

Waste recycling, treatment and disposal sites

hazardous waste treatment plants

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).

Acknowledgements

The Department of the Environment is grateful to the members of the Interdepartmental Committee on the Redevelopment of Contaminated Land (ICRCL), and the following individuals and organisations for assistance in the compilation of this profile:

Mr J F Cannell (Phoenix County Metals Limited)

Mr M W Finch (ICI Specialities, Huddersfield)

Mr C Murphy (Institute of Wastes Management)

National Rivers Authority

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DOE Industry Profile

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This profile is based on work by Dames and Moore International and Consultants in Environmental Sciences Limited and was prepared for publication by the Building Research Establishment.

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: hazardous waste treatment plants

1. Background

Hazardous waste treatment is undertaken for two purposes, to recover useful materials and to prepare the wastes for disposal. Treatment prior to disposal may involve reducing the waste volume or destroying, neutralising or immobilising the harmful properties of the waste. The treatment of hazardous wastes can be accomplished by physical, chemical, thermal and biological means.

This profile only considers facilities dedicated to the treatment of wastes. The on-site treatment of process wastes by producers is not included, although the methods used are generally similar to those described in this profile.

1.1 Legislation

In 1972, the Deposit of Poisonous Waste Act was implemented to control the deposit of industrial wastes on to land and into water. It became an offence to deposit poisonous, noxious or polluting waste in a manner likely to cause a hazard to health or the environment. Prior to this Act, hazardous wastes were only subject to common law, the statutory nuisance provisions of the public health acts and land-use planning controls.

The Control of Pollution Act 1974 (COPA) introduced the concept of site licensing for all disposal facilities for controlled waste (defined within the Act as household, commercial and industrial waste). The site licence was concerned mainly with the types of waste to be handled and the operation of the site. Site licensing began in 1976.

The Environmental Protection Act 1990 (EPA) gave Waste Regulation Authorities (WRAs) the sole responsibility for the regulation of waste management within their areas.

EPA introduced the concepts of the Duty of Care for all wastes and Integrated Pollution Control (IPC) of wastes from the most polluting industries. Many hazardous waste treatment plants are subject to IPC. Authorisations were issued by Her Majesty's Inspectorate of Pollution (HMIP) and are now issued by the Environment Agency.

EPA also provides a much enhanced system of licensing control on the management of waste and prevents a site operator surrendering his licence unless the site is unlikely to cause pollution of the environment or harm to human health.

The Environment Act 1995 created the Environment Agency which inherited the functions of HMIP, the National Rivers Authority (NRA) and the WRAs on 1 April 1996.

1.2 Hazardous waste/special waste

The term 'hazardous waste' is not defined in United Kingdom legislation because

all waste can be considered hazardous if it is disposed of incorrectly. However, the United Kingdom legal definition of 'special waste' is generally understood to represent the most hazardous wastes. The Control of Pollution (Special Waste) Regulations 1980 define special waste as any controlled waste which consists of, or contains, one or more of the listed substances which by reason of their presence make the waste dangerous to life or flammable. DOE Waste Management Paper 23 'Special wastes: a technical memorandum providing guidance on their definition' (see Section 4) provides advice on the examination of wastes according to the criteria contained in the Special Waste Regulations 1980. New special waste regulations are expected to come into force in the summer of 1996.

1.3 Location

At the end of 1995 there were 460 hazardous waste treatment plants in Great Britain licensed by WRAs and in operation. The plants were incinerators, transfer/treatment, treatment and recovery facilities. They were located in all parts of the country but there were concentrations in the industrial areas, for example London, Greater Manchester, South Yorkshire and West Yorkshire.

At the same time, there were 107 current IPC authorisations by HMIP for incinerators and recovery processes in England and Wales.

2. Activities

There is a wide variety of treatment techniques used for various types of waste. The main processes are as follows:

Incineration and pyrolysis

Recovery

eg oils and solvents

Chemical treatments involving reactions transforming hazardous wastes into less hazardous substances

eg neutralisation
precipitation
coagulation and flocculation
oxidation and reduction
stabilisation systems such as solidification

Physical treatment involving separation techniques to purify, or reduce the volume of waste

eg centrifugation
filtration
flotation
evaporation and distillation

Biological treatment involving breakdown of some degradable organic-based hazardous wastes

There is a growing trend for large sewage treatment works to accept tanks of liquid waste for treatment for co-treatment with domestic and industrial sewage.

2.1 Preliminary operations

2.1.1 Delivery

Wastes typically arrive at treatment sites in bulk tankers, in 25 or 200 litre drums, 1000 litre intermediate bulk containers or 1 tonne large bags made of woven fibre with a plastic membrane. Filter cakes from treatment operations may be carried by skip to incinerators.

Wastes delivered by bulk tankers are usually discharged into holding tanks which may be above or below ground. It is current good practice to provide secondary containment bunds around storage and treatment tanks and impermeable paved areas for off-loading tankers with collection and treatment of surface run off. It was once common for tanks to have no secondary containment or for the containment to have been added long after the tank was installed.

Good practice nowadays is to store drummed waste under cover in purpose-built storage compounds with fire suppression equipment and secondary containment of sufficient capacity to receive spills and fire-fighting water. However, inappropriate storage methods, including storage in unprotected outdoor compounds with no spill protection or secondary containment may have been employed at some older sites.

2.1.2 Transfer of materials within the facility

Liquid and pumpable sludge wastes will typically be transferred around treatment plants by overhead pipes. Underground pipes may have been used in older facilities.

Drummed wastes are generally transferred from the storage area to the treatment area by fork-lift truck. Good practice requires the use of dedicated drum clamps. However, drums may have been transferred loosely on pallets in the past.

Drummed liquid wastes are typically transferred to the treatment facility by barrel pump. Drums containing viscous sludges may be agitated or heated to reduce the viscosity of the sludge and allow transfer of the contents to the treatment plant.

Empty drums are generally either returned to the producer or crushed on site and sent to landfill.

Solid wastes may be transferred in skips or on conveyor belts. They may undergo pre-treatment, such as shredding, prior to the main treatment process (for example incineration). Solid wastes may be loaded into hoppers and gravity-fed into the treatment plant.

2.2 Hazardous waste treatment processes

2.2.1 Incineration and pyrolysis

Incineration is a controlled high temperature oxidation process used for primarily organic wastes, such as pesticides, oils and chlorinated hydrocarbons, residues from bag filters, electrostatic precipitators and cyclones and sludges from wet gas scrubbing. The main end products of combustion are carbon dioxide and water.

Other inorganic substances produced from the incineration of wastes include acids, salts and metallic compounds. If not volatilised and emitted to the atmosphere, these substances generally reside in the ash and will be taken for final disposal elsewhere, for example landfill. The ash may sometimes be taken for further treatment, such as solidification, prior to final landfill disposal. Liquid wastes may include furnace quench water and spent liquors from wet gas scrubbers.

The most common types of commercial hazardous waste incinerators are as follows:

Liquid injection	Suitable for virtually any pumpable waste or gas.
Rotary kilns	Capable of handling a wide variety of solid and liquid wastes.
Fluidised bed	Typically used for the treatment of sludges and slurries although solids that have undergone pre-treatment and liquids can be treated.

Pyrolysis, ie thermal decomposition rather than oxidation, is also used for organic compounds.

2.2.2 Recovery

A variety of recovery techniques is available for use with different wastes. Waste types typically sent for recovery are:

- non-toxic inorganic chemicals
- solvents and oils
- resins, paints and organic sludges
- organic chemicals.

Recovery generally involves separation of the relevant chemical from water or other components of a mixture, using some of the chemical and physical techniques discussed below. This stage may be followed by further purification of the chemical, such as re-refining in the case of oils. Residues from recovery processes may be sent to landfill or for incineration.

The recovery of solvents is dealt with in another profile in this series (see Section 4).

2.2.3 Chemical treatments

All chemical treatment plants will require additional chemicals to be stored on site for use in the treatment processes. These are often stored in bulk storage tanks, hoppers, bags or drums.

The following processes are the most common chemical treatment techniques employed.

Neutralisation of acidic and alkaline solutions

Acids are generally neutralised with lime or caustic soda and alkalis with sulphuric or hydrochloric acid. These chemicals are usually stored in bulk storage tanks or, in the case of lime, in hoppers. Treatment may be required for liquid effluents (acidic or alkaline) from the scrubbing of on-site stack gases. After neutralisation, the effluent may be discharged to sewer or subject to further treatment.

Precipitation

Precipitation is often used to remove heavy metals dissolved in wastes. Lime is commonly used to precipitate metals from the waste, as the hydroxides of heavy metals are usually insoluble in alkaline solution. The metals are then removed in the sludge formed during sedimentation, or by filtration. Sludges may then be de-watered or solidified and sent to landfill.

Coagulation and flocculation

Coagulation and flocculation are used to separate suspended solids from liquids when their normal sedimentation rates are too slow to provide effective clarification. This process involves the addition of a coagulant, such as ferric chloride or a synthetic polyelectrolyte, to the waste. The solid particles agglomerate and settle. The sludge resulting from this process is de-watered or solidified and sent to landfill or for incineration, depending on the nature of the chemical precipitated. The clarified effluent may be suitable for disposal or it may require further treatment.

Oxidation and reduction

Oxidation and reduction can be used to convert toxic substances to either harmless or less toxic substances. For example, hexavalent chromium is highly toxic and its presence in a waste requires careful management to avoid harm to human health and the environment. After hexavalent chromium is reduced to trivalent chromium it can be precipitated as chromium (III) hydroxide, which is much less toxic and more acceptable for either subsequent recovery or final disposal. Cyanide wastes may be treated by alkaline chlorination, in which the cyanide is initially oxidised to a less toxic cyanate and then to carbon dioxide and nitrogen.

Ion exchange

Ion exchange is a reversible exchange of ions between solid and liquid phases. This technique can be used for treatments such as those which remove ammonia and heavy metals from waste water.

Stabilisation

Stabilisation is often carried out on the residues or sludges remaining after other treatments. The purpose of stabilisation is to limit or reduce the ultimate release of hazardous constituents from a waste. The waste is usually first de-watered and then made into a solid form using a binding agent or polymer. Some treatment processes use Portland cement as a binding agent, with pozzolanic or other cementitious materials to improve the strength and chemical resistance of the solidified waste.

2.2.4 Physical treatments

Physical treatment involves a wide variety of separation techniques for removing suspended matter from a liquid phase. Some of the more common physical treatment techniques are described below.

Centrifugation

Centrifugation is a method of separating liquids from solids using the centrifugal force generated by rapid rotation. It is frequently employed to de-water sludges to 10-40% (by weight) of solids. Centrifugation is often used for treating waste oils. The residual cake has sufficient density, strength and solids content to be disposed of as solid waste.

Froth flotation

Froth flotation is used for removing low density solids and hydrocarbon solids from liquids. Fine air bubbles are introduced into the waste liquid which attach to the particles to be removed. The particles rise to the surface for removal by skimming.

Evaporation and distillation

Evaporation and distillation are widely used in many applications for liquid hazardous waste management. As a liquid is evaporated, the waste solution becomes more concentrated and eventually saturated with dissolved solids. The advantage of evaporation is that the volume of waste that must ultimately be treated or disposed of is greatly reduced.

Membrane techniques

Liquid waste treatment can include membrane techniques such as reverse osmosis or ultra-filtration.

2.2.5 Biological treatments

Only biodegradable organic wastes are suitable for treatment by biological processes. They use micro-organisms to feed on the waste to break it down into simpler and less hazardous components. A clarified effluent and a sludge is generally produced which undergoes further treatment prior to disposal. Biological treatment processes are not often used because of the need to grow specific organisms for specific wastes.

3. Contamination

A wide range of wastes and chemicals may have been treated or used at hazardous waste treatment facilities. The types of industry in the neighbourhood of a treatment facility may give an indication of the wastes that have been handled, but some facilities take waste from a wide area.

The nature of activities and the physical location of plant buildings may have changed over time. Environmental security is likely to have improved at older facilities, for example secondary containment being placed around tanks after a significant period of use, and more stringent licensing provisions will have improved the operation of many old and new sites.

DOE Industry Profiles usually include a list of potential contaminants associated with the industry discussed but no list is provided in this profile because hazardous waste treatment facilities, taken as a group, may be contaminated by a large range of substances. Contamination at an individual site could be restricted to a limited range of substances. It is recommended that an appropriate site investigation is carried out to determine the exact nature of the contamination that may be associated with an individual site. Investigations should take site history into account.

3.1 Factors affecting contamination

3.1.1 General

The greatest potential for contamination usually arises in connection with waste storage, chemical storage and transfer areas, particularly if they are not constructed on impermeable hardstanding. Leaks and spills associated with

underground tanks and pipes and tanker off-loading areas are of special concern. Stormwater run-off from uncovered storage areas may have caused contamination, particularly if the drainage is to soakaway.

Areas around drum crushers may be contaminated by residues released during crushing operations. The extent of any contamination will depend largely upon whether operations were undertaken on impermeable hardstanding and the nature of any drainage system.

Most treatment techniques produce some residual sludge (for example filter cake) or solid that requires disposal in a landfill. A site may include lagoons for the settlement of sludges and storage of incineration residues, such as ash and wastes from flue gas treatment.

At older hazardous waste treatment facilities, on-site landfilling of residues may have taken place. The landfills may not always have been suitably designed for the waste types received in them.

In addition to any oil-containing wastes stored on site, fuel oil used to provide heat and power to treatment plants may be stored on site. Areas around such storage tanks could be contaminated as a result of spillage and leakage. Also, at older sites, asbestos may have been used in pipe lagging and as bonded asbestos sheet in building construction. Transformers and capacitors present on site may be a potential source of polychlorinated biphenyls (PCBs).

3.1.2 Incinerators

The operation of incinerators produces two distinct types of ash: furnace ash, which is left in the combustion chamber after incineration, and fly ash which is recovered from gas cleaning and emission control processes. Both are generally disposed of to landfill.

Furnace ash contains non-combustible material such as clinker, glass, ceramics, large metal items, unburnt organic matter and masonry. In addition, it may contain heavy metals and organic compounds such as polychlorinated dibenzo-p-dioxins (dioxins), polychlorinated dibenzofurans (furans), polychlorinated biphenyls (PCBs) and polycyclic aromatic hydrocarbons (PAHs). Fly ash has a similar composition except that it has no large particulate material and the concentration of certain heavy metals, dioxins and furans may be one or two orders of magnitude greater than in furnace ash.

Wastewater from the quenching of the hot ash contains unburnt organic material and particulates from the incinerator residues and is acidic. It may be associated with ash storage areas, underground tanks, sumps or leaking pipes and may have contaminated both surface and groundwater.

Waste may also be generated from any flue gas scrubbing operations. Wet systems produce liquors and sludges which contain the neutralisation products of the acid gases and the contaminants associated with fly ash. Dry systems produce a solid waste consisting of the gas cleaning agents (for example lime, bicarbonates or carbon) and the contaminants associated with neutralised flue gases and fly ash.

After gas cleaning processes, residual emissions from incinerators are discharged

to the atmosphere. These emissions may contain dusts, particulates, heavy metals, acidic gases (such as hydrogen fluoride, hydrogen chloride and sulphur dioxide) and carbon monoxide. Contamination due to past atmospheric emissions at incinerator sites may be concentrated around the site of the chimney (from condensate running down the sides) or dispersed across the site and beyond (by plume dispersion). The extent of any contamination will depend upon the method of operation of the incinerator, including such factors as plume moisture content and exit velocity, chimney height and meteorological conditions.

3.2 Migration and persistence of contaminants

Relatively small amounts of organic liquids, including hydrocarbon fuels, pose a considerable threat to water resources, both through surface run-off and groundwater infiltration. Once spilled into the ground, the liquids flow downwards under gravity but leave a residue. The less soluble compounds which become adsorbed on to clay or organic matter may represent continuing sources of water pollution, long after the original source has been removed, by continuing to allow the contaminant to slowly desorb into the soil-water. Generally, the higher the organic matter and clay content within the soil, the greater the adsorption of hydrocarbons and the lower their mobility. Conversely the greatest migration of contaminants will occur in coarse-grained sands and gravels with little organic matter. Organic solvents may also increase the solubility of less mobile organic chemicals and increase the risk of their reaching groundwater. The non-chlorinated organic liquids are mostly less dense than water and the non-soluble components will float on the water table.

Chlorinated hydrocarbons can contaminate drinking water at very low concentrations. They are generally denser than water and will tend to migrate to the bottom of aquifers, sometimes in the opposite direction to the general groundwater flow. Chlorinated solvents are persistent, degrading slowly and only under specific conditions. Various intermediates formed as a result of their partial degradation may accumulate in the environment. PCBs have a low solubility in water. They are fat-soluble and have a propensity to accumulate in food chains.

Natural biodegradation may result in significant removal of organic compounds. However, potentially biodegradable compounds such as alcohols and petroleum hydrocarbons may persist in an environment unfavourable for microbial activity, such as that due to low temperatures, acid spillages and low soil oxygen content caused by wet conditions.

The phenols are a highly mobile group and can migrate considerable distances from its source. Phenols can also permeate water supply pipes of polymeric materials such as polyvinyl chloride (PVC) and can attack the joints of metal pipes which are usually made of PVC or plastic sealing compounds.

Heavy metal contamination is likely to be localised, since the movement of metals through soil is significantly retarded by the presence of organic matter and by solubility constraints. However, low pH caused by local concentrations of mineral acids could enhance metal mobility, although arsenic may become more mobile in alkaline soils. Metals attenuated in surface or near surface soils may also be transported across site by wind action.

Mineral acids will migrate within soil-water in the dissociated form, ie as the

hydrogen ion and the corresponding anion (for example nitrate or sulphate). The buffering capacity of most soils tends to neutralise slight acidity. Dissolved nitrate and sulphate will migrate fairly freely through the soil.

4. Sources of further information

4.1 Organisations

For information concerning the hazardous waste treatment industry in the United Kingdom, the following organisations should be consulted:

AEA Technology
National Environmental Technology Centre
353 Harwell
Didcot
Oxfordshire
OX11 0RA

Environmental Services Association
(formerly National Association of Waste Disposal Contractors)
Mountbarrow House
6-20 Elizabeth Street
London
SW1W 9RB

Institute of Wastes Management
9 Saxon Court
St Peter's gardens
Northampton
NN1 1SX

Waste Management Information Bureau
F6
Culham
Oxfordshire
OX14 3DB

4.2 Sources of information concerning the activities described in this profile

Aspinwall and Company Limited. *SITEFILE digest of authorised waste treatment and disposal sites in Great Britain.* First edition 1987. Updated quarterly. Subscription via MacMillan Direct.

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

Porteous A. *Hazardous waste management handbook.* Butterworths, 1985.

Wagner K. *Remedial action technology for waste disposal sites.* Noyes Data Corporation, 2nd edition, 1986.

Wentz C A. *Hazardous waste management.* New York and London, McGraw-Hill, 2nd edition, 1995.

United Kingdom legislation mentioned in this profile:

The Deposit of Poisonous Waste Act 1972.

The Control of Pollution Act 1974.

The Control of Pollution (Special Waste) Regulations 1980.

The Environmental Protection Act 1990.

The Environment Act 1995.

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

Waste recycling, treatment and disposal sites: drum and tank cleaning and recycling plants

Waste recycling, treatment and disposal sites: landfills and other waste treatment or waste disposal sites

Waste recycling, treatment and disposal sites: solvent recovery works

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 are:

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: merchant and in-house chemical waste incineration.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/1. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: clinical waste incineration.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/2. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: municipal waste incineration.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/3. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: animal carcass incineration.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/4. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: the burning-out of metal containers.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/5. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: making solid fuel from waste.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/6. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: cleaning and regeneration of carbon.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/7. London, HMSO, 1992.

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, 1992.

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: regeneration of ion exchange resins.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/9. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: recovery of oil by distillation.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/10. London, HMSO, 1992.

Her Majesty's Inspectorate of Pollution. *Waste disposal and recycling: sewage sludge incineration.* Chief Inspector's Guidance to Inspectors. Process Guidance Note IPR 5/11. London, HMSO, 1992.

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.

DOE Industry Profiles

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
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