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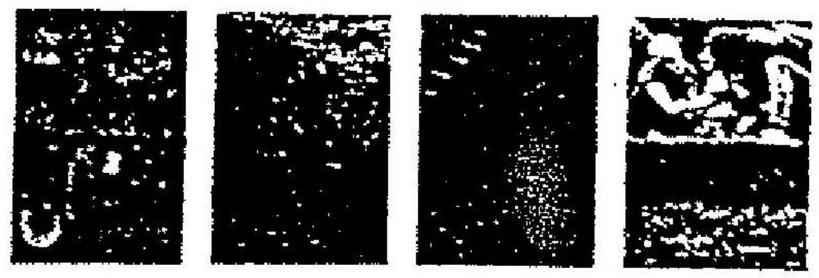
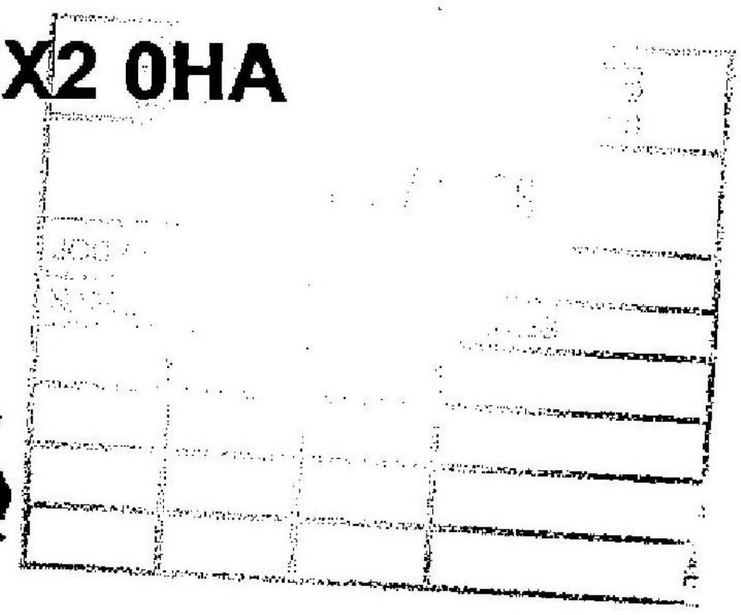


September 2003 - Corsair Project Number: 03-276.01

Stage I/II Geo-Environmental Risk Assessment
at
Toys R Us, Botley Road, Oxford, OX2 0HA
on behalf of



STAGE I/II GEO-ENVIRONMENTAL RISK ASSESSMENT
AT
TOYS R US, BOTLEY ROAD, OXFORD. OX2 0HA.
ON BEHALF OF
TOYS R US

Corsair Project No 03-276.01

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September 2003

CONTENTS - 1

Executive Summary

1.0 Introduction 1
- 1.1 Instruction 1
- 1.2 Scope of Works 1
- 1.3 Site Location 2

2.0 Site Inspection 3
- 2.1 RICS Property Observation Checklist 3
- 2.2 Site Inspection Summary 3

3.0 Site History 5
- 3.1 Historical Map Review 5
- 3.2 Historical Map Interpretation 6
- 3.3 Archaeology 6

4.0 Geology and Mining 7
- 4.1 Geology 7
- 4.2 Mining and Subsidence 7

5.0 Environmental Setting 8
- 5.1 Hydrology 8
- 5.2 Hydrogeology 8
- 5.3 Waste Management 8
- 5.4 Statutory Registers and Authorisations 9
- 5.5 Hazardous Elements and Ground Gases 9
- 5.6 Environmental Setting Summary 9

6.0 Statutory Authority Enquiries 11
- 6.1 Local Authority 11
- 6.2 Environment Agency 11
- 6.3 Petroleum Officer 11
- 6.4 Building Control Department 11

7.0 Contaminative Land Uses 12
- 7.1 On Site 12
- 7.2 Surrounding Area 12

8.0 Qualitative Risk Assessment 13
- 8.1 Qualitative Risk Summary 13
- 8.2 Qualitative Risk Assessment 13
  - 8.2.1 Sources 13
  - 8.2.2 Pathways 14
  - 8.2.3 Targets 14
  - 8.2.4 Pollutant Linkages 14
- 8.3 Risk Estimation 15

CONTENTS - 2

9.0 Site Investigation Fieldwork	**16**
9.1 Method Statement and health and Safety	16
9.2 Site Characterisation	16
9.3 Cable Percussion Boreholes	16
9.4 Hazardous Soil Gas and Groundwater Monitoring Installations	17
9.5 Trial Pits	18
9.6 Hand Dug Trial Pits	18
9.7 Sampling	18
10.0 Strata Encountered	**20**
11.0 Laboratory Analysis	**22**
11.1 Geotechnical Analysis	22
11.2 Contamination Analysis	22
12.0 Geotechnical Appraisal	**24**
12.1 Foundation Design	24
12.1.1 Shallow Foundations	24
12.1.2 Piled Foundations	24
12.1.3 Ground Bearing Floor Slab	24
13.0 Environmental Appraisal	**26**
13.1 Guidance and Methodology	26
13.2 Soil Samples	26
13.3 Leachate Testing	30
13.4 Groundwater Samples	35
13.5 Summary	39
14.0 Environmental Risk Assessment	**41**
14.1 Environmental Site Investigation	41
14.2 Qualitative Risk Assessment Methodology	41
14.2.1 Sources	41
14.2.2 Pathways	42
14.2.3 Targets	42
14.2.4 Pollutant Linkages and Risk Assessment	42
14.3 Waste Management	43
14.4 Buried Concrete	43
14.5 Hazardous Ground Gases	43
15.0 Conclusions & Recommendations	**44**
16.0 Limitations to Geo-Environmental Risk Assessments	**45**

FIGURES

Figure 1	Site Location Plan
Figure 2	Street Plan
Figure 3	Site Layout Plan (Extract) and Proposed Extension
Figure 4	Extract from Ordnance Survey Plan of 1876
Figure 5	Extract from Ordnance Survey Plan of 1900
Figure 6	Extract from Ordnance Survey Plan of 1922
Figure 7	Extract from Ordnance Survey Plan of 1938
Figure 8	Extract from Ordnance Survey Plan of 1958
Figure 9	Extract from Ordnance Survey Plan of 1968
Figure 10	Extract from Ordnance Survey Plan of 1972
Figure 11	Extract from Ordnance Survey Plan of 1981
Figure 12	Extract from Ordnance Survey Plan of 1982
Figure 13	Extract from Ordnance Survey Plan of 1991
Figure 14	Geological Extract from BGS Survey Sheet 236 Witney
Figure 15	Exploratory Hole Location Plan
Figure 16	Cross-Section A - A

APPENDICES

Appendix I	Borehole and Trial Pit Records
Appendix II	Geotechnical Test Results
Appendix III	Contamination Test Results
Appendix IV	References and other sources of information
Appendix V	Criteria for the Chemical and Biological GQA gradings
Appendix VI	Groundwater Vulnerability - Geological Classification Definitions
Appendix VII	Groundwater Vulnerability - Soil Classification Definitions
Appendix VIII	Letter received from Environment Agency, 3rd September 2003

EXECUTIVE SUMMARY
STAGE I/II GEO-ENVIRONMENTAL RISK ASSESSMENT
AT
TOYS R US, BOTLEY ROAD, OXFORD, OX2 0HA
ON BEHALF OF
TOYS R US

Corsair Project No 03-276.01

Corsair Environmental Consultants Limited were commissioned by Toys R Us, through MJMC Consulting Engineers, to perform a Stage I/II geo-environmental desk study and intrusive investigation at a site on the Botley Road, Oxford. The work is required to determine the past land usage, the existing ground conditions and associated geotechnical and environmental risks associated with the proposed extension to an existing store. The following principal findings have been established:

- The site is located in an established retail park located immediately to the south of Botley Road (A420) and to the east (0.5km) of the A34 Oxford ring road. The store is positioned to the west of Oxford city centre. The proposed extension is to the west of the existing store on an area of the site currently used for customer car parking. The site is generally level;

- Geological information indicates that the site is underlain by Alluvial Clay Deposits and associated River Terrace Deposits over Oxford Clay of Upper Jurassic age. The Oxford Clay deposits are recorded to depths up to 100 metres (m) in this area. There is no evidence of mineral extraction in the site locality;

- The underlying strata is considered a minor-aquifer (controlled water receptor). The nearest surface watercourse is the Seacourt stream which is located approximately 120m to the west of the site boundary. There are no recorded licensed abstraction points within 1000m from the site. The site lies within a river floodplain and there is a risk of flooding. The EA will require a flood risk assessment to be performed;

- Historical information indicates that up until around 1980 the site was undeveloped. At this time the site was partially developed as a 'Works' although the nature of the business is not known. A number of tanks are recorded within the site boundary and close to the site. In close proximity to the site a bakery and then a garage have been recorded with other 'works' and warehouses in the locality. Information from the Local Authority notes that a garage was demolished close to the site in the early 1990's when the Toys R Us store was constructed;

- Risk of potential contamination exists within the site and the surrounding area from the sites historical use and includes hydrocarbons, metals, acids and alkalis, sulphates and asbestos. Sensitive receptors exist in the form of controlled waters, site workers and development end use. It is therefore possible that the contaminated land hazard identification convention (i.e. source-pathway receptor pollutant linkage) may be complete for this site;

- Made ground was encountered below the site to an average depth of 1.50m below ground level (bgl) comprising predominantly of sand and gravel of flints, brick and concrete intermixed with occasional cobbles of brick, concrete and sandstone together with pieces of wood. The made ground overlies soft slightly organic alluvial CLAY River Terrace GRAVEL was recorded to underlie the clay to depths between 5.70m and 7.10m. OXFORD CLAY was proven to underlie the gravel deposits. Groundwater under slight artesian pressure was encountered within the gravels and was monitored in the boreholes at depths between 2.39 and 2.52 m bgl.

- The Oxford Clay Deposits would provide a suitable stratum for piled foundations. Using pre cast concrete driven piles 8m in length anticipated loadings between 115kN (0.3m) and 230kN (0.5m) may be achieved;

- With an anticipated loading of 20KN/m2 Settlement below the centre of the ground bearing floor slab is likely to be 40mm, where the maximum slope across the floor slab would be 1 in 1200, should greater loadings be required then a suspended floor slab should be considered;

- When compared to the CLEA Guidance the results of soil contamination testing indicate that for the proposed end-use the levels detected would not affect the development of the site. It would be prudent to provide an appropriate depth of clean subsoil and topsoil, (0.75 metre), in areas proposed for soft landscaping;

- Provision should be made for the removal of any hydrocarbon impacted soils that may be associated with the historical tanks;

- Buried concrete should be designed to Design Sulphate Class DS1 and ACEC AC-1;

- Results of gas monitoring indicate that soil gases should be excluded from the proposed structure by means of ventilation of the ground bearing floor slab and provision of a gas impermeable membrane;

- Any soils which may need to be removed from site will have to go to an engineered landfill site.

STAGE I/II GEO-ENVIRONMENTAL RISK ASSESSMENT
AT
TOYS R US, BOTLEY ROAD, OXFORD. OX2 0HA.
ON BEHALF OF
TOYS R US

Corsair Project No 03-276.01

1.0 INTRODUCTION

1.1 INSTRUCTION

On behalf of Toys R Us Limited, Corsair Environmental Consultants Ltd (Corsair) have been instructed by MJMC, on 19th August 2003 to undertake a Stage I geo-environmental desk study (risk assessment) and a Stage II intrusive site investigation for a proposed extension at the following site;

Toys R Us Store, Botley Road,Oxford,OX2 OHA.

1.2 SCOPE OF WORKS

The Stage I geo-environmental desk study included an historical survey, site walkover to determine current site conditions and an examination of public domain environmental risk information. This information was then used to determine potential pollutant linkages on a source pathway target principle.

The Stage II intrusive site investigation included three cable percussion boreholes and four trial pits (TP) to obtain samples of the soils for geotechnical and contamination testing, additionally two hand dug trial pits were excavated to expose the existing store foundations. The investigation also included gas and groundwater borehole monitoring installations to identify the presence and proportions of methane, carbon dioxide and oxygen within the soil gas and the extent of groundwater. The investigation included the examination of existing store foundations.

This report presents the findings of the desk top study report and the site investigation. The intrusive investigation works were designed to assess the risks highlighted in the desk top study and to determine the ground conditions beneath the site and make recommendations with respect to the design of foundations and environmental issues which may affect the proposed extension. The report also includes an appraisal of the site using the Contaminated Land Exposure Assessment (CLEA) Model (March 2002) where appropriate with respect to human health.

1.3 SITE LOCATION

The site is located immediately to the south of Botley Road (A420) and to the east (0.5km) of the A34 Oxford ring road. The store is positioned to the west of Oxford city centre in the county of Oxfordshire at National Grid Reference 449250, 206150, as shown in Figures 1 and 2. The site bounded by the Botley Road to the north, a 'Wickes' DIY store and service yard to the west, a retail park with car parking areas to the east and a wooded area to the south. The proposed extension covers an area of approximately 1000m^2 . The centre of the site lies at approximately 57m Above Ordnance Datum (AOD).

2.0 SITE INSPECTION

2.1 RICS PROPERTY OBSERVATION CHECKLIST

A Corsair representative inspected the site on the 3rd September 2003 and any visible features of environmental risk were recorded in accordance with the relevant RICS Property Observation Checklist.

The observed uses within the property and in the vicinity of the site are noted as follows: -

Observed use of Site

	Yes	No
Industry / Manufacturing?	☐	☑
Waste Disposal or Waste Processing?	☐	☑
Surface or underground mineral working?	☐	☑
Vehicle maintenance or refuelling?	☐	☑

Evidence seen of such uses having taken place **within the vicinity of the Site**

	Yes	No
Industry / Manufacturing?	☐	☑
Waste Disposal or Waste Processing?	☐	☑
Surface or underground mineral working?	☐	☑
Vehicle maintenance or refuelling?	☐	☑
Was any watercourse observed within the vicinity?	☑	☐

2.2 SITE INSPECTION SUMMARY

The proposed area for the extension is located to the west of the existing store. The store was open for business at the time of the site inspection.

A plan showing the proposed extension is presented as Figure 3. Access was gained directly from Botley Road.

The proposed extension is rectangular in shape adjacent to the western elevation of the Toys R Us Store. The store itself is set back about 100m from the Botley Road and is of a steel column and brick panel construction with a corrugated plastic coated metal roof. An open area of level tarmac car parking is located between the store and the Botley Road. The existing store building is approximately 8 – 10m in height and is in a good state of repair.

A shallow gravel filled trench with venting pipes was recorded running around the store perimeter, possibly indicative of a methane drainage system. The location of the proposed extension is in an area currently used for customer car parking. A number of manholes were evident in the tarmac indicating buried services in this area. The store generator, boiler room and switch room were recorded adjacent to the western elevation. A concrete service yard was noted to the south of the store. The wooded area to the south west of the store building was fenced off with a 2m high metal security fence, the ground fell away beyond the fence line by about 4- 6 m to an open drain beyond. There was no defined boundary between the store and the surrounding retail units to the east.

The land surrounding the site is occupied by an area of mixed retail and office developments together with occasional residential properties. A significant office development and garage was evident to the east of the site near the junction of the A420 and A34 interchange.

3.0 SITE HISTORY

3.1 HISTORICAL MAP REVIEW

A historical map review was carried out and all salient points identified (Figures 4 through 13). A summary of the history of the site and the surrounding area is given in Table 1.

Table 1 – Historic Map Summary

Map Date	Site Land Use	Land Use in the Surrounding Area
1876 Fig 4	Open Land	Water Course –120m beyond western boundary. An area of marshland to the north-east. Village of Botley located 200m to the west.
1900 Fig 5	Open Land	Railway – 1100m E. Water Course – 120m W flowing east, 300m NE & 900m E. Land to the north noted 'Liable to Flooding'
1922 Fig 6	Open Land	Railway – 1100m E. Stream –120m W, 300m NE. Canal – 900m E.
1938 Fig 7	Open Land	Railway – 1100m E. Seacourt Stream –120m W, 300m NE. Canal - 900m E & 1100m E. Wharf 400m E. Allotment Gardens 250m NE.
1958 Fig 8	Open Land Overhead electricity pylons.	Works – 10m E. Bakery 50m N. Residential properties 100m NE. Warehouses120mE. Sports Ground 50m SE. Ditch – 5m SW. Hinksey Stream – 120m W.
1968 Fig 9	Open Land Overhead electricity pylons.	Works – 10m E& 200m NW Garage – 300m NW. Hinksey Stream – 120m W. Water Course – 300m NE & 950m NE. Drains – Numerous between 250 – 500m to the NW to NE.
1972 Fig 10	Open Land Overhead electricity pylons.	Works – 10mE & 200mNW. Garage – 300m NW. Warehouses – 100mE. Hinksey Stream –120m W. Botley Stream – 300m NE. Bulstake Stream – 500m NE. Drains – Numerous between 250 – 1200m away to the NW to NE & around 500-700m to the SE.

1981 Fig 11	Works (part) Tanks	Tanks – On site, 10m S & 10mE. Works – 10m E. Seacourt Stream – 120m W Drain – W edge of site. Warehouses 100m E. Electricity Pylon – 100m SE. Garage – 20mN.
1982 Fig 12	Works (part) Tanks	Works – 10mE & 200mNW. Garage – 300m NW. Warehouses – 100mE. Hinksey Stream –120m W. Botley Stream – 300m NE. Bulstake Stream – 500m NE. Drains – Numerous between 250 – 1200m away to the NW to NE & around 500-700m to the SE.
1991 Fig 13	Site cleared Tanks	Tanks – On site & 10W. Seacourt Stream –120m W Drain – W edge of site. Trading Estate 120mE.

3.2 HISTORICAL MAP INTERPRETATION

The historical maps indicate that the site was undeveloped until around the early 1980's when a 'Works' is shown to partly encroach on the site. The nature of the works is not known. A number of tanks are recorded both within the site and on the surrounding land, these are probably fuel tanks associated with the local businesses. A bakery (1958) and subsequently a garage were noted immediately to the north of the site in 1981. The site has a number of local watercourses in the vicinity with a ditch running along the south western boundary and the Seacourt or Hinksey stream about 120m to the west. The main potential sources of contamination to the site are the four separate tanks recorded within the site and in close proximity to the site. Other possible sources are the former use of the site to the north as a garage together with three 'Works' buildings in close proximity to the site, although the nature of the businesses is unknown. The area has many streams, rivers, canals and ditches with the maps from 1900, 1922 and 1938 all stating that the land a short distance to the north of the site is liable to flooding.

3.3 ARCHAEOLOGY

There is no evidence to suggest that the area has any archaeological significance.

4.0 GEOLOGY AND MINING

4.1 GEOLOGY

Reference to the British Geological Survey Sheet 236 (Figure 14) (1:50,000 Solid and Drift Edition) of Witney indicates the following sequence of strata to occur beneath the site:

- Quaternary **Alluvium** (Soft organic clays with bands of peat and gravel) over;
- River **Terrace Gravels** (Limestone, quartzite and flint pebbles) over; and,
- **Oxford Clay** of Upper Jurassic age. (Greenish grey mudstone with numerous bivalves).

The alluvial deposits are associated with the tributaries of the River Thames. The Hinskey and Seacourt streams are shown in close proximity to the site.

The alluvial deposits are shown to be underlain by the Oxford Clay which is recorded to be up to 100m thick in this area. Immediately to the west of the site an area of River terrace gravels associated with the Seacourt stream is also evident. The river terrace deposits are recorded to underlie the alluvial deposits.

A previous site investigation carried out by Structural Soils Limited in 1992 confirmed the strata sequence to be made ground recorded to depths between (1.0m – 3.0m) overlying alluvium (soft green grey clay with bands of peat) recorded to (1.8m – 3.8m) where present, overlying terrace gravels (dense – medium dense yellow brown sandy gravels) to depths between (5.5m – 6.8m) overlying Oxford Clay (very stiff green grey very thinly laminated clay) to 15.0m.

4.2 MINING AND SUBSIDENCE

All mining and subsidence information was obtained from Sitescope Ltd, search number 842967 September 2003.

The risk of shallow mining in the vicinity of the site is assessed to be very low. The Sitescope report indicates that there is a low overall risk of foundation damage to properties from natural subsidence hazards.

There are no known mines or quarries in the vicinity of the site.

5.0 ENVIRONMENTAL SETTING

5.1 HYDROLOGY

The nearest watercourse to the site is the Seacourt Stream, which is located approximately 120m to the west of the site boundary. A drain is recorded running along the western site boundary.

The "Quality of Rivers and Canals in England and Wales 1995" published by the Environment Agency (EA), gives a chemical rating of Grade C (fairly good) for the Oxford Canal. The chemical rating for the near by River Thames is grade A (very good), and biological rating grade c (fairly good).

There are no abstraction licences within 1000m of the site.

There are ten discharge consents between within 1000m of the site. Three are within 250m, one is a trade discharge from a mineral oil extraction plant, the other two are noted to be miscellaneous discharge. There is an additional miscellaneous discharge recorded between 250m-500m from the site and a further three between 500m-1000m, there are also three sewage discharges recorded between 500m-1000m of the site.

The Sitescope report did not give any indication of any pollution incidents close to the site.

The site is recorded to lie within a River Floodplain and flood risk assessment will be required by the EA for any proposed development.

5.2 HYDROGELOGY

The National Rivers Authority Groundwater Vulnerability Map Sheet 38, identifies the site to be underlain by strata classified as a Minor Aquifer with a high leaching potential.

Sitescope Limited search number 842967 September 2003, shows that there are no source protection zones within 1000m of the site.

5.3 WASTE MANAGEMENT

Waste management information was obtained from the EA (Appendix VIII) and Sitescope Limited.

There are no landfill sites currently active or previously active within 1000m of the site. There are no metal recycling or scrap yards recorded within 1000m of the site.

5.4 STATUTORY REGISTERS AND AUTHORISATIONS

All information concerning the location and distribution of entries on statutory registers and authorisations was obtained from Sitescope Limited, search number 842967 September 2003.

No fuel sites are listed between within 1000m of the site. There are no IPPC Part A Authorisations recorded within 1000m of the site. There are no radioactive consents recorded within 1000m of the site

5.5 HAZARDOUS ELEMENTS AND GROUND GASES

The British Geological Survey Technical Report WP/95/3, '*Potentially Harmful elements from natural sources and mining areas: characteristics, extent and relevance to planning and development in Great Britain*' locates the site as being in an area where the stream sediment concentrations are below the national average upper limit of background.

The British Geological Survey Technical Report WP/95/1, 'Methane, carbon dioxide, and oil seeps from natural sources and mining area: characteristics, extent and relevance to planning and development in Great Britain' locates the site as being in an area where gas and/or oil may be encounted in boreholes, underground mines or tunnels intersecting buried Carboniferous or younger strata. "Radon: Guidance on protective measures for new dwellings" BRE211, prepared by the Department of the Environment, Transport and Regions in 1999, indicates that the site is located within an area with low risk with less than 1% exceeding action level.

5.6 ENVIRONMENTAL SETTING SUMMARY

Table 2 – Environmental Setting Summary

		On Site	Surrounding Area
Hydrology	Nearest Surface Water Feature	None	Seacourt stream 120m beyond western boundary
	Discharge Consents	None	Ten
	Poilution Incidents	None	None
	Flood Plain	Yes	Large flood plain in area due to a number of rivers

Hydrogeology	Abstraction Licences	None	None
	Groundwater Vulnerability	Minor Aquifer	Minor Aquifer in much of the surrounding area
	Soil Leaching Potential	High	High
	Source Protection Zone	None	None
Waste Management	Current Landfill Sites	None	None
	Former Landfill Sites	None	None
	Scrap Yards	None	None
	Waste Treatment Sites	None	None
Statutory Registers and Authorisations	IPPC Part A	None	None
	COMAH Sites	None	None
	Hazardous Substance Consents	None	None
	Pollution Inventory	None	None
	Radioactive Consents	None	None
	Radio Masts	None	None
Hazardous Elements and Ground Gases	Hazardous Elements	Below national average upper limit of background	
	Methane, Carbon Dioxide and Oil Seeps	Gas/Oil may be encounted	
	Radon	Low	

6.0 STATUTORY AUTHORITY ENQUIRIES

6.1 LOCAL AUTHORITY

A telephone call from Oxford City Council Environmental Health Department on 27th August 2003 reported that there was an investigation performed on the site in 1992 which recorded elevated levels of methane thought to be from natural sources as there are no landfill sites within 1000m. Due to the elevated levels of methane it was recommended that a passive ventilation system should be incorporated in any new buildings constructed. The city council reported that they had received a letter from TOYS R US dated March 2003 which stated that the soil had previously been contaminated with oil due to the proximity of the site to a former garage prior to its development into the TOYS R US store.

6.2 ENVIRONMENT AGENCY

A letter dated 3rd September 2003 from the EA regarding the site confirmed that there are no waste management licenses or landfill sites in force within 250m of the site. The EA are aware of five contamination issues which have previously arisen within 250m from the site. However this does not mean that the site is currently contaminated or that these issues will have an impact on water sources in the area.

6.3 PETROLEUM OFFICER

The Petroleum Officer was not contacted in this instance.

6.4 BUILDING CONTROL DEPARTMENT

The building control department of Oxford City Council was contacted but would not divulge any information regarding ground conditions or existing foundation details.

7.0 CONTAMINATIVE LAND USES

The DoE (now DEFRA) produced a consultation paper in May 1991, which gave definitions of the types of contamination that can affect land. From this listing and information gained from other sections of this report, the following contaminative uses have been identified:

7.1 ON SITE

The results of the historical desk study indicate that the site was formerly occupied by a 'works' the nature of which is not known, additionally a number tanks (suspected fuel tanks) were recorded within and close to the site perimeter.

C.14 INFRASTRUCTURE

C14c) Dismantling, repairing or maintenance of road transport and road haulage; Garages and filling stations.

C.16 MISCELLANEOUS

c.16c) Demolition of buildings, plant or equipment used for any of the activities in this schedule.

7.2 SURROUNDING AREA

A bakery, garage and a number of 'works' have been recorded in close proximity to the site. Demolition from the redevelopment works have also been recorded over a number of years. The surrounding units are currently occupied by a variety of retail enterprises.

C.14 INFRASTRUCTURE

C14c) Dismantling, repairing or maintenance of road transport and road haulage; Garages and filling stations.

From the CLEA report CLR8 & Corsair Environmental Consultants Ltd list of possible contaminants associated with the DEFRA contaminative uses the following contaminants *may* be encountered:

Contaminants associated with the works and the tanks may include hydrocarbons, heavy metals, sulphate and asbestos from the demolition works. The anticipated contaminants would be of a similar nature in the surrounding area. In particular the former garage to the north of the site may give rise to hydrocarbons, acids and alkali's and heavy metals.

8.0 QUALITATIVE RISK ASSESSMENT

8.1 QUALITATIVE RISK SUMMARY

Table 3 – Qualitative Risk Summary

	Risk		
Area of Review	**Low**	**Medium**	**High**
Site History	None	Former 'works' and tanks	None
Site Inspection	None	None	None
Geology and Mining	None	Methane	None
Hydrology	None	On site drains Area liable to flooding	None
Hydrogeology	None	Minor Aquifer	None
Other Data	None	None	None
Radon	Low Risk	None	None
Previous Site Investigation	None	Slight oil contamination Noted	None

8.2 QUALITATIVE RISK ASSESSMENT

Once hazards or potential hazards have been identified, it is necessary to assess the associated risks by considering a Source-Pathway-Receptor (Target) relationship, or Pollutant Linkage.

For a risk to exist as a result of the presence of contamination in, on or under land there must be:

i) a contaminant or potential pollutant (SOURCE);

ii) a PATHWAY; and

iii) a receptor (TARGET).

A risk only exists if all three are present.

8.2.1 SOURCES

Sources of potential contamination would be from the previous uses of the property as works and from the tanks identified on site, detailed in Section 7 above.

8.2.2 PATHWAYS

Pathways between sources of contamination and targets may exist to human receptors by ingestion, skin contact, inhalation and ingestion; by direct contact with the development end use and by soil leachability i.e. lateral and vertical migration of contaminants in groundwater, providing a pathway for soluble contaminants to migrate onto or off site, free product flow to controlled water targets.

8.2.3 TARGETS

Potential targets include;

Human health; site workers, end users and visitors to the site.

Development end use; contact with buildings, services, surfacing and landscaping areas.

Controlled Waters; groundwater (River Terrace Gravels) and surface waters (Seacourt Stream).

8.2.4 POLLUTANT LINKAGES

A risk is present if the contamination identified in the soils and groundwater at the site comes into direct contact with site users and occupiers, plants and animals, any infrastructure running through contaminated soils, ground and surface waters and construction workers when the store extension is developed.

The presence and extent of any contamination has been determined by an intrusive investigation whereby secure samples of the soils were taken from the site.

Three main risks exist for contamination, which are for:

- Processes on the site to contaminate the site itself;
- Processes on the site to contaminate its surroundings;
- Processes carried out in the surroundings to contaminate the site.

SOURCE	PATHWAY	TARGET	RISK
On and off site Soil and groundwater contaminants	Direct contact	Ground workers	Medium
		End Users	Low
	Ingestion	Ground workers	Medium
		End Users	Low
	Leaching	Groundwater	Low-Medium
	Surface Water runoff	Drainage system	Low-Medium

8.3 RISK ESTIMATION

The information available in this assessment has revealed that there is a **LOW- MEDIUM** potential risk of contamination arising from the site from its former uses through leaching to groundwater and the risk to end users is also assessed as **LOW**.

The overall significance of contamination from these sources in respect of the potential impact on the occupation and serviceability of the proposed extension is considered to be of **LOW - MEDIUM** risk.

This risk classification is designed to consider environmental risk in the context of alternative use strategies where redevelopment or a change of use may be required. This must be set in the context of the following hierarchy of risks as follows:-

HIGH: Significant risk of contamination without remediation. Precludes all but the least sensitive of development e.g. Car Parking. Significant potential for environmental pollution. Remediation measures expensive. Site Investigation required.

MEDIUM: Risk of contamination but allowing non-sensitive development e.g. Commercial, for reasonable costs of remediation, although more sensitive development, e.g. Housing may require substantial remedial measures. Potential for environmental pollution. Site Investigation may be required.

LOW: Little risk of contamination where all development options are likely to be possible with little or no remediation measures. Little potential for environmental pollution. Confirmatory site investigation may be required.

9.0 SITE INVESTIGATION FIELDWORK

9.1 METHOD STATEMENT AND HEALTH AND SAFETY

Fieldwork was carried out between 3rd - 5th September 2003 and comprised three cable percussion boreholes (all fitted with gas and groundwater monitoring installations), four machine dug trial pits and two hand dug pits. The locations of the boreholes and trial pits are shown in Figure 15.

Positions of exploratory holes were located such as to give a maximum coverage of the area and maximum data recovery of the features to be investigated.

The site investigation staff were briefed on the potential contaminants likely to be encountered and the appropriate personal protective equipment (PPE) to be adopted for this type of investigation.

All soil sampling was carried out in accordance with Corsair's standard soil sampling methods.

A member of Corsair staff, who logged each sample point and removed appropriate samples, supervised the site investigation works.

9.2 SITE CHARACTERISATION

Historic evidence collected from the Ordnance Survey selection along with information from other sources indicates that the site has been partially occupied by a 'Works' and a number of underground tanks may be present on site. The tanks may have been removed when the site was redeveloped by Wickes and Toys R Us although no records were available to confirm this.

The current operation of the site is as a car parking area for the adjacent Toys R Us store.

The exploratory hole locations were chosen such that they provided full coverage of the site, providing suitable environmental samples, identifying the potential for hydrocarbon and inorganic contamination and geo-technical samples.

9.3 CABLE PERCUSSION BOREHOLES

Between the 3rd – 5th September 2003, three (BH1 – BH3) cable percussion boreholes were drilled to depths of 10.00m bgl at the locations shown on Figure 15.

The cable percussion boreholes provided geotechnical information to a suitable foundation depth and enabled in-situ sampling, and installation, monitoring and testing of groundwater and soil gas. The cable percussion boreholes were also used to supplement information provided by the trial pits. Using a standard Pilcon Wayfarer drilling rig, boring procedures in accordance with the British Drilling Association (BDA) were carried out to facilitate a 150mm diameter borehole.

Undisturbed open-drive U100 samples were attempted within cohesive strata; however, no recovery was possible. Small disturbed and large bulk samples were taken at appropriate intervals during drilling to enable a complete description of the soils encountered.

In accordance with Part 9 of British Standard (BS) 1377:1990, standard penetration tests (SPTs) using a split tub sampler were undertaken at 1.0m intervals (commencing at 1.2m) to allow an assessment of the in-situ shear strength of cohesive soils or density of granular strata encountered. The number of blows required to achieve the initial 150mm seating drive was recorded along with the subsequent number of blows for four successive 75mm drives (300mm) summated to give the 'N' value. Where the 300mm was not achieved due to the density or compactness of the strata, the number of blows along with the drive achieved is recorded on the borehole record. The split tube sampler was replaced with a 60° apex cone when SPTs were required within granular strata.

Groundwater strikes were recorded during drilling, to account for the depth the water was first observed and any subsequent rise after a period of 20 minutes.

Detailed records of the cable percussion boreholes including strata encountered, sampling, in-situ testing and groundwater observations have been produced in accordance with BS 5930:1999 'Code of Practice for Site Investigations', and are shown in Appendix I.

9.4 HAZARDOUS SOIL GAS AND GROUNDWATER MONITORING INSTALLATIONS

Gas and groundwater monitoring installations were constructed in BH1 – BH3 to determine the natural groundwater level and the direction of groundwater flow beneath the site. The installations comprised a high density polyethylene (HDPE) 50mm diameter plastic tube perforated and surrounded with pea gravel between 2.00m and 10.00m bgl.

The upper 2.00m of pipe was sealed with bentonite to prevent possible downward migration of contaminants from the made ground to underlying strata and groundwater. Protective headwork's included a gas tap valve and a ground level flush metal cover secured in concrete. Details of each installation are shown on the borehole records.

The depth to groundwater (m) and the concentrations (%) of carbon dioxide, methane and oxygen and the borehole gas flow rates (litres per hour (l/hr)) were recorded on three occasions at weekly intervals following site investigation fieldwork. The gas concentrations were measured using a Geotechnical Instruments GA90 infra-red triple gas analyser. On each occasion, the atmospheric pressure was recorded and the results of monitoring are shown as Table 1.

Groundwater samples were taken from each borehole on 8th September 2003 using disposable dedicated samplers after developing (purging by three times the volume of water) the installation. A minimum of 2.0 litres was taken in glass jars and stored in cool boxes prior to transportation by courier to Alcontrol Geochem of Chester.

9.5 TRIAL PITS

Using a JCB 3CX backhoe machine, four trial pits were excavated on 3rd September 2003 to depths of between 2.30m (TP3) and 3.20m (TP1 and TP2) bgl as shown in Figure 15. The trial pits were excavated to detail the nature and extent of the underlying strata and to enable environmental sampling. On completion, the pits were backfilled with the materials arising and reinstated with road stone and tar macadam.

Records of the trial pits were produced in accordance with BS5930:1999 'Code of Practice for Site Investigations', and are shown in Appendix I.

9.6 HAND DUG TRIAL PITS

Two hand dug trial pits were excavated on the 3rd September adjacent to the eastern elevation of the existing store building. These pits were excavated to permit an inspection of the existing foundation detail. After detailed examination, measurement and sampling the pits were backfilled with arisings and reinstated with blockwork.

9.7 SAMPLING

Soil samples were taken immediately upon abstraction. Soil samples for heavy metal analyses were placed in laboratory supplied plastic tubs with air tight lids. Groundwater samples were taken and placed in chilled amber bottles (2litres).

Labelled jars were placed in a cool box.

All sample tubs and jars were labelled on site immediately prior to filling. Samples were identified by a label placed on the body of each container and the following information recorded:

1. Unique sample number.
2. Site name.
3. Sample depth.
4. Date and time collected.
5. Initials of collector.
6. Type of analysis required.

Filled tubs, jars and bottles were stored in insulated boxes immediately after filling to keep them at or below 4°C, but above freezing point for the duration of sample storage and transport.

Sampling equipment was cleaned with deionised water between sampling to prevent cross contamination.

All soil samples were sent to either Robertson's Environmental Laboratories of Llandudno or Alcontrol Geochem of Chester under strict chain of custody documentation. Chain of Custody Documentation is provided in Appendix III.

10.0 STRATA ENCOUNTERED

The strata encountered in the cable percussion boreholes and trial pits have been interpreted as **Made Ground** overlying **Alluvial** deposits over **River Terrace Gravels** over **Oxford Clay** of Upper Jurassic age. The general ground profile beneath the site is shown in cross-section in Figure 16, while the lines of cross-section are shown in Figure 15.

As discussed in the desk top report, the site has been previously occupied by a bakery in 1958 and a series of unnamed buildings from 1968 until the present Toys R Us building was constructed in the early 1990's, a garage was also recorded within the site in 1981. These former buildings have since been demolished and the building debris may have been used to level the site.

Made Ground was proved to depths of between 1.10m (TP 2) and 1.80m (BH 2) within the boreholes and trial pits with an average depth across the site of 1.50m.

The near surface made ground generally comprised dark grey clay intermixed with a sand and gravel with occasional sub angular cobbles of brick, concrete and sandstone and pieces of wood. The sand and gravel (flints) content generally increased towards the south of the site. The compactness of the granular material was typically loose-medium dense and the cohesive material was generally soft.

The site was surfaced with a layer of tarmacadam over Type 1 granular fill, overlying the made ground. A number of service pipes were exposed in the trial pits within the made ground.

Soft mottled light grey, brown and blueish slightly organic clay was encountered below the made ground to depths recorded between 2.80m (TP1) and 3.30m (BH3) which represents the **Alluvial Clay** deposits. The alluvial clay band (minimum thickness 1.10m BH2) was found in all exploratory holes across the site.

Medium dense grey and light brown fine-medium Sand and Gravel deposits of quartzite and flint were recorded to depths of 2.90m (BH2) and 3.30m in (BH3) underlying the alluvial clay, these represent the **River Terrace Gravels**.

Underlying the River terrace Gravels a stiff laminated light grey – green clay was recorded to the termination depth of each borehole, this represents the **Oxford Clay** deposits.

Groundwater strikes were encountered in all the boreholes as indicated on the Borehole Records, at depths between 2.80m and 3.20m bgl. The groundwater was generally encountered near the top of the River gravels rising to a piezometric level of between 2.54m and 2.61m bgl within the overlying alluvial clay.

Results of groundwater monitoring within the borehole installations carried out between 9th September and 25th September 2003 are shown in Table 1. The water levels represent the groundwater within the River Terrace Gravels. The average level of the groundwater is 2.58m bgl.

Groundwater data over the monitoring period has remained fairly consistent.

11.0 LABORATORY ANALYSIS

11.1 GEOTECHNICAL ANALYSIS

Soil samples recovered from the boreholes and trial pits were tested in accordance with the recommendations of British Standard BS 1377:1990, 'Methods of Test for Soils for Civil Engineering Purposes'. These tests are listed below and the findings presented in the Results Section, Appendix II.

Classification

i) Natural Moisture Contents

The natural moisture contents of eight soil samples were determined. The results are reported as the percentage moisture content with respect to the dry weight of the soil used in each test. The results of testing are included in the Laboratory Testing Summary Sheet in Appendix II.

ii) Atterberg Limit Tests

In order to establish the consistency of the fine-grained soils, five samples were tested to determine their liquid and plastic limits and plasticity indices. The results are quoted as the percentage moisture with respect to the dry weight of soil used in each test. The results of testing are shown on the Laboratory Testing Summary Sheet in Appendix II.

iii) Mechanical Analysis

Three made ground and natural soil samples of the materials encountered were mechanically analysed by wet sieving for classification and comparison purposes. The results of testing are shown in Appendix II.

Chemical Tests

Chemical analyses have been performed on samples of the natural ground at depth to determine the water soluble sulphate content and pH. The results of testing are included in the Laboratory Testing Summary Sheet in Appendix II.

11.2 CONTAMINATION ANALYSIS

Contamination testing was carried out on seven soil and three groundwater samples recovered from the exploratory holes.

The samples were taken from across the site from the made ground and natural strata and the testing was targeted at the past historical uses of the site identified during the historical research. Analytical suites were chosen in accordance with the sites' past and present uses and any potential contaminants associated with them.

Seven soil samples and three water samples were analysed against a screening set of determinants which includes; arsenic, boron, cadmium, cyanide, chromium, copper, mercury, nickel, lead, pH, selenium, sulphate, sulphide, sulphate, zinc, polycyclic aromatic hydrocarbons (PAH) and phenols.

One soil sample was analysed for speciated Total Petroleum Hydrocarbons (TPH) and one soil sample was analysed for asbestos screening.

Additionally two soil samples were tested in accordance with the EA Leachate procedure.

12.0 GEOTECHNICAL APPRAISAL

Toys R Us Ltd propose to construct an extension to the existing store as shown in Figure 3.

12.1 FOUNDATION DESIGN

The following foundation options can be considered for the given settlement and loading criteria:

12.1.1 SHALLOW FOUNDATIONS

Shallow foundations are not considered suitable for this site due to the depth and variable nature of the made ground together with the band of soft alluvial clay which was found to underlie the made ground. Additionally the River Terrace Gravels recorded below the alluvial clay at an average depth of 3.13m bgl was below the generally accepted level for shallow foundations and the gravels recorded slight artesian groundwater pressure which may have been problematic in forming foundations at this horizon.

12.1.2 PILED FOUNDATIONS

A preferable option would be to use piled foundations end bearing onto the underlying Oxford Clay. Bored piles would be difficult and expensive to construct due to the need for temporary casing. Driven precast piles are considered to be the better choice as the quality of concrete would be higher than that used for bored piles also the risk of providing a pathway for any contaminants within the made ground to the underlying Minor Aquifer in the River Terrace Gravels would be greatly reduced.

The table below indicates the working loads of a single pile 8m long and of various diameters:

	Pile Diameter (m)			
	0.30	0.4	0.50	
Working Load (kN)	115	170	230	

The above working loads ignore the affects of negative skin friction and the influence of pile groups.

It is recommended that the advice of specialist piling contractors should be sought regarding their proprietary piling techniques.

12.1.3 GROUND BEARING FLOOR SLAB

Assuming a uniformly distributed load of 20kN/m^2, the maximum settlement beneath the centre of the proposed floor slab is likely to be 40 millimetres (mm) and the slope across the slab is estimated to be 1:500. Approximately half of the settlement would take place during the construction phase.

The formation should be proof rolled and all soft and hard spots and unsuitable materials are removed and replaced with properly compacted granular material.

Should greater floor loads be required then consideration should be given to using a suspended ground floor slab.

13.0 ENVIRONMENTAL APPRAISAL

13.1 GUIDANCE AND METHODOLOGY

The United Kingdom has very little statutory guidance in relation to soils and groundwater contamination referencing. The main guidance used for soils is the Contaminated Land Exposure Assessment (CLEA) 2002 Model, presented as the Department for Environment, Food and Rural Affairs (DEFRA) and the EA R&D Publications Contaminated Land Reports (CLR) 7 to 10 supported by Collation of Toxicological Data and Intake Values for Humans TOX 1 to 8 and TOX 10 to 12 and Soil Guideline Values (SGV) 1 (arsenic), 3 (cadmium), 4 (chromium), 5 (inorganic mercury), 7 (nickel), 9 (selenium) and 10 (lead). It should be noted that the Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL) for soils, ICRCL guidance note 59/83, has now been formally withdrawn. Reference should no longer be made to this document. The "New Dutch" guidance (RIVM 1999) for soils and groundwater is also referred to where no other guidance is available. Groundwater is also covered by the EA technical advice to third parties on Pollution of Controlled Waters for Part IIA of the Environmental Protection Act 1990 (no. 07_02) which includes Environmental Quality Standards (EQS) and United Kingdom (UK) Drinking Water Standards (DWS). The EQS and UK DWS are considered to be the most appropriate guideline values when assessing the leachate results and groundwater quality at the site. In the absence of these being available, reference will be made to the New Dutch guidance.

13.2 SOIL SAMPLES

Concentrations of determinants are assessed against the CLEA 2002 Model, and Soil Guideline Values (SGV) using documents SGV1 – 10 or the 'New Dutch' guidelines Intervention Values where no CLEA SGV exists.

The CLEA Model Soil Guideline Values in this case are based on a proposed commercial end use. Using the approach outlined in the assessment model, the test results obtained have been subjected to a mean value test. The approach involves the identification of the 95% confidence limit of the measured mean and the comparison of the upper 95th percentile with the appropriate SGV.

The results indicate whether the 95% confidence limits of the arithmetic mean of the test results (conducted on 6 soil samples) have passed or failed the mean value test. Analytical results are given in Appendix III.

pH

pH results from soil samples were within the range 7.4 to 8.2, indicating fairly neutral to slightly alkaline conditions across the site.

Arsenic

The investigation identified arsenic concentrations in soil samples between 19 milligrams per kilogram (mg/kg) and 43mg/kg. All samples have concentrations well below the CLEA SGV of 500mg/kg for commercial/industrial use given in SGV1.

Further evaluation is not considered to be necessary.

Cadmium

The investigation identified cadmium levels below the laboratory detection limit of 1mg/kg in all soil samples. All are below the CLEA SGV of 1400mg/kg for commercial/industrial use given in SGV3.

No further evaluation is considered to be necessary.

Chromium

The results for chromium are reported as total chromium concentration. From the investigation, concentrations between 23mg/kg and 45mg/kg have been recorded. All fall below the CLEA SGV of 5000mg/kg given in SGV4 for commercial/industrial use.

No further evaluation is considered to be necessary.

Lead

From the investigation, concentrations of lead between 20mg/kg and 558mg/kg have been recorded in soil samples from the site. All are below the CLEA SGV of 750mg/kg given in SGV10 for commercial/industrial use.

Further evaluation is not considered to be necessary.

Mercury

The investigation identified mercury concentrations between 0.1mg/kg and 1.7mg/kg at the site. All samples have concentrations below the CLEA SGV of 480mg/kg given in SGV5 for commercial/industrial use.

No further evaluation is considered to be necessary.

Selenium

The investigation identified concentrations of selenium below the laboratory detection limit of 3mg/kg in all soil samples. All samples are below the CLEA SGV of 8000mg/kg for commercial/industrial use given in SGV9.

No further evaluation is considered to be necessary.

Nickel

The investigation identified concentrations of nickel at levels between 28mg/kg and 113mg/kg. All samples are below the CLEA SGV of 5000mg/kg given in SGV7 for commercial/industrial use.

No further evaluation is considered to be necessary.

Boron

Water soluble boron levels between 0.2mg/kg and 1.0mg/kg have been identified during the investigation. Neither the CLEA model nor the 'New Dutch' tables offer guideline values for water soluble boron.

Previous guidelines identified a figure of 3mg/kg to be protective of plant life. All samples are below this value.

No further evaluation is considered to be necessary.

Copper

Concentrations of copper between 24mg/kg and 98mg/kg have been detected in soils samples during the investigation. There is currently no CLEA SGV for copper. All of the soil samples have concentrations below the 'New Dutch' Intervention Value (IV) of 190mg/kg.

No further evaluation is considered to be necessary.

Zinc

The investigation identified concentrations of zinc from soil samples at values between 126mg/kg and 347mg/kg. There is currently no CLEA SGV for zinc. When compared to the 'New Dutch' guidelines, all samples are below the IV of 720mg/kg.

No further evaluation is considered to be necessary.

Sulphur and sulphur containing compounds

Soil sulphate levels in the range 0.04% to 0.15% were identified across the site during the investigation. There are no CLEA or 'New Dutch' guidelines for sulphates. Previous guidelines identified as 1% for gardens allotments and landscaped areas. All sulphate levels are below this value.

Further evaluation is not considered to be necessary.

Sulphide levels between <0.5mg/kg and 1.8mg/kg have been recorded during the investigation. There are no CLEA or 'New Dutch' guidelines for sulphides.

Previous guidelines identified a figure of 250mg/kg for all proposed uses, and all samples are below this.

No further evaluation is considered to be necessary.

Cyanides

Concentrations of total and free cyanide (total cyanide = free cyanide + complex cyanide) are below the laboratory detection limit of 1mg/kg in all samples. There is currently no CLEA SGV for cyanide.

Comparing the results to guidelines given in the 'New Dutch' tables, all soil samples demonstrated concentrations of complex cyanide below the IV of 50mg/kg for soils with a pH value greater than or equal to 5, and the IV of 20mg/kg for free cyanide.

No further evaluation is considered to be necessary.

Phenols

The investigation identified concentrations of monohydric phenol below the laboratory detection limit of 1mg/kg in all samples. No CLEA SGV is available for phenol. Comparing the results to guidelines given in the 'New Dutch' tables all are below the IV of 40mg/kg.

No further evaluation is considered to be necessary.

PAH

Concentrations of total PAH across the site were recorded at levels between <10mg/kg and 154mg/kg during the investigation. There is no CLEA SGV for PAH. When compared to the 'New Dutch' tables, two samples (TP1 at 0.8m bgl and TP3 at 0.5m bgl) have concentrations above the IV of 40mg/kg.

Further evaluation is considered to be necessary.

TPH

The soil sample has a TPH concentration of 81mg/kg with *no characteristic profile*. When compared tentatively to the values given for mineral oil in the New Dutch tables, this is elevated above the target value (TV) of 50mg/kg but well below the IV of 5,000mg/kg.

No further evaluation is considered necessary.

13.3 LEACHATE TESTING

The Environmental Quality Standards (EQS), United Kingdom Drinking Water Standards (UK DWS) and the New Dutch guidance will be used to assess the leachate results.

pH

pH values of 7.3 and 8.1 were recorded in leachate samples.

Arsenic

Leachate samples demonstrated arsenic concentrations of <1µg/l and 1µg/l. These are below the Environmental Quality Standards (EQS) for freshwater and the UK Drinking Water Standard (DWS) of 50µg/l.

No further evaluation is considered to be necessary.

Cadmium

The investigation identified cadmium levels to be below the laboratory detection limit of <0.4µg/l in both leachate samples. These are below the EQS for freshwater and the UK DWS of 5µg/l.

No further evaluation is considered to be necessary.

Chromium

The EQS for chromium is dependant upon water hardness. Table 2b of the Dangerous Substances Directive provides specific EQS values depending on the hardness (mg/l $CaCo_3$) of the water. Data provided from the Drinking Water Inspectorate identifies the site to lie in an area where the water is described as *Hard* to *Very Hard*,

Chromium will therefore be assessed using the EQS for water with a hardness value of >200 – 250mg/l $CaCo_3$.

Chromium concentrations have been detected at 1µg/l in both leachate samples. The concentrations identified in the leachate samples are below the EQS of 50µg/l for freshwaters suitable for Salmonid (coarse) fish and 250µg/l for freshwaters suitable for cyprinid (game) fish, and also below the UK DWS of 50µg/l.

No further evaluation is considered to be necessary.

Lead

Concentrations of lead have been detected at 3µg/l and 2µg/l within the leachate samples. The EQS for lead is dependant upon water hardness. For water with a hardness value of >200 – 250mg/l EQS values of 20µg/l and 250µg/l are given for freshwaters suitable for Salmonid and Cyprinid fish respectively. All leachate samples have concentrations below these values, and the UK DWS of 50µg/l.

No further evaluation is considered to be necessary.

Mercury

Mercury concentrations have been detected at levels of 0.08µg/l and 0.05µg/l within the leachate samples. These are below the EQS and UK DWS of 1µg/l.

No further evaluation is considered to be necessary.

Selenium

The investigation identified concentrations of selenium below the laboratory detection limit of 1µg/l in both leachate samples. These are below the UK DWS of 10µg/l. No EQS is available for selenium.

No further evaluation is considered to be necessary.

Boron

The investigation identified concentrations of boron below the laboratory detection limit of 10µg/l (0.01mg/l) in both leachate samples. These are below the EQS and the UK DWS of 2mg/l.

No further evaluation is considered to be necessary.

Copper

Concentrations of copper were identified at 2µg/l and 1µg/l within the leachate samples.

The EQS for copper is dependant upon water hardness. For water with a hardness value of >200 - 250µg/l an EQS value of 10µg/l is given for freshwaters suitable for all fish life. All leachate samples are below this value and the UK DWS of 3000µg/l.

No further evaluation is considered to be necessary.

Nickel

The investigation identified concentrations of nickel below the laboratory detection limit of 1µg/l in both leachate samples. The EQS for nickel is dependant upon water hardness. For water with a hardness value of >200 - 250µg/l an EQS value of 200µg/l is given for freshwaters suitable for all fish life. All samples are below this and the UK DWS of 50µg/l value.

Further evaluation is not considered to be necessary.

Zinc

The investigation identified concentrations of zinc across at 35µg/l and 27µg/l. The EQS for zinc is dependant upon water hardness. For water with a hardness value of >200 - 250µg/l EQS values of 75µg/l and 250µg/l are given for freshwaters suitable for Salmonid and Cyprinid fish respectively. All leachate samples are below these values and the UK DWS of 5000µg/l.

Further evaluation is not considered to be necessary.

Sulphate

Sulphate levels were identified within the leachate samples at concentrations of 3mg/l and 9mg/l. All are below the EQS of 400mg/l and the UK DWS of 250mg/l.

Further evaluation is not considered to be necessary.

Sulphide

Sulphide levels were all below the laboratory detection limit of 0.05mg/l (50µg/l). This detection limit is above the EQS of 0.25µg/l.

Further evaluation is not considered to be necessary.

Phenols

The investigation identified phenols at concentrations of 7.71µg/l and 6.27µg/l. These are above the UK DWS of 0.5µg/l but below the EQS of 30µg/l.

Further evaluation is considered to be necessary.

PAH

When assessing the individual polyaromatic hydrocarbons (PAH) compounds, naphthalene is considered to be the most mobile, and benzo(a)pyrene is considered to be the most toxic.

Naphthalene has been identified at concentrations of 857µg/l and 851µg/l which are elevated above the EQS of 10µg/l and the New Dutch IV of 70µg/l.

Phenanthrene has been identified at concentrations of 1256µg/l and 107µg/l which are elevated above the New Dutch IV of 5µg/l.

Anthracene has been identified at concentrations of 361µg/l and 37µg/l which are elevated above the New Dutch IV of 5µg/l.

Fluoranthene has been identified at concentrations of 834µg/l and 146µg/l which are elevated above the New Dutch IV of 1µg/l.

Benz(a)anthracene has been identified at concentrations of 118µg/l and 131µg/l which are elevated above the New Dutch IV of 0.5µg/l.

Chrysene has been identified at concentrations of 88µg/l and 67µg/l which are elevated above the New Dutch IV of 0.2µg/l.

Benzo(k)fluoranthene has been identified at concentrations of 17µg/l and 21µg/l which are elevated above the New Dutch IV of 0.05µg/l.

Benzo(a)pyrene has been identified at concentrations of 20µg/l and 27µg/l which are elevated above the UK DWS 0.01µg/l and the New Dutch IV of 0.05µg/l.

Indeno(123cd)pyrene has been identified at concentrations below the laboratory detection limit of 10µg/l in both leachate samples. This detection limit is elevated above the New Dutch IV of 0.05µg/l.

Benzo(ghi)perylene has been identified at concentrations of <10µg/l and 21µg/l which are elevated above the New Dutch IV of 0.05µg/l.

There are currently no guidelines to assess acenaphthylene, acenaphthene, fluorene, pyrene, benzo(b)fluoranthene, dibenzo(ah)anthracene.

Further evaluation of PAH is considered to be necessary.

13.4 GROUNDWATER SAMPLES

The Environmental Quality Standards (EQS), UK Drinking Water Standards (UK DWS) and the New Dutch guidance will be used to assess the groundwater quality.

Analytical results are given in Appendix III.

pH

The groundwater results pH values between 7.75 and 7.89 indicating fairly neutral conditions at the site.

Arsenic

The investigation identified arsenic at concentrations between 5µg/l and 13µg/l. All are below the EQS for freshwater and the UK Drinking Water Standard (DWS) of 50µg/l.

No further evaluation is considered to be necessary.

Cadmium

The investigation identified cadmium levels to be below the laboratory detection limit of 0.4µg/l in all groundwater samples. This is below the EQS for freshwater and the UK DWS of 5µg/l.

No further evaluation is considered to be necessary.

Chromium

The EQS for chromium is dependant upon water hardness. Table 2b of the Dangerous Substances Directive provides specific EQS values depending on the hardness (mg/l $CaCo_3$) of the water. Data provided from the Drinking Water Inspectorate identifies the site to lie in an area where the water is described as *Hard to Very Hard*.

Chromium will therefore be assessed using the EQS for water with a hardness value of >200 – 250mg/l $CaCo_3$.

Chromium concentrations have been detected at levels between 2µg/l and 3µg/l which are below the EQS of 50µg/l for freshwaters suitable for salmonid (coarse) fish and 250µg/l for freshwaters suitable for cyprinid (game) fish, and also below the UK DWS of 50µg/l.

No further evaluation is considered to be necessary.

Lead

The investigation identified concentrations of lead at levels between <1µg/l and 3µg/l. The EQS for lead is dependant upon water hardness. For water with a hardness value of >200 – 250mg/l EQS values of 20µg/l and 250µg/l are given for freshwaters suitable for Salmonid and Cyprinid fish respectively. All water samples have concentrations below these values, and the UK DWS of 50µg/l.

No further evaluation is considered to be necessary.

Mercury

The investigation identified mercury concentrations below the laboratory detection limit of 0.05µg/l in all three groundwater samples. These are below the EQS and UK DWS of 1µg/l.

No further evaluation is considered to be necessary.

Selenium

Concentrations of selenium between 1µg/l and <3µg/l have been identified within the groundwater at the site. All are below the UK DWS of 10µg/l. No EQS is available for selenium.

No further evaluation is considered to be necessary.

Boron

Boron levels between 76µg/l and 84µg/l (0.076mg/l and 0.084mg/l) have been identified in the groundwater at the site. All are below the EQS and UK DWS of 2mg/l.

No further evaluation is considered to be necessary.

Copper

The investigation identified concentrations of copper at between 3µg/l and 7µg/l.

The EQS for copper is dependant upon water hardness. For water with a hardness value of >200 – 250mg/l an EQS value of 10µg/l is given for freshwaters suitable for all fish life.

All samples are below the EQS and the UK DWS of 3000µg/l.

Further evaluation is not considered to be necessary.

Nickel

Concentrations of nickel between 2µg/l and 28µg/l were detected within the groundwater. The EQS for nickel is dependant upon water hardness. For water with a hardness value of >200 – 250mg/l an EQS value of 200µg/l is given for freshwaters suitable for all fish life. All samples were below the EQS given above and the UK DWS of 50µg/l.

No further evaluation is considered to be necessary.

Zinc

The investigation identified concentrations of zinc at levels between 34µg/l and 51µg/l. The EQS for zinc is dependant upon water hardness. For water with a hardness value of >200 – 250mg/l EQS values of 75µg/l and 250µg/l are given for freshwaters suitable for Salmonid and Cyprinid fish respectively. All samples are below the EQS and the UK DWS of 5000µg/l.

No further evaluation is considered to be necessary.

Sulphur and sulphur containing compounds

Sulphate levels were identified within the range 50mg/l to 100mg/l within the groundwater at the site during. All are below the EQS of 400mg/l and the UK DWS of 250mg/l.

No further evaluation is considered to be necessary.

Sulphide levels were all below the laboratory detection limit of 0.05mg/l (50µg/l) in all shallow and deep groundwater samples from both monitoring visits. This detection limit is above the EQS of 0.25µg/l.

Cyanides

Concentrations of total cyanide were in the range <0.05mg/l to 0.05mg/l (<50µg/l - 50µg/l) in groundwater samples. No samples are elevated above the UK DWS for cyanide of 50µg/l. No EQS values are given.

No further evaluation is considered to be necessary.

All groundwater samples have thiocyanate concentrations below the laboratory detection limit of <0.05mg/l (<50µg/l). Comparing the results to guidelines given in the 'New Dutch' tables, all are below the IV of 1500µg/l.

No further evaluation is considered to be necessary.

Phenols

Concentrations of phenols between 60µg/l and 90µg/l) have been identified at the site. These are above the UK DWS of 0.5µg/l and the EQS of 30µg/l.

Further evaluation is considered to be necessary.

PAH

When assessing the individual PAH compounds, naphthalene is considered to be the most mobile, and benzo(a)pyrene is considered to be the most toxic.

Naphthalene has been identified at concentrations between 50µg/l and 13,929µg/l which are all elevated above the EQS of 10µg/l and two out of three are elevated above the New Dutch IV of 70µg/l.

Phenanthrene has been identified at concentrations between 32µg/l and 9,306µg/l which are elevated above the New Dutch IV of 5µg/l.

Anthracene has been identified at concentrations between 21µg/l and 2002µg/l which are elevated above the New Dutch IV of 5µg/l.

Fluoranthene has been identified at concentrations between 32µg/l and 1,753µg/l which are elevated above the New Dutch IV of 1µg/l.

Benz(a)anthracene has been identified at concentrations between <10µg/l and 94µg/l. One sample is elevated above the New Dutch IV of 0.5µg/l, and the detection limit for the remaining two samples is above the New Dutch IV.

Chrysene has been identified at concentrations between <10µg/l and 60µg/l. One sample is elevated above the New Dutch IV of 0.2µg/l, and the detection limit for the remaining two samples is above the New Dutch IV.

Concentrations of benzo(k)fluoranthene are all below the laboratory detection limit of 10µg/l. This detection limit is above the New Dutch IV of 0.05µg/l.

Concentrations of Benzo(a)pyrene are all below the laboratory detection limit of 10µg/l. This detection limit is elevated above the UK DWS 0.01µg/l and the New Dutch IV of 0.05µg/l.

Indeno(123cd)pyrene has been identified at concentrations below the laboratory detection limit of 10µg/l all three groundwater samples. This detection limit is elevated above the New Dutch IV of 0.05µg/l.

Benzo(ghi)perylene has been identified at concentrations below the laboratory detection limit of 10µg/l. This detection limit is elevated above the New Dutch IV of 0.05µg/l.

There are currently no guidelines to assess acenaphthylene, acenaphthene, fluorene, pyrene, benzo(b)fluoranthene, dibenzo(ah)anthracene.

Further evaluation of PAH is considered to be necessary.

TPH

Concentrations of mineral oil between <10µg/l and 53µg/l have been detected within the groundwater at the site. One sample is elevated above the UK DWS of 10µg/l for oils/hydrocarbons. All samples are below the IV of 600µg/l given for mineral oil in the New Dutch tables. There is no EQS given.

Further evaluation is considered to be necessary.

13.5 SUMMARY

Elevated concentrations of total **PAH** were identified in soil samples taken from TP1 at 0.8m bgl, and TP3 at 0.5m with concentrations of 59mg/kg and 154mg/kg compared to the New Dutch IV of 40mg/kg.

Leachate samples demonstrated elevated concentrations of **phenols** and individual **PAH** compounds in TP1 at 2.0m bgl and TP3 at 0.5m bgl when compared to EQS, UK DWS or New Dutch guidelines.

Groundwater samples demonstrated elevated concentrations of **phenols**, **PAH** and **TPH** when compared to EQS, UK DWS or New Dutch guidelines.

14.0 ENVIRONMENTAL RISK ASSESSMENT

14.1 ENVIRONMENTAL SITE INVESTIGATION

The site investigation has chemically examined the soils and groundwater. It has also examined local geology, historical and recent uses of the site and its immediate surrounds. From the site investigation it has been established that;

- Elevated concentrations of total **PAH** were identified in soil samples taken from the made ground at the site;
- Leachate samples demonstrated elevated concentrations of **phenols** and **PAH**, and
- Groundwater samples demonstrated elevated concentrations of **phenols**, **PAH** and **TPH**.

14.2 QUALITATIVE RISK ASSESSMENT METHODOLOGY

Once hazards or potential hazards have been identified, it is necessary to assess the associated risks by considering a Source-Pathway-Target relationship, or Pollutant Linkage.

For a risk to exist as a result of the presence of contamination in, on, or under land there must be;

iv) a contaminant or potential pollutant (SOURCE);
v) a PATHWAY; and
vi) a receptor (TARGET).

A risk only exists if all three are present.

14.2.1 SOURCES

Corsair's investigation revealed the main source of contamination within the soils at the site to be elevated concentrations of **PAH** within the made ground at the site. Leachate samples demonstrated elevated concentrations of **phenols** and **PAH**, and groundwater samples demonstrated elevated concentrations of **phenols**, **PAH** and **TPH**.

14.2.2 PATHWAYS

Pathways between sources of contamination and targets may exist in the form of direct contact such as ingestion, inhalation and dermal contact; by soil leachability e.g. lateral and vertical migration of contaminants into the groundwater; by contaminated groundwater providing a pathway for soluble contaminants to migrate onto or off site.

14.2.3 TARGETS

Potential targets can include end users and occupiers of the site, plants and animals, structures, infrastructure, construction workers, groundwater, and surface waters. Due to the known presence of contaminated sites in the vicinity of the development site, the development site itself is considered to be a potential target for contamination migrating onto it from these off-site sources.

14.2.4 POLLUTANT LINKAGES AND RISK ASSESSMENT

The following pollutant linkages have been identified.

SOURCE	PATHWAY	TARGET	RISK/ SOLUTION
Contaminated soils; PAH	Ingestion, inhalation, dermal contact	Ground workers,	Medium Ground workers may be at risk during development works. A health and safety risk assessment should be performed prior to any works being carried out and workers should be advised to employ suitable personal protective equipment.
Contaminated soils; PAH	Ingestion, inhalation, dermal contact	Site users/occupiers	Low The site will be covered by hardstanding (ground floor slab and car parking area) breaking the pollutant linkage between contaminated soils and site users/occupiers.
Contaminated leachate/groundwater; PAH, phenols, TPH	Groundwater migration	Controlled waters	Low The site is in an area of low sensitivity in term of controlled water resources. The River Terrace Gravels at the site are classified as a Minor Aquifer. A band of relatively impermeable alluvial clay underlies the site which forms an impermeable barrier preventing downward migration of groundwater. The site does not lie within a source protection zone, and there are no groundwater abstractions within 1000m of the site. From the Environmental Data Sheets, there are no protected water sources within 1000m of the site.

The overall significance of contamination from the sources identified in respect of the potential impact on the occupation and serviceability of the site in its current state is considered to be of **LOW** risk. The proposed end use of the site is for commercial development.

The site would be considered as a **MEDIUM** risk during development works due to the presence of contaminants identified at the site, and workers should be advised to employ suitable PPE.

14.3 WASTE MANAGEMENT

When considering disposal of soils to landfill, the results of contamination testing indicate that elevated levels of Phenol and PAH were detected above the 'Upper Threshold Concentration' Interim Guidance in the Disposal of Contaminated Soils, 1st Edition, 1997. Accordingly these soils would have to be disposed of at an engineered landfill site.

14.4 BURIED CONCRETE

The average sulphate content in soils is 0.48g/l (range <0.05g/l to 0.87g/l) and the average pH value is 7.8 (range 7.7 to 8.2). These measurements indicate that the site is in Design Sulphate Class DS-1 of Special Digest 1 (BRE, 2001), which replaced the former Digest 363 (BRE, 1996) which has now been withdrawn. The presence of mobile groundwater at the site indicates that the Aggressive Chemical Environment for Concrete (ACEC) site classification would be AC-1.

14.5 HAZARDOUS SOIL GASES

Results of gas monitoring of the borehole installations are shown in Table 1. Results indicate that methane (CH_4) was detected to a maximum concentration of 8.3% (BH3), with concentrations of carbon dioxide CO_2, maximum 4.6% (BH3), coupled with depleted oxygen O_2 levels to 0.7% (BH2). However, no gas flow rates were recorded in the boreholes during the gas monitoring process.

On the basis of the above it is recommended that passive gas exclusion measures are incorporated into the completed structure by means of ventilation of the ground floor slab and a gas impermeable membrane within the floor slab and sealing external service and utility entry points.

15.0 CONCLUSIONS AND RECOMMENDATIONS

15.1 CONCLUSIONS

The site is considered to be a low risk for the proposed extension to the existing Toys R Us store, however the risk for construction workers during the construction phase of the works is considered to be medium.

15.2 RECOMMENDATIONS

During the construction phase of the works the contractor should carry out a health and safety risk assessment based upon the laboratory tests results as required under the Construction Design and Management Regulations (CDM Regs). Appropriate PPE equipment should be made available for construction workers. The contractor should prepare a working Health and Safety plan based upon the findings of this report and put into place any measures which will minimise the risk to site workers.

Specific geotechnical recommendations and contamination recommendations are contained in Section 12 and Section 14 respectively.

16.0 LIMITATIONS TO GEO-ENVIRONMENTAL RISK ASSESSMENTS

Corsair obtained, reviewed, and evaluated information from the client, property owner, local authority, and others. Corsair's conclusions, opinions, and recommendations are based on this information and observations made during the site reconnaissance and site investigation.

The recommendations contained in this report represent our professional opinions. These opinions were arrived in accordance with currently accepted industry practices and hydrological and engineering practices. The report takes into consideration potential sources, pathways, receptors and evaluates potential pollutant linkages. Corsair's professional interpretation relies solely on the intrusive points that have been sampled and the implications of the results on the intended use of the site. Every care has been made to ensure that the interpretation of the site condition is based on all known data collected and as such is not a guarantee that the Site is free of hazardous or potentially hazardous materials or conditions in areas not tested.

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