GEOENVIRONMENTAL
CONSULTING ENGINEERS

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Report No	Date
EB00668/R1	**April 2007**

Project

Holmer Trading Estate, College Road, Hereford
Phase I & II Geoenvironmental Assessment

Client

Bryan Smith Associates

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Holmer Trading Estate, College Road, Hereford **Phase I & II Geoenvironmental Assessment**

Issue Number	Status	Description of Amendments

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EXECUTIVE SUMMARY

Clarke Bond GeoEnvironmental Limited (CBGE) was commissioned by Bryan Smith Associates to undertake a Phase I and Phase II intrusive Geoenvironmental investigation on Holmer Trading Estate, College Road, Hereford.

The objectives of the investigation were to determine the sub-surface conditions in respect of:

- Phase I Geoenvironmental Assessment and setting of the site and to provide a preliminary assessment of potential environmental liability within the site.
- Conceptual Model following intrusive site investigation
- Foundations for proposed structures.
- Design guidance for access road and car park construction.
- Preliminary contamination assessment to consider potential significant pollutant linkages arising from the historic site use.
- Gas monitoring to consider the potential risk of gas migration from the backfilled canal known to exist on site.

The site is approximately triangular in plan shape and covers an area of 3.56ha. The site is presently utilised as a trading estate with a topography that slopes down to the east. Holmer Trading Estate is a collection of small industrial units, containing both old and recent construction. The following site uses are significant in relation to potential contamination; Laundry Services, Car Dealers, Motor Cycle Breakers & Dismantles; Garage Services; Car Body Repairs; Scrap Metal Merchants; Commercial Vehicle Bodybuilders & Repairers

Historically the site was open fields before the development of a Tile Works. Along the southern boundary is a backfilled section of the Hereford and Gloucester Canal. It is understood to have been partially backfilled with waste from the tile works

The underling geology is the Raglan Mudstone Formation comprising interbedded mudstones and siltstones. The majority of the site is underlain by 1m of Made Ground underlain by the Weathered Raglan Mudstone Formation. The bedrock is highly weathered to 3-4m. The Canal is backfilled with 4-6m of granular and clayey Made Ground. No puddle clay lining was proven.

If the levels of the site are to be raised, the typical depth for excavation for pad foundations would be in the region of 4-4.5m depth. This is likely to be uneconomic, Design bearing pressures of 150kN/m^2 and 125kN/m^2 are recommended for 1m and 2m wide foundations respectively taken down to the Weathered Raglan Mudstone at 3.5-4m depth. Deep excavations are likely to be predominantly in unstable Made Ground and will result over dig of foundation excavations and/or require significant side support.

Ground improvement of the Made Ground and the shallow depth Raglan Mudstone by the application of Vibro replacement maybe feasible to reduce the anticipated settlements beneath pad or strip foundations. According to Keller Ground Engineering the soils revealed in the majority of the trial pits would be suitable for the installation of Dense Stone Columns, and subsequently the adoption of shallow ground bearing foundations and ground bearing floor slabs.

Driven piles may be suitable and would reduce arising that may have to be taken off site. Piles should be taken down into the ‘unweathered’ Mudstone at depth. Some obstructions have been encountered. Some pre-drilling of selected pile locations may be required. Bored cast insitu or continuous flight auger (cfa) piles are suitable and should be taken down through the Made Ground and Weathered Raglan Mudstone and designed as 'rock sockets' in the ‘unweathered mudstone’. Preliminary calculations suggest that 15m depth piles will be required for 450mm and 600mm diameter piles carrying working loads typically 275kN and 375kN respectively. Helical Displacement piles should also be considered in order to minimise the soil arising to the surface.

The former tiling works and kilns should be mapped on site in order to predict where the obstructions are likely to be encountered. Such obstructions will have to be removed prior to construction of foundations.

A Foundation Works Risk Assessment is likely to be required in order to satisfy the environment agency that the piling does not provide additional pathways for contamination migration.

In line with NHBC guidelines, suspended ground floor slabs (e.g. "beam and block" type) should be adopted for houses/buildings where the slab will be underlain by 600mm or mix of "non-engineered" fill material. This should be adopted unless the ground improvement option is considered.

Excavations to at least 2m depth should generally be suitable with conventional soils excavating machinery. Pneumatic tools will be required to break out existing foundations and masonry obstructions.

From a geotechnical viewpoint the spoil resulting from excavations in the Made Ground and the Weathered Raglan Mudstone will generally be suitable for reuse as structural fill, thus minimising the requirement of disposed of off site. The levels of lead in the soils as solid and leachate will affect the usability of the soils.

The redevelopment has three types of development, residential with gardens, residential without and industrial commercial. The existing soils will not be suitable for reuse beneath gardens without the design of a barrier system. Whilst it is feasible that a barrier system could be design to allow the reuse that remains the aspect of blight and the developer should consider whether the mere presence would affect the saleability of the properties.

The majority of excavations, outside the line of the former canal, should remain dry. Occasional slight seepages should be anticipated at the boundary between the Made Ground and the underlying, relatively impermeable, clay. Where encountered excavations can be kept dry by localised pumping. A temporary discharge consent will be required from the local water authority.

Temporary excavations in the Made Ground will stand unsupported in the short term at gradients of not more than 1 on 2.5. Excavations below approximately 1m depth will require sheeting and shoring for personnel to enter safely.

Formations in the Weathered Raglan Mudstone will be moderately susceptible to deterioration due to site traffic and weather and should be protected immediately on exposure with either 150mm of granular material or 75mm of lean mix concrete.

The insitu soils were generally too granular with obstructions for Mexicone penetrometer tests to be completed. Where they were completed in the Weathered Raglan Mudstone, minimal results of 5% were recorded. The final CBR of the pavement formation will depend on the final site levels. For budget costing purposes it should be assumed that the existing Made Ground has a design CBR value of 3% and the Weathered Raglan Mudstone of 5%. We recommend insitu CBR Testing be completed to confirm.

Soakage testing has not been carried out as part of this investigation. It is understood that the following the restoration of the canal section, it has been made clear to the developers that the Hereford & Gloucester Canal Trust/British Waterways would welcome the discharge of storm water into the re-exposed canal, as this acts as a top up to the canal water levels. As discussed in Section 7.0, it is likely that the Environment Agency would allow discharge through soakaways based on the leachate tests of the Made Ground completed to date.

The levels of lead suggest that reuse may be feasible beneath the residential without plant uptake areas and also the industrial commercial areas. Theoretically the materials will also be suitable for reuse beneath hardstanding areas and roads. This aspect should be discussed with the highways authorities regarding the adoption of roads where contaminated soils have been used as engineered soils.

Results for arsenic is slightly in excess of the SGVs for residential development with plant uptake, however the levels are not considered significant. The raised levels of copper, nickel and zinc may be symptomatic of the general current use of the site for various vehicle uses, such as paint spraying car breaking and repair. They do not greatly exceed the GAC. The levels are significant from a residential development viewpoint, however, they are not significantly below the levels acceptable for commercial development.

Chemical tests completed to date suggest that no special precautions will be required for the protection of buried concrete. Based on the recommendations of BRE Special Digest 1 (2007) we recommend a design sulphate class of DS-1 and an ACEC (Aggressive Chemical Environment for Concrete) of AC-1s. Based on the final levels and foundation plan it may be prudent to complete additional testing on the Raglan Mudstone bedrock to confirm the above classifications, however, this formation is no know to contain significant amounts of gypsum bearing minerals.

Chrysotile Fibres (White asbestos) was detected in two of three samples qualitatively analysed. Blue and Brown asbestos was not detected. Additional testing should be completed to confirm if the material is more widely present. Chrysotile is the least harmful cement bonded asbestos. It is not generally considered as requiring off site disposal and requires a suitable cover soils system to prevent incidental contact with future occupiers of the site. During the earthworks dust mitigation measures will be required.

Groundwater monitoring indicates that the dissolved concentrations for lead and boron in the groundwater require further consideration. Groundwater samples analysed were not impacted by TPH or PAH. The water samples tested to date show that the water in the backfilled canal is locally significantly elevated in lead, 250µg/l in comparison with the EQS of 25µg\l and the DWS of 10µg/l. The levels of boron are raised in relation to the drinking water standard.

The groundwater and leachate testing results suggest that there is a risk to the groundwater regime from dissolved lead. A tier III groundwater risk assessment should be completed to further assess the likely impact. A remediation and development strategy will be required by the Environment Agency to confirm that the development and the reuse of soils will not further impact the groundwater.

The main aspect for this development will be the level of lead within the soils. The levels relate to the former use as a tile factory and come from glazes used. Locally the levels significantly exceed the SGV for commercial development. The results from TPH and PAH testing suggest that there are localised areas of hydrocarbon impact from both the high range and low range elements. These are as anticipated and are likely to be related to the use as a car breakers yard and car repairers etc. The results for benzo(a)pyrene, alphatics (EC12-15) and aromatics (EC21-35) require further consideration.

Soils are locally impacted by hydrocarbons in the areas around the breakers yard and the some in the areas close to the vehicle repairs. Raised levels of benzo(a)pyrene have been proven and are significant in relation to residential development. However, it is likely that the high range organics will volatilise during the earthworks. Validation testing should be completed to confirm the levels across the site.

Targeted human health risk assessments should be completed for the contaminants that are currently perceived to be a risk. These assessments are not generic and consider the individual source, pathways and receptors for each of the standard land uses. These will provide sire specific Guideline values. These will be required for the local Environmental Health office to allow the reuse of the soils beneath the different part of the site. It may be that the soils impacted with lead may not be suitable for reuse under residential land, although suitable for commercial.

NRA leachate results have been compared to Environment Agency Leachate Quality Thresholds, Table 1 2nd Edition. Samples were raised in Lead and boron.

The development programme should consider the location of the contaminated materials in relation to the type of development being considered. If a phased development requires the commercial area to

be developed first and the main areas of contamination are beneath proposed residential areas which are to be developed at a later date, such contaminated materials would not be available for reuse beneath commercial areas and would require disposal off site.

It is generally understood that the Environment Agency will be keen on the reuse of soils on site as opposed to the disposal off site. Further assessment will be required, however, in order to prevent any further impact on the groundwater, the developer will have to consider the following:

- Reuse of soils beneath cover systems (although not considered favourable by the Environmental Health)
- Reuse of soils beneath commercial areas and hardstanding
- Cement stabilisation of soils

Further chemical analyses will be required to consider reuse on site. A treatability study should be completed on the option of cement stabilisation. For costing purposes, we estimate approximately 12,000m^3 of soils to be treated, assuming a 4-8% OPC addition, treatment costs should be allowed in the range £30-60 per m^3, £350,000-£700,000. An exemption will be required from the EA for movement and reuse of any excavated or treated soils if designated for reuse on site, which will be an additional cost to the above. It is understood that the soil stabilisation method has been used on a similar site in Hereford.

Japanese Knotweed and Giant Hogweed have not been identified during the site walkover, however, this was completed during the winter months when they are not so easily identifiable. We recommend a site walkover by a suitably qualified ecologist to confirm the absence of these and other invasive species.

Based on the solid test results the majority of the soils will be classified as Hazardous based solely on the lead content. Waste Acceptance Criteria (WAC) testing has been completed and these tests confirm that the materials can be classified as Hazardous Stable Non Reactive. Additional testing should be completed to further delineate the areas of raised lead.

Based on the guidance in Ciria C659 (2006) we recommend that the site is classified as Characteristic Situation 2. Although the monitoring results to date have shown slight diminishing levels of carbon dioxide. Further monitoring of the existing wells is recommended.

Based on the above classification the typical scope of protective measures for Residential housing (not low rise) and office/commercial/industrial units would be as follows

- Reinforced concrete cast in situ floor slab. 1200g DPM and under floor venting.
- Beam or block or precast concrete floor slab 2000g DPM/gas membrane and underfloor venting.
- All joints and penetrations sealed.

For low-rise housing development based on the carbon dioxide levels we recommend classification as Amber 1 in the NHBC Traffic light system. This a low to intermediate gas regime and required low level gas protection measures typically comprising a membrane and ventilated sub-floor void to create a permeability contrast t limit the ingress of gas into the buildings.

Further investigation will be required at this site in order to satisfy the local authority that following the remediation and development of the site there will be no risk to the future occupiers and the wider environment. This will require further delineation of the contamination in the Made Ground. The investigations will also be required to satisfy the Environment Agency that the redevelopment will not provide any additional risk to the local groundwater regime. The objectives of the further investigations and reporting should be as follows:

- Human Health Risk Assessments using CLEA Beta (2005)
- P20 Tier III Groundwater Risk Assessments
- Cement Stabilisation Treatability Assessment of Made Ground.

- Further delineation of hydrocarbon and metals contamination around engineering workshops and scrap yard and car repairs works.
- Determination of Remediation Strategy

In order to complete the above we recommend further intrusive ground investigations. These should be completed based on the proposed end use for the individual phases of the development. Additional sampling should be completed to further delineate the lead concentrations within the Made Ground and assess the leachability.

If chemical stabilisation of soils excavated from the former infilled canal is considered, additional sampling will be required. Large bulk samples will be required to allow a treatability study to be completed. Various percentage additions of cement are then added to the soil samples with subsequent NRA leaching tests undertaken to establish the most appropriate mix to reduce the mobility of lead to below acceptable limits.

Further investigations will also be required to further assess the applicability of the soils this site for ground improvement to allow pad foundations and ground bearing slabs in lieu of potential piles and suspended floor slabs. Confirmatory boreholes should be completed to confirm the strength with depth profiles of the shallow depth soils.

1.0 INTRODUCTION

1.1 Instruction

Clarke Bond GeoEnvironmental Limited (CBGE) was commissioned by Bryan Smith Associates to undertake a Phase I and Phase II intrusive Geoenvironmental investigation on Holmer Trading Estate, College Road, Hereford.

1.2 Scope of Works

The objectives of the investigation were to determine the sub-surface conditions in respect of:

- Phase I Geoenvironmental Assessment and setting of the site and to provide a preliminary assessment of potential environmental liability within the site.
- Conceptual Model following intrusive site investigation
- Foundations for proposed structures.
- Design guidance for access road and car park construction.
- Preliminary contamination assessment to consider potential significant pollutant linkages arising from the historic site use.
- Gas monitoring to consider the potential risk of gas migration from the backfilled canal known to exist on site.

1.3 Report Layout

- Section 2 of this report provides a record of the Phase 1 assessment including the site history, as established from available public record information.
- Section 3 presents a preliminary Conceptual Model for the site.
- Section 4 details the intrusive investigation carried out to validate the conceptual model.
- Section 5 details the ground conditions encountered
- Section 6 makes recommendations for geotechnical design in respect of the proposed development.
- Section 7 presents the records of the chemical analyses undertaken and gives the results of the qualitative risk assessment carried out using the results of the chemical analyses and taking account of the proposed end use of the site.
- Section 8 provides conclusions and recommendations arising from this investigation.

1.4 Limitations

Subsoils are inherently variable and by their very nature are hidden from view such that no investigation can be exhaustive to the extent that all soil conditions are revealed. Conditions may therefore be present beneath the site that were not apparent from the data available for review. Similarly, this assessment has been based to a large extent on third party data acquired from Landmark. This data has been taken at face value and has not been subjected to any third party validation.

Unless specifically noted to the contrary, it should be assumed that this report has not been submitted to any regulatory authorities for approval. Redevelopment sites in particular may have planning conditions attached in respect of contaminated land assessment. Where we are made aware of such conditions in advance of scoping the works, we can tailor the report to the regulatory authority requirements. Where we are not made aware of any such requirements there can be no certainty that our investigation will meet any or all of the regulatory authority requirements.

2.0 PHASE 1 ASSESSMENT

2.1 Site Location

The site is located on the eastern side of the town of Hereford at approximate Ordnance Survey Grid Reference 351750E 241750W. A site location plan is presented as Figure EB00668/R1/F1.

2.2 Site Description

A site walkover was undertaken on 15th January 2007 with supporting photographs presented as a Photofile in Appendix A. A site layout plan is included as Figure EB00668/R1/F2

The site is approximately triangular in plan shape and covers an area of 3.56ha. The site is presently utilised as a trading estate with a topography that slopes down to the east (Plate 1).

The site can be accessed from College Road via the main entrance at the western end of the site. A tarmac road runs around the entire site providing access to the various units. Immediately to the south of the entrance, is a wooded area surrounded by a wire fence. The wooded area slopes down to a canal that runs into a brick tunnel, which runs west under the road. To the east of the wooded area is a car and caravan sales area (Plate 2). Moving east along the southern edge of the site leads to several gravel compounds that are used as car parks and storage for building material (Plate 3), gas bottles and unused above ground storage tanks (Plate 4).

Immediately to the north of the entrance is a grassed mound with bushes and shrubs. The grassed area slopes down in a southeasterly direction from College Road and is separated from a tarmac car park by a 0.5m high, brick retaining wall (Plate 5). To the east of the car park is a single storey, brick and aluminium retail centre that contains a furniture store, café, biscuit manufacturers, laundry and art shop. Eastwards from the retail centre are 1-2 storey brick and aluminium units, utilised as workshops and a catering company. Several tarmac and gravel car parks (Plate 6) lie between the buildings, one of which is used as a lorry storage yard for a distribution company. In the eastern area of the site are further workshops that are utilised for car repairs, restoration and recovery. A vehicle storage area with a concrete surface is present in the northeast corner of the site (Plate 7), which contains an oil bund in its southwest corner (Plate 8).

Along the northern boundary of the site, from east to west, is a large single storey brick building that is used for vehicle repairs, a tyre replacement workshop and a joinery (Plate 9). A single unit is empty that has been occupied by scrap metal merchants in the past. Outside this building is a weighbridge (Plate 10). Between the workshops in the centre and north of the site are several above ground storage tanks (Plate 11).

West along the northern boundary of the site is a scaffold yard, followed by a residential, 2-storey, brick house and a concrete yard that utilises two gravel compounds and a 2-storey, brick cottage.

The site is bounded to the south by a 2m high chain link fence with a hedge and gravel footpath immediately beyond. An electricity substation is present beyond the southwest boundary. Further to the south is a residential area. The site is bounded to the east by a 2m high metal fence with a 2-storey aluminium building and car storage area beyond. An old canal stretches eastwards from the southeast corner of the site. Further to the east is a works and agricultural land. The site is bounded to the north by a 2m high chain link fence with a railway line, factory and agricultural land beyond. Immediately to the east of the site is College Road, close b are the Bridge Inn pub, a factory, playing fields and residential housing.

2.3 Geology

The geology of the site is shown on the 1:50,000 scale Geological Centremapslive map, presented in Appendix B. This indicates that Recent/Pleistocene alluvium covers the southern extremes of the site, with superficial deposits absent over the remainder of the site. The underlying 'solid' geology is likely to occur as interbedded siltstone and mudstone of the Raglan Mudstone Formation of Silurian age.

Details of the published geology are included as Appendix B.

2.4 Hydrology

Surface water features in the vicinity of the site include a former canal immediately to the east of the site. A tributary of the River Lugg flows from northwest to southeast approximately 250m northeast of the site, just beyond the eastern most extent of the former canal. There are also four ponds between 250m and 500m north and east of the site. Several small streams are present 1000m to the southeast. Due to the proximity the potential risk to these receptors is deemed to be high.

2.5 Hydrogeology

Guidance from the Environment Agency indicates that the underlying bedrock deposits are designated as a minor aquifer. These can be fractured rocks that do not have a high primary permeability and do not produce large quantities of water for abstraction. However they are important in maintaining base flows of local rivers and for local supplies. The overlying drift deposits of the majority of the site have Intermediate Leaching Potential, with the exception of the southeastern area of the site, which is of High Leaching Potential. As such the site sensitivity is regarded as medium.

2.6 Site History

Historical maps of the site area have been obtained via Landmark. Pertinent information determined from review of these maps is set out in the following table:

Table 1: Historic Mapping Review

Mapping Date	On-site	Off-site
1887-1888	Victoria Tile Works is shown in the centre of the site, surrounded by orchards and a network of drains. Hereford & Gloucester Canal is flowing along the southern boundary of the site.	The north the site is bound by the Shrewsbury & Hereford Railway line. Orchards are present the railway. A clay pit with adjacent Brick, Tile, & Drain Pipe Works are shown approximately 200m to the northeast. To the west Bridge Inn Road bounds the site with the Bridge Inn is located approximately 50m to the west. The area to the south and northwest of the canal is undeveloped.
1904 - 1905	The Tile Works have been expanded and covers the majority of the site. The Hereford & Gloucester Canal is now shown as Old Canal. Coniferous trees have been planted along the edge of the Canal.	Jubilee Cider Works is shown approximately 300m to the north and the orchards have been expanded to the west. The Brick, Tile, & Drain Pipe Works are now shown as the Holmer Brick and Tile Works.
1929 - 1931	The Victoria Tile Works have been redeveloped and chimneys are shown at three locations. Some coniferous trees along the canal have been replaced by deciduous.	The Old Canal is shown to have been overgrown with reeds to the southeast of the site. The previously mentioned Holmer Brick and Tile Works are no longer shown and are called The Follies. A sewage tank is shown approx 600m to the northwest of the site. A tunnel is shown approximately 200m to the southwest of the site.
1937	Victoria Tile Works has been redeveloped and one of the three chimneys has been removed.	No significant change.

Table 1: Historic Mapping Review (continued)

1938- 1953	No significant change	A significant residential development is present approximately 300m to the southwest of the site. A pond is shown at the place of the former clay pit with the issues flowing northeast to the southwest.
1964	No significant change	No significant change.
1967-1971	Victoria Tile Works has been redeveloped and a refuse tip is shown at the location of the Old Canal.	A depot beyond the orchard to the north of the site is present. Burcott Cottages are shown approximately 200m to the southwest of the site. A pump is shown approximately 50m east of the site near issues. A track is present approximately 100m to the south. Playing fields are shown to the southeast and southwest of the site approximately 150m and 50m away respectively. Alloy Works are shown approximately 200m to the southwest of the site. The Bridge Inn Road to the west of the site is now shown as College Road.
1966-1997	No significant change	No significant change
1973	No significant change	The Burcott Cottages are now shown as the Burcott Farm. The pump to the east of the site is not shown. To south and southeast, beyond College Hill, a significant residential area has been built. To the west of College Road there is a large industrial area occupied by buildings, tanks, gasholders and depots.
1975-1990	The Victoria Tile Works are not shown. Several industrial buildings within Holmer Trading Estate occupy the site.	The orchard is not shown and Centurion Way, with several adjacent buildings has been built in its place. The issues to the southeast of the site are shown as a pond and several industrial buildings have been built to the south of the pond. A large residential area has been built adjacent to the southern boundary of the site.
1993-2002	No significant change	No significant

Copies of the historic maps are presented in Appendix C

2.7 Environmental Database

An Envirocheck report was commissioned to provide an indication of the site history and surrounding land uses available on the public registers. The report provides data from a number of service providers including the British Geological Survey, Environment Agency and English Nature. The report is included in Appendix D.

The location of data point references is provided relative to the National Grid Reference for the site centre. The search radius extends 1km from the site centre.

The table below indicates the risk scoring used on the potential pollutant linkages identified from the historic data search. The degree of risk (R) is calculated by multiplying the likelihood (L) with the effect (E):

Degree of risk (R) = Likelihood (L) x Effect (E)

Likelihood (L)	Description	Probability	Effect (E)	Description	Increase In Cost And Time
5	Almost certain	>70%	5	Very high	>20%
4	Probable	50-70%	4	High	10-20%
3	Likely	30-50%	3	Medium	4-10%
2	Unlikely	10-30%	2	Low	1-4%
1	Negligible	<10%	1	Very low	<1%

Risk (R)	Risk Level	Action
1-5	Trivial	None
6-10	Significant	Undertake appropriate mitigation measures to reduce the risk level by appropriate on-site practice at little additional cost.
>10	Substantial	Designers should take such risks into account and avoid or reduce risk level to acceptable levels. Additional resources required.

The following table provides a summary of the data reference points, together with an indication of the hazard, likelihood, severity and degree of risk.

Table 3: Environmental Data Review

Data Type	Distance from site	Hazard	Likelihood	Effect	Degree of risk	Mitigation measures
Discharge consents	31m SE	Source – Unspecified at Roman Road Old Canal Receiving water – Old Canal – Tributary of Sutto.	1 1	2 2	2 2	No action No action
	31 – 141m E&SE	All consents are expired or revoked.				
	308m NW	Source – Sewage Discharges - Final/Treated Effluent Receiving water – Trib or River Lugg				
	335m NW	All consents are expired or revoked.	1	2	2	No action
	391m NE	All consents are expired or revoked.				
	531- 745m E	Source – Sewage Discharges - Final/Treated Effluent Receiving water Trib or River Lugg	1	2	2	No action
	776 – 824m W & SW	All consents are expired or revoked.				
	875m E	Source – Unspecified Receiving water – Lugg Rheay	1	2	2	No action
	887 – 899m SW	All consents are expired or revoked.				
	896m SE	Consent expired.				
	905 – 918m SW	All consents are expired or revoked.				
	931m NE & N	Consent expired.				
	948m SW	Consent expired.				
Enforcement and Prohibition Notices	587m W	Source – A leak of 100kg of dilute Chromic Acid into Ayles Brook (2001)	1	3	3	No action
	549m W	Source – A series of breaching of the emission limit for a shot blasting unit (2001)	1	2	2	No action
Integrated Pollution Controls	681m W	Revoked – Now IPPC				
Integrated Pollution Prevention and Control	681m W	Source – Special Metals Wiggin ltd. Activity Description – 1. Surface treating metals and plastics; electrolytic/chemical; Carbon Disulphide or Ammonia; Ammonia release to air; non-ferrous metals; melting and making alloys, combustion.	2	2	4	No action

Table 3: Environmental Data Review (Cont.)

Data Type	Distance from site	Hazard	Likelihood	Effect	Degree of risk	Mitigation measures
Local Authority Integrated Pollution Prevention and Control	689m SW	Source ▯ Hot dip galvanising	1	2	2	No action
Local Authority Pollution Prevention and Controls	47-54m NE&E	Respraying of road vehicles	2	2	4	No action
	118m NW	Respraying of road vehicles	1	2	2	No action
	131m E	Coating of metal and plastic	1	2	2	No action
	278-279m E	Wood coating	1	2	2	No action
	586m W	Coating of metal and plastic	1	2	2	No action
	685m W	Zinc and zinc alloy processes	1	1	1	No action
	687-931m SW & W	Transferred to LAIPPC or revoked	1	1	1	No action
Nearest surface water feature	14m E	-	3	3	3	Risk Assessment
Pollution Incidents to Controlled Waters	On site	Source ▯ Rubbish ▯ Significant Incident (1994)	2	3	6	Site investigation
	26-37m SE	Source ▯ Light oil/unknown/ algae/mud/clay/soil ▯ all minor incidents	2	2	4	No action
	66m E	Source ▯ Miscellaneous ▯ Vehicle washings and dewaxing ▯ Minor incident	2	1	2	No action
	82m E	Source ▯ Heavy Fuel oil ▯ Significant Incident (1992)	2	2	4	No action
	83m E	Source ▯ Unknown ▯ Minor incident	2	1	2	No action
	87m E	Source ▯ Coal Solids ▯ Significant incident	2	2	4	No action
	90 -148m E	Source ▯ Farm Effluent/Slurry, sullage, firewater/foam ▯ all minor incidents	2	1	2	No action
	186m E	Source ▯ Miscellaneous ▯ Vehicle washings and dewaxing ▯ Significant incident	2	1	2	No action
	330 - 335mNW	Source ▯ Sewage ▯ septic tank effluent ▯ Minor incidents	1	1	1	No action
	588-590m E	Source ▯ Unknown, Sewage ▯ septic tank effluent ▯ Minor incident				
	612m SE	Source ▯ Mud/Clay/Soil ▯ Significant incident	1	1	1	No action
	722m E	Source ▯ Sewage ▯ treated effluent ▯ Minor incident	1	1	1	No action
	736m W	Source ▯ Unknown ▯ Minor incident	1	1	1	No action

Table 3: Environmental Data Review (Cont)

Data Type	Distance from site	Hazard	Likelihood	Effect	Degree of risk	Mitigation measures
	804m SW	Source ▯ Algae ▯ Significant incident	1	1	1	No action
	842m SW	Source ▯ Mud/clay/soil/ - Minor incident	1	1	1	No action
	825m N	Source ▯ Unknown ▯ Minor incident	1	1	1	No action
	840m SW	Source ▯ Oils ▯ Diesel and Chemicals ▯ other organic ▯ Significant incidents (1995)	1	1	1	No action
	843m SW	Source ▯ Crude sewage ▯ Minor incident	1	1	1	No action
	846m SW	Source ▯ Blood and Offal ▯ Minor incident	1	1	1	No action
	859m E	Source ▯ Unknown ▯ Minor incident	1	1	1	No action
	867m SW	Source ▯ Light Oil ▯ Minor incident	1	1	1	No action
	885m N	Source ▯ Septic tank effluent ▯ Minor incident	1	1	1	No action
	891m S	Source ▯ Heavy fuel oil ▯ Minor incident	1	1	1	No action
	905m SW	Source ▯ Vegetation/Cuttings ▯ Minor incident	1	1	1	No action
	964m E	Source ▯ Farm Effluent/Slurry ▯ Significant incident	1	1	1	No action
	968m W	Source ▯ Crude Sewage ▯ Minor incident	1	1	1	No action
	979m SW	Source ▯ Coal Solids ▯ Significant incident	1	1	1	No action
River Quality	963m E	River Lugg ▯ River Quality ▯ B	-	-	-	-
Substantiated Pollution Incident Register	741m SW	Source ▯ Oils and Fuel: Mixed/Waste Oils Water ▯ No Impact, Air ▯ Significant Incident Land ▯ Minor incident	1	1	1	No action
	769m W	Source ▯ Inorganic Chemicals/Products: heavy Metals. Water ▯ Significant incident, Air/ Land ▯ No Impact	1	1	1	No action
Water Abstractions	692-914m NE & N	Status ▯ all revoked, lapsed or cancelled	-	-	-	No action
	1025m NW	Borehole at Marley House	1	1	1	No action
	1052m NW	Status ▯ revoked, lapsed or cancelled	-	-	-	No action
	1102m SW	Borehole at Merton Meadow	1	1	1	No action
	1200m NE	Well at New House	1	1	1	No action
	1220-1249m NE&N	Status ▯ all revoked, lapsed or cancelled	-	-	-	No action
	1258m S	Tan Brook& Ayles Brook	1	1	1	No action
	1267m E	Status ▯ revoked, lapsed or cancelled	-	-	-	No action
	1287-1401m	Status ▯ all revoked, lapsed or cancelled	-	-	-	No action

Table 3: Environmental Data Review (Cont.)

Data Type	Distance from site	Hazard	Likelihood	Effect	Degree of risk	Mitigation measures
	1422m SW	Borehole at Cattle Market	1	1	1	No action
	1467-1490m	Status II all revoked, lapsed or cancelled	-	-	-	No action
	1490m SW	Factory at Westfield Trading Estate	1	1	1	No action
	1492m +		1	1	1	No action
Groundwater Vulnerability	On site	Minor Aquifer (Variably permeable) Soils of Intermediate Leaching Potential to High Leaching Potential	2	2	4	No action
Extreme Flooding from Rivers or Sea without Defences	None	-	-	-	-	No action
Flooding from Rivers or Sea without Defences	None	-	-	-	-	No action
Areas Benefiting from Flood Defences	None	-	-	-	-	No action
Flood water storage areas	None	-	-	-	-	No action
Flood Defences	None	-	-	-	-	No action
Licensed Waste Management Facilities	On site	End of life Vehicles	5	4	20	Site Investigation
	768m SW	Metal Recycling Sites	1	2	2	No action
	782m SW	End of life Vehicles	1	2	2	No action
	802m SW	Household, commercial and industrial transfer stations	1	2	2	No action
Registered Waste Transfer Sites	644m W	Household & Commercial Waste, Polythene pipe, scrap metal	1	2	2	No action
	1000m SW	Paint & solvents	1	2	2	No action
Registered Waste Treatment or Disposal Sites	On site	Scrap yard (batteries, cars/vehicles, engines, oils, tyres)	5	4	20	Site Investigation
	747m SW	Scrap yard (aluminium, batteries, engines etc.)	1	2	2	No actions

Table 3: Environmental Data Review (Cont.)

Data Type	Distance from site	Hazard	Likelihood	Effect	Degree of risk	Mitigation measures
Control of Major Accident Hazards Sites (COMAH)	681m W	Special Metals Wiggin Ltd – Lower Tire	1	2	2	No action
Planning Hazardous Substance Consents	681- 695m W	Special Metals Wiggin Ltd	1	2	2	No action
Planning Hazardous Substance Consents	682W	British Gas Plc – application revoked or cancelled	1	2	2	No action
BGS 1:625,000 Solid Geology	On site	Lower Old Red Sandstone, incl. Downtonian	-	-	-	-
Coal mining area which may not be affected by coal mining	On site					
Potential for Collapsible Ground Stability Hazards	On site	Geotechnical risk classed as "No Hazard"	1	1	1	No action
Potential for Compressible Ground Stability Hazards	On site 6m S 169m N 234m N	Geotechnical risk classed as "No Hazard" Geotechnical risk classed as "Moderate" Geotechnical risk classed as "Low" Geotechnical risk classed as "Moderate"	1 2 1 1	1 3 2 2	1 6 2 2	No action Site investigation No action No action
Potential for Landslide Ground Stability Hazards	On site	Geotechnical risk classed as " Very Low"	1	1	1	No action
Potential for Running Sand Ground Stability Hazards	On site 7m S 168m N 234m N	Geotechnical risk classed as "No Hazard" Geotechnical risk classed as "Low" Geotechnical risk classed as " Very Low" Geotechnical risk classed as "Low"	1 1 1 1	1 2 1 1	1 2 1 1	No action No action No action No action
Potential for Shrinking or Swelling Clay Ground Stability Hazards	On site 17-85m NE&N 161-238m W	Geotechnical risk classed as "No Hazard" "Very Low" Geotechnical risk classed as "No Hazard" Geotechnical risk classed as "No Hazard"	1 1 1	1 1 1	1 1 1	No action No action No action
Radon Affected Areas	On Site	Source – alpha particle inhalation	2	2	4	Between 1% and 3% of homes are above the Action level. Basic radon protective measures are necessary.

Table 3: Environmental Data Review (Cont)

Data Type	Distance from site	Hazard	Likelihood	Effect	Degree of risk	Mitigation measures
Shallow Mining Hazard		Geotechnical risk classed as ‘No Hazard’	1	1	1	No action
Contemporary Trade Directory Entries	On site	Laundry Services	4	4	12	Site Investigation
		Car Dealers	4	4	12	Site Investigation
		Hydraulic Equipment & Accessories – Sales & Service	4	4	12	Site Investigation
		Autogas Suppliers & Installers	4	4	12	Site Investigation
		Laundry Equipment – Sales & Service	3	3	9	Site Investigation
		Motor Cycle Breakers & Dismantles	4	4	12	Site Investigation
		Caravan Dealers & Manufactures	4	4	12	Site Investigation
		Garage Services	4	4	12	Site Investigation
		Car Body Repairs	4	4	12	Site Investigation
		Scrap Metal Merchants	4	4	12	Site Investigation
		MOT Testing Centres	4	4	12	Site Investigation
		Commercial Vehicle Bodybuilders & Repairers	4	4	12	Site Investigation
		Food Products – Manufactures	4	4	12	Site Investigation
	48 -112m	Commercial Vehicle Dealers, Car Body Repairs, Car Dealers, Heat Treatment – Metals, Precision Engineers	3	3	9	Site Investigation
	120m +	Car Dealers, Road Haulage Services, Hospitals, Corrosion Prevention & Control, Lawnmowers & Garden Machinery, Heating Equipment – Sakes and Service, Garage Services, Commercial Vehicle Servicing, Repairs, Parts & Accessories, Scrap Metal Merchants, Car breakers & dismantles, Printed Circuit services, Car painters & sprayers, Builderls Merchants, Commercial cleaning services, Sand, gravel & other aggregates, Alloys, Firework Stockists etc.	2	2	4	No action
Nitrate Vulnerable Zones	942m W	Source – Nitrates	2	2	4	No action
Sites of Special Scientific Interest	987m E	River Lugg – Biological	1	2	2	No action
	991m E	River Lugg – Special Area of Conservation	1	2	2	No action
Special Areas of Conservation	987E	River Wye	1	2	2	No action
	991E	River Wye	1	2	2	No action

2.8 Local Authority Enquiries

Written requests for information relating to the site history were made to Herefordshire Council Planning Department on 23rd January 2007 and a response was received on 15th February. The response confirmed that no specific records relating to the ground conditions are held and the site is not included on the Environmental Protection Act Part 2a register. A copy of the letter is included as Appendix E.

2.9 Previous Investigations

A Phase I and Phase II investigation of land to the east of the trading estate was carried by PB Kennedy & Donkin Limited in Report BEEBL156 Phase I Environmental Review and Phase II Site Investigation, Land to the North of M T Cavanagh Limited, Holmer Trading Estate, November 1999. The ground conditions encountered can be summarised as follows:

Depth (m)	Brief Description
GL to 0.55/1.50	Made Ground comprising fragments of stone, metal, clinker, coke, coal, ceramic tile, brick glass, wood, plastic, insulation material and tarmac in a brown silty, occasionally sandy and ashy clay matrix.
0.55/1.50 to 1.40 ‖ 3.60+	Firm to stiff, orange to red and brown with occasional green, grey and black staining, friable, silty CLAY.

The main conclusions of the investigation were as followed:

- Groundwater was encountered in the Made Ground as a perched water table.
- Contaminants including heavy metals, TPH and PCBs were observed in the Made Ground with concentrations found to be above the Dutch Intervention values.
- Landfill gas was not detected.
- The impermeable clay layer implies potential for horizontal migration off site.
- The surface water drainage system comprises two petrol interceptors for the study site and the Holmer Trading Estate, with the condition unknown.
- There is likely to be a risk posed to site workers during foundation excavation due to soil and perched groundwater contamination.

It should be noted that the Dutch Intervention Levels do not and never have had any legal standing in the UK and the degree of potential contamination should not be referred to with such values.

3.0 PRELIMINARY CONCEPTUAL MODEL

The site characterisation attempts to identify potential previous and existing site sources of contamination. The conceptual model links the identified sources likely to cause significant possibility of significant harm via pathways to identified critical receptors. The conceptual model is therefore based on a number of identified source-pathway-receptor scenarios. For land to be classified as contaminated a significant pollutant linkage will need to be identified which will include each component of the conceptual model. The absence or removal of a source or interception of a pathway will 'break' the pollutant linkage.

The conceptual model is characterised by identification of the following:

- On-site sources which may impact on-site receptors via plausible pathways.
- On-site source which may impact off-site receptors via plausible pathways.
- Off-site sources which may impact on-site receptors via plausible pathways.

A preliminary conceptual model is included as Figure EB00668/R1/F3.

The change of land use will require assessment of the new site development layout within the context of introducing new exposure pathways. The planning regime will require assessment of the site to ensure the new development will not be classed as contaminated land under the definition provided by the Part 2A of the Environment Act 1990 as defined in the Environment Protection Act 1995.

The Contaminated Land Legislative Background is presented in Appendix F.

4.0 SITE INVESTIGATION

4.1 General

An intrusive site investigation utilised machine dug trial pitting, window sampling and cable percussion drilling was completed between 25th January 2007 and 20th February 2007.

The locations of each exploratory hole were checked for service clearance using a service plan provided by HRD Estates and by the use of a cable avoidance tool (CAT).

A plan showing the exploratory hole locations is presented as Figure EB00668/R1/F2. The investigation comprised the following:

- 14 trial pits
- 10 window samples
- 7 dynamic penetration tests
- 3 cable percussive boreholes

4.2 Window Sampling and Dynamic Penetration Testing

10 No window sampling holes were drilled across the site using a Competitor 130 track mounted window sampling rig between 25th and 26th January 2007. Undisturbed soil samples are retained in a uPVC tube and allows for ex-situ observations of the ground conditions with soil samples of appropriate size for proposed analysis obtained. Window sampling allowed an initial insight into to the ground conditions across the site without causing disruption to site occupiers and allows the trial pits to appropriately located.

7 No dynamic penetration tests were completed across the site using the Competitor 130 drilling rig. Dynamic probing involves driving a drive rod with a conical tip into the ground using a 63.5kg hammer to provide a continuous strength profile of the soil. The results can be equated to the Standard Penetration Test (SPT). Based on past experience the summation of four successive n100 blows is approximately equivalent to the SPT N Value. A plot of equivalent SPT N values with depth are included in Appendix G, along with the window sample logs and penetration test records.

4.3 Machine Dug Trial Pitting

14 No trial pits were excavated across the site using a JCB 3CX excavator between 30th and 31st January 2007. The trial pits were only entered where safe to do so to a maximum depth of 1.2m. Detailed soil descriptions were recorded in accordance with BS5930:1999. The soil strength was determined where appropriate using a Hand Shear Vane and CBR values measured with a Mexicone Penetrometer. A Minirae Photo Ionisation Detector (PID) meter was used to measure Isobutylene vapours emitted by the soil.

Soil samples of appropriate size for proposed analysis were obtained from the sides of the excavation. Excavations below 1.2m were logged visually from the surface by measuring depths of stratum changes and inspection, testing and sampling of arisings.

Several previously unknown services were encountered during the trial pitting. A plastic foul water pipe was encountered at a depth of 1m in TP8 and a metal water pipe was encountered at a depth of 0.3m in TP11. In each case it was possible to extend the trial pit to avoid the pipes. A 150mm diameter clay pipe was encountered in TP14 at a depth of 0.5m but it was not possible to extend or relocate the trial pit due to limited space in the locality. The services at each location were not damaged. Trial Pit logs are included as Appendix H.

4.4 Cable Percussion Drilling

3 No boreholes were sunk using percussion boring, between the 19th and 20th February 2007. The locations were all within the backfilled canal to obtain sample of the Made Ground and groundwater, whilst also proving the depth the backfilling.

Small disturbed samples were recovered in between SPT samples, providing a continuous record of the strata. 150mm diameter steel casing was installed to prevent the borehole walls collapsing. Penetration through obstructions was achieved using a heavy chisel. The depth and strength of groundwater seepage was noted and drilling suspended for 20 minutes before the standing level was recorded.

An engineering geologist examined the samples obtained from the boreholes, who produced detailed logsheets, included as Appendix I.

4.5 Monitoring

Dual groundwater and gas monitoring standpipes were installed in WS1, WS5, WS9 and WS10 and the three cable percussion boreholes. The standpipes comprised a 50mm diameter uPVC pipe with screw connectors between each 1m length. The standpipe comprised 1m of plain pipe with slotted pipe below to allow the free ingress of water with a gas valve inserted at the top of the pipe. The annulus between the standpipe and the borehole wall was filled with granular material. A stopcock cover at the ground surface was installed to protect the standpipe.

Monitoring visit have been completed on 8th, 19th and 26th February 2007 to record resting water levels, allow groundwater sampling, and record gas levels were monitored using a LMXsi gas monitor. The gas and groundwater monitoring results are included as Appendix J.

4.6 Sampling and Analysis

Environmental sample collection was carried our in accordance with Clarke Bond Geo-Environmental Standard Operating Procedures. All soil samples were collected using either clean stainless steel utensils or clean disposable gloves and placed directly into clean containers provided by the laboratory. Groundwater samples were collected using a clean disposable bailer and place directly into clean containers provided by the laboratory. Samples obtained during the investigation were subjected to a range of geotechnical and geochemical and physical testing at appropriate UKAS accredited laboratories.

Samples were submitted for geotechnical laboratory testing to characterise the engineering properties of the soil. The following testing was scheduled:

- Classification tests (Atterberg Limits)
- Moisture Content
- BRE Sulphate suite

Testing was carried out in accordance with the procedures outlined in BS1377:1990. Geotechnical laboratory test data is presented in Appendix K.

Soil samples were sent for chemical analysis to Alcontrol Geochem laboratories to be analysed for:

- Maxi indicator suite comprising arsenic, boron (water soluble), cadmium, copper, chromium, lead, mercury, nickel, selenium, zinc, total cyanide, free cyanide, total sulphate, phenols, speciated PAH, pH, sulphide, total sulphur, thiocyanate.
- Speciated Total Petroleum Hydrocarbons (TPH by GRO/EPH includes BTEX/MTBE),
- Asbestos
- PCBs

On receipt of the preliminary results of the solid soil testing, the results were assessed against appropriate guidance values. NRA Leachate testing was subsequently completed for those raised contaminants.

Water samples from across the site and from the backfilled canal were also analysed for the following:

- Maxi indicator suite comprising arsenic, boron (water soluble), cadmium, copper, chromium, lead, mercury, nickel, selenium, zinc, total cyanide, free cyanide, total sulphate, phenols, speciated PAH, pH, sulphide, total sulphur, thiocyanate.
- Speciated Total Petroleum Hydrocarbons (TPH by GRO/EPH includes BTEX/MTBE),

The chemical laboratory test results are presented in Appendix L.

5.0 GROUND CONDITIONS

5.1 General

The following table provides a summary of the strata encountered and the depth to the base of each stratum in metres encountered in the exploratory holes.

Stratum	WS1	WS2	WS3	WS3A	WS4	WS5	WS6	WS6A	WS7	WS8	WS9	WS10
Tarmac	0.1		0.1	0.1				0.05			0.05	
Concrete		0.2	0.3		0.17	0.1	0.1		0.1			
Made Ground	0.6	1.1	0.9+	0.95+	0.63+	0.5	2.0+	0.9	1.1	3.0+	1.6	3.4
Clay	4.9+	3.9+				3.0+		2.0+	2.8+		3.0+	4.0+

Stratum	TP1	TP2	TP3	TP4	TP5	TP6	TP7	TP8	TP9	TP10	TP11	TP12	TP13	TP14
Tarmac			0.05								0.05			
Gravel	0.5	0.1	0.1				0.1	0.1	0.15	0.1		0.05		
Concrete				0.1	0.2	0.2			0.3			0.1		
Made Ground	2.8+	2.6+	2.0	0.9	1.7	1.0	1.4	1.5+	1.4		1.1+	0.4	0.4	0.5+
Clay			3.2+	2.8+	3.0+	3.1+	3.2+	–	3.3+	2.0+		3.0+	2.0+	

Stratum	BH1	BH2	BH3
Made Ground	6.8	5.4	4.2
Clay	8.5m+	5.7m+	5.5m+

The ground conditions across the site are fairly consistent and for the purposes of this report can be subdivided into two zones; The Main Site and the Backfilled Canal. The following tables provide summaries of the ground conditions for both these areas. Tentative geological Sections are included as Figures EB00668/R1/F4, F5, F6 and F7.

The Main Site

Depth (m)	Brief Description
GL to 0.05 - 0.3	Made Ground comprising tarmac, concrete, topsoil or hardcore gravel
0.3 to 0.4/1.4	Made Ground comprising loose light brown, brown and black silty, sandy gravel and soft, dark brown, very gravely silt/clay. Gravel is predominately fine to coarse sub-rounded to sub-angular tiles and brick.
or	or
0.3 to 0.5 ‖ 2.0	Made Ground comprising loose red, brown and black, silty, gravely sand. Gravel is predominately sub-rounded to sub-angular brick, tiles and concrete. Brick cobbles were encountered in TP2 and TP12.
Below 0.5/2.0m	Soft to firm reddish brown, occasionally friable, CLAY (WEATHERED RAGLAN MUDSTONE FORMATION) becoming progressively stiffer with depth

The Backfilled Canal

Depth (m)	Brief Description
GL to 1.0/1.5	Made Ground comprising loose brown silty gravely Sand with brick and tile cobbles
1.0/1.5 to 4.0/7.0	Made Ground comprising loose brown and black silty, sandy gravel and soft, dark brown, very gravely silt/clay. Gravel is predominately fine to coarse sub-rounded to sub-angular tiles and brick.
Below 4.0/7.0m	Soft to firm reddish brown, occasionally friable, CLAY (WEATHERED RAGLAN MUDSTONE FORMATION)

The Made Ground was thickest at the western end of the canal.

5.2 Strata Encountered

Made Ground

The Made Ground encountered varied across the site. In the backfilled canal along the southern area of the site Made Ground was observed throughout TPIs 1, 2 and 8 to depths of between 1.8m and 2.8m. The cable percussion boreholes subsequently proved the depth of Made Ground at between 4.2m in the east (BH3) and 6.8m in the west (BH1). The soils were typically described as predominately loose, grey and brown, silty sandy gravel with concrete cobbles, with gravel of fine to coarse sub-rounded to sub-angular tiles, brick and concrete was encountered. Isolated pockets of Made Ground comprising soft to firm, dark grey, silty, sandy, gravely clay with occasional slag and brick cobbles with gravel of fine to coarse sub-angular to angular tiles, brick and slag were encountered together some pockets of soft dark grey to brown sandy, gravely silt with gravel of fine to coarse sub-rounded to sub-angular ash, slag and coal.

The Made Ground across the main site typically comprised loose grey, light brown, brown and black, silty, gravely sand with gravel of sub-rounded to sub-angular coal, tiles, brick, mudstone and concrete and areas of glass, plastic and metal and was encountered at depths between 0.5m and 2.0m. Brick cobbles were abundant in TP12 and brick and concrete boulders were present in TP9.

Made Ground comprising loose to medium dense, red and brown to dark brown, silty, sandy gravel with gravel of fine to coarse sub-rounded to angular brick, coal, ash, slag and tiles was encountered in WS1, WS2, WS7, WS9, WS10, TP3, TP4, TP5 and TP13 to depths of between 0.4m and 3.0m.

The depth of Made Ground was not proven in some area of the site and may require further investigation. In the area of TP11 and WS3, approximately central to the site a solid iron floor prevented advancement.

WS8 on the eastern side of the site proved 3m of Made Ground. The loose material from 2-3m was continually collapsing preventing the borehole from being taken deeper.

Weathered Raglan Mudstone Formation

The Weathered Raglan Mudstone was encountered in the majority of exploratory locations and initially typically comprised soft to firm, reddish brown and brown CLAY. Across the Main Site the natural ground was encountered at depths of between 0.5m and 2m, although it was not proven in all locations and could be in excess of 3m deep, as shown from WS8.

Along the line of the canal the Weathered bedrock was encountered at 4,2m at the east end and 6.8m at the west end.

Although there is a slightly increase in strength with depth, the bedrock appears to be fairly deeply weathered. The strength with depth profiles produced from the dynamic penetration test results SPT [N] values in excess of 10-20 are not typically encountered until 3.5-4.0m depth

below existing ground levels, where there is a fairly rapid transition to weak mudstone and a rapid increase in strength.

Atterberg Limits have been completed on the Weathered Raglan Mudstone. Liquid limits were recorded in the range 28-43% and plastic limits in the range 18-19% with resulting plasticity indices of 10-24%. Based on these results alone the soils would typically classify as soils of low plasticity.

Underground Structures
Underground structures in the form of brick walls were presented in TP5 running north to south, TP11 running west to east, TP14 running west to east and TP3 where the corner of a north to south and west to east running wall. An iron floor was also encountered in TP11 that could not be penetrated which had tracks running south to north on its surface.

5.3 Groundwater & Gas Monitoring

Groundwater strikes were encountered during the drilling process in WS10 and in digging TP9. The water level in WS10 was 2.5mbegl and water inflow occurred in TP9 between 2.2-2.5mbegl. Water was not encountered in the remaining exploratory holes. Return monitoring visits recorded the water level in WS10 at 2.42m and in WS9 at 2.7mbegl. WS1 and WS5 were dry.

Groundwater and ground gas monitoring results are included in Appendix J.

Oxygen levels were recorded in the range 15-21%, carbon dioxide levels were recorded up to a maximum of 5.6% at the lowest atmospheric pressure of 976mb.

Slight traces of methane were detected in nearly all monitoring wells p to a maximum of 0.4% by volume.

6.0 GEOTECHNICAL ASSESSMENT

6.1 Proposed Redevelopment

The Holmer Trading Estate redevelopment is for mixed use. Along the northern side of the site are a series of small industrial units and office for the relocation of the current occupiers of the site. At the western end of the site, close to the entrance will be a 3- storey apartment block. The area to the east and along the canal are conventional town houses with back gardens. The development is to include the restoration of the section of the Hereford to Gloucester Canal that runs along the southern boundary of the site.

The current investigations partly included chemical testing and assessment to provide a preliminary assessment on whether the excavated soils are suitable for reuse on site and do not pose any additional risk to the groundwater regime.

6.2 Foundations and Ground Floor Slabs

Across the main area of the site there is a variable thickness of predominantly loosely compact granular Made Ground, overlying the Weathered Raglan Mudstone. The bedrock is deeply weathered and the soils are generally soft until 3-4m depth below existing ground levels.

If the levels of the site are to be raised, the typical depth for excavation for pad foundations would be in the region of 4-4.5m depth and this is likely to be uneconomic, however, we recommend the following design bearing pressures for guidance.

Depth (m) BEGL	Stratum (Cu)	Design Bearing Pressure (kN/m^2) 1m*	2m*	
3.5-4.0	Weathered Raglan Mudstone (75kN/m^2)	150	125	75

Notes: * Indicates width of foundation

Excavations to these depths are predominantly likely be in unstable Made Ground and will result over dig of foundation excavations and/or require significant side support.

Consideration has therefore been given to ground improvement of the Made Ground and the soft shallow depth Raglan Mudstone by the application of Vibro replacement of what will be predominantly granular Made Ground and the poor quality shallow depth soils to reduce the anticipated settlements beneath pad or strip foundations. According to a specialist contractor (Keller Ground Engineering, Contact RMJ Millar 07770 845088) the sols revealed in the majority of the trial pits would be suitable for the installation of Dense Stone Columns, and subsequently the adoption of shallow ground bearing foundations and ground bearing floor slabs. A copy of the response from Keller Ground Engineering is included as Appendix M.

For costing purposes we have also considered the adoption of piled foundations. A wide range of both driven and bored piles would be suitable at this site.

Driven piles may be suitable in this predominantly commercial area and would reduce arising that may have to be taken off site. Driven pre-cast or cast insitu piles should be taken down through the Made Ground and Weathered Raglan Mudstone and into the ‘unweathered’ Mudstone at depth. Some obstructions have been encountered during the preliminary trial pitting and window sampling so some pre drilling of pile locations may be required at selected locations.

Bored cast insitu or continuous flight auger (cfa) piles should be taken down through the Made Ground and Weathered Raglan Mudstone and designed as 'rock sockets' in the unweathered mudstone. Preliminary calculations suggest that 15m depth piles will be required for 450mm and 600mm diameter piles carrying working loads typically 275kN and 375kN respectively.

Helical Displacement piles should also be considered in order to minimise the soil arising to the surface.

Prior to final design a Foundation Works Risk Assessment is likely to be required in order to satisfy the environment agency that the piling does not provide additional pathways for contamination migration.

In line with NHBC guidelines, suspended ground floor slabs (e.g. beam and block type) should be adopted for houses/buildings where the slab will be underlain by 600mm or mix of non-engineered fill material. This should be adopted unless the ground improvement option is considered.

6.3 Earthworks

Excavations to at least 2m depth should generally be suitable with conventional soils excavating machinery. Pneumatic tools will be required to break out existing foundations and masonry obstructions. The former tiling works and kilns should be mapped on site in order to predict where the obstructions are likely to be encountered. Such obstructions will have to be removed prior to construction of foundations.

From a geotechnical viewpoint the spoil resulting from excavations in the Made Ground and the Weathered Raglan Mudstone will generally be suitable for reuse as structural fill, thus minimising the requirement of disposed of off site. The levels of lead in the soils as solid and leachate will affect the usability of the soils.

The redevelopment has three types of development, residential with gardens, residential without and industrial commercial. The existing soils will not be suitable for reuse beneath gardens without the design of a barrier system. Whilst it is feasible that a barrier system could be design to allow the reuse that remains the aspect of blight and the developer should consider whether the mere presence would affect the saleability of the properties.

The levels of lead suggest that reuse may be feasible beneath the residential without plant uptake areas and also the industrial commercial areas. Theoretically the materials will also be suitable for reuse beneath hardstanding areas and roads. This aspect should be discussed with the highways authorities regarding the adoption of roads where contaminated soils have been used as engineered soils.

The majority of excavations, outside the line of the former canal, should remain dry. Occasional slight seepages should be anticipated at the boundary between the Made Ground and the underlying, relatively impermeable, clay. Where encountered excavations can be kept dry by localised pumping. A temporary discharge consent will be required from the local water authority.

Temporary excavations in the Made Ground will stand unsupported in the short term at gradients of not more than 1 on 2.5. Excavations below approximately 1m depth will require sheeting and shoring for personnel to enter safely.

Formations in the Weathered Raglan Mudstone will be moderately susceptible to deterioration due to site traffic and weather and should be protected immediately on exposure with either 150mm of granular material or 75mm of lean mix concrete.

6.4 Pavements

The insitu soils were generally too granular with obstructions for Mexicone penetrometer tests to be completed. Where they were completed in the Weathered Raglan Mudstone, minimal results of 5% were recorded.

For budget costing purposes it should be assumed that the existing Made Ground has a design CBR value of 3% and the Weathered Raglan Mudstone of 5%.

Insitu CBR testing should be completed within a second phase of ground investigation. The final CBR of the pavement formation will depend on the final site levels.

6.5 Drainage

Soakage testing has not been carried out as part of this investigation. It is understood that the following the restoration of the canal section, it has been made clear to the developers that the Hereford & Gloucester Canal Trust/British Waterways would welcome the discharge of storm water into the re-exposed canal, as this acts as a top up to the canal water levels. As discussed in Section 7.0, it is likely that the Environment Agency would allow discharge through soakaways based on the leachate tests of the Made Ground completed to date.

6.6 Buried Concrete

Chemical tests completed to date suggest that no special precautions will be required for the protection of buried concrete. Based on the recommendations of BRE Special Digest 1 (2007) we recommend a design sulphate class of DS-1 and an ACEC (Aggressive Chemical Environment for Concrete) of AC-1s.

Based on the final levels and foundation plan it may be prudent to complete additional testing on the Raglan Mudstone bedrock to confirm the above classifications, however, this formation is no know to contain significant amounts of gypsum bearing minerals.

6.7 Gas Measures

Based on the guidance in Ciria C659 (2006) we recommend that the site is classified as Characteristic Situation 2. Although the monitoring results to date have shown slight diminishing levels of carbon dioxide. Further monitoring of the existing wells is recommended.

Based on the above classification the typical scope of protective measures for Residential housing (not low rise) and office/commercial/industrial units would be as follows

- Reinforced concrete cast in situ floor slab. 1200g DPM and under floor venting
- Beam or block or precast concrete floor slab 2000g DPM/gas membrane and underfloor venting
- All joints and penetrations sealed

For low-rise housing development based on the carbon dioxide levels we recommend classification as Amber 1 in the NHBC Traffic light system. This a low to intermediate gas regime and required low level gas protection measures typically comprising a membrane and ventilated sub-floor void to create a permeability contrast t limit the ingress of gas into the buildings.

7.0 CONTAMINATION ASSESSMENT

7.1 Analytical Results - Soils

The measured concentrations of metals, speciated PAHs and speciated TPH have been used to calculate the Upper 95th Percentile (US_{95}), which has been used for subsequent comparison with published Soil Guideline Values (SGVs) and Generic Assessment Criteria values. The Mean Value Test (US_{95}) results are presented in Appendix

The following table provides the US_{95} and published SGVs for residential and commercial developments.

Compound	US_{95} mg/kg	SGV/GAC Residential (with plant uptake) mg/kg	SGV/GAC Residential (without plant uptake) mg/kg	SGV/GAC Commercial mg/kg
Arsenic	**21**	20	20	500
Cadmium	1.2	1-8	30	1400
Chromium	122	130	200	5000
Copper (GAC)	**175**	111	2080	45700
Mercury	1	8	15	480
Nickel	**490**	50	75	5000
Lead	**3173**	450	450	450
Selenium	3	35	260	8000
Zinc (GAC)	**771**	330	8250	188000

The measured concentrations of speciated PAH and TPH have been used to calculate the Upper 95th Percentile (US_{95}), which has been used for subsequent comparison with Generic Assessment Criteria for Human Health Risk Assessment.

Speciated PAH	US_{95} mg/kg	GAC Residential (with plant uptake) mg/kg	GAC Residential (without plant uptake) mg/kg	GAC Commercial mg/kg
Benzo(a)pyrene	**2.942**	1.12	1.3	29.7
Dibenzo(a,h)anthracene	0.615	1.14	1.3	29.7
Fluorene	0.133	3.84E+01	2.77E+03	5.9E+04
Napthalene	1.205	3.47	6.94	290
Speciated TPH				
Aliphatic				
EC 5-6	0.01	2.11E+00	2.11E+00	9.53E+01
EC >6-8	0.01	5.37E+00	5.37E+00	2.42E+02
EC >8-10	0.05	1.46E+00	1.46E+00	6.59E+01
EC >10-12	0.27	8.53E+00	8.60E+00	2.99E+04
EC >12-16	**78.74**	4.07E+01	4.21E+01	2.99E+04
Aromatic				
Benzene	0.01	5.75E-01	6.13E-01	2.69E+01
Toluene	0.01	6.24E-01	6.94E-01	3.04E+01
EC >8-10	0.14	1.09E+00	2.39E+00	1.07E+02
EC >10-12	0.40	1.94E+00	1.42E+01	6.25E+02
EC >12-16	12.78	2.19E+00	7.27E+01	1.22E+04
EC >16-21	64.65	1.15E+02	2.91E+02	9.19E+03
EC >21-35	**585.23**	1.57E+02	4.17E+02	9.25E+03

PCB's

There are no published guideline values for PCBs in the UK. The peak result of 0.67mg/kg has been compared to the Australian Health Investigation level for guidance and this is set at 10mg/kg and therefore not deemed significant in the context of human health. The Dutch intervention level is set at 1mg/kg. Neither guidance has any legal standing in the UK, and comparisons are deemed in orders of magnitude. Agreement will be sort for site specific values as part of any planning application.

Asbestos

Chrysotile Fibres (White asbestos) was detected in two of three samples qualitatively analysed. Blue and Brown asbestos was not detected.

7.2 Analytical Results - Groundwater

Water samples taken from the monitoring wells have been submitted for analysis. The concentrations of dissolved metals (µg/l) measured in the groundwater samples have been compared with the Drinking Water Standard (DWS) and Environmental Quality Standard (EQS) in the following table.

Compound	Peak (µg/l)	DWS (µg/l)	EQS (µg/l)µ
Arsenic	4	10	50
Boron	1300	1000	2000
Cadmium	<0.4	5	5
Chromium	32	50	2
Copper	29	2000	1
Mercury	0.06	1	0.3
Nickel	21	20	30
Lead	250	10	25
Selenium	10	10	--
Zinc	150	5000	--

The above table indicates that the dissolved concentrations for lead and boron in the groundwater require further consideration and this is discussed below.

Five water samples were analysed for speciated TPH aliphatic and aromatic fractions including BTEX and MtBE. The concentrations were all below the laboratory limit of detection (LOD) of 10µg/l.

Five water samples were analysed for speciated PAH. The concentrations were all below 10ng/l. These concentrations are not considered significant.

7.3 Comparison with Published Soil Guideline Values

The maximum results for arsenic is only slightly in excess of the SGVs for residential development with plant uptake and at these levels are not considered significant. Further testing as part of additional site investigation may be a consideration to confirm the levels.

The raised levels of copper, nickel and zinc may be symptomatic of the general current use of the site for various vehicle uses, such as paint spraying car breaking and repair. and do not greatly exceed the GAC. The levels are significant from a residential development viewpoint, however, they are not significantly below the levels acceptable for commercial development.

The main aspect for this development will be the levels of lead within the soils. The levels relate to the former use as a tile factory and come from glazes used. Locally the levels significantly exceed the SGV for commercial development.

The results from TPH and PAH testing suggest that there are localised areas of hydrocarbon impact from both the high range and low range elements. These are as anticipated and are likely to be related to the use as a car breakers yard and car repairers etc.

The results for benzo(a)pyrene, alphatics (EC12-15) and aromatics (EC21-35) require further consideration.

7.4 Comparison with Published Drinking Water Standards/EQS

The water samples tested to date show that the water in the backfilled canal is locally significantly elevated in lead, 250µg/l in comparison with the EQS of 25µg\l and the DWS of 10µg/l. The levels of boron are raised in relation to the drinking water standard.

7.5 Leaching Tests

NRA leachate tests were completed on some of the samples, focusing on the contaminants where raised levels of contamination had been encountered from the solid testing. The tests have been completed in relation to the materials being retained on site. Soil testing for waste disposal off site are not applicable in this instance.

The results have been compared to Environment Agency Leachate Quality Thresholds, Table 1 2nd Edition. Samples were raised in Lead and boron.

7.6 Quantitative Risk Assessment

The contamination testing results to date are generally as anticipated. Soils are locally impacted by hydrocarbons in the areas around the breakers yard and the some in the areas close to the vehicle repairs. Raised levels of benzo(a)pyrene have been proven and are significant in relation to residential development. However, it is likely that the high range organics will volatilise during the earthworks. Validation testing should be completed to confirm the levels across the site.

Similarly raised levels of metals such as nickel zinc and copper are raised in these areas. The levels are significant in relation to residential development, although below the commercial guidelines. The development programme should consider the location of the contaminated materials in relation to the type of development being considered. For instance if a phased development requires the commercial area to be developed first and the main areas of contamination are beneath proposed residential areas which are to be developed at a later date, such contaminated materials would not be available for reuse beneath commercial areas and would require disposal off site.

Asbestos (chrysotile) has been encountered in two samples. Additional testing should be completed to confirm if the material is more widely present. Chrysotile is the least harmful cement bonded asbestos. It is not generally considered as requiring off site disposal and requires a suitable cover soils system to prevent incidental contact with future occupiers of the site. During the earthworks dust mitigation measures will be required.

Targeted human health risk assessments should be completed for the contaminants that are currently perceived to be a risk. These assessments are not generic and consider the individual source, pathways and receptors for each of the standard land uses. These will provide sire specific Guideline values. These will be required for the local Environmental Health office to allow the reuse of the soils beneath the different part of the site. It may be that the soils impacted with lead may not be suitable for reuse under residential land, although suitable for commercial.

At present the groundwater and leachate testing results suggest that there is a risk to the groundwater regime from dissolved lead. A tier III groundwater risk assessment should be completed to further assess the likely impact. A remediation and development strategy will be required by the Environment Agency to confirm that the development and the reuse of soils will not further impact the groundwater.

Based on the current levels proven the lead impacted soils pose a threat to the groundwater. However, it is generally understood that the Environment Agency will be keen on the reuse of soils on site as opposed to the disposal off site. Further assessment will be required, however,

in order to prevent any further impact on the groundwater, the developer will have to consider the following:

- Reuse of soils beneath cover systems (although not considered favourable by the Environmental Health)
- Reuse of soils beneath commercial areas and hardstanding
- Cement stabilisation of soils

Further chemical analyses will be required to consider reuse on site. A treatability study should be completed on the option of cement stabilisation. For costing purposes, we estimate approximately 12,000m^3 of soils to be treated, assuming a 4-8% OPC addition, treatment costs should be allowed in the range £30-60 per m^3, £350,000-£700,000. An exemption will be required from the EA for movement and reuse of any excavated or treated soils if designated for reuse on site, which will be an additional cost to the above. It is understood that the soil stabilisation method has been used on a similar site in Hereford.

7.7 Invasive Species

Japanese Knotweed and Giant Hogweed have not been identified during the site walkover, however, this was completed during the winter months when they are not so easily identifiable. We recommend a site walkover by a suitably qualified ecologist to confirm the absence of these and other invasive species.

7.8 Waste Acceptance Criteria

Based on the solid test results the majority of the soils will be classified as Hazardous based solely on the lead content. Waste Acceptance Criteria (WAC) testing has been completed and these tests confirm that the materials can be classified as Hazardous Stable Non Reactive. Additional testing should be completed to further delineate the areas of raised lead.

7.9 Further Investigations

Further investigation will be required at this site in order to satisfy the local authority that following the remediation and development of the site there will be no risk to the future occupiers and the wider environment. This will require further delineation of the contamination in the Made Ground.

The investigations will also be required to satisfy the Environment Agency that the redevelopment will not provide any additional risk to the local groundwater regime.

The objectives of the further investigations and reporting should be as follows:

- Human Health Risk Assessments using CLEA Beta (2005)
- P20 Tier III Groundwater Risk Assessments
- Cement Stabilisation Treatability Assessment of Made Ground.
- Further delineation of hydrocarbon and metals contamination around engineering workshops and scrap yard and car repairs works.
- Determination of Remediation Strategy

In order to complete the above we recommend further intrusive ground investigations. These should be completed based on the proposed end use for the individual phases of the development. Additional sampling should be completed to further delineate the lead concentrations within the Made Ground and assess the leachability.

If chemical stabilisation of soils excavated from the former infilled canal is considered, additional sampling will be required. Large bulk samples will be required to allow a treatability study to be completed. Various percentage additions of cement are then added to the soil samples with subsequent NRA leaching tests undertaken to establish the most appropriate mix to reduce the mobility of lead to below acceptable limits.

Further investigations will also be required to further assess the applicability of the soils this site for ground improvement to allow pad foundations and ground bearing slabs in lieu of potential piles and suspended floor slabs. Confirmatory boreholes should be completed to confirm the strength with depth profiles of the shallow depth soils.

8.0 CONCLUSIONS AND RECOMMENDATIONS

8.1 General Conclusions

AC1 Holmer Trading Estate is a collection of small industrial units, containing both old and recent construction. The following site uses are significant in relation to potential contamination; Laundry Services, Car Dealers, Motor Cycle Breakers & Dismantles; Garage Services; Car Body Repairs; Scrap Metal Merchants; Commercial Vehicle Bodybuilders & Repairers

AC2 Historically the site was open fields before the development of a Tile Works. Along the southern boundary is a backfilled section of the Hereford and Gloucester Canal. It is understood to have been partially backfilled with waste from the tile works

AC3 The underling geology is the Raglan Mudstone Formation comprising interbedded mudstones and siltstones.

8.2 Geotechnical Conclusions

BC1 The majority of the site is underlain by 1m of Made Ground underlain by the Weathered Raglan Mudstone Formation. The bedrock is highly weathered to 3-4m.

BC2 The Canal is backfilled with 4-6m of granular and clayey Made Ground. No puddle clay lining was proven.

BC3 If the levels of the site are to be raised, the typical depth for excavation for pad foundations would be in the region of 4-4.5m depth. This is likely to be uneconomic, Design bearing pressures of 150kN/m^2 and 125kN/m^2 are recommended for 1m and 2m wide foundations respectively taken down to the Weathered Raglan Mudstone at 3.5-4m depth.

BC4 Deep excavations are likely to be predominantly in unstable Made Ground and will result over dig of foundation excavations and/or require significant side support.

BC5 Ground improvement of the Made Ground and the shallow depth Raglan Mudstone by the application of Vibro replacement maybe feasible to reduce the anticipated settlements beneath pad or strip foundations. According to Keller Ground Engineering the soils revealed in the majority of the trial pits would be suitable for the installation of Dense Stone Columns, and subsequently the adoption of shallow ground bearing foundations and ground bearing floor slabs.

BC6 Driven piles may be suitable and would reduce arising that may have to be taken off site. Piles should be taken down into the "unweathered" Mudstone at depth. Some obstructions have been encountered. Some pre-drilling of selected pile locations may be required. Bored cast insitu or continuous flight auger (cfa) piles are suitable and should be taken down through the Made Ground and Weathered Raglan Mudstone and designed as 'rock sockets' in the "unweathered mudstone". Preliminary calculations suggest that 15m depth piles will be required for 450mm and 600mm diameter piles carrying working loads typically 275kN and 375kN respectively. Helical Displacement piles should also be considered in order to minimise the soil arising to the surface.

BC7 In line with NHBC guidelines, suspended ground floor slabs (e.g. "beam and block" type) should be adopted for houses/buildings where the slab will be underlain by 600mm or mix of "non-engineered" fill material. This should be adopted unless the ground improvement option is considered.

BC8 Excavations to at least 2m depth should generally be suitable with conventional soils excavating machinery. Pneumatic tools will be required to break out existing foundations and masonry obstructions.

BC9 From a geotechnical viewpoint the spoil resulting from excavations in the Made Ground and the Weathered Raglan Mudstone will generally be suitable for reuse as structural fill, thus minimising the requirement of disposed of off site. The levels of lead in the soils as solid and leachate will affect the usability of the soils.

BC10 The redevelopment has three types of development, residential with gardens, residential without and industrial commercial. The existing soils will not be suitable for reuse beneath gardens without the design of a barrier system. Whilst it is feasible that a barrier system could be design to allow the reuse that remains the aspect of blight and the developer should consider whether the mere presence would affect the saleability of the properties.

BC11 The majority of excavations, outside the line of the former canal, should remain dry. Occasional slight seepages should be anticipated at the boundary between the Made Ground and the underlying, relatively impermeable, clay. Where encountered excavations can be kept dry by localised pumping. A temporary discharge consent will be required from the local water authority.

BC12 Temporary excavations in the Made Ground will stand unsupported in the short term at gradients of not more than 1 on 2.5. Excavations below approximately 1m depth will require sheeting and shoring for personnel to enter safely.

BC13 Formations in the Weathered Raglan Mudstone will be moderately susceptible to deterioration due to site traffic and weather and should be protected immediately on exposure with either 150mm of granular material or 75mm of lean mix concrete.

CC14 The insitu soils were generally too granular with obstructions for Mexicone penetrometer tests to be completed. Where they were completed in the Weathered Raglan Mudstone, minimal results of 5% were recorded. The final CBR of the pavement formation will depend on the final site levels.

CC15 Soakage testing has not been carried out as part of this investigation. It is understood that the following the restoration of the canal section, it has been made clear to the developers that the Hereford & Gloucester Canal Trust/British Waterways would welcome the discharge of storm water into the re-exposed canal, as this acts as a top up to the canal water levels. As discussed in Section 7.0, it is likely that the Environment Agency would allow discharge through soakaways based on the leachate tests of the Made Ground completed to date.

8.2 Contamination Conclusions

CC1 The levels of lead suggest that reuse may be feasible beneath the residential without plant uptake areas and also the industrial commercial areas. Theoretically the materials will also be suitable for reuse beneath hardstanding areas and roads. This aspect should be discussed with the highways authorities regarding the adoption of roads where contaminated soils have been used as engineered soils.

CC2 Chemical tests completed to date suggest that no special precautions will be required for the protection of buried concrete.

CC3 Chrysotile Fibres (White asbestos) was detected in two of three samples qualitatively analysed. Blue and Brown asbestos was not detected. Additional testing should be completed to confirm if the material is more widely present. Chrysotile is the least harmful cement bonded asbestos. It is not generally considered as requiring off site disposal and requires a suitable cover soils system to prevent incidental contact with

future occupiers of the site. During the earthworks dust mitigation measures will be required.

CC4 Groundwater monitoring indicates that the dissolved concentrations for lead and boron in the groundwater require further consideration. Groundwater samples analysed were not impacted by TPH or PAH

CC5 Results for arsenic is slightly in excess of the SGVls for residential development with plant uptake, however the levels are not considered significant. The raised levels of copper, nickel and zinc may be symptomatic of the general current use of the site for various vehicle uses, such as paint spraying car breaking and repair. They do not greatly exceed the GAC. The levels are significant from a residential development viewpoint, however, they are not significantly below the levels acceptable for commercial development.

CC6 The main aspect for this development will be the level of lead within the soils. The levels relate to the former use as a tile factory and come from glazes used. Locally the levels significantly exceed the SGV for commercial development.

CC7 The results from TPH and PAH testing suggest that there are localised areas of hydrocarbon impact from both the high range and low range elements. These are as anticipated and are likely to be related to the use as a car breakers yard and car repairers etc. The results for benzo(a)pyrene, alphatics (EC12-15) and aromatics (EC21-35) require further consideration.

CC8 The water samples tested to date show that the water in the backfilled canal is locally significantly elevated in lead, 250µg/l in comparison with the EQS of 25µg\l and the DWS of 10µg/l. The levels of boron are raised in relation to the drinking water standard.

CC9 NRA leachate results have been compared to Environment Agency Leachate Quality Thresholds, Table 1 2nd Edition. Samples were raised in Lead and boron.

CC10 Soils are locally impacted by hydrocarbons in the areas around the breakers yard and the some in the areas close to the vehicle repairs. Raised levels of benzo(a)pyrene have been proven and are significant in relation to residential development. However, it is likely that the high range organics will volatilise during the earthworks. Validation testing should be completed to confirm the levels across the site.

CC11 The development programme should consider the location of the contaminated materials in relation to the type of development being considered. If a phased development requires the commercial area to be developed first and the main areas of contamination are beneath proposed residential areas which are to be developed at a later date, such contaminated materials would not be available for reuse beneath commercial areas and would require disposal off site.

CC12 The groundwater and leachate testing results suggest that there is a risk to the groundwater regime from dissolved lead. A tier III groundwater risk assessment should be completed to further assess the likely impact. A remediation and development strategy will be required by the Environment Agency to confirm that the development and the reuse of soils will not further impact the groundwater.

CC13 The current proven levels of lead pose a threat to the groundwater. However, it is generally understood that the Environment Agency will be keen on the reuse of soils on site as opposed to the disposal off site. Further assessment will be required, however, in order to prevent any further impact on the groundwater, the developer will have to consider the following:

- Reuse of soils beneath cover systems (although not considered favourable by the Environmental Health)

- Reuse of soils beneath commercial areas and hardstanding
- Cement stabilisation of soils

Further chemical analyses will be required to consider reuse on site. A treatability study should be completed on the option of cement stabilisation. For costing purposes, we estimate approximately 12,000m^3 of soils to be treated, assuming a 4-8% OPC addition, treatment costs should be allowed in the range £30-60 per m^3, £350,000-£700,000. An exemption will be required from the EA for movement and reuse of any excavated or treated soils if designated for reuse on site, which will be an additional cost to the above. It is understood that the soil stabilisation method has been used on a similar site in Hereford.

CC14 Japanese Knotweed and Giant Hogweed have not been identified during the site walkover, however, this was completed during the winter months when they are not so easily identifiable. We recommend a site walkover by a suitably qualified ecologist to confirm the absence of these and other invasive species.

CC15 Based on the solid test results the majority of the soils will be classified as Hazardous based solely on the lead content. Waste Acceptance Criteria (WAC) testing has been completed and these tests confirm that the materials can be classified as Hazardous Stable Non Reactive. Additional testing should be completed to further delineate the areas of raised lead.

8.4 Recommendations

R1 The former tiling works and kilns should be mapped on site in order to predict where the obstructions are likely to be encountered. Such obstructions will have to be removed prior to construction of foundations.

R2 A Foundation Works Risk Assessment is likely to be required in order to satisfy the environment agency that the piling does not provide additional pathways for contamination migration.

R3 For budget costing purposes it should be assumed that the existing Made Ground has a design CBR value of 3% and the Weathered Raglan Mudstone of 5%. We recommend insitu CBR Testing be completed to confirm.

R4 Based on the recommendations of BRE Special Digest 1 (2007) we recommend a design sulphate class of DS-1 and an ACEC (Aggressive Chemical Environment for Concrete) of AC-1s.

R5 Based on the final levels and foundation plan it may be prudent to complete additional testing on the Raglan Mudstone bedrock to confirm the above classifications, however, this formation is no know to contain significant amounts of gypsum bearing minerals.

R6 Based on the guidance in Ciria C659 (2006) we recommend that the site is classified as Characteristic Situation 2. Although the monitoring results to date have shown slight diminishing levels of carbon dioxide. Further monitoring of the existing wells is recommended.

Based on the above classification the typical scope of protective measures for Residential housing (not low rise) and office/commercial/industrial units would be as follows

- Reinforced concrete cast in situ floor slab. 1200g DPM and under floor venting
- Beam or block or precast concrete floor slab 2000g DPM/gas membrane and underfloor venting
- All joints and penetrations sealed

For low-rise housing development based on the carbon dioxide levels we recommend classification as Amber 1 in the NHBC Traffic light system. This a low to intermediate gas regime and required low level gas protection measures typically comprising a membrane and ventilated sub-floor void to create a permeability contrast t limit the ingress of gas into the buildings.

R7 Targeted human health risk assessments should be completed for the contaminants that are currently perceived to be a risk. These assessments are not generic and consider the individual source, pathways and receptors for each of the standard land uses. These will provide sire specific Guideline values. These will be required for the local Environmental Health office to allow the reuse of the soils beneath the different part of the site. It may be that the soils impacted with lead may not be suitable for reuse under residential land, although suitable for commercial.

R8 Further investigation will be required at this site in order to satisfy the local authority that following the remediation and development of the site there will be no risk to the future occupiers and the wider environment. This will require further delineation of the contamination in the Made Ground. The investigations will also be required to satisfy the Environment Agency that the redevelopment will not provide any additional risk to the local groundwater regime. The objectives of the further investigations and reporting should be as follows:

- Human Health Risk Assessments using CLEA Beta (2005)
- P20 Tier III Groundwater Risk Assessments
- Cement Stabilisation Treatability Assessment of Made Ground.
- Further delineation of hydrocarbon and metals contamination around engineering workshops and scrap yard and car repairs works.
- Determination of Remediation Strategy

In order to complete the above we recommend further intrusive ground investigations. These should be completed based on the proposed end use for the individual phases of the development. Additional sampling should be completed to further delineate the lead concentrations within the Made Ground and assess the leachability.

R9 If chemical stabilisation of soils excavated from the former infilled canal is considered, additional sampling will be required. Large bulk samples will be required to allow a treatability study to be completed. Various percentage additions of cement are then added to the soil samples with subsequent NRA leaching tests undertaken to establish the most appropriate mix to reduce the mobility of lead to below acceptable limits.

R10 Further investigations will also be required to further assess the applicability of the soils this site for ground improvement to allow pad foundations and ground bearing slabs in lieu of potential piles and suspended floor slabs. Confirmatory boreholes should be completed to confirm the strength with depth profiles of the shallow depth soils.