Department of the Environment
Industry Profile

Waste recycling, treatment and disposal sites

solvent recovery works

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Contaminated Land and
Liabilities Division

Industry Profiles, together with the Contaminated Land Research Report series, are financed under the Department of the Environment's contaminated land research programme.

The purpose of these publications is to provide regulators, developers and other interested parties with authoritative and researched advice on how best to identify, assess and tackle the problems associated with land contamination. The publications cannot address the specific circumstances of each site, since every site is unique. Anyone using the information in a publication must, therefore, make appropriate and specific assessments of any particular site or group of sites. Neither the Department or the contractor it employs can accept liabilities resulting from the use or interpretation of the contents of the publications.

The Department's Contaminated Land Research Report series deals with information needed to assess risks; procedures for categorising and assessing risks; and evaluation and selection of remedial measures.

General guidance on assessing contaminated land and developing remedial solutions which is complementary to the Department's publications is provided by the Construction Industry Research and Information Association (CIRIA).

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DOE Industry Profile

Waste recycling, treatment and disposal sites: solvent recovery works

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Preface

DOE Industry Profiles provide developers, local authorities and anyone else interested in contaminated land, with information on the processes, materials and wastes associated with individual industries. They are not definitive studies but they introduce some of the technical considerations that need to be borne in mind at the start of an investigation for possible contamination.

Every site is unique. Investigation of a site should begin with documentary research to establish past uses. Information on the site's history helps to focus a more detailed investigation. This knowledge needs to be supplemented by information on the type of contamination that may be present and where on site it may be found. Profiles give information on the contamination which might be associated with specific industries, factors that affect the likely presence of contamination, the effect of mobility of contaminants and guidance on potential contaminants.

The date when industrial practices first commenced on a site and its location are important clues in establishing the types of operations that may have taken place, so each profile provides a summary of the history of the industry and its likely geographical spread within the United Kingdom.

Profiles should be read with the following reservations in mind:

> individual sites will not necessarily have all of the characteristics described in the profile of that industry;
>
> practices can vary between sites and change over time;
>
> as practices change, problems of possible contamination may also change;
>
> the profile may refer to practices which are no longer followed, and may omit current practices which avoid contamination.

The risks presented by contaminated sites depend on the nature of the contaminants, the targets to which they are a potential threat (such as humans or groundwater) and the routes or pathways by which they reach these targets. The current or proposed use of a site and its environmental setting are crucial in deciding whether treatment is necessary and if so, the methods to be used. Some sites may not need treatment.

The information in profiles may help in carrying out Control of Substances Hazardous to Health (COSHH) assessments for work on contaminated land - see Health and Safety Guidance Note HS(G) 66 *Protection of workers and the general public during the development of contaminated land,* Health and Safety Executive, 1991, and *A guide to safe working practices for contaminated sites,* Construction Industry Research and Information Association, 1995.

Note: the chemical names given to substances in this profile are often not the modern chemical nomenclature, but the names used historically for those substances.

Waste recycling, treatment and disposal sites: solvent recovery works

1. Background

This profile covers the off-site recovery of used industrial solvents for reuse or re-sale. The term 'industrial solvent' is generally applied to organic liquids which are used on an industrial scale to clean, dissolve, suspend or change the physical properties of materials.

Solvents which have been used in manufacturing or process industries may be contaminated with a variety of substances. The purpose of the solvent recovery process is to separate the solvent from impurities to produce either a solvent that can be reused for the original application, or a lower grade solvent which can be used for different purposes. Typically, the recovery process involves a physical treatment stage followed by either distillation or evaporation of the solvent. There is no change in the chemical structure of the solvent.

The recovery of solvents at their point of use is not discussed here; the treatment technologies used will be much the same, although the risks of contamination during transportation are avoided.

Solvent recovery activities did not develop in the United Kingdom until the late 1940s and 1950s, when the chemical manufacturing industry became firmly established. The recovery of solvents demanded trained personnel and relatively sophisticated equipment and processes. Sites were often developed to take advantage of an individual industry's needs. Solvent recovery works developed throughout the United Kingdom, on old industrial sites such as former gas works and tar distilleries, with the greatest concentration in the industrial areas of North West and North East England. The more recent facilities are generally located in areas with good motorway links to industrial areas.

A considerable impetus was given to the solvent recovery industry in the 1970s by the Deposit of Hazardous Waste Act 1972 and the Control of Pollution Act 1974. This legislation prevented the disposal of large quantities of certain waste products, like solvents, through the ordinary waste management channels without some form of treatment. Waste management contractors were encouraged to develop facilities for handling these materials and the industry expanded as a result.

There are currently approximately 20 companies in the United Kingdom involved in the recovery of used solvents. A number of these companies have operated solvent recovery processes over many years and the potential for contamination of soil and groundwater may be high, especially where solvent recovery works developed on old industrial sites. Newer companies are likely to have better processing equipment, which provides safer and more effective treatment of used solvents.

2. Activities

2.1 Raw materials

Industrial solvents may be organic (for example aromatic or aliphatic compounds) or inorganic (such as silanes) and will typically have boiling points in the range 70-200°C. A solvent may be used as a single, relatively pure compound, or a mixture of two or more compounds.

Solvents recovered for processing may contain a wide range of impurities, although not all of these may be removed by the treatment process. Typical impurities include water, organic or inorganic solids, dissolved inorganic compounds and chlorinated and non-chlorinated organic compounds, dissolved or as a separate phase.

The identity and amounts of any contaminants present in the solvents delivered to the site will vary according to the industry from which the materials originate.

2.2 Method of delivery and transfer of materials on site

The solvents normally arrive in bulk road or rail tankers or in 0.2 m^3 drums; smaller drums or containers may also be used. A typical facility will process 50-500 m^3 of materials per week and have a total storage capacity of approximately two to three times this volume.

Solvent transported by bulk tankers will normally be pumped directly into bulk storage tanks, sited above or below ground, using a flexible hose attached to fixed pipework. Samples are taken to confirm the composition or characteristics of the liquids. Modern underground storage tanks are required to be double skinned with leak detection facilities. Bulk storage vessels are now normally sited on impervious floors with bund walls to contain any spills; most are fitted with alarms to prevent overfilling. Tanker unloading areas are normally secondarily contained and not connected to any surface water drainage systems.

Drummed wastes are stored in purpose-built, covered storage compounds, with adequate fire suppression equipment and secondary containment of sufficient capacity to receive spills and fire-fighting water. However, less stringent storage methods, including storage in unprotected outdoor compounds with no spill protection or secondary containment, may have been practised in the past.

Movement of drummed materials in and out of storage is typically by fork-lift truck. Good practice requires the use of dedicated drum clamps.

Liquid and pumpable sludge wastes are typically transferred around the treatment plants by overhead pipes, although underground pipes may have been used in older facilities. One advantage of overground pipes is that they allow leaks to be detected early; leaks in underground pipes may remain undetected.

Liquid wastes are typically transferred from their drums to the treatment facility by a barrel pump or vacuum suction system. Transfer areas may not have any secondary containment and, because spills may occur, they are potential sites of soil contamination.

2.3 Processes

Solvents received for processing undergo a number of pre-treatment and recovery steps. Owing to the diversity of materials processed, the majority of these will be carried out as batch or semi-continuous processes.

2.3.1 Pre-treatment processes

Decantation
Solvents which are insoluble in water may be allowed to stand for a period of time so that any water can be separated out. Decantation is carried out in the delivery drums or in separation tanks.

Sedimentation
High levels of suspended solids, for example from paint manufacture and use, may be separated from solvents by sedimentation (gravity separation) which is typically carried out in a bulk storage vessel. The settled sludges are then drained to another vessel or sent off site for processing or disposal.

Filtration
In-line mesh strainers may be necessary to remove large solid particles in the feedstock in order to prevent blockages or damage to equipment from the liquid streams. Further filtration may be necessary to remove solid particles from the solvent which may operate under pressure or vacuum. Often, a sufficient level of solids removal can be attained by the use of simple cartridge filters. The captured solids will contain solvents and may require further processing before disposal.

Neutralisation
If the solvent is sufficiently acidic or alkaline to cause corrosion of the processing equipment, it may be necessary to adjust the pH prior to processing. Mildly acidic or alkaline streams may be neutralised by substances such as amines or acetic acid. The neutralisation will typically be carried out by adding incremental quantities of acid or alkali to the solvent in a bulk storage vessel or in a dedicated neutralisation vessel.

Acids and alkalis used for this purpose may be stored in a storage vessel or used directly from drums.

Other additives include sequestrants and plasticisers to modify the behaviour of residues during distillation.

2.3.2 Recovery processes

Flash distillation
A crude separation of volatile compounds from solvents, oils and solids with higher boiling points can be accomplished by flash distillation, ie heating the solvent to its boiling point and condensing the vapour which is generated. This is often carried out under vacuum to reduce the amount of heating that is required. This type of process provides little control over the composition of the recovered solvent; it can be carried out by a batch or continuous process. The residue of compounds and solids with higher boiling points may require further treatment prior to off-site disposal. The distillate containing the volatile compounds may undergo further treatment, such as fractional distillation, to adjust the composition of the final product.

Steam stripping
Steam may also be injected into the liquid to aid the removal of volatile compounds; this is known as 'steam stripping'. This process increases the relative vapour pressure of high molecular weight solvents which are insoluble in water and thus speeds up the recovery process. This is particularly advantageous for solvents which are vulnerable to decomposition near to their boiling points and also allows the processing of mixtures with very high solids content. Steam stripping has the disadvantage of producing large quantities of contaminated wastewaters and residues which may need further treatment before discharge.

Fractional distillation
If a higher degree of control is required over the composition of the recovered product, fractional distillation may be used. This allows the individual components of a mixture of liquids to be separated by means of the difference in their boiling temperatures. The mixture, which is preheated to its boiling point, is fed to the centre of the distillation column. Trays fitted with bubble caps are installed along the distillation columns to create a large surface area on which ascending vapour and descending liquid come into contact. At each level, vapour ascends via the bubble caps and condensate is collected in the trays. This mechanism allows condensate of low boiling temperature to be collected high up the column and high boiling point temperature condensate to remain near the base. Condensate from different levels of the column is drawn off continuously.

The distillation can be carried out at a number of different pressures (including vacuum) and temperatures depending on the composition of the solvent mixture and the products required. The processing may be either continuous or batch depending on the volume throughputs and the process equipment available. Distillation columns can vary in size, from a few metres to tens of metres in height, depending on the processing capacity required.

Evaporation
Solvents (including water) can be removed from a solution or slurry by evaporation. Evaporators are generally used to provide a high degree of solvent removal from liquids containing solids and slurries; they produce a waste stream containing high concentrations of solids and a product substantially free from solids. The product may undergo further processing such as fractional distillation.

The evaporation is typically carried out in a pressure vessel fitted with a steam heating coil and an agitator. The preheated feedstock is added to the vessel continuously or in batches and the vapour formed is drawn from the vessel and condensed. The solids and any less volatile liquids remain in the vessel and can be periodically pumped-off to a storage vessel. Other types of evaporators, such as falling or wiped film, may be used where viscous solvents are to be processed.

2.3.3 *Product finishing*

The recovered solvent may be blended with other solvents to achieve the required specification. Adjustment of pH with acids or alkalis may also be carried out at this stage. These operations are typically carried out in a bulk storage vessel or in a dedicated vessel fitted with an agitator.

2.4 Waste management

A solvent recovery works is likely to generate a number of waste streams which include:

Used drums
These may be washed prior to sending to a contractor for recycling, or crushed for disposal (typically to landfill).

Contaminated water
From washing operations and settled out from solvents. Volatiles insoluble in water can be easily separated. Wastewater may need treatment if the organic material is water soluble; conventional wastewater treatment methods are used. Contaminated water may be processed in a flash unit to remove solvents prior to tankering off site or disposal to sewer.

Sludges and solids
Non-volatile residues from distillation processes consist of organics such as oily wastes and sludges. These can be separated from any remaining solvent by decanting, centrifuging or other physical separation techniques. The final waste, which may contain complex chlorinated organic compounds such as dioxins, furans and polychlorinated biphenyls (PCBs), may have been landfilled on or off site. In future, landfilling of such materials will not be authorised.

Non-specification solvent
Solvent that is received on site and is not suitable for processing, may be sent for incineration or returned to the original customers.

Volatile emissions
Fugitive and process emissions of volatilised solvent to air require pollution abatement plant. Chlorinated solvents present more problems with emission control than do non-chlorinated solvents. Furthermore, chlorinated solvents are ozone depleting substances and emissions are now severely restricted.

Waste-derived fuels
At some sites, solvent residues are blended to specification to produce waste suitable for use as fuels, for example in cement kilns.

The handling and storage of wastes containing solvent residues have the potential to cause soil and groundwater pollution if they are not carried out in suitably designed secondary containment areas. At older facilities, on-site landfilling of residues may have occurred. These landfills may not have been suitably designed for containing solvent-contaminated wastes.

3. Contamination

The contaminants on a site will largely depend on the history of the site and on the range of materials processed there. Potential contaminants are listed in the Annex and the probable locations on site of the main groups of contaminants are shown in Table 1. It is most unlikely that any one site will contain all of the contaminants listed. It is recommended that an appropriate site investigation be carried out to determine the exact nature of the contamination associated with individual sites.

3.1 Factors affecting contamination

The operations at a solvent recovery works which present the highest risk of soil or groundwater contamination are transfer and storage operations. However, all areas where solvents are present, including processing, packaging and waste management areas, may be sites of contamination, especially if leakages or spillages have occurred. Areas where solvents have been stored or transferred to or from drums or bulk tankers, are likely to have been contaminated if spills have occurred on open or poorly-sealed ground. Historically, it was common for tanks to have no secondary containment. The integrity of some underground storage facilities may not always have been regularly tested. Containment bunds may have been added around tanks after they had been used for some time. Current guidance from Her Majesty's Inspectorate of Pollution (see Section 4) advises that bulk storage tanks should be sited above ground. Leakage of solvents from underground tanks and pipework at older sites may result in contamination of soil. Leakages may be caused by corrosion in the pipeline or movement of the soil in the area of the pipe, giving rise to pipeline fracture.

Given the mobility of some of these compounds, it is possible that solvent contamination may spread a considerable distance from its source.

It is likely that the nature of activities and the locations of buildings and storage areas will have changed on older sites. Waste management practices are likely to have altered. Consequently, investigations should take account of site history.

It is possible that on older sites, plant buildings and infrastructure may have been insulated with asbestos lagging, or asbestos cement sheeting used for roofing and cladding. Contamination could have occurred during demolition of buildings or removal of plant.

Some sites may have had transformers in electricity sub-stations which, in the past, may have contained polychlorinated biphenyls (PCBs) as a dielectric fluid. Contamination may have occurred during spills, retrofitting or break up of this plant.

3.2 Migration and persistence of contaminants

3.2.1 Solvents

Relatively small amounts of solvent pose a considerable threat to water resources. The magnitude of the risk to groundwater depends on the depth of the water table, the soil structure and its properties. Generally, the higher the natural organic matter and clay content within the soil, the greater the adsorption of solvents and the lower their mobility. Conversely, the greatest migration of contaminants will occur in coarse-grained sands and gravels with little organic matter.

The soluble components will dissolve in the groundwater and migrate in the direction of groundwater flow. The less soluble organic compounds which become adsorbed onto clay or natural organic matter will provide on-going sources of water pollution, long after the original source has been removed, by continuing to desorb into the soil-water.

A further problem frequently encountered with volatile solvents is that vapours moving through unsaturated soils may dissolve into the groundwater. If vapours accumulate in poorly ventilated, confined spaces such as drains, they can present a fire or explosion hazard.

Non-chlorinated solvents tend to be volatile liquid organic compounds. The aqueous solubilities of toluene, benzene and xylenes are relatively low but are nonetheless of environmental significance. The non-chlorinated solvents which are least soluble in water are mostly less dense than water and float on the water surface. A number of other commonly recycled solvents (for example alcohols, ketones and glycerol) are more water soluble and able to migrate. This suggests that they have a significant potential for surface and groundwater contamination.

Chlorinated solvents, such as chloroform, trichloroethylene and dichloromethane, are volatile liquid organic compounds. Chlorinated solvents can contaminate drinking water at very low concentrations. They are more dense than water and tend to migrate to the bottom of aquifers. Their migration may be different to the general direction of groundwater flow.

Natural biodegradation may result in significant removal of solvents. Most non-chlorinated solvents, such as benzene and toluene, are potentially biodegradable but may persist in soil owing to conditions unfavourable for microbial activity.

Chlorinated solvents are persistent, their biodegradability decreasing with increasing chlorination. They degrade slowly and only under specific conditions.

Biodegradation processes in soils can be influenced by a number of factors, namely moisture content, oxygen concentration and pH, acting separately or in combination. For example, low moisture content reduces microbiological activity, while high moisture content can reduce oxygen penetration and possibly lead to anaerobic soil conditions. Such conditions enhance the biodegradation of some materials, for example chlorinated compounds, while aerobic conditions are needed to biodegrade many oils. Also, low pHs tend to reduce the bacterial population and encourage fungal activity; at pHs lower than 5, microbiological activity is much reduced. The presence of heavy metals also inhibits micro-organisms. Consequently at high concentrations in soil, even relatively non-persistent compounds may not biodegrade readily.

If contamination by organic solvents is widespread, it may provide the opportunity for groundwater contamination by other materials, such as some metal salts, which have low solubilities in water but are readily soluble in such solvents.

Organo-metallic compounds, PCBs and some of the halogenated organics are fat-soluble and have a propensity to accumulate in food chains. This is of significance when surface and ground waters are contaminated. PCBs have a low aqueous solubility and are usually highly persistent.

3.2.2 Mineral oils

The mineral oils which are potentially present as contaminants associated with solvent recovery works encompass a wide range of petroleum hydrocarbons. Some of the lower boiling point fractions (particularly below C_{12}) will have been lost through volatilisation. All types have the recognisable petroleum-type odours and are potentially flammable.

Mineral and fuel oils move through the soil in the same way as solvents and may pose a threat to water supplies. Oils are generally less dense than water and so tend to float on the water table surface. Even if the aqueous solubilities of many of the individual components of mineral oils are low, the dissolved quantity may be of significance. As a contaminant of groundwater, mineral oil may be present as micro-droplets in an emulsified phase.

The n-alkanes (paraffins) are generally degradable under favourable conditions; the iso-alkanes and cycloalkanes degrade at a much slower rate. Degradation of the polycyclic aromatic hydrocarbons (PAHs) and heavy fractions of oils will be slow and these, together with cycloalkanes (particularly branched and multi-ringed alicyclic compounds), will tend to persist in soil.

3.2.3 Metals and metallic compounds

A number of metals and metallic compounds may be present as contaminants within solvent wastes. The metals most likely to be encountered are those used in machinery and components which may have undergone degreasing at some stage during maintenance.

The aqueous solubility of metal salts will depend on the compound involved; in general, sulphates, nitrates and chlorides are likely to be soluble whereas the sulphides and oxides are insoluble in water. Most metals (for example copper, zinc and lead) are more soluble at lower pHs. In other cases the relationship is more complex. For example, trivalent chromium is more soluble under acidic conditions, whereas the solubility of hexavalent chromium is increased under both acidic and alkaline conditions.

The movement of metals through the soil is significantly retarded by the presence of clay minerals and natural organic matter but may be enhanced by the presence of solvents. Micro-organisms may mineralise some organo-metallic complexes, possibly altering metal mobility. Metals may migrate more readily as part of a complex anion, for example chromate.

The presence of heavy metals may inhibit microbial activity, restricting the biodegradation of other pollutants present, such as oils. Metals are not biodegradable.

Certain heavy metal contaminants may be taken up by plants, thereby entering the food chain; organic lead compounds readily accumulate in fatty tissue.

3.2.4 Other contaminants

Acids and alkalis are corrosive and a spillage could enhance the mobility of other contaminants. Acid spillage near buildings may affect the integrity of concrete/cements used in foundations.

Asbestos is neither soluble nor biodegradable. Wind may be a transport mechanism where there is gross surface contamination by some of the less mobile contaminants such as asbestos fibres and metals.

4. Sources of further information

4.1 Organisations

For information concerning the solvent recovery industry in the United Kingdom, the following organisations should be consulted:

Chemical and Oil Recycling Association
9 Luned
Kinmel Bay
Rhyl
Clwyd
WL18 5JG

Cleanaway Limited
D5 Red Scar Industrial Estate
Longridge Road
Preston
Lancashire
PR2 5NQ

Lanstar Oil Refineries
Shelah Road
Halesowen
West Midlands
B63 3PN

Lothian Chemical Company Limited
West Shore Road
Granton
Edinburgh
EH5 1QD

4.2 Sources of information concerning the activities described in this profile

Aldred J B and Lord D W. *Experience in the investigation of contaminated land.* Symposium on Hazardous Waste Disposal and the Re-Use of Contaminated Land, Kensington Close Hotel, London, 3 July 1984. Society of Chemical Industry.

Craig T O and Grzonka R B. *Persistent land contamination from the operation and subsequent fire destruction of a solvent recovery plant.* Environmental Protection Bulletin, page12-18, 1992.

Dragun J. *The soil chemistry of hazardous materials.* Hazardous Materials Control Research Institute, Silver Spring, MD, USA, 1988.

Eckroth D, Graber E, Klingsberg A and Siegel P M. *Kirk Othmer concise encyclopaedia of chemical technology.* J Wiley and Sons, Chichester, 1985.

Tameside Metropolitan Borough Council. *Contaminated land at the Chemstar Site, Stalybridge and Ruby Street, Denton.* Memorandum submitted by Tameside Metropolitan Borough Council. Contaminated Land, House of Commons Environment Committee First Report: Volume II, page 135-138. London, HMSO, 1990.

Case study including information relevant to this profile:

Paul V. *Bibliography of case studies on contaminated land: investigation, remediation and redevelopment.* Garston, Building Research Establishment, 1995.

Information on researching the history of sites may be found in:

Department of the Environment. *Documentary research on industrial sites.* DOE, 1994.

4.3 Related DOE Industry Profiles

Chemical works: organic chemicals manufacturing works
Engineering works: electrical and electronic equipment manufacturing works (including works manufacturing equipment containing PCBs)
Gas works, coke works and other coal carbonisation plants.

4.4 Health, safety and environmental risks

The Notes issued by the Chief Inspector of Her Majesty's Inspectorate of Pollution (HMIP) provide guidance for the processes prescribed for integrated pollution control in Regulations made under the Environmental Protection Act 1990. Of particular relevance is:

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: recovery of organic solvents by distillation.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/8. London, HMSO, 1993.

The Control of Substances Hazardous to Health (COSHH) Regulations 1994 and the Management of Health and Safety at Work Regulations 1992 are available from HMSO. Information on relevant health and safety legislation and approved codes of practice published by HSE publications are available from Health and Safety Executive Books, PO Box 1999, Sudbury, Suffolk, CO10 6FS (telephone 01787 881165), as well as HMSO and other retailers.

Information on the health, safety and environmental hazards associated with individual contaminants mentioned in this profile may be obtained from the following sources:

Howard P H. *Handbook of environmental fate and exposure data for organic chemicals.* Vols I and II. USA, Lewis Publishers, 1990.

Sax N and Lewis R. *Hazardous chemicals desk reference.* New York, Van Nostrand Reinhold Company, 1987.

Verschueren K. *Handbook of environmental data on organic chemicals.* 2nd Edition. New York, Van Nostrand Reinhold Company, 1983.

4.5 Waste disposal and remediation options

Useful information may be obtained from the Department of the Environment series of Waste Management Papers, which contain details of the nature of industrial waste arisings, their treatment and disposal. A current list of titles in this series is available from HMSO Publications Centre, PO Box 276, London, SW8 5DT. Of particular relevance is:

> **Department of the Environment.** *Special Waste: A technical memorandum providing guidance on their definition.* Waste Management Paper No. 23. London, HMSO, 1981. New edition in preparation.

Publications containing information on the treatment options available for the remediation of contaminated land sites, prepared with the support of the Department of the Environment's Research Programme, can be obtained from National Environmental Technology Centre Library, F6, Culham, Abingdon, Oxfordshire, OX14 3DB.

A full list of current titles of Government publications on all aspects of contaminated land can be obtained from CLL Division, Room A323, Department of the Environment, Romney House, 43 Marsham Street, London, SW1P 3PY.

Advice on the assessment and remediation of contaminated land is contained in guidance published by the Construction Industry Research and Information Association (CIRIA), 6 Storey's Gate, Westminster, London, SW1P 3AU.

Annex Potential contaminants

The diverse nature of the feedstocks for solvent recovery processes results in the possibility of an equally wide range of potential contaminants occurring. The chemical compounds and other materials listed below generally reflect those associated with the industry and which have the potential to contaminate the ground. The list is indicative, not exhaustive; neither does it imply that all these chemicals might be present nor that they have caused contamination.

Non-chlorinated solvents and hydrocarbons	alcohols aldehydes aliphatic hydrocarbons alicyclic hydrocarbons aromatic hydrocarbons esters ethers ketones nitrogen-containing hydrocarbons sulphur-containing hydrocarbons
Halogenated hydrocarbons	chlorinated solvents chlorofluorohydrocarbons (CFCs)
Fuel oils	
Metals and their compounds	cadmium chromium copper iron lead nickel zinc
Alkalis	sodium hydroxide
Acids	hydrochloric acetic
Polychlorinated biphenyls (PCBs)	
Asbestos	

Table 1 Main groups of contaminants and their probable locations

Waste recycling, treatment and disposal sites: solvent recovery works

Main groups of contaminants	Location							
	Delivery and storage	Building fabric	Pre-treatment	Recovery process	Product finishing	Product packaging and dispatch	Waste storage/ disposal	Electrical transformer areas
Metals and their compounds	▨		▨				▨	
Acids	▨		▨		▨		▨	
Alkalis	▨		▨		▨		▨	
Solvents	▨		▨	▨	▨	▨	▨	
Oils	▨		▨	▨			▨	
Asbestos		▨					▨	
Polychlorinated biphenyls (PCBs)							▨	▨

Shaded boxes indicate areas where contamination is most likely to occur.

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Airports
Animal and animal products processing works
Asbestos manufacturing works
Ceramics, cement and asphalt manufacturing works
Chemical works: coatings (paints and printing inks) manufacturing works
Chemical works: cosmetics and toiletries manufacturing works
Chemical works: disinfectants manufacturing works
Chemical works: explosives, propellants and pyrotechnics manufacturing works
Chemical works: fertiliser manufacturing works
Chemical works: fine chemicals manufacturing works
Chemical works: inorganic chemicals manufacturing works
Chemical works: linoleum, vinyl and bitumen-based floor covering manufacturing works
Chemical works: mastics, sealants, adhesives and roofing felt manufacturing works
Chemical works: organic chemicals manufacturing works
Chemical works: pesticides manufacturing works
Chemical works: pharmaceuticals manufacturing works
Chemical works: rubber processing works (including works manufacturing tyres or other rubber products)
Chemical works: soap and detergent manufacturing works
Dockyards and dockland
Engineering works: aircraft manufacturing works
Engineering works: electrical and electronic equipment manufacturing works (including works manufacturing equipment containing PCBs)
Engineering works: mechanical engineering and ordnance works
Engineering works: railway engineering works
Engineering works: shipbuilding, repair and shipbreaking (including naval shipyards)
Engineering works: vehicle manufacturing works
Gas works, coke works and other coal carbonisation plants
Metal manufacturing, refining and finishing works: electroplating and other metal finishing works
Metal manufacturing, refining and finishing works: iron and steelworks
Metal manufacturing, refining and finishing works: lead works
Metal manufacturing, refining and finishing works: non-ferrous metal works (excluding lead works)
Metal manufacturing, refining and finishing works: precious metal recovery works
Oil refineries and bulk storage of crude oil and petroleum products
Power stations (excluding nuclear power stations)
Pulp and paper manufacturing works
Railway land
Road vehicle fuelling, service and repair: garages and filling stations
Road vehicle fuelling, service and repair: transport and haulage centres
Sewage works and sewage farms
Textile works and dye works
Timber products manufacturing works
Timber treatment works
Waste recycling, treatment and disposal sites: drum and tank cleaning and recycling plants
Waste recycling, treatment and disposal sites: hazardous waste treatment plants
Waste recycling, treatment and disposal sites: landfills and other waste treatment or waste disposal sites
Waste recycling, treatment and disposal sites: metal recycling sites
Waste recycling, treatment and disposal sites: solvent recovery works
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    Fibreglass and fibreglass resins manufacturing works
    Glass manufacturing works
    Photographic processing industry
    Printing and bookbinding works

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