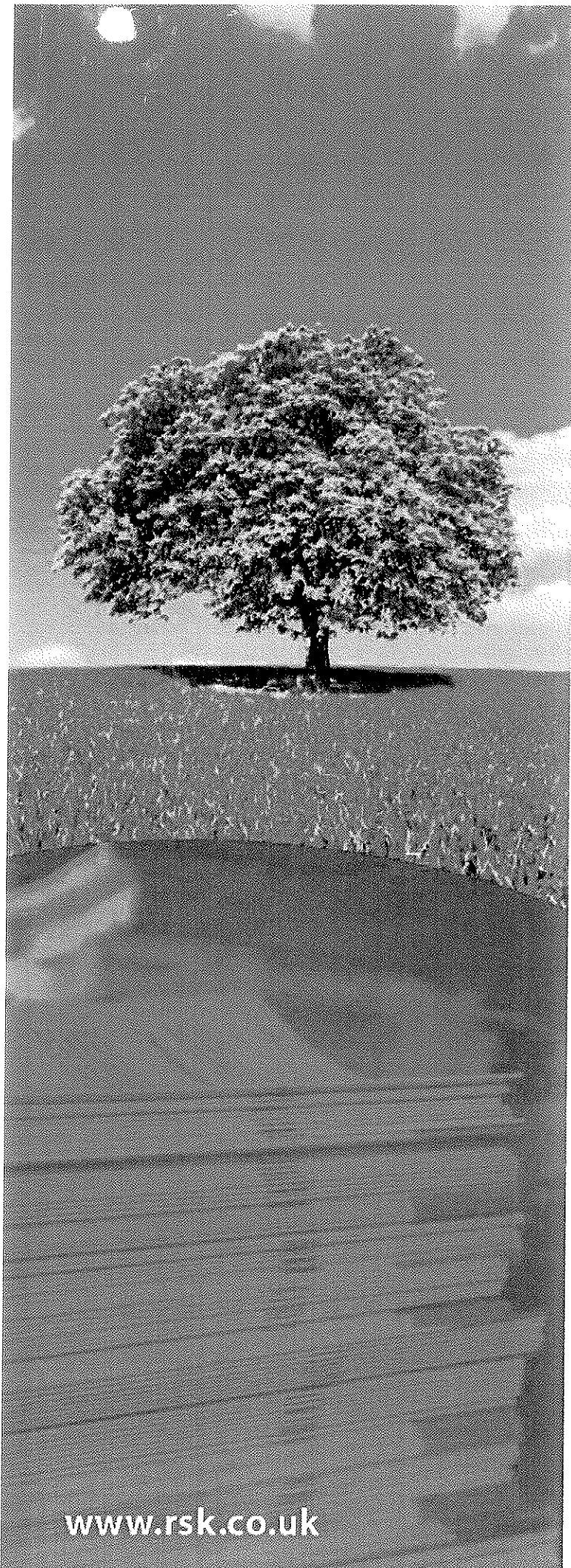




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REVISED ENVIRONMENTAL SITE
ASSESSMENT

TETROSYL, BEVIS GREEN SITE,
WALMERSLEY, BURY, LANCASHIRE

REFERENCE: 16565-R1 (00)

TETROSYL LTD

17 FEBRUARY 2011

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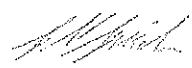
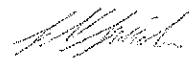
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**REVISED ENVIRONMENTAL SITE ASSESSMENT
TETROSYL BEVIS GREEN SITE, WALMERSLEY, BURY**

REPORT NO : 16565-R1 (00)

**Client : TETROSYL LIMITED
BEVIS GREEN SITE
WALMERSLEY
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This report is not to be used for contractual or engineering purposes unless the above is signed where indicated by the author, the project manager and the technical reviewer of the report, and the report is designated "FINAL".



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- Appendix C Turley Associates Draft Masterplan for Tetrosyl Bevis Green Site
- Appendix D Methodology for Risk Assessment
- Appendix E Human Health Generic Assessment Criteria
- Appendix F Generic Assessment Criteria for Phytotoxic Effects, Pipelines and Controlled Waters

EXECUTIVE SUMMARY

RSK STATS Geoconsult Limited (RSK) was commissioned by Tetrosyl Limited (Tetrosyl) to conduct a review and reassessment of a site investigation at Tetrosyl's Bevis Green site in Walmersley, Bury that was conducted by a predecessor company (ENSR International Ltd) in 2002. The site is currently an operational car products formulation plant and has a long industrial history as a former cotton mill, dye house and print works.

It is intended to relocate the operational part of the site, and to redevelop the site for a mix of residential housing and open space. In order to provide information to support such a planning application, the information from the site investigation reported in 2003 has been reviewed and the chemical information has been assessed against current guidance values.

There are several areas of the site which have been infilled over time, including a former reservoir at the south of the site, two other small reservoirs, an old quarry in the centre of the site and parts of the edges of the existing on-site reservoir. Map based evidence of an air shaft and adits connected with shallow coal mining to the east of the site were also noted in the 2003 report. The current reservoir retaining wall is of unknown construction and integrity. All these aspects would require engineering assessment prior to redevelopment of the site.

Analysis of chemical contaminants on site showed the presence of some arsenic, lead and cyanide in surface soils or made ground at concentrations which would exceed Generic Acceptance Criteria (GAC) for a residential with gardens end-use. The areas affected were predominantly in the central and southern part of the site and were generally associated with the presence of made ground. These conditions are unlikely to have changed since the site investigation was undertaken in 2002. Copper and zinc concentrations in three groundwater samples were also found at concentrations which exceed controlled water targets for freshwater. The source is likely to be the made ground and some remedial works may be required during any redevelopment.

Areas of soil and made ground were detected with concentrations of total petroleum hydrocarbons (TPH) above levels suitable for residential housing. These oil impacted areas were generally associated with historic or current site operations such as fuel storage tanks. Remedial works would be required to remove or treat hydrocarbon impacted soils prior to redevelopment of the site. BTEX compounds and TPH were also found in some groundwater samples at concentrations which exceeded surface water target concentrations. It is likely that removal of hydrocarbon impacted soil and made ground would be sufficient to remove the source of hydrocarbons to groundwater. No chlorinated solvents or free phase product were found on site.

A site walkover by RSK personnel (April 2010) confirmed that site conditions had not changed significantly since the 2002 site investigation was conducted. The ground conditions were assessed with a total of 11 trial pits, 45 probe holes and eleven boreholes across the site, targeted in areas of potential concern due to historic or current activities.

Solvents and VOCs were not detected in soils or groundwaters of the site. PCBs were not detected in soil at the site.

Methane and carbon dioxide were detected in considerably elevated concentrations in several of the infilled areas of the site, with the highest concentration at the southernmost part of the site at BH10. The risk posed to on-site construction workers, future site residents and off-site residents from ground gases should be further investigated by gas monitoring under current guidance and to provide more recent data on ground gas conditions.

Asbestos was detected in three out of five soil samples analysed. An asbestos survey and removal programme will be required prior to redevelopment of the site.

In summary, the findings of the 2003 report were reviewed and found to reflect current conditions at the site. Any future analysis of TPH would benefit from being for speciated TPH which would allow more accurate assessment of the risks from the hydrocarbons present on-site to be assessed. Analysis for PAH was not conducted, but these compounds are likely to be present in made ground on-site. The reassessment has confirmed that the site is suitable for residential redevelopment if appropriate remedial works are undertaken. Ground stability should also be considered when planning redevelopment. Remediation would include localised removal of contaminated made ground or provision of clean cover. Hydrocarbon impacted soils may be suitable for in-situ or ex-situ bioremediation. The risks from methane and CO₂ in infilled areas, hydrocarbon impact to soil and waters, asbestos, and some metal and cyanide impact in made ground are the main contaminant issues on site, with dissolved phase hydrocarbons and some minor metal impact to groundwaters also noted. The contaminant status of reservoir sediments is not known. The north-western part of the site is less affected by contaminants and made ground, and would require less remediation prior to development compared with the central and southern parts of the site where greater impact from the site's history is evident.

1. INTRODUCTION

RSK STATS Geoconsult Limited (RSK) was commissioned by Tetrosyl Limited (Tetrosyl) to carry out a Revised Environmental Site Assessment of the land at Tetrosyl's Bevis Green site in Walmersley, Bury. This revised assessment was carried out with the understanding that the site is to be redeveloped with a mix of residential properties. This assessment was carried out as a part of the information required to support a planning application.

1.1 Objectives

The objectives of this assessment are as follows:

- To review the findings of a previous site investigation report (ENSR 2003 ⁽¹⁾ (NB references indicated by number superscripts are listed at the end of this report in Section 10)) on the site and undertake a revised environmental assessment against current guidelines and with regard to the proposed residential development plans; and
- To assess the risks to proposed end-users and the environment from any sources of contamination identified on-site during the previous site investigation.

1.2 Scope

The scope and layout of this report has been designed in accordance with CLR11⁽²⁾ and guidance issued by the Environment Agency in July 2005 for land contamination reports⁽³⁾. A summary of relevant legislation and government policies applicable to land development is included in Appendix B.

The risk management process comprises up to three stages of risk assessment: preliminary, generic quantitative and detailed quantitative (PRA, GQRA and DQRA). The basis for the risk assessment is a conceptual model that is produced as part of the PRA and is updated throughout the risk management process.

The scope of works for the revised environmental assessment includes:

- A PRA involving the review of the existing report including utility location information, geological, hydrogeological and hydrological information, historical plans and site walkover. This information is used to construct an outline conceptual model and consider any possible pollutant linkages (where a receptor may be connected to a source by a viable pathway) that may be present under the proposed scheme of residential development;
- GQRA to assess possible pollutant linkages identified in the PRA and enable the outline conceptual model to be refined; and

- Provide recommendations for further works, DQRA and remedial actions of ground and groundwater (if deemed applicable).

1.3 Limitations

The comments given in this report and the opinions expressed are based on the information provided in the original ENSR site investigation report of 2003 and the ground conditions encountered during the original site work and on the results of tests made in the field and in the laboratory. However, there may be conditions pertaining to the site that have not been disclosed by the investigation and therefore could not be taken into account. In particular, it should be noted that there may be areas of made ground not detected due to the limited nature of the investigation or the thickness and quality of made ground across the site may be variable. In addition, groundwater and ground gas levels may vary from those reported due to seasonal, or other, effects.

This report is subject to the RSK STATS Geoconsult Limited service constraints given in Appendix A.

1.4 Previous Work

The following report detailing previous investigative works at the site was made available for review:

- Phase I and Phase II Environmental Site Assessment, Tetrosyl, Bevis Green Works, Walmersley, Bury. January 2003. Report No. 10468-1(01). Prepared by ENSR International Ltd on behalf of Tetrosyl Ltd, Walmersley, Bury.

ENSR International Ltd is a precursor company to RSK STATS Geoconsult and the original documents and report are available to us in-house.

Where pertinent, information from this previous report has been included in this current report and referenced appropriately.

2. SITE DETAILS

The site location, description and future development are discussed below.

2.1 Site Location

The Tetrosyl, Bevis Green Works site is situated on Walmersley Old Road, Walmersley, Bury and is located at OS Grid reference SD 810 140. The site is in a mixed residential and commercial area in the outskirts of Walmersley, north of Bury with housing,

commercial premises and agricultural land and farm buildings surrounding the property. A site location plan is presented as Figure 1.

2.2 Site Description

The site occupies approximately 25.2 acres of which approximately 4.4 acres is designated as green belt land in the north of the site. The site is an operational formulation plant for Tetrosyl's car care products, with mixing, blending, packaging, storage and distribution activities on-going in parts of the site. The site is on the outskirts of Walmersley with the M66 motorway located beyond the north eastern corner of the site. The site occupies an irregular rectangular shape with the longest axis north to south with the land falling from north to south and west to east. A small brook (a tributary of Pigs Lee Brook) and wooded valley lies to the east of the site and a section is located within the Tetrosyl property boundary. The brook flows through the property and into a holding reservoir on-site before discharging via an overflow weir and spillway. The brook is then culverted through the site and emerges to the south of the site. A site plan is presented as Figure 2.

A detailed site description is available in the ENSR 2003 Phase I and II Site Investigation Report ⁽¹⁾. RSK staff undertook a site visit in April 2010 and the main features of the site do not appear to have changed significantly since that report was produced.

2.3 Future Development

Tetrosyl Limited propose to vacate their Bevis Green site in Walmersley as a production site and offer the site for sale for redevelopment with a proposed mix of residential properties and open space. Options for the redevelopment of the site have been investigated with consideration of the existing features of the site and the future requirements of the area. A draft proposed plan for development is shown in a drawing from Turley Associates in Appendix C. The main intention of the redevelopment is to provide a mix of residential properties on the site, and to maintain some of the integral character of the site by maintaining the landfall, the reservoir and watercourse, and the required retention of the greenbelt area in the north of the site. It is proposed to open the culverted watercourse downstream of the reservoir to form a stream through part of the lower site.

3. PRELIMINARY RISK ASSESSMENT

The following describes a summary of the information available in the ENSR 2003 ⁽¹⁾ Site Investigation report for the site. RSK staff conducted a site visit in April 2010 to confirm that the situation at the Tetrosyl site has not changed in a significant way from that described in the earlier report. The present report considers the finding of the 2003

investigation work in relation to guidance on assessment of contaminated land for protection of human health that was published by the Environment Agency during 2009. The information has been used to identify potential contaminant sources and sensitive receptors, from which an outline conceptual site model has been developed. The proposed development of the site is to include a mixture of residential building types, with detached and semi-detached properties towards the upper part of the site to the north and a variety of 2, 3 and 4 storey town houses in the lower parts of the site towards the south. The PRA has been undertaken with these proposed residential end-uses of the site in mind.

3.1 Geology

Published records ⁽⁴⁾ for the area indicate the geology of the site to comprise Glacial Till (Boulder Clay) deposits overlying Haslingden Flags of the Millstone Grit series (Upper Carboniferous). The strata are recorded as dipping in a south easterly direction.

The BGS geological map records a sub crop of the 'Six Inch Mine' (coal seam) adjacent to and crossing the southeastern boundary of the property. The sub crop is recorded as running parallel to the eastern boundary of the property. There is one air shaft marked immediately to the northeast of the reservoir at the site, the opening of this shaft was not identified in the 2003 site investigation, nor in the recent site visit by RSK staff.

A British Coal (now the Coal Authority) report dated October 17, 2002⁽¹⁾, provided the following information about the site;

- One seam of coal has been mined at shallow depth within 20m of the site, with the last extraction recorded as being in 1877;
- Records show that surface strata in the area could be coal bearing and the possibility of unrecorded mining activities cannot be discounted;
- There are believed to be two adits present in the southeastern corner of the site and one coalmine shaft (marked on the maps as an 'Air Shaft') in the northeast of the site. There are no records of the measures that were taken to fill in the shaft or adits.

An abandoned mine plan for Lumn Mills Colliery, Sand Rock Mine (Abandonment Plan No. 818) notes two adits located at the eastern boundary of the property connecting to coal workings to the east of the property. The coal seam is recorded as 1ft 9in thick, and the map states this is a shallow working in the rough rock, though there are no specific details of the actual depth of the workings. No further information was found on the air shaft.

3.2 Hydrogeology

The Groundwater Vulnerability Map ⁽⁶⁾ shows the bedrock under the site to be classified as a Secondary Aquifer defined as fractured or potentially fractured rocks, which do not have a high primary permeability, or other formations of variable permeability including unconsolidated deposits. These aquifers will seldom produce large quantities of water for abstraction, but are important for both local supplies and in supplying base flow to rivers. The overlying soils are classified as having high leaching potential. In areas where there is covering of Glacial Till (Boulder Clay) over the solid strata there will be some restriction to the vertical infiltration.

3.2.1 Groundwater Abstractions

Information on the Environment Agency website ⁽⁶⁾ indicates the site is not situated within a groundwater Source Protection Zone.

The nearest groundwater abstraction point (for a private water supply) is located 830m to the northeast of the property, i.e. up gradient of water flow. There are a number of boreholes located to the southeast and southwest (down gradient) of the property at distances in excess of 1km. The nearest down gradient borehole is located at approximately 1080m southwest with water use for agriculture and general use.

3.3 Hydrology

There is a tributary of the Pigs Lee Brook running through the eastern side of the site. This small brook rises from a point approximately 2km north of the property and flows through four connected reservoirs before entering the northern boundary of the property. A reservoir is present at the northern end of the property, formed historically by damming this tributary and flooding part of the valley in which the property is situated. The brook enters the site and the on-site reservoir from the north. It then discharges via a spillway to an engineered channel and spillway, initially in an open channel, then culverted under the building structures. The stream continues in a southerly and south easterly direction to join Pigs Lee Brook approximately 450m southwest of the southern property boundary. Pigs Lee Brook joins the River Irwell approximately 2km southwest of the property.

There is a land drain originating on land to the north of the property which flows north to south through the property across the Green Belt land, to the east of the tank farm and is believed to discharge to the reservoir on the property.

A spring was formerly located on the hardstanding area in the north of the property. This spring is connected to the surface water drainage system of the Tetrosyl property by a subsurface drain. A well is also noted on a historic map of the site in the Green Belt area adjacent to the tributary soon after entering the site.

Pigs Lee Brook flows south approximately 100m to the east of the property through two small reservoirs located 100m east and 300m south of the property.

Surface infiltration of rainwater will occur in areas of soft landscaping, and shallow perched water in surface soils is likely to be to the south-southeast direction. The surface water drainage system of the site also discharges from the site to the south.

3.3.1 Flooding

Information from the Environment Agency in 2002 stated that they have no record of the property being subject to fluvial flooding in the past. They note that due to the proximity of the watercourse, the possibility of flooding in the future cannot be entirely dismissed. The EA also recommended that a flood risk assessment be carried out to support a planning application.

3.4 Site History Review

A review of the site history was detailed in the ENSR 2002 report and was carried out through the study of Ordnance Survey maps dating from the late 1800s, information from the regulatory authorities and trade directories and information provided by facility personnel. The review is designed to identify potential historic sources of contamination that may have impacted soil or groundwater quality beneath the site and to identify any potentially contaminative land uses in the area that may have impacted the site.

Bently Mill, a cotton mill and Lumn Mill were already present on the 1851 OS map in the south of the site with a chimney present in the centre of the site. Two reservoirs were present at this time, one in the northeast, which is still present, and one in the south west which has been infilled and is the present car park location. By 1893, extensive buildings are present on site, noted as a mill and dye works. Two additional small reservoirs are also shown in the south eastern part of the site in 1893, these are now both infilled. A well and an air shaft are noted in the north of the property and an 'old shaft' was noted 200m southeast of the property boundary.

By 1930, the site is occupied by Bevis Green Print Works, with changes on-site including the infilling of the reservoir in the south eastern buildings. A quarry and adjacent spoil heap is shown in the middle of the site, approximately 50m west of the remaining northern reservoir. Disused sewage tanks are shown 50m west of the southern boundary. By 1960 the quarry is disused and noted as a pond, and the disused sewage tanks are no longer shown. In 1971 a 'refuse tip' is indicated around the east and south of the disused quarry and the works are noted as Car Accessories Factory, i.e. the Tetrosyl car-care production operations. By 1984, the southern reservoir is infilled and two new buildings are present (the Tetrosyl warehouses). According to Tetrosyl personnel, material removed during the construction of these warehouses in the

1970's was used to infill the reservoir in the south of the site which is now the car park area and office buildings. The former quarry in the north of the site is not present by 1984 and a concreted drum storage area is shown located in the same area. The M66 motorway embankment adjacent to the north of the site is now shown.

Later maps show some infilling of the remaining reservoir to provide the current turning area south of the reservoir and some infilling of the north western edge of the reservoir. A plan showing the known areas of historical infilling is presented in Figure 3.

3.4.1 Previous Environmental Assessment Information

In 2003, ENSR conducted and reported an Environmental Site Assessment for the site following an intrusive site investigation in 2002. The scope and findings of the assessment are discussed in detail in Section 4 of this report, however the information from the 2002 investigation has been used to inform the PRA detailed below.

3.4.2 Summary of Historic Potentially Contaminative Land Uses

The review of the site history and findings from the previous site investigation indicates several potentially contaminative land uses at the site derived from it's former and current industrial usage.

Operations known or likely to have caused impact to the soil or groundwater include the storage and use of fuels oils on site including bitumen, diesel, heating oil and kerosene. Solvent and solvent storage tanks (both above and below ground) have been present on site for many years and the potential for leaks and spills from such tanks is high. The site has been an operational mill, dye works, print factory and car care formulation plant over a 150 year period. The potential for pockets of other contaminants across the large site is present and would need to be considered during remediation. There is some evidence of historic, shallow and small-scale coal mining just to the east of the site boundary, and the presence of spoil heaps and shafts on site is possible.

There are many parts of the site which have been infilled with made ground over the years, some of this being ashy deposits which have the potential to have high concentrations of PAH compounds and some metals associated with the ash. The infilled ground is likely to be a source of the ground gas detected on site in some locations. Asbestos has been found in some soil samples from the site.

The condition of the sediments in the current on-site reservoir is not known, and there is potential for these sediments to have been impacted by chemical contamination during the period of site operation.

Historic potentially contaminative land uses in the vicinity of the site were shallow coal mining to the east of the site and the former sewage works to the south of the site. The

sewage works has been demolished since before 1960 and were shown as disused before this. The sewage plant was down gradient of the Tetrosyl site and thus the likelihood of any impact to the site is considered negligible. The shallow coal mining is historic and seemed to have been on a small scale. Any excavated materials may have brought contaminants associated with coal deposits such as PAHs to the made ground on-site. However a more serious concern may be potential ground instability in this area.

3.5 Site Walkover

A site inspection was carried as part of the 2002 ENSR site investigation which noted areas of potential concern (APC) due to past on-site activities and historical use. RSK staff conducted a site visit in April 2010 and found that little had changed on-site since 2002 and the APC would remain the same as follows:

1. Underground storage tanks (USTs) containing white spirit and mono ethylene glycol (MEG)
2. Antifreeze mixing area including three ASTs
3. Tetrosyl maintenance workshop and former Dyeworks mechanics shop
4. Raw material drum compound
5. Tetrosyl vehicle maintenance shed since the compound was constructed on an area of ash fill
6. Fuel oil (diesel) AST supplying fuel for the vehicle maintenance shed
7. Diesel AST used for vehicle filling
8. Kerosene AST
9. Fuel (heating oil) ASTs
10. ASTs containing methylene chloride, sodium silicate, kerosene and white spirit
11. Electrical transformer
12. Sprinkler pump and diesel AST
13. Heating oil ASTs
14. Former Tetrosyl cap spraying room
15. AST not in use (former contents not known)
16. Bitumen AST
17. Tetrosyl resin room and location of former reservoir for the print works
18. Infilled former reservoir
19. Former USTs infilled with concrete
20. Solvent drum filling area
21. Solvent recovery plant
22. Drum crushing plant
23. Solvent tank farm
24. Waste sludge reclamation plant
25. Former quarry and landfill
26. Heating oil AST
27. Open area surfaced with road planings

- 28. Diesel AST
- 29. Area adjacent to off-site infilled sewage tanks. Mill Road car park
- 30. Former reservoir (north of maintenance shed)
- 31. Infilled ground to south of reservoir
- 32. Infilled ground to east of reservoir.

3.5.1 Other

There were two adits identified from the PRA relating to shallow coal mining to the immediate east of the southern part of the site. These would have been access tunnels to the shallow coal workings which have been indicated. There is no information as to whether or not these have been infilled, capped or otherwise treated. These adits were not located during the 2002 intrusive investigation, nor during the 2010 site visit.

Similarly the old air shaft noted on historic maps in the north of the site below the green belt land has not been located, nor is it known whether this has been infilled or capped.

3.6 Summary of Potential Contaminant Sources

There are many locations on site that have the potential to be impacted by historic and current operations as mentioned in Section 3.5, but many of the contaminants are similar compounds and potential contaminant sources can be summarised as follows:

- Ashy made ground containing elevated metal, sulphate and possibly PAH compounds;
- Asbestos in soil and structures on-site;
- Areas of soil or shallow groundwater impacted with TPH and BTEX, generally from areas of hydrocarbon storage on site such as fuel tanks;
- Solvent compounds in soil or groundwater, associated with the solvent recovery area and associated tanks, and some underground storage tanks. However, little evidence of solvents or VOCs was noted in the 2003 ENSR report and this source does not appear to be significant; and
- High sulphate concentrations in some areas of made ground that may impact buried structures of future developments.

3.7 Sensitive Receptors

The proposed redevelopment of the site would include various residential areas and open spaces and access roads. The retention of the majority of the existing on-site reservoir is also proposed in the development scheme. The water course flowing from the reservoir and currently culverted under the site, is planned to be opened into a surface stream for much of its length on-site.

Thus the sensitive receptors will include:

- Future site residents;

- Site workers during redevelopment;
- The retained site reservoir;
- Tributary to Pigs Lee Brook;
- Secondary aquifer underlying the site;
- Proposed infrastructure on-site; and
- Off-site residents and local commercial workers.

3.8 Summary of Plausible Pathways

The routes by which the sources could impact the sensitive receptors are as follows:

- Direct contact with impacted soil and groundwaters by site workers during development and future site residents;
- Surface water run-off to surface water features nearby;
- Existing or proposed service runs;
- Leaching from soil to shallow groundwater;
- Migration of shallow groundwater to minor aquifer or off site;
- Vapour migration and inhalation from volatile compounds in soil or groundwater;
- Ground gas migration; and
- Dust inhalation.

3.9 Data Gaps and Uncertainties

The proposed layout of residential units is not final we understand, and there may be some small variations in the layout or number of the houses on the site. This slight uncertainty is likely to be the case until planning considerations are finalised, however it would not materially affect much of the remedial works required for the site as it is all proposed to be residential areas. Structural issues may be more pertinent regarding layout, for example the variation in depths of made ground in the lowest part of the site.

PAH analysis was not carried out in the 2003 assessment and given the presence of ashy made ground at some locations across the site, it is likely that PAH compounds will be present in some of the made ground.

Only total petroleum hydrocarbons (TPH) were analysed in samples from the site in 2003. Current best practice is to analyse for speciated hydrocarbons so that the lighter fractions can be distinguished from the heavier fractions and unnecessary remediation is not carried out on hydrocarbon fractions which are not likely to cause a risk to human health. Measurement for speciated TPH in soil and groundwater samples would be likely to reduce the amount of material that would be considered necessary to remediate or remove.

The known presence of hydrocarbons is likely to have diminished slightly on site since the ENSR investigation was undertaken, assuming good practices have been maintained on-site since 2003. Thus hydrocarbon concentrations in soil and

groundwater may have diminished since the 2003 report, however metal contamination and issues such as asbestos contamination are unlikely to have changed with time.

Whilst the 2003 report was of good quality and coverage of the site, some analytical methods and guidance for assessments of contaminated sites have moved on since that date. Thus the assessment of the site is re-examined in Section 5 against current Environment Agency guidance.

3.10 Conceptual Site Model

The information presented in Sections 2, 3 and 4 has been used to compile an outline conceptual model. The identified potential contaminants and receptors have been considered with any possible pathways that may link them. The resulting pollutant linkages are considered in Table 1. The risk classification has been estimated in accordance with information in Appendix D.

Table 1: Risk Estimation for Potential Pollutant Linkages in Outline Conceptual Model

Potential Source	Potential Receptor	Possible Pathway	Likelihood	Severity	Risk
TPH and BTEX in made ground or groundwater	Future site residents, site construction workers.	Vapour migration from soils or groundwaters and inhalation	Likely	Severe	High
		Direct contact with impacted soils or groundwater, or dust inhalation	Likely	Severe	High
	Shallow groundwater and surface waters on - site	Leaching and migration in shallow groundwaters. Movement to surface waters	Likely	Medium	Moderate
	Secondary aquifer underlying the site	Leaching and vertical migration of impacted shallow groundwaters.	Likely	Medium	Moderate
Elevated metals and other	Future site residents, site construction workers.	Direct contact with impacted soils or groundwater, or dust inhalation	Likely	Medium	Moderate

Potential Source	Potential Receptor	Possible Pathway	Likelihood	Severity	Risk
compounds in ashy made ground	Shallow groundwater and surface waters on - site	Leaching and migration in shallow groundwaters. Movement to surface waters	Likely	Medium	Moderate
	Secondary aquifer underlying the site	Leaching and vertical migration of impacted shallow groundwaters	Likely	Medium	Moderate
Solvent compounds in soil or groundwater	Future site residents, site construction workers.	Vapour migration from soils or groundwaters and inhalation	Likely	Severe	High
		Direct contact with impacted soils or groundwater, or dust inhalation	Likely	Severe	High
	Shallow groundwater and surface waters on - site	Leaching and migration in shallow groundwaters. Movement to surface waters	Likely	Medium	Moderate
	Secondary aquifer underlying the site	Leaching and vertical migration of impacted shallow groundwaters	Likely	Medium	Moderate
High sulphate in made ground	Buried building structures, concrete	Via leaching and chemical attack	Likely	Medium	Moderate
Asbestos in made ground and building structures	Future site residents, site construction workers.	Inhalation	Likely	Severe	High

The conceptual model identifies the following potential pollutant linkages:

- Migration of hydrocarbons and solvents potentially present in soils and shallow groundwaters to surface water bodies or to the minor aquifer beneath the site;

- Volatilisation of hydrocarbon and solvents potentially present in soils and shallow groundwaters prior to inhalation by site construction workers and residents;
- Inhalation of asbestos fibres by site construction workers and residents;
- Sulphate in made ground attacking concrete in buried structures on site;
- Leaching of metals to shallow groundwaters and migration to impact surface waters or the secondary aquifer beneath the site; and
- Direct contact of site construction workers and residents of soil impacted with contaminants including hydrocarbons, solvents and metals.

4. SUMMARY OF 2003 SITE INVESTIGATION AND ASSESSMENT

An intrusive site investigation and subsequent ground gas and groundwater monitoring was undertaken in 2002 and reported by ENSR in 2003 to confirm any potential pollutant linkages identified their Phase I Environmental Site Assessment.

4.1 Sampling Strategy and Methodology

Eleven trial pits (TP1 to 11) were excavated and 45 probeholes (PH1 to PH45) were sunk during October 2002 in locations chosen to address the areas of potential concern identified in the Phase I report and listed above in Section 3.5 of this report. Eleven boreholes (BH1 to BH11) were sunk to allow for groundwater monitoring, although two of these (BH7 and BH8) were abandoned due to obstruction. Monitoring installations were installed in nine boreholes and eight probeholes to allow for groundwater sampling and monitoring of groundwater levels and gas flow rates, pressures and concentrations.

The location of the intrusive investigations are shown in the 2003 ENSR report and reproduced in Figure 2 of this report. The exploratory hole records are also provided in the 2003 ENSR report.

4.1.1 Soil Sampling

Representative soil samples were taken from the trial pits, probeholes and boreholes and a selection of these samples were sent for laboratory analysis. Fourteen soil samples were analysed for total petroleum hydrocarbons (TPH) and aromatic hydrocarbons (BTX). Volatile organic compounds (VOCs) were analysed in 17 soil samples and polychlorinated biphenyl (PCB) analysis was carried out on one soil sample.

Seventeen soil samples were also analysed for a suite of potential contaminants including metals, sulphate, sulphide, phenols and cyanide.

Asbestos analysis was undertaken on 5 made ground samples to determine the concentration and type of asbestos that may be present

4.1.2 Groundwater Sampling

Depths to groundwater were recorded using an electronic dip meter. Seven groundwater samples were collected from the monitoring well points at the site, six from boreholes and one from a probehole. Six samples were analysed for TPH, BTEX and VOCs. Three samples were analysed for the general analysis suite.

Surface water from the reservoir on site was not collected.

4.1.3 Ground Gas Monitoring

Four visits were made to the site during November 2002 to monitor concentrations of methane, carbon dioxide and oxygen in the standpipes installed in the probeholes and boreholes. Gas concentrations were measured using an infra-red gas analyser and both peak and steady concentrations were recorded along with atmospheric pressure. Flow rates from the installations were also recorded. On two occasions hydrocarbon vapour concentrations were measured using a MiniRae PID.

Methane was detected at concentrations above 1% by volume at BH10, BH5, PH24, BH2 and PH42. BH10 adjacent to the underground tank storage area on the southern boundary showed consistently high methane concentrations over the 4 readings ranging from 23.4% to 39% by volume. The measured flow rates were low, from <0.1 to 1.5 litres per hour. The other locations had lower methane concentrations ranging from 7.4% to 0.1% all with low flow rates.

Carbon dioxide was detected at concentrations above 1.5% by volume at BH1, BH10, BH4, PH9, PH10, PH24 and PH42. BH1 on the northern boundary of the property showed a carbon dioxide reading of 8.1% with the other locations ranging from 3.3% to <0.1%. Measured flow rates were low, ranging between 0.1 – 2%. Both methane and carbon dioxide were thus over the threshold concentrations at BH10, PH24 and PH42.

4.2 Ground Conditions

Detailed information on the ground conditions encountered in the 2002 site investigation is provided in the ENSR report. From a site visit in 2010 and discussions with Tetrosyl personnel there do not appear to have been any changes on site which would give rise to significant changes in ground conditions to those found and reported in the ENSR 2003 report.

Buildings, concrete slabs and areas of hardstanding cover a large proportion of the site. Made ground was present with depths ranging from 0.16m at PH3 to 11m at BH9.

Made ground was generally overlying clay deposits or weathered sandstone. The made ground composition varied across the site and included reworked natural material, sands and gravels, coal, ashy materials and clinker, brick and timber fragments. Solid bitumen was encountered in layers within sands at depths of 0.3 and 0.5 m in made ground at PH17 and PH18.

Areas of significant infilling, including former on-site reservoirs and quarries are shown on Figure 3 which is reproduced from the 2003 ENSR report.

Topsoil was present to depths of around 0.2m in the greenbelt area in the north of the site and no made ground was encountered in this area.

Groundwater was found at around 2.5 to 3m below ground level at many intrusive locations, with water rising in the holes by about 0.5m. Groundwater was noted at shallower locations adjacent to the reservoir sides in the infilled ground.

Hydrocarbon odours and visual evidence of hydrocarbons was noted in the following locations:

- Solvent recovery area (BH6, PH34, PH37)
- Underground tanks (BH10, BH11, PH42)
- Offices (BH4)
- South of reservoir (TP6, hydrocarbon sheen noted)
- Car park, former reservoir (BH2)

4.3 Observed Contamination

A full description of the analytical results from the soil and water samples tested in 2002 is reported in the ENSR 2003 report and only a summary of the concentrations of contaminants detected over the threshold concentrations in use at that time is provided here. The Dutch system of screening results was predominantly used in 2002, and concentrations in soil exceeding the Dutch Target Value are listed below.

Soil samples exceeding the Dutch TV in 2002 were:

- TPH concentration - BH4, PH10, PH 15, PH17 and PH42;
- BTEX concentration - BH4, PH15, PH16, PH17, PH30, PH35, PH36, PH37, PH42 (only PH16 and PH37 had benzene concentrations above the Dutch TV);
- VOCs - none
- Metals - PH1 (As, Cr), PH9 (As), PH10 (As), PH11 (As, Cu, Ni, Zn), PH21 (As, Pb, Cu, Zn, Ni), PH41 (As, Pb);
- Phenol - PH12;
- Cyanide - PH14;
- Sulphate - TP6, PH9, PH14, PH21, PH28.

Six of the seven groundwater samples were analysed for BTEX, TPH and VOCs. One groundwater sample was analysed for a general suite of metals and other contaminants. TPH was found in groundwater above the thresholds used in the 2003 report at PH42, BH6 and BH4. BTEX compounds were found above the 2003 threshold at the same locations, but only PH42 had benzene above threshold concentrations in groundwater. VOCs and compounds in the general suite were not found in groundwater above the thresholds used in the 2003 report.

Asbestos was found in three of the five samples analysed, with amosite found at PH16 and PH29, and chrysotile found at PH14 and PH29.

4.4 ENSR Site Assessment Summary

In brief summary, the analytical results and site investigation conducted by ENSR in 2002 detailed the following areas where contamination was found and may need further investigation or treatment prior to redevelopment:

Areas of the property where soil has been impacted with TPH and/or BTEX were as follows:

- Solvent recovery area (PH30, PH35, PH36, PH37)
- Offices – former underground storage tanks (BH4)
- Infilled area south of the reservoir and nearby AST (TP6, BH17)
- Near to kerosene AST (PH16)
- Hydrocarbon ASTs (PH15)
- Diesel AST (PH10)
- Underground storage tank area (PH42)
- Phenol found in soil (PH12).

Areas of the property where elevated metals were found in soils were as follows:

- Arsenic - PH1, PH10, PH11, PH21, PH41
- Lead - PH21, PH41
- Chromium - PH1
- Copper - PH11, PH21
- Nickel - PH11, PH21
- Zinc - PH11, PH21

The areas of the site impacted with metals are predominantly areas of ashy made ground with a number of areas of sandy or clayey made ground.

There was one sample with cyanide impact at shallow depth (PH14). This was in association with the ashy made ground found at this location and may be related to the ash content.

High sulphate concentrations were found in various locations across the site and this would have implications for buried concrete structures in any proposed redevelopment.

The 2002 risk assessment was based on these results, but under a different scheme of assessment guidance that was in force at that time. Section 5 below reconsiders the results of the 2003 report under current UK guidance.

5. GENERIC QUANTITATIVE RISK ASSESSMENT

The assessment of the site investigation results reported in 2003 was carried out in accordance with guidance available at that time. Since then, more information and guidance on the assessment of contaminated land has been made available mostly via the UK Environment Agency; the latest suite of guidance material was released during 2009. RSK have been asked to consider the data provided by the site investigation in the light of the most recent guidance and current protocols.

In line with CLR11⁽²⁾, there are two stages of quantitative risk assessment, generic and detailed. The GQRA comprises the comparison of soil, groundwater and ground gas results with generic assessment criteria (GAC) that is appropriate to the linkage being assessed. The GAC used in this assessment are included in Appendix E for human health (together with details of their derivation) and in Appendix F for the assessment of phytotoxic effects, risks to plastic utilities and to controlled waters.

The site data were compared with GAC for a residential with gardens end-use scenario since the site is likely to be developed with a mixture of residential houses, detached, semi-detached and townhouses, but all with some garden areas.

There are GAC available for speciated TPH and PAH which were not analysed for in the 2003 site investigation. Total TPH were reported, and the use of total TPH can mean an overestimation of the risks posed to human health from petroleum hydrocarbons since some fractions are considered to be more toxic than others and a worst case scenario has to be assumed. It would greatly help a remedial programme to have speciated TPH results available as a more accurate picture of material that required remedial treatment could then be made.

The ground gas monitoring at the site confirmed the presence of elevated concentrations of methane and carbon dioxide, but the frequency of sampling and the length of time since the initial investigations was undertaken is likely to mean that the ground gas monitoring would not satisfy current planning requirements and this aspect of the investigation would most likely have to be repeated prior to submission for planning ⁽⁷⁻¹³⁾. Ground gas monitoring is now usually carried out over six monitoring rounds, as considered the minimum for residential housing in line with the NHBC

report ⁽⁶⁾. This is to include periods of low and/or falling atmospheric pressures and after/during rainfall.

The site investigation work and refinement of the conceptual site model indicates that there are relevant pollutant linkages at the site, which require further consideration.

5.1 Relevant Linkages for Assessment

The linkages for assessment are presented in Table 2.

Table 2: Linkages for Generic Quantitative Risk Assessment

Relevant Pollutant Linkage	GAC
Direct contact pathways to future residents or construction workers including inhalation pathways	Human health GAC for a proposed residential end use with private gardens as this is the proposed development (see Appendix E). Shorter term risks to construction workers should be mitigated by good working practices and appropriate PPE.
Leaching and dissolved phase migration to secondary aquifer and surface waters	Those recorded in Table 3 of Appendix F for secondary aquifers.
Concentrations of methane and carbon dioxide in ground gas entering and accumulating in: • Depressions and excavations during any site works and development that could affect site workers; and • Enclosed spaces or small rooms in new buildings, which could affect future residents. In the case of methane, this could create a potentially explosive atmosphere, whilst death by asphyxiation could result from carbon dioxide.	Gas screening values (GSV) can be calculated using maximum methane and carbon dioxide concentrations with maximum flow rates recorded at the site. The GSV are then compared with the generic Traffic Lights, as presented within the NHBC ground gases guide ⁽⁸⁾ and the CIRIA Report 659 ⁽⁷⁾ owing to the development comprising predominantly low-rise housing with suspended floors. There is insufficient information from the existing 2003 site report to conduct this assessment in full.

5.2 Methodology and Results

The methodology and results of the generic quantitative risk assessment are presented for each relevant pollutant linkage in turn.

5.2.1 Direct Contact and Vapour Inhalation by Future Residents

Since the soil and groundwater samples collected at the site were located in a targeted manner having identified areas of concern at the site, statistical analysis of the data is not considered appropriate in line with current UK guidance ⁽¹⁴⁾, and the laboratory analytical data have been compared directly with the GAC.

5.2.1.1 Soils exceeding the Residential GAC – metals

Table 3: Soils exceeding the Residential GAC – Metals

	Location	Concentration (mg/kg)	GAC (mg/kg) residential (1%SOM)
Arsenic	PH1 0.15-0.25m	32	32
	PH10 1.7-1.8 m	43	
	PH11 0.8-0.9 m	70	
	PH21 0.5-0.6 m	84	
Cadmium	No exceedence		10
Chromium (III) oxide	No exceedence		3,000
Chromium (VI) hexavalent	No exceedence		3.2
Copper	No exceedence		2,300
Lead	PH21 0.5-0.6 m	1,528	450
	PH41 0.8-0.9 m	492	
Mercury (inorganic)	No exceedence		170
Nickel	No exceedence		130
Selenium	No exceedence		350
Zinc	No exceedence		3,800
Cyanide	PH1 0.15-0.25 m	24.9	3.7
	PH9 0.8-0.9 m	4.3	
	PH14 0.3 m	436.9	
	PH24 1.0 m	4.99	

Notes: Where total chromium was over 100 mg/kg, the sample was tested for hexavalent chromium.

There was no evidence of mercury contamination thus no need for elemental or methyl mercury analysis.

Arsenic, lead and cyanide concentrations in soil exceeded residential GAC in several locations.

5.2.1.2 Soils exceeding the Residential GAC – Chlorinated Solvents

No chlorinated solvents were found in any of the 10 samples analysed. PH40 1.0m, PH42 1.7m, PH12 0.5m, PH30-D1 0.3-0.5m, PH32-D2 1.6-1.8m, PH35-D2 1.8-1.9m,

PH36-D2 3.7-3.8m, PH37-D2 1.7-1.9m, PH21 1.0-1.1m, BH6-D4 1.5-1.95m. No PCB was found in soil at PH5 0.19-0.5m.

5.2.1.3 Soils exceeding the Residential GAC – PAH

No soils were analysed for speciated PAH on the site. Only one sample (PH18 1.6-1.8m depth, next to bitumen tank) was analysed for Total PAH and the results were below detection limit.

5.2.1.4 Soils exceeding the Residential GAC – TPH

Table 4: Soils exceeding the Residential GAC – Petroleum Hydrocarbons

	Sample Location and Depth	Concentration (mg/kg)	GAC (mg/kg) residential (1% SOM)
Benzene	PH16 0.4m PH37 1.7-1.9m	0.1 0.1	0.079
Toluene	PH42 1.7m	620	120
Ethylbenzene	PH42 1.7m	95	65
Xylene	BH4 3.0-3.1m PH42 1.7m	92 280	44
MTBE			1.8
Total TPH	PH10 0.6-0.7m PH15 0.2m PH16 0.4m PH17 2.4-2.6m PH30 0.3-0.5m PH35 1.8-1.9m PH37 1.7-1.9m BH4 3.0-3.1m PH42 1.7m TP6 1.0m	>4,000 1,200 830 170 13 10 38 200 1,600 22	NA
Aliphatic C ₅ -C ₆			30
Aliphatic C ₆ -C ₈			73
Aliphatic C ₈ -C ₁₀			19
Aliphatic C ₁₀ -C ₁₂			93
Aliphatic C ₁₂ -C ₁₆			7,400
Aliphatic C ₁₆ -C ₂₁			45,000
Aliphatic C ₂₁ -C ₃₅			45,000
Aromatic C ₈ -C ₁₀			27
Aromatic C ₁₀ -C ₁₂			69
Aromatic C ₁₂ -C ₁₆			140
Aromatic C ₁₆ -C ₂₁			250
Aromatic C ₂₁ -C ₃₅			890

Exceedences of residential screening values for BTEX were noted, but for TPH it is difficult to directly compare the results with current GACs without being too conservative. Some high concentrations of TPH are noted in some areas of the site and speciated TPH analysis would be recommended for these areas.

No groundwaters exceeded human health GAC for any compounds analysed. Concentrations of TPH measured were a maximum of 26 mg/l which could not be directly compared with current GAC values.

5.2.2 Uptake of Contaminants by Vegetation Potentially Inhibiting Plant Growth

The soil results for zinc, nickel and copper, which can all be phytotoxic, have been compared with the GAC presented in Appendix F for this linkage. The results indicate that three soil samples had concentrations of copper or zinc above the screening value for the relevant metal. The GAC for these metals are pH dependent. Samples from PH9 (copper), PH11 (zinc) and PH21 (copper and zinc) were all above the relevant phytotoxic GAC. All these samples were in fairly shallow soils and it is likely that a pollutant linkage may exist for phytotoxic effects.

5.2.3 Permeation of Plastic Utilities

The results of the 2003 investigation have been compared with the GAC presented in Appendix F for this linkage. The results indicate that a relevant pollutant linkage may exist associated with the permeation of plastic utilities, particularly with regard to sulphate, pH, arsenic, cyanide and TPH at various locations.

5.2.4 Leaching of Contaminants to Groundwater and Surface Waters

Some soil samples were analysed for leachable metals. Concentrations detected in the leachate were generally below the laboratory detection limit, and all were below the GAC for surface waters and secondary aquifers as provided in Appendix F. Soil samples were not analysed for leachable PAH or TPH. The concentrations of TPH found in soils indicate that leaching to groundwater and surface waters could be a relevant pollutant linkage at the site.

5.2.5 Migration of Dissolved Phase Contaminants to Surface Water and Secondary Aquifer

Owing to the relatively small number of groundwater samples obtained, the laboratory data have been compared directly with the GAC rather than undertaking statistical analysis. The GAC used to assess this linkage are presented in Appendix F and comprise the Secondary Aquifer and surface watercourse GACs. These are generally the relevant EQS where available ⁽¹⁵⁾, and other suitable standards if not ⁽¹⁶⁾. These were considered the most appropriate GAC owing to the site's location over a

Secondary Aquifer and with surface water bodies on-site (reservoir and water course). The controlled waters screening table is included in Appendix F. The determinants that exceeded the GAC are presented in Table 5 below.

Table 5: Summary of Controlled Waters Screening Results

Determinant	GAC (mg/l)	Exceedances
Benzene	0.03	PH42 (0.045)
Toluene	0.05	PH42 (21.0), BH6 W2 (8.3)
Ethylbenzene	0.02	PH42 (1.5), BH4 W1 (0.55), BH6 W2 (0.78)
Xylene	0.03	PH42 (4.4), BH4 W1 (1.6), BH6 W2 (1.9)
TPH	0.01	PH42 (26.9), BH4 W1 (1.6), BH6 W2 (8.5)
Copper	0.001 (min)	BH9 (0.007), BH5 W3 (0.006)
Zinc	0.008 (min)	BH9 (0.3)
Notes:		
Numbers in brackets under exceedances column are concentration in mg/l		

The comparison indicates that some compounds are present in groundwaters under the site at concentrations which exceed the current regulations for protection of Controlled Waters. The BTEX and TPH concentrations are particularly high at PH42 which is at the southern-most end of the site. The concentrations noted have the potential to adversely affect surface waters on site, and shallow perched waters found on-site. Dilution in the surface water would be likely to mitigate some of this impact.

It may be possible that the concentrations of contaminants in groundwaters has diminished with time since the investigation in 2002. However this would be subject to the source of the hydrocarbons from soil or storage tanks being reduced during this time period.

The ground investigation has indicated that clay of the glacial deposits underlies the site at depth in most locations. This is in line with expected superficial geology and will provide a barrier to limit migration of contaminants to the secondary aquifer beneath the site.

5.2.6 Ground Gas

Measured concentrations of methane above 1% were detected at BH10, BH5, PH24, BH2 and PH42 with a maximum concentration of 39% by volume at BH10. Carbon dioxide above 1.5% was detected at BH1, BH10, BH4, PH9, PH10, PH24 and PH42 with a maximum concentration of 8.1% by volume at BH1. The flow rates for methane and carbon dioxide were low.

In order to assess the significance of ground gases at the site under current guidelines, more monitoring occasions will have to be undertaken under different atmospheric conditions prior to making a classification based on ground gases and flow rates.

5.3 Environmental Assessment Conclusions

The locations where contamination in soil or groundwater exceeds current residential GACs or has been detected in elevated concentrations (e.g. methane) have been marked on the site plan for information and shown in Figure 4.

A refined conceptual site model based on the findings of the 2003 report and the current assessment of the results is shown schematically as Figure 5.

The relevant pollutant linkages that require further action are:

- The hydrocarbon and metal content of some soil samples on site is sufficient to pose a risk to future site residents via a direct contact pathway including permeation of plastic utility pipes. Remedial measures such as source removal or provision of clean cover materials would be required prior to redevelopment of the site and utility providers should be contacted to ensure appropriate materials are used;
- Hydrocarbon compounds are present in some soil samples at concentrations which may pose a risk to future site residents via volatilisation. Removal of areas of soil with elevated TPH concentration and verification of this remediation with speciated TPH analysis is recommended as part of the site remedial works. The north west of the site is largely free of TPH exceedences in soils;
- Ground gases (methane and carbon dioxide) have been detected on-site at elevated concentrations with low flow rates. They have been detected in many of the previously infilled areas of the site. Further monitoring of ground gases will be required in the infilled areas of the site prior to any decisions regarding redevelopment on the infilled areas;
- Migration of dissolved phase hydrocarbons and some metals is possible and remedial measures to reduce the hydrocarbon source should be undertaken to protect surface waters on-site;
- The likely presence of PAH compounds in made ground on-site has not been determined and measures designed to mitigate the impact of PAHs such as removal of made ground or the placement of clean cover material should be used during the redevelopment of the site unless testing for PAHs is undertaken;
- Asbestos has been noted on site and an asbestos survey and programme of removal will be required as part of the redevelopment;
- Cyanide is present at high concentration in one soil sample, and this should be removed prior to redevelopment and the area tested to ensure removal is complete; and

- Ground stability in areas of historic infilling and potential adits, wells and shafts should be carefully investigated as part of any redevelopment works. The stability of the reservoir retaining wall and the condition of sediments within the reservoir is not known.

6. WASTE

A redevelopment of the site will require a Site Waste Management Plan setting out how waste will be disposed of and how material re-use and recovery will be implemented on site. A Site Waste Management Plan should follow the DEFRA guidance (2008) ⁽¹⁷⁾.

6.1 Waste Classification

All wastes will require pre-treatment prior to disposal at landfill. Pre-treatment must be a physical / thermal / chemical / biological process, including sorting, that changes the characteristics of the waste in order to reduce its volume / reduce its hazardous nature / facilitate its handling / enhance its recovery. It is best practice to provide the waste collector (or the disposal site) with details of how the waste has been treated. The waste collector may provide a pre-treatment confirmation form or space on the waste transfer note to detail the pre-treatment, alternatively a standard form produced by the Environment Agency may be used.

Three soil samples out of five screened positive for asbestos. Asbestos is classified as a stable, non-reactive hazardous waste and, as such, can be disposed of within a stable non-reactive hazardous waste cell in a non-hazardous waste landfill.

6.2 Waste Acceptance Criteria

All inert, stable non-reactive hazardous and hazardous wastes must be tested and found to be below the Waste Acceptance Criteria (WAC) leaching limit values for the classification of landfill they are being disposed in. Currently, no WAC are in place for non hazardous waste.

6.3 Re-use of Soils on Site

It is assumed that any soils or other material intended for re-use on site would be analysed and assessed for its suitability for the proposed end-use on site. A materials management plan should be part of the Site Waste Management Plan for the overall site.

7. GEOTECHNICAL SITE ASSESSMENT

Discussion of suitable foundation requirements given the various depths of made ground present on site were discussed in the ENSR 2003 report based on the findings of the intrusive investigation across the site. This current report cannot comment further on the geotechnical aspects of the site development as no further assessment has been made beyond that reported in 2003.

However, the planned residential redevelopment option proposed would include infilling and building over some of the existing on-site reservoir margins. The condition of the retaining wall of the reservoir is not known, nor have materials at the base of the reservoir been investigated for contamination or physical properties. A full engineering assessment of the reservoir and its retaining sides would be required prior to developing the site.

7.1 Chemical Attack on Buried Concrete

The 2003 report indicated slightly elevated total soluble sulphate concentrations in several soil samples from the site, and that this may give rise to sulphate attack on buried concrete. Thus as a precaution it was recommended that all buildings, foundations and subsurface structures are designed to take this into consideration and that further testing may be required to determine requirements for buried concrete in some areas of the proposed development.

7.2 Utilities

The GQRA in Section 5 has identified that plastic utilities are not likely to be suitable due to ground contamination found in several locations on site. It may be necessary to specify protecta-line type mains water supply pipes for the development. It may also need to be considered whether service lines have the potential to become preferential pathways for the migration of vapours of dissolved contaminants.

8. DEVELOPMENT CONSTRAINTS

The historically developed Bevis Green site will have some specific development constraints due to its past industrial use and site history. The watercourse through the site has been altered and used for over 150 years, including the formation and subsequent infilling of several reservoirs. The existing reservoir and the steep fall of the land will need to be considered during redevelopment.

Land stability issues should be considered in all areas of deep made ground where reservoirs or earthworks have been infilled, for old mine shafts, wells and possible adits on-site, and for the retaining wall of the existing reservoir. Ground gases were detected

in the 2002 investigation in several locations and further monitoring of this is likely to be necessary prior to redevelopment, particularly in the infilled areas.

8.1 Existing Reservoir and Infilled Areas

The existing on-site reservoir covers an area of 1.25 hectares and would likely be classified as a reservoir under the Flood and Management Bill where water bodies over 10,000 m³ confer particular responsibilities of maintenance and safety on the developer. Some development options involve altering the shape and extent of the reservoir, and in all cases the strength of the existing embankments and reservoir walls would need investigation and proper construction. The chemical and physical condition of silts at the bottom of the reservoir are not known as these were not sampled during the site investigation.

The water course is currently culverted from the spillway from the reservoir to the bottom of the site at the south of the works. It is the Environment Agency's policy to encourage open river flows rather than culverts, and a sensible option would be to route the stream along the eastern boundary of the site after leaving the retained reservoir, or for it's full length if the reservoir is not retained. A no-build zone of 8m width either side of a watercourse is required by the Environment Agency, and this may be easiest to achieve along the site boundary rather than through the centre of the site.

Many on-site infilled areas have been located, either from historic site information or from the site investigation work in 2002. These infilled locations are shown in Figure 3 and are areas of concern for proposed redevelopment works with regard to ground surface stability.

8.2 Ground gases

The infilled reservoirs and quarries on site have been confirmed during the site investigation and development over these areas would require further ground gas monitoring prior to planning application. If, as is likely, the presence of ground gas at unacceptable levels is confirmed under the current regulations, the development will have to allow for gas mitigation measures or potential remedial works to address this issue.

Foundation design will have to consider the nature of the made ground in the various areas of the site, particularly over the previous reservoirs and former quarry areas. The potential historic presence of a well, mine shaft and two adits on site should be investigated prior to any redevelopment to ensure that any shafts have been safely treated.

8.3 Asbestos

Asbestos was found on site in three out of five soil samples tested. Given the long history and industrial use of the site an asbestos survey and removal programme will be required prior to demolition and during remedial works on site.

9. CONCLUSIONS AND RECOMMENDATIONS

There have been no major changes on site since the ENSR site investigation and environmental site assessment was completed in 2002, although there are on-going operations in parts of the site. Thus the report provides a good basis for a revised risk assessment. However, analytical methods and guidance on acceptable concentrations have changed since 2002 and will have a bearing on a revised environmental assessment.

Points of concern raised by the revised risk assessment are as follows:

- Almost no PAH (poly aromatic hydrocarbons) were analysed in the original investigation. Only one soil sample taken near the old bitumen tank at 1.6m-1.8m depth which was below detection limit. PAHs are commonly associated with ash and products of hydrocarbon combustion (i.e. generator residues, bonfires etc). Much of the infilled areas contained at least some ash and clinker and PAH presence would be expected. This gives two basic options for planning, either to provide clean soil (probably with a break layer) to a depth of 600mm in all residential garden areas, or to investigate the proposed residential development areas for soil PAH concentration. Given the known presence of infilled material, it may be expected that fails of the PAH screening values would be found and clean cover would be needed to be provided anyway regardless of further investigation;
- Similarly for TPH (total petroleum hydrocarbons), only total TPH was analysed for the original report. Analytical techniques have improved and speciated TPHs are commonly analysed for in soil samples on site such as this. Use of the total TPH values can lead to an overestimate of the risk from petroleum hydrocarbons where present since the lighter fractions (benzene, petrol) are more toxic than the heavier fractions (fuel oil, bitumen etc). It may be necessary to take soil samples for speciated TPH analysis during the redevelopment, perhaps as hydrocarbon contaminated areas are removed to provide validation of remediation.
- Some areas of the site had elevated hydrocarbon concentrations in soils and groundwaters. These are predominantly in areas associated with fuel storage and site operations and remedial measures will be required for some of these locations prior to redevelopment. Some metals were also present in soils at the

site in concentrations which would not be suitable for residential gardens without some remedial measures being undertaken.

- Water samples at BH6 had high concentrations of toluene, ethylbenzene, xylene and total TPH. This is near the solvent recovery area, and it is possible that concentrations now may be lower due to natural attenuation if no further discharges or spills to soil or water have occurred. Water samples at PH42 in the vicinity of the old underground storage tanks also had high concentrations of BTEX and TPH, again this may have reduced with time due to natural attenuation. The water sample at BH4 under the present office building also had high concentrations of TPH, ethylbenzene and xylene.
- The lack of evidence of chlorinated solvents in soil samples on site is reassuring, and does not currently give cause for concern. Also there was no evidence of PCB contamination and there is no requirement for radon protection measures at this location.
- Ground gas was identified at high concentrations at several locations across the site, at BH10, BH5, PH24, BH2 and PH42, all in areas known to be previously infilled. The maximum methane concentration was 39% by volume, where the screening value is 1% by volume. Flow rates were generally low, but the concentrations were high in some locations, particularly BH10. It will probably be necessary to reinvestigate the ground gas concentrations of the infilled areas to satisfy planning regulations and decide on the level of gas protection measures which will be needed for any redevelopment.
- Ground stability issues for the presently infilled areas, for the old mining shaft and possible adits, and for the existing reservoir, either as present or in a new outline, will need engineering consideration.
- Asbestos was noted in 3 out of 5 soil samples tested, and a full asbestos survey would be recommended for the site prior to or during redevelopment.
- A high cyanide result of 437 mg/kg (ppm) of cyanide was found at PH14 at shallow depth and this will require remedial action, probably by localised and removal and testing.

The current proposed layout of the site has the retained greenbelt at the northern most end of the site, detached and semi-detached residential development below this as the site descends, adjacent to the reservoir, then with terraced townhouses primarily at the further down slope towards the south. Generally, the north west of the site was not found to have contaminants present above current screening values and would be suitable for residential development with fewer requirements expected for remediation than other areas of the site. The central area of the site, some areas adjacent to the reservoir and leading towards the southern boundary were impacted in many locations with TPH and metals in shallow soils. Groundwater in these areas was also impacted, particularly in the centre of the site. Methane has been measured in high concentrations, though low flow rates, in several of the areas subject to historic infilling of reservoirs or quarry areas on site. Concentrations of methane were highest in the very southernmost part of the site, near the boundary in areas where deep made ground was identified in

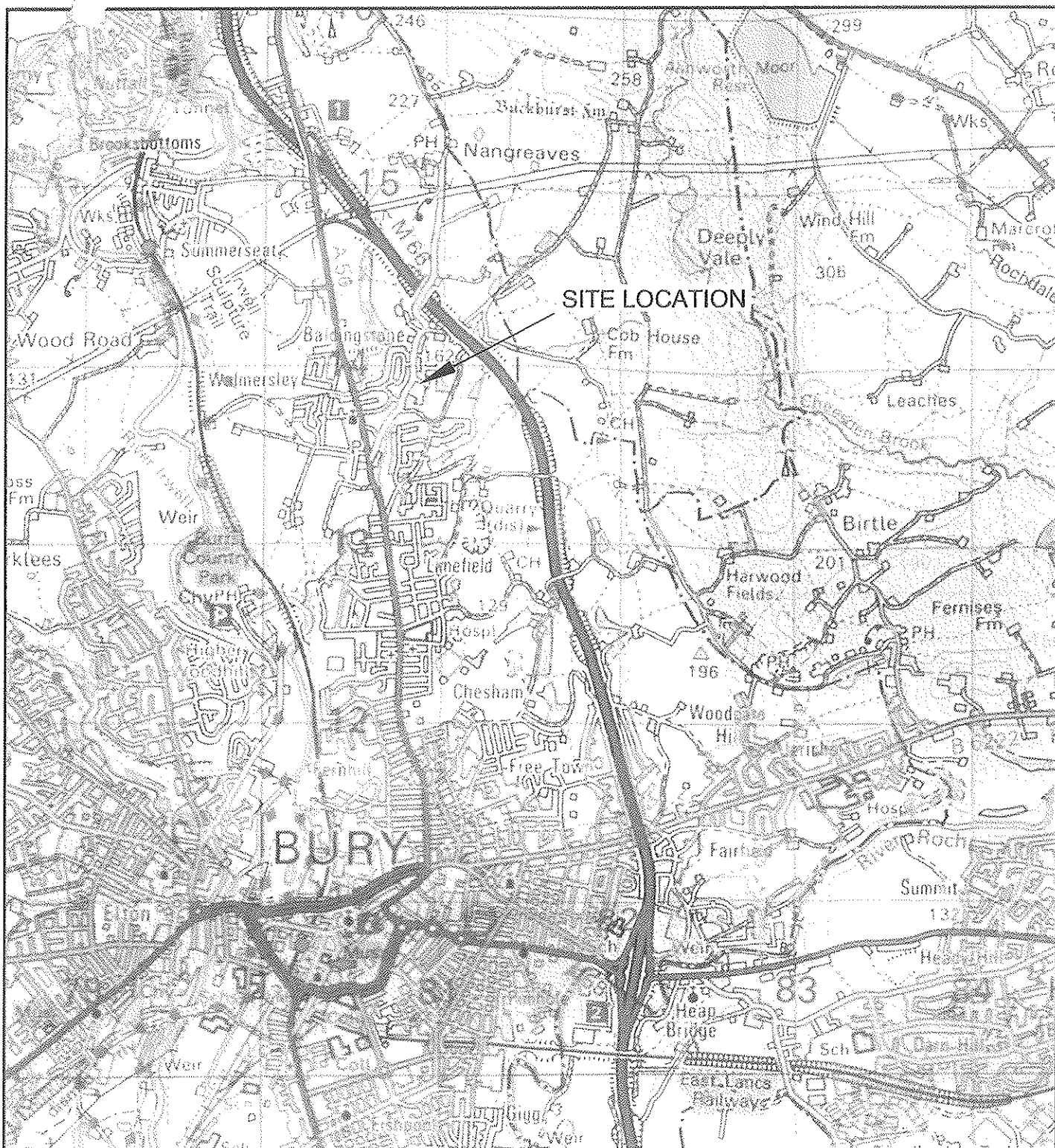
the 2002 site investigation. Potential infilling of part of the reservoir for development purposes should also proceed with caution due to the unknown chemical condition and physical nature of the sediments and the unknown stability of retaining walls. Land stability issues will also be important considerations during any redevelopment of the site.

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FIGURES



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Client

TETROSYL LIMITED

Project Title

**BEVIS GREEN SITE, WALMERSLEY, BURY
REVISED ENVIRONMENTAL SITE ASSESSMENT**

Drawing Title

SITE LOCATION PLAN

Drawn	Date	Checked	Date	Approved	Date
HD	15.02.11	LP	15.02.11	LP	15.02.11

Project No.

16565

Drawing File

16565-R01(00)D001A

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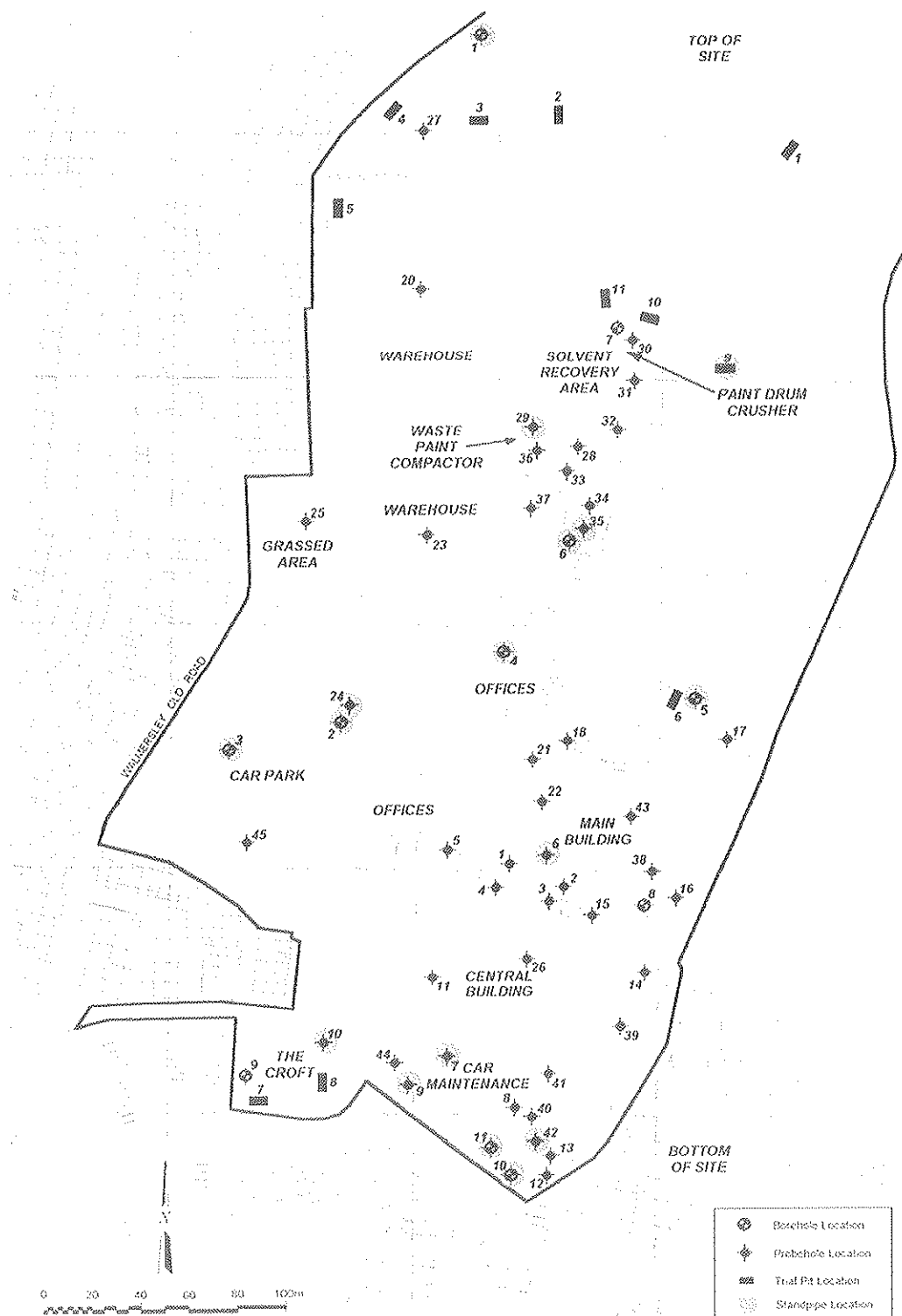
Orig Size
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Dimensions
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Drawing No.

FIGURE 1

Rev.
A



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TETROSYL LIMITED

Project Title

BEVIS GREEN SITE, WALMERSLEY, BURY
REVISED ENVIRONMENTAL SITE ASSESSMENT

Drawing Title

SITE PLAN SHOWING INTRUSIVE
INVESTIGATION LOCATIONS

Drawn	Date	Checked	Date	Approved	Date
HD	15.02.11	LP	15.02.11	LP	15.02.11

Project No.
16565

Drawing File
16565-R01(00)D002A

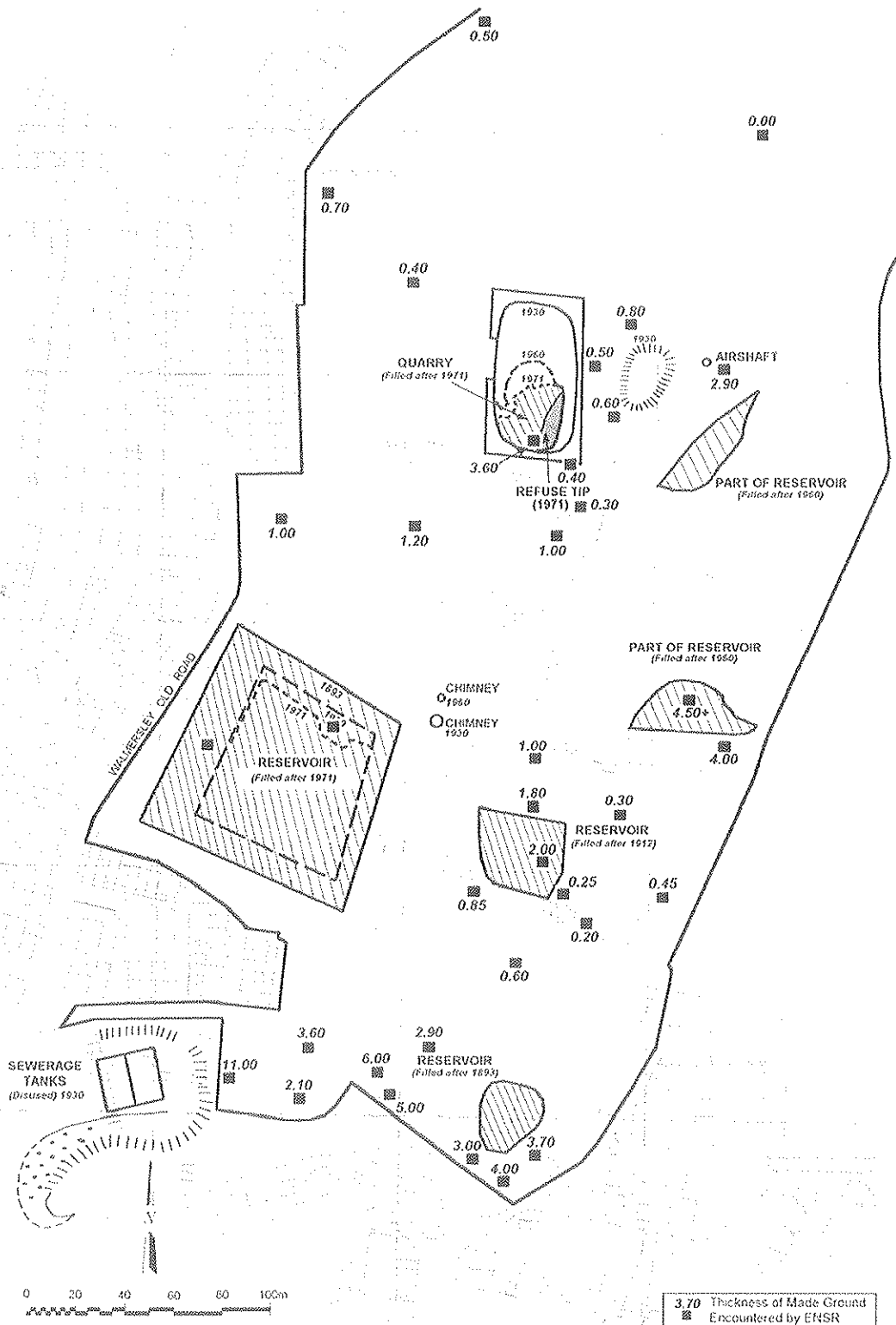
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Drawing No.
FIGURE 2

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A



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Client

TETROSYL LIMITED

Project Title

BEVIS GREEN SITE, WALMERSLEY, BURY
REVISED ENVIRONMENTAL SITE ASSESSMENT

Drawing Title

SITE PLAN SHOWING HISTORICALLY
FILLED AREA AND THICKNESS OF MADE
GROUND ENCOUNTERED IN 2003

Drawn	Date	Checked	Date	Approved	Date
HD	15.02.11	LP	15.02.11	LP	15.02.11

Scale
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Orig Size
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Dimensions
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Project No.

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Drawing File

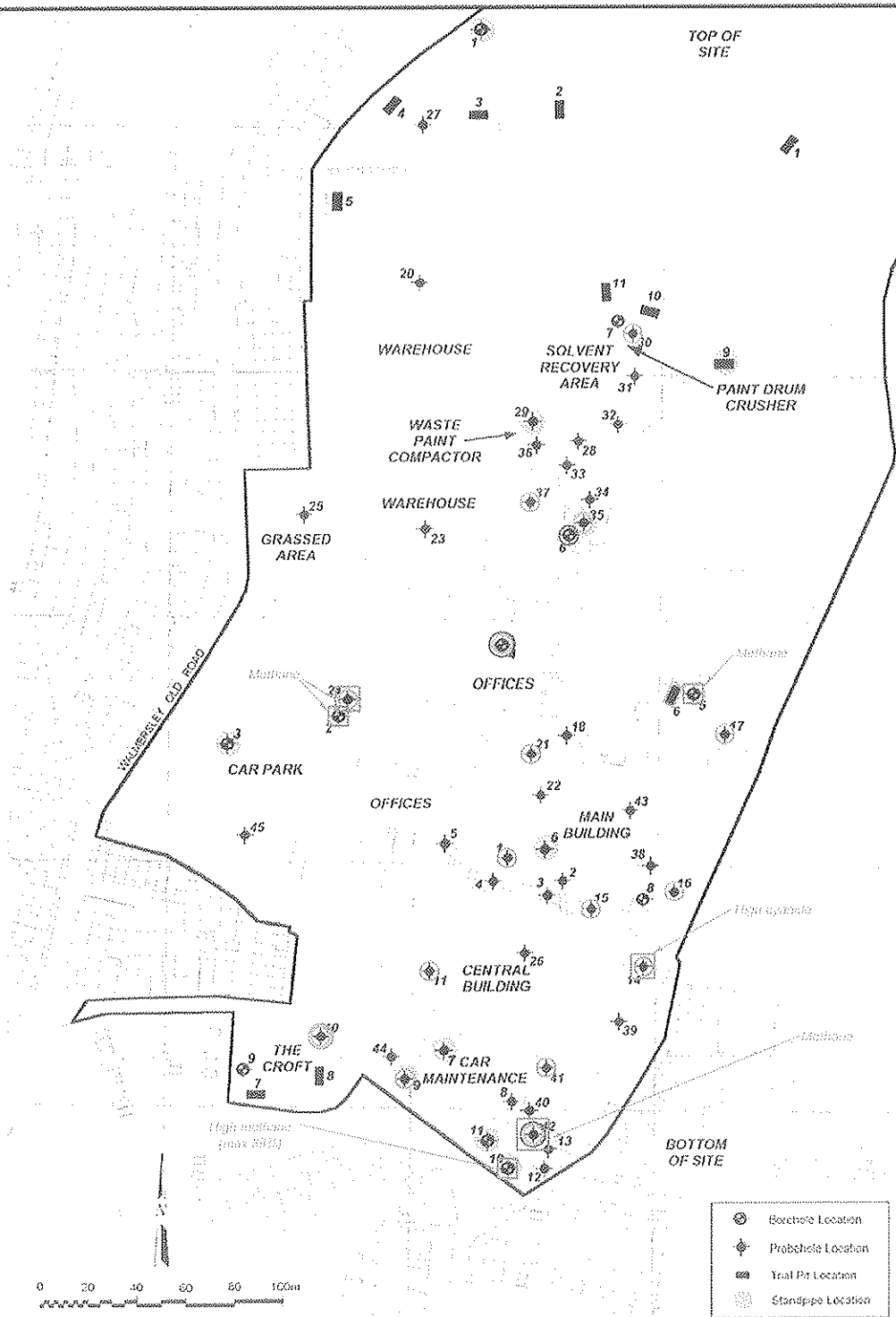
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FIGURE 3

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SOIL

- ☐ Metals and cyanide exceeding residential guidelines
- ☐ TPH - elevated, may exceed guidelines for residential development

WATER

- ☐ High TPH, inc BTEX in water samples

☐ Other issues

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Client

TETROSYL LIMITED

Project Title

BEVIS GREEN SITE, WALMERSLEY, BURY
REVISED ENVIRONMENTAL SITE ASSESSMENT

Drawing Title

SITE PLAN SHOWING AREAS OF
IDENTIFIED CONTAMINATION

Drawn	Date	Checked	Date	Approved	Date
HD	16.02.11	LP	16.02.11	LP	16.02.11

Project No.

16565

Drawing File

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Orig Size
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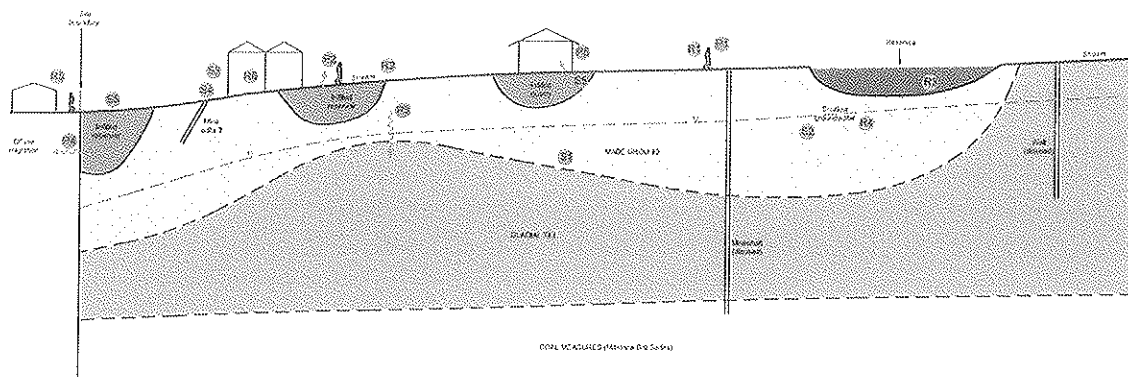
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FIGURE 4

Rev.

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POTENTIAL CONTAMINATIVE SOURCES

- Made ground containing elevated metals, cyanide and possibly PAH compounds;
- Soil and shallow groundwater impacted with TPH and BTEX;
- Asbestos in soil and structures on site;
- High sulphate concentrations in some made ground possibly impacting buried structures; and
- Ground gases (methane) from infilled ground.

POTENTIAL RECEPTORS

- Future residents;
- On-site stream;
- On-site reservoir;
- Secondary aquifer below site;
- Off-site residents and commercial workers; and
- Proposed on-site infrastructure.

POTENTIAL PATHWAYS

- Direct contact with impacted soil and groundwater via dust inhalation or dermal contact;
- Vapour migration and inhalation from soil or groundwater;
- Leaching from soil to shallow groundwater;
- Off-site migration of impacted shallow groundwater; and
- Ground gas migration to buildings or structures.

LEGEND

- Sources
- Receptors
- Pathways
- Potential Contamination pathways

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1	10.02.11	ISSUED FOR COMMENT	NTS	A3	
TETROSYL LIMITED					
REVIS GREEN SITE, WALMERSLEY, BURY					
REVISED ENVIRONMENTAL SITE ASSESSMENT					
REFINED CONCEPTUAL SITE MODEL					
DRAWING NO: 16555 DRAWING DATE: 16.02.11					
BY:	DATE:	CONTRACT NO:	REV:		
HD	10.02.11			FIGURE 5	
				A	

APPENDIX A

Service Constraints

**RSK STATS GEOCONSULT LIMITED
SERVICE CONSTRAINTS**

1. This report and the site investigation carried out in connection with the report (together the "Services") were compiled and carried out by RSK STATS Geoconsult Limited (RSK) for Tetrosyl Limited (the "client") in accordance with the terms of a contract between RSK and the "client". The Services were performed by RSK with the skill and care ordinarily exercised by a reasonable environmental consultant at the time the Services were performed. Further, and in particular, the Services were performed by RSK taking into account the limits of the scope of works required by the client, the time scale involved and the resources, including financial and manpower resources, agreed between RSK and the client.
2. Other than that expressly contained in paragraph 1 above, RSK provides no other representation or warranty whether express or implied, in relation to the Services.
3. Unless otherwise agreed the Services were performed by RSK exclusively for the purposes of the client. RSK is not aware of any interest of or reliance by any party other than the client in or on the Services. Unless expressly provided in writing, RSK does not authorise, consent or condone any party other than the client relying upon the Services. Should this report or any part of this report, or otherwise details of the Services or any part of the Services be made known to any such party, and such party relies thereon that party does so wholly at its own and sole risk and RSK disclaims any liability to such parties. Any such party would be well advised to seek independent advice from a competent environmental consultant and/or lawyer.
4. It is RSK's understanding that this report is to be used for the purpose described in the introduction to the report. That purpose was a significant factor in determining the scope and level of the Services. Should the purpose for which the report is used, or the proposed use of the site change, this report may no longer be valid and any further use of or reliance upon the report in those circumstances by the client without RSK's review and advice shall be at the client's sole and own risk. Should RSK be requested to review the report after the date hereof, RSK shall be entitled to additional payment at the then existing rates or such other terms as agreed between RSK and the client.
5. The passage of time may result in changes in site conditions, regulatory or other legal provisions, technology or economic conditions which could render the report inaccurate or unreliable. The information and conclusions contained in this report should not be relied upon in the future without the written advice of RSK. In the absence of such written advice of RSK, reliance on the report in the future shall be at the client's own and sole risk. Should RSK be requested to review the report in the future, RSK shall be entitled to additional payment at the then existing rate or such other terms as may be agreed between RSK and the client.
6. The observations and conclusions described in this report are based solely upon the Services which were provided pursuant to the agreement between the client and RSK. RSK has not performed any observations, investigations, studies or testing not specifically set out or required by the contract between the client and RSK Limited. RSK is not liable for the existence of any condition, the discovery of which would require performance of services not otherwise contained in the Services. For the avoidance of doubt, unless otherwise expressly referred to in the introduction to this report, RSK did not seek to evaluate the presence on or off the site of asbestos, electromagnetic fields, lead paint, heavy metals, radon gas or other radioactive or hazardous materials.
7. The Services are based upon RSK's observations of existing physical conditions at the Site gained from a walkover survey of the site together with RSK's interpretation of information including documentation, obtained from third parties and from the client on the history and usage of the site. The Services are also based on information and/or analysis provided by independent testing and information services or laboratories upon which RSK was reasonably entitled to rely. The Services clearly are limited by the accuracy of the information, including documentation, reviewed by RSK and the observations possible at the time of the walkover survey. Further RSK was not authorised and did not attempt to independently verify the accuracy or completeness of information, documentation or materials received from the client or third parties, including laboratories and information services, during the performance of the Services. RSK is not liable for any inaccurate information or conclusions, the discovery of which inaccuracies required the doing of any act including the gathering of any information which was not reasonably available to RSK and including the doing of any independent investigation of the information provided to RSK save as otherwise provided in the terms of the contract between the client and RSK.
8. The phase II or intrusive environmental site investigation aspects of the Services is a limited sampling of the site at pre-determined borehole and soil vapour locations based on the operational configuration of the site. The conclusions given in this report are based on information gathered at the specific test locations and can only be extrapolated to an undefined limited area around those locations. The extent of the limited area depends on the soil and groundwater conditions, together with the position of any current structures and underground facilities and natural and other activities on site. In addition chemical analysis was carried out for a limited number of parameters [as stipulated in the contract between the client and RSK] [based on an understanding of the available operational and historical information.] and it should not be inferred that other chemical species are not present.
9. Any site drawing(s) provided in this report is (are) not meant to be an accurate base plan, but is (are) used to present the general relative locations of features on, and surrounding, the site.

APPENDIX B

Summary of Legislation and Policy Relating to Contaminated Land

Summary of legislation and policy relating to contaminated land

Part IIA of the Environmental Protection Act (EPA) and its associated Contaminated Land Regulations 2000 (SI 2000/227), which came into force in England on 1 April 2000, are the basis for the current regulatory framework and form the statutory regime for the identification and remediation of contaminated land.

Part IIA of the EPA 1990 defines contaminated land as 'any land which appears to the Local Authority in whose area it is situated to be in such a condition by reason of substances in, on or under the land, that significant harm is being caused, or that there is significant possibility of significant harm being caused, or that pollution of controlled waters is being or is likely to be caused'. Controlled waters, defined by the Water Resources Act, are considered all groundwater, inland waters and estuaries.

The intention of the EPA 1990 Part IIA is to deal with contaminated land issues that are considered to cause significant harm, on land that is not undergoing development, (see circular 2-2000 for definitions of what is significant harm, website link - <http://www.defra.gov.uk/environment/land/contaminated/circ2-2000/index.htm>).

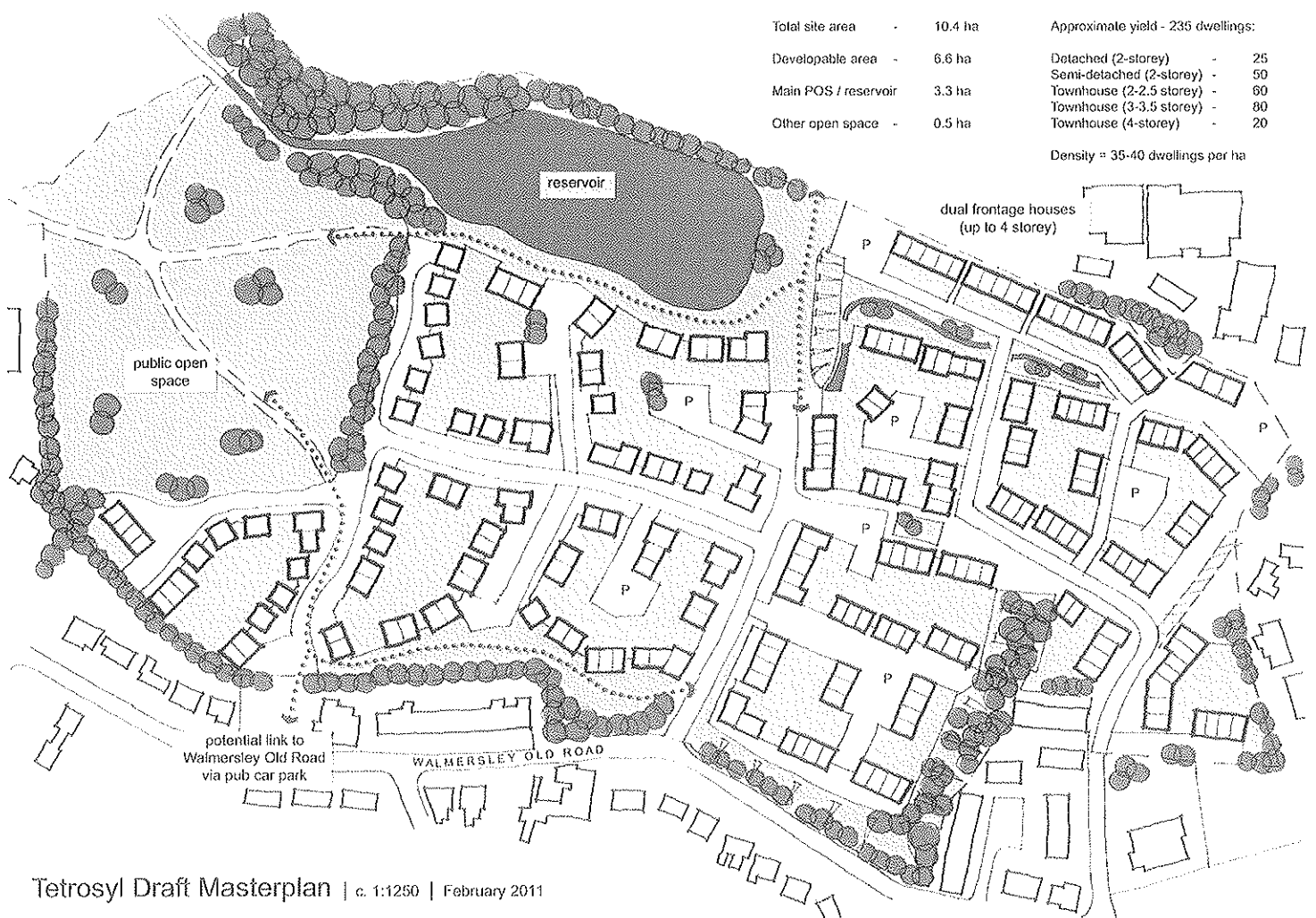
The Water Framework Directive 2000/60/EC (WFD) legislation aims to deliver long-term protection of the water environment and to improve the quality of all water bodies, including rivers, wetlands, coasts, estuaries, lakes, man-made structures and groundwater.

The Water Resources Act 1991 introduces an offence to cause or knowingly permit pollution of controlled waters. The Act provides the Environment Agency with powers to implement remediation necessary to protect controlled waters and recover all reasonable costs of doing so. The Groundwater Regulations, 1998, aim to complement EPA 1990. These regulations give the Environment Agency the power to *prevent* the discharge of List I substances and *restrict* the discharge of List II substances to groundwater.

Contaminated land is often dealt with through planning because of land redevelopment. This approach is documented in Planning Policy Statement: Planning and Pollution Control PPS23, which states that it remains the responsibility of the landowner and developer to identify land affected by contamination and carry out sufficient remediation to render the land suitable for use. The overall aim of the planning and pollution control policy is to promote the sustainable and beneficial use of land (in particular, encouraging reuse of previously developed land in preference to greenfield sites). Within this aim, polluting activities that are necessary for society and the economy should be so sited and planned, and subject to such planning conditions, that their adverse effects are minimised and contained to within acceptable limits.

APPENDIX C

**Turley Associates Draft Masterplan
for Tetrosyl Bevis Green Site**



APPENDIX D

Methodology for Risk Assessment

Risk Assessment Methodology

CLR11 outlines the framework to be followed for risk assessment in the UK. The framework is designed to be consistent with UK legislation and policies including planning. Under CLR11, three stages of risk assessment exist: Preliminary, Generic Quantitative and Detailed Quantitative. An outline Conceptual Model should be formed at the preliminary risk assessment stage that collates all the existing information pertaining to a site in text, tabular or diagrammatic form. The outline conceptual model identifies potentially complete (termed possible) pollutant linkages (source–pathway–receptor) and is used as the basis for design of the site investigation. The outline Conceptual Model is updated as further information becomes available, for example as a result of the site investigation.

Production of a Conceptual Model requires an assessment of risk to be made. Risk is a combination of the likelihood of an event occurring and the magnitude of its consequences. Therefore, both the likelihood and the consequences of an event must be taken into account when assessing risk. RSK has adopted guidance provided in CIRIA C552 for use in the production of conceptual models.

The likelihood of an event can be classified on a four-point system using the following terms and definitions based on CIRIA C552:

- Highly likely: the event appears very likely in the short term and almost inevitable over the long term or there is evidence at the receptor of harm or pollution;
- Likely: it is probable that an event will occur or circumstances are such that the event is not inevitable, but possible in the short term and likely over the long term;
- Low likelihood: circumstances are possible under which an event could occur, but it is not certain even in the long term that an event would occur and it is less likely in the short term; and
- Unlikely: circumstances are such that it is improbable the event would occur even in the long term.

The severity can be classified using a similar system also based on CIRIA C552. The terms and definitions relating to severity are:

- Severe: short term (acute) risk to human health likely to result in 'significant harm' as defined by the Environment Protection Act 1990, Part IIA. Short-term risk of pollution of sensitive water resources. Catastrophic damage to buildings or property. Short-term risk to an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);
- Medium: chronic damage to human health ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000), pollution of sensitive water resources, significant change in an ecosystem or organism forming part of that ecosystem (note definition of ecosystem in 'Draft Circular on Contaminated Land', DETR 2000);

- Mild: pollution of non-sensitive water resources. Significant damage to crops, buildings, structures and services ('significant harm' as defined in 'Draft Circular on Contaminated Land', DETR 2000). Damage to sensitive buildings, structures or the environment; and
- Minor: harm, not necessarily significant, but that could result in financial loss or expenditure to resolve. Non-permanent human health effects easily prevented by use of personal protective clothing. Easily repairable damage to buildings, structures and services.

Once the likelihood of an event occurring and its severity have been classified, a risk category can be assigned the table below.

		Consequences			
		Severe	Medium	Mild	Minor
Probability	Highly likely	Very high	High	Moderate	Moderate/Low
	Likely	High	Moderate	Moderate/Low	Low
	Low likelihood	Moderate	Moderate/Low	Low	Very Low
	Unlikely	Moderate/Low	Low	Very Low	Very Low

Definitions of these risk categories are as follows together with an assessment of the further work that might be required:

- Very high: there is a high probability that severe harm could occur or there is evidence that severe harm is currently happening. This risk, if realised, could result in substantial liability and urgent investigation and remediation are likely to be required;
- High: harm is likely to occur. Realisation of the risk is likely to present a substantial liability and urgent investigation is required and remedial works may be necessary in the short term and are likely over the long term;
- Moderate: it is possible that harm could arise, but it is unlikely that the harm would be severe and it is more likely that the harm would be relatively mild. Investigation is normally required to clarify the risk and determine the liability. Some remedial works may be required in the longer term;
- Low: it is possible that harm could occur, but it is likely that if realised this harm would at worst normally be mild; and
- Very Low: there is a low possibility that harm could occur and if realised the harm is unlikely to be severe.

APPENDIX E

Human Health Generic Assessment Criteria

Generic Assessment Criteria for Human Health
Residential Scenario – Private Gardens

The human health generic assessment criteria (GAC) have been developed during a period of regulatory review and updating of the Contaminated Land Exposure Assessment (CLEA) project. Hence, the Environment Agency (EA) is in the process of publishing updated reports relating to the CLEA project and the GAC presented in this document may change to reflect these updates. This issue was prepared following the publication of soil guideline value reports and associated publications⁽¹⁾ for mercury, selenium, benzene, toluene, ethylbenzene and xylene in March 2009, arsenic and nickel in May 2009, cadmium and phenol in June 2009, dioxins, furans and dioxin-like PCBs in September 2009. It was also produced following publication of GAC by LQM⁽⁶⁾. Where available, the published soil guideline values (SGV)⁽¹⁾ have been used as GAC.

1. Model Selection

Soil assessment criteria (SAC) were calculated using CLEA v1.06 and the supporting UK guidance⁽¹⁻⁶⁾. Groundwater assessment criteria (GrAC) protective of human health via the inhalation pathway were derived using the RBCA 1.3b model. RSK has updated the inputs within RBCA to reflect the UK guidance⁽¹⁻⁶⁾. The SAC and GrAC collectively are termed GAC.

2. Conceptual Model

In accordance with EA Science Report SC050221/SR3⁽³⁾, the residential with private garden scenario considers risks to a female child between the ages of 0 and 6 years old. In accordance with Box 3.1, SR3⁽³⁾, the pathways considered for production of the SAC in the residential with gardens scenario are:

- Direct soil and dust ingestion;
- Consumption of homegrown produce;
- Consumption of soil attached to homegrown produce;
- Dermal contact with soil and indoor dust, and
- Inhalation of indoor and outdoor dust and vapours.

Figure 1 is a conceptual model illustrating these linkages.

The pathway considered in production of the GrAC is the volatilisation of compounds from groundwater and subsequent vapour inhalation by residents whilst indoors. Figure 2 illustrates this linkage. Although the outdoor air inhalation pathway is also valid, this contributes little to the overall risks owing to the dilution in outdoor air. Within RBCA, the solubility limit of the determinant restricts the extent of volatilisation, which in turn drives the indoor air inhalation pathway. Whilst the same restriction is not built into the CLEA model, the CLEA model output cells are flagged red where the soil saturation limit has been exceeded.

An assumption used in the CLEA model is that of simple linear partitioning of a chemical in the soil between the sorbed, dissolved and vapour phase⁽⁴⁾. The upper boundaries of this partitioning are represented by the aqueous solubility and pure saturated vapour concentration of the chemical. The CLEA software uses a traffic light system to identify when individual and/or combined assessment criteria exceed the lower of either the aqueous or vapour based saturation limits. Where model output cells are flagged red the soil or vapour saturation limit has been exceeded and further consideration of the SAC to be used within the assessment is required. One approach that could be adopted is to use the 'modelled' solubility saturation limit or vapour saturation limit of the compound as the SAC. However, as stated within the CLEA Handbook⁽⁴⁾ this is likely to not be practical in many cases because of the very low limits

and is in any case highly conservative. Unless free-phase product is present, concentrations of the chemical are unlikely to be present at sufficient concentration to result in an exceedance of the health criteria value (HCV).

RSK has adopted an approach for petroleum hydrocarbons in accordance with LQM/CIEH⁽⁶⁾ whereby the concentration modelled for each petroleum hydrocarbon fraction has been tabulated as the SAC with the corresponding solubility or vapour saturation limit given in brackets. Therefore, when using the SAC's to screen laboratory analysis the assessor should take note if a given SAC has a corresponding solubility or vapour saturation limit (in brackets), and subsequently incorporate this piece of information within the screening analytical discussion. If further assessment is required following this process then an additional approach can be utilised as detailed within Section 4.12 of the CLEA model manual⁽⁴⁾ which explains how to calculate an effective assessment criterion manually.

3. Input Selection

Chemical data was obtained from EA Report SC050021/SR7⁽⁵⁾ and the health criteria values (HCV) from the UK TOX⁽¹⁾ reports where available. For SAC for total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAH) toxicological and chemical specific parameters were obtained from the LQM/CIEH report⁽⁶⁾. Similarly, toxicological and specific chemical parameters for the volatile organic compound 1,2,4-trimethylbenzene were obtained from EIC/AGS/CL:AIRE⁽⁷⁾.

For total petroleum hydrocarbons (TPH), aromatic hydrocarbons C₅-C₈ were not modelled since benzene and toluene are being modelled separately. The aromatic C₈-C₉ hydrocarbon fraction comprises ethylbenzene, xylene and styrene. Since ethylbenzene and xylene are being modelled separately, the physical, chemical and toxicological data for this band has been taken from styrene.

Owing to the lack of UK-specific data, default information in the RBCA model was used to evaluate methyl tertiary butyl ether (MTBE). No published UK data was available for 1,3,5-trimethylbenzene, so information was obtained from the US EPA as in the RBCA model. RBCA uses toxicity data for the inhalation pathway in different units to the CLEA model and cannot consider separately the mean daily intake (MDI), occupancy periods or breathing rates. Therefore, the HCV in RBCA was amended to take account of:

- Amendments to the MDI using Table 3.4 of SR2⁽²⁾;
- A child weighing 13.3kg (average of 0-6 year old female in accordance with Table 4.6 of SR3⁽³⁾) and breathing 11.85m³ (average daily inhalation rate for a 0-6 yr old female in accordance with Table 4.14 of SR3⁽³⁾); and
- The 50% rule (for petroleum hydrocarbons, 1,3,5-trimethylbenzene and MTBE)⁽²⁾ where MDI data is not available but background exposure is considered important in the overall exposure.

4. Physical Parameters

For the residential with private gardens scenario, the CLEA default building is a small two-storey terrace house with concrete ground bearing slab. The house is assumed to have a 100m² private garden consisting of lawn, flowerbeds and incorporating a 20m² plot for growing fruit and vegetables consumed by the residents. SR3⁽³⁾ notes this residential building type to be the most conservative in terms of protection from vapour intrusion. The building parameters are outlined in Table 5.

The parameters for a sandy loam soil type were used in line with SR3⁽³⁾. This includes a value of 6% for the percentage soil organic matter (SOM) within the soil. In RSK's experience, this is rather high for many sites. To avoid undertaking site specific risk assessments for this parameter, RSK has produced an

additional set of SAC for an SOM of 1% and 2.5%. For the GrAC, the depth to groundwater was taken as 2.5m based on RSK's experience of assessing the volatilisation pathway from groundwater.

5. GAC

The SAC were produced using the input parameters in Tables 1 to 5 and the GrAC using input parameters in Table 6. The final selected GAC are presented by pathway in Table 7 and the combined GAC in Table 8.

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH
Residential Scenario – Private Gardens



Figure 1
Conceptual Model for CLEA Residential Scenario – Private Gardens

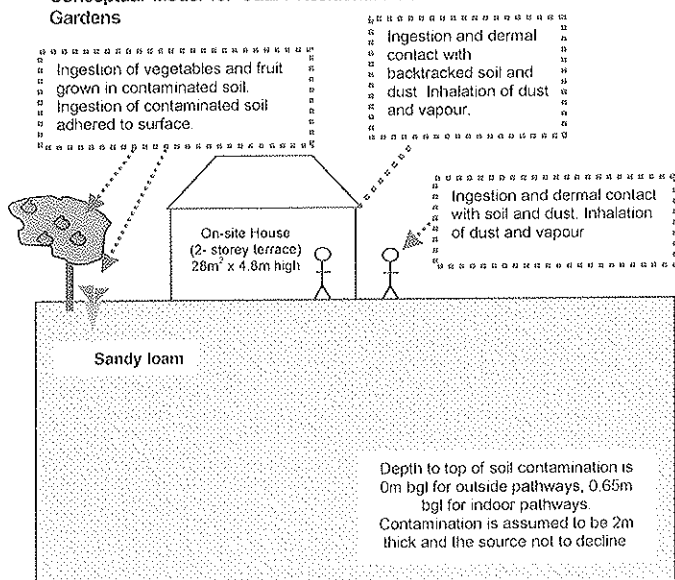


Table 1
Exposure Assessment Parameters for Residential Scenario - Private Gardens – Inputs for CLEA Model

Parameter	Value	Justification
Land use	Residential with homegrown produce	Chosen land use
Receptor	Female child age 1 to 6	Key generic assumption given in Box 3.1, report SC050021/SR3 ⁽³⁾
Building	Small terraced house	Key generic assumption given in Box 3.1, report SC050021/SR3. Two storey small terraced house chosen as it is the most conservative residential building type in terms of protection from vapor intrusion (Section 3.4.6, report SC050021/SR3) ⁽³⁾
Soil type	Sandy Loam	Most common UK soil type (Section 4.3.1, From Table 3.1, report SC050021/SR3) ⁽³⁾
Start AC (age class)	1	Range of age classes corresponding to key generic assumption that the critical receptor is a young female child aged zero to six. From Box 3.1, report SC050021/SR3 ⁽³⁾
End AC (age class)	6	
SOM (%)	6	Representative of sandy loamy soil according to EA Guidance note dated January 2009 entitled 'Changes We Have Made to the CLEA Framework Documents' ⁽⁶⁾
	1	To provide SAC for sites where SOM <6% as often observed by RSK
	2.5	
pH	7	Model default

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH
Residential Scenario – Private Gardens



Table 2
Residential with Private Gardens – Homegrown Produce Data for CLEA Model

	Consumption Rate (g FW kg ⁻¹ BW day ⁻¹) by Age Class						Dry Weight Conversion Factor	Homegrown Fraction (average)	Homegrown Fraction (high end)	Soil loading factor	Preparation correction factor
Name	1	2	3	4	5	6	g DW g ⁻¹ FW	-	-	g g ⁻¹ DW	-
Green vegetables	7.12	6.85	6.85	6.85	3.74	3.74	0.096	0.05	0.33	1.00E-03	2.00E-01
Root vegetables	10.69	3.30	3.30	3.30	1.77	1.77	0.103	0.06	0.4	1.00E-03	1.00E+00
Tuber vegetables	16.03	5.46	5.46	5.46	3.38	3.38	0.21	0.02	0.13	1.00E-03	1.00E+00
Herbaceous fruit	1.83	3.96	3.96	3.96	1.85	1.85	0.058	0.06	0.4	1.00E-03	6.00E-01
Shrub fruit	2.23	0.54	0.54	0.54	0.16	0.16	0.166	0.09	0.6	1.00E-03	6.00E-01
Tree fruit	3.82	11.96	11.96	11.96	4.26	4.26	0.157	0.04	0.27	1.00E-03	6.00E-01
Justification	Table 4.17, SR3 ⁽³⁾						Table 6.3, SR3 ⁽³⁾	Table 4.19, SR3 ⁽³⁾		Table 6.3, SR3 ⁽³⁾	

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH
Residential Scenario – Private Gardens



Table 3
Residential with Private Gardens – Land Use Data for CLEA Model

Parameter	Unit	Age Class					
		1	2	3	4	5	6
EF (soil and dust ingestion)	day yr ⁻¹	180	365	365	365	365	365
EF (consumption of homegrown produce)	day yr ⁻¹	180	365	365	365	365	365
EF (skin contact, indoor)	day yr ⁻¹	180	365	365	365	365	365
EF (skin contact, outdoor)	day yr ⁻¹	180	365	365	365	365	365
EF (inhalation of dust and vapour, indoor)	day yr ⁻¹	365	365	365	365	365	365
EF (inhalation of dust and vapour, outdoor)	day yr ⁻¹	365	365	365	365	365	365
Justification		Table 3.1, SR3 ⁽³⁾					
Occupancy period (indoor)	hr day ⁻¹	23	23	23	23	19	19
Occupancy period (outdoor)	hr day ⁻¹	1	1	1	1	1	1
Justification		Table 3.2, SR3 ⁽³⁾					
Soil to skin adherence factor (indoor)	mg cm ⁻² day ⁻¹	6.00E-02	6.00E-02	6.00E-02	6.00E-02	6.00E-02	6.00E-02
Soil to skin adherence factor (outdoor)	mg cm ⁻² day ⁻¹	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00	1.00E+00
Justification		Table 8.1, SR3 ⁽³⁾					
Soil and dust ingestion rate	g day ⁻¹	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01	1.00E-01
Justification		Table 6.2, SR3 ⁽³⁾					

Of note, for **cadmium**, the exposure assessment for a residential land use is based on estimates representative of lifetime exposure AC1-18. This is because the TDI_{oral} and TDI_{inh} – are based on considerations of the kidney burden accumulated over 50 years. It is therefore reasonable to consider exposure not only in childhood but averaged over a longer time period. See the Environment Agency Science report: SC05002 / TOX 3⁽¹⁾ and Science Report SC050021 / Cadmium SGV⁽¹⁾ for more information.

Table 4
Residential with Private Gardens – Receptor Data for CLEA Model

Parameter	Unit	Age Class						Justification
		1	2	3	4	5	6	
Body weight	kg	5.6	9.8	12.7	15.1	16.9	19.7	Table 4.6, SR3 ⁽³⁾
Body height	m	0.7	0.8	0.9	0.9	1	1.1	
Inhalation rate	m ³ day ⁻¹	8.5	13.3	12.7	12.2	12.2	12.2	Table 4.14, SR3 ⁽³⁾
Max exposed skin fraction (indoor)	m ² m ⁻²	0.32	0.33	0.32	0.35	0.35	0.33	Table 4.8, SR3 ⁽³⁾
Max exposed skin fraction (outdoor)	m ² m ⁻²	0.26	0.26	0.25	0.28	0.28	0.26	

See **cadmium** note as per Table 3 above.

Table 5
Residential with Private Gardens – Soil and Building Inputs for CLEA Model

Parameter	Unit	Value	Justification
SOIL PROPERTIES for sandy loam			
Porosity, total	cm ³ cm ⁻³	0.53	Default soil type is sandy loam, section 4.3.1, SR3 ⁽³⁾ Parameters for sandy loam from Table 4.4, SR3 ⁽³⁾
Porosity, air filled	cm ³ cm ⁻³	0.20	
Porosity, water filled	cm ³ cm ⁻³	0.33	
Residual soil water content	cm ³ cm ⁻³	0.12	
Saturated hydraulic conductivity	cm s ⁻¹	3.56E-03	
van Genuchten shape parameter (m)	-	3.20E-01	
Bulk density	g cm ⁻³	1.21	Default value taken from Section 9.2.2, SR3 ⁽³⁾
Threshold value of wind speed at 10m	m s ⁻¹	7.20	
Empirical function (F _x) for dust model	-	1.22	Value taken from Section 9.2.2, SR3 ⁽³⁾
Ambient soil temperature	K	283	Annual average soil temperature representative of UK surface soils. Section 4.3.1, SR3 ⁽³⁾
AIR DISPERSION MODEL			
Mean annual wind speed (10 m)	m s ⁻¹	5.00	Default value taken from Section 9.2.2, SR3 ⁽³⁾
Air dispersion factor at height of 0.8 m	g m ⁻² s ⁻¹ per kg m ⁻³	2400	Values for a 0.01 ha site, appropriate to a residential land use in Newcastle (most representative city for UK). (from Table 9.1, SR3 ⁽³⁾) Assumed child of 6 is not tall enough to reach 1.6m
Air dispersion factor at height of 1.6 m	g m ⁻² s ⁻¹ per kg m ⁻³	0	
Fraction of site with hard or vegetative cover	m ² m ⁻²	0.75	Section 3.2.6, SR3 ⁽³⁾ based on residential land use
BUILDING PROPERTIES for small terrace house with ground-bearing floor slab			
Building footprint	m ²	28	From Table 3.3 and 4.21, SR3 ⁽³⁾
Living space air exchange rate	hr ⁻¹	0.50	
Living space height (above ground)	m	4.8	
Living space height (below ground)	m	0.0	Assumed no basement
Pressure difference (soil to enclosed space)	Pa	3.1	From Table 3.3, SR3 ⁽³⁾
Foundation thickness	m	0.15	
Floor crack area	cm ²	423	
Dust loading factor	µg m ⁻³	50	Default value for a residential site taken from Section 9.3, SR3 ⁽³⁾
VAPOUR MODEL			
Default soil gas ingress rate	cm ³ s ⁻¹	25	Generic flow rate, Section 10.3, SR3 ⁽³⁾
Depth to top of source (beneath building)	cm	50	Section 3.2.6, SR3 ⁽³⁾ states source is 50cm below building or 65cm below ground surface
Depth to top of source (no building)	cm	0	Section 10.2, SR3 ⁽³⁾ assumes impact from 0-1m for outdoor inhalation pathway
Thickness of contaminant layer	cm	200	Model default for indoor air, Section 4.9, SR4 ⁽⁴⁾
Time average period for surface emissions	years	6	Time period of a 0 to 6 year old, Box 3.5, SR3 ⁽³⁾
User-defined effective air permeability	cm ²	3.05E-08	Calculated for sandy loam using equations in Appendix 1, SR3 ⁽³⁾

Figure 2
GrAC Conceptual Model for RBCA Residential with Private Gardens
Scenario

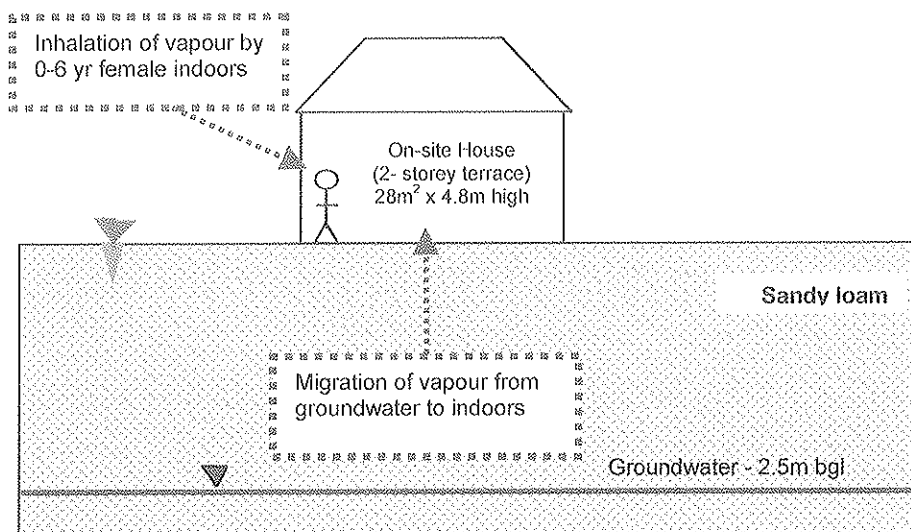


Table 6
Residential with Private Gardens RBCA Inputs

Parameter	Unit	Value	Justification
RECEPTOR			
Averaging time	Years	6	From Box 3.1, SR3 ⁽³⁾
Receptor weight	kg	13.3	Average of CLEA 0-6 year old female data, Table 4.6, SR3 ⁽³⁾
Exposure duration	Years	6	From Box 3.1, report, SR3 ⁽³⁾
Exposure frequency	Days/yr	350	Weighted using occupancy period of 23 hours per day for 365 days of the year
SOIL TYPE – SANDY LOAM			
Total porosity	-	0.53	CLEA value for sandy loam. Parameters for sandy loam from Table 4.4, SR3 ⁽³⁾
Volumetric water content	-	0.33	
Volumetric air content	-	0.20	
Dry bulk density	g cm ⁻³	1.21	CLEA value for saturated conductivity of sandy loam, Table 4.4, SR3 ⁽³⁾
Vertical hydraulic conductivity	cm s ⁻¹	3.56E-3	
Vapour permeability	m ²	3.05E-12	Calculated for sandy loam using equations in Appendix 1, SR3 ⁽³⁾
Capillary zone thickness	m	0.1	Professional judgement
Fraction organic carbon	%	(i) 0.0348	Representative of sandy loam according to EA Guidance note dated January 2009 entitled Changes We Have Made to the CLEA Framework Documents (ref)
		(ii) 0.0058	To provide SAC for site's where SOM < 6% as often observed by RSK
BUILDING			
Building volume/area ratio	m	4.8	Table 3.3, SR3 ⁽³⁾
Foundation area	m ²	28	
Foundation perimeter	m	22	Calculated assuming building measures 7m x 4m to give 28m ² foundation area
Building air exchange rate	d ⁻¹	12	Table 3.3, SR3 ⁽³⁾
Depth to bottom of foundation slab	m	0.15	
Foundation thickness	m	0.15	
Foundation crack fraction	-	0.0151	Calculated from floor crack area of 423 cm ² and building footprint of 28m ² in Table 4.21, SR3 ⁽³⁾
Volumetric water content of cracks	-	0.33	Assumed equal to underlying soil type in assumption that cracks become filled with soil over time. Parameters for sandy loam from Table 4.4, SR3 ⁽³⁾
Volumetric air content of cracks	-	0.2	
Indoor/outdoor differential pressure	Pa	3.1	From Table 3.3, SR3 ⁽³⁾

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - RESIDENTIAL WITH PRIVATE GARDENS

Table 7
Human Health Generic Assessment Criteria by Pathway for Residential Scenario - Private Gardens

Compound	Units	GIAC (mg/kg)	SAC Appropriate to Pathway SOM 1% (mg/kg)			Soil Saturation Limit (mg/kg)	SAC Appropriate to Pathway SOM 2.5% (mg/kg)			Soil Saturation Limit (mg/kg)	SAC Appropriate to Pathway SOM 5% (mg/kg)			Soil Saturation Limit (mg/kg)
			Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Metals														
Arsenic	µg/kg	-	3.25E+01	8.50E+01	-	NIL	3.25E+01	8.50E+01	-	NIL	3.25E+01	8.50E+01	-	NIL
Cadmium	µg/kg	-	1.50E+01	3.50E+01	-	NIL	1.50E+01	3.50E+01	-	NIL	1.50E+01	3.50E+01	-	NIL
Chromium (VI) - oxide	-	-	1.50E+04	3.50E+02	8.00E+00	NIL	1.50E+04	3.50E+02	2.00E+03	NIL	1.50E+04	3.50E+02	2.00E+03	NIL
Chromium (VI) - hexavalent	-	-	1.00E+01	4.00E+00	3.21E+00	NIL	1.00E+01	4.00E+00	3.21E+00	NIL	1.00E+01	4.00E+00	3.21E+00	NIL
Copper	-	-	3.50E+02	1.50E+04	2.00E+03	NIL	3.50E+02	1.50E+04	2.00E+03	NIL	3.50E+02	1.50E+04	2.00E+03	NIL
Lead	µg/kg	-	4.50E+02	-	-	NIL	4.50E+02	-	-	NIL	4.50E+02	-	-	NIL
Elemental Mercury (Hg ⁰)	µg/kg	9.00E+03	-	1.50E+01	-	4.51E+00	-	1.50E+01	-	1.07E+04	-	1.50E+01	-	2.50E+04
Inorganic Mercury (Hg ²⁺)	µg/kg	-	1.50E+02	2.50E+00	1.00E+02	NIL	1.50E+02	2.50E+00	1.00E+02	NIL	1.50E+02	2.50E+00	1.00E+02	NIL
Methyl Mercury (Hg ⁺)	µg/kg	2.00E+01	1.50E+01	1.50E+01	7.00E+02	7.35E+01	1.50E+01	1.50E+01	9.50E+00	1.47E+02	1.50E+01	1.50E+01	1.50E+01	3.04E+02
Nickel	µg/kg	-	3.51E+02	1.22E+02	-	NIL	3.51E+02	1.22E+02	-	NIL	3.51E+02	1.22E+02	-	NIL
Selenium	µg/kg	-	5.00E+02	-	-	NIL	5.00E+02	-	-	NIL	5.00E+02	-	-	NIL
Zinc	µg/kg	-	3.74E+03	2.50E+02	-	NIL	3.74E+03	2.50E+02	-	NIL	3.74E+03	2.50E+02	-	NIL
Cyanide	µg/kg	-	2.00E+01	3.07E+00	3.60E+00	NIL	2.00E+01	3.07E+00	3.60E+00	NIL	2.00E+01	3.07E+00	3.60E+00	NIL
Volatile Organic Compounds														
Acetone	µg/kg	1.70E+00	1.70E+01	2.00E+01	7.07E+02	1.27E+03	2.20E+01	4.50E+01	1.07E+01	2.70E+03	4.80E+01	1.04E+02	3.30E+01	4.71E+03
Formaldehyde	µg/kg	1.80E+03	3.70E+02	2.70E+02	1.50E+02	8.09E+02	3.30E+02	1.30E+02	2.70E+02	1.80E+03	7.50E+02	3.50E+02	6.17E+02	4.50E+03
Ethylbenzene	µg/kg	2.00E+02	1.00E+02	1.70E+02	6.57E+01	5.14E+02	2.51E+02	3.80E+02	1.04E+02	1.20E+03	6.70E+02	6.50E+02	3.54E+02	2.64E+03
Xylene - m	µg/kg	8.40E+01	2.00E+02	5.50E+01	4.50E+01	6.24E+02	4.80E+02	1.31E+02	1.00E+02	1.47E+03	1.00E+02	3.07E+02	7.00E+02	3.40E+03
Xylene - o	µg/kg	1.00E+02	1.84E+02	5.00E+01	4.50E+01	4.74E+02	4.20E+02	1.24E+02	1.00E+02	1.17E+03	9.00E+02	3.77E+02	2.60E+02	2.62E+03
Xylene - p	µg/kg	8.40E+01	1.01E+02	3.54E+01	3.17E+01	5.70E+02	3.51E+02	1.20E+02	8.00E+01	1.35E+03	1.00E+02	2.04E+02	2.00E+02	3.17E+03
Toluene	µg/kg	8.40E+01	2.00E+02	5.50E+01	4.50E+01	6.24E+02	4.80E+02	1.31E+02	1.00E+02	1.47E+03	1.00E+02	3.07E+02	7.00E+02	3.40E+03
Methyl Ethyl Ether	µg/kg	7.20E+03	1.70E+02	1.84E+02	1.74E+02	1.60E+04	3.50E+02	2.60E+02	3.07E+02	2.10E+04	7.50E+02	3.70E+02	7.37E+02	3.34E+04
Trichloroethene	µg/kg	1.80E+00	2.50E+00	1.00E+01	1.00E+01	1.64E+03	6.55E+00	2.00E+01	2.22E+01	3.22E+03	1.80E+01	3.11E+01	4.00E+01	1.14E+03
Tetrachloroethene	µg/kg	3.00E+00	1.50E+01	1.00E+00	9.30E+01	4.27E+02	2.40E+01	2.30E+00	2.10E+00	9.51E+02	3.55E+01	5.20E+00	4.80E+00	2.14E+03
1,1,1-Trichloroethane	µg/kg	2.00E+01	3.50E+00	8.50E+00	8.27E+00	1.83E+03	3.07E+02	1.20E+01	1.27E+01	2.97E+03	1.00E+01	2.84E+01	2.30E+01	8.30E+02
1,1,1,2-Tetrachloroethane	µg/kg	1.50E+01	1.00E+00	1.00E+00	8.02E+01	2.60E+03	1.20E+01	2.00E+00	2.00E+00	6.07E+03	2.70E+01	5.90E+00	4.80E+00	1.40E+04
1,1,2,2-Tetrachloroethane	µg/kg	1.40E+01	2.70E+00	2.70E+00	1.57E+02	7.67E+03	6.85E+02	3.80E+00	2.67E+00	5.40E+03	1.20E+01	1.24E+01	3.50E+00	1.20E+04
Carbon tetrachloride	µg/kg	5.00E+02	1.00E+00	1.01E+02	1.70E+02	1.50E+03	2.41E+02	3.07E+02	3.00E+02	3.32E+03	3.44E+02	6.60E+02	8.80E+02	7.54E+03
1,2-Dichloroethane	µg/kg	3.00E+01	3.00E+02	6.40E+01	3.24E+02	3.41E+03	3.30E+02	7.90E+01	7.00E+01	4.01E+03	1.60E+01	1.60E+01	1.50E+01	8.43E+03
Vinyl Chloride	µg/kg	1.50E+02	3.00E+02	5.40E+01	4.70E+01	1.30E+03	6.04E+02	7.90E+01	6.30E+01	1.70E+03	1.70E+02	3.07E+02	6.80E+01	2.60E+03
1,2,4-Trichlorobenzene	µg/kg	7.00E+02	-	3.81E+01	-	5.57E+02	-	6.93E+01	-	1.30E+03	-	2.10E+02	-	3.20E+03
1,3,5-Trichlorobenzene	µg/kg	4.10E+02	1.40E+01	1.60E+01	3.20E+01	9.41E+01	3.37E+01	3.10E+00	1.00E+00	2.70E+02	3.04E+01	3.50E+00	7.90E+00	5.30E+02
Semi-Volatile Organic Compounds														
Acetophenone	µg/kg	3.20E+00	2.10E+02	3.40E+03	2.00E+02	5.70E+04	6.00E+02	8.44E+03	4.20E+02	1.41E+02	1.00E+03	2.02E+04	1.01E+03	3.90E+02
Benzaldehyde	µg/kg	4.70E+00	1.70E+02	3.27E+03	1.60E+02	8.04E+04	2.11E+02	8.60E+03	3.07E+02	2.17E+02	8.80E+02	1.01E+04	6.81E+02	5.90E+02
Aniline	µg/kg	2.10E+02	2.31E+03	1.00E+04	2.20E+03	1.17E+05	4.03E+03	2.85E+04	4.80E+03	2.91E+04	9.20E+03	6.20E+04	9.10E+03	6.90E+02
Benzophenone	µg/kg	3.00E+00	7.00E+00	1.50E+01	3.10E+01	1.14E+04	8.80E+00	2.40E+01	4.60E+00	4.20E+03	3.00E+00	1.45E+01	3.00E+00	1.80E+04
Benzonitrile	µg/kg	2.40E+02	8.00E+00	1.70E+01	1.60E+01	1.20E+04	9.70E+02	1.07E+03	6.50E+02	3.04E+04	1.91E+04	2.00E+04	2.00E+04	1.20E+04
Benzyl Alcohol	µg/kg	7.60E+04	6.80E+04	1.27E+05	4.30E+04	1.41E+07	7.04E+04	1.32E+05	4.50E+04	4.11E+07	7.10E+04	1.34E+05	4.60E+04	9.20E+02
Benzyl Benzoate	µg/kg	8.00E+04	1.20E+04	2.00E+04	1.51E+03	9.91E+04	1.40E+04	2.50E+04	6.50E+03	1.72E+05	1.60E+04	2.81E+04	1.60E+04	6.10E+03
Benzyl Propyl Ether	µg/kg	2.60E+04	8.70E+00	1.60E+01	6.60E+00	4.90E+04	1.20E+01	3.40E+01	3.40E+01	1.10E+05	1.50E+01	2.70E+01	9.21E+00	2.04E+04
Chrysene	µg/kg	4.00E+04	1.10E+02	2.10E+02	7.07E+01	2.93E+04	1.30E+02	2.50E+02	8.60E+01	9.02E+04	1.50E+02	2.10E+02	9.07E+01	2.30E+02
Dibenz[a,h]anthracene	µg/kg	2.50E+01	2.50E+02	2.50E+04	2.67E+02	1.87E+01	4.04E+02	6.20E+04	4.80E+02	4.73E+04	8.70E+02	1.20E+05	9.74E+02	1.13E+02
Fluorene	µg/kg	1.00E+02	1.10E+02	4.50E+03	1.60E+02	3.60E+01	3.01E+02	1.07E+04	3.77E+02	7.65E+04	6.00E+02	2.64E+04	1.70E+02	1.60E+02
Indeno[1,2,3-cd]pyrene	µg/kg	2.00E+04	4.84E+03	1.64E+04	5.10E+03	6.10E+02	5.74E+03	1.77E+04	2.80E+03	1.50E+01	6.37E+03	1.22E+04	4.50E+03	2.60E+01
Phenanthrene	µg/kg	5.50E+01	2.50E+01	5.00E+02	9.10E+01	2.60E+01	2.04E+02	1.25E+04	2.01E+02	8.60E+01	3.81E+02	2.80E+04	3.70E+02	2.14E+02
Pyrene	µg/kg	1.80E+01	5.60E+02	0.16E+04	1.60E+02	2.20E+00	1.60E+03	1.44E+04	1.64E+03	5.60E+00	1.60E+03	1.07E+05	1.64E+03	1.30E+04
Benzo[a]pyrene	µg/kg	3.00E+00	1.21E+00	2.60E+02	2.30E+02	9.11E+01	1.40E+00	2.81E+00	6.40E+01	2.21E+00	1.20E+00	2.00E+00	9.80E+01	5.40E+00
Naphthalene	µg/kg	1.90E+01	2.80E+01	1.80E+03	1.54E+03	1.04E+01	8.80E+01	3.90E+03	3.70E+03	1.81E+02	1.40E+02	2.77E+03	2.71E+02	4.30E+02
Phenol	µg/kg	-	4.21E+02	3.37E+02	1.84E+02	4.16E+04	3.50E+02	4.20E+02	2.00E+02	8.15E+04	2.50E+03	1.21E+02	4.10E+02	1.74E+05

GENERIC ASSESSMENT CRITERIA FOR HUMAN HEALTH - RESIDENTIAL WITH PRIVATE GARDENS

Table 7
Human Health Generic Assessment Criteria by Pathway for Residential Scenario - Private Gardens

Compound	Notes	GAC (mg/g)	SAC Appropriate to Pathway SOM 1% (mg/kg)			Soil Saturation Limit (mg/kg)	SAC Appropriate to Pathway SOM 2.5% (mg/kg)			Soil Saturation Limit (mg/kg)	SAC Appropriate to Pathway SOM 6% (mg/kg)			Soil Saturation Limit (mg/kg)
			Oral	Inhalation	Combined		Oral	Inhalation	Combined		Oral	Inhalation	Combined	
Total Petroleum Hydrocarbons														
Aliphatic hydrocarbons C ₁₀ -C ₁₄		1.00E+01	4.70E+03	2.00E+01	2.00E+01	3.00E+02	1.00E+04	5.00E+01	5.00E+01	5.00E+02	2.00E+04	3.00E+02	3.00E+02	1.10E+03
Aliphatic hydrocarbons >C ₁₅ -C ₁₉		5.40E+00	1.40E+04	3.20E+01	3.20E+01	1.40E+02	2.20E+04	1.00E+02	1.00E+02	3.20E+02	6.00E+04	3.70E+02	3.70E+02	7.00E+02
Aliphatic hydrocarbons >C ₂₀ -C ₂₄		2.30E+01	1.40E+03	3.00E+01	3.00E+01	7.70E+01	2.40E+03	3.00E+01	3.00E+01	1.00E+02	3.00E+03	1.00E+02	1.00E+02	4.50E+02
Aliphatic hydrocarbons >C ₂₅ -C ₂₉		2.60E+02	3.00E+02	9.00E+01	9.00E+01	4.70E+01	4.00E+03	2.00E+02	2.00E+02	1.10E+02	4.00E+03	6.00E+02	6.00E+02	2.00E+02
Aliphatic hydrocarbons >C ₃₀ -C ₃₄		7.60E+01	4.00E+03	7.00E+02	7.00E+02	2.00E+01	4.00E+03	1.00E+02	1.00E+02	5.00E+01	4.00E+03	4.00E+02	4.00E+02	1.00E+02
Aliphatic hydrocarbons >C ₃₅ -C ₃₉	(d)	4.50E+04	4.50E+04	-	-	8.00E+00	6.00E+04	-	-	2.00E+01	7.00E+04	-	-	5.00E+01
Aliphatic hydrocarbons >C ₄₀ -C ₄₄	(d)	4.50E+04	4.50E+04	-	-	8.00E+00	6.00E+04	-	-	2.00E+01	7.00E+04	-	-	5.00E+01
Aromatic hydrocarbons >C ₁₀ -C ₁₄ (naphthalene)		7.00E+02	1.00E+02	2.00E+02	2.00E+02	3.00E+02	3.00E+02	3.00E+02	3.00E+02	1.00E+03	3.00E+02	3.00E+02	3.00E+02	3.00E+03
Aromatic hydrocarbons >C ₁₅ -C ₁₉		7.00E+00	5.00E+01	3.00E+01	3.00E+01	6.00E+02	1.00E+02	3.00E+01	3.00E+01	1.00E+03	3.00E+02	3.00E+02	3.00E+02	3.00E+03
Aromatic hydrocarbons >C ₂₀ -C ₂₄		2.00E+01	7.00E+01	1.00E+02	1.00E+02	3.00E+01	3.00E+02	3.00E+02	3.00E+02	6.00E+02	3.00E+02	3.00E+02	3.00E+02	2.10E+03
Aromatic hydrocarbons >C ₂₅ -C ₂₉		5.00E+00	1.00E+02	2.00E+02	2.00E+02	1.00E+02	3.00E+02	3.00E+02	3.00E+02	4.00E+02	3.00E+02	3.00E+02	3.00E+02	1.00E+03
Aromatic hydrocarbons >C ₃₀ -C ₃₄	(d)	-	2.00E+02	-	-	3.00E+01	3.00E+02	-	-	1.00E+02	3.00E+02	-	-	3.00E+02
Aromatic hydrocarbons >C ₃₅ -C ₃₉	(d)	-	8.00E+02	-	-	4.00E+01	3.00E+02	-	-	1.00E+02	3.00E+02	-	-	3.00E+02
Aromatic hydrocarbons >C ₄₀ -C ₄₄	(d)	-	8.00E+02	-	-	4.00E+01	3.00E+02	-	-	1.00E+02	3.00E+02	-	-	3.00E+02
Aromatic hydrocarbons >C ₄₅ -C ₄₉	(d)	-	8.00E+02	-	-	4.00E+01	3.00E+02	-	-	1.00E+02	3.00E+02	-	-	3.00E+02

Notes:

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

NR - the compound is not volatile and therefore a soil saturation limit not calculated within CLEA

FC - equivalent carbon. GAC - groundwater assessment criteria. SAC - soil assessment criteria.

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

Calculated SAC exceeds soil saturation limit and may significantly affect the interpretation of any exceedances into the contribution of the indoor and outdoor vapour pathway to total exposure is >10%. This shading has also been used for the RBCA output where the theoretical solubility limit has been exceeded. The SAC has been taken as the model calculated SAC with the saturation limit shown in brackets.
Calculated SAC exceeds soil saturation limit but does not affect the SNV signficantly since the contribution of the indoor and outdoor vapour pathway to total exposure is <10%.
Calculated SAC does not exceed the soil saturation limit.

For compounds where the theoretical solubility limit within RBCA has been exceeded in production of the GAC, these cells have also been shaded red

The SAC for organic compounds are dependent upon soil organic matter (SOM) (%) content. In this SAC SOM from total organic carbon (TOC) (%) divided by 0.58. 1% SOM is 0.55% TOC. (R. Flaws Soil Science: Methods and Applications, Lewis, 1994)

SAC for TPH fractions, polycyclic aromatic hydrocarbons, MIBK, BTEX and insecticides compounds were produced using an attenuation factor for the indoor air inhalation pathway of 10 to reduce conservatism associated with the vapour inhalation pathway. Section 10.1.1, SNV

(a) GAC taken as lowest Soil Guideline Value (owing to uncertainty regarding toxicological approach to be adopted by the Environment Agency)

(b) GAC taken from the Environment Agency SNV reports published 2009

(c) SAC for aliphatic, cycloalkane and aromatic hydrocarbons $\text{C}_{10}\text{H}_{22}$ does not include inhalation pathway owing to absence of toxicity data. SAC for aromatic is only based on oral calculation (rather than combined) owing to the relative small contribution from inhalation in accordance with the SNV report. This same approach has been adopted for the

(d) SAC for chlorinated naphthalene, chlorinated biphenyl and naphthalene is based on the inhalation pathway only owing to an absence of toxicity for chemical category, in accordance with the SNV report for naphthalene and LQM report for chlorinated biphenyl

Table 8
Human Health Generic Assessment Criteria for Residential Scenario - Private Gardens

Compound	GrAC for Groundwater (mg/l)	SAC for Soil SOM 1% (mg/kg)	SAC for Soil SOM 2.5% (mg/kg)	SAC for Soil SOM 6% (mg/kg)
Metals				
Arsenic	-	32	32	32
Cadmium	-	10	10	10
Chromium (III) - oxide	-	3,000	3,000	3,000
Chromium (VI) - hexavalent	-	4.3	4.3	4.3
Copper	-	2,300	2,300	2,300
Lead	-	450	450	450
Elemental Mercury (Hg ⁰)	0.009	0.17	0.42	1.0
Inorganic Mercury (Hg ²⁺)	-	170	170	170
Methyl Mercury (Hg ⁴⁺)	20	7.4	9.6	11
Nickel	-	130	130	130
Selenium	-	350	350	350
Zinc	-	3,800	3,800	3,800
Cyanide	-	3.7	3.7	3.7
Volatile Organic Compounds				
Benzene	7	0.079	0.157	0.33
Toluene	1,900	120	270	610
Ethylbenzene	260	65	154	350
Xylene - m	100	44	103	240
Xylene - o	87	45	106	250
Xylene - p	84	42	98	230
Total xylene	84	44	103	240
Methyl tertiary butyl ether (MTBE)	2,200	1.8	3.7	7.4
Trichloroethene	1.8	0.11	0.2	0.49
Tetrachloroethene	3.6	0.94	2.1	4.8
1,1,1-Trichloroethane	26	6.2	12.7	28
1,1,1,2-Tetrachloroethane	14	0.89	2.1	4.8
1,1,2,2-Tetrachloroethane	14	1.4	2.87	6.3
Carbon Tetrachloride	0.055	0.018	0.039	0.089
1,2-Dichloroethane	0.30	0.0053	0.0080	0.014
Vinyl Chloride	0.019	0.00047	0.0006	0.001
1,2,4-Trimethylbenzene	0.075	0.35	0.85	2.1
1,3,5-Trimethylbenzene	0.047	0.46	1.1	2.6
Semi-Volatile Organic Compounds				
Acenaphthene	3.2	210	480	1,000
Acenaphthylene	4.2	170	400	850
Anthracene	0.021	2,300	4,900	9,200
Benzo(a)anthracene	0.0038	3.1	4.7	5.9
Benzo(b)fluoranthene	0.0020	5.6	6.5	7.0
Benzo(g,h,i)perylene	0.00026	44	46	47
Benzo(k)fluoranthene	0.00080	8.5	9.6	10
Chrysene	0.0020	6.0	8.0	9.3
Dibenzo(a,h)anthracene	0.00060	0.76	0.86	0.90
Fluoranthene	0.23	260	460	670
Fluorene	1.9	160	380	780
Indeno(1,2,3-cd)pyrene	0.0002	3.2	3.8	4.2
Phenanthrene	0.53	92	200	380
Pyrene	0.13	660	1,000	1,600
Benzo(a)pyrene	0.0038	0.83	0.94	1.0
Naphthalene	19	1.5	3.7	8.7
Phenol	-	180	290	420
Total Petroleum Hydrocarbons				
Aliphatic hydrocarbons EC ₆ -EC ₉	10	30	55	110
Aliphatic hydrocarbons >EC ₆ -EC ₉	5.4	73	160	370
Aliphatic hydrocarbons >EC ₈ -EC ₁₀	0.23	19	46	110
Aliphatic hydrocarbons >EC ₁₀ -EC ₁₂	0.034	93 (48)	230 (118)	540 (283)
Aliphatic hydrocarbons >EC ₁₂ -EC ₁₅	0.00076	744 (24)	1,700 (59)	3,000 (142)
Aliphatic hydrocarbons >EC ₁₀ -EC ₃₅	-	45,100 (8.48)	64,000 (21)	76,000
Aliphatic hydrocarbons >EC ₂₅ -EC ₃₄	-	45,100 (8.48)	64,000 (21)	76,000
Aromatic hydrocarbons >EC ₆ -EC ₁₀ (styrene)	7.4	130	316	700
Aromatic hydrocarbons >EC ₉ -EC ₁₀	7.4	27	65	150
Aromatic hydrocarbons >EC ₁₀ -EC ₁₂	25	69	160	346
Aromatic hydrocarbons >EC ₁₂ -EC ₁₅	5.8	140	310	593
Aromatic hydrocarbons >EC ₁₀ -EC ₂₁	-	250	480	770
Aromatic hydrocarbons >EC ₂₁ -EC ₃₅	-	890	1,100	1,230
Aromatic hydrocarbons >EC ₃₅ -EC ₄₄	-	890	1,100	1,230

Notes:

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

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

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

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

The SAC has been set as the model calculated SAC with the saturation limit shown in brackets.
For consistency where the GrAC exceeds the solubility limit, GrAC has been set at the solubility limit. The GrAC is conservative since concentrations of the chemical are very unlikely to be at sufficient concentration to result in an exceedance of the health criteria value at the point of exposure (i.e. indoor air) provided free-phase product is absent.

REFERENCES

- 1) Environment Agency, 31 March 2009, May 2009 and September 2009. Science Report SC050021 / benzene SGV, toluene SGV, ethylbenzene SGV, xylene SGV, mercury SGV, selenium SGV, nickel SGV, arsenic SGV, cadmium SGV, phenol SGV, dioxins, furans and dioxinlike PCBs SGVs. Supplementary information for the derivation of SGV for: benzene, toluene, ethylbenzene, xylene, mercury, selenium, nickel, arsenic, cadmium, phenol, dioxins, furans and dioxin-like PCBs. Contaminants in soil: updated collation of toxicological data and intake values for humans: benzene, toluene, ethylbenzene, xylene, mercury, selenium, nickel, arsenic, cadmium, phenol, dioxins, furans and dioxin-like PCBs.
- 2) Environment Agency, January 2009. Science Report SC050021/SR2 Human Health Toxicological Assessment of Contaminants in Soil.
- 3) Environment Agency, January 2009. Science Report SC050021/SR3 Updated Technical Background to the CLEA Model.
- 4) Environment Agency, September 2009. Science Report SC050021/SR4 CLEA Software (Version 1.05) Handbook.
- 5) Environment Agency. 2008. Science Report SC050021/SR7. Compilation of Data for Priority Organic Pollutants for Derivation of Soil Guideline Values.
- 6) Land Quality Management (LQM) and Chartered Institute of Environmental Health (CIEH) 2009. The LQM/CIEH Generic Assessment Criteria for Human Health Risk Assessment. 2nd Edition.
- 7) The Soil Generic Assessment Criteria for Human Health Risk Assessment, Report ref. ISBN 978-1-905046-20-1, December 2009, published by CL:AIRE
- 8) Changes made to the CLEA framework documents after the 3 month evaluation period in 2008, released January 2009 by the Environment Agency.

APPENDIX F

Generic Assessment Criteria for Phytotoxic Effects, Pipelines and Controlled Waters

GENERIC ASSESSMENT CRITERIA FOR PHYTOTOXIC EFFECTS, PIPELINES AND CONTROLLED WATERS

This appendix presents the generic assessment criteria (GAC) that RSK considers are suitable for assessing risks to:

- Vegetation via the uptake of phytotoxic determinants through plant roots;
- Water supply pipes constructed using conventional pipe materials, i.e. polyethylene; and
- Controlled waters.

The GAC for each of these receptors is discussed in turn.

PHYTOTOXIC DETERMINANTS TO FACILITATE HEALTHY PLANT GROWTH

Copper and zinc can inhibit plant growth but are not normally hazardous to human health. The GAC for this pollutant linkage have been taken from Department of the Environment Publication, Code of Practice for Agricultural Use of Sewage Sludge, 1996. The GAC for the phytotoxic determinants are presented in Table A1. The table also includes nickel since this is also phytotoxic determinant and the Soil Guideline Value (SGV which is protective of human health) for a commercial (5000mg/kg) or residential without plant uptake (75mg/kg) is greater than the GAC to protect plant growth in acidic soil. Therefore, the SGV may not be suitably protective of the phytotoxic effects pathway.

Table A1: Generic Assessment Criteria for Phytotoxic Determinants

Determinant	Generic Assessment Criteria (mg/kg)			
	pH 5.0 < 5.5	pH 5.5 < 6.0	pH 6.0 < 7.0	pH >7.0
Zinc	200	200	200	300
Copper	80	100	135	200
Nickel	50	60	75	110

WATER SUPPLY PIPES

Risks to water supply pipes have been assessed in accordance with the Water Regulations Advisory Scheme Information and Guidance Note 9-04-03, dated October 2002.

The regulations include a requirement to use only suitable materials when laying water pipes and laying water pipes without protection is not permitted at contaminated sites. The water supplier has a statutory duty to enforce the regulations. Therefore, this assessment is a guide, the results of which should be checked with the water supplier.

Since water supply pipes are typically laid at a minimum depth of 750mm below finished ground levels, sample results from depths between 0.5m and 1.5m below finished level are generally

considered suitable for assessing risks to water supply. Samples outside these depths can be used providing the strata is the same as that in which water supply pipes are likely to be located. The GAC for this linkage are recorded in Table A2 and are based on recommendations of the 'Foundation for Water Research Guidance Note, FR0448: Laying Potable Water Pipelines in Contaminated Ground, 1994'. Owing to the number of caveats and lack of research into contaminants that could affect water supply, the water industry has undertaken research on a project entitled 'Pipe Materials Selection and Specification for use in Contaminated Land'. This document will be used to update the GAC for this pathway once available.

Table A2: Generic Assessment Criteria for Water Supply Pipes

CONTAMINANT	GAC (mg/kg dried soil)
Corrosion	
Sulphate (SO ₄)	2000
Sulphur (S)	5000
Sulphide	250
pH	Less than pH5 Greater than pH8
Toxic Substances	
Antimony (Sb)	10
Arsenic (As)	10*
Cadmium (Cd)	3
Chromium (hexavalent) (Cr)	25
Chromium (total) (Cr)	600
Cyanide (free) (CN)	25*
Cyanide (complexed) (CN)	250*
Lead (Pb)	500
Mercury (Hg)	1
Selenium (Se)	3
Thiocyanate (SCN)	50
Organic Contaminants	
Coal Tar	50
Cyclohexane extractable	50
Phenol	5
Polycyclic Aromatic Hydrocarbons	50
Toluene extractable	50
Petroleum Hydrocarbons	50
Notes: * denotes 'it is not recommended that water pipes should be laid in sites where these substances are identified or suspected'.	

CONTROLLED WATERS

The GAC for controlled waters are presented in Table A3. In line with the Environment Agency's Remedial Targets Methodology dated December 2006, the GAC for controlled waters are termed 'target concentrations'.

The target concentration can be derived by several means with consideration to:

- Whether the substance is classified as List I or List II substance by the EU under the Groundwater Directive 80/68/EEC;
- Background concentrations in the aquifer; and
- Published guidance such as Environmental Quality Standards that are protective of ecology or The Water Supply (Water Quality) Regulations 2001 that are protective of drinking water.

A list of target concentrations considered suitable to assess risks to principle aquifers and secondary aquifers are presented in Table A3. Those for a principal aquifer are taken from the UK Water Supply (Water Quality) Standards where possible owing to the possibility of a drinking water supply being within an influencing distance from the site or the possibility of one being installed. The target concentrations for a secondary aquifer are generally taken as the freshwater Environmental Quality Standards where available owing to groundwater in secondary aquifers commonly providing baseflow to surface watercourses.

Table A3: Target Concentrations for Controlled Waters

Determinant	Target Concentrations (mg/l)	
	Principal Aquifer/Source Protection Zone	Secondary Aquifer/Surface Watercourse
Metals		
Arsenic	0.01 ⁽¹⁾	0.05 ⁽⁷⁾
Cadmium	0.005 ⁽¹⁾	0.005 ⁽⁷⁾
Chromium (total)	0.05 ⁽¹⁾	0.005, 0.01, 0.02, 0.02, 0.05, 0.05 ⁽⁸⁾
Copper	2.0 ⁽¹⁾	0.001, 0.006, 0.01, 0.01, 0.01 0.028 ⁽⁸⁾
Lead	0.025 ⁽¹⁾	0.004, 0.01, 0.01, 0.02, 0.02, 0.02 ⁽⁸⁾
Mercury	0.001 ⁽¹⁾	0.001 ⁽⁷⁾
Selenium	0.01 ⁽¹⁾	0.01 ^(1,12)
Nickel	0.02 ⁽¹⁾	0.05, 0.1, 0.15, 0.15, 0.2, 0.2 ⁽⁸⁾
Zinc	5 ⁽²⁾	0.008, 0.05, 0.075, 0.075, 0.075, 0.125 ⁽⁸⁾

Chlorinated Solvents		
Trichloroethene	0.01 ⁽¹⁾	0.01 ⁽⁷⁾
Tetrachloroethene		0.01 ⁽⁷⁾
1,1,1-Trichloroethane	0.0001 ⁽³⁾	0.1 ⁽⁷⁾
1,1,2-Trichloroethane	0.0001 ⁽³⁾	0.4 ⁽⁷⁾
Carbon Tetrachloride	0.003 ⁽¹⁾	0.012 ⁽⁷⁾
1,2-Dichloroethane	0.003 ⁽¹⁾	0.01 ⁽⁷⁾
Vinyl Chloride	0.0005 ⁽¹⁾	0.0005 ^(1,12)
Trihalomethanes	0.1 ⁽⁴⁾	0.1 ^(4,12)
Chloroform (one of the trihalomethanes included above)	-	0.012 ⁽⁷⁾
Polycyclic Aromatic Hydrocarbons		
Acenaphthene	0.0058 ^(9,13)	0.0058 ⁽⁹⁾
Acenaphthylene	0.0058 ^(9,13)	0.0058 ⁽⁹⁾
Anthracene	0.000012 ^(9,13)	0.000012 ⁽⁹⁾
Benzo(a)anthracene	0.000018 ^(9,13)	0.000018 ⁽⁹⁾
Benzo(b)fluoranthene	0.0001 ⁽¹⁾	0.000014 ⁽⁹⁾
Benzo(k)fluoranthene		0.000014 ⁽⁹⁾
Benzo(g,h,i)perylene		0.00002 ⁽⁹⁾
Indeno(1,2,3-cd)pyrene		No data ⁽⁹⁾
Chrysene	0.00001 ^(9,13)	0.00001 ⁽⁹⁾
Dibenzo(a,h)anthracene	0.00001 ^(9,13)	0.00001 ⁽⁹⁾
Fluoranthene	0.00001 ^(9,13)	0.00001 ⁽⁹⁾
Fluorene	0.0021 ^(9,13)	0.0021 ⁽⁹⁾
Phenanthrene	0.003 ^(9,13)	0.003 ⁽⁹⁾
Pyrene	0.00004 ^(9,13)	0.00004 ⁽⁹⁾
Benzo(a)pyrene	0.00001 ⁽¹⁾	0.000015 ⁽⁹⁾
Naphthalene	0.01 ^(9,13)	0.01 ⁽⁷⁾
Petroleum Hydrocarbons		
Total Petroleum Hydrocarbons	0.01 ⁽²⁾	0.01 ^(2,10)
Benzene	0.001 ⁽¹⁾	0.03 ⁽⁷⁾
Toluene	0.004 ⁽³⁾	0.05 ⁽⁷⁾
Ethylbenzene	0.02 ^(8,13)	0.02 ⁽⁸⁾
Xylene	0.003 ⁽³⁾	0.03 ⁽⁷⁾
Methyl t-Butyl ether	0.015 ⁽⁶⁾	0.015 ^(6,12)
Pesticides and Herbicides		
Aldrin	0.00003 ⁽¹⁾	0.00001 ⁽⁷⁾
Dieldrin	0.00003 ⁽¹⁾	0.00003 ^(1,12)
Heptachlor	0.00003 ⁽¹⁾	0.00003 ^(1,12)
Heptachlor epoxide	0.00003 ⁽¹⁾	0.00003 ^(1,12)
Other pesticides	0.0001 ⁽¹⁾	0.0001 ^(1,12)
Total pesticides	0.0005 ⁽¹⁾	0.0005 ^(1,12)

Endrin	0.000005 ^(7,13)	0.000005 ⁽⁷⁾
Total DDT	0.000025 ^(7,13)	0.000025 ⁽⁷⁾
Azinphos - methyl	0.00001 ^(7,13)	0.00001 ⁽⁷⁾
Cyfluthrin	0.000001 ^(7,13)	0.000001 ⁽⁷⁾
Demeton	0.0005 ^(7,13)	0.0005 ⁽⁷⁾
Dichlorvos	0.000001 ^(7,13)	0.000001 ⁽⁷⁾
Dimethoate	0.001 ^(7,13)	0.001 ⁽⁷⁾
Endosulphan	0.000003 ^(7,13)	0.000003 ⁽⁷⁾
Fenitrothion	0.000001 ^(7,13)	0.000001 ⁽⁷⁾
Flucifuron	0.001 ^(7,13)	0.001 ⁽⁷⁾
Malathion	0.00001 ^(7,13)	0.00001 ⁽⁷⁾
Mevinphos	0.00002 ^(7,13)	0.00002 ⁽⁷⁾
Omethoate	0.00001 ^(7,13)	0.00001 ⁽⁷⁾
PCSDs	0.00005 ^(7,13)	0.00005 ⁽⁷⁾
Permethrin	0.00001 ^(7,13)	0.00001 ⁽⁷⁾
Sulcofuron	0.025 ^(7,13)	0.025 ⁽⁷⁾
Triazaphos	0.000005 ^(7,13)	0.000005 ⁽⁷⁾
Atrazine & Simazine	0.002 ^(7,13)	0.002 ⁽⁷⁾
Bentazone	0.5 ^(7,13)	0.5 ⁽⁷⁾
Linuron	0.002 ^(7,13)	0.002 ⁽⁷⁾
Mecoprop	0.02 ^(7,13)	0.02 ⁽⁷⁾
Trifluralin	0.0001 ^(7,13)	0.0001 ⁽⁷⁾
Miscellaneous		
Cyanide	0.05 ⁽¹⁾	0.05 ^(1,12)
Phenol	0.0005 ⁽²⁾	0.03 ⁽⁷⁾
Sodium	200 ⁽¹⁾	170 ⁽⁷⁾
Chloride	250 ⁽¹⁾	250 ⁽⁷⁾
Ammonium (as NH ₄ ⁺)	0.5 ⁽¹⁾	0.5 ^(1,12)
Ammonia (NH ₃ as N)	0.015 ^(7,13)	0.015 ⁽⁷⁾
Sulphate	250 ⁽¹⁾	400 ⁽⁷⁾
Iron	0.20 ⁽¹⁾	1 ⁽⁷⁾
Manganese	0.05 ⁽¹⁾	0.05 ^(1,12)
Aluminium	0.2 ⁽¹⁾	0.2 ^(1,12)
Nitrate (as NO ₃)	50 ⁽¹⁾	50 ^(1,12)
Nitrite (as NO ₂)	0.5 ⁽¹⁾	0.5 ^(1,12)

Notes

1. Statutory Instrument 2000 No 3184. The Water Supply (Water Quality) Regulations.
2. Statutory Instrument 1989 No 1147. The Water Supply (Water Quality) Regulations, 1989.
3. Environment Agency. Minimum Reporting Values listed in Appendix 7 of Hydrogeological Risk Assessments for Landfills and the Derivation of Groundwater Control and Trigger Levels. LFTGN01. Note target concentration for xylenes is 0.003mg/l each for o-xylene and m/p xylene.
4. Statutory Instrument 1989 No 3184. The Water Supply (Water Quality) Regulations, 2000 – sum of chloroform, bromoform, dibromochloromethane and bromodichloromethane.
5. Target concentration for Principal Aquifer receptor taken as equal to target concentration for Secondary Aquifer owing to absence of published guidance for PAH compounds other than those which are carcinogenic.
6. Environment Agency MTBE Guidance.
7. Freshwater Environmental Quality Standards.
8. Freshwater Environmental Quality Standards for all fish life (including game) and dependent upon hardness range. Hardness ranges are: 0-50mg/l CaCO₃, 50-100 mg/l CaCO₃, 100-150 mg/l CaCO₃, 150-200 mg/l CaCO₃, 200-250 mg/l CaCO₃ and >250 mg/l CaCO₃. The target concentrations included in Table 3 are listed in order of increasing calcium carbonate concentrations.
9. Polycyclic Aromatic Hydrocarbons (PAH): Priorities for Environmental Quality Standard Development, WRc Plc, R&D Technical Report P45. 2002. Where Predicted No-Effect Concentration is below the laboratory method detection limit (LMDL) for chrysene, dibenzo(ah)anthracene and fluoranthene, the target concentration has been set at the LMDL of 0.00001mg/l.
10. Owing to hydrocarbons being List I substances, 0.01mg/l (DWS) should be used in the first instance against the total of the hydrocarbon bands. However, if the hydrocarbon concentrations measured in groundwater exceed this value, an alternative value of 0.05mg/l could be used providing it is justified based on the type of aquifer and distance to secondary receptors such as a stream. The value is taken as the lowest concentration in Statutory Instrument 1996 No. 3001 titled The Surface Waters (Abstraction for Drinking Water) (Classification) Regulations, 1996.
11. Value for ethylbenzene taken from R&D Technical Report P2-115/TR4 – Proposed Environmental Quality Standards for Ethylbenzene in Water.
12. Where a published target concentration considered suitable for use with a minor aquifer could not be found for certain substances such as selenium, the target concentration used for the major aquifer has been adopted.
13. Where a published target concentration considered suitable for use with a major aquifer could not be found for certain substances such as ethylbenzene, the target concentration used for the minor aquifer has been adopted.

∴ A target concentration for chloroform for a principal aquifer is absent since it is one of the trihalomethane compounds. See note 4 above.