

Procter & Gamble

**Phase 2
Site Investigation**

Procter & Gamble Product Supply (UK) Ltd,
Havant

August 2003

Entec UK Limited

Report for

Chris Humby
Procter & Gamble Ltd
Dunsbury Way
Havant
Hampshire
PO9 5DG

Main Contributors

Trina Scobie
Neil Woodbridge

Issued by

[Redacted]
Ben Smee

Approved by

[Redacted]
James McNally

Entec UK Limited

17 Angel Gate
City Road
London
EC1V 2SH
England
Tel: +44 (0) 207 843 1400
Fax: +44 (0) 207 843 1410

\\elonfs01\data\data\projects\cl-240\11000 - 12000\11397 - p &
g havant\docs\rr012i2.doc

Procter & Gamble

Phase 2 Site Investigation

Procter & Gamble Product Supply (UK)
Ltd, Havant

August 2003

Entec UK Limited



Certificate No. FS 13881



In accordance with an environmentally responsible approach, this document is printed on recycled paper produced from 100% post-consumer waste or TCF (totally chlorine free) paper

Executive Summary

Terms of Reference

Entec UK was commissioned by Procter & Gamble Paper Products Ltd (P&G) to undertake a Phase Two Site Investigation of issues identified as posing an immediate significant environmental risk. These issues were identified in a Phase One Desk Study Report undertaken by Entec at The P&G site in Havant, Hampshire, (Entec Reference 10657RR02i2).

The issues warranting further investigation were;

- oil spillage evident in the stream prior to the removal of the underground fuel oil storage tank;
- an historical sewage treatment works;
- oil spillage inside a cable duct;
- an historical infilled sand pit;
- historical above ground tanks of unknown usage;
- Former electrical transformer and aboveground fuel tanks;
- Current diesel fuelling point;
- Made Ground (infill material) quality under former Scalextric site;
- Redundant underground fuel pipes.

This report details the findings of the subsequent Phase Two site investigation work into the potential environmental liabilities associated with the identified contaminants.

Environmental Setting

Geology - The site is underlain by, for the most part, the Bognor Sand, which is bedded within the London Clay, which extends to a depth of around 77 - 120 m. Extensive Made Ground, predominantly re-worked clay, is present on site, varying from a minimal thickness to the north of the site to a depth of around 2.8 m along the south eastern site boundary.

Hydrogeology - The geological formations in the area contain insignificant quantities of groundwater, and are classified as a 'non aquifer' and negligibly permeable. The natural flow of groundwater beneath the site would be towards the Hermitage Stream Tributary to the south east of the site. It is thought that groundwater across the site becomes locally perched during times of heavy rainfall. The major aquifer of the Chalk underlies the London Clay.

Hydrology - A tributary of Hermitage Stream runs east to west along the southeastern boundary of the site. To the northeast at the rear of the warehouse, an unnamed ditch feeds into the tributary stream. River quality in the area is unclassified.

Site Investigation

The site investigation consisted of eight dynamic sampling holes and two hand dug trial pits to investigate potential contamination. Soil and groundwater samples were collected and analysed for various contaminants at an accredited laboratory. In addition a sludge sample, collected prior to the site investigation by P&G, was sent for analysis.

Some evidence of hydrocarbon contamination was noted during the site investigation from samples taken around the area of the historical oil spillage.

Results

Slight elevations in PAH concentrations in soil were observed above generic guideline values in sample location DS10. (See Figure 3.1 for details of sampling locations)

Elevated Petroleum Range Organics (PRO) levels were observed in the area of the historical oil spillage in the south of the site, and boron levels above Environmental Quality Standard guideline values were noted in the groundwater at locations DS6 and DS7. A broken Chrysotile asbestos fragment was found in the infill material near the surface at sample location DS4.

Risk Assessment

The following risk assessment has been based on the results of intrusive investigation. It should be noted that during site decommissioning and redevelopment, further contamination may be identified which without remedial measures may increase risks to future site users.

Human (Site Redevelopment Workers)

A moderate to high risk to site redevelopment works was identified from asbestos cement in the area behind the warehouse. For ground workers without PPE, the risk from PAH contamination was identified as moderate.

Human (Future users - commercial or residential)

The risk to future site users from the identified organic contamination in the soil is considered to be low. If the presence of asbestos on site, noted above, is not addressed this will pose a moderate risk to future site users.

Groundwater

Boron and Pentachlorophenol (PCP) contamination has been identified in perched groundwater. During decommissioning/redevelopment of the site, the source of boron and PCP will require removal.

The deep groundwater in the chalk underlying the site is not considered to be at risk as the overlying clays are around 70 m thick.

Controlled Water - Surface Water

Low risk ratings were given for boron or pentachlorophenol contamination of the surface water in the Hermitage Stream tributary located along the site's southern boundary.

Flora

Boron was identified as a moderate risk to flora around the area of DS9 and DS10.

Recommendations

The 7 hectare site has historically been used for a number of light industrial processes and it can be assumed that other contamination issues may be present that have not been identified by the limited intrusive investigation undertaken. It is recommended that prior to redevelopment, further investigation is undertaken at an intensity commensurate with the sensitivity of the desired end use.

The investigation to date has highlighted localised areas of slight contamination that will require remediation prior to site redevelopment. The extent and nature of remediation will depend on the sensitivity of the end use planned for the site.

Contents

1. Introduction	1
1.1 Terms of Reference	1
1.2 Site Location	1
1.3 Objectives	1
1.4 Approach and Methodology	2
2. Environmental Setting	3
2.1 Geology	3
2.2 Hydrogeology	3
2.2.1 Aquifer Classification	3
2.3 Hydrology	3
2.4 Drainage	4
3. Site Investigation	5
3.1 Introduction	5
3.2 Site Works	5
3.3 Sampling and Monitoring	6
3.3.1 Soil Sampling	6
3.3.2 Groundwater Development, Monitoring and Sampling	6
3.3.3 Sludge Sampling	7
3.4 Laboratory Analysis	7
3.4.1 Post Sampling Procedures	7
3.4.2 Soil Analysis	7
3.4.3 Groundwater Water Analysis	8
3.4.4 Asbestos Analysis	8
3.4.5 Sludge Analysis	8
4. Ground Conditions	9
4.1 Strata Encountered	9
4.1.1 General	9
4.1.2 Made Ground	9
4.1.3 Natural Ground	9

4.2	Groundwater	9
4.3	Visual and Olfactory Evidence of Contamination	10
4.4	Groundwater Observations	11
5.	Results	13
5.1	Assessment Approach	13
5.1.1	Contaminated Land Regime	13
5.1.2	Water Pollution Legislation	14
5.1.3	Legal Risks	14
5.2	Assessment Framework	14
5.2.1	Assessment Guidelines	15
5.3	Soil Analysis	16
5.4	Groundwater and Sludge Analysis	19
6.	Environmental Assessment	21
6.1	Introduction	21
6.2	Risk Assessment	21
6.2.1	Chemicals of Concern	21
6.2.2	Sources	22
6.3	Qualitative Environmental Risk Assessment	24
6.3.1	Risk Classification Rationale	29
7.	Recommendations	31
Table 3.1	Sampling locations, methods and potential contaminants	5
Table 4.1	Groundwater Monitoring	10
Table 5.1	Analytical Results for Soils - units mg/kg unless stated otherwise	18
Table 5.2	Analytical Results for Water - units µg/l	20
Table 6.1	Potential Consequences of Source- Receptor Linkage	24
Table 6.2	Risk Classifications	25
Table 6.3	Summary of Potential Significance of Identified Environmental Risks, Procter & Gamble, Havant	27
Figure 1.1	Site Layout	After Page 2
Figure 1.2	Potentially Contaminative Issues	After Page 2
Figure 3.1	Sample locations	After Page 8
Figure 6.1	Contamination Issues (identified during site investigation on 2/7/3 and 3/7/3)	After Page 30
Appendix A	Borehole Logs	
Appendix B	Laboratory Results	

1. Introduction

1.1 Terms of Reference

Entec UK was commissioned by Procter and Gamble Paper Products Ltd (P&G) to undertake a Phase Two Site Investigation of a number of issues identified as posing moderate or high environmental risk. These issues were previously identified in a Phase One Desk Study undertaken by Entec in June 2003 at the P&G site in Havant, Hampshire (Entec Reference 10657RR02i2). Entec recommend that this Phase Two report is read in conjunction with the Phase One report.

This report details the findings of the subsequent Phase Two site investigation work into the potential environmental liabilities and discusses the findings in the context of a number of future land uses.

The proposed scope of work for the Phase Two investigation was detailed in Entec's e-mail to Chris Humby (ref. 01397-C005) of 5 June 2003. Authority to proceed with the investigation was received by a purchase order dated 8 June 2003 from P&G.

1.2 Site Location

This site is located within the town of Havant, Hampshire. The A3(M) motorway is located about 2 km to the west of the site. Access to the site is gained through a predominantly residential area, off Dunsbury Way. The National Grid Reference of the site is NGR SU71330847. The site address is:

Procter & Gamble Ltd
Dunsbury Way
Havant
Hampshire
PO9 5DG

1.3 Objectives

The overall objective of the study was to further assess through intrusive investigation, the contamination issues identified through qualitative risk assessment in Entec's Phase 1 Desk Study of the P&G Havant site (Report ref. A10657RR02i2 July 2003). When considering potential redevelopment options for the site including sensitive land uses such as residential housing with gardens, a conservative risk assessment identified nine potential sources of contamination which could pose a moderate or greater risk to human or environmental receptors.

These sources are listed below:

- oil spillage evident in the adjacent stream prior to the removal of the underground fuel oil storage tank;

- an historical sewage treatment works;
- oil spillage inside a cable duct;
- an historical infilled sand pit;
- historical above ground tanks, with unknown usage;
- a former electrical transformer and two aboveground fuel tanks;
- the current diesel fuelling point;
- unknown quality of Made Ground (infill material) under former Scalextric site;
- redundant underground fuel pipes.

1.4 Approach and Methodology

The Phase Two intrusive site investigation comprised the percussive drilling of eight dynamic sampling holes and the excavation of two hand dug trial pits, with the subsequent installation of two groundwater monitoring wells. Soil and groundwater samples were taken during and after drilling. These samples, together with a sludge sample which P&G had collected from an on site chamber, were collected and analysed in accordance with Entec Standard Operating Procedures (SOPs). The results were interpreted against generic guideline values, including CLEA Soil Guideline Values, Dutch Intervention Values and the DEFRA Soil Code.

Subsequent exceedences of respective generic guideline values were additionally assessed through an environmental risk assessment matrix in accordance with current industry best practice.

Recommendations have been based on the outcome of the environmental risk assessment.

Key

Procter & Gamble Site Boundary



Procter & Gamble
Havant

Figure 1.1
Site Layout

July 2003
11397-S01 xfallm

Entec

Key

Procter & Gamble Site Boundary



Current Transformer



Procter & Gamble
Havant

Figure 1.2
Potentially Contaminative Issues

July 2003
11397-S02 xfallm

2. Environmental Setting

2.1 Geology

An overview of the geological setting of the site and environs was obtained from a review of the geological map for the Fareham area (Sheet 316, Fareham, 1:50 000 scale). This map indicates that the site is underlain by, for the most part, the Bognor Sand.

The Bognor Sand is a glauconitic fine to medium grained sand, which is bedded within the London Clay. The London Clay is made up of silty clay and is the first geological layer in the extreme south west of the site, and beyond the site's eastern boundary. The London Clay extends to a depth of around 77 - 120 m, below which lies the Chalk.

Local ground conditions indicate Made Ground predominantly of re-worked clay to depths of 3 m along the site boundary to the south east (along an adjacent tributary of the Hermitage Stream), and minimal thickness in the north of the site as the site is cut into the rising natural ground.

2.2 Hydrogeology

2.2.1 Aquifer Classification

According to the National Rivers Authority Groundwater Vulnerability Map (Sheet 45, West Sussex and Surrey) the geological formations in the area contain insignificant quantities of groundwater. This map classifies the ground in the area of the site as a 'non aquifer', and negligibly permeable. However, it should be noted that groundwater flow through the formation although low (very slightly permeable), does take place and so risk associated with persistent pollutants cannot be ignored.

It is thought that groundwater across the site becomes locally perched during times of heavy rainfall as the northern part of the site at the foot of the embankments does not naturally drain and requires human intervention to prevent localised flooding.

2.3 Hydrology

A stream runs east to west along the south-eastern boundary of the site. This stream is a tributary of Hermitage Stream. To the north east at the rear of the warehouse, an unnamed ditch feeds into the tributary stream. The Hermitage Stream indicative floodplain lies around 400 m to the south west of the site, whilst the Lavant Stream floodplain is just over a kilometre to the east of the site. An indicative tidal floodplain is located 1.6 km to the south west of the site, along Hermitage Stream. River quality in the area is unclassified.

2.4 Drainage

The surface water drainage system in the northern part of the site is pumped via several chambers, prior to discharge to the surface water drainage system in Dunsbury Way. This in turn discharges into the tributary of the Hermitage Stream. There are two interceptors for car park run-off located in the north and south of the site respectively. These interceptors also discharge into the storm water drainage system under Dunsbury Way. Surface water drainage on the south east side of the warehouse discharges directly into the Hermitage Stream tributary.

Foul water from the site discharges into the main public sewer also under Dunsbury Way and another public sewer which traverses inside the fence line, along the southern site boundary.

3. Site Investigation

3.1 Introduction

A Phase Two intrusive site investigation was designed by Entec on the basis of the findings of the Phase One Land Quality Assessment. The locations, sampling methods and potential contaminants being investigated are listed in the table below:

Table 3.1 Sampling locations, methods and potential contaminants

Location	Sampling Method	Potential Contaminants
DS1	Dynamic Sampling	Investigate historical oil in cable pit
DS2	Dynamic Sampling	Infilled material of former sand pit
DS3	Hand dug Trial Pit	Historical location of circular concrete tanks (1960's photo)
DS4	Hand dug Trial Pit	Contamination from neighbouring fuel tanks
DS5	Dynamic Sampling	Former transformer, 2 above ground oil storage tanks, known contamination excavated during new service trench
DS6	Dynamic Sampling	Contamination from historical sewage treatment works
DS7	Dynamic Sampling	Investigate contamination from historical oil spill
DS8	Dynamic Sampling	Investigate contamination from historical oil spill
DS9	Dynamic Sampling	Investigate unknown historical use
DS10	Dynamic Sampling	Investigate unknown historical use

Figure 3.1 shows these sampling locations on the site plan.

3.2 Site Works

The site investigation works were carried out on the 2nd and 3rd July 2003. Prior to the commencement of intrusive site works, a review of existing site plans detailing site utilities was undertaken. In addition to this, a sub-surface cable detection tool (CAT) was used at each location to ensure that the site utilities were avoided. The site works comprised the following:

- Service utilities clearance;
- Dynamic window sampling/trial pit excavation and soil sampling;
- Monitoring well installation and development;
- Groundwater sampling.

A total of eight boreholes, DS1, DS2 and DS5 to DS10, were sunk by a dynamic sampling rig to depths of between 2.0 and 5.0 m below ground level (BGL). The locations of the boreholes are illustrated on Figure 3.1.

The exploratory holes were sunk to investigate the extent of potential contamination identified during the Phase 1 Desk Study. In addition, the intrusive works also established the underlying lithology, recording the interface between made and natural ground beneath the site. Boreholes were installed with permanent groundwater monitoring wells, permitting the sampling of groundwater for subsequent laboratory analysis.

The well instrumentation consisted of a combination of 50 mm plain and 50 mm, 2 mm slotted screen HDPE pipe installed to the base of the borehole. The depth of the slotted section was based on the logged borehole geology and observed depths of groundwater of each well. A washed gravel filter pack (with smallest particle diameter greater than the 2 mm slotted screen size) was established around the slotted section of the installation and a bentonite clay seal placed above the slotted section to eliminate any surface water infiltration into the well. These standard well construction procedures ensure a clean interface to be established between the groundwater and the standpipe. The borehole logs in Appendix A describe the exact construction details of each monitoring well installation.

The drill casing was checked for contamination between each borehole. In addition to this, vegetable oil was used as the lubricant for the casing threads to ensure there was no potential for oil and grease based hydrocarbons from the drilling equipment cross contaminating the samples.

The site works were supervised by an Entec Environmental Engineer experienced in the investigation of contaminated sites and associated wastes. All the boreholes were logged to BS5930 with close attention to any visual or olfactory signs of contamination. Borehole logs are presented in Appendix A.

3.3 Sampling and Monitoring

3.3.1 Soil Sampling

Representative disturbed soil samples were obtained from the boreholes for examination and laboratory analysis. The samples were selected at significant changes in lithology or where there was evidence of contamination. The samples were collected immediately upon retrieval from the boreholes using a clean stainless steel trowel and placed in amber glass jars with screw lids and labelled. The trowel was washed between samples to avoid the potential for cross contamination. A minimum of two soil samples was collected at each location. Samples were stored in cool boxes for dispatch to the laboratory for chemical analysis.

3.3.2 Groundwater Development, Monitoring and Sampling

Following well installation, the wells were developed using established groundwater sampling protocols which specifies removing a calculated 10 well volumes to initiate the inward flow of groundwater, thus establishing a good communication between the groundwater in the natural geology and the well. Following well development, the well was left to recover over a 24 hour period.

Groundwater levels were subsequently recorded using an Interface Probe used to detect the presence and thickness of any free product on the surface of the groundwater. Each well was

then further purged prior to sampling using dedicated bailers for each borehole to prevent cross contamination. Samples were stored in appropriate sample containers and placed in cool boxes for dispatch to the laboratory for chemical analysis.

3.3.3 Sludge Sampling

P&G had already taken samples of sludge from a chamber located beneath the warehouse on site. This chamber predates the warehouse and was probably associated with historical manufacturing processes. As these processes are unknown, the sludge was submitted for analysis, in order to determine the contaminants which might be present.

3.4 Laboratory Analysis

Laboratory analysis was carried out by Alcontrol Geochem, which are a UKAS accredited laboratory. They also participate in CONTEST, an inter laboratory QA/QC scheme. Samples were all scheduled on a 5-day turn-around.

Analytical data and details of the analytical methods are contained within Appendix B, while Section 5 of this report discusses analytical results.

3.4.1 Post Sampling Procedures

Soil, water and sludge samples were stored in cool boxes with ice packs for shipment to the testing laboratory within 24 hours of sampling. The samples were transported to the laboratory under full chain-of-custody procedures (see Appendix B).

3.4.2 Soil Analysis

Soil samples were collected from the ten locations described in Table 3.1. Tests were carried out for the following determinands, with each sample being tested for the specific suspected contaminants as well as being screened for possible contamination from unsuspected sources:

- CLEA metals (arsenic, cadmium, chromium, copper, mercury, nickel, lead, selenium, zinc and water soluble boron).
- Diesel Range Organics (DRO)
- Petrol Range Organics (PRO)
- Polyaromatic Hydrocarbons (PAH's)
- PolyChlorinated Biphenyls (PCB's)
- Semi-Volatile Organic Compounds (SVOC)
- Benzene, Toulene, Ethylbenzene and/or Xylene (BTEX)
- Asbestos (screen)
- Total Petroleum Hydrocarbons (GC EZ Flash)

3.4.3 Groundwater Water Analysis

Groundwater samples were collected from 2 locations and analysed for the following determinands:

- CLEA metals (as for soil analysis) and water soluble boron.
- Low level mercury test
- Diesel Range Organics
- Petrol Range Organics
- Semi-Volatile Organic Compounds
- Benzene, Toluene, Ethylbenzene and/or Xylene

3.4.4 Asbestos Analysis

In addition to the groundwater and soil sample testing, a piece of asbestos cement was found at DS4. This was bagged and sent for identification at the laboratory.

3.4.5 Sludge Analysis

The sludge sample collected prior to the site investigation by Procter & Gamble was analysed for the following determinands:

- CLEA metals (as before)
- Total Petroleum Hydrocarbons (GC EZ Flash)
- Semi Volatile Organic Compounds
- Benzene, Toulene, Ethylbenzene and/or Xylene
- Low level mercury test

Key

• DS7 Sample Locations

Procter & Gamble Site Boundary



Procter & Gamble
Havant

Figure 3.1
Sample Locations

July 2003

4. Ground Conditions

4.1 Strata Encountered

4.1.1 General

In general, the lithology of site comprises Made Ground and reworked clays, overlying the natural grey and brown clays.

It was known prior to the site visit that the surface of the natural ground, beneath the Made Ground, slopes down from the northern site boundary to the stream just adjacent the site's southern boundary. This was confirmed during the site investigation, with the recorded depth of Made Ground varying from 0.5 m below ground level (bgl) at the northern end of the site to around 2.8 m bgl at the southern end of the site.

4.1.2 Made Ground

Made Ground was recorded in all sampling locations to depths varying as described in section 4.1.1 above. The Made Ground generally consisted of soft brown or grey silty clay (sometimes mottled) with flint gravels, brick, breeze-block, concrete and, in places, occasional ash, clinker and coal. Soft grey mottled yellow brown reworked clay was also encountered in DS5 and DS7.

4.1.3 Natural Ground

Natural ground was encountered at depth in sampling locations DS1 and DS5 to DS10. At all sampling locations the natural ground consisted of silty clay, usually grey in colour and with varying degrees of mottling with brown, orange and yellow organic clay. In locations DS7, DS8 and DS9, the clay included some gravel pockets.

4.2 Groundwater

All groundwater levels were recorded in the monitoring wells where encountered. This is summarised in Table 4.1.

Table 4.1 Groundwater Monitoring

Sample Location	Groundwater strike depth during exploration (m bgl)	Standing Groundwater Level in open hole (m bgl)	Groundwater depth in installation after development (m bgl)	Stratum
DS1 (installed)	1.35 as seepage			Natural Clay, contaminated with oil
DS2	None			
DS3	None			
DS4	None			
DS5	None			
DS6 (installed)	2.7		2.67	Made Ground (brown clay with gravel and occasional clinker)
DS7	4.7 as seepage	2.36 (overnight)		Natural Clays
DS8	None			
DS9 (installed)	0.8		1.25	Natural Clays
DS10	None			

Note : Initial strike in brackets m bgl.

Groundwater levels recorded in the four boreholes along the site's southern boundary vary by up to 1.4 m. This suggests that the groundwater in the natural clays in this location is perched, and varies with the extent of gravel and sand banding in the clays, and with the nature of the Made Ground.

4.3 Visual and Olfactory Evidence of Contamination

Visual and olfactory evidence of contamination in soil was observed in four of the sampling locations during the site investigation as follows;

- DS1, 1.1 to 1.5 m bgl; Slight hydrocarbon odour in Made Ground, small pockets of oil within fissures in clay causing discolouring. Slight film on groundwater seepage.
- DS4, 0.25 m bgl; Broken asbestos cement tile recovered from Made Ground
- DS5, 0.5 m bgl; very slight hydrocarbon odour in ground
- DS8, 1.55 to 1.85 bgl; slight hydrocarbon odour
- DS9, at around 3 m bgl; strong hydrocarbon odour

4.4 Groundwater Observations

The shallow strata, predominantly the Bognor Sand Member and surrounding London Clays, are classified as Non Aquifers. Given that water levels monitored in the sample locations varied widely, the groundwater identified is considered to be perched groundwater which is not continuous across the site.

The impact on the surface water stream from contamination present in the perched groundwater will depend on the rate of groundwater transport from the ground on site to the stream. The rate of groundwater transport is likely to be dictated by:

- local lithography - i.e. the continuity of the permeable bands within the clay and Made Ground;
- the intensity of rainfall events;
- the rise and fall of localised groundwater levels;

In addition, the degree of dilution of groundwater percolating to the stream with the base flow of the surface water body will affect the dilution of the contaminants, and their potential to impact receptors downstream.

5. Results

5.1 Assessment Approach

5.1.1 Contaminated Land Regime

Under Part IIA of the Environmental Protection Act 1990, new legislation for the management of Contaminated Land were introduced in April 2000. The regime provides a definition of 'contaminated land' and sets out the nature of liabilities that can be incurred by owners of contaminated land and groundwater.

According to the Act, contaminated land is defined as that which is in such a condition that:

- **significant harm** is being caused or there is **significant possibility** of such harm being caused; or
- **pollution of controlled waters** is being, or is **likely to be** caused.

The following situations are defined where harm is to be regarded as **significant** (or where there is the significant possibility of such harm):

- i) Death, disease, serious injury, genetic mutation, birth defects or the impairment of reproductive functions of humans;
- ii) Irreversible adverse change or other harm to the ecological system;
- iii) Substantial damage to, or failure of buildings;
- iv) A substantial diminution in yield or loss of value resulting from death, disease or other physical damage of crops;
- v) Substantial loss in value resulting from death, disease or serious injury of livestock;
- vi) The pollution of controlled waters.

Central to the new regulatory system is a rigorous procedure of risk assessment which is used to determine the existence of 'contaminated land according to the new definition'. Under the risk assessment procedure for such harm to the environment or pollution of controlled waters to be possible, there must be a 'pollutant linkage', as follows:

- a **Source** of pollution (Hazard);
- a **Pathway** for the pollutant to move from source to receptor;
- a **Receptor** (Target) which is affected by the pollutant. This includes human beings, other living organisms, controlled waters, physical systems and built structures which could be affected by the hazard.

5.1.2 Water Pollution Legislation

The risk of statutory liability is increased where pollution of controlled waters (groundwater or surface water) is being or is likely to be caused.

The Anti-Pollution Works Regulations, 1999 enable the Environment Agency (EA) to serve 'Work Notices' on polluters or potential polluters requiring such persons to carry out works or operations to remedy or prevent pollution of controlled waters. Persons who 'knowingly permit' pollution of groundwater or surface water can be targeted as polluters. The EA also has the power to carry out anti-pollution works itself under Section 161 of the Water Resources Act 1991 ('WRA') and then recover costs from the person responsible.

5.1.3 Legal Risks

Additional risks associated with contaminated land fall into several categories, as follows:

- Potential criminal liability for breaches of legislation (especially in relation to water pollution) resulting from pollution migration off-site;
- Potential civil liability for damage caused by pollution migrating off-site;
- Potential remediation costs pursuant to the service of a statutory notice (remediation costs can include investigation, clean-up, and follow-up costs);
- Valuation issues in respect of property and business transactions (the open market value of a property or business may be reduced);
- Planning conditions or obligations associated with redevelopment (e.g. requiring investigation, restoration, or aftercare) which act as a constraint or deterrent to investment.

Primary responsibility for clean up of contaminated land or polluted groundwater/surface water (under both Part IIA EPA and the WRA) rests with the person or persons who 'caused or knowingly permitted' the contamination or water pollution. This is the principle of 'the polluter pays' i.e. the original polluter must, where possible, pay for the pollution/contamination that he/she has caused. The concept of 'knowingly permitting', however, may mean that if any subsequent owner or occupier knows about contamination/water pollution and does nothing to remedy it, he may become primarily responsible for cleaning it up.

5.2 Assessment Framework

The application of this new system of regulation is supported by comprehensive guidance on risk management methodologies; additional guidance is currently in preparation by government agencies.

Entec's approach to undertaking a risk assessment in line with the regulations is based on a Tiered Framework as outlined below:

- Tier 1:
- Qualitative 'Source (hazard) – Pathway – Receptor (target)' risk assessment to identify the 'pollutant linkages' of most concern.
 - Screening of analytical results against published guidelines to identify issues that require more detailed consideration.

- Tier 2:
- Application of simple site specific quantitative risk assessment procedures to clarify risks of concern.
 - For soil contamination this may involve quantitative consideration of potential site specific exposure scenarios taking into account toxicological properties of substances to derive site specific safe levels. To undertake the assessment proprietary models such as the RBCA model or the Dutch RiskHuman model may be used.
 - For groundwater this may involve simple analytical calculations of groundwater flow and contaminant attenuation to ascertain if a risk is posed to a groundwater receptor and to allow acceptable levels at the site to be defined. Tier 2 may also involve the collection of additional data.
- Tier 3:
- More complex 'fate and transport' modelling of contaminant behaviour in the sub surface and groundwater. More detailed quantitative human health risk assessment.

In general the application of increased tiers of analysis may result in less conservative remediation targets thereby resulting in less costly remedial action. Recent experience of tiered QRAs suggests, however, that some criteria may be more onerous, notably PAHs. The cost for increased tiers of assessment may be justified where remediation liabilities are potentially high and less costly solutions may be established as acceptable by detailed risk assessment.

This report is based upon a Tier 1 assessment.

5.2.1 Assessment Guidelines

Assessment Guidelines

New guidance has been issued to support the implementation of the new Contaminated Land provisions in the form of the Contaminated Land Exposure Assessment (CLEA) model. This was published by DEFRA and the Environment Agency on 14 March 2002. The CLEA model has been used to derive guideline concentrations for selected substances for various site end uses, with respect to chronic risks to human health. The model sets out Soil Guideline Values (SGVs) which may be considered to be an intervention value, above which the assessor may choose to either undertake a site-specific risk assessment or move straight to remediation work. To date, guidelines for only seven contaminants have been published, with additional guidelines due to be published as part of a rolling programme in the future.

It is understood that the release of some organic SGVs has been delayed pending the issue of a new version of the software, and gaining Government Department agreement on suitable toxicological values to input to the CLEA Model. Thus Entec is unable to generate site specific or generic screening values for organic determinants until the new version of the CLEA model is released alongside Government –supported Toxicological values. Interim reliance is placed on the appropriate Dutch Target and Intervention Values, as these are based on sound science and have an established track record. The specific assumptions associated with the Dutch values are also taken into account. Phytotoxic contaminants are assessed against The Soil Code (revised 1998) published by DEFRA.

For groundwater a tiered assessment framework, similar to that outlined above is proposed, with screening levels appropriate to the anticipated use of the water body e.g. drinking water.

Tier 1 screening of contamination in soils and groundwater has been undertaken using the following published guidelines:

- i) Soils: CLEA guidelines for selected determinands published to date (arsenic, cadmium, nickel, lead, mercury, selenium and chromium Soil Guideline Values);
- ii) Dutch Guidelines, 2001;
- iii) The Soil Code, Code of Good Agricultural Practice for the Protection of Soil, 1998.
- iv) Concrete in Aggressive Ground by Building Research Establishment 2001
- v) Groundwater: Dutch Guidelines, 2001;
- vi) The Surface Waters (Dangerous Substances) Regulations, various dates

For soils the primary screening criteria utilised are the CLEA soil guideline values (SGV) for commercial/industrial land use and residential with plant uptake. This is followed by Dutch Intervention Values for other chemicals of concern that could impact human health. Phytotoxic Metals are considered under Soil Code criteria for where plants are to be grown.

For groundwater, reference is primarily made to Dutch guidelines and also the Environmental Quality Standards.

5.3 Soil Analysis

Analytical data for the soil samples collected during the site investigation are summarised in Table 5.1. Results which exceed the guidance criteria are highlighted on this table. Three exceedances were found, two were for copper and zinc in the Made Ground in DS10 at a depth of 0.25m. These two values were considered to be outliers, as no other exceedances were found for heavy metals within this sample or in any other sample on the rest of the site. The other exceedance was for total PAH at a depth of 1.9 m in location DS10. This elevated value is probably due to the clinker and ash in the ground in this location.

The Petrol Range Organics (PRO) value at a depth of 1.55 in DS8 were recorded as 646 mg/kg. This value is a measurement of predominantly volatile hydrocarbons. Although there are no direct comparison intervention levels for PRO, previous work has indicated that intervention would be appropriate where levels exceed 90 mg/kg.

Boron levels of 4 mg/kg were noted at depth in location DS9 and near the surface at location DS10. Again, there are no direct comparison intervention levels however, a value of 3 mg/kg has historically been used to indicate contamination potentially sufficient to be phytotoxic.

The hydrocarbon odours which were noted during the site investigation corroborate with elevated Diesel Range Organics (DRO) values noted at locations DS8 and DS9. Elevated DRO levels in DS1 also correspond with the observed oil contamination. A speciated (compound specific) analysis of the DRO compounds was undertaken at locations DS9 and DS1. This analysis indicates that the hydrocarbon compound found in DS9 is biodegradable diesel and that

kerosene residues are present in the soil around location DS1. All results for DRO were recorded below the guidance criteria (Dutch Intervention) of 5000 mg/kg.

Samples at locations DS1, DS2, DS5, DS7 and DS8 were screened for asbestos. No asbestos was found at these locations during laboratory analysis. However, it should be noted that a broken asbestos cement tile was found in location DS4, which was identified during analysis as Chrysotile. It is possible that isolated fragments of asbestos cement is present in the Made Ground around the warehouse.

PCB analysis was undertaken at a depth of 0.5 m at sample location DS5, this yielded a total value of <1 µg/kg.

A speciated SVOC analysis was carried out, which is included in the results in Appendix B. This analysis yielded results below detection limits on all samples analysed, apart from the values listed below for analysis of the soil at a depth of 1.55m at sample location DS10:

- Phenanthrene 197 µg/kg
- Fluoranthene 228 µg/kg
- Pyrene 240 µg/kg
- Chrysene 125 µg/kg

It should be noted, however, that the total for tentatively identified hydrocarbon compounds in this analysis is below intervention levels.

For the purposes of quality assurance, two samples from the same location (samples 20 and 5, both at a depth of 3 m in DS9) were analysed and compared. The chemical analysis of these samples is very similar, although a significant variance is noted between the two PAH values. The mean percentage variance is 5.8%, which would indicate that the quality of analysis is reasonable.

Table 5.1 Analytical Results for Soils - units mg/kg unless stated otherwise

Sample Identity	Soil Code 1998	Dutch Intervention Value	CLEA SGV Resid ¹	CLEA SGV comm	DS1	DS1	DS2	DS2	DS2	DS3	DS4	DS5	DS5	DS6	DS6	DS7	DS8	DS8	DS9	DS9	DS9	DS10	DS10
Depth (m)					1.10	1.60	0.40	1.30	1.50	1.50	1.45	0.50	2.00	1.80	3.20	0.70	1.70	0.90	2.55	3.00	4.15	3.00	0.25
Arsenic			20	500	<1	4	2	-	4	4	8	2	-	4	<1	-	4	-	2	<1	-	<1	1
Boron (Water Soluble)					<1	<1	2	-	<1	<1	<1	<1	-	1	<1	-	1	-	1	<1	-	<1	4
Cadmium			30	1400	<1	<1	<1	-	<1	<1	<1	<1	-	<1	<1	-	<1	-	<1	<1	-	<1	1
Chromium			200	5000	27	32	16	-	36	40	29	-	-	31	17	-	33	-	21	34	28	32	33
Copper	250				6	11	8	-	15	13	7	-	-	14	49	-	14	-	9	56	8	8	342
Mercury			8	480	<1	<1	<1	-	<1	<1	<1	<1	-	<1	<1	-	<1	-	<1	<1	-	<1	<1
Nickel	75		50	5000	12	28	6	-	25	26	6	-	-	14	39	-	17	-	8	52	11	12	18
Lead			450	750	4	6	43	-	5	7	<1	<1	-	25	4	-	12	-	28	511	8	8	75
Selenium			35	8000	<1	<1	<1	-	<1	<1	<1	2	-	2	2	-	<1	-	<1	<1	-	<1	<1
Zinc	300				33	59	34	-	65	69	22	-	-	53	73	-	60	-	44	107	42	50	378
Benzene (µg/kg)		1,000			<10	<10	-	-	-	<10	<10	<10	-	-	-	<10	-	<10	-	<10	<10	-	<10
Ethylbenzene (µg/kg)		50,000			<10	<10	-	-	-	<10	<10	<10	-	-	-	<10	-	<10	-	<10	167	-	<10
Toluene (µg/kg)		130,000			<10	<10	-	-	-	<10	<10	<10	-	-	-	<10	-	<10	-	<10	<10	-	<10
Xylene (µg/kg)		25,000			<10	<10	-	-	-	<10	<10	<10	-	-	-	<10	-	<10	-	<10	456	-	<10
TPH Screen C8-40 by GC-EZ Flash					-	-	28	<10	<10	<10	-	-	<10	<10	<10	-	<10	<10	-	-	-	-	135
Petrol Range Organics					3	<0.01	-	-	-	<0.01	<0.01	<0.01	-	-	-	<0.01	-	646	-	<0.01	33	-	<0.01
Diesel Range Organics		5000			217	358					1.26	3.82				9.35		27.4		111	2699	155	6.36
pH Value In Soil					8.71	7.52	8.01	-	8.19	8.19	9.90	-	-	8.41	8.33	-	8.47	-	6.84	6.34	8.02	-	8.05
Total PAH (sum of 10)		40			0.29	0.1	5.24	<10	<0.01	<0.01	-	-	<10	1.06	0.62	<10	0.34	<10	<10	0.12	4.37	0.64	-

Indicates the concentration exceeds the relevant guidance value

¹ Values given are from DRO EPH results (samples 5 to 8) and totals from SVOC analysis of the DRO range (all other DRO values listed).² Values calculated by addition of levels of: anthracene, benzo(a)anthracene, benzo(k)fluoranthene, benzo(a)pyrene, chrysene, phenanthrene, fluoranthene, indeno(1,2,3-cd)pyrene, naphthalene and benzo(g,h,i)perylene. Values listed as <10 are totals from analysis of all PAH compounds.

h:\projects\cl-240\11000 - 12000\11397 - p & g\avant\docs\rr01212.doc

August 2003

Entec

5.4 Groundwater and Sludge Analysis

Analytical data for the groundwater samples from locations DS6 and DS9, as well as the data from analysis of the sludge sample are summarised in Table 5.2.

Exceedances of the Environmental Quality Standard (EQS) for boron are noted at both locations. The levels in DS6 and DS9 are 19 and 172 µg/l respectively, whereas the EQS value is 2 µg/l. This indicates the boron in the soil has leached into the groundwater.

From the speciated SVOC analysis (included in Appendix B) an exceedance is noted for pentachlorophenol in DS9. Levels of 18µg/l are noted where the Dutch Intervention Value is 3 µg/l. Other values from the SVOC analysis on groundwater from DS9, which are above detection limits, are listed below:

- 2-Methylnaphthalene 5 µg/l
- Acenaphthene 2 µg/l
- Molecular Sulphur 7 µg/l (retention time 24 mins)
- Phenanthrenecarboxylic acid 35 µg/l (retention time 27 mins)

High levels of organic contamination, both in the petrol and in the diesel ranges, are noted for the sludge sample. As no soil or groundwater sampling was undertaken in this location it is not possible to determine whether this contamination has leached into the surrounding soil and groundwater.

Table 5.2 Analytical Results for Water - units µg/l

Sample Identity	Dutch Intervention Value	Environmental Quality Standard	DS6	DS9	Sludge
Mercury Low Dutch Target AA	0.3	1	<0.05	<0.05	<0.05
Benzene by GC	30	30	<10	<10	<10
Ethylbenzene by GC	150	150	<10	<10	<10
Petrol Range Organics by GC			<10	<10	3606
Toluene by GC	1000	50	<10	<10	<10
Xylene by GC	70	0	<10	<10	<10
pH Value in Water			7.86	8.22	7.33
Arsenic by ICP-MS	60	50	1	14	24
Boron by ICP-MS		2	19	172	<10
Cadmium by ICP-MS	6	5	<0.4	<0.4	<0.4
Chromium by ICP-MS	30		<1	<1	2
Copper by ICP-MS	75		3	2	2
Nickel by ICP-MS	75		5	4	3
Lead by ICP-MS	75		<1	<1	<1
Selenium by ICP-MS			3	1	6
Zinc by ICP-MS	800		38	18	19
Mineral Oil	600		<10	163	64660



Indicates the concentration exceeds the relevant guidance value

6. Environmental Assessment

6.1 Introduction

The risk and liability assessment has been based on the established SOURCE - PATHWAY - RECEPTOR methodology where:

Source	A contaminant that has potential to cause harm to or pollution of environmental receptors.
Pathway	The route by which the source is brought into contact with the receptor. This can include the transport of contamination via groundwater, wind-blown dust, vapours, excavation and deposition etc.
Receptor	Human beings, other living organisms, physical systems and built structures that could be affected by the source. A receptor will only be affected if a pathway from the source to the receptor is present. Groundwater and surface water systems can be considered as receptors in their own right as their quality is regulated by the statutory bodies, as well as being pathways for contaminant migration to other receptors.

The SOURCE - PATHWAY - RECEPTOR relationship allows an assessment of potential environmental risk to be determined, based on the nature of the source, the degree of exposure of a receptor to a source and the sensitivity of the receptor. On this basis an assessment is then made of the environmental liabilities associated with the risk. These can be expressed, for example, in terms of additional costs associated with site redevelopment and remedial measures, the potential for costs, fines or penalties imposed for breaches of environmental legislation or third party claims, and loss of land value.

6.2 Risk Assessment

6.2.1 Chemicals of Concern

As a first stage in the assessment of environmental risk i.e. screening against generic guideline values, the main Chemicals of Concern (COCs) on the site have been identified. These are summarised below:

Soil: PAH, Petrol Range Organics (PRO), Diesel range Organic (DRO), copper, zinc, Boron, Asbestos

Groundwater: Boron, Pentachlorophenol (PRO)

Sludge: High Petrol and Diesel Range Organics

This list is based on the determinands which exceeded the generic screening criteria as detailed in Section 5. At the next stage of the risk assessment, these COCs have been attributed to identified sources on site where possible, which allows them to be considered in the context of their likely extent and distribution. These identified sources are discussed in Section 6.2.2.

6.2.2 Sources

The intrusive investigation targeted a number of potential sources identified during the phase one desk study. The potential sources and the results of the investigation are discussed below.

Oil Spillage

A historical spillage of diesel occurred in 1994 during the removal of a 6000 gallon underground storage tank, when it filled with rainwater and overflowed into the Hermitage Stream. Following remedial works in the stream and tank, no validation testing is known to have been undertaken and it is possible that residual hydrocarbon contamination may remain in situ.

Exploratory holes DS7, DS8 and DS9 targeted the areas adjacent to the diesel spill.

Made Ground in DS8 at a depth of 1.55 m bgl exhibited olfactory evidence of hydrocarbon contamination. This coincided with an elevated level of PRO of 646 mg/kg. Natural Clay in DS9 at a depth of ~3.0 m bgl included a slight to strong hydrocarbon odour. Slightly elevated TPH was detected in a shallower sample at 2.55 m bgl and elevated DRO of 2699 mg/kg was detected at 4.15 m bgl. An exceedance of the Dutch Intervention Value for pentachlorophenol in the groundwater at location DS9 was also recorded.

These results suggest that the fuel tank and/or spillage in 1994 have resulted in residual hydrocarbon contamination of this area.

Historical Sewage Works

Part of a sewage treatment works has been located in the southern corner of the site including the settling tanks and filter beds. It was considered that bacteriological contamination and heavy metals may be present in residual sludges, and that physical obstructions in the form of buried foundations might be present.

The historical sewage treatment works was targeted by exploratory hole DS6. This exploratory hole encountered considerable thickness of Made Ground to a depth of at least 3.3 m bgl. Analysis of samples from this hole did not include elevated heavy metals.

Oil in Cable Pit

Oil has been identified in the cable catch pit on the site. It is reported that in the past a trench was excavated around the concrete lined cable duct and no residual hydrocarbon was visually noted outside of the cable pit. However there was no soil sampling to verify its absence. In addition there is no confirmation that the historical oil spill has not migrated vertically to the top of the underlying perched groundwater body. The extent of the oil within the cable catch pit is also not known. It is possible that oil may be leaking along the route of the cable.

Exploratory hole DS1 was located adjacent to the catch pit where oil was evident in the catch pit. Natural Clays beneath at depths of between 1 and 1.5 meters included oil staining and droplets, however samples taken from depths of 1.1 and 1.6 m bgl contained only slightly elevated concentrations of DRO. The presence of observable free phase oil within the clay would suggest a previous significant oil leakage in this area.

Infilled Sand Pit

The former sand pit would have been landfilled, there is no information as to the type of infill materials that may have been used. At the turn of the last century it is possible that waste will have included household waste, ash and clinker.

This location was targeted by exploratory hole DS2. This borehole contained only 0.8 m of Made Ground containing only brick gravel and a little ash and scrap metal. Analysis for metals, TPH and PAH did not identify elevated concentrations. This result would indicate that either very little infilling has occurred in this area or that the exploratory hole did not encounter the full thickness of the waste.

Unknown Historical Tanks

Located to the north of the site in the 1960's, the use of these large cylindrical tanks together with any potential historical contamination associated with them, is unknown.

This location was targeted by hand dug trial pit DS3 to a depth of 1.2 m bgl. This hole did not encounter any significant contamination.

Oil Staining near Plant Room

During excavation work adjacent to the plant room, hydrocarbon contamination of the soil was noted. It is considered likely that this may be from one of two sources; a historical electricity sub-station on site may potentially have leaked transformer oil, which may contain PCB's; two former above ground storage tanks have been located in this area.

Exploratory hole DS5 was located to the south of this area, within the carpark to avoid work in disruption to the site road. Slight hydrocarbon odour was noted in Made Ground at 0.5 m bgl within this exploratory hole.

Diesel Fuelling Point

Slight staining was noted around the concrete base from minor spillages during refuelling activities, which may have led to localised hydrocarbon contamination. In addition this location is adjacent to a bunded chemical storage compound, although there is no evidence of any staining and the bunds integrity appears to be in good to fair condition.

This location was targeted by hand dug trial pit DS4 to 1.3 m bgl. No evidence of hydrocarbon contamination was identified either during the soil logging or from the chemical analysis, however a piece of cement sheet containing asbestos was found at a depth of 0.25 m bgl.

Made Ground along southern boundary

The southern area of the site has been built up substantially, initially the area of the site occupied by the original Scalextric factory building, latterly the warehouse building. The quality of the imported fill material and any spills and leakages from processes involved in the manufacturing of die-cast toy cars and the use of plastics, have the potential to reduce land quality on this part of the site.

A number of exploratory holes, targeted at other potentially contaminative features were located along the southern boundary of the site including DS6 to DS10. From the borehole logs, clinker was noted in sample locations DS6, and DS8 to DS10. DS10 contained slightly elevated PAH

(104 mg/kg against a Dutch Intervention Value of 40 mg/kg), which is likely to be associated with the clinker. Slightly elevated concentration of Boron were also detected in DS9 and DS10.

Drainage Manhole

In addition to the above targets, due to a strong hydrocarbon odour, a sludge sample was recovered from a drain, which was subsequently found to contain elevated PRO and DRO.

The source of contamination in the sludge sample was probably fuel used in historical manufacturing processes. The extent of this contamination is unknown and may be dependent on the extent and integrity of the pipe system connected to the chamber.

6.3 Qualitative Environmental Risk Assessment

In Table 6.3, a two stage assessment has been carried out based on the identified sources, pathways and receptors.

Initially, the column designated as 'Potential Consequence of Source - Receptor Linkage' gives an indication of the sensitivity of a given receptor to a particular source/contaminant of concern (CoC) being considered. It is a worst case classification and is based on full exposure via the particular linkage being examined. The derivation of the classes used to rank this particular aspect is as follows:

Table 6.1 Potential Consequences of Source- Receptor Linkage

Classification	Human Health	Controlled Water	Livestock	Ecological	Built Environment
Severe	Irreversible damage to human health	Substantial pollution of sensitive water resources	Loss in value of livestock resulting from death, disease or physical damage	Significant change to the number of one or more species or ecosystems	Irreparable damage to buildings, structures or the environment
Moderate	Non-permanent health effects to humans	Pollution of non-sensitive water resources or small scale pollution of sensitive water resources	Non permanent health effects, from disease or physical damage which result in reduction in value	Change to population densities of non-sensitive species	Damage to sensitive buildings, structures or the environment
Mild	Slight short term health effects to humans	Slight pollution to non-sensitive water resources	Slight or short term health effects which result in slight reduction in value.	Some change to population densities but with no negative effects on the function of the ecosystem	Easily repairable effects of damage to buildings or structures
Negligible	No measurable effects on humans	Insubstantial pollution to non-sensitive water resources	No significant reduction in value	No significant changes to population densities in the environment or in any ecosystem	Very slight non-structural damage or cosmetic harm to buildings or structures

Subsequently, in the column entitled 'Likelihood of Source-Receptor Linkage', an assessment is made of the probability of the selected source and receptor being linked by the identified pathway.

This assessment is ranked based on site specific conditions as follows:

Very unlikely	0 to 5%;
Unlikely	5 to 45%;
Possible	45 to 55%;
Likely	55 to 95%;
Almost Certain	95 to 100% (i.e. impact noted during the investigation).

The 'Risk Classification' column is an overall assessment of the actual risk, which considers the likely consequence of a given risk being realised and the likelihood of that risk being realised. The risk classifications are assigned using the following consequence/likelihood matrix:

Table 6.2 Risk Classifications

Likelihood	Very Unlikely	Unlikely	Possible	Likely	Almost Certain
Potential Consequence					
Severe	Low	Low to moderate	Moderate to high	Very High	Very High
Moderate	Negligible to low	Low	Moderate	Moderate to high	High
Mild	Negligible	Low	Low	Low to moderate	Moderate
Negligible	Negligible	Negligible	Negligible to low	Low	Low

Overall risks are described as follows:

Negligible	The presence of the identified source does not give rise to the potential to cause significant harm.
Low	It is possible that harm could arise to a designated receptor from an identified source, however, this is likely to be mild.
Moderate	It is possible that harm could arise to a designated receptor from an identified source, but it is likely that such harm would likely be relatively localised or non-permanent. Remedial action may be necessary.
High	A designated receptor is likely to experience significant harm from an identified source without remedial action.
Very High	There is a high probability that severe harm could arise to a designated receptor from an identified source without appropriate remedial action.

A number of environmental risks have been considered and are summarised in Table 6.3. The shaded rows indicate a risk classification which is assessed as requiring some form of risk

management action for the defined source - pathway - receptor linkage to mitigate any harm or impact. The risk management approaches required are discussed in Section 7, where residual risks are also assessed using the same approach.

The elevated hydrocarbon levels found in the sludge sample are not considered in Table 6.3. before considering the risks associated with these chemicals, the potential for leaching should be determined. As there is no information available on the integrity of the chamber or the condition of surrounding soil, the risk cannot be classified.

Table 6.3 Summary of Potential Significance of Identified Environmental Risks, Procter & Gamble, Havant

Area/ Structure	Pollutant (Source) (Exceeding Guideline Value)	Potential Receptor	Potential Pathway to Receptor	Associated Hazard	Potential Consequence of Source - Receptor Linkage (from observed concentrations)	Likelihood of Source - Receptor Linkage	Risk Classification
Area of historical oil spillage	PRO, DRO and Pentachlorophenol (soil and groundwater)	Humans (site redevelopment workers)	Ingestion, Dermal Contact, Inhalation	Toxic, Carcinogenic, Hazardous to human health	Mild	Possible	Low
		Humans (future residential end use)	Ingestion, Dermal Contact, Inhalation	Toxic, Carcinogenic, Hazardous to human health	Mild	Unlikely	Low
		Humans (future commercial end use)	Ingestion, Dermal Contact, Inhalation	Toxic, Carcinogenic, Hazardous to human health	Mild	Unlikely	Low
	PAH's (Soil)	Perched Groundwater	Dissolution, Permeation through soil	Contamination of perched groundwater	Negligible	Almost Certain	Low
		Surface water (Hermitage Stream)	Leaching, Groundwater flow, surface water run off	Surface water contamination	Mild	Possible	Low
		Flora and Fauna	Leaching, uptake	Phytotoxic	Moderate	Unlikely	Low
Made Ground around DS10	PAH's (Soil)	Humans (site redevelopment workers)	Ingestion, Inhalation, Dermal Contact	Toxic, Carcinogenic	Moderate	Possible	Moderate
		Humans (future residential end use)	Ingestion, Dermal Contact, Inhalation	Toxic, Carcinogenic, Hazardous to human health	Moderate	Unlikely	Low

Area/ Structure	Pollutant (Source) (Exceeding Guideline Value)	Potential Receptor	Potential Pathway to Receptor	Associated Hazard	Potential Consequence of Source - Receptor Linkage (from observed concentrations)	Likelihood of Source - Receptor Linkage	Risk Classification
		Humans (future commercial end use)	Ingestion, Dermal Contact, Inhalation	Toxic, Carcinogenic, Hazardous to human health	Moderate	Unlikely	Low
		Perched Groundwater	Dissolution, Leaching, Permeation through soil	Contamination of perched groundwater	Mild	Likely	Low/Moderate
		Surface water (Hermitage Stream)	Leaching, Groundwater flow, surface water run off	Surface water contamination	Moderate	Unlikely	Low
		Flora and Fauna	Leaching, uptake	Phytotoxic	Moderate	Unlikely	Low
Made Ground	Boron	Flora and Fauna	Leaching, uptake	Phytotoxic	Moderate	Possible	Moderate
		Perched Groundwater	Dissolution, Leaching, Permeation through soil	Contamination of perched groundwater	Negligible	Almost Certain	Low
		Surface water (Hermitage Stream)	Leaching, Groundwater flow, surface water run off	Surface water contamination	Moderate	Unlikely	Low
Made Ground	Asbestos cement	Humans (site redevelopment workers)	Ingestion, Dermal Contact, Inhalation	Toxic, Carcinogenic, Hazardous to human health	Severe	Possible	Moderate to High
		Humans (future residential end use)	Ingestion, Dermal Contact, Inhalation	Toxic, Carcinogenic, Hazardous to human health	Severe	Possible	Moderate to High
		Humans (future commercial end use)	Ingestion, Dermal Contact, Inhalation	Toxic, Carcinogenic, Hazardous to human health	Severe	Unlikely	Low to Moderate

6.3.1 Risk Classification Rationale

The rationale behind the ranking of the identified potential source - pathway - receptor linkages summarised in Table 6.3 is discussed below:

Human (Site Redevelopment Workers)

The presence of asbestos cement tile at sampling location DS4 poses a moderate to high risk to site redevelopment workers. It is possible that asbestos may also be deposited elsewhere in the Made Ground behind the warehouse on site, however, the extent of the hazard is unknown. It is also possible that site redevelopment workers without PPE will come into contact with the areas of PAH and petroleum hydrocarbon contamination on site, so the risk associated with this hazard has been assessed as moderate.

Human (Future users - commercial or residential)

A site redeveloped to include residential end use with gardens will pose greater risk to future site users than a commercial redevelopment. However, based on the currently held information, the fact that petrol range organic and PAH contamination is located at a depth of over 1.5 m is reflected in the low risk ratings for those two contaminants on both receptors. If the presence of asbestos cement on site, noted above, is not addressed, this will pose a moderate risk to future site users.

It is possible that other as yet unidentified contamination may be present of site, that without remedial works may represent an increased risk to future site users.

Groundwater

The groundwater around sampling locations DS6 and DS9 has been noted to have elevated levels of boron, and high levels of pentachlorophenol were observed at DS9. Therefore, contamination of the perched groundwater has already occurred. The groundwater in the chalk underlying the site is not considered to be at risk as the clays which overlie it are around 70 m thick.

Provided that the original source of contamination has been eliminated, the localised impact on perched water is not considered to be significant.

Controlled Water - Surface Water

A tributary to Hermitage Stream is located along the site's southern boundary. Groundwater percolates from the area around DS9 to the Hermitage Tributary Stream to the south of the site and it is possible that during prolonged rainfall events pentachlorophenol and boron contamination within the perched groundwater could be 'flushed out' by rising water levels.

However, the risk associated with the transport of boron to the stream is considered minimal, as the dilution of groundwater with stream water will be high. Pentachlorophenol was the only semi-volatile compound to be identified above the guideline values. Overall the total levels of semi-volatile compounds identified were below guideline values, so this risk is considered minimal.

Flora

High levels of boron were found in the groundwater in DS9 and near the surface of DS10. This localised area of boron contamination could pose a moderate risk to flora in that area of the site.

Key

Procter & Gamble Site Boundary

Procter & Gamble
Havant

Figure 6.1
Contamination Issues (identified during site
investigation on 2nd and 3rd July, 2003)

July 2003

Entec



7. Recommendations

The limited intrusive investigation has been targeted at areas perceived to be of highest risk.

The investigation has highlighted localised areas of slight contamination that will require remediation prior to site redevelopment. The extent and nature of remediation will depend on the sensitivity of the end use planned for the site. It is understood that the proposed future site use will consist of a combination of commercial and residential use.

The 7 hectare site has historically been used for a number of light industrial processes and it can be assumed that other contamination issues may be present that have not been identified by the limited intrusive investigation undertaken. It is recommended that prior to redevelopment, further investigation is undertaken at an intensity commensurate with the sensitivity of the desired end use.

Principal remediation issues based on the information gained from the intrusive investigation are discussed below.

Commercial End Use

The targeted site investigation has not identified ground or groundwater contamination that is considered to represent a statutory risk. However site investigation of 10 shallow exploratory holes has covered only a small area of the site and it is possible that other areas of contamination will be encountered during development works.

The results to date indicate that the site is suitable for redevelopment for a commercial end use comprising buildings and hard cover such as carparking. Where areas are to be developed for open space or landscaping, it is possible that it will be necessary to replace Made Ground with clean sub and topsoil. Removal and replacement of Made Ground will provide the necessary soil quality for plant growth, while addressing potential human health risk from fragments of asbestos cement.

Residential End Use

If the proposed end use of the site is to include residential property with gardens, it will be necessary to remove Made Ground over the foot print of gardens and replace this with a suitable thickness of clean sub and topsoil.

This action will mitigate risk from the following areas of contamination that have been identified:

- Isolated areas of hydrocarbon contamination from historical leakages and spillages.
- elevated phytotoxic metals (copper and zinc) encountered in shallow Made Ground in the area of DS10;
- Elevated boron in the area of DS10;
- Removal of all fragments of asbestos cement tile;

Other deeper hot spots of contamination will require removal where areas coincide with garden areas. These should include:

- elevated petrol range organics in the area of DS8.
- Elevated lead and boron in the area of DS9
- Elevated total petroleum hydrocarbons and specifically diesel range organics in the area of DS9

It is likely that during redevelopment, other areas of contamination will be encountered which will require remediation.

Site Decommissioning

A number of contamination issues have been identified which will need addressing as part of the site decommissioning and redevelopment. These include:

- Removal and further investigation of sludge in the manhole in the south of the site which is heavily contaminated with petroleum hydrocarbons. This should include an investigation of the connecting pipe work, and the source and the outlet of the drainage, as well as an intrusive investigation of the area surrounding the manhole and all connecting pipework;
- Removal and further investigation of oil evident within the cable pit near DS1. Free phase oil contamination has been identified in DS1 indicating that the oil in the cable pit may be leaking into the soil. The route of the cable pit should be identified. During decommissioning and removal, any soils impacted by spillages should also be excavated and validation testing undertaken.
- Slight hydrocarbon contamination was identified near to the location of the former fuel tank near the southern boundary. It is not known whether this tank was removed or was infilled and left in place. If the tank is present, it is suggested that it is excavated and that validation testing is undertaken around the sides of the excavation. Any associated pipe work should be decommissioned.
- There is a number of electrical transformers on site which have not been investigated. It is recommended that when transformers are decommissioned, validation testing is undertaken for hydrocarbons and PCB's to prove the soil quality in these areas.
- A small number of lower risk areas have been identified which have the potential to have resulted in historical ground contamination but which has not been investigated. These include the historical solvent and petroleum store, the waste oil store and the machine shop. It is recommended that validation testing is undertaken when the structures and floor slabs are removed.

Appendix A Borehole Logs

Entec

Appendix B

Laboratory Results

Entec

Entec UK Limited

8/9 Magellan Terrace, Gatwick Road,
Crawley, West Sussex RH10 9PJ, England
Tel: +44 (0) 1293 646950
Fax: +44 (0) 1293 646951

Doherty Innovation Centre, Pentlands Science Park,
Bush Loan, Penicuik, Midlothian EH26 0PZ, Scotland
Tel: +44 (0) 131 445 6112
Fax: +44 (0) 131 445 6113

6/7 Newton Terrace,
Glasgow G3 7PJ, Scotland
Tel: +44 (0) 141 222 1200
Fax: +44 (0) 141 222 1210

Gables House, Kenilworth Road,
Leamington Spa, Warwickshire CV32 6JX, England
Tel: +44 (0) 1926 439000
Fax: +44 (0) 1926 439010

Regents Park House, Regent Street,
Leeds LS2 7QN, England
Tel: +44 (0) 113 223 7303
Fax: +44 (0) 113 223 7304

17 Angel Gate, City Road,
London EC1V 2SH, England
Tel: +44 (0) 207 843 1400
Fax: +44 (0) 207 843 1410

Northumbria House, Regent Centre, Gosforth,
Newcastle upon Tyne NE3 3PX, England
Tel: +44 (0) 191 272 6100
Fax: +44 (0) 191 272 6592

Windsor House, Gadbrook Business Centre,
Gadbrook Road, Northwich, Cheshire CW9 7TN, England
Tel: +44 (0) 1606 354800
Fax: +44 (0) 1606 354810

Atlantic House, Imperial Way,
Reading RG2 0TD, England
Tel: +44 (0) 1189 036061
Fax: +44 (0) 1189 036261

160-162 Abbey Foregate,
Shrewsbury, Shropshire SY2 6BZ, England
Tel: +44 (0) 1743 342000
Fax: +44 (0) 1743 342010

www.entecuk.com



Rev 5 08.2002

Entec