8), which are modelled separately.

For the Commercial GrAC, the Health Criteria Values (HCV) used in the modelling were derived using the toxicological data discussed above, amended as follows:

- An adult weighing 70kg and breathing 15.7m^3 air per day in accordance with the revised exposure parameters used in the SP1010 final project report for the Category 4 Screening Levels (C4SL) (Table 3.2[8]) and USEPA data[9]
- Background inhalation (mean daily intake(MDI)) for an adult (Age Class 17).

The amended HCV used in the derivation of the RSK GrAC are presented in Table 1.

Table 1: Amended Health Criteria Values

	Modified HCV (mg/m^3)
VOC / SVOC	Adult (Commercial)
MTBE	3.2064
Benzene	0.0062
Toluene	6.2362
Ethylbenzene	0.3301
Xylenes	0.2609
Trimethybenzenes	0.0085
TPH_Aliph EC5-EC6	11.1465
TPH_Aliph >EC6-EC8	11.1465
TPH_Aliph >EC8-EC10	0.6465
TPH_Aliph >EC10-EC12	0.6465
TPH_Aliph >EC12-EC16	0.6465
TPH_Arom >EC8-EC10	0.1338
TPH_Arom >EC10-EC12	0.1338
TPH_Arom >EC12-EC16	0.1338
Acenaphthene	0.2675
Acenaphthylene	0.2675
Naphthalene	0.0037
Vinyl chloride	0.0013
Dichloroethane-1,2	0.0005
Tetrachloroethene	0.0363
Carbon tetrachloride	0.0114
Trichloroethane-1,1,1	2.6752
Trichloroethene	0.0025
Tetrachloroethane 1,1,2,2 & 1,1,1,2	0.0257
1,1,2-Trichloroethane	0.0216
1,1-dichloroethene	0.2541
Chloroethane	12.7374
Chloromethane	0.0115
Dichloromethane	0.5765

Note on Trimethylbenzenes

For trimethylbenzenes the CL:AIRE report[7] based background inhalation from non-soil sources (MDI) on a Dutch study from 1985, which is reported to have identified an average daily dose of 1,2,4-trimethylbenzene of 86 ug d^{-1} (1,3,5-trimethylbenzene was 20.5 ug d^{-1}). This dose value was based on the upper end of the identified concentration range of 1,2,4-trimethylbenzene (2.46 – 5.66 ug m^{-3}) and was used to calculate an a MDI of 1.23 ug kg^{-1} bw d^{-1} for a 70 kg adult breathing 20 m^3 of air daily.

The approach recommended in SR2[10], and also adopted for the C4SLs[8], for non-carcinogenic (threshold) compounds such as trimethylbenzenes is to subtract the MDI from the tolerable daily intake (TDI) to obtain a tolerable daily intake from soil (TDSI) in units of ug kg^{-1} bw d^{-1}. For 1,2,4-trimethylbenzene, the adult MDI from the Dutch study used in the CL:AIRE report[7] (1.23 ug kg^{-1} bw d^{-1}) is a significant proportion of the TDI (2.0 ug kg^{-1} bw d^{-1}), resulting in a low TDSI (1.0 ug kg^{-1} bw d^{-1}) when the 50% rule is applied (i.e. TDSI = TDI * 0.5 when MDI is high relative to TDI).

This TDSI equates to an Inhalation Reference Concentration (or modified Health Criteria Value) for adults of 3.4 ug m^{-3} (70 kg adult breathing 15.7 m^3 d^{-1}).

By comparison the adult inhalation modified HCV for benzene is 6.2 ug m^{-3}, which is proven human carcinogen (non-threshold compound).

The MDI for 1,2,4-trimethylbenzene is considered by RSK to be overly conservative for the following reasons:

- The Dutch 1985 study is dated and air quality has improved since this time
- The maximum value in the range (5.66 ug m^{-3}) was used in calculating the MDI
- Experience has shown that trimethylbenzenes often appear to drive inhalation risks to a greater extent than benzene, even though the latter is carcinogenic and more volatile.

As an alternative to the 1985 Dutch study, RSK have obtained automated roadside air quality monitoring data for the UK from www.uk-air.defra.gov.uk/. The average concentration of 1,2,4-trimethylbenzene measured during 2015 at Eltham, south-east London (urban) was 0.309 ug m^{-3}, significantly lower than that identified in the Dutch study and used by CL:AIRE[7] for calculation of a MDI. Whilst an average concentration of 1,2,4-trimethylbenzene in UK urban and rural areas is likely to be significantly below 0.0.309 ug m^{-3}, this value is considered to be suitably conservative for the calculation of a modified HCV for trimethylbenzenes in the UK.

On this basis, the HCV for 1,2,4-trimethylbenzene for adults and children was calculated as 8.5 ug m^{-3} (0.0085 mg m^{-3}) and 2.6 ug m^{-3} (0.0026 mg m^{-3}), respectively (see Table 3). Due to the paucity of toxicological data for 1,2,3-trimethylbenzene and 1,3,5-trimethylbenzene the modified HCV for 1,2,4-trimethylbenzene is considered suitable for assessing total trimethylbenzenes.

Note on aqueous solubility and the RSK GrAC

Where the modelled assessment criteria, or the modelled assessment criteria with the correction factor applied to those contaminants specified below, exceeds the aqueous solubility limit the assessment criteria defaults to this concentration and consequently the GrAC is set at the limit of solubility. These assessment criteria are shaded in red in Table 3 at the end of this document.

The theoretical aqueous solubility is the maximum amount of a single chemical that will dissolve in pure water at a specified temperature. Above this concentration, the chemical will exist in the non-aqueous phase (i.e. in its natural physical form as a solid, liquid (NAPL) or gas). If the contaminant, based on its toxicity, is not considered to pose a risk to human health at the aqueous solubility concentration then the contaminant can be considered not to pose a risk to human health. Where the GrAC is set at the aqueous solubility limit (shaded in red on Table 3), this is not a risk based assessment criteria but is indicative of the maximum amount of chemical that would be found dissolved in the water. Therefore an exceedance of the RSK GrAC set at the aqueous solubility limit is <u>not</u> indicative that there may be potential risks to human health. It should be noted that for certain contaminants (e.g. the lighter petroleum hydrocarbon fractions) the aqueous solubility is very low and may be at, or below, the laboratory method detection limit. It should also be noted that non-aqueous phase may exist where concentrations of individual compounds are well below their solubility limits where they are part of a mixture, in accordance with Raoult's Law.

Input selection - physical parameters

For the commercial scenario, the CLEA default pre-1970s three-storey office building was used. SR3[3] notes this commercial building type to be the most conservative in terms of risk from vapour intrusion. The building parameters used in the production of the RSK GACs are the default CLEA v1.06 inputs presented in Table 3.3 of SR3[3].

The RSK GrAC have been calculated for both Sand and Sandy Loam soils. The soil parameters used in the derivation of the RSK GrAC are those presented in Table 3.1 of SR3[3].

The RSK GrAC have been derived for groundwater depths of 0.65 m, 1.5 m, 2.5 m and 5.0 m below ground level, incorporating a capillary fringe (see Table 2).

Input selection - attenuation factors

In line with recommendations provided in Environment Agency SR3[3] a sub-surface to indoor attenuation factor of 10 has been applied to certain RBCA derived 'site-specific target levels'. SR3[3] states that, as a general rule of thumb, it is recognised that estimating vapour phase concentrations from dissolved and sorbed phase petroleum hydrocarbons by using partition coefficients are at least a factor of ten higher than those likely to be measured on-site. This difference is likely to be due to a number of factors, however aerobic biodegradation in the unsaturated zone is believed to be largely responsible. RSK has therefore applied this attenuation factor to all volatile petroleum hydrocarbon fractions (including BTEX, trimethylbenzenes and the polycyclic aromatic hydrocarbons (PAH) naphthalene, acenaphthene and acenaphthylene). No such attenuation factors have been applied to other non-hydrocarbon chemical species, including chlorinated hydrocarbons or fuel oxygenates such as MtBE.

Convective (volumetric) air flow through foundation cracks (Q_{soil}) is a sensitive parameter in the calculation of GrAC and has been calculated within RBCA on a soil-specific basis for Sand and Sandy Loam in a residential exposure scenario (see Table 2). This approach is less conservative than using the default Q_{soil} value recommended in SR3[3] for a Sandy Loam (150 cm^3 s^{-1}) and used in the CLEA model (version 1.071) for Sandy Loam (and Sand) soils (150 cm^3 s^{-1}) in a commercial scenario.

Table 2: Commercial scenario – RBCA inputs

Parameter	Unit	Value	Justification
Receptor – female child			
Averaging time	Years	49	From Box 3.5, SR3[3]
Receptor weight	kg	70	Female adult, Table 4.6, SR3[3]
Exposure duration	Years	49	From Box 3.5, SR3[3]
Exposure frequency	Days yr^{-1}	86.25	Weighted using occupancy period of 9 hours per day for 230 days of the year ((9hours x 230 days)/24 hours)
Soil type – sand			
Total porosity	-	0.54	CLEA value for sand. Parameters for sand from Table 4.4, SR3[3] Volumetric water content in the vadose zone is a highly sensitive parameter within the model and potentially highly variable in the field.
Volumetric water content – unsaturated (vadose) zone	-	0.24	
Volumetric air content - unsaturated (vadose) zone	-	0.30	
Dry bulk density	g cm^{-3} or kg L^{-1}	1.18	
Volumetric water content – capillary zone	-	0.35	Calculated using SR3 Equation 4.1. Value taken as the average moisture content calculated for suction heads (cm H_2O); 0 (i.e. saturated), 10, 20, 30, 40, 50 (i.e. unsaturated soil at field capacity). This is a highly sensitive parameter within the model.
Volumetric air content - capillary zone	-	0.19	Calculated from total porosity and volumetric water content of capillary zone. This is a highly sensitive parameter within the model.
Vertical hydraulic conductivity	cm d^{-1}	636	CLEA value for saturated conductivity of sandy loam, Table 4.4, SR3[8] equivalent to 7.36 E-03 cm s^{-1}
Vapour permeability	m^2	7.54 E-12	Calculated for sand using equations in Appendix 1, SR3[3]
Capillary zone thickness	m	0.25	Taken from C W Fetter, Applied Hydrogeology 4th Ed, 1994[11] and R Heath, Basic groundwater hydrology 1992[12] for a medium sand
Fraction organic carbon	%	0.0058	Equivalent to SOM = 1%. Note that GrAC are independent on FOC/SOM content since partitioning is assumed to be between aqueous and vapour phases only
Soil type – sandy loam			
Total porosity	-	0.53	CLEA value for sandy loam. Parameters for sandy loam from Table 4.4, SR3[3]. Volumetric water content in the vadose zone is a highly sensitive parameter within the model and potentially highly variable in the field.
Volumetric water content – unsaturated (vadose) zone	-	0.33	
Volumetric air content - unsaturated (vadose) zone	-	0.20	
Dry bulk density	g cm^{-3} or kg/L	1.21	
Volumetric water content – capillary zone	-	0.42	Calculated using SR3 Equation 4.1[3]. Value taken as the average moisture content calculated for suction heads (cm H_2O); 0 (i.e. saturated), 10, 20, 30, 40, 50 (i.e. unsaturated soil at field capacity). This is a highly sensitive parameter within the model.
Volumetric air content - capillary zone	-	0.11	Calculated from total porosity and volumetric water content of capillary zone. This is a highly sensitive parameter within the model.

Parameter	Unit	Value	Justification
Vertical hydraulic conductivity	cm d^{-1}	308	CLEA value for saturated conductivity of sandy loam, Table 4.4, SR3[3] equivalent to 3.56E-3 cm s^{-1}
Vapour permeability	m^2	3.05 E-12	Calculated for sandy loam using equations in Appendix 1, SR3[3]
Capillary zone thickness	m	0.4	Taken from R Heath, Basic Groundwater Hydrology 1992[12] for a fine sand. Note: C W Fetter, Applied Hydrogeology 4th Ed, 1994[11] value for fine sand is 0.5 m
Fraction organic carbon	%	0.0058	Equivalent to SOM = 1%. Note that GrAC are independent on FOC/SOM content since partitioning is assumed to be between aqueous and vapour phases only
Building – pre-1970 three storey office			
Building volume/area ratio	m	9.6	Table 3.10, SR3[3]
Foundation area	m^2	424	
Foundation perimeter	m	82.40	Based on square root of building area being 20.59m
Building air exchange rate	d^{-1}	24	Table 3.10, SR3[3] Building air exchange rate equivalent to 2.8 E-04 s^{-1}
Depth to bottom of foundation slab	m	0.15	
Foundation thickness	m	0.15	
Foundation crack fraction	-	3.89E-04	Calculated from floor crack area of 0.165m^2 and building footprint of 424m^2 in Table 4.21, SR3[3]
Volumetric water content of cracks	-	0.24 / 0.33	For sand / sandy loam, assumed equal to underlying soil type in assumption that cracks become filled with unsaturated zone soil over time. Parameters for sand and sandy loam from Table 4.4, SR3[3]
Volumetric air content of cracks	-	0.30 / 0.20	
Indoor/outdoor differential pressure	Pa	4.4	From Table 3.3, SR3[3] Equivalent to 44g/cm/s^2
Convective air flow through cracks (Q_{soil}) - Sand	m^3 s^{-1}	1.95 E-04	Soil-specific calculated parameter in RBCA equivalent (and cross checked) with equations A1, A2, A3, A8, A9 in SR3[3]. Equivalent to **195 cm^3 s^{-1}**
Convective air flow through cracks (Q_{soil}) – Sandy Loam	m^3 s^{-1}	7.7 E-05	Soil-specific calculated parameter in RBCA equivalent (and cross checked) with equations A1, A2, A3, A8, A9 in SR3[3]. Equivalent to **77 cm^3 s^{-1}**

RSK GrAC derivation outputs

The RSK GrACs are presented in Table 3.

Within the RSK GrAC the following should be noted:

- GrAC do not take account of outdoor inhalation exposure to VOC, which is considered to contribute minimally to overall inhalation exposure
- GrAC do not take account of other exposure routes potentially relevant to VOC in shallow groundwater such as direct contact or root uptake
- No biodegradation is assumed to occur in the unsaturated zone. Where aerobic conditions on site are known to exist the GrAC for hydrocarbons may therefore be conservative
- GrAC do not take account of preferential flow into buildings such as through unsealed service entries. In such circumstances GrAC may not be appropriate for use
- GrAC are based on a soil vapour intrusion CSM and are not appropriate for use when the foundation is in direct contact with contaminated groundwater

- GrAC assume that the capillary fringe is un-contaminated with VOC, which is unlikely, particularly where groundwater levels are variable
- GrAC set at the theoretical aqueous solubility limit are not considered to pose a risk to human health
- GrAC do not take into account the interaction between contaminants and the influence this may have on the theoretical aqueous solubility
- GrACs are only applicable to dissolved phase contaminants where the modelled assessment criteria is below the aqueous solubility limits

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	Table 3: RSK GrAC (ug/l)							
	COMMERCIAL							
	SAND				SANDY LOAM			
GW Depth (m)	0.65	1.5	2.5	5	0.65	1.5	2.5	5
Metals								
Elemental mercury	56	56	56	56	56	56	56	56
Methyl mercury	100000	100000	100000	100000	100000	100000	100000	100000
Volatile Organic Compounds								
Benzene	30740	40200	51330	79160	158660	193720	234960	338070
Toluene	590000	590000	590000	590000	590000	590000	590000	590000
Ethylbenzene	180000	180000	180000	180000	180000	180000	180000	180000
Xylene - m	200000	200000	200000	200000	200000	200000	200000	200000
Xylene - o	173000	173000	173000	173000	173000	173000	173000	173000
Xylene - p	200000	200000	200000	200000	200000	200000	200000	200000
Total xylene	173000	173000	173000	173000	173000	173000	173000	173000
Methyl tertiary-Butyl ether (MTBE)	12068580	16013210	20653950	32255810	48000000	48000000	48000000	48000000
Trichloroethene	820	1090	1400	2180	4410	5400	6550	9440
Tetrachloroethene	7430	9930	12870	20210	41190	50460	61360	88610
1,1,1-Trichloroethane	456280	604180	778170	1213140	1300000	1300000	1300000	1300000
1,1,1,2 Tetrachloroethane	35130	47100	61190	96410	180890	225050	277000	406880
1,1,2,2-Tetrachloroethane	231900	313430	409350	649150	844250	1131800	1470100	2315840
Carbon Tetrachloride	1200	1590	2050	3210	6600	8050	9760	14030
1,2-Dichloroethane	1290	1690	2160	3350	5860	7330	9060	13390
Vinyl Chloride	90	120	140	220	460	550	660	930
1,2,4-Trimethylbenzene	55900	55900	55900	55900	55900	55900	55900	55900
Semi-Volatile Organic Compounds								
Acenaphthene	4100	4100	4100	4100	4100	4100	4100	4100
Acenaphthylene	7950	7950	7950	7950	7950	7950	7950	7950
Naphthalene	19000	19000	19000	19000	19000	19000	19000	19000
Petroleum Hydrocarbons								
Aliphatic hydrocarbons EC5-EC6	35900	35900	35900	35900	35900	35900	35900	35900
Aliphatic hydrocarbons >EC6-EC8	5370	5370	5370	5370	5370	5370	5370	5370
Aliphatic hydrocarbons >EC8-EC10	427	427	427	427	427	427	427	427
Aliphatic hydrocarbons >EC10-EC12	33.9	33.9	33.9	33.9	33.9	33.9	33.9	33.9
Aliphatic hydrocarbons >EC12-EC16	0.759	0.759	0.759	0.759	0.759	0.759	0.759	0.759
Aromatic hydrocarbons >EC8-EC10	64600	64600	64600	64600	64600	64600	64600	64600
Aromatic hydrocarbons >EC10-EC12	24500	24500	24500	24500	24500	24500	24500	24500
Aromatic hydrocarbons >EC12-EC16	5750	5750	5750	5750	5750	5750	5750	5750

Notes:

Values less than 100 have not been rounded up or down; values greater than 100 have been rounded to the nearest 10.

Highlighted values exceed solubility limit for the pure compound in water (aqueous solubility); GrAC defaults to the limit of solubility.

No vadose zone biodegradation considered

Sub-surface to indoor air correction factor of 10 applied to all petroleum (non-chlorinated) hydrocarbons

All GrAC are for 1% SOM (0.0058 FOC)

Generic assessment criteria for human health: commercial scenario

Background

RSK's generic assessment criteria (GAC) were initially prepared following the publication by the Environment Agency (EA) of soil guideline value (SGV) and toxicological (TOX) reports, and associated publications in 2009[1]. RSK GAC were updated following the publication of GAC by LQM/CIEH in 2009[2]. RSK GAC are periodically revised when updated information on toxicological, land use or receptor parameters is published.

Updates to the RSK GAC

In 2014, the publication of Category 4 Screening Levels (C4SL)[3,4], as part of the Defra-funded research project SP1010, included modifications to certain exposure assumptions documented within EA Science Report SC050221/SR3 (herein after referred to as SR3)[5] used in the generation of SGVs.

C4SL were published for six substances (cadmium, arsenic, benzene, benzo(a)pyrene, chromium VI and lead) for a sandy loam soil type with 6% soil organic matter, based on a low level of toxicological concern (LLTC; see Section 2.3 of research project report SP1010[3]). Where a C4SL has been published, the RSK GAC duplicates the C4SL published values using all input parameters within the SP1010 final project report[3] and associated appendices[6], and adopts them as GAC for these six substances.

For all other substances the only C4SL exposure modification relevant to a commercial end use are daily inhalation rates.

The RSK GAC have also been revised with updated toxicology published by LQM/CIEH in 2015[7] or by the USEPA[14], where a C4SL has not been published.

RSK GAC derivation for metals and organic compounds

Model selection

Soil assessment criteria (SAC) were calculated using the Contaminated Land Exposure Assessment (CLEA) tool v1.071, supporting EA guidance[5,8,9] and revised exposure scenarios published for the C4SL[3]. The SAC are also termed GAC.

Pathway selection

In accordance with SR3[5] the commercial scenario considers risks to a female worker who works from the age of 16 to 65 years. It should be noted that this end use is not suitable for a workplace nursery but may be appropriate for a sports centre or shopping centre where children are present. In accordance with Box 3.5, SR3[5] the pathways considered for production of the SAC in the commercial scenario are

- direct soil and dust ingestion
- dermal contact with soil both indoors and outdoors
- indoor air inhalation from soil and vapour and outdoor inhalation of soil and vapour.

With respect to volatilisation, the CLEA model assumes a simple linear partitioning of a chemical in the soil between the sorbed, dissolved and vapour phase[9]. The upper boundaries of this partitioning are represented by the maximum aqueous solubility and pure saturated vapour concentration of the chemical. The CLEA model estimates saturated soil concentrations where these limits are reached[9]. The CLEA software uses a traffic light system to identify when individual and/or combined assessment criteria exceed the lower of either the aqueous- or vapour-based soil saturation limits. Model output cells are flagged red where the saturated soil concentration has been exceeded and the contribution of the indoor and outdoor vapour pathway to total exposure is greater than 10%. In this case, further consideration of the following is required[9]:

- Free phase contamination may be present.
- Exposure from the vapour pathways will be over-predicted by the model, as in reality the vapour phase concentration will not increase at concentrations above saturation limits
- Where the vapour pathway contribution is greater than 90%, it is unlikely the relevant health criteria value (HCV) will be exceeded at soil concentrations at least a factor of ten higher than the relevant HCV.

Where the vapour pathway is the predominant pathway (contributes greater than 90% of exposure) or the only exposure route considered and the cell is highlighted red (SAC exceeds saturation limit), the risk based on the assumed conceptual model is likely to be negligible as the vapour risk is assumed to be tolerable at maximum possible soil concentrations. In such circumstances, the vapour pathway exposure should be considered based on the presence of free phase or non-aqueous phase liquid sources and the measured concentrations of volatile organic compounds (VOC) in the vapour phase. Screening could be considered based on setting the SAC as the modelled soil saturation limits. However, as stated within the CLEA handbook[9], this is likely to not be practical in many cases because of the very low saturation limits and, in any case, is highly conservative.

It should also be noted that for mixtures of compounds, free phase may be present where soil (or groundwater) concentrations are well below saturation limits for individual compounds.

Where the vapour pathway is only one of the exposure pathways considered, an additional approach can then be utilised as detailed within Section 4.12 of the CLEA model handbook[9], which explains how to calculate an effective assessment criterion manually.

SR3[5] states that, as a general rule of thumb, it is recognised that estimating vapour phase concentrations from dissolved and sorbed phase contamination by petroleum hydrocarbons are at least a factor of ten higher than those likely to be measured on-site. RSK has therefore applied an empirical subsurface to indoor air correction factor of 10 into the CLEA model chemical database for all petroleum hydrocarbon fractions (including BTEX, trimethylbenzenes and the polycyclic aromatic hydrocarbons (PAH) naphthalene, acenaphthene and acenaphthylene) to reduce this conservatism.

Input selection

The most up-to-date published chemical and toxicological data was obtained from EA Report SC050021/SR7[10], the EA TOX[1] reports, the C4SL SP1010 project report and associated appendices[3,6], the 2015 LQM/CIEH report[7] or the USEPA IRIS database[14]. Where a C4SL has been published, the RSK GAC have duplicated the C4SL published values using all input parameters within the SP1010 final project report[3] and associated appendices[6], and has

adopted them as GAC for these six substances. Toxicological and specific chemical parameters for 1,2,4-trimethylbenzene, methyl tertiary-butyl ether (MTBE), 1,1,2-trichlorethane, 1,1-dichloroethene, 1,2-dichloropropane, 2-chloronaphthalene, chloroethane, chloromethane, cis 1,2-dichloroethene, dichloromethane, hexachloroethane and trans 1,2-dichloroethene were obtained from the CL:AIRE Soil Generic Assessment Criteria report[11].

For TPH, aromatic hydrocarbons C_5–C_8 were not modelled, as this range comprises benzene (>EC5-EC7) and toluene (>EC7-EC8), which are modelled separately.

Physical parameters

For the commercial end use, the CLEA default pre-1970s three-storey office building was used. SR3[5] notes this commercial building type to be the most conservative in terms of protection from vapour intrusion. The default input building parameters presented in Table 3.10 of SR3[5] have been used.

The parameters for a sandy loam soil type were used in line with Table 4.4 of SR3[5]. This includes a value of 6% for the percentage of soil organic matter (SOM) within the soil. In RSK's experience, this is rather high for many sites. To avoid undertaking site-specific risk assessments for this SOM, RSK has produced an additional set of GAC for SOM of 1% and 2.5% for all substances using the CLEA tool.

Summary of modifications to the default CLEA SR3[5] input parameters for a commercial land use

In summary, the RSK commercial GAC were produced using the default input parameters for soil properties, the air dispersion model, building properties and the vapour model detailed in SR3[5]. Modifications to the default SR3[5] exposure scenarios based on the C4SL exposure scenarios[3] are presented in Table 2 below. The sole modification to the default commercial input parameters is the updated inhalation rate.

The final selected GAC are presented by pathway in Table 3 with the combined GAC in Table 4.

Figure 1: Conceptual model for CLEA commercial scenario

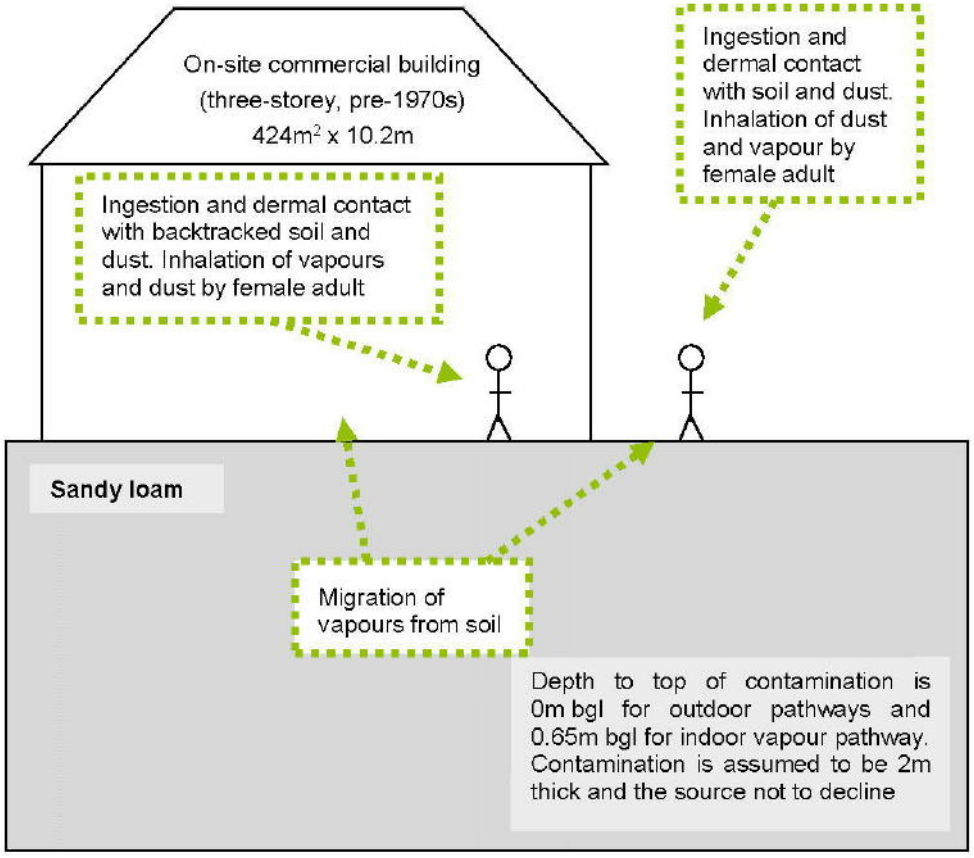

Table 1: Exposure assessment parameters for commercial scenario – inputs for CLEA model

Parameter	Value	Justification
Land use	Commercial	Chosen land use
Receptor	Female worker	Taken as female adult exposed over 49 years from age 16 to 65 years, Box 3.5, SR3[5]
Building	Office (pre-1970)	Key generic assumption given in Box 3.5, SR3[5]. Pre-1970s three-storey office building chosen as it is the most conservative in terms of protection from vapour intrusion (Section 3.4.6, SR3[5])
Soil type	Sandy loam	Most common UK soil type (Section 4.3.1, Table 4.4, SR3[5])
Start age class (AC)	17	AC corresponding to key generic assumption that the critical receptor is a working female adult exposed over a 49-year period from age 16 to 65 years. Assumption given in Box 3.5, SR3[5]
End AC	17	
SOM (%)	6	Representative of sandy loam according to EA guidance note dated January 2009 entitled 'Changes We Have Made to the CLEA Framework Documents'[13]
	1	To provide SAC for sites where SOM < 6% as often observed by RSK
	2.5	
pH	7	Model default

Table 2: Commercial – modified receptor inputs

Parameter	Unit	Value	Justification
Inhalation rate (AC17)	m^3 day^{-1}	15.7	Mean value USEPA, 2011[12]; Table 3.2, SP1010[3]

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GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - COMMERCIAL

Table 3

Human health generic assessment criteria by pathway for commercial scenario

Compound	Notes	SAC appropriate to pathway SOM 1% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 2.5% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 6% (mg/kg)			Soil saturation limit (mg/kg)
		Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Metals													
Arsenic	(a,b)	6.35E+02	1.25E+03	NR	NR	6.35E+02	1.25E+03	NR	NR	6.35E+02	1.25E+03	NR	NR
Cadmium	(a)	7.73E+02	8.57E+02	4.10E+02	NR	7.73E+02	8.57E+02	4.10E+02	NR	7.73E+02	8.57E+02	4.10E+02	NR
Chromium (III) - trivalent	(c)	3.31E+05	8.57E+03	NR	NR	3.31E+05	8.57E+03	NR	NR	3.31E+05	8.57E+03	NR	NR
Chromium (VI) - hexavalent	(a,d)	9.62E+02	4.91E+01	NR	NR	9.62E+02	4.91E+01	NR	NR	9.62E+02	4.91E+01	NR	NR
Copper		1.89E+05	8.96E+04	6.83E+04	NR	1.89E+05	8.96E+04	6.83E+04	NR	1.89E+05	8.96E+04	6.83E+04	NR
Lead	(a)	2.32E+03	NR	NR	NR	2.32E+03	NR	NR	NR	2.32E+03	NR	NR	NR
Elemental Mercury (Hg^0)	(d)	NR	1.54E+01	NR	4.31E+00	NR	3.26E+01	NR	1.07E+01	NR	5.80E+01	NR	2.58E+01
Inorganic Mercury (Hg^{2+})		1.18E+03	1.97E+04	1.12E+03	NR	1.18E+03	1.97E+04	1.12E+03	NR	1.18E+03	1.97E+04	1.12E+03	NR
Methyl Mercury (Hg^{1+})		3.38E+02	2.13E+03	2.92E+02	7.33E+01	3.38E+02	3.87E+03	3.11E+02	1.42E+02	3.38E+02	7.33E+03	3.23E+02	3.04E+02
Nickel	(d)	3.06E+03	9.83E+02	NR	NR	3.06E+03	9.83E+02	NR	NR	3.06E+03	9.83E+02	NR	NR
Selenium	(b)	1.23E+04	NR	NR	NR	1.23E+04	NR	NR	NR	1.23E+04	NR	NR	NR
Zinc	(b)	7.35E+05	1.97E+08	NR	NR	7.35E+05	1.97E+08	NR	NR	7.35E+05	1.97E+08	NR	NR
Cyanide (free)		6.56E+02	7.51E+04	6.53E+02	NR	6.56E+02	7.51E+04	6.53E+02	NR	6.56E+02	7.51E+04	6.53E+02	NR
Volatile Organic Compounds													
Benzene	(a)	1.09E+03	2.79E+01	2.72E+01	1.22E+03	1.09E+03	5.19E+01	4.96E+01	2.26E+03	1.09E+03	1.08E+02	9.80E+01	4.71E+03
Toluene		4.24E+05	6.49E+04	5.83E+04	8.69E+02	4.24E+05	1.43E+05	1.07E+05	1.92E+03	4.24E+05	3.24E+05	1.84E+05	4.36E+03
Ethylbenzene		1.91E+05	5.89E+03	5.71E+03	5.18E+02	1.91E+05	1.38E+04	1.28E+04	1.22E+03	1.91E+05	3.21E+04	2.75E+04	2.84E+03
Xylene - m		3.43E+05	6.26E+03	6.15E+03	6.25E+02	3.43E+05	1.47E+04	1.41E+04	1.47E+03	3.43E+05	3.44E+04	3.12E+04	3.46E+03
Xylene - o		3.43E+05	6.73E+03	6.60E+03	4.78E+02	3.43E+05	1.57E+04	1.50E+04	1.12E+03	3.43E+05	3.65E+04	3.30E+04	2.62E+03
Xylene - p		3.43E+05	6.03E+03	5.92E+03	5.75E+02	3.43E+05	1.41E+04	1.36E+04	1.35E+03	3.43E+05	3.28E+04	3.00E+04	3.17E+03
Total xylene		3.43E+05	6.03E+03	5.92E+03	6.25E+02	3.43E+05	1.41E+04	1.36E+04	1.47E+03	3.43E+05	3.28E+04	3.00E+04	3.46E+03
Methyl tertiary-Butyl ether (MTBE)		5.72E+05	7.58E+03	7.48E+03	2.04E+04	5.72E+05	1.23E+04	1.21E+04	3.31E+04	5.72E+05	2.34E+04	2.24E+04	6.27E+04
1,1,1,2 Tetrachloroethane		1.10E+04	1.09E+02	1.08E+02	2.60E+03	1.10E+04	2.53E+02	2.47E+02	6.02E+03	1.10E+04	5.88E+02	5.59E+02	1.40E+04
1,1,2,2-Tetrachloroethane		1.10E+04	2.81E+02	2.74E+02	2.67E+03	1.10E+04	5.75E+02	5.46E+02	5.46E+03	1.10E+04	1.26E+03	1.13E+03	1.20E+04
1,1,1-Trichloroethane		1.14E+06	6.80E+02	6.60E+02	1.43E+03	1.14E+06	1.35E+03	1.35E+03	2.92E+03	1.14E+06	2.98E+03	2.95E+03	6.39E+03
1,1,2 Trichloroethane		7.62E+03	9.02E+01	8.91E+01	4.03E+03	7.62E+03	1.84E+02	1.80E+02	8.21E+03	7.62E+03	4.02E+02	3.82E+02	1.80E+04
1,1-Dichloroethene		8.76E+04	2.43E+01	2.43E+01	2.23E+03	8.76E+04	4.30E+01	4.30E+01	3.94E+03	8.76E+04	8.68E+01	8.67E+01	7.94E+03
1,2-Dichloroethane		2.29E+02	6.73E-01	6.71E-01	3.41E+03	2.29E+02	9.71E-01	9.67E-01	4.91E+03	2.29E+02	1.67E+00	1.66E+00	8.43E+03
1,2,4-Trimethylbenzene		NR	3.29E+02	NR	4.74E+02	NR	6.41E+02	NR	1.16E+03	NR	1.04E+03	NR	2.76E+03
1,3,5-Trimethylbenzene	(e)	NR	NR	NR	2.30E+02	NR	NR	NR	5.52E+02	NR	NR	NR	1.30E+03
1,2-Dichloropropane		2.57E+04	3.14E+00	3.13E+00	1.19E+03	2.57E+04	5.54E+00	5.54E+00	2.11E+03	2.57E+04	1.11E+01	1.11E+01	4.24E+03
Carbon Tetrachloride (tetrachloromethane)		7.62E+03	2.87E+00	2.87E+00	1.52E+03	7.62E+03	6.29E+00	6.28E+00	3.32E+03	7.62E+03	1.43E+01	1.42E+01	7.54E+03
Chloroethane		NR	9.01E+02	NR	2.61E+03	NR	1.22E+03	NR	3.54E+03	NR	1.97E+03	NR	5.71E+03
Chloromethane		NR	9.54E-01	NR	1.91E+03	NR	1.11E+00	NR	2.24E+03	NR	1.49E+00	NR	2.99E+03
Cis 1,2 Dichloroethene		1.38E+01	NR	NR	3.94E+03	2.29E+01	NR	NR	6.61E+03	4.44E+01	NR	NR	1.29E+04
Dichloromethane		9.04E+03	2.69E+02	2.57E+02	7.27E+03	9.04E+03	3.50E+02	3.39E+02	9.68E+03	9.04E+03	5.53E+02	5.26E+02	1.53E+04
Tetrachloroethene		1.12E+04	1.86E+01	1.86E+01	4.24E+02	1.12E+04	4.17E+01	4.16E+01	9.51E+02	1.12E+04	9.57E+01	9.49E+01	2.18E+03
Trans 1,2 Dichloroethene		3.23E+04	2.07E+01	NR	3.42E+03	3.23E+04	8.74E+01	NR	6.17E+03	3.23E+04	7.83E+01	NR	1.26E+04
Trichloroethene		9.53E+02	1.23E+00	1.23E+00	1.54E+03	9.53E+02	2.58E+00	2.57E+00	3.22E+03	9.53E+02	5.72E+00	5.69E+00	7.14E+03
Vinyl Chloride (chloroethene)		2.67E+01	5.95E-02	5.94E-02	1.36E+03	2.67E+01	7.70E-02	7.67E-02	1.76E+03	2.67E+01	1.18E-01	1.17E-01	2.69E+03
Semi-Volatile Organic Compounds													
2-Chloronaphthalene		1.53E+05	3.71E+02	3.70E+02	1.14E+02	1.53E+05	9.07E+02	9.02E+02	2.80E+02	1.53E+05	2.13E+03	2.10E+03	6.69E+02
Acenaphthene		1.10E+05	2.75E+06	1.06E+05	5.70E+01	1.10E+05	5.98E+06	1.06E+05	1.41E+02	1.10E+05	8.83E+06	1.06E+05	3.36E+02
Acenaphthylene		1.10E+05	2.68E+06	1.05E+05	8.61E+01	1.10E+05	5.23E+06	1.07E+05	2.12E+02	1.10E+05	8.65E+06	1.08E+05	5.06E+02
Anthracene		5.49E+05	1.13E+07	5.23E+05	1.17E+00	5.49E+05	2.35E+07	5.36E+05	2.91E+00	5.49E+05	4.13E+07	5.42E+05	6.96E+00
Benzo[a]anthracene		2.84E+02	4.08E+02	1.67E+02	1.71E+00	2.84E+02	4.47E+02	1.74E+02	4.28E+00	2.84E+02	4.67E+02	1.76E+02	1.03E+01
Benzo[a]pyrene	(a)	7.68E+01	2.04E+02	5.56E+01	9.11E-01	7.68E+01	2.09E+02	5.61E+01	2.28E+00	7.68E+01	2.11E+02	5.63E+01	5.46E+00
Benzo(b)fluoranthene		7.13E+01	1.17E+02	4.43E+01	1.22E+00	7.13E+01	1.20E+02	4.47E+01	3.04E+00	7.13E+01	1.21E+02	4.49E+01	7.29E+00

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - COMMERCIAL

Table 3

Human health generic assessment criteria by pathway for commercial scenario

Compound	Notes	SAC appropriate to pathway SOM 1% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 2.5% (mg/kg)			Soil saturation limit (mg/kg)	SAC appropriate to pathway SOM 6% (mg/kg)			Soil saturation limit (mg/kg)
		Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Benzo(g,h,i)perylene		6.29E+03	1.05E+04	3.93E+03	1.54E-02	6.29E+03	1.06E+04	3.95E+03	3.85E-02	6.29E+03	1.07E+04	3.96E+03	9.23E-02
Benzo(k)fluoranthene		1.88E+03	3.11E+03	1.17E+03	6.87E-01	1.88E+03	3.17E+03	1.18E+03	1.72E+00	1.88E+03	3.21E+03	1.19E+03	4.12E+00
Chrysene		5.67E+02	8.89E+02	3.48E+02	4.40E-01	5.67E+02	9.25E+02	3.52E+02	1.10E+00	5.67E+02	9.47E+02	3.55E+02	2.64E+00
Dibenzo(a,h)anthracene		5.67E+00	9.32E+00	3.53E+00	3.93E-03	5.67E+00	9.52E+00	3.55E+00	9.82E-03	5.67E+00	9.64E+00	3.57E+00	2.36E-02
Fluoranthene		2.29E+04	1.89E+05	2.25E+04	1.89E+01	2.29E+04	2.72E+05	2.27E+04	4.73E+01	2.29E+04	3.32E+05	2.27E+04	1.13E+02
Fluorene		7.31E+04	4.55E+05	6.30E+04	3.09E+01	7.31E+04	1.06E+06	6.84E+04	7.65E+01	7.31E+04	2.24E+06	7.06E+04	1.83E+02
Hexachloroethane		2.09E+01	NR	NR	8.17E+00	4.96E+01	NR	NR	2.01E+01	1.11E+02	NR	NR	4.81E+01
Indeno(1,2,3-cd)pyrene		8.10E+02	1.31E+03	5.01E+02	6.13E-02	8.10E+02	1.35E+03	5.06E+02	1.53E-01	8.10E+02	1.37E+03	5.09E+02	3.68E-01
Naphthalene		3.64E+04	1.87E+03	1.78E+03	7.64E+01	3.64E+04	4.39E+03	3.92E+03	1.83E+02	3.64E+04	9.94E+03	7.81E+03	4.32E+02
Phenanthrene		2.29E+04	5.35E+05	2.19E+04	3.60E+01	2.29E+04	1.09E+06	2.24E+04	8.96E+01	2.29E+04	1.86E+06	2.25E+04	2.14E+02
Pyrene		5.49E+04	4.47E+06	5.42E+04	2.20E+00	5.49E+04	6.46E+06	5.44E+04	5.49E+00	5.49E+04	7.91E+06	5.45E+04	1.32E+01
Phenol		1.10E+05	2.65E+04	2.59E+04	2.42E+04	1.10E+05	3.04E+04	2.96E+04	3.81E+04	1.10E+05	3.46E+04	3.35E+04	7.03E+04
Total petroleum hydrocarbons													
Aliphatic hydrocarbons EC5-EC6		4.77E+06	3.19E+03	3.19E+03	3.04E+02	4.77E+06	5.86E+03	5.86E+03	5.58E+02	4.77E+06	1.21E+04	1.21E+04	1.15E+03
Aliphatic hydrocarbons >EC6-EC8		4.77E+06	7.79E+03	7.78E+03	1.44E+02	4.77E+06	1.74E+04	1.74E+04	3.22E+02	4.77E+06	3.97E+04	3.96E+04	7.38E+02
Aliphatic hydrocarbons >EC8-EC10		9.53E+04	2.02E+03	2.00E+03	7.77E+01	9.53E+04	4.91E+03	4.85E+03	1.90E+02	9.53E+04	1.17E+04	1.13E+04	4.51E+02
Aliphatic hydrocarbons >EC10-EC12		9.53E+04	9.97E+03	9.69E+03	4.75E+01	9.53E+04	2.47E+04	2.29E+04	1.18E+02	9.53E+04	5.89E+04	4.73E+04	2.83E+02
Aliphatic hydrocarbons >EC12-EC16		9.53E+04	6.26E+04	5.86E+04	2.37E+01	9.53E+04	2.04E+05	8.17E+04	5.91E+01	9.53E+04	4.81E+05	9.02E+04	1.42E+02
Aliphatic hydrocarbons >EC16-EC35	(b)	1.58E+06	NR	NR	8.48E+00	1.75E+06	NR	NR	2.12E+01	1.83E+06	NR	NR	5.09E+01
Aliphatic hydrocarbons >EC35-EC44	(b)	1.58E+06	NR	NR	8.48E+00	1.75E+06	NR	NR	2.12E+01	1.83E+06	NR	NR	5.09E+01
Aromatic hydrocarbons >EC8-EC10		3.81E+04	3.55E+03	3.48E+03	6.13E+02	3.81E+04	8.66E+03	8.11E+03	1.50E+03	3.81E+04	2.05E+04	1.70E+04	3.58E+03
Aromatic hydrocarbons >EC10-EC12		3.81E+04	1.92E+04	1.62E+04	3.64E+02	3.81E+04	4.69E+04	2.79E+04	8.99E+02	3.81E+04	1.10E+05	3.42E+04	2.15E+03
Aromatic hydrocarbons >EC12-EC16		3.81E+04	2.02E+05	3.62E+04	1.69E+02	3.81E+04	4.76E+05	3.73E+04	4.19E+02	3.81E+04	1.03E+06	3.78E+04	1.00E+03
Aromatic hydrocarbons >EC16-EC21	(b)	2.82E+04	NR	NR	5.37E+01	2.83E+04	NR	NR	1.34E+02	2.84E+04	NR	NR	3.21E+02
Aromatic hydrocarbons >EC21-EC35	(b)	2.84E+04	NR	NR	4.83E+00	2.84E+04	NR	NR	1.21E+01	2.84E+04	NR	NR	2.90E+01
Aromatic hydrocarbons >EC35-EC44	(b)	2.84E+04	NR	NR	4.83E+00	2.84E+04	NR	NR	1.21E+01	2.84E+04	NR	NR	2.90E+01

Notes:

EC - equivalent carbon. GrAC - groundwater screening value. SAC - soil screening value.

The CLEA model output is colour coded depending upon whether the soil saturation limit has been exceeded.

Calculated SAC exceeds soil saturation limit and may significantly affect the interpretation of any exceedances as the contribution of the indoor and outdoor vapour pathway to total exposure is >10%.

Calculated SAC exceeds soil saturation limit but the exceedance will not affect the SAC significantly as the contribution of the indoor and outdoor vapour pathway to total exposure is <10%.

Calculated SAC does not exceed the soil saturation limit.

The SAC for organic compounds are dependant upon soil organic matter (SOM) (%) content. To obtain SOM from total organic carbon (TOC) (%) divide by 0.58. 1% SOM is 0.58% TOC. DL Rowell Soil Science: Methods and Applications, Longmans, 1994.

SAC for TPH fractions, PAHs naphthalene, acenaphthene and acenaphthylene, BTEX and trimethylbenzene compounds were produced using an attenuation factor for the indoor air inhalation pathway of 10 to reduce conservatism associated with the vapour inhalation pathway (Section 10.1.1, SR3)

(a) SAC for arsenic, benzene, benzo(a)pyrene, cadmium, chromium VI and lead are derived using the C4SL toxicology data.

(b) SAC for selenium should not include the inhalation pathway as no expert group HCV has been derived; aliphatic and aromatic hydrocarbons >EC16 should not include inhalation pathway due to their non-volatile nature and inhalation exposure being minimal (oral, dermal and inhalation exposure is compared to the oral HCV); arsenic should only be based on oral contribution (rather than combined) owing to the relative small contribution from inhalation in accordance with the SGV report. The Oral SAC should be adopted for zinc and benzo(a)pyrene.

(c) SAC for CrIII should be based on the lower of the oral and inhalation SAC (see LQM/CIEH 2015 Section 6.8)

(d) SAC for elemental mercury, chromium VI and nickel should be based on the inhalation pathway only.

(e) SAC for 1,3,5-trimethylbenzene is not recorded owing to the lack of toxicological data, SAC for 1,2,4 trimethylbenzene may be used.

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - COMMERCIAL

Table 4
Human Health Generic Assessment Criteria for Commercial Scenario

Compound	SAC for Soil SOM 1% (mg/kg)	SAC for Soil SOM 2.5% (mg/kg)	SAC for Soil SOM 6% (mg/kg)
Metals			
Arsenic	640	640	640
Cadmium	410	410	410
Chromium (III) - trivalent	8,600	8,600	8,600
Chromium (VI) - hexavalent	49	49	49
Copper	68,000	68,000	68,000
Lead	2,300	2,300	2,300
Elemental Mercury (Hg^0)	15 (4)	33 (11)	58 (26)
Inorganic Mercury (Hg^{2+})	1,120	1,120	1,120
Methyl Mercury (Hg^{4+})	290 (73)	310 (142)	320
Nickel	980	980	980
Selenium	12,000	12,000	12,000
Zinc	740,000	740,000	740,000
Cyanide (free)	650	650	650
Volatile Organic Compounds			
Benzene	27	60	98
Toluene	56,000 (869)	107,000 (1,916)	184,000 (4,357)
Ethylbenzene	6,000 (518)	13,000 (1,216)	27,000 (2,844)
Xylene - m	6,200 (625)	14,100 (1,474)	31,200 (3,457)
Xylene - o	6,600 (478)	15,000 (1,120)	33,000 (2,618)
Xylene - p	5,900 (576)	13,600 (1,353)	30,000 (3,167)
Total xylene	5,900 (625)	13,600 (1,474)	30,000 (3,457)
Methyl tertiary-Butyl ether (MTBE)	7,500	12,100	22,400
1,1,1,2 Tetrachloroethane	110	250	560
1,1,2,2-Tetrachloroethane	270	550	1,130
1,1,1-Trichloroethane	700	1,300	3,000
1,1,2 Trichloroethane	69	160	362
1,1-Dichloroethene	24	43	87
1,2-Dichloroethane	0.67	0.97	1.65
1,2,4-Trimethylbenzene	330	640	1,040
1,3,5-Trimethylbenzene	NR	NR	NR
1,2-Dichloropropane	3	6	11
Carbon Tetrachloride (tetrachloromethane)	2.9	6.3	14.2
Chloroethane	901	1,223	1,972
Chloromethane	1.0	1.1	1.5
Cis 1,2 Dichloroethene	14	23	44
Dichloromethane	257	339	526
Tetrachloroethene	20	40	90
Trichloroethene	1	3	6
Trans 1,2 Dichloroethene	21	37	78
Trichloroethene	1	3	6
Vinyl Chloride (chloroethene)	0.06	0.08	0.12
Semi-Volatile Organic Compounds			
2-Chloronaphthalene	370 (114)	902 (280)	2,098 (689)
Acenaphthene	110,000	110,000	110,000
Acenaphthylene	110,000	110,000	110,000
Anthracene	520,000	540,000	540,000
Benzo(a)anthracene	170	170	180
Benzo(a)pyrene	77	77	77
Benzo(b)fluoranthene	44	45	45
Benzo(g,h,i)perylene	3,900	3,900	4,000
Benzo(k)fluoranthene	1,200	1,200	1,200
Chrysene	350	350	350
Dibenzo(a,h)anthracene	3.5	3.6	3.6
Fluoranthene	23,000	23,000	23,000
Fluorene	63,000 (31)	68,000	71,000
Hexachloroethane	21 (8)	50 (20)	111 (48)
Indeno(1,2,3-cd)pyrene	500	510	510
Naphthalene	1,800 (76)	3,900 (183)	7,800 (432)
Phenanthrene	22,000	22,000	23,000
Pyrene	54,000	54,000	54,000
Phenol	440*	690*	1,300*
Total Petroleum Hydrocarbons			
Aliphatic hydrocarbons EC_5-EC_6	3,200 (304)	5,900 (558)	12,100 (1,150)
Aliphatic hydrocarbons >EC_6-EC_8	7,800 (144)	17,400 (322)	39,600 (735)
Aliphatic hydrocarbons >EC_8-EC_{10}	2,000 (78)	4,800 (190)	11,300 (451)
Aliphatic hydrocarbons >EC_{10}-EC_{12}	9,700 (48)	22,900 (118)	47,300 (283)
Aliphatic hydrocarbons >EC_{12}-EC_{16}	59,000 (24)	82,000 (59)	90,000 (142)
Aliphatic hydrocarbons >EC_{16}-EC_{35}	1,000,000**	1,000,000**	1,000,000**
Aliphatic hydrocarbons >EC_{35}-EC_{44}	1,000,000**	1,000,000**	1,000,000**
Aromatic hydrocarbons >EC_5-EC_{10}	3,500 (613)	8,100 (1,503)	17,000 (3,560)
Aromatic hydrocarbons >EC_{10}-EC_{12}	16,000 (354)	28,000 (899)	34,000 (2,150)
Aromatic hydrocarbons >EC_{12}-EC_{16}	36,000 (169)	37,000	38,000
Aromatic hydrocarbons >EC_{16}-EC_{21}	28,000	28,000	28,000
Aromatic hydrocarbons >EC_{21}-EC_{35}	28,000	28,000	28,000
Aromatic hydrocarbons >EC_{35}-EC_{44}	28,000	28,000	28,000
Minerals			
Asbestos	No asbestos detected with ID or <0.001% dry weight'		

Notes:

'-' Generic assessment criteria not calculated owing to low volatility of substance and therefore no pathway, or an absence of toxicological data.

NR - SAC for 1,3,5-trimethylbenzene is not recorded owing to the lack of toxicological data, SAC for 1,2,4 trimethylbenzene may be used

EC - equivalent carbon. GrAC - groundwater assessment criteria. SAC - soil assessment criteria.

* The GAC for Phenol is based on a threshold which is protective of direct contact (SC050021/Phenol SGV report)

** Denoted SAC calculated exceeds 100% contaminant, hence 100% (1,000,000mg/kg) has been taken as SAC

The SAC for organic compounds are dependent on Soil Organic Matter (SOM) (%) content. To obtain SOM from total organic carbon (TOC) (%) divide by 0.58.
1% SOM is 0.58% TOC. DL Rowell Soil Science: Methods and Applications, Longmans, 1994.

SAC for TPH fractions, PAHs naphalene, acenaphthene and acenaphthylene, BTEX and trimethylbenzene compounds were produced using an attenuation factor for the indoor air inhalation pathway of 10 to reduce conservatism associated with the vapour inhalation pathway, section 10.1.1, SR3.

(VALUE IN BRACKETS)

RSK has adopted an approach for petroleum hydrocarbons in accordance with LQM/CIEH whereby the concentration modelled for each petroleum hydrocarbon fraction has been tabulated as the SAC with the corresponding solubility or vapour saturation limits given in brackets.

APPENDIX D
ENVIRONMENT AGENCY CORRESPONDENCE

Product 4 (Detailed Flood Risk Data) for HR1 2BJ

Reference number: 140892
Date of issue: 11/09/2019

We are unable to provide you with a full product 4 response because the model in this location (Yazor Brook) is owned by Herefordshire County Council, please contact the Council to gain access to this model.

Flood Map for Planning (Rivers and Sea)

The Flood Map for planning (Rivers and Sea) indicates the area at risk of flooding, **assuming no flood defences exist**, for a flood event with a 0.5% chance of occurring in any year for flooding from the sea, or a 1% chance of occurring for fluvial (river) flooding (flood zone 3). It also shows the extent of the Extreme Flood Outlines (Flood zone 2) which represents the extent of a flood event with a 0.1% chance of occurring in any year, or the highest recorded historic extent if greater. The flood zones refer to the land at risk of flooding and **does not** refer to individual properties. It is possible for properties to be built at a level above the floodplain but still fall within the risk area.

The Flood Map only indicates the extent and likelihood of flooding from rivers or the sea. It should also be remembered that flooding may occur from other sources such as surface water sewers, road drainage, etc.

To find out which flood zone a location is in please use: https://flood-map-for-planning.service.gov.uk/

Definition of flood zones

- **Zone 1** - The area is within the lowest probability of flooding from rivers and the sea, where the chance of flooding in any one year is less than 0.1% (i.e. a 1000 to 1 chance).
- **Zone 2** - The area which falls between the extent of a flood with an annual probability of 0.1% (i.e. a 1000 to 1 chance) fluvial and tidal, or greatest recorded historic flood, whichever is greater, and the extent of a flood with an annual probability of 1% (i.e. a 100 to 1 chance) fluvial / 0.5% (i.e. a 200 to 1 chance) tidal. (Land shown in light blue on the Flood Map).
- **Zone 3** - The chance of flooding in any one year is greater than or equal to 1% (i.e. a 100 to 1 chance) for river flooding and greater than or equal to 0.5% (i.e. a 200 to 1 chance) for coastal and tidal flooding.

Note: The Flood Zones shown on the Environment Agency's Flood Map for Planning (Rivers and Sea) do not take account of the possible impacts of climate change and consequent changes in the future probability of flooding. Reference should therefore also be made to the Strategic

Flood Risk Assessment when considering location and potential future flood risks to developments and land uses.

Areas Benefitting From Defences

Where possible we show the areas that benefit from the flood defences, in the event of flooding:

- from rivers with a 1% (1 in 100) chance in any given year, or;
- from the sea with a 0.5% (1 in 200) chance in any given year.

If the defences were not there, these areas would flood. Please note that we do not show all areas that benefit from flood defences.

The associated Dataset is available here: https://data.gov.uk/dataset/flood-map-for-planning-rivers-and-sea-areas-benefiting-from-defences

Recorded Flooding

Following an examination of our records of historical flooding we do hold records of flooding for this area, please find tabulated information below for these recorded flood events.

Flood Event Date	Source of Flooding	Cause of Flooding
1947	Fluvial	Channel capacity exceeded (no raised defences)
1960	Fluvial	Channel capacity exceeded (no raised defences)

The corresponding recorded flood outline/s can be accessed here:

https://data.gov.uk/dataset/recorded-flood-outlines1

The Recorded Flood Outlines take into account the presence of defences, structures, and other infrastructure where they existed at the time of flooding. It includes flood extents that may have been affected by overtopping, breaches or blockages. Any flood extents shown do not necessarily indicate that properties were flooded internally. It is also possible that the pattern of flooding in this area has changed and that this area would now flood or not flood under different circumstances.

Please note that our records are not comprehensive and that the map is an indicative outline of areas which have previously flooded, not all properties within this area will have flooded. It is possible that other flooding may have occurred that we do not have records for.

You may also wish to contact your Local Authority or Internal Drainage Board (where relevant), to see if they have other relevant local flood information.

Flood Defences

Flood defences do not completely remove the chance of flooding. They can be overtopped by water levels which exceed the capacity of the defences.

If flood defences are located in your area, you can access this data here:
https://data.gov.uk/dataset/spatial-flood-defences-including-standardised-attributes

Planning developments

If you have requested this information to help inform a development proposal, then you should note the information on GOV.UK on the use of Environment Agency Information for Flood Risk Assessments. You can also request pre application advice:

https://www.gov.uk/planning-applications-assessing-flood-risk
https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion

Supporting Information

Surface Water

Managing the risk of flooding from surface water is the responsibility of Lead Local Flood Authorities. The 'risk of flooding from surface water' map has been produced by the Environment Agency on behalf of government, using information and input from Lead Local Flood Authorities.

You may wish to contact your Local Authority who may be able to provide further detailed information on surface water.

It is not possible to say for certain what the flood risk is but we use the best information available to provide an indication so that people can make informed choices about living with or managing the risks. The information we supply does not provide an indicator of flood risk at an individual site level. Further information can be found on the Agency's website:

https://flood-warning-information.service.gov.uk/long-term-flood-risk

Flood Risk from Reservoirs

The Flood Risk from Reservoirs map can be found on the Long Term Flood Risk Information website:

https://flood-warning-information.service.gov.uk/long-term-flood-risk/map?map=Reservoirs

Flood Alert & Flood Warning Area

We issue flood alert/warnings to specific areas when flooding is expected. If you receive a flood warning you should take immediate action.

You can check whether you are in a Flood Alert/Warning Area and register online using the links below:

https://www.gov.uk/check-flood-risk

https://www.gov.uk/sign-up-for-flood-warnings

If you would prefer to register by telephone, or if you need help during the registration process, please call Floodline on 0345 988 1188.

The associated dataset for flood warning areas is available here: https://data.gov.uk/dataset/flood-warning-areas3

The associated dataset for flood alert areas is available here: https://data.gov.uk/dataset/flood-alert-areas2

Flood Risk Activity Permits

We now consider applications for works, which may be Flood Risk Activities, under Environmental Permitting Regulations. This replaces the process of applying for a Flood Defence Consent. You may need an environmental Permit for flood risk activities if you want to do work:

- in, under, over or near a main river (including where the river is in a culvert)
- on or near a flood defence on a main river
- in the flood plain of a main river
- on or near a sea defence

Please go to this website to find out more about how to apply: https://www.gov.uk/guidance/flood-risk-activities-environmental-permits.
Please be aware that Bespoke and Standard Rules permits can take up to 2 months to determine and will incur a charge.

Further details about the Environment Agency information supplied can be found on the GOV.UK website:

https://www.gov.uk/browse/environment-countryside/flooding-extreme-weather

Email: Enquiries_Westmids@environment-agency.gov.uk
Website: www.gov.uk/government/organisations/environment-agency

APPENDIX E
HEREFORDSHIRE COUNCIL CORRESPONDENSE

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Model Node Location Map - created 04 March 2020

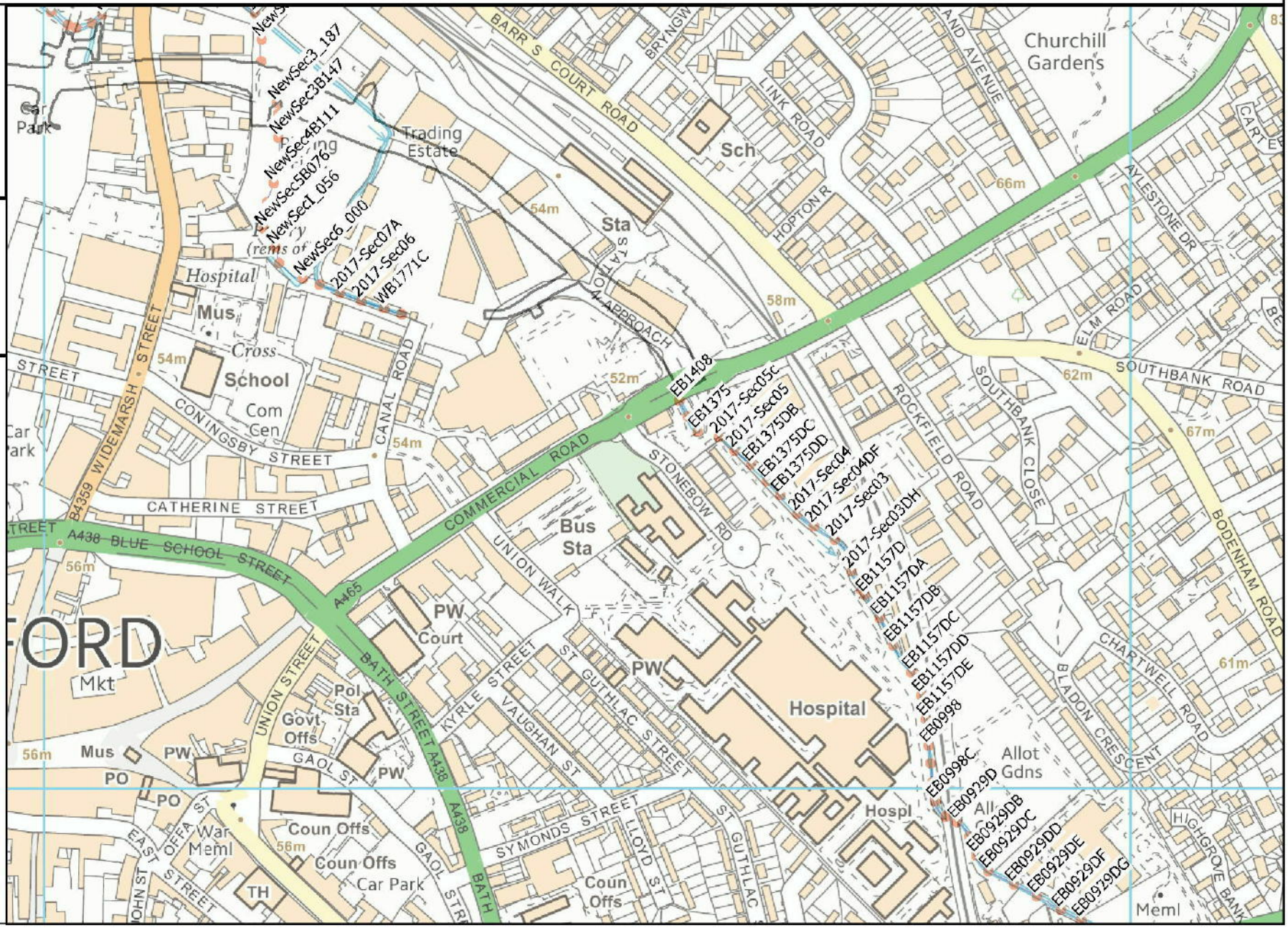
Herefordshire Council

N W E S

1:5,000

Legend

- Model Nodes 4007



Model Runs: HER_BA_F_xx_xx_xxxxCxx_25HR_4007 & HER_BA_F_xx_xx_xxxxCxx_5HR_4007

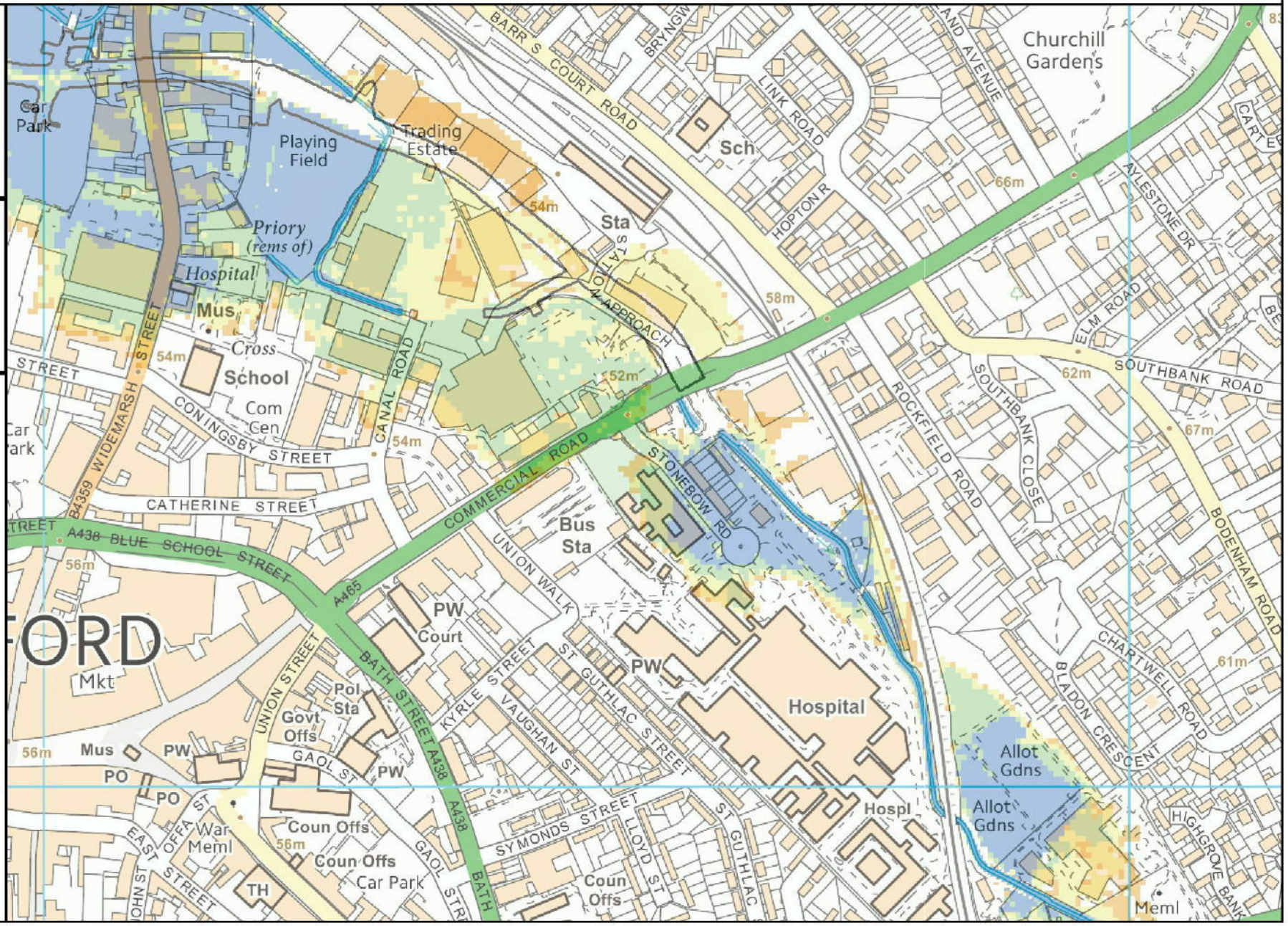
Modelled Flood Extent (residual risk) - created 04 March 2020

Herefordshire Council

N W E S

1:5,000

- 1 in 20yr
- 1 in 100yr
- 1 in 100yr +35%
- 1 in 100yr +70%
- 1 in 1000yr



Model Runs: HER_BA_B_xx_xx_xxxxCxx_25H_4007 & HER_BA_B_xx_xx_xxxxCxx_5H_4007

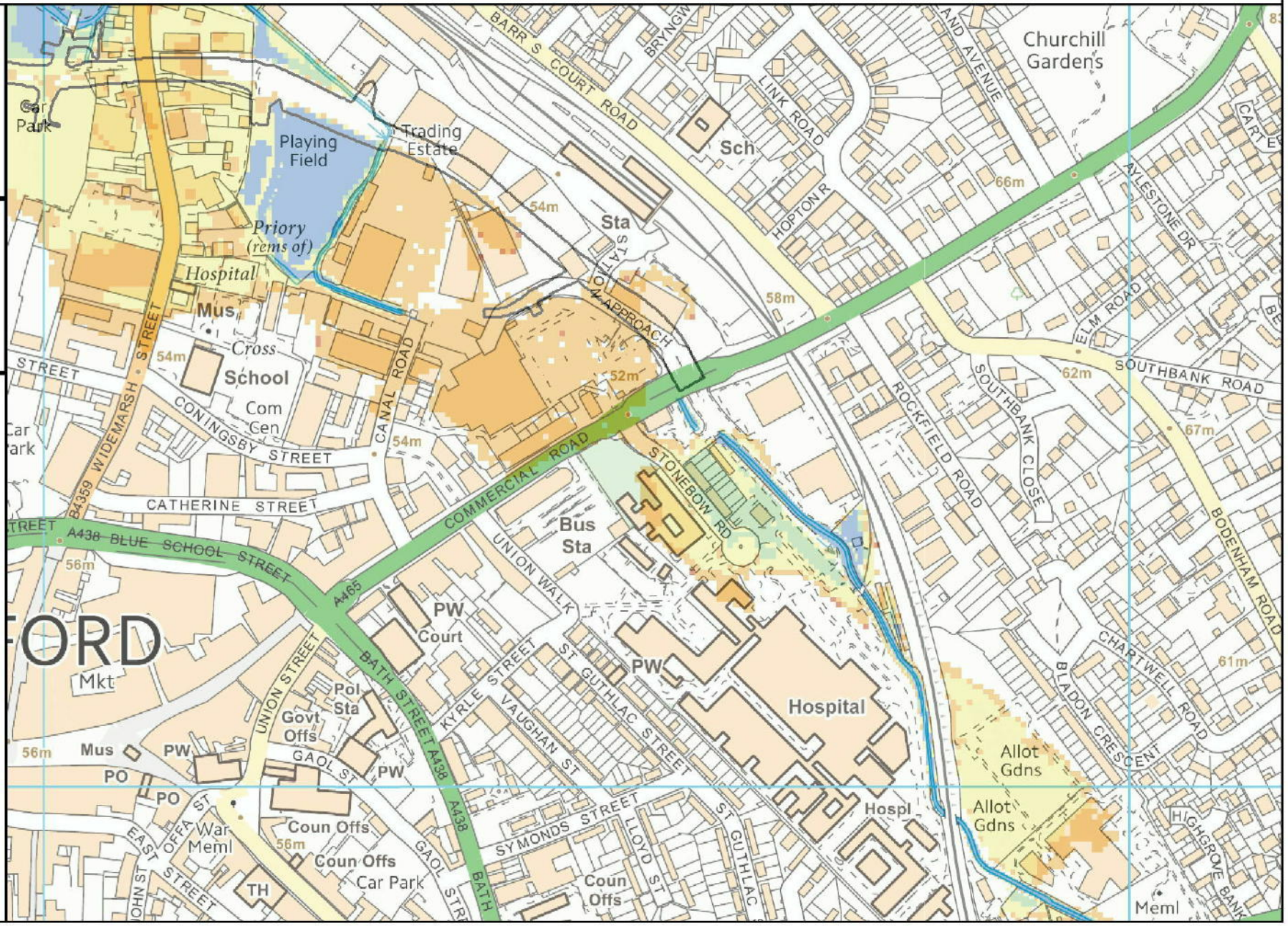
Modelled Flood Extent - created 04 March 2020

Herefordshire Council

N W E S

1:5,000

- 1 in 20yr
- 1 in 100yr
- 1 in 100yr +35%
- 1 in 100yr +70%
- 1 in 1000yr



Model Runs: HER_BA_F_xx_xx_xxxxCxx_25H_4007 & HER_BA_F_xx_xx_xxxxCxx_5H_4007

Herefordshire Council

Yazor Brook / Widemarsh Brook Hydraulic Model

Modelled Water Levels (mAOD)

Node Label	Watercourse	Modelled Flood Levels					Modelled Residual Risk Flood Levels				
		1 in 20	1 in 100	1 in 100 +35% climate change	1 in 100 +70% climate change	1 in 1000	1 in 20	1 in 100	1 in 100 +35% climate change	1 in 100 +70% climate change	1 in 1000
NewSec3_187	Widemarsh Brook	52.53	52.77	53.40	53.88	53.89	53.21	53.77	53.98	54.01	54.08
NewSec3B179	Widemarsh Brook	52.53	52.76	53.40	53.88	53.89	53.21	53.77	53.98	54.06	54.03
NewSec3A160	Widemarsh Brook	52.51	52.76	53.40	53.88	53.89	53.21	53.77	53.97	54.00	54.08
NewSec3B147	Widemarsh Brook	52.51	52.76	53.40	53.88	53.90	53.21	53.77	53.97	53.98	54.12
NewSec4B111	Widemarsh Brook	52.50	52.76	53.40	53.91	53.88	53.21	53.77	54.07	54.33	54.00
NewSec4C088	Widemarsh Brook	52.46	52.73	53.40	53.88	53.90	53.21	53.77	53.97	53.98	54.11
NewSec4_131	Widemarsh Brook	52.51	52.75	53.40	53.91	53.88	53.21	53.77	54.08	54.39	54.00
NewSec5_081	Widemarsh Brook	52.46	52.71	53.40	53.89	53.89	53.21	53.77	53.98	54.03	54.05
NewSec5B076	Widemarsh Brook	52.43	52.69	53.40	53.89	53.88	53.21	53.77	54.00	54.09	54.00
NewSecl_056	Widemarsh Brook	52.40	52.67	53.40	53.89	53.90	53.20	53.77	53.96	53.99	54.10
NewSecl_035	Widemarsh Brook	52.38	52.65	53.40	53.88	53.89	53.20	53.77	53.98	54.05	54.02
NewSec6_000	Widemarsh Brook	52.36	52.63	53.38	53.88	53.88	53.18	53.76	53.97	54.02	54.05
2017-Sec07	Widemarsh Brook	52.25	52.56	53.35	53.85	53.86	53.14	53.73	53.96	54.02	54.02
2017-Sec07A	Widemarsh Brook	52.17	52.51	53.33	53.84	53.84	53.12	53.72	53.94	54.00	53.99
2017-Sec06	Widemarsh Brook	52.14	52.49	53.32	53.83	53.84	53.11	53.72	53.94	53.99	54.00
WB1771C	Widemarsh Brook	52.11	52.47	53.31	53.83	53.83	53.10	53.71	53.94	54.00	53.98
WB1705	Widemarsh Brook	52.10	52.46	53.31	53.82	53.83	53.09	53.71	53.93	53.98	54.00
EB1408	Eign Brook	51.94	52.26	52.68	52.81	52.81	52.61	52.77	52.84	52.87	52.87
EB1408A	Eign Brook	51.94	52.26	52.69	52.82	52.82	52.61	52.78	52.86	52.88	52.88
EB1375	Eign Brook	51.93	52.25	52.69	52.83	52.84	52.61	52.80	52.88	52.91	52.91
2017-Sec05c	Eign Brook	51.81	52.01	52.26	52.42	52.42	52.21	52.34	52.55	52.66	52.65
2017-Sec05	Eign Brook	51.79	52.00	52.25	52.42	52.42	52.20	52.34	52.55	52.66	52.65
EB1375DB	Eign Brook	51.77	51.98	52.24	52.42	52.42	52.18	52.34	52.55	52.66	52.65
EB1375DC	Eign Brook	51.75	51.96	52.22	52.41	52.41	52.16	52.32	52.54	52.65	52.64
EB1375DD	Eign Brook	51.73	51.94	52.22	52.42	52.42	52.16	52.33	52.55	52.66	52.65
2017-Sec04	Eign Brook	51.69	51.89	52.16	52.36	52.36	52.09	52.27	52.50	52.61	52.61
2017-Sec04DF	Eign Brook	51.68	51.89	52.15	52.34	52.34	52.09	52.25	52.49	52.59	52.59
2017-Sec03	Eign Brook	51.67	51.88	52.14	52.34	52.34	52.08	52.25	52.48	52.59	52.59
2017-Sec03DH	Eign Brook	51.66	51.86	52.13	52.33	52.34	52.07	52.24	52.49	52.60	52.59
EB1157	Eign Brook	51.63	51.83	52.09	52.30	52.30	52.03	52.20	52.46	52.58	52.58
EB1157D	Eign Brook	51.41	51.61	51.96	52.25	52.25	51.86	52.13	52.43	52.55	52.55
EB1157DA	Eign Brook	51.33	51.53	51.89	52.17	52.18	51.79	52.06	52.34	52.47	52.46
EB1157DB	Eign Brook	51.26	51.45	51.79	52.08	52.08	51.70	51.96	52.25	52.38	52.38
EB1157DC	Eign Brook	51.18	51.37	51.71	51.99	51.99	51.62	51.87	52.17	52.30	52.30
EB1157DD	Eign Brook	51.10	51.28	51.61	51.89	51.89	51.52	51.77	52.07	52.21	52.20
EB1157DE	Eign Brook	51.00	51.17	51.50	51.78	51.78	51.41	51.65	51.96	52.10	52.09
EB0998	Eign Brook	50.86	51.03	51.35	51.63	51.64	51.26	51.51	51.82	51.96	51.96
EB0998A	Eign Brook	50.77	50.94	51.25	51.53	51.53	51.16	51.40	51.71	51.85	51.85
EB0998B	Eign Brook	50.68	50.84	51.14	51.41	51.41	51.06	51.29	51.58	51.73	51.72
EB0998C	Eign Brook	50.58	50.75	51.02	51.27	51.27	50.95	51.15	51.43	51.58	51.57
EB0929	Eign Brook	50.48	50.65	50.89	51.11	51.11	50.83	51.00	51.25	51.39	51.38

Model Runs: HER_BA_F_XX_XX_XXXXCXX_5HR_4007; HER_BA_F_XX_XX_XXXXCXX_25HR_4007; HER_BA_B_XX_XX_XXXXCXX_5HR_4007; HER_BA_B_XX_XX_XXXXCXX_25HR_4007

Herefordshire Council

Node Label	Watercourse	Modelled Flood Levels					Modelled Residual Risk Flood Levels				
		1 in 20	1 in 100	1 in 100 +35% climate change	1 in 100 +70% climate change	1 in 1000	1 in 20	1 in 100	1 in 100 +35% climate change	1 in 100 +70% climate change	1 in 1000
EB0929D	Eign Brook	50.47	50.61	50.80	50.92	50.92	50.77	50.86	50.96	51.01	51.01
EB0929DA	Eign Brook	50.34	50.48	50.65	50.70	50.70	50.61	50.68	50.78	50.86	50.86
EB0929DB	Eign Brook	50.21	50.35	50.57	50.74	50.74	50.51	50.67	50.84	50.91	50.91
EB0929DC	Eign Brook	50.08	50.22	50.46	50.68	50.68	50.39	50.58	50.81	50.89	50.89
EB0929DD	Eign Brook	49.96	50.09	50.38	50.62	50.62	50.29	50.53	50.76	50.86	50.85
EB0929DE	Eign Brook	49.84	49.98	50.29	50.51	50.52	50.20	50.42	50.68	50.80	50.79
EB0929DF	Eign Brook	49.73	49.88	50.16	50.43	50.43	50.08	50.31	50.62	50.75	50.75
EB0929DG	Eign Brook	49.64	49.79	50.08	50.37	50.37	50.00	50.23	50.58	50.73	50.72

Notes:
1. Refer to accompanying maps for details of the modelled flood extents and node locations.
2. Residual risk scenario assumes no operation of the Yazor Brook Flood Alleviation Scheme.
3. Modelled water levels are the maximum of two storm scenarios (5 hour and 25 hour). Refer to the model summary note for further information.

Model Runs: HER_BA_F_XX_XX_XXXXCXX_5HR_4007; HER_BA_F_XX_XX_XXXXCXX_25HR_4007; HER_BA_B_XX_XX_XXXXCXX_5HR_4007; HER_BA_B_XX_XX_XXXXCXX_25HR_4007

Herefordshire Council

Model	Yazor Brook / Widemarsh Brook Hydraulic Model
Location	Hereford
Watercourses	Yazor Brook, Widemarsh Brook, Eign Brook and Ayles Brook

Objectives/Areas of interest

The model was originally developed for the purpose of Environment Agency flood mapping of the ordinary watercourses (Yazor Brook and Widemarsh / Eign Brook) through Hereford but has since been extended and used to develop a flood mitigation strategy for the Edgar Street Grid area in Hereford. Details of the model development are provided below.

Model Development

The various phases of Yazor Brook modelling are detailed in the following table:

Model Name	Model Extents	Details
Hereford SFRM, Capita Symonds, August 2007	Yazor Brook - 3.9km from Three Elms Road Bridge (NGR SO491414) to River Wye River Wye (NGR SO506395) Widemarsh / Eign Brooks - 4.0km from bifurcation with Yazor Brook (NGR SO498407) to River Wye (NGR SO522392)	Strategic Flood Risk mapping (SFRM) study of the Hereford Critical Ordinary Watercourses (COWs) for Environment Agency Wales. Involved the production of a linked 1-dimension to 2-dimension hydraulic model of the urban area of Hereford. The 2-dimensional element of the model was initially based on information gained from sewer plans and later updated using LIDAR data when this became available in 2006. The 1d model was constructed using channel survey.
ESG Hereford Flood Mitigation Options Appraisal, Capita Symonds, December 2007	Yazor Brook - 9.8km from Bishon Common (NGR SO426435) to River Wye River Wye (NGR SO506395) Widemarsh / Eign Brooks - 4.0km from bifurcation with Yazor Brook (NGR SO498407) to River Wye (NGR SO522392)	Assessment of possible options to reduce flooding within Hereford. A preliminary options review investigated the effects of implementing channel improvements within Hereford town centre. The model was subsequently extended upstream in order to assess upstream mitigation options. The model was extended upstream by approximately 8.1km from Three Elms Bridge to Bishon Common. The downstream boundary remained at the outfall to the River Wye. The 1d model was extended up to the Roman Road using data from the Whitecross High School Flood Risk Assessment model (Halcrow Group Ltd, September 2003). New channel survey was collected to define the channel between Bishon Common and the Roman Road. The 2006 LIDAR coverage was adequate to define the 2D model element. To reduce the simulation time the new model reach was defined in a separate model domain using a 10m grid size (the existing urban domain was modelled using a 5m grid size). This was deemed appropriate as the level of detailed required in the rural upstream reach was low.
Hereford Livestock Market Flood Risk Assessment, Capita Symonds, 2008	Yazor Brook - 9.8km from Bishon Common (NGR SO426435) to River Wye River Wye (NGR SO506395) Widemarsh / Eign Brooks - 4.0km from bifurcation with Yazor Brook (NGR SO498407) to River Wye (NGR SO522392)	The existing hydraulic model was utilised to assess the impact of fluvial flooding at the proposed livestock market site (to the south of the Roman Road). This section of the model was previously defined using the upper reach of the Whitecross High School Flood Risk Assessment model (Halcrow Group Ltd, September 2003) which was created prior to the redevelopment of the Roman Road. Therefore the model representation was improved in the proximity of the site using the Roman Road 'as-built' drawings and additional topographic and channel survey.

Yazor Brook Flood Alleviation Scheme, Planning Submission and FRA, Capita Symonds, July 2009 [model archive # 1]	Yazor Brook - 9.8km from Bishon Common (NGR SO426435) to River Wye River Wye (NGR SO506395) Widemarsh / Eign Brooks - 4.0km from bifurcation with Yazor Brook (NGR SO498407) to River Wye (NGR SO522392)	This assessment took forward the preferred flood alleviation scheme for planning. Additional hydrological and hydraulic assessments were completed to inform the scheme design and test its impacts with respect to flood risk. The study included a review of the hydrological assessment for the Yazor Brook which resulted in a change to the design hydrology.
ESG Link Road Flood Risk Assessment, Capita Symonds, October 2009 [model archive # 2]	Yazor Brook - 3.9km from Three Elms Road Bridge (NGR SO491414) to River Wye River Wye (NGR SO506395) Widemarsh / Eign Brooks - 4.0km from bifurcation with Yazor Brook (NGR SO498407) to River Wye (NGR SO522392)	Modelling completed to assess the impact of the proposed Link Road and ESG Blackfriars Urban Village site on flood risk in the area in support of the Link Road planning submission. Assessment utilised only the downstream domain of the of the full Yazor Brook model, in order to optimise model simulation time. Inflows extracted from the full model were used to define the 'trimmed' model's upstream boundary conditions.
Merton Meadows Flood Risk Assessment, Capita Symonds, April 2013 [model archive # 3&4]	Yazor Brook - 9km from Kenchester (NGR SO435433) to Friars Street (NGR SO526403) Widemarsh / Eign Brooks - 4.0km from bifurcation with Yazor Brook (NGR SO498407) to River Wye (NGR SO522392) Ayles Brook - 0.4km from downstream of the disused railway line (NGR SO509410) to confluence with Widemarsh Brook through pipe outfall underneath Widemarsh Bridge (SO511408).	Hydraulic modelling of the Yazor Brook through Hereford was completed as part of the Flood Risk Assessment (FRA) for the proposed redevelopment of the Merton Meadows car park in Hereford. For this assessment, the upstream extent of the Yazor Brook was trimmed at Kenchester and the downstream extent trimmed at Friars Street a (short distance downstream from the Bulmers Factory). The extent was reduced primarily to allow simulation of the model using a limited node license.
ESG Drainage Strategy, Capita Property and Infrastructure, July 2014 [model archive # 5]	As above	Hydraulic modelling of the final ESG development scenario to assess the impact of ground level changes required for the drainage strategy.
Jewsons (Canal Road) Culvert Upgrade Assessment, WSP | PB, May 2015 [model archive # 6]	As above	Modelling and assessment to establish the necessity of the Jewsons culvert upgrade taking place alongside the construction of the Link Road. Changes were made to the Link Road scenario (T002) to reflect the latest understanding of the proposals, principally that the channel diversion would take place at the same time hence no temporary Link Road culvert as assumed in earlier iterations. Also included sensitivity scenarios
Fire Station Flood Risk Asessment (FRA), WSP | PB, July 2015 [model archive # 6]	As above	No model changes, just modelling of additional scenarios with the changes from the Jewsons assessment.

Widemarsh Brook Channel Design, WSP | PB, 2015 - 2016 [model archive # 7]	As above	Hydraulic assessment to inform the design of the Widemarsh channel diversion. Details of proposed channel diversion, attenuation basin, Link Road and Jewsons culvert updated to reflect current design proposals (channel and basin) and as-built (Link Road and jewsons culverts). Also included some wider model updates following a review and a range of sensitivity analyses.
ESG Flood Mitigation WSP | PB, 2016 - 2017 [model archive # 8]	As above	Hydraulic assessment to determine the potential for mitigation for the Edgar Street Grid (ESG) development proposals in Central Hereford. Onsite and offsite mitigation options were explored with the goal of providing a more robust mitigation to facilitate development. Model naming convention was revised and the model updated with new survey [Hereford ESG Mitigation Supplementary Topo and Channel Survey Feb 2017 (survey archive # 13)] in several locations, better representation of walls, updated mastermap layers for material roughness, allowance for potential groundwater ingress to channel, topographic amendments and a number of other minor adjustments and corrections. **NB: As of February 2018 the assessment of future development proposals and mitigation is ongoing.**
Development of "Present Day" scenario for 3rd party issue WSP 2018 [model archive # 9]	As above	Creation of a new scenario to represent the "Present Day" and to reflect recent construction work in and around the ESG site, related to the Link Road construction. The model update includes: the new Jewsons / Canal Road culvert; the Hereford City Link Road (including new brook culvert); and the channel diversion between Widemarsh Street and Canal Road. As of January 2018 the Link Road, Link Road culvert and Jewsons culvert have been constructed however the channel diversion and Link Road attenuation pond have not yet been constructed with the channel following a temporary diversion through this reach. The permanent channel diversion and attenuation pond construction is expected to take place shortly. The model representation is based on draft design drawings for the channel diversion.

Survey / Topographic Data

Title	Type	Notes
Whitecross High School Flood Risk Assessment, Halcrow Group Ltd, September 2003 [survey archive # 6]	ISIS 1D model and Channel Survey	Preliminary Flood Risk Assessment to support Outline Planning application for the development of Whitecross High School, Three Elms Road, Hereford. Model extends from upstream of the Roman Road (NGR 347700, 242200) to the Three Elms Gauging Station (NGR 349200, 241500). Data used to extend the original SFRM model up to the Roman Road.
Total Surveys, November - December 2005 [model archive # 1]	Channel Survey	Cross-sections provided on Yazor Brook, Widemarsh / Eign Brook within Hereford city centre, from Three Elms Road to the outfalls with the River Wye. Sections used to construct 1D model domain in the original SFRM model.
LiDAR data, flown 2006	LiDAR Digital Terrain Model	1m resolution within Hereford and 2m resolution upstream of Hereford. Complete coverage throughout model reach. Data used to improve the digital terrain model in the SFRM model.

Wye Lugg Confluence Model v3.1, Atkins, 2008	ISIS 1D model	ISIS model of the River Wye and River Lugg created originally for the Hereford Flood Alleviation Project and later used for flood risk mapping of the Wye and Lugg confluence. Model output used to define the downstream boundary conditions for the Yazor Brook and Eign Brook.
Total Surveys, March 2007 [model archive # 2]	Channel and Topographical Survey	Cross-sections provided on Yazor Brook from upstream of the sewage works (NGR 347150, 243080) down to Pinston House (NGR 347890, 242370). Spot levels taken through at Bulmers factory and hospital site. Data used to extend the 1D model domain and improve the 2D model DTM.
Total Surveys, June - July 2007 [model archive # 3]	Channel Survey	Cross-sections provided on Yazor Brook from Bishon Common (NGR 342680, 243520) to Stretton Court Farm (NGR 347030, 243060). Data used to extend the 1D model domain.
Healer Surveys, July 2007 (correction submitted May 2010) [model archive # 7]	Topographical Survey	Topographical survey including: Old Cattle Market site, Edgar Street, Black Friars Road, Widemarsh Street, Police Training Fields and land bordering the railway. Data used to check the accuracy of the LIDAR data.
Total Surveys, July & December 2008 [model archive # 4]	Channel and Topographical Survey	Further detail provided around Credenhill, from upstream of Station Road (NGR 344480, 242950) to downstream of Credenhill Community Centre (NGR 344600, 242900). Detailed topographical survey collected along the proposed flood alleviation scheme pipe route, including bank and floodplain survey adjacent to the Yazor Brook.
Livestock Market Survey, March 2007 [model archive # 5]	Topographical Survey	Topographical survey of the new Livestock Market_site (pre-construction)
A4103 Roman Road 'As Built Drawings'	CAD Drawings	'As Built' drawings of the Roman Road, indicating road levels, drainage paths and culvert / pipe sizes. Data used to improve the 1D and 2D model representation in the vicinity of the Roman Road.
Hereford ESG Topographical and Sewer Asset Survey, July / November 2009 [model archive # 8]	Topographical, threshold level and sewer Survey	Finalised April 2010. Topographical survey of remaining ESG development area not included in Healer Surveys July 2007 survey. Includes sewer and threshold level survey. Data used to check the accuracy of the LIDAR data.
Divers Survey, 2011 [model archive # 11]	Culvert survey	Jewsons culvert survey including photos from divers. This was used in particular to justify the culvert Colebrook-White roughness values.

Healer Surveys, August 2015	Channel survey	Upstream of Jewsons culvert prior to design works. Sections incorrectly surveyed RHB to LHB. Sections do not provide good definition of channel, hence the information was used in combination with the original channel survey to defince the channel through this reach
ESG TopoChannelSurvey Aug2015 [model archive # 12]	Topo and Channel survey	
Hereford ESG Mitigation Supplementary Topo and Channel Survey Feb 2017 [model archive # 13]	Topo and Channel survey	Survey taken as part of the ESG Mitigation project to update and check the model in key areas of interest. Topo survey was primarily to update the walls around Edgar St. Survey Sections 01, 02, 11, 14, & 15 were checked but deemed a good match with previous sections and therefore not updated. Section 13 represents a channel constriction but was deemed larger than the upstream culvert and not subject to out of bank flow and so was not incorporated due concerns over section spacing. Section 10 was checked to be representative of the reach and shifted downstream 10m in the model to maintain consitent section spacing. Section 06 & 07 were not incorporated for the AA (baseline) model scenario as channel work is known to have been carried out so the survey is not representative of this scenario.

Supporting Data

Title	Type	Notes
1. Yazor Brook FAS (Credenhill)	As Built (Construction) drawings for Credenhill	Model was updated to reflect as-built information at Credenhill. No gauge data is yet available to verify the model
2. Yazor Brook FAS (Outfall)	Design drawings	Floodplain has altered since Wye bank collapse. Ongoing review of outfall options may change outfall arrangement
3. Link Road ground model Aug 2015	Proposed Link Road ground model	NB: A later version has been received (below). A brief check showing no significant changes but the new version has not been used in the model. Ground model does not represent current channel and pond proposals.
4. Link Road ground model Sep 2015 (received Oct 16)	Proposed Link Road ground model	NB: This has not been used in the model. A brief check showing no significant changes but the new version has not been used in the model. Ground model does not represent current channel and pond proposals.

5. Jewsons & Link Road Culvert As Built	Drawings of Jewsons culvert upgrade & Link Road culvert	As-built drawing of the Link Road culvert (refer to 3512983AE-HHC-STR02/01/04 dated 22/02/16) providing info on culvert size/invert levels and revised culvert length. Model was updated to reflect as-built information for the Link Road Culvert; of particular note is the use of the information to justify the model inclusion of a 300mm deep layer of natural material therefore reducing culvert height from 1.8m to 1.5m. As-built drawings for the Jewson culverts were used to update the model with changes being included in model version 3657
6. Widemarsh Brook channel proposals Jun 2016	Proposed channel diversion design	NB: Channel design not finalised. May 2017 draft channel design proposals (see below) used to check and refine the channel representation in the model but model representation based on both sets of data.

Model	Yazor Brook / Widemarsh Brook Hydraulic Model
Location	Hereford
Watercourses	Yazor Brook, Widemarsh Brook, Eign Brook and Ayles Brook

Modelling Approach

The Yazor Brook/Widemarsh Brook hydraulic model is a 1D / 2D FMP-TUFLOW model , extending from Kenchester (approximately 1km upstream of Credenhill) to its confluence with the River Wye within Hereford (upstream of Greyfriars Bridge). A bifurcation at Moor Park creates the Widemarsh Brook (also known as Eign Brook downstream of Commercial Road) which passes through Hereford city centre before joining the River Wye near Bartonsham. The Widemarsh / Eign Brook, as well as its tributary the Ayles Brook, are included in the model.

The schematisation of the hydraulic model reflects the catchment flooding mechanisms and key areas of interest. The model consists of two domains with the boundary between the two located along Three Elms Road, to the western side of Hereford. The upstream domain is predominantly rural and has been modelled using a 10m grid size. The downstream domain covers the urban area of Hereford, which is the focus of interest, and therefore has been modelled in more detail using a grid cell size of 5m.

Watercourse	Modelled Length (km)	Upstream	Downstream
Yazor Brook	9.0	343500, 243280	352590, 240250
Widemarsh Brook / Eign Brook	4.0	349760, 240670	350220, 239340
Ayles Brook	0.4	350880, 241040	351120, 240780

Model Schematisation

Model Method	1D / 2D
Software	Flood Modeller Pro (version 4.2.0.192) / TUFLOW (build 2016-03-AD)
Run Settings	Unsteady simulation
Channel	1D surveyed sections
Floodplain	LIDAR data supplemented with survey
Other comments	The model consists of 2 model domains; upstream of Three Elms Road a 10m grid is used, while the urban area downstream is represented using a 5m grid.

GIS Data

OS Tiles - 10k: SO33NE, SO33SE, SO34SE, SO34NE, SO43NE, SO43NW, SO43SE, SO43SW, SO44NE, SO44NW, SO44SE, SO44SW, SO53NE, SO53NW, SO53SE, SO53SW, SO54NE, SO54SE, SO54SW,
50k: SO33, SO34, SO43, SO44, SO53, SO54

LIDAR - Resolution: 1m within Hereford and 2m upstream of Hereford
Flown Date : 2006

Mastermap - Date: circa 2007 (AA Scenario) circa 2017 (BA, EB Scenario)

Hydrology/Model inflows

Herefordshire Council

Catchment flows are modelled as a mixture of point and distributed inflows in the model. The flow hydrographs have been derived as follows:
- Yazor Brook (upstream of Hereford): ReFH1 method with the T_p and BF_0 model parameters improved using data from the Three Elms gauging station, other model parameters are derived from catchment descriptors.
- Ayles Brook: FEH Rainfall Runoff method with model parameters derived from catchment descriptors.
- Sewer inflows (to Yazor and Widemarsh Brooks through Hereford) - Modified Rational method used to estimate peak flows, manual catchment and triangular hydrograph definition.

Two hydrological scenarios have been tested to date. For the catchment wide storm all hydrographs have been derived for a design storm with duration of 25 hours and area of 44km^2. For the local storm scenario it was assumed that no rainfall occurs over the upper catchment (YA03 and YA04 inflows set to baseflow) and a design storm with duration of 5.5 hours and area 25km2 occurred over the lower catchment.

The hydrology was last reviewed in 2013.

A series of small 'Dummy' flows have been used within the model to enable it to run for low flows; without these additional flows the model would not function due to model stability issues at low flows.

Mannings 'n' Roughness Coefficients

Manning's n coefficients have been used to represent the roughness of the open channel and floodplain. Estimates of the channel roughness were made following site visits and from channel survey data. The definition of roughness in the 2D domain is based on land use information from OS MasterMap data.

Boundary Conditions

The downstream boundary for the Widemarsh / Eign Brook is the River Wye. This has been modelled using a fixed water level taken from the Wye Lugg Confluence model . A 2 year return period level of 49.21mAOD for the River Wye is applied.

The Yazor Brook outfalls into the River Wye upstream of Grey Friars Bridge. As discussed above the Yazor Brook model extent was trimmed to Friars Street, by which point the watercourse is culverted through to its outfall. A stage-discharge relationship was extracted from the complete model prior to trimming in order to provide accurate boundary conditions.

Herefordshire Council

Model	Yazor Brook / Widemarsh Brook Hydraulic Model
Location	Hereford
Watercourses	Yazor Brook, Widemarsh Brook, Eign Brook and Ayles Brook
Model Runs and Output Definitions	

File name: MMM_$$_H_??_&&_****"C"!!_DDD_@@@@

e.g. HER_CA_F_A1_BA_0100C35_25H_4005

MMM	Model Name
$$	Development scenario and phasing - *This is used to define the main scenario. A scenario letter will be assigned when the model is issued*
H	FAS scenarios - whether or not model includes the Yazor Brook FAS
??	Secondary Scenario
&&	Sensitivity and blockage scenarios, or other specific identifiers that may be needed in the future (Note: naming convention to work back from z to avoid confusion with development scenarios [skip xx])
****	Return period
"C"!!	Climate change allowance
DDD	Hydrological scenario - Storm duration of the model in hours
@@@@	Version number of the model
NB	Where inserted after && it represents the removal of the Merton Meadow Car Park access Bridge, WB2368Bu. This has been applied in large events only to resolve model stability issues.

Models (MMM)

HER	Full Yazor Brook (Hereford) hydraulic model (including CRD [Credenhill] and ESG [Edgar Street Grid] domains).

Model Topographic Scenarios ($$)

The first letter represents a particular overarching scenario type (e.g. pre development or final development). A new first letter is defined for additional works such as a stand alone FRA study. The second letter represents subsets or versions of the defined scenario type with the exception of AA which can only have one version.	
B( )	This represents present day and is updated accordingly as development and mitigation options progress. The first letter "B" should remain the same, while the second letter can be updated as time progresses.
BA	Scenario reflects the Present Day (last updated February 2018). The main changes from the baseline scenario (AA) include: The Yazor Brook FAS; Jewsons / Canal Road culvert; City Link Road and culvert - all constructed. The model also includes the proposed Widemarsh Brook diversion between Widemarsh Street and Canal Road, and the CLR attenuation pond, based on draft design information (May 2017). As of Feb 2018 these are expected to be constructed shortly. **This is the model that has been issued.**

FAS Scenarios (H)

The Credenhill Flood Alleviation Scheme (FAS) was implemented to divert flows and enable development in Hereford. The pre FAS option forms a baseline scenario for comparison with ESG development scenarios. No FAS is a past case scenario not an existing case scenario because the scheme is completed.	
F	FAS **in operation**
B	Blocked FAS, as per scenario F with the scheme complete but with no flow allowed down the scheme.

Mitigation or secondary scenarios (??)

Denotes mitigation or secondary options whereby the letter represents a proposed mitigation scheme, while the number represents variants of that scheme (e.g. The letter may represent a culvert upgrade, while the number may represent the specific dimensions to be tested).	
xx	No scenario applied

Residual Risk/ Sensitivity Scenarios (&&)

Represents scenarios of residual risk or sensitivity. New scenarios applied as 2 letter identifiers moving backwards from zz.	
xx	No scenario applied

Return period and climate change allowance

Return period represented with 4 digits and climate change represented by "C" followed by the	
0020C00	1 in 20 year
0100C00	1 in 100 year
0100C35	1 in 100 year with 35 % increased flows for consideration of climate change
0100C70	1 in 100 year with 70 % increased flows for consideration of climate change
1000C00	1 in 1000 year

Hydrological Scenarios

25H	25 hour storm duration, full catchment storm.
05H	5.5 hour storm duration to assess flood impacts from the lower catchment

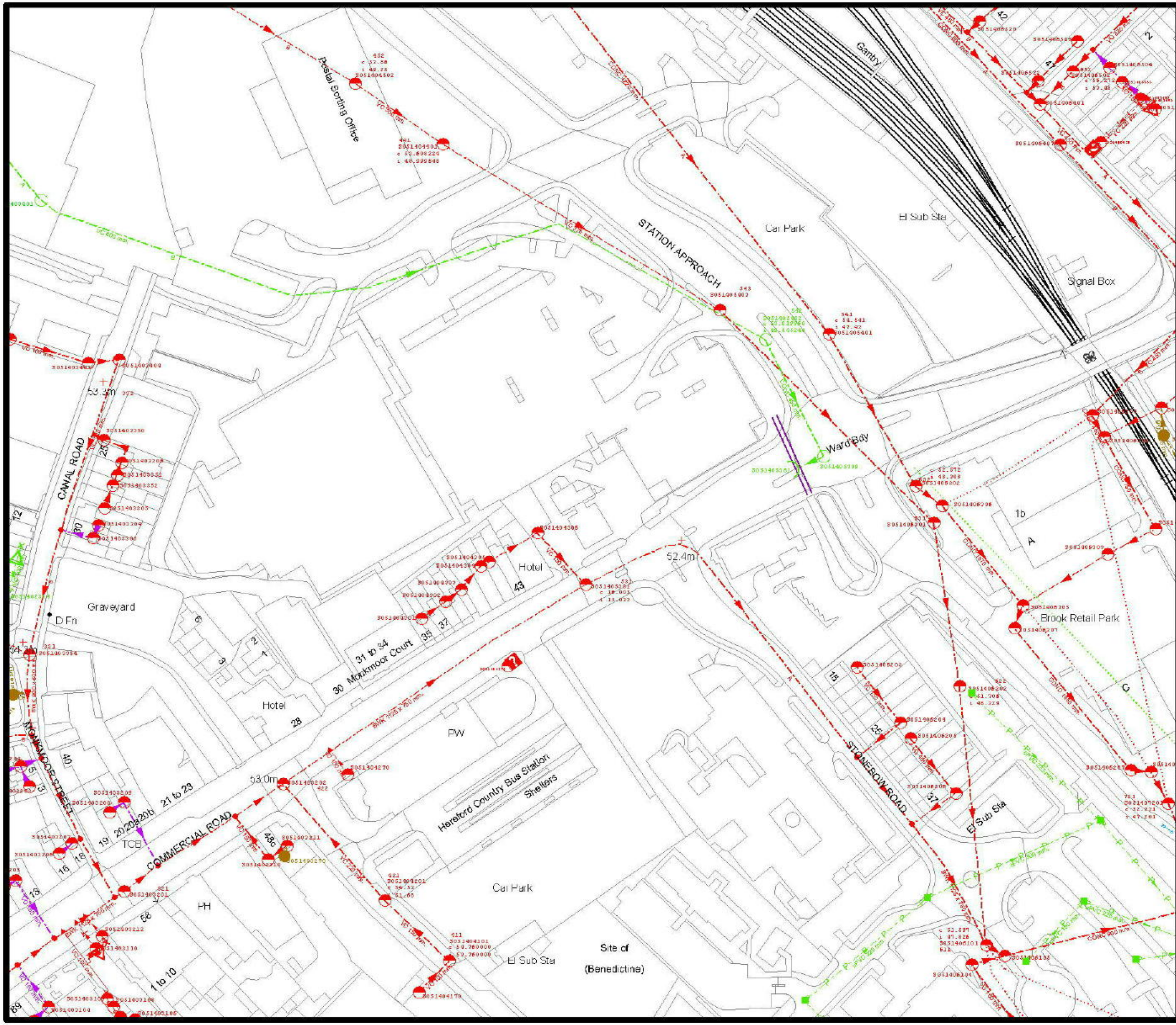
Model Grid Suffix References (where provided)

File name example: HER_BA_F_xx_xx_0100C35_5H_25H_4007_d_Max(maxmax).asc	Grid showing the combined modelled results for the 5.5hr and 25hr model runs. At each location, the maximum value from either scenario is shown.
File name example: HER_BA_F_xx_xx_0100C35_5H_25H_4007_d_Max(maxmax)_src.asc	Grid showing which source grid the values in the maxmax grids have been taken from (i.e the 5.5hr or the 25hr model run).
HER_BA_F_xx_xx_0100C35_25HR_4007	Model run reference
X_Max	Grid type: dMax Maximum Depth Grid hMax Maximum Water level Grid vMax Maximum Velocity Grid ZUK0Max Maximum Hazard Grid
Trim001	Denoting that the grid is a trimmed version of the model data and the data request number.

Node	Location	X	Y	Description	GIS_source	Modelling Approach	Approximate Dimensions	Photo Ref	Additional Comments
New and replacement structures installed since first model build									
Yezor Brook									
SD10005uRa	Credenhill Flood Alleviation Scheme, Credenhill	346550	242851	Credenhill Flood Alleviation Scheme - 24.6m side weir spills into concrete structure before passing flow into 3m circular culvert. Water level at weir is controlled by flume structure located immediately downstream (details below)	As built drawings: \\ukwspgroup.com\central data\Projects\700226xx\70022687 - Yezor Brook Model Data 1617\MODELS\Supporting_Data\03. Yezor Brook FAS As Built Credenhill 2013	Spill unit used to represent 14.56m side weir.	Side weir length 14.56m, height 0.55m above channel bed levels and 2.8m above downstream bed level. Concrete box structure 19.385m long by 3m deep, culvert 2m diameter and 6.05m long.	N/A	The full length of the culvert has not been modelled - model includes a sufficient length to ensure the downstream boundary does not impact the offtake of flow from the brook.
FLUME	Credenhill Flood Alleviation Scheme, Credenhill	346600	242900	Concrete flume structure used to control water levels at the FAS offtake weir.	As built drawings: \\ukwspgroup.com\central data\Projects\700226xx\70022687 - Yezor Brook Model Data 1617\MODELS\Supporting_Data\03. Yezor Brook FAS As Built Credenhill 2013	Q-H Control defined using output from analysis using the Direct Method Transcritical Solver	Throttle 3m wide and 1.5m high.	N/A	
Middlemarsh / Elgn Brook									
NewCul3_934	Link Road Culvert - New	353210	240960	New box culvert where brook passes under the City Link Road	As built drawing; \\ukwspgroup.com\central data\Projects\700226xx\70022687 - Yezor Brook Model Data 1617\MODELS\Supporting_Data\05. Jewsons & Link Road Culverts As Built Jun 2015	Rectangular conduit	3.3m wide, 1.8m height (bottom 300mm assumed soft bed, 1.5 m height used in model)	N/A	
WBDC2U	Canal Road Culvert - replaces WB0702 (WBDCU, WBDC2U) below.	353340	240960	Length of culvert was upgraded and is now in place.	As built drawing; \\ukwspgroup.com\central data\Projects\700226xx\70022687 - Yezor Brook Model Data 1617\MODELS\Supporting_Data\05. Jewsons & Link Road Culverts As Built Jun 2015	Rectangular conduit			
WB0702CU2	Railway upstream of Millbrook Street	350720	240750	Updated arch geometry at outfall of railway culvert	Hereford EIC Mitigation Supplementary Topo and Channel Survey Feb 2017 [model archive #13] 03_M00995 dwg Jo 1 0119	Irregular conduit section	1.7m wide arch, 1.15 high	IMG_0594.JPG	only arch dimensions have been updated. Model units, inverts roughness values etc. have all been retained.
Aylas Brook									
All other structures									
Yezor Brook									
10023 cu	Kenchester Road Culvert	343748	243234	Culvert underlying Kenchester RD	Total_Surveys_June_2007 - YB_10023	Culvert	Height =1.72 m x 3.84m wide, length = 6.8m	YB_10023-us face-far	
-	Access Bridge	343967	243205	N/A	N/A	Not Modelled	N/A	N/A	2 x flood relief culverts & old railway bridge also included in Tuflow model
YB_8315cu	Station Rd Twin Arch Culvert	344535	242937	Twin Arch Culvert	Total_Surveys_June_2008 - 2008-07-07-Jun2008-XS	Sprung conduit (arch culvert)	Height: 1.67m x 3.13m wide (x2) Length = 31.4m	YB_08115-ds face-near	
YB_8518cu	Mill Farm Access Bridge	344960	242697	Thin decked foot bridge	Total_Surveys_June_2007 - YB_8518	Culvert (Two adjacent bridges modelled as one structure)	Height =1.02m x 2.45m wide Length = 36.7m	YB_08518-us face-near	
YB_8304cu	Old Roman Rd / Disused Railway Culvert	345135	242965	Skewed rectangular concrete culvert	Total_Surveys_June_2007 - YB_8304	Culvert	Approx: 3.38m x 3.84m, Length = 46.5m	YB_08304-us face-far; YB_08304-ds face-far	
YB_7839cu	Access Bridge (Corrugated)	345537	242735	Slim deck road bridge	Total_Surveys_June_2007 - YB_07839	Culvert	Approx: 2.13m x 2.67m, Length = 6.35m	YB_07839-us face-far	
YB_7716cu	Access bridge	345620	242751	Rectangular culvert with trash screen	Total_Surveys_June_2007 - YB_07716	Culvert with trash screen	Approx: 2.38m x 2.2m, length = 24.55m	YB_07716-us face-far	
YB_6940cu	A400 twin arch Bridge	345329	242940	Brick twin arch road bridge	Total_Surveys_June_2007 - YB_06940	Arch Bridge	Approx: 2.22m x 2.46m (x2), length = 9.6m	YB_06940-us face-far	
YB_6792cu	Stretton Court Farm Access Bridge	345528	242884	Rectangular culvert, stone parapet	Total_Surveys_June_2007 - YB_06792	Culvert. Parapet included in spill	Approx: 2.16m x 2m Length = 6.3m	YB_06792-ds face-far	
YB_6681abu	Stretton Court Farm Access Bridge	345586	242903	Twin brick arch brick built bridge. Stone parapet	Total_Surveys_June_2007 - YB_06681	Twin Arch Bridge. Parapet included in spill	Approx: 0.85 x 2.08m (x2), Length = 5.1m	YB_06681-us face	
YB_6561abu	Stretton Court Footpath access bridge	345668	242941	Twin brick arch footpath access bridge	Total_Surveys_June_2007 - YB_06561	Twin Arch Bridge	Approx: 0.97m x 1.82m (x2), Length: 3.7m	YB_06561-ds face-far	
YB_6048cu	Footpath bridge	347146	243085	Arched footpath bridge	Site observation	USBPR Bridge	Approx: 3.6m x 0.7m	-	
RB11.5Awu	Weir	347752	242419	Broad crested weir	Site observation	Broad crested weir	N/A	-	
YB04664cu (BOXCULU, RB11.5Acu)	Roman Road Culvert	347750	242395	Roman road re-c ulvert. Stone parapet. Otter pass	Total_Surveys_March_2007 - YB04664	Rectangular conduit. Seperate conduit for otter pass	Approx: 3.03m x 3.53m, Length = 8.4m	YB04664 U/S FR	Flood relief culverts under Roman Road included in Tuflow model
CS06Cu (Bar06u)	Huntington House Foot bridge	348494	241997	Wooden Foot bridge	006-Whitecross_High_School_Sept_2003 - drg- CROSS SECTIONS	Bernoulli unit	Approx: 0.94m x 6.4m, length = 6.5m	-	From Whitehouse Scoish FRA model
CS08Bu (BRHBu)	Hungtington Court access bridge	348518	241901	Stone triple arch bridge with wooden rails.	006-Whitecross_High_School_Sept_2003 - drg- CROSS SECTIONS	Triple arch Bridge	Approx: 2.15m x 7.5m, Length = 6.3m	-	From Whitehouse Scoish FRA model
N/A	Sluice - outlet from Huntington Court pond	348715	241926	Sluice gate	-	Not modelled	-	-	From Whitehouse Scoish FRA model
CS14 (Bar14u)	Foot bridge	348798	241798	Foot bridge	006-Whitecross_High_School_Sept_2003 - drg- CROSS SECTIONS	Bernoulli unit	Approx: 0.9m x 6.5m, Length = 1.8m	-	From Whitehouse Scoish FRA model
CSPB (BRPBu)	Pipe crossings	348014	241484	Pipe crossings	006-Whitecross_High_School_Sept_2003 - drg- CROSS SECTIONS	Orifice	Approx: 3.3m x 1m	-	From Whitehouse Scoish FRA model
YB3055cu	Three Elms road bridge	348895	241451	Rectangular road bridge	Total_Surveys_November_2005 - YB03055	Rectangular culvert	approx: 8.4m x 9.45m, Length = 20.6m	-	
YB3007mu	Three Elms Gauge+ weir & Foot bridge	348934	241450	Gauge STN Weir: interlocking steel foot bridge	Total_Surveys_November_2005 - YB3007	Orifice	Approx: 0.89m x 7.01m, Length = 7.74m	-	
YB2624cu	Foot bridge	348416	241288	Foot bridge	Total_Surveys_November_2005 - YB2624	USBPR Bridge	Approx: 0.71m x 5.25m, Length = 3.84m	-	
YB2124cu	Yezor Road Bridge	348500	240852	Rectangular bridge	Total_Surveys_November_2005 - YB02124	Culvert	Approx: 0.89m x 5.48m, Length = 39.7m	-	
YB2029cu	Foot bridge	348574	240767	Timber foot bridge.	Total_Surveys_November_2005 - YB2029	USBPR Bridge	Approx: 2.06m x 7.62m, Length = 3.31m	-	
YB1861cu	Foot bridge	348692	240657	Foot bridge	Total_Surveys_November_2005 - YB01861	USBPR Bridge	Approx: 0.97m x 5.31m, Length = 2.35m	-	-
YB1761Su	Weir - Middlemarsh Brook bifurcation	348764	240673	Weir	Total_Surveys_November_2005 - YB01761	Spill	-	-	
YB1607CU	Foot bridge	348911	240671	Steel foot bridge	Total_Surveys_November_2005 - YB01607	Bernoulli unit	Approx: 2.54m x 7.08m, Length = 2.35m	-	-
YB1221Cu	Yezor Brook Plough Lane Culvert	350285	240575	Rectangular culvert with Trash screen	Total_Surveys_November_2005 - YB01221	Orifice & conduit	Approx: 2.23m x 3.91m, Length = 217.8m	-	
YB0982 (YBBCU, YBBCU)	Bulmers culvert	350442	240402	Rectangular concrete culvert.	Total_Surveys_November_2005 - YB0982cu	Rectangular Conduit. Orifice for culvert entrance. Inverted syphons under footpath	Approx: 3.6m x 5.09m, Length = 160m	-	
YB0671	Sluice	350506	240149	Sluice gate	Total_Surveys_November_2005 - YB0671	Spill	N/A	-	
YB055 (YBCCU)	Friars Street culvert	350593	240126	Rectangular culvert	Total_Surveys_November_2005 - (YB-XS) YB0556, (YB-US)	Conduit. Orifice for entrance.	Approx: 2.35m x 2.04, Length = 280m	-	Culverts horizontal. QH boundary extracted from full model and applied to downstream boundary.
Middlemarsh / Elgn Brook									

Node	Location	X	Y	Description	Data_source	Modelling Approach	Approximate Dimensions	Photo Ref	Additional Comments
New and replacement structures installed since first model build									
WB3942BU	Widemarsh Brook bifurcation weir	349755	240674	Weir	Total_Surveys_November_2005 - WB03943	Spill	N/A	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS for Ch: 3912	
WB3939	Widemarsh Brook bifurcation Weir And Footbridge	349756	240674	Weir and Foot bridge with 3 pipes	Total_Surveys_November_2005 - WB03940	Orifice	Approx: 2.2m x 4.9m; Length = 10.5m	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS for Ch: 3913	
WB3931Bu	Footbridge	349837	240809	Thin deck timber footbridge	Total_Surveys_November_2005 - WB03943	Bridge - USBPR	Approx: 0.96m x 4.63m; Length =	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS Ch: 3951	
WB3263BU	Powerstation access bridge & pipe crossings	350164	240771	Rectangular culvert with pipe crossings	Total_Surveys_November_2005 - WB03293	Orifice	Approx: 3.41m x 5.37m; Length: 8.0m	WIDEMARSH & EIGN BROOKS PHOTOS - Looking US for Ch: 3263	Skew angle = 63 degrees
WB3210bu	Widemarsh Brook Disused Railway Bridge	350263	240733	Rectangular stone walled bridge underlying disused railway line.	Total_Surveys_November_2005 - WB03210	USBPR Bridge	Approx: 3.30m x 3.69m; length = 15.3m	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS near Ch: 3200	-
WB3157BU	Footbridge	350297	240709	Slim deck concrete footbridge plus pipe crossing	Total_Surveys_November_2005 - WB03157	Orifice	Approx: 1.9m x 1.5m	WIDEMARSH & EIGN BROOKS PHOTOS - Looking US for Ch: 3127	
WB2952CU3	Old Railway Culvert	350718	240759	Rectangular culvert with trash screen under disused railway. Changes to arch culvert along length	Total Surveys - November 2005, Section WB02732	Rectangular & Irregular Conduit units	Approx: 3.045m x 2.17m Length = 84m	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS for Ch: 2702, Looking US near Ch: 2668	Downstream arch geometry updated based on check survey May 2017 as part of EIG mitigation project.
WB2835BU	Millbrook Street road bridge	350757	240761	Rectangular culvert	Total Surveys - November 2005, Section WB02615	Orifice	Approx: 0.74m x 3.71m; Length = 7.5m	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS near Ch: 2605	-
WB2631Cu	Edgar Street road bridge	350905	240749	Rectangular concrete culvert	Total Surveys - November 2005, Section WB02513	Orifice	Approx: 0.72m x 3.32m; Length = 38m	WIDEMARSH & EIGN BROOKS PHOTOS -Looking DS for Ch: 2480	-
WB2388Bu	Merton Meadow car park access bridge	351026	240702	Rectangular concrete bridge	Total Surveys - November 2005, Section WB02393	Orifice	Approx: 2.33m x 6.05m; Length = 8.2m	WIDEMARSH & EIGN BROOKS PHOTOS -Looking DS for Ch: 2338	
WB2237 (WB2237CU & C2U)	Widemarsh Street Culvert	351107	240761	Twin arch stone walled culvert.	Total Surveys - November 2005, Section WB02237	Twin Culvert	Approx: 2.38m x 2.03m (x2), Length= 26.7m	WIDEMARSH & EIGN BROOKS PHOTOS -Looking DS near Ch: 2207	-
-	Access Bridge	351125	240772	Rectangular access bridge	Total Surveys - November 2005, Section WB02203	Not modelled (minor obstruction)	Approx: 3m x 1.1m	WIDEMARSH & EIGN BROOKS PHOTOS -Looking US for Ch: 2207	
WB1702 (WB1CU, WB1C3U)	Canal Road Culvert	351237	240719	Twin Brick Arch Culvert	Total Surveys - November 2005, Section WB01703	Irregular conduit units. Orifice for culvert entrance D1	Approx 2mx 2m & 1.2mx 1.2m, Length = 25m	WIDEMARSH & EIGN BROOKS PHOTOS -Looking DS near Ch: 1672	Continuous culvert with change in section *STRUCTURE WAS REPLACED IN 2015 AS PART OF THE LINK ROAD WORKS - SEE DETAILS ABOVE*
WB1C3U	Morrisons culvert	351385	240/484	Rectangular concrete culvert	Total Surveys - November 2005, WB1E Longsection	Irregular conduit	Approx: 3 x 1.6m; Length = 156m	N/A	Continuous culvert with change in section
WB1C3U	Commercial Road culvert	351529	240374	Arched concrete culvert	Total Surveys - November 2005, WB1E Longsection, EB01408		Approx: 2.2 x 2.4m, Length 12.25m	WIDEMARSH & EIGN BROOKS PHOTOS -Looking US near Ch: 1408	Continuous culvert with change in section
EB1375Cu	Eign Brook KFC access bridge	351614	240338	Concrete Arch culvert	Total Surveys - November 2005, Section WB01702	Orifice	Approx: 3.55m x 3.42m; Length = 30.4m	WIDEMARSH & EIGN BROOKS PHOTOS -Looking DS near Ch: 1375	-
EB1357BU	Footbridge	351754	240381	Slim deck access bridge	Total Surveys - November 2005, Section EB01357	Bernoulli unit	Approx: 0.95 x 4.02m Length = 5.24m (skew angle = 62 degrees)	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS near Ch: 1357	Bernoulli Loss and spill updated May 2017 as part of EIG mitigation Project.
EB0929Cu	Eign Brook railway culvert	352035	239574	Stone walled arch culvert	Total Surveys - November 2005, Section EB0929	Arch Bridge	Approx: 2.63m x 4.25m; Length = 31.4m	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS near Ch: 929	-
EB0711CU	Ledbury Road bridge	352014	239650	Arch road bridge	Total Surveys - November 2005, Section EB0711	Irregular conduit	Approx: 3.32m x 6.32m; Length = 24m	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS near Ch: 711	
EB0675U	Eign Road bridge	352236	239269	Rectangular culvert changing to arch culvert	Total Surveys - November 2005, Section EB1067 & EB00675	USBPR bridge	Approx: 4.2m x 2.2m (3.6 x 3.4d), Length 22m	WIDEMARSH & EIGN BROOKS PHOTOS - Looking DS near Ch: 67, Looking US for Ch: 45	Change to arch not modelled - dominated by DS boundary
Ayles Brook									
AY0395	Old railway culvert (Ayles Brook	350990	241049	Rectangular culvert	Site observation	Not modelled - upstream extent of	Rectangular culvert approx 1.5 m by 1m	-	
-	Footbridge into netail park	350962	240945	Slim deck footbridge	Site observation	Not modelled - high level bridge,	N/A	-	
AY0336	Access Bridge	350816	240951	Access bridge into retail park	Site observation	Not Modelled - wide structure with high soffit, unlikely to cause obstruction flow	Approx: 6m by 3m	IMAG0336.jpg	
AY0188C	Ayles Brook - under old canal	350648	240937	Arched culvert - conveys flow from Ayles brook along the old canal alignment, outfalls into Widemarsh Brook under the Widemarsh Street culvert	Site observation	Sprung arch conduit	Approx: 1.5m by 3m (spring level approx. 0.75m fro	IMAG0188.jpg	

APPENDIX F
SEWER RECORDS



Dŵr Cymru Welsh Water

40 Commercial Road

N
W E
S

LEGEND(Representative of most common features)

Waste network

	Foul chamber		Outfall
	Surface water chamber	LH	Lamphole
	Combined chamber		Storm Overflow
CO	Combined sewer overflow		Rising main
SPC	Special purpose chamber		Gravity sewer
	Treatment works	P	Private sewer
	Pumping station	S 104 P	Private sewer subject to Sect. 104 adoption agreement
		T	Private Sewer Transfer
		L	Lateral Drain
			Inspection Chamber

NB: Sewer symbol colour indicates the type.

RED - Combined
GREEN - Surface Water
BROWN - Foul
Purple - Former S24 sewers (for indicative purposes only)

Notes:

Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets, there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF). It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation.

Dŵr Cymru Cyfyngedig ("the Company") gives this information as to the position of its underground apparatus by way of general guidance only and on the strict understanding that it is based on the best information available and no warranty as to its correctness is [illegible] the Company [illegible] in accordance with statutory requirements of sections 198 and 199 of the Water Industry Act 1991 which is based upon the best information available and [illegible] It should be noted that the records [illegible] 1 September 1989 [illegible] the New Roads and Street Works Act 1991 and the Company's right to be compensated for any damage to its apparatus.

[illegible]

EXACT LOCATIONS OF ALL APPARATUS TO BE DETERMINED ON SITE.

Map Ref:	351508,240352
Map scale:	1:1250
Printed by:	Denning Kelly-Ann
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