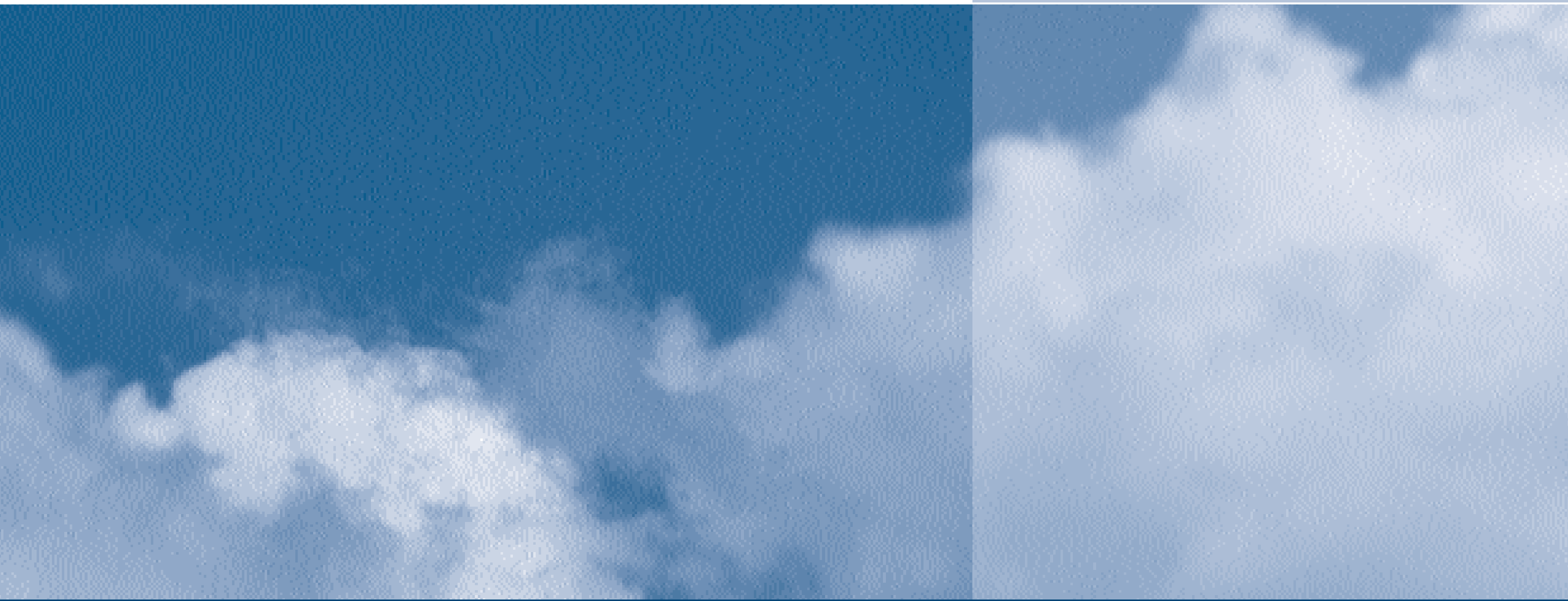

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Environmental Impact of Controlled Burns

Technical Report P388

Environment Agency

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Statement of Use:
This report details a study on the environmental impact of controlled burns. The report will be used to revise and/or supplement the Agency's pollution prevention guidance note PPG18 so that it provides guidance on the issues involved to Agency staff, the Fire Service and other interested parties.

Science Project reference:
P2-081

Science at the Environment Agency

Science underpins the work of the Environment Agency, by providing an up to date understanding of the world about us, and helping us to develop monitoring tools and techniques to manage our environment as efficiently as possible.

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- **Sponsoring science**: To fund people and projects in response to the needs identified by the agenda setting.
- **Managing science**: To ensure that each project we fund is fit for purpose and that it is executed according to international scientific standards.
- **Carrying out science**: To undertake the research itself, by those best placed to do it - either by in-house Agency scientists, or by contracting it out to universities, research institutes or consultancies.
- **Providing advice**: To ensure that the knowledge, tools and techniques generated by the science programme are taken up by relevant decision-makers, policy makers and operational staff.

Professor Mike Depledge Head of Science

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EXECUTIVE SUMMARY

The Best Practical Environmental Option (BPEO) principle can be applied to pollution releases from fires at sites storing substances hazardous to the environment. In purely BPEO terms, the appropriate firefighting response is the one having the smallest overall environmental impact over all media (air, land and water). The concept of the controlled-burn tactic has developed and involves a restricted or controlled use of water or foam on fires to reduce potential environmental impacts of chemicals and contaminated firewater runoff. The Environment Agency wishes to develop policy on controlled burns and to establish workable guidelines on when controlled burn may be appropriate.

There are many parties with an interest in controlled burn, for instance: regulators, the Fire Service, operators, insurers and local authorities. These parties were contacted, so that any guidance and policy on controlled burn could be informed by their views. Most parties agreed with the basic philosophy behind controlled burn provided safeguards were in place to protect public and firefighter health and safety, and provided financial factors were also taken into account.

Six case studies were examined in detail. These highlighted the lack of financial information available on which to look in detail at costs versus environmental benefits. Costs were therefore assigned into broad categories. For each case-study incident, the environmental impacts were assessed, including impacts on human health, controlled waters, air pollution and the terrestrial environment. A rigid, quantitative approach was not possible because of the lack of measurements and quantitative data from the incidents. Therefore a semi-quantitative risk-ranking approach was used. The assessments of case studies involving controlled burns showed significant reductions environmental impacts compared to the probable impacts of conventional tactics.

Drawing on the approach used to assess the environmental impacts in the case studies, guidance has been prepared on the application of controlled burn as a firefighting tactic. Central to the guidance is the need for at-risk sites to carry out a risk assessment and, if necessary, put in place an emergency fire plan. A rapid screening assessment has been developed to identify such at-risk sites. Guidance has been given on the key stages of a full risk assessment and this has been augmented with a worked example.

Potential legal conflicts of adopting controlled-burn guidance were examined. Of particular concern was the relationship between the Fire Services Act 1947 and the Water Resources Act 1991 and the Environmental Protection Act 1990. Current legal opinion on this is that there is no overriding duty under the 1947 Act to extinguish fires, nor is there is an overriding duty to protect property. Therefore, a decision whether or not to carry out firefighting operations would be governed by general principles of public law reasonableness (and by any applicable guidance). It is not hard to imagine circumstances where it would be reasonable for a fire officer to decide not to carry out firefighting operations because the consequences of carrying out the operations (whether these be environmental or some other consequences) would be worse than the destruction of property caused by failing to carry them out.

Under the 1990 and 1991 Acts, fire authorities may incur criminal or civil liability as a result of firefighting operations which cause the release of polluting materials into the environment. The issue here is not so much a conflict or inconsistency with the 1947 Act, but rather that legitimate

firefighting operations are capable of creating criminal and regulatory liabilities under the 1990 and 1991 Acts. These liabilities would theoretically arise even where the consequences of failing to carry out the operations were severe, and the environmental consequences of carrying them out minor. In practice, it is not expected that the environmental enforcing authorities would exercise their discretion to pursue fire authorities in such a case. Indeed, to do so would probably be an unreasonable use of their discretion.

This Technical Report concludes with a series of recommendations covering further work on substance thresholds, warning symbols, site screening, collection of financial data, the treatment of important buildings, and communications between parties.

Keywords:

CONTROLLED BURN; FIRE; FIREFIGHTING; FIRE SERVICE; FOAM; HAZARD; POLLUTION; RISK; RISK ASSESSMENT

1. INTRODUCTION

This Environment Agency national Research and Development (R&D) Project is concerned with the environmental impact of allowing fires to burn out in a controlled and contained manner (controlled burns) instead of being extinguished, at sites storing materials hazardous to the environment. A working definition of controlled burn for this project is "*a restricted or controlled use of water or foam on fires to reduce potential environmental impacts of chemicals and contaminated firewater runoff*". In controlling pollutant releases (including accidental pollution incidents), the appropriate option is the one having the smallest *overall* environmental impact over all media (air, land and water[*]) – known as the Best Practical Environmental Option (BPEO). The BPEO principle could be applied to the question of whether the fire should be put out with water or foam (with perhaps a risk to surface or groundwater from contaminated firewater runoff); or allowed to burn out (with the possibility of both short-term air pollution and longer-term pollution of land and water from deposition of airborne contaminants).

However, BPEO is concerned overwhelmingly with minimising environmental impact, whereas in practice the decision to allow controlled burn is complicated by other important factors, such as:

- whether immediate action is needed to prevent injury to people in or around the building;
- the legal and financial consequences of allowing fires to burn;
- the requirements of the site owner, insurance company and other organisations involved; and
- the legal liability of the Fire Service when allowing a building to burn.

As well as being the best environmental option in some circumstances, controlled burn may also reduce risks to fire fighters. The Environment Agency (the Agency) has published a new Pollution Prevention Guidance note PPG21 *Pollution Incident Response Planning*, which highlights the importance of developing fire-fighting strategies (including controlled burn) to prevent environmental damage. Also, the Agency has published two revised versions of guidance on preventing water pollution: PPG 2 covering primary containment (i.e. bunding), and PPG18 dealing with secondary (i.e. remote) containment.

The Environment Agency has already agreed a protocol with the Local Government Association that covers areas of mutual interest with the Fire Service. The Agency is keen to examine the views and attitudes of all the parties that may be involved. This research project will be used to promote discussion internally and externally on the issue of controlled burns, to develop Agency policy on controlled burns and to workable guidelines on when controlled burn may be appropriate.

Chapters 2 and 3 of this research report contain background reviews of relevant literature. In Chapter 2 the current regulatory framework for hazardous substances is reviewed. Chapter 3 describes the fundamental concepts of environmental risk assessment and environmental impact and reviews existing approaches for assessing risks and impacts from hazardous substances. Comments are made on their possible relevance to fires at sites storing such substances.

[*] For the purposes of this study, the definition "environmental impact" also includes the protection of public water supplies.

Chapter 4 covers the information gathering stage of the project. In this section the methodology and findings of our discussions with interested parties have been summarised. The views are those of individuals and not necessarily those of the Agency or other organisations. Out of these discussions came a list of incidents involving fires at sites storing substances hazardous to the environment. Chapter 5 includes case studies giving detailed assessments of the environmental impacts of selected incidents.

Taking into account the concerns, views and attitudes of interested parties, and the findings of the case studies, some guidance on the application of the controlled burn principle has been developed in Chapter 6. It includes a description of the objectives and overall philosophy of the approach, together with a strategy for applying the controlled-burn principle and an example assessment procedure for inclusion in site emergency plans.

The lines of communication for the project are shown in Figure 1.1.

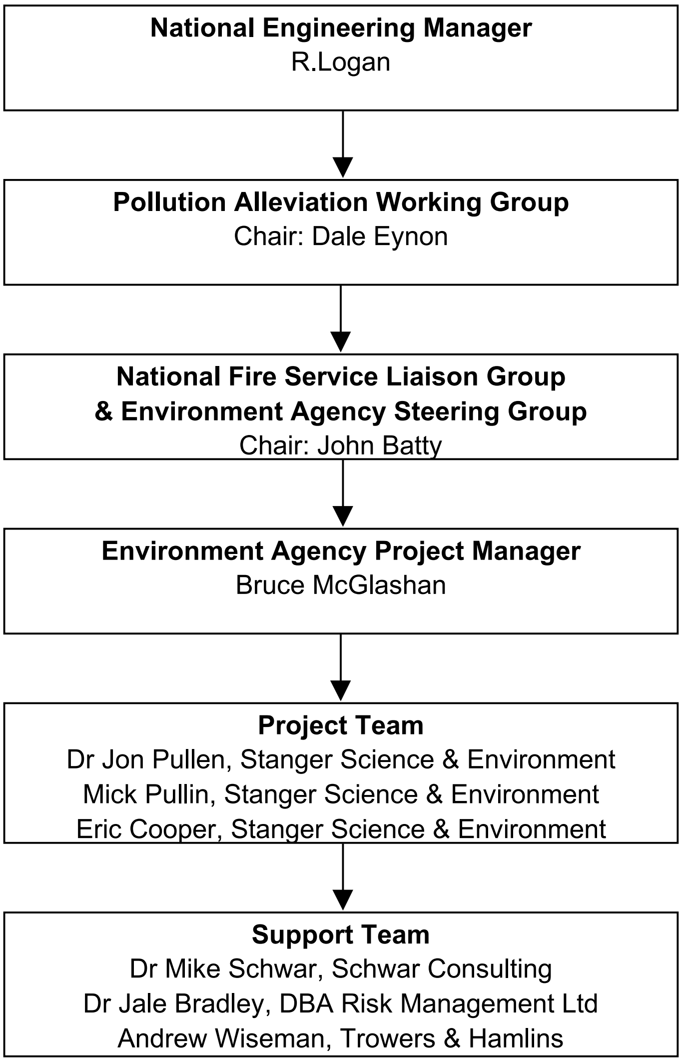

Figure 1.1 Controlled burn project - lines of communication

2. REGULATORY FRAMEWORK RELEVANT TO FIRES AND HAZARDOUS MATERIALS

2.1 General Framework

In this chapter, the regulatory framework applying to fires, major accidents and sites storing hazardous materials is reviewed. Firstly, the specific area of fire services is considered; then other key legislative areas, focusing particularly on their relevance to fires and how they affect the environment. Some legislation is included because it describes how controlled burn guidance might be introduced, whilst other legislation is reviewed because it concerns the provision of the information (e.g. ecotoxicity) needed to make informed decisions about the environmental effects of fires.

Site owners and process operators face a myriad web of regulations. Excellent guidance on compliance has been given to small or medium sized chemical manufacturers in the UK Chemicals Regulatory Atlas[1], produced by the Laboratory of the Government Chemist (LGC). The regulatory framework facing chemical manufacturers (and other industrial sectors) can be broken down into the following main areas:

- pollution control and waste disposal;
- health and safety;
- buildings and storage;
- chemical products regulations; and
- transport and carriage of chemicals.

2.2 Fire Services

2.2.1 The Fire Services Act 1947

The Fire Services Act 1947[2] places a duty on every fire authority to make provision for fire fighting purposes. The authority must ensure that reasonable steps are taken to prevent or mitigate damage to property resulting from measures taken in dealing with fire. The authority also has a duty to have efficient arrangements for obtaining, by inspection or otherwise, information required for fire fighting purposes. It is important to note that the Act does not take into consideration effects on the natural environment and simply requires the provision of water to be available to fight fires. (Views on whether this potentially conflicts with pollution legislation are given in Section 4.8.) At any fire, the senior fire brigade officer has sole charge and control of all operations for the extinction of the fire, including the fixing of the positions of fire engines and apparatus, the attaching of hoses to any water pipes or the use of any water supply, and where the water will be directed.

The Act also gives the fire authority the power to use fire brigade equipment for purposes other than fire fighting for which it appears to the authority to be suitable, and if they think fit, to make such a charge for this. This is now beginning to happen with chemical spills and assistance to the Environment Agency.

A further addition was made with the Fire Services Act 1959[3]. A number of subsections of the principal act were repealed to accommodate amendments made to conditions of service and pension schemes. There is further no imminent legislation expected in this area.

2.3 Pollution Control

2.3.1 Environmental Protection Act 1990

The concept of Best Practicable Environmental Option (BPEO) was a foundation of the Integrated Pollution Control (IPC) regime incorporated into UK legislation in Part 1 of the Environmental Protection Act 1990[4]. This act (EPA90) established a requirement to control industrial processes involving substances with the highest potential to damage the environment. Part 1 of the Act contained provisions for application of a system of Integrated Pollution Control (IPC) to the most polluting or complex industries, and Local Authority Air Pollution Control (LAAPC) to others. IPC applies only to those processes that have been "prescribed" as Part A, or major polluting, processes by the Secretary of State. The relevant industries and substances are given by the Environmental Protection (Prescribed Processes and Substances) Regulations[5]. Responsibility for implementing IPC resides with the Environment Agency; local authorities are responsible for implementing LAAPC, with the air quality division of the Department of Transport Environment and the Regions (DETR) taking responsibility for consistent application of LAAPC nationally. The main features[6] of IPC are:

- It is pro-active, requiring the operator of a prescribed process to apply in advance to the Environment Agency or local authority for an authorisation to operate the process, allowing conditions to be attached to authorisations, and requiring authorisation to be reviewed at regular intervals;
- It is holistic in that a single regulatory body is charged with controlling emissions from the process to all environmental media;
- It is precautionary, requiring the process to minimise releases of prescribed substances to the environment and to render harmless all releases.

An operator of a prescribed process is expected to render harmless the release of all substances from the process. However, for "prescribed substances", deemed to be the most harmful to the environment, the requirement is stricter and the operator is expected to prevent (or minimise) their release to the environment. Operators must use the most effective means to prevent or minimise releases of substances from their process using the Best Available Techniques Not Entailing Excessive Cost (BATNEEC) principle. For IPC processes, the objective is to achieve the Best Practical Environmental Option (BPEO) for pollution control at source, taking releases to all environmental media into account.

2.3.2 Clean Air Act 1993

Emissions of dark or black smoke that are not controlled under IPC or LAAPC are regulated under the Clean Air Act 1993[7], although in practice few, if any, emissions from industrial processes will fall within the scope of this act. The Clean Air Act prohibits emissions of dark smoke from a chimney of any building, subject to certain defences and allowable periods. It is also an offence to cause or permit the emission of dark smoke from industrial or trade premises (as distinct from chimneys), subject to certain exemptions[8].

2.3.3 Water Resources Act 1991

Discharges to controlled waters are covered by the Water Resources Act 1991[9], unless the discharges are from a prescribed process and are already subject to control under EPA90. Discharge consents are considered, issued and periodically reviewed by the Environment Agency under the provisions of the Control of Pollution (Applications, Appeals and Registers) Regulations 1996[10]. The discharge consents specify legally binding limits on the composition of the discharge (description, concentration, amount discharged).

Section 85 of the Water Resources Act makes it an offence for a person to cause or knowingly permit any "*poisonous noxious or polluting matter*" to enter "*controlled waters*", including groundwaters. Section 161 of the Act enables the Agency to take action to prevent any such matters from entering any controlled waters, if there is any likelihood of this happening.

The Water Resources Act requires the Environment Agency to have regard to the statutory duties of the water companies. A separate piece of legislation, The Water Industries Act 1991(Section 68)[11] requires such water undertakers "*to supply only water which is wholesome at the time of supply....*", which is usually interpreted as being water free from contaminants that could affect its palatability or the health of the consumer[12].

2.3.4 The Anti-Pollution Works Regulations 1996

The Anti-Pollution Works Regulations 1996[13] took effect on 29 April 1999. These regulations enable the Environment Agency to prevent water pollution by serving works notices on potential polluters and to serve notices requiring the effects of water pollution to be remedied. This new power follows insertion of a new section, 161A, into the Water Resources Act 1991 to replace the previous Section 161 which allowed the Agency only to carry out works itself where it believed water pollution was likely to occur or had occurred and needed remediation. Under the new regulations, notices may be served on anyone who has "*caused or knowingly permitted*" polluting matter to be present at a place from which it is likely to enter controlled waters or be present in them. The purposes of serving notices are: to prevent the entry of polluting matter into waters; to require the removal or disposal of polluting matter which has entered controlled waters, or to remedy or mitigate pollution caused by its presence; and to require so far as "*reasonably practicable*" the restoration of waters (including any flora and fauna dependent on them) to their state "*immediately before*" polluting matter entered them. The Agency is also entitled to recover from the persons on whom notices are served the costs of any investigations needed to determine the source of pollution.

The new works notices will be used by the Agency[14] in a way that minimises overlaps between the new powers and several other existing controls such as the new Groundwater Regulations[15] and regulations introduced in 1991 to control pollution from agricultural point sources[16].

2.3.5 Integrated Pollution Prevention and Control

The Pollution Prevention and Control Bill[17] is aimed at creating a framework for the European Community (EC) system for Integrated Pollution Prevention and Control (IPPC)[18], which required national implementation by 30 October 1999. The UK missed that deadline and, following a fourth consultation paper[19] on implementation, the Regulations finally came into force in August 2000.

The scope of IPPC will extend more widely than IPC by requiring the licensing of installations rather than processes. It is likely that all installations currently subject to IPC and LAAPC will ultimately be regulated under IPPC, together with a significant number of installations under control for the first time, e.g. food and drink manufacturing and fertiliser plant. Such sites can potentially pose a risk to the environment during fires.

The main principles of IPC in the present UK regulations form the main basis for IPPC, but the latter regime goes considerably further– importantly in its provisions on the consequences of accidents, their prevention and minimisation in determining BAT. A further significant difference is that IPPC installations must use Best Available Techniques (BAT) rather than BATNEEC as the basis for pollution control. The Directive defines BAT in rather an imprecise way, leaving considerable flexibility for interpretation by member states[20].

2.3.6 Regulations covering waste disposal

Provisions for the disposal of chemical waste in the UK are made under Parts II and VIII of EPA90 and Part V of the Environment Act 1995. EPA90 extended the provisions of the Control of Pollution Act 1974[21] (Part 1) relating to waste on land and amended the provisions of the Food and Environment Protection Act 1985[22] regarding the dumping of waste at sea. Under EPA90, chemical wastes are subject to the provisions of the Waste Management Licensing Regulations 1994[23] to bring the UK into line with the EC Waste Framework Directive[24]. Further controls over the movement of wastes with hazardous properties exist by means of the Special Waste Regulations 1996[25] made under EPA90. The DETR is currently undertaking a review of the Special Waste Regulations 1996 and is seeking industry views on a wide range of issues including how future objectives for hazardous waste control can be achieved, the efficiency and effectiveness of the current system and possible options for future control. These regulations (which revoked and replaced the Control of Pollution (Special Waste) Regulations 1980) implement in the UK the requirements of the EC Directive on Hazardous Waste[26] and incorporate its definition of “hazardous waste”.

The Environmental Protection (Duty of Care) Regulations 1991[27] introduced under EPA90 apply to anyone who produces, imports, carries, keeps treats or disposes of “Directive” or “Special” waste. Regulation 18 of the Special Waste Regulations relates to offences: Regulation 19(2) provides a statutory defence in an emergency. The Agency has drafted a guidance note[28] detailing the working assumptions by which the fire or police officer in charge can remove water immediately without waiting for a registered waste carrier if this is needed to prevent unacceptable risks to the public or environment.

The new Groundwater Regulations 1998[29] specify measures to prevent the introduction of List I substances into groundwater, and measures to limit the introduction of List II substances into groundwater to avoid pollution. List I and List II substances are defined in the schedule to the Regulations. Controls are placed on the tipping and disposal of these compounds in areas that may come into contact with groundwater. Authorisations to discharge or tip may be granted in some circumstances if proper surveillance of groundwater is carried out. Trivial discharges and activities for which waste management licences are required (within the meaning of EPA90) are excluded. The DETR has issued a consultation of draft guidance on the Regulations, which explain the provisions of the Regulations and how they will be implemented.

2.3.7 Other regulations concerning pollution control

There are numerous other national, European Union (EU) and international agreements which control directly or indirectly the quantities of specific chemicals or chemical classes (e.g. pesticides) used in or discharged into the environment. Community-wide legislation under the "Marketing and Use" Directive[30] is amended as different substances become subject to EU-wide control measures. Another EU Directive[31] is aimed at preventing pollution of the aquatic environment by specified chemical substances or families of substances. Substances for inclusion in this Directive have been selected primarily on the grounds of their persistence, toxicity and bioaccumulation properties. The Directive divides the dangerous substances into two groups: substances on List 1 (the "black list") are subject to Community-wide controls, and those on List 2 (the "grey list") to control by individual Member States. The Directive allows for controls to be based either on specified effluent discharge levels or on environmental quality objectives (EQOs).

Proposed new EU legislation includes the Water Framework Directive[32]. The overall environmental objective of the proposal is to achieve "good water status" throughout the EU by 2010 and for it to be maintained thereafter. The proposed Directive would provide the basis for future daughter Directives in the area of both water quality and quantity. The proposal is for good water status to be met by a management plan for each river basin, including limit values to control emissions from point sources and environmental quality standards to address the cumulative impact of emissions.

A future EU environmental policy initiative covers environmental liability. In January 1998, DGXI suggested an EU framework for future environmental liability that would oblige member states to ensure that damaged and/or polluted environments are restored where liable polluters have been identified. Liability would fall on the "operator", that is the person who exercises control over the activity. However, the strategy is strongly opposed by industry, several member states including the UK, and within the Commission itself[20].

2.4 Health and Safety

2.4.1 Health and Safety at Work Act 1974

The Health and Safety at Work Act 1974[33] (HSAW) is a very wide-ranging piece of legislation, but also places very specific requirements on employers and employees. Key purposes of the Act are to secure the health, safety and welfare of persons at work; to protect those not at work from the risks to health and safety arising from the activities of work; and to control the keeping and use of dangerous substances.

2.4.2 The Management of Health and Safety at Work Regulations 1992

The Management of Health and Safety at Work Regulations 1992[34] strengthen the general requirements of the 1974 HSAW Act and add considerable detail to it. Important requirements of these regulations are: the assessment of risk to the health and safety of employees at work; the assessment of risk to the health and safety of persons not in employment by the employer; the need to implement planning, organisation, control, monitoring and review procedures, and health surveillance where necessary; the need to use suitably qualified staff to perform the above tasks; that emergency procedures must be in place; and that information and adequate safety training for employees must be provided.

2.4.3 The Control of Substances Hazardous to Health Regulations 1999

Another major set of regulations under the Act, The Control of Substances Hazardous to Health (COSHH) Regulations[35], aim to protect persons against risks to their health arising from exposure to substances hazardous to health (SHH). The latest version of the regulations came into force at the end of March 1999 to replace the 1994 COSHH Regulations. There are 19 regulations in total, but the most relevant for the purposes of this study into fires at sites storing hazardous chemicals are: interpretation of the term substance hazardous to health; employers and employees duties, including the duty on employers to apply the regulations to the employees and, as far as is reasonably practicable, to other people who may enter the premises or be affected by the work; assessment of the health risks created by work involving SHH; prevention or control of exposure to SHH; and information, instruction and training for persons who may be exposed to SHH.

2.5 Buildings and Storage

2.5.1 Town and Country Planning Act 1990

Compliance is required with both building-engineering regulations and storage of chemicals regulations. For the former, general provisions for controls on planning in the UK are made under the Town and Country Planning Act 1990[36]**.** Planning regulations drawn up under the Act require that the consent of the local planning authority be obtained before a new facility is constructed or before existing facilities are modified. An Environmental Impact Assessment (EIA) may be required as part of the consent process under the Town and Country Planning (Assessment of Environmental Effects) Regulations 1988[37.]

2.5.2 Planning (Hazardous Substances) Act 1990

The Planning (Hazardous Substances) Regulations 1992[38] made under the Planning (Hazardous Substances) Act 1990[39] apply to facilities where controlled hazardous substances are stored, manufactured, processed, transferred or used in quantities above a specified minimum. Controlled substances and quantities are those listed on Schedule 1 of the regulations, and may range from as little as 1 kg for dioxins up to 10 000 tonnes for a liquid with a flash point below 21°C. Consents for controlled substances are obtained from the local hazardous substances authority (i.e. the local government authority), which is required to consult with bodies such as the Health and Safety Executive (HSE) and the Environment Agency. The Dangerous Substances (Notification and Marking of Sites) Regulations 1990[40] apply to sites (other than those already notified under CIMAH/COMAH - see below, or the

Planning (Hazardous Substances) Regulations) that hold more than 25 tonnes or more of dangerous substances, and require notification to the local fire authority and the enforcing authority (HSE or local authority).

2.5.3 CIMAH and COMAH

Following the Seveso incident in 1976, the EU introduced a Directive to control major accident hazards, requiring consideration of possible effects on both man and the environment. The Seveso I Directive[41] was implemented in the UK by the Control of Industrial Major Accident Hazards (CIMAH) Regulations 1984[42], and enforced by the HSE. These regulations were applied at sites carrying out certain potentially hazardous industrial activities which use dangerous substances and required on-site and off-site emergency plans to be prepared, together with discussions between the operator and the HSE on the "Safety Case" - a justification by the operator that an activity was being carried out safely. Production, processing and storage of dangerous substances (identified in the regulations either by name or dangerous properties: toxicity, flammability or explosivity) were included within the scope of the regulations together with a requirement to carry out an assessment of the location, design, construction and operation of facilities used for these activities. Regulation 4 required manufacturers to demonstrate that they had identified major accident hazards to people or the environment arising out of their activities and had taken adequate steps to prevent such major accidents and limit their consequences. The extent to which the application of this regulation has led to a proper risk-based consideration of major accidents has been variable[12].

The adoption of European Community Directive on The Control of Major Accident Hazards Involving Dangerous Substances[43] (the so-called Seveso II Directive) increased the range of sites covered by European major-hazards legislation, introduced new duties to protect the environment, and provided more detailed and specific indication of what is required. This is expected to lead to an improvement in the quality of environmental aspects of major accident safety reports. Britain has transposed the Directive into national law by means of The Control of Major Accident Hazards (COMAH) Regulations[44], which came into force on 1 April 1999. COMAH has a number of significant differences to CIMAH. It is simpler than its predecessor in that it contains fewer named substances and relies more on generic categories of qualifying hazardous chemicals. It also applies to a wider range of operators, particularly with the inclusion in Schedule 1 of the Regulations of substances classified as "dangerous to the environment", and the removal of some exemptions (such as chemical hazards on nuclear sites and sites licensed under the Explosives Act 1875[45]).

The COMAH Regulations cover activities that might cause serious injury to people or the environment – both inside and outside the site. "Top-tier" operators are defined as operators who have substances above the higher of the two threshold quantities given in Schedule 1 for a particular substance or class of substance. "Lower-tier" operators have these above the lower of the two thresholds. The Regulations introduce a duty on "top-tier" operators to prepare an on-site emergency plan for dealing with the consequences of possible major accidents. Their local authority must prepare an off-site emergency plan for dealing with the off-site consequences of possible major accidents. All operators are required to have a major accident prevention policy (MAPP), the purpose of which is "to guarantee a high level of protection for persons and the environment by appropriate means, structures and management systems". However, only "lower-tier" operators are required to produce the MAPP as a separate document. Unlike the CIMAH Regulations, the COMAH Regulations do not distinguish between process and storage: neither is there a requirement for there to be a defined “industrial activity”. The Regulations simply apply if an establishment has, or is likely to have, or could generate a dangerous substance above a threshold quantity. The need to apply a risk-based approach to the protection of the environment from major accidents is more explicitly stated.

Associated guidance for the new regulations has been issued by the Environment Agency on risk assessments[46] and by the HSE on emergency planning[47] and preparing safety reports[48,49]. The approaches are expected to have major benefits in protection of the environment at those sites that are covered by COMAH and the guidance produced may be transferable to non-COMAH sites in appropriate situations[12]. Because the new Regulations cover environmental as well as human hazards, a new competent authority comprising the HSE and environment agencies will enforce them.

2.5.5 Other regulations concerned with buildings and storage

Other legislation affecting buildings include the Fire Precautions Act 1971[50], which requires that buildings have adequate means of escape in the event of fire and appropriate equipment for controlling and fighting fires. However, under the Fire Certificates (Special Premises) Regulations 1978[51], licensing of some premises (where large quantities of dangerous substances are kept) is under the control of the HSE. Other regulations relevant to the storage of chemicals include: those regulations made under HSAW Act (CHIP and COSHH); and regulations for particular types of chemicals such as the Environmental Protection (Prescribed Processes and Substances) Regulations 1991, the Petroleum (Consolidation) Act 1928[52], the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972[53], and the Control of Pesticides Regulations 1986[54]. The last of these requires that sites storing 200 kg or more of pesticides must be under the control of a person holding a recognised certificate of competence.

2.6 Chemical Products

2.6.1 Notification of New Substances Regulations 1993

Substances which were on the market in the EC at some time between 1 January 1971 and 18 September 1981 are defined as existing substance, and are listed on the European Inventory of Existing Commercial Chemical Substances (EINECS). A new substance is defined as one which is not listed on EINECS, and in the UK is subject to the Notification of New Substances Regulations 1993[55], known as NONS, which implements the European Directive 92/32/EEC[56].

The main relevance for controlled burn is that a new substance must pass through the EC new substance notification process, which includes submitting to the authorities a classification, data sheet and risk assessment. The latter requires the competent authority (the HSE and the Environment Agency in the UK) to provide an assessment of the risks the new substance poses to people and the environment (e.g. acute toxicity to fish, daphnia and algae; biotic and abiotic degradation; and adsorption to soil). It is then placed on the European List of Notified (New) Chemical Substances (ELINCS).

2.6.2 The Notification of Existing Substances (Enforcement) Regulations 1994

The EC Regulation 793/93 on the evaluation and control of the risks of existing substances[57] applies to all EC manufacturers or importers of existing EINECS-listed substances. The intention of the Existing Chemicals Regulation is to achieve the same standards for the EINECS substances as for those on ELINCS, the data requirements being broadly similar. Enforcement in the UK is through The Notification of Existing Substances (Enforcement) Regulations 1994[58].

2.6.3 CHIP

The foundation of general chemicals regulation, and part of the UK`s compliance with the Dangerous Substances Directive[59], is achieved by the Chemicals (Hazard Information and Packaging for Supply) (Amendment) Regulations 1999[60], known as CHIP. At the time of writing, the HSC has gone out to consultation on its latest amendment, CHIP 99. CHIP is enacted in the UK within the Health and Safety at Work Act 1974.

The relevance to controlled burn is that the regulations cover how substances and preparations should be classified for their intrinsic hazards, set out the labels and packaging based on the properties, and how hazard information should be communicated to users of substances by safety data sheets. The user of a substance is therefore warned of intrinsic hazardous properties via the labelling. For professional users this warning label is reinforced with a safety data sheet which gives more detailed information. For example, advice on avoiding spillage to drain and on the appropriate methods of treating, recycling or disposal of waste should be provided so that the user can minimise releases to the environment[61].

When safety data sheets are prepared, information must be given under 17 obligatory headings. Of particular relevance to fires and controlled burn are the categories: identification; composition (including chemical names, classifications code letters and risk phrases); hazards identification (including adverse human health effects); first-aid measures; fire-fighting measures; accidental release measures (covering safety, environmental protection and clean-up, appropriate responses to releases); handling and storage; exposure control and personal protection; physical and chemical properties (including solubility); toxicological information (acute and chronic effects, routes of exposure); ecological information (environmental fate of the chemical and its effects, which could include known or predicted environmental transport to soil, water, air or organisms, patterns of degradation and accumulation, effects on aquatic, soil and terrestial organisms, effects on the atmosphere, and effects on water treatment plants); disposal considerations; transport information; and regulatory information.

2.6.4 Other relevant chemicals classifications

The Organisation for Economic Co-operation and Development (OECD) has a complementary programme for a harmonised system of classifying existing high production volume (HPV) chemicals according to their toxic and ecotoxic properties. Full implementation is expected by 2001[62]. The International Council of Chemical Associations (ICCA) (www.icca.org) has started an initiative to help fill in gaps in basic health and safety information for HPV chemicals and aims to provide complete toxicological and ecotoxicological data for 1000 HPV chemicals by 2004[63].

The Comité Européen des Assurances (CEA) Commission Incendie has its own published[64] classification of materials and goods, which is used by the UK insurance industry. The classification was designed to avoid serious misunderstandings and contradictions between it and existing national and international classifications and is based on the CEA Catalogue of Materials and Goods, 1980; United Nations (UN) classifications; the guidelines for the transport of dangerous goods (e.g. IMDG, ADR, RID, IATA); the EC guidelines on dangerous substances; and the EC and German indexes of water-polluting materials. The list covers about 1400 materials, each is given a classification and hazard grade for combustibility and explosibilty, toxicity to humans and the environment. Of particular relevance to controlled burn is that some substances not hazardous to humans but hazardous to the aquatic environment (e.g. sugar, molasses, milk) are included in the list.

2.6.5 Future controls on chemicals

It was announced in mid-1998 that EU chemicals legislation would be reviewed, as there was a general consensus among environment ministers that the existing policy, which has developed piecemeal over the past 30 years, was in need of improvement[65]. An inspection project[66] found extensive non-compliance with EC chemicals legislation. Of the 100 companies inspected across the Community, one third of the firms were breaking the law, over 40% of the dangerous substances inspected were not labelled properly, and 5% either could not be identified or were on the market illegally. Other serious findings were that 25% of substances were wrongly classified, 42% wrongly labelled, only 66% had material safety data sheets available, and of the latter 20% were not incorrect[67]. An evaluation of the main EU legal instruments governing industrial chemicals highlighted the need to:

- use the legal instruments more efficiently;
- ensure rigorous and consistent implementation;
- streamline and develop instruments to take account of new issues such as endocrine disruption; and
- recognise the important role of science, but also take account of public and consumer concerns by giving full consideration to the precautionary principle.

The Commission has consulted stakeholders and there is general agreement that the current EU system is too complicated and has achieved rather little. There is less agreement on how future controls on chemicals should be determined, with non-governmental organisations (NGOs) calling for hazard-based restrictions based (i.e. based on intrinsic properties of substances), with industry preferring an risk-based assessment. A Communication on future EU chemicals strategy is expected in late 1999.

2.7 Transport of Chemicals by Road and Rail

2.7.1 Road regulations

Fires from mobile sources such as road and rail tankers have given cause for concern about their effects on the environment. International carriage of chemicals is covered by the UN Recommendations on the transport of dangerous goods by all modes (road, rail, air and sea), that cover classification, identification (UN numbers), packaging and labelling. These recommendations have been adopted into international road regulations: the most relevant here being the European Agreement Concerning the International Carriage of Dangerous Goods by Road, known by the French abbreviation ADR[68], which covers the EC and most of the former Soviet Union.

UK road regulations are based on the UN recommendations and the ADR. The principal regulations are: the Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations 1996[69], known as CDGCPL2; and The Carriage of Dangerous Goods by Road Regulations 1996[70], known as CDCRoad. Other regulations apply for explosives and radioactive material. Road transport legislation is enforced by the HSE in consultation with the DETR.

2.7.2 Rail regulations

For rail transport, the relevant international agreement is the International Convention Concerning International Carriage by Rail, and its constituent Regulations Concerning the International carriage of Dangerous Goods by Rail[71], known by the French abbreviation RID. UK rail regulations are based on the UN recommendations and RID, the principal regulations being: CDGCPL2; and The Carriage of Dangerous Goods by Rail Regulations 1996[72], known as CDCRail. Other regulations apply for radioactive material. Rail transport of dangerous goods was until recently controlled by British Rail, although responsibility for safety issues has been transferred to the HSE.

Both road and rail transport are subject to the classification, packaging and labelling requirements of CDGCPL2. An Approved Carriage List (ACL) covers goods which have approved information and a further guidance document sets out details of requirements and test methods[73]. Ten categories of information are contained in the ACL: shipping name; UN number; hazard classification code; subsidiary hazard code; emergency action code; hazard identification number; whether the goods may be carried in tanks; whether the goods may be carried in bulk; the packing group; and the code for any special provisions (e.g. environmental).

3. ENVIRONMENTAL ASSESSMENT

3.1 Fundamental Concepts

The boundaries between impact assessment and risk assessment are not hard and fast and the term "impact assessment" has been used[74] as an umbrella term for a range of techniques, including:

- Environmental impact assessment (EIA)
- Risk assessment
- Cumulative effects assessment
- Environmental health impact assessment (EHIA)
- Biodiversity impact assessment (BIA)
- Social impact assessment (SIA)
- Strategic environmental assessment (SEA)

Similarly, the risk field is littered with alternative phrases that can sometimes confuse discussions. The boundaries between risk assessment, risk evaluation, risk analysis and risk management are often blurred, leading to complications when discussing the relative importance of each, and confusion over the precise activities that comprise each component[75]. Nevertheless, in this report a broad division between the two categories has been attempted based on the following characteristics:

Environmental risk assessment	The assessment quantifies the probability of an adverse effect from exposure to a contaminant
Environmental impact assessment	The assessment focuses on quantifying the severity of adverse effects on the medium and/or receptor via different pathways, and usually involves comparison with environmental quality standards or guidelines. Usually, the probability of an adverse effect is not quantified.

Box 3.1 Assessment charachteristics

In this chapter, the different types of risk assessment relevant to controlled burn are described briefly. A short review is then given of some existing risk-assessment approaches that might be of use in developing specific guidance for controlled burn.

3.2 Environmental Risk Assessment

3.2.1 Definitions and meanings of terms

Some of the terms involved (particularly hazard and risk) have been applied interchangeably and possess different meanings to different parties, or have developed common usages that lack precision and are open to ambiguity. The OECD`s definitions[76] contain a useful synthesis of terms. In environmental risk assessment the following definitions[77,78,79] are best applied:

Hazard	The substance's or physical situation's inherent **potential** to cause harm.
Risk	An estimation of the **likelihood** of that potential being realised, within a specified period or in specified circumstances, and the consequence.
Environmental	Referring to the routes of exposure for both humans and wildlife.

Box 3.2 Assessment definitions

For example, a storage area containing an ecotoxic liquid adjacent to a watercourse would be a hazard; the corresponding risk might be that there was a 1 in 100 chance per year that an accidental fire would lead to spillage or runoff and kill 500 coarse fish. Some hazards are less readily identifiable than others because as well as the direct hazard posed by ecotoxic substances, other substances may be mobilised or formed during the course of the fires, because the combustion products may have significantly different properties to those of the materials burnt[79].

Risk tries to describe both the likelihood of an event and the consequence, but in order to compare risks it is necessary to "fix" the consequence. For example, if the consequence of an environmental release is 500 coarse fish killed, the risks from a series of activities can be compared by considering the frequency with which these activities also cause 500 coarse fish to be killed. However, if one activity is likely to cause a fish kill but the likelihood is very low, and another activity is likely to have a less serious impact (e.g. smoke nuisance) but with a higher frequency, then no simple and unambiguous method is available to compare the two risks[77].

Other important terms are:

- *Risk estimation:* a quantification of how big the risk is.
- *Risk evaluation:* a decision on how significant is the risk or hazard and to whom.
- *Risk assessment:* the study of decisions subject to uncertain consequences. It consists of risk estimation and risk evaluation.

3.2.2 The source-pathway-receptor link

Three components need to be present before a risk exists, namely:

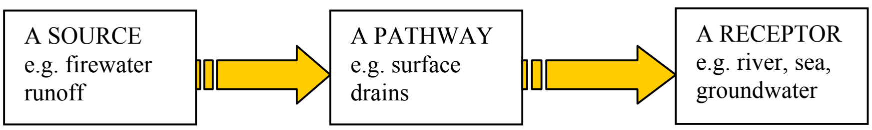

Figure 3.1 The source-pathway-receptor link

This chain of events - termed in a collective sense an exposure pathway - is the complete environmental route by which chemicals from the site can reach receptors. It *must* occur to result in exposure. If any parts of the source-pathway-receptor chain are missing then there is no risk of exposure.

The simple source-pathway-receptor chain is made up of the following components:
- Source
- Chemical release mechanisms (e.g. leaching)
- Transport mechanisms (e.g. groundwater flow)
- Transfer mechanism (e.g. sorption)
- Transformation mechanism (e.g. biodegradation)
- Exposure point (e.g. residential well)
- Receptors (e.g. residents consuming potable water from the well)
- Exposure routes (e.g. ingestion of water)

However, care must be taken to ensure that a risk is not dismissed because part of the exposure pathway is missing, if this omission is because of a system/barrier that might in practice fail. For example, a bund might be considered as a method of removing the pathway between the source and the receptor; this would not be a valid reason for concluding that there was no risk since there is a finite probability that the bund would be ineffectual.

3.2.3 Exposure pathways for humans

During a fire at a site storing hazardous substances, people may be exposed by inhalation, the oral route and dermal (skin contact) route. Pathways for impacts on human receptors can be summarised as follows:
- *Air inhalation* - inhalation of contaminants emitted from a site as dust and inhalation of gases and aerosols.
- *Dermal contact* – skin contact resulting from exposure to airborne dust or skin contact with pollutants deposited on land or water.
- *Soil/dust ingestion* - ingestion of dust or soil as a result of contamination of hands while playing or working outdoors. Soil and contaminated pasture is also ingested by grazing animals and may enter the human food chain via milk or meat.
- *Water ingestion* - groundwater and surface water containing chemicals can be ingested directly as potable water, it can support fish consumed by humans or it can be used as irrigation water for market gardens, etc.
- *Ingestion of local fish* - the consumption of fish from local streams and rivers is a potentially significant source of indirect exposure to releases from a site.
- *Ingestion of local produce and crops* – this is a major route of exposure for some pollutants, such as dioxins, lead and fluoride.

Depending on the nature of the activity or on the vicinity of the site, receptors can be exposed via one or a combination of these pathways[80] (see Table 3.1). Some pathways are likely to be more important if a controlled-burn tactic is employed than if the fire is extinguished.

Exposure pathways relevant to assessment of risks to human health from landfilling of household wastes are shown in Figure 3.2. Though obviously not directly applicable to controlled burn, this example does show very similar release media and routes of exposure.

Table 3.1 Some possible pathways for pollutant releases from fires

Release medium	Route	Exposure
Emissions to air	suspended/dispersed in air	via inhalation of contaminants
	deposited onto soil followed by uptake by crops	via ingestion of crops
	deposited onto soil followed by contamination of aquifers	via drinking water
	deposited onto surface waters	via drinking water, ingestion of fish
Aqueous releases (e.g. firewater runoff)	direct to surface waters	via drinking water, ingestion of fish
	to drains, sewage treatment works (STWs), then surface waters	via drinking water, ingestion of fish

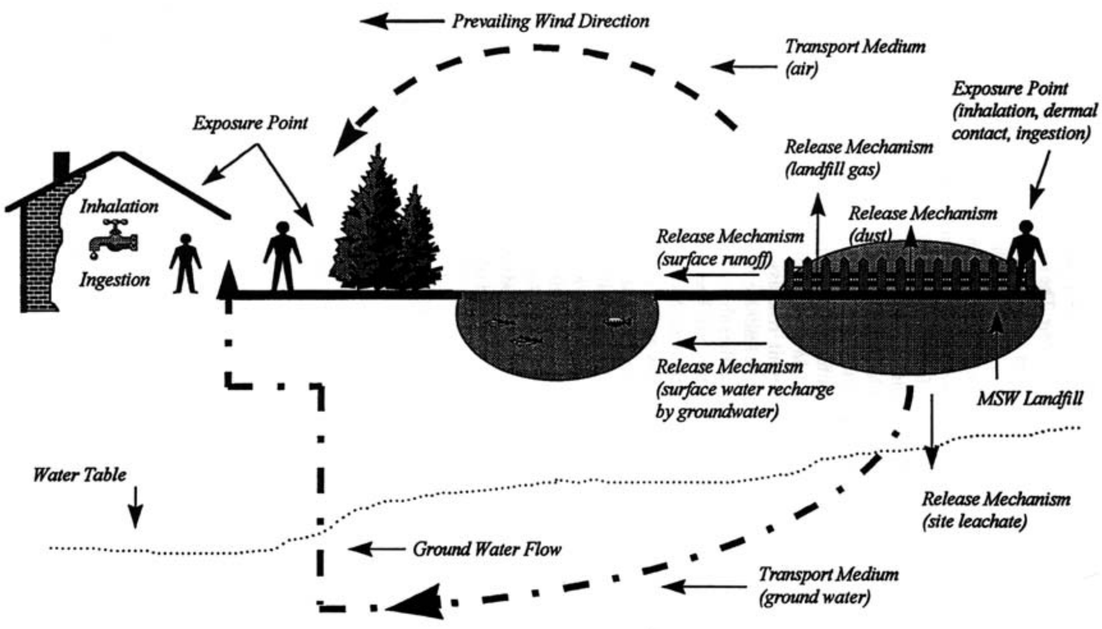

Figure 3.2 Releases and exposure pathways at municipal waste site (MWS) landfills[80]

3.2.4 Chemical changes and transformations

Chemical changes to the substances are quite likely to occur during the fire due to decomposition and reactions brought about by burning or intense heat. Further chemical transformations may take place in the atmosphere, in the water or on chemicals that seep into the ground (see Table 3.2).

Table 3.2 Fates of some pollutants released to land

Substance	Fate in soil
Organic chemicals	Degraded by micro-organisms in the landfill and by hydrolysis in groundwater environments.
Chlorinated aliphatic organics	Can be dehalogenated under anaerobic conditions to produce lower molecular weight chlorinated compounds such as vinyl chloride, which can be released from the site as a gas or via leachate.
Chlorinated aromatics	Some are amenable to degradation, but fragmentation of the aromatic ring requires the presence of oxygen. Dioxins are not readily degraded, but they are strongly hydrophobic, adsorbing onto soil and remaining highly immobile.
Metals	Not in themselves degraded. Mobilisation within the ground, primarily via leachate, depends on the species and reaction conditions[80].

3.2.5 The main steps in the risk assessment

The scientific principles of risk assessment involve a systematic and stepwise approach, and are gradually becoming assimilated and codified in environmental and safety regulatory frameworks, especially in the United States (US) and Europe. Most of the legislation is concerned with controlled releases and yet spectacular impacts to human health and ecological systems often arise from uncontrolled accidents and these often command much public attention. Here, the principles of risk assessment are similar, but the predicted environmental concentrations and their likelihood of occurrence depend on the likelihood of failure[78].

The greatest number of reported accidental releases of chemicals is made to the aquatic environment and this is where the greatest progress has been made with quantified risk assessment techniques. These have been developed to cover many of the key elements of aquatic pollution risk management, from looking at the likelihood of a chemical spill, to modelling concentrations in the environment and the frequency with which they might be anticipated. The key factors in a risk assessment of an accidental release of contaminants are shown in Table 3.3.

What is an acceptable risk? Risk criteria are a difficult issue, as they embrace all aspects of a society's capability and willingness to pay to protect its environment. Ultimately, the results of a risk assessment are likely to be compared with risk acceptability criteria and determining what risk management actions need to be taken. This is based on the concept of risk tolerability which requires that measures are taken to reduce the likelihood and the consequences of hazards until further reduction of risks cannot be justified, i.e. the risks are "as low as reasonably practicable" (ALARP). When it is environmental risk being considered, this trade-off between the costs of risk reduction and the benefits obtained is analogous to the BATNEEC concept[79]. This is illustrated in Figure 3.3.

Table 3.3 Key stages in a risk assessment of accidental releases to the environment

1	*What can go wrong?*	**Hazard identification** Involves identifying the sources of potential accidents, the ways in which they could happen, and any substances involved that are hazardous to health and environment.
2	*What gets out and how much?*	**Releases to environment** Estimate the likely amount, rate, duration and timing of the release of any toxic or ecotoxic substance.
3	*How often?*	**Frequency** Estimate the probability of the occurrence accident happening and leading to the release.
4	*Where does it get to?*	**Transport** Identify the routes though which exposures can occur. Estimate the movement (e.g. dispersion and deposition) of the released substances through the environmental media to the receptors. Estimate the concentrations which will be present in the environment at the receptors.
5	*What are the consequences?*	**Impact assessment** An assessment of the potential consequences of exposure on human health and the environment. An exposure assessment may be focussed on one particular medium and one exposure route (e.g. oral intake from drinking water), or it may include a component for each route (inhalation, oral, dermal).
6	*What are the risks?*	**Risk characterisation** This stage integrates the information from the previous steps to develop a subjective, qualitative or quantitative estimate of the real likelihood of harm to people and the environment. This is the step in which risk-assessment results are expressed.
7	*Is the combination of frequency and consequence acceptable?*	**Risk evaluation** Comparison with risk-acceptability criteria.
8	*How can the combination of frequency and consequence be reduced to an acceptable level?*	**Risk management** Action to reduce to ALARP or BATNEEC level.

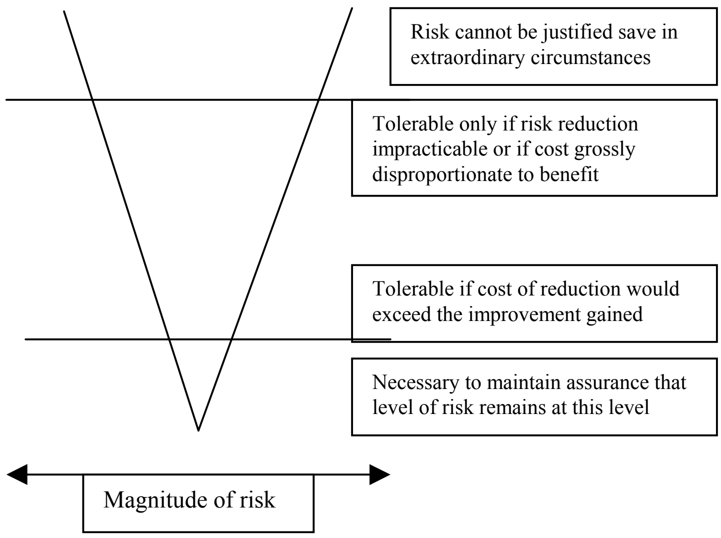

Figure 3.3 Levels of risk and their acceptability[81]

3.2.6 How sophisticated should the risk assessment be?

It is important to get the right balance between the complexity of the assessment process and the level of protection that can be afforded to the environment by any risk-reduction measures which might be identified. In order to ensure costs and benefits are proportionate, it is usual to employ a number of levels of risk assessment of increasing complexity, with progression to the more complex levels depending on demonstration of significant risk by the simpler techniques[12]. In broad terms, there is a hierarchy of risk-assessment approaches of increasing complexity, ranging from simple qualitative estimates through semi-quantitative assessments to fully quantitative risk analyses (Box 3.3).

Taking for example, compliance with the COMAH regulations, the depth and type of risk assessment will vary from installation to installation[79], but is likely to be proportionate to:

a) the scale and nature of the major accident hazards presented by the installations and activities on them;
b) the risks posed to neighbouring populations and the environment and the extent of the possible damage; and
c) the complexity of the major accident hazard process and activities, and difficulty in deciding and justifying the adequacy of the risk-control measures adopted.

By adopting this approach, the lower risk activities are "screened out" and do not require more complex assessment. In line with the precautionary principle, where information is incomplete, progression to a more complex assessment is generally required. Were there is insufficient information to make a judgement, then it may be necessary to implement a set of standard pollution-prevention measures which will, of necessity, be precautionary. At each level of assessment, costs and benefits are taken into account[12]. A major advantage of risk-benefit analysis is its ability to target the attention and resources (expertise and financial), of both regulators and industry, to the potentially most damaging activities. This approach is shown in schematic form in Figure 3.4.

Qualitative risk assessment
The comprehensive identification and description of hazards from a specified activity, to people or the environment. The range of possible events may be represented by broad categories, with classification of the likelihood and consequences, to facilitate their comparison and the identification of priorities.

Semi-quantitative risk assessment
The systematic identification and analysis of hazards from a specified activity, and their representation by means of both qualitative and quantitative descriptions of the frequency and extent of the consequences, to people and the environment. The importance of the results is judged by comparing them with specific examples, standards or results from elsewhere. A variation is the Comparative Risk Assessment, which ranks risk issues by their severity in order to prioritise and justify resource allocation[75]. This type of risk assessment is normally semi-quantitative or even qualitative.

Quantitative risk assessment (QRA)
Application of methodology to produce a numerical representation of the frequency and extent of a specified level of exposure or harm, to specified people ot the environment, from a specified activity. This will facilitate comparison of the results with specified criteria. QRA is a term often used in the chemical industry to describe a distinct type of risk assessment relating to an activity or substance and attempts to quantify the probability of adverse effects due to exposure[77].

Box 3.3. Types of risk assessment[79]

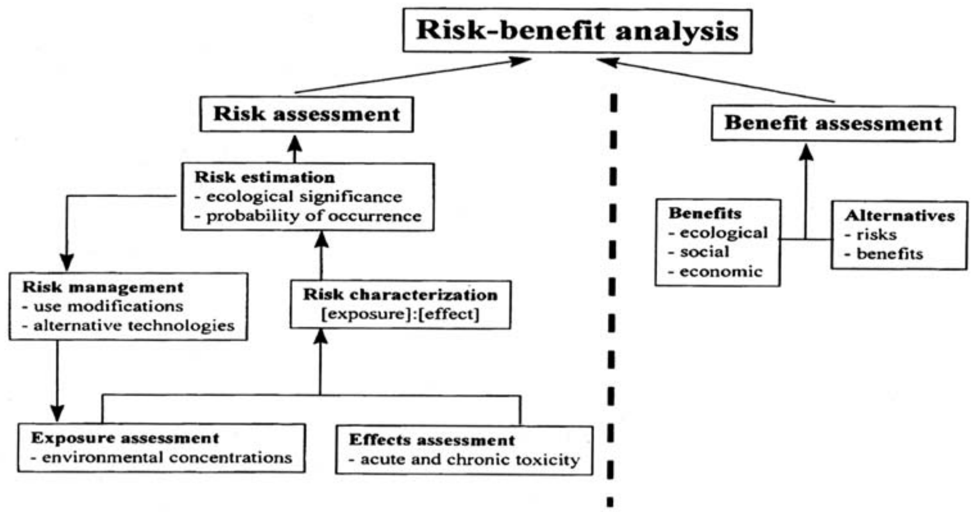

Figure 3.4. Principal processes of risk-benefit analysis for pesticides[82]

There are two principal approaches to risk assessment:

1. *Deterministic approaches*[79,82] – one value is taken for each parameter used in the risk assessment. A standard exposure and effect scenario is used to develop a single effect and exposure concentration, which are then used to develop a risk quotient. This is the most commonly used approach for pesticides risk assessment schemes.

2. *Probabilistic approaches*[82] - Many of the parameters used in a risk assessment can take a number of values. For example, when modelling the dispersion of a pollutant in a river it is possible to envisage flow conditions ranging from low (or no) flow through to high flows or floods. It is usual to categorise these conditions and to ascribe a probability of occurrence to each category. In the risk assessment, each category is then considered and the results weighted according to the probability of, in this example, the river flow. A spectrum of possible outcomes is obtained, each with an associated frequency of occurrence. Other parameters in the model may be treated in this way, e.g. exposure and effect concentrations. This probabilistic risk assessment (PRA) approach is often used in the nuclear industry, but has only recently begun to be considered for agrochemical risk assessment where its application is still under discussion.

Any of the types of risk assessment summarised in Box 3.3 may, in principle, be either deterministic or probabilistic. However, in practice, qualitative approached are generally used only for probabilistic assessments. In general, for the COMAH regulations (and for controlled burn), it is expected that deterministic risk assessment will be undertaken but, where appropriate, a probabilistic approach may be applied[79]. It should be recognised that the subject of risk assessment is complex and developing rapidly. Some of the techniques used are subjects in their own right.

3.3 Risk Perception and Communication

3.3.1 Risk perception versus risk assessment

The idea of risk perception and communication has stemmed from genuine expert puzzlement over active public opposition to technologies that scientists thought were safe. Initially the belief was that the public was irrational and merely had to be educated. However, following early work to identify what was an acceptable level of risk, it became clear that the concept of risk means more to individuals than measurable fatalities and injuries.

Psychometric research has shown perception of risk depends not only to the nature of potential harm, but also on:
- the potential for control;
- concern over equity in risk bearing; and
- the extent to which risk-management institutions can be trusted to manage risks.

On the last factor, the consensual rather than adversarial culture between the regulator and industry in the UK means that risk-assessment techniques still remain largely a “black box” to the general public.

Local public concerns over dioxins emissions from incinerator stacks is one example of the difference between assessed risk and public perception. A risk assessment by HMIP concluded that dioxins emissions from incinerator stacks at the current UK standard would be of no significant risk to exposed individuals irrespective of the location and size of the plant or the characteristics of the exposed population. However, in the public domain an argument that operation to a national standard provided proof of acceptable risk at a specific site was not acceptable[75].

3.3.2 Public acceptance of risk

There also needs to be a clear understanding of what is being protected. In the case of human health the aim is to protect individuals. In the environment, some harm to the individual organism may be accepted (often depending on the emotive response to the organism, e.g. housefly versus seal) provided the existence of the species and the overall structure of the ecosystems are preserved[61].

There are important issues concerning the perception of risk, and what constitutes acceptable (or tolerable) levels of risk. It is argued that the best way of viewing acceptable risk is as a decision-making problem and that acceptable risk must be considered in terms of what level of risk is acceptable to whom, when and in what circumstances. In addition risk perception is, at least in part, dependent on personal and group-related variables. These group-related variables are discussed within the social, economic, political and cultural environment within which peoples or individuals live and think. One key idea is that risk is a culturally defined concept. Thus it is widely recognised that the assessment of risk necessarily depends upon human judgements and the extent to which risk is a subjective or an objective and measurable "quantity" is not clear cut[77].

In the UK, the responsibility for regulating risks is shared by several government departments and by regulators with a large degree of autonomy. Though there is now a considerable commonality of approaches between departments and regulators, they are aware that this evolved over time within organisations and has not been developed systematically from the centre. Such considerations led to the setting up of the Inter-Departmental Liaison Group on Risk Assessment (ILGRA), organised by the HSE on behalf of all government departments in order to provide a mechanism for the development of consistent and coherent policies and practices on risk assessment[83]. The ILGRA has recommended that public agencies formulate and publish their frameworks for the regulation and management of risks. The HSE has responded with a consultation policy paper[84] covering its own statutory responsibilities. The fundamental propositions are:

1. People are generally prepared to live with a risk so as to secure certain benefits in the confidence that the risk is one worth taking and is being properly controlled;
2. The concept of risk must encompass more than physical harm. It needs to take account of other factors such as ethical and social considerations;
3. The pursuit of zero risk is a chimera with the result that decisions about risks are mainly concerned with whether the risk from an activity can be controlled to a level that is tolerable, and with the distribution and balancing of the detriments and benefits from undertaking the activity;
4. Decision-making on the basis of individual interest alone is not a workable proposition since that might expose others to unacceptable risks and also give rise to the prospect of individuals being able to veto measures that are of benefit to the wider community;

5. To succeed, a decision-making process on risk must follow the principles of good regulation, i.e. they are targeted (at the most serious hazards or where the risks are less well controlled), consistent, proportional, and transparent; and
6. Stakeholders need to be involved in the decision-making process if they are to accept the decisions as valid and contribute to their implementation.

3.4 Existing Approaches for Assessing Risks and Impacts from Hazardous Substances

3.4.1 Layout of this section

A number of schemes have been developed to assess the risk of exposure or environmental impact from hazardous substances for different scenarios. These are reviewed briefly in this section and their relevance and applicability to fires is discussed. Firstly, the approach for assessing BPEO in general is reviewed; then assessment schemes focusing on fires and emergency releases; and finally, other related risk assessment schemes that could be useful models for this study. More comprehensive descriptions of some of these approaches are given in Appendix 1.

3.4.2 Environment Agency BPEO impact assessment

The introduction in April 1991of Integrated Pollution Control (IPC) under the Environmental Protection Act 1990, required operators of IPC processes to demonstrate that the choice of process represented Best Available Techniques Not Entailing Excessive Cost (BATNEEC) having regard to the Best Practicable Environmental Option (BPEO). Initially, only general guidance on how environmental assessments for IPC could be conducted was available. Later, guidance[85] on the application of BPEO methodology to IPC processes was published by the Environment Agency. BPEO an be defined as: the option which in the context of releases from a prescribed process, provides the most benefit or least damage to the environment as a whole, at acceptable cost, in the long term as well as the short term. The seven stages of a BPEO assessment are:

1. define the objective;
2. generate options;
3. evaluate the options;
4. summarise and present the evaluation;
5. select the BPEO;
6. review the BPEO; and
7. implement and monitor.

The underlying philosophy underpinning the BPEO assessment is the evaluation of releases on the environment as a whole. Such an integrated impact assessment is extremely complex and the effect on the environment will be dependent on many factors, including:

- the chemical and physical properties of the released substances;
- the amount of each substance released;
- the rate of release of each substance;
- ambient concentrations of released substances already in the environment;
- the location of receptors in the environment; and
- the degree of sensitivity of these receptors to the released substances.

With complete knowledge about all these factors it would, in principle, be possible by the use of modelling and monitoring, to predict or measure the effects of all the released substances on all sensitive receptors in the environment. In practice, knowledge about these factors is limited and such a comprehensive assessment is likely to be too time-consuming and costly in most cases.

The environmental effect of a substance released to a particular medium is quantified as the Environment Quotient (EQ) for that substance in that medium. The EQ is the ratio of the process contribution (PC) – for the purposes of this study a fire incident - to the reference level. The overall effects in water, air and land can be expressed as the sum of the three Environmental Quotients and the quantity so obtained is known as the Integrated Environmental Index (IEI).

$$IEI = EQ_{(air)} + EQ_{(water)} + EQ_{(land)}$$

The final stage of the process is to compare both the costs and environmental benefits of each option.

The methodology in the Agency guidance is designed primarily to apply to:

- the concentrations in air from controlled releases to air;
- the concentrations in water from controlled releases to water; and
- the concentrations on land from controlled releases to air and deposition on land.

Nevertheless, many of the principles are also relevant to this study of accidental releases from fires. If sufficient quantitative input data were available, the approach would be well suited for *comparing* alternative environmental options - such as putting a fire out or allowing a controlled burn - and quantifying *relative* impacts, because the nature of the receiving environment will effectively be the same for all options. This is illustrated in Figure 3.5.

However, for assessment of BPEO for accidental releases from fires, it is very unlikely that sufficient quantitative data will be available to enable such a thorough, analytical approach to be taken. A best-judgement, subjective, or semi-quantitatively estimate of the risks into broad categories is likely to be the most realistic approach.

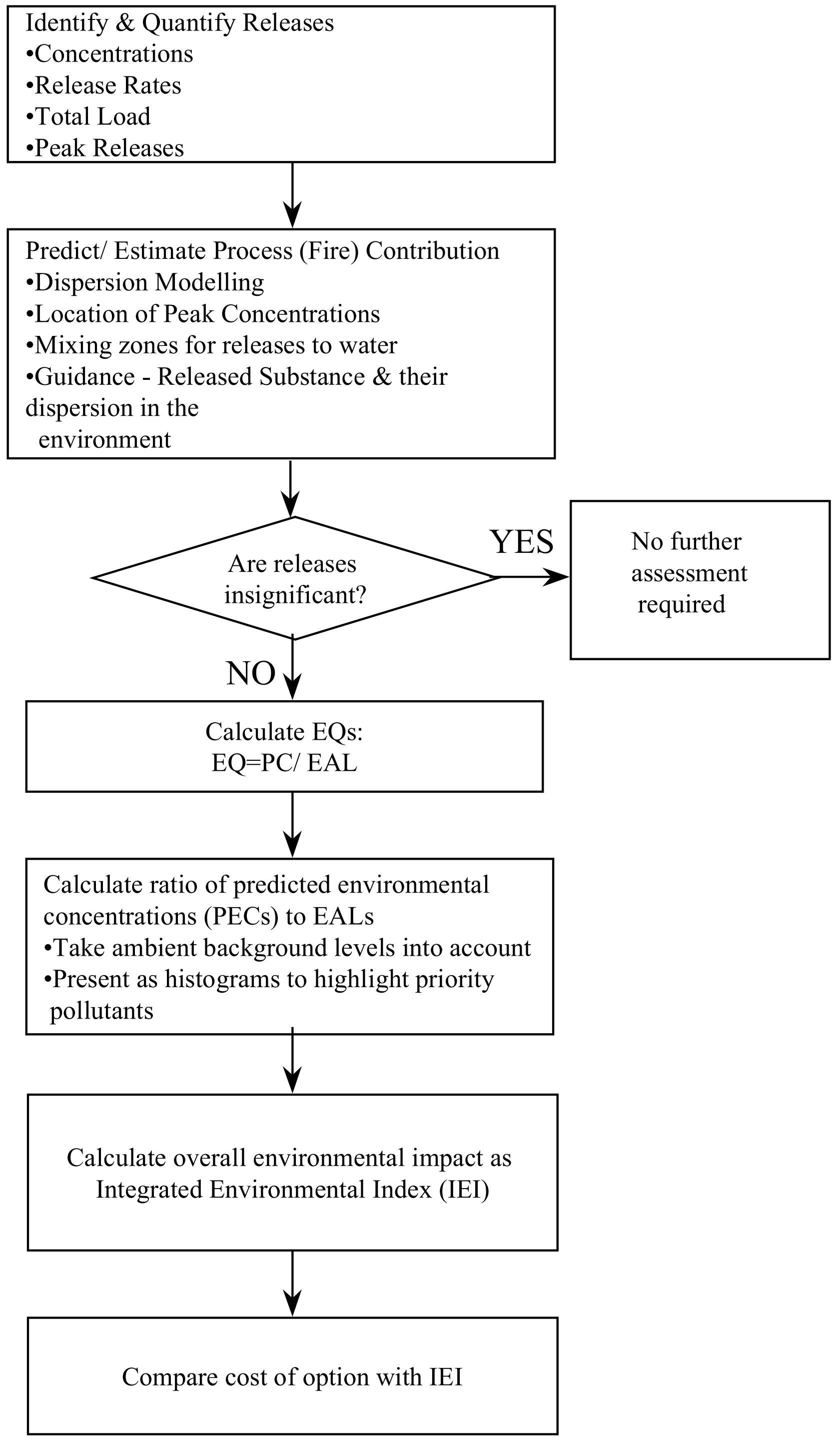

Figure 3.5 The BPEO process

3.4.3 COMAH safety report environmental risk assessment

COMAH requires operators of sites where dangerous substances are present to take all measures necessary to prevent and mitigate the effects of major accidents to man and the environment. The non-prescriptive guidance contains descriptions of the principles and likely information requirements of the environmental risk assessment.

There is a hierarchy of risk assessment approaches of increasing complexity ranging from simple qualitative estimates through semi-quantitative assessments to fully-quantitative risk analyses. For compliance with the COMAH regulations, the depth and type of risk assessment required will vary from installation to installation, but is likely to be proportionate to:

- the scale and nature of the major accident hazards presented by the installations and activities on them;
- the risks posed to neighbouring populations and the environment and the extent of the possible damage; and
- the complexity of the major accident hazard process and activities, and difficulty in deciding and justifying the adequacy of the risk-control measures adopted.

The guidance recognises that even though the techniques for environmental risk assessment aregenerally available, there is sometimes a paucity of associated good-quality environmental data. This means that pragmatic, but justified, choices may need to be made during the environmental risk assessment process. When data are deficient the "Precautionary Principle" should be applied, i.e. choices should overestimate rather than underestimate the risks. One of the basic criteria used to determine if the hazard is to be considered further, is whether the accident is a Major Accident To The Environment (MATTE). Operators may chose to use a less severe accident than a MATTE as the threshold determining whether or not the hazard is considered further; however, all accidents that are at least as severe as a MATTE *must* be considered.

The COMAH guidance recognises that releases during accidents (especially fires) at some installations can consist of a cocktail of chemicals. In such cases there is the additional need to predict the composition of the release, taking into account the presence of combustion or reaction products, including those not normally present in the process, and any other materials mobilised during the accident. It should be possible to identify these compounds, although there will generally be some uncertainty concerning the quantities involved. The guidance suggests the following two relatively simple approaches which may provide sufficient confidence in the predictions from the risk assessment:

a) Instead of trying to consider the full cocktail of chemicals, choose a suitable representative "marker" chemical as an indicator of environmental effects. The Precautionary Principle should govern the selection of the marker.
b) Review information on accidents to see what the effects have been and where they have occurred. Use this information to identify any similarities with the situation of concern, which may enable a judgement to be made on its likely effects.

It is important, however, that the uncertainties in the predictions from these (and indeed any other) approaches are properly recognised in making any decisions.

In some circumstances, the two simplified approaches described above will not be suitable. This may be when there are possible antagonistic or synergistic effects of chemical mixtures on the environment. In these and some other circumstances, there may be no practicable alternative to either undertaking a detailed environmental risk assessment or, alternatively, reducing the risks by introducing physical systems or risk-management practices. The essential information that is expected in a COMAH environmental risk assessment is:

- hazardous substances information;
- site description;
- description of the local environment;
- external factors (e.g. geology, earthquakes, subsidence, flooding, weather, air traffic);

- hazard identification and quantification;
- frequency assessment;
- consequence assessment;
- risk management; and
- off-site emergency planning.

The guidance contains advice on carrying out all the above elements of the risk assessment. The guidance has clearly been developed with accidental releases, including fires, as one of the intended applications. The top-tier COMAH sites should already have in place an on-site emergency plan based on an assessment of major accidents (including fires) that takes the environmental risk assessment (ERA) into account. For lower-tier COMAH sites and sites not covered by COMAH, the ERA approach is still valid: the guidance on cocktails of reaction and combustion products would be especially useful in any simplified guidance developed for these sites. Similarly, the essential information referred to in the preceding paragraph applies to all sites, although some components (e.g. hazard identification, frequency assessment and consequence assessment) may need to be simplified.

3.4.4 CEA fire risk assessment for protection of stores containing hazardous substances

The Comité Européen des Assurances (CEA) Commission Incendie has published recommendations[86] with the aim of the limiting the hazard generated by fire at stores which contain hazardous substances above certain threshold quantities. The fire risk in a store containing hazardous substances is be appraised by:

1. identifying and estimating the hazard potential (sum total of the hazards posed by hazardous substances, including quantity, storage conditions, grade of fire hazard and toxicity/ecotoxicity);
2. identifying and estimating the inception hazard (how the fire or explosion can occur);
3. estimating the possible extent (risk) of damage and the probability of an incident occurring for each scenario, taking into account the hazard potential, protection measures, and possible location effects on people (at the workplace and in surrounding residential areas, schools, hospitals, hostels, meeting places, etc.) or on the environment (ground water, surface waters, animals, vegetation and on threatened material assets).

The risk appraisal provides the basis for determining the requirement for risk-reduction measures:

Appraised Risk		**Risk Reduction Required**
unacceptably high risk	→	absolutely essential
acceptable risk	→	recommended
negligible risk	→	not necessary

Protection objectives and protection methods are given: recommendations state that wherever possible the operations of the fire brigade should be integrated into the preventative fire protection and environmental protection plans. This also applies to any controlled burn. Recommended organisational protection measures include, among other things, an emergency plan.

For any Agency policy or guidance on the application of controlled burn, substance thresholds will need to be set, to avoid including premises using or storing trivial quantities. The CEA scheme contains a list of classifications and thresholds that could be used. The advantage is that the scheme is already in operation (in Europe as well as the UK). Much of the information should be readily available to site operators as it is already required for insurance purposes.

3.4.5 Environment Agency PPG18 risk assessment*

Environment Agency pollution-prevention guidance note PPG18[87], *Pollution Prevention Measures for the Control of Spillages and Fire-Fighting Run-off,* recommends that *all* companies carry out some form of hazard/risk assessment. The guidance suggests first identifying the hazard (sources, pathways, receptors); then (unless the hazard is negligible) producing a risk assessment by identifying events potentially leading to loss of containment, and a quantitative assessment of frequency that such events could occur.

The additional costs of carrying out the risk assessment stage should be balanced against the potential benefits. These could include: what does the public think? How could action/inaction affect the company's products or public image? A variety of risk assessment approaches may be used. PPG18 details the factors to be included when assessing site sensitivity.

3.4.6 Environment Agency risk assessments for Water Protection Zones

Section 93 of the Water Resources Act 1991 allows the Environment Agency to apply to the appropriate Secretaries of State for the designation of Water Protection Zones (WPZs), if it is necessary for activities to be controlled or prohibited. The Agency developed a methodology[12] to form the technical basis for implementation of protection zone order. This included:

- obtaining data on the identity and quantity of chemicals stored in the catchment;
- estimating the size and likelihood of chemical spillages from individual sites;
- predicting the consequences of such spillages; and
- determining whether the combination of frequency and magnitude of the consequences is acceptable.

A "catchment inventory" of hazards (stored chemicals or chemicals in reaction vessels) was compiled to enable initial screening, prior to more complex assessments. A threshold quantity was applied to avoid including prohibitively large amounts of data on very small quantities of substances, which will usually present a negligible risk. The cut-off quantity was determined by consideration of the most toxic substances that might be found, and the initial dilution that might be afforded if they were accidentally released.

A Rapid Risk Assessment was then carried out. The first stage, known as Initial Hazard Assessment, required the hazard to be subjectively assessed against 15 possible issues, divided into categories of:

- type of site/activity;

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* The recently published, revised version of PPG18 deals only with secondary (i.e. remote) containment. Primary containment (i.e. bunding) is now covered in a revised version of PPG 2 (which formerly dealt with bunding for oil spills). Controlled burn tactics appear in a new emergency planning/response note, PPG21.

- substances;
- incident history;
- vulnerability of watercourse/groundwater; and
- use of watercourse/groundwater.

The second-level assessment, known as Primary Risk Assessment, used a scoring system to reduce subjectivity, and considered the same issues in more detail and with greater emphasis on site management, but the need for detailed toxicity and flow information was kept to a minimum.

The third-level assessment had greater data requirements, requiring both river flow and toxicity information. This hierarchy of assessment levels acted as a screen, ensuring that only the sites or activities that appeared unsatisfactory in the simpler assessments were considered by the more complex techniques. The cost-benefit assessment was also considered at each stage of the assessment.

For a full risk assessment, prediction of the consequence element of the risk management process in rivers was carried out using PRAIRIE (Pollution Risk from Accidental Influx to Rivers and Estuaries), a piece of PC-based software

The spill-risk assessment is the part of the risk management process that is most specialised and involved the assessment of the probability of various release scenarios occurring. Again, a screening process was used to eliminate chemical stores which, even in a realistic worst-case spill scenario, could not result in concentrations of concern being exceeded in the receiving water. When a spill risk assessment is required, it is necessary to identify all of the possible scenarios that might result in the substance entering the watercourse. The chain of events for each scenario will include the failure of containment devices, such as bunds. Generic failure rate data are used to calculate the probability of each alternative combination of events occurring. When PRAIRIE is run in its probabilistic mode for the series of possible combinations of events producing spills of varying size, each with a related probability, it produces a frequency versus concentration curve for assessment against the relevant risk criteria.

Many of the elements of the approach used for risk assessments of WPZs would be relevant to controlled burn risk assessments. In particular this applies to the threshold approach to eliminating low-risk sites, and the protocol for incorporating cost-benefit into escalating complexities of risk assessments. The more complex assessment methods described are designed for regional assessments by regulators and are unlikely to be useful for self-assessment at sites previously unregulated by IPC, COMAH, etc. However, some of the screening procedures and the simpler risk assessments may find a place in any controlled-burn guidance.

3.4.7 Environment Agency risk assessment for groundwater

The protection of groundwater from pollution needs a different approach from surface waters in recognition of the long-term nature of any pollution and the difficulty of predicting the fate of contaminants. The use of risk assessment in relation to groundwaters normally falls into one of three categories[12]:

- determining vulnerable areas and situations which are at risk (e.g. groundwater protection policy and its associated vulnerability maps and source protection zones);
- assessing new developments to determine the acceptability, constraints or engineering needs to mitigate potential impact (e.g. LandSim – see below)
- regulating existing operations or land/water quality to evaluate the activities/contaminants that pose the greatest threat, and prioritising regulatory actions.

LandSim (Landfill Risk Assessment by Monte Carlo Simulation) is a software package developed by the Agency (R&D Projects PI-256 and PI-294) as a tool to help in the assessment of new landfill sites. It forces regulators to think about their decision in terms of risks to groundwater and encourages discussion and agreement with landfill operators over the key data needs. Similar tools to LandSim are being developed as assessment aids in the related areas of groundwater pollution prevention and remediation and contaminated land management.

In terms of the relevance to controlled burn, the approach is likely to provide most benefit in its ability to assess the impacts of accidental releases after they have happened. Except at high-risk sites where the environmental benefits of such a sophisticated assessment outweigh the costs, the approach is unlikely to be used in routine pre-incident planning of BPEO for fires.

3.4.8 Environment Agency risk assessment for landfilling of household wastes

In seeking to identify the BPEO for household waste, the Environment Agency commissioned research on the public health risks associated with household waste disposal by landfilling[88]. The framework procedure for the risk assessment comprised of the following elements[80]:

- *Hazard identification* - consideration of the properties and concentrations of the chemicals on the site that could give rise to harm.

- *Release and transport of contaminants* - the concentrations of contaminants at the exposure points via all relevant pathways, estimated using bespoke computer models.

- *Exposure assessment* - received dose calculated for each route of exposure (i.e. ingestion, inhalation and dermal contact) taking into account concentrations, duration of contact and people's activity patterns.

- *Toxicity assessment* - the dose-response relationship for each of the indicator chemicals.

- *Risk estimation and evaluation* - the total intake of each chemical into the body is estimated from the exposure-assessment stage. Then, the intake of each chemical is compared against an appropriate Tolerable Daily Intake (TDI) or reference dose, to obtain a Hazard Index (HI). The criterion for "acceptable" air or water quality in relation to a pollutant released from the landfill is the ratio of the modelled exposure concentration for that pollutant to its air or water quality standard (i.e. the HI). The ratio should not exceed 1.0, since this would indicate that the exposure concentration is equal to the standard for air or water quality.

This assessment procedure has some relevance to the study of the impacts of fires because it considers impacts on all three environmental media. However, use of this rigorous, quantitative treatment for BPEO assessment of fires is likely to be restricted to high-risk sites where the environmental benefits of such a sophisticated assessment outweigh the costs. In many cases, such sites will already be controlled under other regulations (e.g. COMAH) for which risk assessment guidance is already available. The approach is unlikely to be used in routine pre-incident planning of BPEO for fires. However, there are many elements of the approach that would have relevance even in simple guidance for otherwise unregulated sites, such as the advice on targeting compounds of concern and the approach to mixtures.

3.4.9 Environment Agency OPRA risk assessment

The main purpose of Operator and Pollution Risk Appraisal (OPRA)[89] is to provide an objective, consistent assessment of the environmental risk from IPC processes, to improve the targeting of inspection effort. OPRA assesses the inherent level of risk in the process and environmental performance of the Operator in managing that risk. It is designed as a rapid, easy-to-use screening tool, and is not intended for detailed assessment of process risk or Operator performance. OPRA evaluation of risk involves two main elements:

I. the *pollution hazard* of the process (the inherent risk *(sic)* in the process due to type and amount of materials present, frequency of operations, location, etc.); and
II. the *Operator performance* (relating to the chosen methods and standards of management of the process, e.g. management and training, etc.) in managing the pollution hazard *(sic)* of the process.

Both parts of the OPRA system - Operator Performance Appraisal (OPA) and Pollution Hazard Appraisal (PHA) - include an evaluation of 7 main factors (attributes) and a simple method for converting these into numerical ratings for the process. (The attributes may additionally be assigned weighting factors, based on the Agency's current view of the importance of each attribute to the overall risk level, but these are not currently used while the system is being established.) The OPA and PHA scores may be used together to give an overall OPRA Rating.

Each PHA attribute is scored between 1 (low level of harm) and 5 (highly harmful effects and persistent). PAH1-6 are the "real" hazards to the environment, whereas PAH7 is a separate evaluation of the offensive characteristics of the process, e.g. odours, visible releases, appearance, taste and lack of amenity. These characteristics have an emotional impact. Although these generally do not constitute a significant impact on the environment, they often generate a public perception of risk, which may be unrelated to actual environmental harm. Though this may effect the regulatory effort required for a process (often leading to a large amount of regulatory work arising from public concerns and complaints), the Agency considers it very important to separate them out from the "real" risks. Therefore, the overall PHA score is based on the combination (sum) of attributes PHA1-6.

Table 3.4. Pollution hazard attributes used in OPRA risk assessments

Attribute	Title	Basic Meaning (OPRA)	Possible Meaning in Fire Plans
PHA1	Presence of hazardous substances	Inherent environmental hazard posed by the properties of the representative hazardous substance present in the process.	Directly relevant.
PHA2	Scale of hazardous substances	Amount of hazardous substance that could be released from the process.	Directly relevant.
PHA3	Frequency and nature of hazardous operations	Frequency of hazardous releases given the nature of the process and associated operations.	Not really relevant to a fire, which is an unforeseen, uncontrolled, emergency.
PHA4	Technologies for hazard prevention and minimisation	Steps taken to control the hazard at source.	May be analogous to proper storage, fire-resistance of containers, etc.
PHA5	Technologies for hazard abatement	Steps taken to control the hazard through use of abatement systems.	May be analogous to bunds, interceptors, etc.
PHA6	Location of process	Vulnerability and significance of environmental receptors within range of the hazard.	Directly relevant.
PHA7	Offensive characteristics	Offensive characteristics of the process and strength of adverse public perception.	Directly relevant to emotional impact.

In principle, all releases that may potentially harm the environment need to be considered within OPRA. However, in practice the procedure adopted is to identify (as part of the PHA1 evaluation) the substance and release scenario (in the case of this study, a fire) which represents the major risk to the environment from the process. Once the *representative substance* is identified, PAH1-6 must be scored in relationship to that substance to ensure consistency. Each attribute must be scored separately to avoid "double-counting" of influencing factors*. The appropriate representative substance is that which contributes the major proportion of the overall pollution risk. This corresponds to the substance with the highest sum of scores PHA1-6.

An OPRA-style assessment could have some applications in assessing BPEO for fires at sites storing hazardous substances. The Pollution Hazard Appraisal (PHA) could be used for hazard identification and some possible interpretations of the different attributes in the context of fires are shown in Table 3.4. Some of the attributes may be more or less relevant to fires than they are for OPRA`s inspection application. However, this can be reflected in the weighting given to attributes, or more relevant attributes could be substituted.
The OPRA approach could be used as a screening tool to see if a fire plan is needed, and a possible application is shown in Figure 3.6. Alternatively, the OPRA process could be carried out twice - once an extinguished fire and once for controlled burn - to decide which is the BPEO. The Operator Performance Appraisal (OPA) aspect of OPRA has fewer obvious

* For example, if the main pollution risk is metals discharge to water, PHA1 is based on the aquatic toxicity of the metals, PHA2 relates to the scale of discharge of the metals, PHA3 relates to the frequency and nature of discharge operations, PHA4 and 5 relate to technologies to prevent/ minimise and abate the metals, and PHA6 relates to the proximity and vulnerability of surface waters to such releases. Note that PHA6 is not scored higher if the metals are particularly toxic as this is already reflected in the PHA1 score.

applications for controlled-burn guidance. Some attributes, such as the performance of the Operator in preventing emergencies/fires, having an existing emergency plan, having adequate bunds, etc., could also form part of the Regulator's screening process to identify sites needing an emergency plan under separate controlled-burn guidance.

Some advantages of using an OPRA-based system would be:
- Some guidance is already available;
- It is an existing Agency system, with Agency policy to extend its applications where appropriate;
- Simple to use - important for self-assessment of small to medium-size enterprises (SMEs);
- Covers most of the attributes relevant to fires;
- Has been field-tested by Agency staff;and
- Costs have been evaluated.

Possible drawbacks are:
- It is only a screening tool, not a detailed assessment of process risk;
- Not designed to be directly applicable to fires and would need some further guidance for such an application;
- Would need to be done twice, once for an extinguished fire and once for controlled burn; and
- No direct link between PHA score and control measures. Would need further work/guidance.

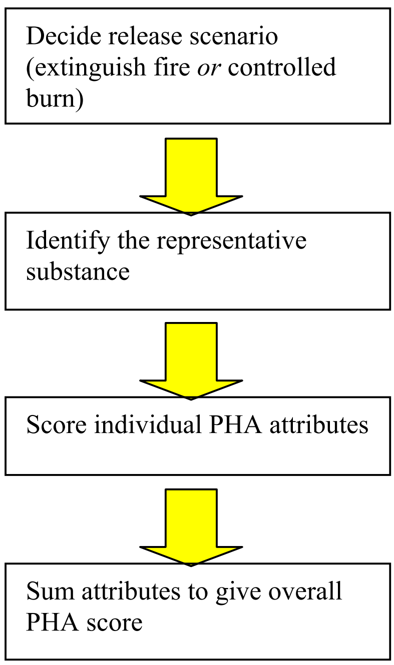

Figure 3.6 Possible application of OPRA approach to BPEO for fires

3.4.10 Occupational exposure risk assessments

A fundamental first step in complying with the COSHH Regulations is carrying out a risk assessment of substances used in the workplace. Assessments for some chemicals involved straightforward comparisons with occupational exposure limits (OELs); however, for substances not assigned OELs, guidance has simply recommended that employers determine their own working practices and in-house standards of control. Experience showed that this was outside the capabilities of many small firms, requiring expertise and equipment not readily available to them. The Health and Safety Commission's Advisory Committee on Toxic Substances (ACTS) set up a working group to provide a more useful and workable new approach[90] that would meet the following four criteria:

1. advice should be of practical help to small and medium size enterprises (SMEs);
2. the best use should be made of any hazard information already available;
3. the approach should be easy to understand and use; and
4. any information should be readily accessible to SMEs.

The scheme fits in well with the HSE`s policy on risk assessment[91] and has since been adopted by the HSE and published as official guidance[92] to aid employers carry out risk assessment and selection of control measures.

The scheme needed to take into account the range of health risks presented by the myriad of chemicals in regular use and the wide variety of possible scenarios. The working party developed a simple system of generic assessments based on readily available hazard information and likely use scenarios, to determine a range of control strategies and control advice. The approach draws from and builds on earlier schemes such as that of the Royal Society of Chemistry[93]. The model considers the intrinsic health hazard and surrogates for exposure potential, using information that will be readily available to firms and intermediaries. Each of these factors (hazards, exposure potential) and combinations of these are grouped in some way to generate a set of control approaches.

To make the best use of available hazard information, the model uses the R-phrases assigned to substances by suppliers under the CHIP Regulations, to represent human health hazard. To keep the scheme easily workable, the R-phrases have been assigned to one of 5 hazard bands, A to E. Bands A-D have associated ranges of exposure by inhalation for dusts and vapours: Band D contains substances presenting the most serious health effects (e.g. carcinogens) and signals that generally very tight control will be needed and specialist advise should be sought. There is also a sixth band, S, to which substances harmful by contact with skin and eyes can be assigned and where the appropriate precautions can be emphasised.
While this approach has the advantage of using readily available hazard information, it does mean it is restricted to substances classified under CHIP. It therefore excludes chemicals such as pesticides and pharmaceuticals.

Having identified hazards and acceptable ranges of exposure, it is necessary to establish exposure potential. This is critical in determining how much of a substance is likely to become airborne. The model uses two factors to represent exposure potential: the physical properties (dustiness of solids and volatility of liquids), and the amount used. To keep the scheme workable and easy to use, simple definitions of high, medium and low dustiness and volatility are given. The amount is divided into three groupings of small (g, ml), medium (kg, l) and large (tonnes, m^3).

The last element of the model is the control approaches for each combination of these factors. The basic components of the model are summarised in Figure 3.7.

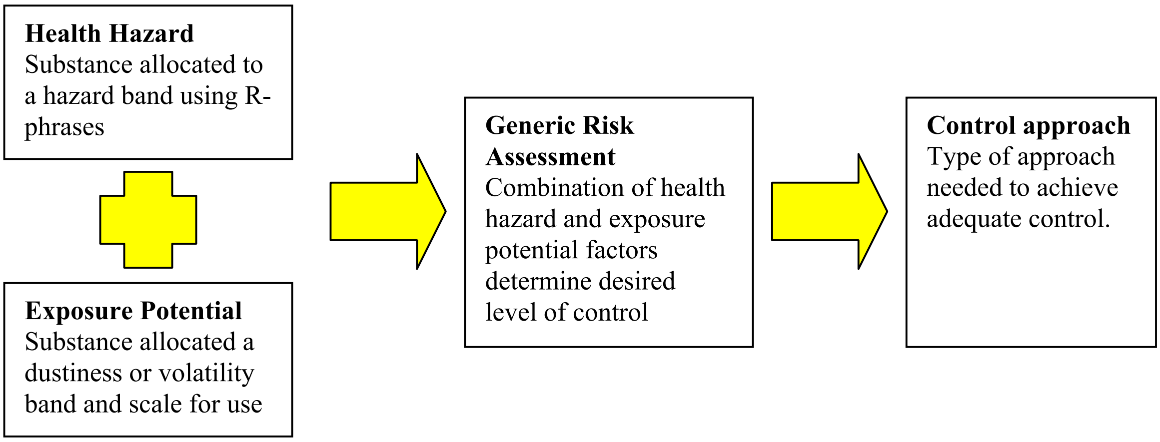

Figure 3.7 Basic components of occupational exposure risk assessment

The HSE`s views on SMEs needing straightforward, practical guidance is highly relevant to introducing guidance on controlled burns, as it is largely these firms that are not currently covered by other emergency plan requirements. The HSE`s four criteria for guidance would be highly relevant for any self-assessment emergency plans covering fires at sites storing hazardous materials.

On the relevance of the model itself to controlled-burn decisions, the use of readily-available hazard data – in this case R-phrases assigned to substances by suppliers under the CHIP Regulations – and allocation to one of a small number of hazard bands, is very desirable because of its simplicity. However, an obvious shortcoming is that CHIP is a classification relevant to impact on human health, not to environmental/ecological impact. For fire plans, the risk to environment would also need to consider. Careful consideration would also have to be given to whether the substance changes when burned and what risks the burned substances pose.

The use of substances hazard data from CHIP classifications would not be expected to cause insurmountable problems. There are some substances of concern to the Agency, such as beer, orange juice, milk and plastics that are not classified under CHIP. Further guidance on hazards to the environment from these might be needed. Pesticides (in agricultural applications, rather than in stores, retail premises) would be covered by BASIS. The basic framework of the model could still be used with alternative sources of hazard data (e.g. the CEA classification) if these were more appropriate.

If this method of estimating exposure potential is modified for use with fire-risk assessments, then apart from determining how much of a substance is likely to become airborne because of its dustiness or volatility, it would also be necessary to consider:
- how it is transported to water and land;
- what is the chemical transformation in the fire; and
- how likely it is to disperse in a fire.

A major difference of a fire BPEO assessment compared to a COSHH assessment is that in the former more than one receptor is exposed to the impacts. These include the human health (mainly by inhalation) of fireman and local people; the aquatic environment; land and crops; and aquifers/potable water. It might be necessary to carry out a risk assessment for each of these and then either combine them or put them in a matrix.

3.4.11 Biodiversity impact assessment

The UK Round Table on Sustainable Development has produced a step-by-step guide[94] specifically for businesses, for integrating nature conservation and biodiversity into environmental management systems. It is based on a report examining the role that business could have in assisting in the implementation of the UK Biodiversity Action Plan[95] and takes the view that there is a business case for protecting biodiversity. The working group consisted of business, NGOs and DETR officials. The booklet contains a useful checklist and matrix for review and assessment of environmental impacts to air, water and land; and also considers ecology, waste, noise, resources, socio-economic issues.

For assessing biodiversity sensitivity, the guide suggests consideration of:

- the proximity of the site to rivers, breeding grounds, protected sites, waterways, groundwater sources and residential communities;
- whether any of the sites have "designated" status;
- which habitats/species are present;
- whether there are any habitats or species that may be sensitive to emissions to air, water, land;
- what proportion of a particular habitat/species would be lost or significantly disturbed (for a particular pollution incident);
- whether there are similar habitats or populations in the region or locally;
- how valuable the potentially affected environments are in nature conservation/ecological terms;
- whether any species/habitats reached the limits of viability (or are near these limits); and
- how likely the impact is and its duration.

Three criteria given for "*significant effect"* are:

- loss of biodiversity or irreplaceable habitat (e.g. ancient countryside);
- loss of strategic resources; or
- prosecution.

The sensitivity list and significant effects list cover only biodiversity criteria, but analogous criteria for water quality and air quality could easily be devised. The approach used is a type of comparative risk assessment, ranking issues by their severity to estimate biodiversity impact. Examples are given of financial reasons (e.g. fines, claims, loss of market share) and relationship-cost reasons (e.g. bad press, poor morale) why conserving biodiversity matters to business. Many of these apply just as well to pollution from fires at sites storing hazardous substances.

3.4.12 OECD/EU environmental risk assessment of chemicals

Under EU legislation[56, 57], it is specifically required that risk assessments (including those on the environment are carried out on all newly notified substances and on priority existing chemicals (see Section 2.6). Risks are managed by warning the user of a substance of intrinsic hazardous properties via appropriate labelling. For professional users this warning label is reinforced with a safety data sheet which gives information "*necessary for the protection of man and the environment*". Thus, advice on avoiding spillage to drains and on the appropriate methods of treating, recycling or disposal of waste should be provided so that the user can minimise release to the environment[61].

The Annex III to the Risk Assessment Directive and Regulation specifies the procedures to be used for environmental risk assessments and the Technical Guidance Document (TGD)[96] provides guidance details are given on estimating the predicted environmental concentration (PEC) and predicted no effect concentration (PNEC), for aquatic toxicity and inhibition of microbial activity at sewage treatment plant (STP). Work is still underway on producing robust methods for assessing sediment PNEC and soil PNEC.

The Organisation for Economic Co-operation and Development (OECD) has an on-going chemicals programme whereby numerous Test Guidelines[97] are developed and updated for environmental data for specific chemicals. These cover physico-chemical data, degradation data and acute and chronic toxicity data. Many of these have either been adopted or used as EU test methods. Some of the work has been carried out in collaboration with the International Standards Organisation (ISO) whose test methods have also been adopted or referenced within EU methods. The European Commission has collated the official EU test methods[98]. However, the risk assessment methods used for the chemicals themselves are too specialised to be used in the BPEO assessment of fires at sites storing hazardous substances, where a more holistic assessment approach is required.

4. INFORMATION GATHERING

4.1 Objectives

There is currently little information or guidance available on the subject of controlled burn and there is therefore a recognised requirement for research into the issue to enable Agency staff and outside organisations to make informed decisions during incidents and when drawing-up emergency plans. The specific objectives of the information-gathering part of the study were:

- to examine the present policy, legal obligations, views and attitudes of the parties that may be involved in controlled burn and thus help promote discussion internally and externally (to the Agency) on the issue;
- to provide information on the environmental impacts of fires at sites storing polluting material and of allowing fires to burn, including impacts on man (both physically and emotionally), controlled waters, land and air;
- to provide information on legal and financial consequences of allowing fires to burn, in particular the requirements of the Fire Service Act 1947, the Water Resources Act 1991 and the Environmental Protection Act 1990; and
- to consider the implications of new regulations such as COMAH and IPPC.

4.2 Method

4.2.1 General approach

There are many parties with an interest in controlled burn, for instance: regulators, the Fire Service, operators, insurers and local authorities. Guidance and policy on controlled burn needs to be informed by their views. The first task of the study team was to initiate discussions with the following parties involved with fire incidents.

Regulators

- Pollution-control staff of four Environment Agency regions (North West, Anglian, Southern and Thames);
- Scottish Environmental Protection Agency (SEPA);
- Heritage Department of Northern Ireland (HDNI);
- British Agrochemical Standards Inspection Scheme (BASIS); and
- Health & Safety Executive (HSE).

Fire Service

- Chief & Assistant Chief Fire Officers` Association (CACFOA); and
- Six operational fire services (Dorset, Devon, Cleveland, Northamptonshire, Avon and Royal Berkshire).

Insurers

- Loss Prevention Council (LPC).

Industry and operators
- Chemical Industries Association (CIA); and
- UK Petroleum Industry Association (UK PIA).

Local authorities
- Environmental Health Officers (EHOs).

Information was collected from these key organisations with the aid of previously prepared checklists followed by structured interviews and/or written responses to ensure all the relevant issues were covered. There were three main aims when talking to interested parties:
1. Firstly, to obtain the policies, concerns, views, attitudes and current practices of interested parties relating to controlled burn.
2. Secondly, to identify the legal obligations of the party (e.g. enforcement or contractual) and thus help with the literature review by identifying relevant acts, regulations, circulars, official codes of practice, official guidance, professional guidance, British Standards, industry standards and guidance, reports of experts in the public domain, historic data in the public domain, statistical information in the public domain and terms and conditions.
3. Thirdly, to identify specific fires which illustrate the benefits or dis-benefits of current practices. This was to provide practical information for the case studies (Chapter 5) and for building future policy and guidance.

Detailed questions were developed for each one of the issues, so that a structured picture could be built up. Initial discussions were carried out with some of the organisations in order to create a workable and efficient checklist. To make effective use of resources, many interviews were conducted over the telephone, but a number of interviews were face-to-face. Some organisations preferred to provide written submissions. The information was gathered by the appropriate member of the study team. For example, the fire specialist was responsible for collecting information from CACFOA and the fire services; the water specialist was responsible for collecting information from BASIS. The information gathered was then collated and summarised.

Additional advice was sought from Environmental law firm Trowers and Hamlins on the legal issues surrounding controlled burns.

4.2.2 Contacting interested parties

The National Fire Service Liaison Group and Environment Agency Steering Group was able to provide contact leads for many of the organisations. The contact needed to be able to provide information as an authorised representative of the organisation for whom they worked, being responsible for either policy or enforcement. The CIA did not reply as an organisation itself, but arranged for two member organisations to make responses directly as operators. For a local authority viewpoint, the Chartered Institute of Environmental Health (CIEH) was approached. The CIEH contacted all its members, inviting participation from EHOs with experience of the issue of controlled burn. As a result, EHOs from two local authorities contributed to this stage of the study.

Consistency of effort in chasing-up interviewees for information was considered important. It was expected that the extent of co-operation from those approached would be good, but it was necessary to avoid the possibility of spending 80% of the effort chasing 20% of interviewees.

A guideline was needed, both to ensure the time remained on budget and also to avoid different amounts of persistence from different members of the team unduly weighting the returns. It was agreed that after personal contact had been made with the right person in the organisation and a request made for a meeting, interview or information, they would be chased-up one further time for information if they did not respond. In the event the majority of respondents needed to be chased-up more times that this in order to obtain sufficient data. Some parties (SEPA, HDNI and UK PIA) did not respond even after persistent chasing and therefore could not be included in the study.

4.3 Findings: The Main Concerns, Views and Attitudes

This section lists the main concerns, views and attitudes of interested parties. A more detailed and comprehensive description is given in the sections following.

- The Environment Agency's main concerns were prevention and minimisation of environmental pollution using BPEO in fires, protection of water supplies, public safety, long-term impacts, and the need for careful management and liaison with affected parties.
- The main concerns of local authority Environmental Health Officers were that the decision is technically correct, is made by the correct person, and is transparent.
- Site operators` main concerns were the protection of life, emissions to air and water, and cost.
- The HSE considered that controlled burn is a difficult principle and could rebound badly the first time someone dies. Is the Agency being realistic? There is never a situation where plans work ideally. People panic, and the HSE believed firefighters themselves have little expertise in controlled-burn philosophy. The statutory obligation of the fire service is to save life, not property.
- The HSE was not aware of any incidents at all where controlled burn had been applied for environmental reasons, only safety. In fact, the HSE stated it had refused to sign up to Environment Agency pollution run-off guidance and advised inspectors to disregard it because HSE feared possible risks to public safety.
- The Environment Agency believed the issue of controlled burn is one of significant importance, illustrated by the number of recorded pollution incidents following fires.
- However, the Agency felt that it had not been very pro-active on the issue and further guidance and training should be produced. Guidance needs to be something that all interested parties can sign-up to.
- Site operators did not think there was sufficient guidance on fires at sites storing substances hazardous to the environment. The guidance that does exist is poor for larger sites, and too onerous for small sites.
- Local authority EHOs would like to see spin-off guidance from PPG18 offering strong guidance on the balance of financial impact versus environmental impact, some desk-top and case studies involving EHOs and guidance on all agencies working together at incidents.
- The LPC stressed the need in guidance for there to be a balance between risk to the environment and the financial impact, pointing out that the site owner and insurance company require some idea of the costs involved.
- The Environment Agency did not consider existing guidance on fires adequately balances the risks to water, air and land, and this is one of the drivers for this project. Some site operators agreed, and furthermore they did not believe that the right balance with property or finance has been achieved.

- A significant concern for the Environment Agency was pollution of the aquatic environment and groundwater from firewater runoff. There was some opinion within the Agency that insufficient attention had been paid to the threat to groundwater as a result of fires, though matters are said to be improving and groundwater maps have been passed to fire brigades. BASIS thought that adequate attention was being paid to groundwater but site operators were split on this issue. The LPC agreed that the threat to surface waters is a problem.
- Though the Environment Agency recognised that immediate risk to life and limb and public health must take precedence, contamination of public water supplies has its own public health impacts.
- Long-term environmental effects were of particular concern to local authorities because they are left with the legacy of the fire; local authorities had concerns about the practical problems, resource problems and financial implications of post-incident site clean-up. The LPC was also concerned about local impacts of pollution, e.g. schools, asthma.
- Local authority EHOs were of the opinion that the Environment Agency needs to consider impacts other than those to water more seriously, and needs to listen more closely to other experts outside the Agency.
- The Environment Agency would like site owners, operators and insurers to pre-plan for accidental fires and their consequences, and take action to install pollution-prevention measures. In the Agency's opinion, too many decisions are made "on the hoof" during an incident. Pre-planning would also ensure all parties have the opportunity to be consulted, and would reduce the potential for wrong decisions if an Environment Protection Officer (EPO) could not attend the incident.
- BASIS, the LPC and the Environment Agency representatives contacted felt they had adequate involvement in controlled-burn issues. The latter consider that the Agency is as a whole addressing the issue. Local authority EHOs considered their present level of involvement on the issue was largely adequate.
- Site operators wanted to be involved in the decision-making process. Not all operators felt their present level of involvement was adequate.
- The HSE thought it essential that views on controlled-burn policy and guidance were sought from the Police, the Emergency Planning Society and the Society of Industrial Emergency Services Officers. Also perhaps the National Farmers Union.
- The Protocol states that it and its concepts should be brought to the attention of all relevant Fire Service and Environment Agency staff by training programmes. CACFOA pointed out that controlled burn is a relatively new practice in the Fire Service. Those officers attending the Hazardous Substances Course at the Fire Service College receive an appreciation of the tactic. The course is only available to senior officers and it is junior offices that can be left vulnerable, as it is not an exact science and will depend on the availability of professional guidance where a pre-determined plan has not been devised. Brigades are encouraged to ensure that local crews are aware of the damage to the natural environment which may occur as a result of firefighting runoff water, airborne pollution, etc. Fire Officers themselves believed that levels of awareness of the controlled burn issue vary (some fire brigades have specialist Hazardous-Materials Officers to deal with this), but generally the level of awareness was considered acceptable and is improving all the time. Further training was seen as being necessary to raise awareness in the future in response to additional pressures and litigation possibilities that come with controlled burn. CACFOA felt this was a resourcing issue for each brigade to consider.
- The LPC was aware of the Protocol but had not seen PPG18. Only one of the two site operators was aware of PPG18. Local authority Environmental Health Officers felt there was some way to go in promoting the existence of PPG18 and the Protocol. EHOs agreed

with the generic approach of PPG18 and considered its main job was to make people aware of the issues so the decision could be made quickly. The principles of draft PPG18 fit in well with the local authority's role.
- BASIS meets with the Environment Agency three times per year. The degree of contact between the Agency and the emergency services on the issue of controlled burn is not consistent. Contacts are very regular in some regions, but much less so in others. It was suggested that there should be more pooling of information between the Agency regions and fire brigades. Dialogue between local authorities and other relevant agencies on controlled burn is variable: they have emergency exercises, but active dialogue could be improved. The LPC has regular contact with the emergency services at a policy level, not on individual cases. Liaison and dialogue between local authorities and the Environment Agency is generally good at an officer-to-officer level and at specific incidents. However EHOs felt that communications (in both directions) at management level needed improving. Dealing with the Agency was said to feel like dealing with three separate organisations for water, land and air. This does not help during fire incidents were an integrated view needs to be taken.
- Local authority EHOs believed the Environment Agency needs to be more locally accountable if the controlled burn tactic is to receive public support.

4.4 Findings: Current Approaches to Controlled Burn

4.4.1 Definitions and understandings

Precise definitions and understandings of controlled burn varied between and within the organisations that were consulted. However, there were many areas of common agreement. The Environment Agency regions all agreed that controlled burn is a decision to minimise environmental pollution by allowing the fire to burn in a controlled manner. This pollution can impact on all environmental media, though some regions emphasised the impact of firewater runoff on water quality. The Loss Prevention Council's definition of controlled burn was simply a fire that is managed, and it preferred the term contained burn to describe the tactic of preventing the escalation and spread of the fire. The Fire Services and CACFOA stressed some of the operational aspects of controlled burn, defining it as:
- a tactical fire-fighting decision made and carried out under supervision of a competent person; and
- a whole or partial allowance for a fire to burn itself out in a controlled manner within defined boundaries, taken because the alternative of extinguishing the fire would pose worse risks to property, health and the environment.

4.4.2 Policies on controlled burn

The Environment Agency currently has no formal policy specifically on controlled burn, though the Protocol does refer to the tactic. Attitudes within the Agency varied on the issue. The Environment Agency saw its involvement in the issue of controlled burn as one of pollution control, i.e. minimising the impact of the incident on the environment (including public water supplies). This would include:
- attending incidents, usually with the emergency services;
- consulting and liasing with the Fire Service Officer in Charge (OiC) on environmental issues at an incident;
- providing advice for the assessment of environmental impacts of alternative tactics; and

- involvement with site owners and emergency services in emergency and contingency planning discussions.

The fire brigades did not all have formal policies in place for controlled burn. Some brigades reported they treat every single case on its merits, whilst others have defined types of fire incidents where they would be minded to consider a controlled-burn tactic. The Loss Prevention Council (LPC) did have a policy on controlled burn. Local authority EHOs did not operate under any official policy on the issue: they regarded controlled burn as an operational decision based on individual circumstances, and feared that a formal policy could be too rigid. EHOs did consider pollution from fires to be an important issue and had put considerable thought and effort into the problem.

4.4.3 Tactical responsibility

There was unanimous agreement between the Environment Agency, Fire Service, BASIS, HSE and local authority EHOs that the Fire Service OiC - the incident commander - should make the final decision on whether the tactic of controlled burn is used or not. The one different view came from the Loss Prevention Council, which floated the idea that perhaps the loss adjuster should have the final decision, as he would know the value of the items and building costs. All parties agreed, however, that the final decision should be informed by expert advice. Consideration of advice from the Environment Agency to the Fire Service is formalised in the Protocol. The Fire Services and local authorities also felt that the local EHO should contribute advice to the OiC and liase with other emergency services. The Fire Service has procedures in place (described in the Protocol) to ensure the Agency and local authority are informed if it is believed there would be potential for environmental damage. Such procedures were said to be encouraged by CACFOA. At present, there does not appear to be a common approach to the review of policies and procedures across the Fire Services: some reviewed them annually; others infrequently. Those fire brigades with policies and procedures in place generally had positive experiences of working to them. The Environment Agency regions, EHOs, BASIS and the LPC also agreed that the present approach – experts providing advice to the Fire Service OiC – has generally worked well. Site operators thought the present system worked well (though it had not been tested in their organisations) and that generally advice from operators is usually well received. The Environment Agency pointed out that Agency EPOs were not present at some incidents. Some doubt was expressed as to whether a broader, tripartite discussion between the Fire Service, Environment Agency and local authority EHO had been tested at a proper incident. The Agency felt that because the Protocol was not definitive about when the Fire Service should contact them, there are probably other incidents that should be notified to the Agency and some regions expressed the view that the Agency should always be contacted whenever a controlled-burn option is being considered.

4.4.4 Communication of decisions

The Environment Agency's view is that the decision to use a controlled burn tactic should be communicated to all the relevant interested parties involved: the Environment Agency, Fire Service, BASIS, the local authority and (depending on the severity of the incident) health agencies. The Agency presently relies on local authorities to give public-health advice during incidents. Local authority EHOs agree that the decision should be passed on to all agencies present at the incident (for a Bronze/Silver-Level incident) so that they can then all deal with it according to their roles. EHOs highlight the role of incident briefings to the media: these are usually joint press meetings involving the local authority, Environment Agency and Fire Service. The LPC believes that the final decision should also be communicated to the insurance companies. The LPC itself does not expect to be informed during an incident: the loss adjuster will inform them after the event.

The Environment Agency was firm that potential threats to water, land and air must be (and indeed are) part of the decision-making process. The Agency strongly believes that its EPOs should be the experts providing advice for decisions with a potential impact on controlled waters, but there was some feeling that the degree to which the EPO could assess impacts to other media would depend on his or her personal experience (EPOs are not specifically trained on air pollution impacts). There does not appear to be any conflict with the local authority view here: EHOs tend to defer to the Environment Agency on water-quality issues and are content to continue doing so. Environmental considerations now form part of the LPC`s decision-making process, the issues of spillage and the fire itself being given equal weighting.

4.4.5 Appropriate circumstances for controlled burn

All parties that responded agree that preventing immediate risk to life and limb is of paramount importance and overrides environmental implications. The Environment Agency and the Fire Service have formalised this approach in the Protocol. If there is no immediate threat to life and limb, the decision on whether to apply controlled burn will need to be assessed individually for each situation, taking into account the health impacts, the environmental impacts and the financial implications of each option. The Agency’s view was that controlled burn would be a particularly inappropriate option when:

- life is at immediate risk;.
- property is at risk (where other remedial action is in place);
- there is a risk of the fire spreading extensively; or
- important buildings are involved.

The Environment Agency viewed controlled burn as an appropriate option when:

- life is not at risk;
- drainage from the site leads to an environmentally sensitive area;
- chemicals harmful to the environment (e.g. List I and II) would run to controlled waters;
- firewater runoff would impact on a potable supply intake and other abstractions; or
- firewater runoff could knock out a STW.

It was also noted that an additional benefit of controlled burn was reduced risk to fire fighters.

BASIS-registered stores are (generally large) chemical warehouses. There are smaller pesticides stores on agricultural sites for farmers` own needs, and for these BASIS took the view that controlled burn is appropriate when there is no risk to life and no risk to property other than the pesticide store itself. BASIS added the proviso that the fire must be burning at sufficiently high temperature to completely incinerate chemical residues. The HSE noted that in some cases the properties of the material/substance would be such that the option (extinguish or let burn) would be clear. In many cases the HSE believes that the important issue will be not whether or not to fight the fire, but rather whether to fight it with water or foam. A road tanker can be doused with foam very easily.

CACFOA believed that the circumstances surrounding each individual case need to be considered. In general terms, the factors that need to be taken into account should cover life risks, the natural environment, the consent of the property owner and the weight of loss against environmental damage, climatic conditions and adjacent risks.

The fire brigades` overall approach is to use controlled burn when it is the best option, taking into account all other operational tactics, extinguishing efforts and the dynamic risk assessment undertaken at the fireground. Safety of personnel is the overriding factor. The decision would be made after consultation with the Environment Agency, and location, surrounding risks, occupancy, weather, process, community value and costs would be considered. The fire brigades considered controlled burn would be particularly inappropriate when:

- the fire must be extinguished to save lives;
- the risks to fire-fighters are low;
- the spread of the fire is likely, leading to loss of property or increase in the environmental impact by spreading to more hazardous materials and processes;
- there is a high success forecast for extinguishing the fire; or
- where the products produced from the burning material (e.g. atmospheric fall-out) would damage the environment more than the extinguishing medium.

The fire brigades considered controlled burn to be particularly appropriate in situations when:

- human life is at risk from fire-fighting options involving extinguishing the fire;
- there is no immediate risk to life and limb from letting burn;
- there is a low success forecast of extinguishing the fire;
- weather conditions are appropriate (wind strength and direction taking the plume away from population centres);
- the risk of environmental damage from the fire being left to burn is lower than the risk of environmental damage from the fire-fighting action;
- the fire involves a hazardous substance where the continued application of extinguishing medium would cause greater environmental damage and risk to human life, e.g. pollution of drainage systems, watercourses, groundwater aquifers, drinking water supplies; or
- the incident involves asbestos.

Not surprisingly, EHOs also viewed risk to life and health as the overriding factor in the decision-making process, but emphasised that this should include the general public as well as operational staff at the incident. The hierarchy should be risk to life, then health, then environmental damage, and then economic factors. Local authorities were concerned particularly about long-term environmental damage, as they are usually left to deal with this once the Environment Agency and Fire Service have departed.

4.4.6 Financial impacts

Although the Environment Agency's policy is to include cost-benefit assessment in all its activities, the responses from regions did not suggest the financial impacts (on operators, insurers, fire brigades, the Agency, etc.) are being considered in individual fire incidents. BASIS thought that risks to the environment should take precedence over financial impacts. Some fire brigades saw the financial impact as an important factor in deciding on controlled-burn tactics, others did not. Where costs to the Fire Service did form part of the decision-making process they were considered relative to the expected outcomes: very high costs are hard to justify to prevent minor pollution. However, inaction or inappropriate action may of course result in litigation with its own associated high costs. What was considered most important was whether or not the decision was appropriate and could be justified given the prevailing circumstances. Site operators thought that the financial impacts were minor factors in the decision-making process, and the financial impact on the fire brigade should not be an issue. According to EHOs, local authorities don't try to quantify risks to health financially, they just concentrate on getting the job done well. They might however try to recover costs later through, for example, insurers. The LPC was of the opinion that the Fire Service would be able to recover its costs.

4.5 The scale of the Problem of Pollution from Fires in the UK

4.5.1 Sector analysis of fires

It is important to examine the scale of the problem of environmental damage from fires, and the perceptions that certain industrial sectors contribute to the problem disproportionately. What are the implications in terms of environmental costs (to the Agency and in clean up costs) and in terms of material/business costs to the stakeholders affected by the fire? One insurer (not LPC) was concerned about the balance between costs and benefits: in particular whether the costs of preventive measures to industry as a whole would be greater than the cost of the losses if things occasionally go wrong in some industry sectors. This section investigates the order of magnitude of the problem, e.g. is it £1m, £10m or £100m per year? The nature of any policy or guidance that emerges should reflect the scale of the problem. Table 4.1 summarises the numbers of fires and estimated losses, as published in the 1998/99 Fire Protection Yearbook. The losses cover direct damage and business interruption, though these form only part of the total costs of an incident (see Section 4.3.8 for more detail on financial impact of fires). Data for the year 1995 was examined in detail. The type of premises suffering fire and their loses are compared in Table 4.2. Other data were obtained from the insurance industry, summarised in Table 4.3, concentrate on major fire and explosion incidents and include details of fatalities as well as costs.

Table 4.1 Ten-year review of UK fires

Year	Total no of fires	Loss (£m)
1986	981	305
1987	920	316
1988	703	263
1989	739	282
1990	794	346
1991	814	334
1992	761	324
1993	537	201
1994	509	198
1995	514	250

Table 4.2 Seven occupancy categories suffering the largest losses for 1995

Occupancy category	No of fires	Loss (£m)
Food, drink and tobacco	13	30.2
Education (schools and colleges)	50	29.9
Recreation and cultural	37	25.1
Retail distribution	49	22.8
Transport and communication	22	17.9
Chemical and allied industries	8	11.5
Dwellings	69	7.8

Table 4.3 Summary of major fires and explosions in the UK between 1974 and 1998

Category	Total fatalities	Av. fatalities per year	Av. incidents per year	Total cost (£m)	Av. cost per year (£m)	Av. cost per incident (£m)
All types	322	13	1.75	2630	110	61
Industrial only	201	8	0.92	1705	71	77
In buildings	91	4	0.49	446	19	41
In warehouses	0	0	0.29	374	16	53

Just over half of all major fire and explosion incidents occurred in the industrial sector (excluding warehouse storage). Warehouses accounted for about 17% of incidents. 65% of average total annual losses were accounted for by industry, and 15% by warehouse storage. However, when a fire or explosion incident did occur at a warehouse, the average loss tended to be quite high.

In Table 4.4, the Fire Protection Yearbook statistics for 1995 are examined by industrial sector. Three-quarters of the losses came from just two industrial sectors - food, drink and tobacco, and chemical and allied industries.

Table 4.4 Industrial sector losses during 1995

Industrial sector	No of fires	Loss (£m)
Food, drink and tobacco	13	30.2
Chemical and allied industries	8	11.5
Agricultural, forestry and fishing	26	7.3
Engineering	14	5.7
Metal manufacturing	5	1.6
Mining and quarrying	0	0
Coal and petroleum products	0	0

4.5.2 Pollution from fires

Having summarised the scale of fires and explosions in the UK, it is helpful to examine available data on pollution incidents and then pollution incidents resulting from fires. In 1997 there were 30 699 reports of water pollution, of which 19 571 were substantiated upon investigation[99]. These numbers fell to 28 670 and 17 863 in 1998. The number of the most harmful (Category 1 - Major) incidents had risen from 156 in 1996, to 194 in 1997 and then fell to 128 in 1998. In just one Agency region (Southern) in 1999, there were 143 Category 1 and 2 incidents. More than half of these came from unregulated sites, processes and activities, illustrating the impact of SMEs.

Recorded incidents (water pollution) involving fire in the Agency's Thames Region in 1998 were: Category 1 = 0; Category 2 = 4; Category 3 = 60; and Category 4 = 164. The Environment Agency estimates that the Fire Service currently reports about 10% of all fire incidents to them and these go onto the Pollution Incident Database.

The Environment Agency does not categorise separately the number of pollution incidents caused as a result of fire, and the Pollution Incident Database covers only water pollution (although in the memo field there is a code for pollution type, e.g. firewater). A greater level of detail is contained in an EPO`s notebook. There will shortly be a National Incident Reporting System (NIRS) covering a wider range of pollution, i.e. not just water. However, the Agency estimates[100] that about 10-15 incidents out of approximately 200 Category 1 water pollution incidents per year were due to fires. The Fire Brigade responses provided no clear picture of the number or proportion of fires that involve materials hazardous to the environment, citing one of the reasons as the many ways of defining the latter. However, the few estimates given range from ≤20% of fires in one region, to *"...probably more than we think"* in another region. Local authorities do not keep separate records of pollution incidents due to fires. One local authority, Milton Keynes, estimates it has four to five incidents per year where chemicals are involved. Further data on the prevalence of sites storing substances hazardous to the environment can be obtained from applications to local authorities for hazardous substances consents[101] for 1998/99. Of 379 hazardous substances consent decisions, 218 (55%) were for "flammable substances", 111 (28%) related to "toxic substances" and 67 (17%) were for "highly reactive and explosive substances".

4.5.3 Prevalence of controlled burn tactics

According to the Environment Agency, the application of controlled burn tactics at fires involving hazardous substances is infrequent at the moment, although it is growing. Barn fires are the most common application. Both the Agency and the LPC believed the use of the controlled-burn tactic varies from brigade to brigade, and in some instances from division to division.

In summary, there are on average 1.75 major fire or explosion incidents per year, of which 1.21 per year are in the industrial and warehousing sectors. For 1995, there were a total of 514 fires of all types and 66 fires at industrial sites. About 20 fires per year lead to serious environmental pollution incidents.

4.6 The Role of Emergency Plans used in Controlled Burn

4.6.1 Is planning needed?

Both the Environment Agency and BASIS agreed that controlled burn should be included in general fire safety planning. Most (but not all) fire brigades agreed with this. Some fire brigades highlighted the importance of considering the controlled burn option at an early stage (when producing the emergency plan or revising the risk inspection). Other brigades felt it was more probable that the controlled-burn option would be considered during the early stages of an incident as part of the risk assessment. For high-risk sites, CACFOA encourages a pre-determined plan approach that includes controlled burn. The Environment Agency and EHOs would like to see emergency plans covering controlled burn drawn up at as early a stage as possible: for new sites during development; and at existing sites if a screening risk assessment indicated possible problems. The Agency hopes the Protocol will drive this. On the issue of screening, EHOs pointed out that it would be impractical to require all sites to have emergency plans, and the logistics of holding all the plans would make this impossible for the Fire Service and local authority.

The HSE and LPC were of the opinion that the BPEO decision should not be left until the incident: it should be part of the risk assessment and emergency plan. The HSE felt that otherwise, there is the danger of arguing for hours at the incident about whether or not to put out the fire. Operators were also in favour of a pre-planned response for fire: at the design stage, or authorisation (e.g. IPPC) stage where applicable. The LPC believed that if the site has to write an emergency plan, then controlled-burn consideration should be included as part of it.

There was a recognition within the Environment Agency that the controlled-burn decision should be informed by the pre-planning, but in reality (particularly at small sites) the response would be incident-specific and the final decision would need to be made on the fireground. Operators shared this view. The local authority view was similar: plans should be drawn up before the incident, but there must be guidance available that is robust enough to allow decisions to be made during an incident if circumstances change.

Does the size of the fire matter? The Environment Agency's view was that the threshold for consideration of controlled burn shouldn't really be the size of fire (number of pumps, etc.) but the quantity and type of substance involved. Again, it was emphasised that the decision on whether controlled burn needs consideration should be established at the emergency plan stage. The fire brigades agreed: for anything other than a very small fire, a risk assessment should be used to show whether controlled burn needs to be considered. The LPC`s view was that if a fire is small, it should be extinguished: it should not be left to grow to become a controlled burn.

4.6.2 Work completed so far on plans

The Protocol states that the Environment Agency and Fire Service will jointly ensure contingency plans for fire-fighting at high-risk sites, including provision to minimise contamination of controlled waters. Development of joint Environment Agency-Fire Service contingency plans has so far been achieved on a limited scale only: all BASIS sites and some large chemical sites covered by COMAH (e.g. ICI and Shell in North Wales) have established emergency plans covering fires. Operators pointed to a limited number of large warehouses and storage tanks having such plans. Local authority EHOs knew of no sites having emergency plans other than COMAH sites. Operators have consulted the Environment Agency very infrequently for help in the development of such plans. There is still much work to be done between the Agency and individual fire brigades on promoting emergency plans, and the responses indicated that there are some efforts from within the Agency to progress this.

The HSE pointed out that for COMAH sites (400-500 top-tier sites) the emergency plan involves statutory consultation with amongst others the fire brigade, police and the joint competent authority (HSE and Environment Agency/SEPA). The HSE was not convinced that controlled burn could be covered in the emergency plan, but if it was "do-able" then it would have to be tackled at that stage. The HSE also mentioned that it might be appropriate to include the fire plan in the COMAH Safety Report.

4.6.3 Involvement in production of the plan

The Environment Agency believed that it should be involved in producing the emergency plan, together with the Fire Service, BASIS (where relevant), the operator/site owner, the insurer, probably the local authority and (where runoff could impact on a STW) the water company. However, the Agency would want to restrict its own involvement to commenting on plans produced by the operator/site owner. The LPC also thought the operator should be responsible for making the emergency plan, but there should be some involvement from the insurers. CACFOA favoured inputs from the Fire Service, Environment Agency, local authority and the site operator/owner. Operators` opinions were along the same lines: they would want to be involved in drawing up the emergency fire plan, with assistance from the Agency, the Fire Service and where appropriate the local authority EHO and Emergency Planning Officer. The HSE, in its role as part of the Joint Competent Body for emergency plans and safety reports under COMAH, demands the inclusion of certain things, but doesn't second-guess the plan detail and doesn't criticise it. The HSE views the Fire Service as the lead experts in this.

4.6.4 Communication of the plan

The Environment Agency and Operators favoured the emergency fire plan being communicated to all the relevant interested parties involved. The Agency defined the latter as itself, the Fire Service, BASIS and the local authority, and believed the public should be shown the emergency plan only where the law requires it. The local authority pointed out the role of their Emergency Planning Officer, and also suggested the HSE be informed of the plan.

4.7 Views on Sites to be Covered by Controlled-Burn Policy and Guidance

4.7.1 Identifying at-risk sites

The HSE expected the types of premises that could be allowed to burn to the ground to be far and few between, especially if one couldn't be absolutely sure of what was inside. The Environment Agency thought it important that all high-risk sites are covered by future controlled-burn guidance. The Agency believed that a risk-based approach (similar to OPRA) rather than a prescriptive list should be used to identify these sites. Operators, CACFOA and local authority EHOs agreed with the risk-based approach, though EHOs made this conditional upon sufficient clear guidance being provided. The HSE recommended that no site should be excluded from a risk-assessment-based approach: risk assessment might be something that all industry sectors need to think about. However, the HSE qualified this by saying that there needs to be a real net benefit for one option over the other for it to be worthwhile doing the assessment. The HSE also believed that industry would complain loudly if the principle was transferred down to smaller sites. One insurer (not LPC) was concerned about emergency plans being required for all sites and the need for a balance between costs and benefits.

The views of the fire brigades varied: some favoured the risk-assessment approach of the Agency to select sites; at the other extreme was the view that all commercial or special sites should be included. A less wide-ranging criterion (and one to which CACFOA also subscribed) was to include all sites storing environmentally hazardous materials that do not have adequate run-off containment*. The HSE was pessimistic that the Agency could hope to identify all (or necessarily the nastiest) of the sites for controlled burn, partly because the threshold levels for notification do not always take into account environmental damage (e.g. milk).

4.7.2 Progress so far

The revised PPG18 offers guidance on identifying sites and the Protocol mentions that individual fire brigades should draw-up with the Environment Agency a list of at-risk sites (including Part A processes) and emergency plans. This process does not yet appear to have been established in an organised way. Some Agency regions reported they were drawing-up with the Fire Service a list of at-risk sites, but in other regions it was less formalised. Responses from the Agency indicated that sites are identified for controlled burn consideration mainly by the Agency officer's instinct or professional judgement, although some risk assessment tools (e.g. OPRA) have been used. Local authority EHOs also felt that high-risk sites were not presently being identified for controlled burn consideration in any consistent way. Respondents believed that this area of the guidance and Protocol requires further development.

4.7.3 Sites of particular concern

Most Environment Agency regions believed that future controlled-burn guidance should be broad enough to cover the range of potential incidents within the remit of the Agency, i.e. water-pollution incidents from any source, air pollution from IPC/IPPC processes, and regulated waste movement and disposal and special contaminated sites. There were some types of site of particular concern to the Agency and BASIS. These included:

- timber-treatment plants;
- tyre dumps;
- metal finishers;
- plastics manufacturing and recycling;
- petrochemicals refineries;
- chemicals warehouses;
- agrochemical stores;
- pesticides stores;
- farm buildings;
- DIY superstores and garden centres holding significant quantities of chemicals; and
- sites storing substances not hazardous to human health, but which can have a serious impact if spilled into surface waters, e.g. milk, orange juice, beer, sugar, mollases.

The timber-treatment industry already has a good code of practice that covers controlled burn (albeit more detail may be required). BASIS and the metal-finishing industry also have codes of practice. Operators pointed out that some individual companies have established their own procedures. The risk-assessment approach should pick up sites that are not on this list but could nevertheless cause serious pollution, e.g. sites storing pet food. The fire brigades listed

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* The Environment Agency takes the presence and capacity of liquid-spillage containment systems and other control systems (e.g. sprinklers) into account in deciding on controlled burn. However, it was thought that in practice there have probably been few incidents where the Fire Service knows whether containment systems exist before they arrive at the incident. The availability of this information is now improving though.

many of the above sites as giving them particular concern, as well as COMAH sites and chemical works. Operators thought warehouses (especially those storing agrochemical, pharmaceutical and veterinary products), tank farms, fuels and petrochemical sites should be covered by any guidance. The HSE believed farms would be a good sector to concentrate on. The LPC viewed the introduction of COMAH as a major step forward as this will achieve emergency pre-planning for a wider range of sites than was previously the case. The LPC would also like IPPC sites, contract warehouses and DIY superstores to have such emergency plans, together with sites on the "11D Form" from the fire brigade. The LPC advised that the Association of British Insurers (ABI) was currently working on a form to be completed by the assured. The form is to be confidential between the assured and the insurance company and will ask pertinent questions regarding pre-planning for emergencies.

Most Environment Agency regions thought that sites covered under specific regulations of the HSAW Act should be given special attention: for example the COMAH Regulations (both the rigidly controlled top-tier sites and also the lower-tier sites); and the Planning (Hazardous Substances) Act 1992 which covers the storage of certain hazardous substances above a "controlled quantity". Local authority EHOs pointed out that though some of these sites may pose a serious safety risk, they are not necessarily an environmental risk (and vice versa) and so cannot be considered en-masse to require an emergency plan for controlled burn. Local authorities would be concerned about any wide-ranging classification of sites (e.g. all B1-use sites), because the numbers could be unmanageable. Their view was that any policy or guidance should stand alone and not be tied only to IPPC sites, COMAH sites, etc., although it may well need to include many of them. EHOs shared the concerns about many of the types of site mentioned by the Environment Agency and fire brigades and had additional concerns about the petroleum industry. However, they did not regard the problem as industry-specific and (in common with operators and the LPC) favoured risk-derived criteria based on:

- the type of substance stored on site (environmentally hazardous in its own right, or in a fire, e.g. tyres);
- the quantity of substance; and
- location-specific issues (e.g. site sensitivity, distance to receptors).

4.7.4 Substances of particular concern

The LPC would like all substances to be included, but there was strong support from the Environment Agency for a screening checklist for assessing the environmental sensitivity of an individual site. This would reduce the number of sites requiring a full risk assessment. Operators were divided on the benefit of a screening checklist. The HSE appeared to support a screening approach, noting that for the COMAH regulations they took the view that if an ecotoxic chemical could not get through the route (e.g. watercourse) or to the target (e.g. seals) then this would not be a high risk. Hence proximity is an important factor.

Substances of particular concern to the Environment Agency included List I and List II substances, pesticides and pollutants toxic to marine life. (annexes to PPG18 and the Protocol contain lists of substances of concern.)

Though desirable for practical reasons, the Environment Agency recognised the difficulty of setting size/quantity thresholds for sites/substances to be covered by controlled-burn policy and guidance. In reality the risk depends on the sensitivity of the receptor: for example, whether it is a small, sensitive watercourse, or a large, less-sensitive watercourse. The revised PPG18 offers guidance on threshold quantities for reporting spillages of different substances. Though these cannot be considered entirely relevant, sufficient or appropriate for controlled burn specifically, the Agency considered it acceptable as an initial guide provided the vulnerability of the individual site was always borne in mind. The LPC had not seen PPG18 and pointed to the CEA Classification of Materials and Goods document and the Joint Working Group Report for relevant size/quantity thresholds.

4.7.5 Mobile pollution sources

There was strong feeling within the Environment Agency (especially in its National Emergency Management Group) and support from local authorities and the LPC, for controlled-burn policy and guidance to cover mobile potential pollution sources, e.g. road tankers. Sections of the M25 motorway having high-risk receptor areas are currently being identified in a project between the Agency and DETR/Highways Agency. A database of control measures on highways will also be worked on. The Agency did, however, recognise the practical problems. Firstly, there may be a conflict with the interests of the Police over traffic management. Secondly, how would emergency-plan information be passed to the Environment Agency and Fire Service involved in the event of a fire incident with a mobile source? EHOs have suggested extending the use of the HazChem symbol system and establish a new symbol for environmentally hazardous goods. This suggestion finds support with the LPC.

4.8 Views on the Legal Aspects of Controlled Burn

4.8.1 The Environment Agency and BASIS

The Environment Agency has responsibilities (including enforcement of legislation) in the area of environmental protection, water resources, flood defences, fisheries, conservation, navigation and recreation. It acts under the following statutes:

- the Environmental Protection Act 1990;
- the Water Resources Act 1991; and
- the Environment Act 1995.

With regard to pollution caused by fires, the Water Resources Act 1991 and the Environmental Protection Act 1990 are the main pieces of legislation, supported by guidance note PPG18 and the Protocol with the Fire Service. BASIS operates in an advisory capacity only, under an approved code of practice: the Yellow Code. Where a fire poses a risk to the environment, the Environment Agency would expect the company to take appropriate control measures and follow applicable legislation and guidance. Under the Water Resources Act 1991, it is an offence to cause pollution, and the Agency would expect the owner to provide relevant information on substances, quantities, etc. For accidental fires involving hazardous substances, enforcement is not generally an outcome (in fact no examples of prosecutions called could be recalled). Rather, the Agency has to date taken the opportunity for gathering information (e.g. monitoring) and learning lessons. Two relatively recent pieces if legislation: the Anti-Pollution Works Regulations 1996 and the Groundwater Regulations 1998; give the Agency powers to issue notices to bring about works to prevent pollution.

4.8.2 Local authorities

A similar picture emerged from local authorities: although technically the site operator could be committing an offence under the Clean Air Act 1993 by emission of dark smoke*, they have not prosecuted to date if the fire was accidental. The local authority also has the power under Sections 79-85 of EPA 90, to take action in respect of statutory nuisances, including premises that are in such a state as to be prejudicial to health. In fact no details were available of any prosecutions for fires carried out under these acts or the other act relevant to EHOs – the HSAW Act. Other regulatory responsibilities of local authorities include their roles as the relevant enforcing authorities in some situations, such as Petroleum Licensing Regulations. Local authorities respond to spillages of petroleum and are involved with COMAH sites, where they are responsible for liasing with council services, e.g. to trigger the emergency plan and evacuation.

4.8.3 Health and Safety Executive

The HSE operates under the HSAW Act 1974. Under Section 25 of the Act, the HSE has powers to seize and render harmless any article or substance on land which they have the power to enter which is a cause to imminent danger of serious personal injury. In the past, the HSE has closed-down at least one site after a fire using a Safety Order on the basis of the risk posed by the dioxins they found. Of particular relevance to controlled burn now, is that the HSE - together with the Environment Agency and SEPA – forms the joint competent body for implementation of COMAH.

4.8.4 Fire Service

Before the introduction of any controlled-burn policy and guidance, there must be a careful review of the legal implications, especially on whether it would introduce any conflicts between different acts and regulations. The Fire Services Act 1947 places a duty on every fire authority to ensure that reasonable steps are taken to prevent or mitigate damage to property resulting from measures taken in dealing with fire. Care must be taken to ensure any controlled burn policy is not in conflict with this duty. Another interpretation of the Act that we encountered, was that it simply requires the provision of water to be available to fight fires rather than explicitly requiring fires to be put out. The Act also means that at any fire, the senior fire brigade officer has sole charge and control of all operations for the extinction of the fire, including the fixing of the positions of fire engines and apparatus, the attaching of hoses to any water pipes or the use of any water supply, and where the water will be directed. To avoid a conflict with this Act, any controlled burn guidance would have to recognise the primacy of the senior fire brigade officer in operational matters. The Act does not take into consideration effects on the natural environment.

4.8.5 Legal conflicts and application of guidance

The Agency's view was that a conflict already exists because the Fire Service has a duty to protect property under Fire Services Act 1947, but this is not a defence under the Water Resources Act 1991 or the Environmental Protection Act 1990 (though protection of life and health is). The Agency's opinion was that this has a potentially serious implication for any

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* Under the Clean Air Act 1993 it is an offence to cause or permit the emission of dark smoke from industrial or trade premises (as distinct from chimneys), subject to certain exemptions. The only relevant exemption for this study is "*Matter which is burnt in connection with: a) research into the cause or control of fire, or b) training in fire fighting.*

controlled-burn policy and guidance. There could also be possible implications, conflicts or applications under the Groundwater Directive. The opinions of fire brigades varied on this point and are summarised as follows:

- Some took a similar view to the Environment Agency – that the conflict could not be resolved easily, as controlled burn was little thought about in 1947, and if the building was allowed to burn it is likely that the owner or insurer would take legal action against the fire authority.
- A different view expressed was that any conflict was purely a matter of perception, as the 1947 Act does not place a duty on the Fire Service to extinguish the fire. However CACFOA pointed out that the fire authority is likely to face litigation where its actions at an incident are judged to have made the incident worse (as in the Capital & Counties v Hampshire County Council case).
- Other fire brigades thought the 1947 Act was not compromised by a risk-assessed safe-system of work.
- Others thought that the primacy of the risk-assessment process versus the Fire Protection Act 1947 would only be established through case law.

The introduction of the COSHH Regulations set the precedent for risk-assessment (rather than prescriptive)-based procedures. This was followed by the Management of Health & Safety Regulations, which also used the principle of assessing risk to decide control measures. Fire brigades carry out a safety risk assessment at an incident before embarking on firefighting measures. From time to time, occasions arise where the risk to the fire crew is too great to put the fire out. In such cases, a decision to let the fire burn will have been made under the above regulations. This seems to have become accepted practice without any apparent conflict with Fire Services Act 1947.

The LPC noted that fire law is currently being reviewed, which presents opportunities for reconciliation with environmental issues. In 1999 the Health and Safety Commission (HSC) embarked on a major consultation and review of health and safety law after 25 years of the Health and Safety at Work Act. The Royal Society of Chemistry (RSC) in its submissions[102] drew attention to the potential conflicts between health and safety and environmental risks and suggested that they were likely to be an area of increasing concern. In the RSC`s view, better methodologies for integrated environment, health and safety assessment are needed.

In the Environment Agency’s opinion, controlled-burn policy and guidance might be enacted through the COMAH Regulations, IPC/IPPC and possibly the Works Notices provisions.

4.8.6 The opinion of environmental law specialists

The Environmental Law Group of law firm Trowers & Hamlins was requested to review the relationship between the Fire Services Act 1947 on the one hand, and the Water Resources Act 1991 and the Environmental Protection Act 1990 on the other. It should be noted that this opinion does not constitute legal advice since, pending a decision by a court, this is an issue where legal opinions may legitimately differ. Trowers & Hamlins recommend taking specific legal advice before taking actions.

The Fire Services Act 1947

Trowers & Hamlins was of the opinion that the 1947 Act does not impose an overriding duty on fire authorities to put out fires, or to protect property. Section 1 of the Act places a duty on fire authorities to make provision for "*fire-fighting purposes*" (meaning "*the extinction of fires and the protection of life and property in case of fire*"), and Section 13 places a duty on fire authorities to take all reasonable measures to provide an adequate supply of water in case of fire. Under Section 30 (3) the senior fire brigade officer present at the scene of a fire has sole charge of operations for the extinction of the fire. There are no further provisions in the Act as to how the fire authority is to carry out fire-fighting operations.

In the case of Capital Counties plc v Hampshire County Council (1997 QB 1004 at 1030A), the Court of Appeal held that the 1947 Act impliedly gives fire authorities the power to fight fires, but does not fix them with a duty to do so. The Capital Counties case suggests strongly that in the absence of a positive negligent act by fire personnel (such as negligently turning off a sprinkler system), there will be no liability on the part of the fire authority to persons suffering loss as a result of firefighting operations, or failure to carry out fire-fighting operations. In particular, it was held that Section13 of the 1947 Act does not establish a right of action where fire authorities fail to provide an adequate supply of water.

Strictly speaking, the judgment in the Capital Counties case concerns only the liability of fire authorities to third parties, rather than the proper interpretation of fire authorities' public law duties. Nevertheless, the Court of Appeal's judgement is persuasive when it comes to interpreting public law duties.

As noted in the preceding section of this report, risk assessments procedures based on safety of fire personnel exist alongside the 1947 Act, apparently without difficulty. It is suggested that a court would be unlikely to find that a properly reasoned decision not to carry out fire-fighting operations on the grounds that such operations would create an unacceptable health and safety or environmental risk, was either unreasonable in public law terms, or would create a right of action on the part of a person whose property was damaged as a result of such a decision.

Water Resources Act 1991

A fire authority which, in extinguishing a fire, caused contaminants to enter "*controlled waters*" (the term is wide enough to cover most waters) could in theory be liable of an offence under Section 85 (1) of the Act. Section 85 (1) establishes a strict liability offence, so an authority could be guilty of the offence even if it did not know that its actions would cause water pollution. This is a matter of criminal law (a person found guilty of the offence is liable to a fine or imprisonment) rather than public law duty.

It is a defence to a Section 85 offence if the entry of the matter into controlled waters comes about "*in an emergency in order to avoid danger to life or health*", provided the person takes all reasonable steps to minimise the extent of the water pollution, and the Environment Agency is informed of the water pollution (Section 89 (1) of the 1991 Act). Therefore, a fire authority would have a defence to a Section 85 charge where its fire-fighting operations caused water pollution, if the operations were directed at avoiding danger to "*life or health*" (so long as reasonable steps were taken to minimise water pollution). On the other hand, where fire-fighting operations directed only to the protection of property cause water pollution, the authority would not have a defence.

In addition, where a fire authority causes water pollution in the course of extinguishing a fire, and works are required to rectify the water pollution, the fire authority could be liable to carry out remediation under the powers in Section 161A of the 1991 Act (or in certain circumstances, to meet the cost of remediation works carried out by the Environment Agency under Section 161). This is a civil, regulatory liability (though failure to carry out the regulator's requirements is a criminal offence). The defences available to the Section 85 criminal offence would not be available for the Section161A liability. This means that the reason for the water pollution is, strictly speaking, irrelevant, as far as the clean-up provisions are concerned.

These liabilities under the 1991 Act will in practice only arise if the Environment Agency decides to prosecute or take regulatory action. On the basis of the Agency's published prosecution policy (which notes the importance of intent in deciding when to prosecute) it is unlikely that a prosecution would be launched against a fire authority which had caused water pollution in the course of reasonable fire-fighting operations. Indeed, fire authorities and the Agency work together closely to prevent pollution arising from fire-prevention operations.

Environmental Protection Act 1990

In addition to the liability for the clean up of water pollution, there is a theoretical liability under the new Part IIA of the 1990 Act for a fire authority which causes land to be "*contaminated land*" (this is a defined term under Part IIA) in extinguishing a fire. The fire authority could be liable to carry out remediation works so that the land is no longer in a contaminated state, or, in certain circumstances, to pay for remediation carried out by the regulatory authority (which in this context is either the Environment Agency or the local authority).

Summary of legal opinion

Trowers & Hamlins` opinion is that there is no overriding duty under the 1947 Act to extinguish fires, nor is there is an overriding duty to protect property. Therefore, a decision whether or not to carry out fire fighting operations would be governed by general principles of public law reasonableness (and by any applicable guidance). It is not hard to imagine circumstances where it would be reasonable for a fire officer to decide not to carry out fire-fighting operations because the consequences of carrying out the operations (whether these be environmental or some other consequences) would be worse than the destruction of property caused by failing to carry them out.

Under the 1990 and 1991 Acts, fire authorities may incur criminal or civil liability as a result of fire-fighting operations which cause the release of polluting materials into the environment. The issue here is not so much a conflict or inconsistency with the 1947 Act, but rather that legitimate fire-fighting operations are capable of creating criminal and regulatory liabilities under the 1990 and 1991 Acts. These liabilities would theoretically arise even where the consequences of failing to carry out the operations were severe, and the environmental consequences of carrying them out minor.

In practice, it is suggested that the environmental enforcing authorities are unlikely to pursue fire authorities in such a case. Indeed, to do so would probably be an unreasonable use of their discretion.

It is important that any guidance that is issued emphasises the position to the Fire Authorities. Firefighting officers are likely to need reassurance that they will not is prosecuted for committing an environmental offence or incur civil liability to the owner of the property.

4.9 Views on Public Involvement with Controlled Burn

4.9.1 Public involvement at the planning stage

The Environment Agency believed that public involvement at the emergency planning stage is a difficult area. Any requirements under legislation (e.g. COMAH) for public involvement would obviously need to be followed. Where this not the case, the Agency's view was that it should depend on the site circumstances. Although local liaison is desirable, some Agency regions believed the public should be involved only if the site is so close that it directly influences them. The Agency recognised that the involvement of any non-statutory participants might meet resistance from the site operators. Operators themselves were split between preferring zero public involvement and open dialogue. One option suggested by the Agency was that the local authority could represent the public interest at the emergency planning stage. This would meet some of the local authority EHOs` concerns that more direct public involvement in the planning stage could lead the process grinding to a halt through the actions of "NIMBYs". EHOs favoured involvement of the public by extending existing democratic channels used in IPC and COMAH (i.e. the system of advertising and notification) to emergency planning for fires at site storing environmentally hazardous substances. Town and parish councils should be provided with information and opportunities for consultation. The LPC would also like to see the local authority involved, suggesting the town and country planning process.

The HSE respondents took a number of views on public involvement or participation on emergency plans for fires, and on who should be consulted and involved in making such plans. One view was that the Environment Agency has existing routes of consultation and it is up to the Agency who they consult - they should have enough faith in their BPEO decision process to stand up in court and defend it. Having said that, the HSE would want to be consulted and pointed out that the Agency could not impose the approval/consultation route, because other enforcing bodies or statutory bodies are involved, e.g. fire brigades, elected bodies. Another view from the HSE was that any controlled-burn fire plans for larger sites should go through the public consultation mill in a similar manner to COMAH sites. For the latter, the public is involved and consulted about the Off-Site Plan and has a right to see the Safety Report. The HSE tells the local authority of a minimum radius that defines the term "public", but the local authority may then extend this to consolidate into wards, borough, etc. The local authority must have in place arrangements to warn the public of an incident and tell them when it is over. For smaller sites, the HSE questioned how the public could be involved, as it is not practical to have public information zones around, for example, farms.

EHOs felt that once the emergency plan had been agreed, it should be a public document. The Environment Agency's view was that emergency plans should be communicated to the public only where the law specifies this.

4.9.2 Public involvement at the incident

All parties agreed that the public should have no direct involvement at the fire incident itself, but should be kept informed. The Environment Agency presently relies on local authorities to give public-health advice during incidents. The Agency and the Association of Chief Police Officers have recently signed a memorandum of understanding (MoU), which sets out how they will work together to protect the environment. The aim is to ensure effective co-operation between the Agency and the police during incidents in which the environment is at risk of harm. The MoU covers communications arrangements as well as effective liaison during major environmental incidents in which the police are involved.

According to EHOs, the present means of informing the public about a fire incident in progress is site-specific and can range from press briefings and announcements on television and radio, to police vans issuing public-address warnings or even door-knocking. EHOs felt the appropriate means should be covered in the controlled-burn guidance. They believed dissemination of information during an incident should be agreed as part of the emergency plan. Operators and the LPC also saw a role for the media and local press while the incident is in progress. Views varied within the Environment Agency on the information that should be given to the public during an incident, and these are summarised as follows:

- It could be difficult to divulge any information other than that required by statute because of confidentiality. Information given out may need to be restricted to Public Register information for appropriate (e.g. COMAH, IPC/IPPC, LAAPC) sites.
- Care needs to be taken not to cause unnecessary alarm.
- The media can be a big help, or a big problem, in influencing public perception of an incident.
- A good medium for giving out public information, is a joint press briefing by the Fire Service OiC and the Agency investigating officer.

BASIS took the view that no information should be given to the public during an incident unless specifically required by legislation (e.g. COMAH).

4.10 Views on the Financial Aspects of Controlled Burn

4.10.1 Categories of costs

There are a number of financial consequences to the Environment Agency and Fire Service of allowing fires to burn. These may differ for controlled burn compared to putting the fire out in the normal way. The types of costs include:

- contingent costs, e.g. litigation and legal expenses, personal injury, natural-resource damage, and remediation costs;
- conventional up-front costs, e.g. staff costs, capital equipment, materials and supplies.
- partially-hidden environmental costs, e.g. site studies, planning, reporting, records keeping, permitting, training and audits; and
- image and relationship costs, e.g. corporate image, relationship with industry, relationship with investors, relationship with insurers, relationship with staff, relationship with lenders and relationship with host communities.

4.10.2 Contingency costs

The LPC agreed that there could be potential financial impacts on the Fire Service and Environment Agency resulting from litigation. The LPC was of the opinion that if the decision was not planned as part of controlled-burn policy and involving all the interested parties, it may result in litigation. A suggestion was that a loss adjuster appointed by the insurance company should be more involved in pre-planning and emergency response. The loss adjuster could be called out to be present during an incident. Improved communications between the fire brigade and the loss adjuster could result in smaller losses and therefore lower claims. The LPC advised that the Fire Service and Environment Agency should obtain insurance cover for this. Litigation could include:

- claims by the site owner or insurer if the Agency advises controlled burn and the building and contents are destroyed; or
- claims by the water company if the Agency doesn't advise controlled burn and pollution results from the firewater run-off.

CACFOA took the view that the pre-determined emergency plan should take costs - including the potential for litigation - into account. The fire brigades emphasised that firefighting activities and tactical decisions, such as controlled burn, are based on safety and life risk, not on cost. The Environment Agency pointed to the possibility that some of these costs might be recovered through regulation charges, e.g. IPC or IPPC fees. Additionally, any increased costs may be more than balanced by prevention of serious incidents and the associated costs for environmental damage and remediation. (At present, the Agency is often not able to recover fully the remediation costs for a pollution incident.)

4.10.3 Conventional up-front costs

Up-front costs to the Environment Agency were expected to be higher for the controlled burn option because of increased staff costs: its officers would be required to stay longer in attendance on site. But again, this has to be balanced against the higher costs for environmental damage, remediation, and pollution monitoring if the fire is extinguished in the normal way and contaminated firewater gets out.

The fire brigade would still need to maintain existing resources for strategic fire cover, whichever fire tactic is chosen in any particular circumstance. On an individual case-by-case basis, some brigades thought that controlled burn would be more costly to them because of the prolonged attendance of firefighters; whereas other brigades thought that controlled burn could be a cheaper option (unless litigation resulted). A number of brigades thought there would be no significant differences in financial consequences to them for the two options, and the reduction in material resources needed for the incident (savings on foam, fewer pumps, reduced clean-up and decontamination costs) would balance out any increased staff costs. CACFOA agreed with this: in general (and the circumstances of every incident are different) controlled burn is a defensive tactic that is likely to require fewer resources, but fire crews will need to be at the incident for much longer periods. This will be significant in rural brigade areas that rely on retained crews.

For local authorities, staff costs are not a major factor affecting their view of the BPEO at a particular incident.

4.10.4 Partially-hidden costs

There is also a financial impact from partially hidden environmental costs for the Fire Service and Regulators for a controlled-burn policy. These costs are likely to include site studies, inspections, audits, permitting, reporting, training and guidance.

Introduction of a controlled-burn policy or guidance could have partially hidden costs for local authorities, depending on how much involvement they were to have. It was estimated that the cost to Milton Keynes Council would be £50k to £100k to categorise all plastics manufacture and storage sites in its area. The increase in cost would be even more dramatic if the local authority was involved in recording, auditing and training, or if the frequency of joint exercises with the Fire Service was increased.

4.10.5 Image and relationship costs

The extent of financial impact from image and relationship costs on the Fire Service and Regulators for a controlled-burn policy is difficult to quantify. It depends on how each organisation values and puts a price on its corporate image, relationship with public, relationship with staff, relationship with host communities and relationship with owners/operators. The Environment Agency provided no information on how this impact would affect it, but believed it could be a key issue for the Fire Service and good public relations (PR) would be needed to explain why they are adopting this approach. It was thought that if the public and media are briefed well, the impact should be positive. Such PR will have a cost.

4.10.6 Financial impacts on operators, owners and insurers

There is the potential for similar financial impacts on operators, site owners and insurers as the result of a fire incident. Some of these may differ for controlled burn compared to extinguishing the fire. Contingent costs associated with a fire may involve personal injury, legal expenses, penalties and fines, property damage, natural-resource damage, remediation costs, and economic-loss damage.

Conventional up-front costs are likely to involve losses of capital equipment, materials, supplies and structures. Operators thought these costs might not always differ greatly, as there would be little difference in smoke and water damage. In other cases there could be big differences in losses and costs between controlled burn and conventional fire fighting, but these would vary from site to site and would be very incident specific.

Partially hidden environmental costs would be made up of site studies, planning, reporting, records keeping, permitting, training and audits, and operators did not expect these to differ greatly for controlled burn compared to conventional fire fighting.

Image and relationship costs would include corporate image, relationship with customers, relationship with investors, relationship with insurers, relationship with staff, relationship with lenders, relationship with host communities and relationship with Regulators. Few views and no monetary estimates were given on how these costs would differ for controlled burn compared to putting the fire out in the normal way. It was hoped that quantitative cost data would emerge from the case studies (see Chapter 5).

4.10.7 Insurance and environmental liability

Questions on insurance were raised at meetings of National Fire Service Liaison Group and Environment Agency Steering Group, such as:

- Does the operator/site owner understand what he has to insure?
- Are current insurance policies appropriate for covering controlled burn?
- What about contingent costs - do environmental liability policies cover this issue?
- Do the insurers (in general, as well as the specialists) understand what they are insuring with regards to this issue, or do they just charge a premium +10% to cover such eventualities?

Little further clarification of these issues was obtained from the respondents in this study. The LPC thought that guidelines would need to be developed for site clean-up costs. According to the LPC, the operator or site owner does not currently get any reduction in premium for having an Environmental Management System or an Emergency Plan. Insurance cover does not extend to civil liability costs. Operators believed they were generally well-insured on environmental risks. Sudden and accidental damage to any third party is usually covered by a company's public liability policy - this would normally include environmental damage unless specifically excluded.

4.11 Views on the Emotional Impacts of Controlled Burn

Emotional effects on people may differ for controlled burn compared to putting the fire out in the normal way. These might show themselves as adverse publicity, or hostility from the local community. Each incident is, of course, very different and so generalisations are difficult. Operators believed there would probably be little difference in emotional impact for the two options. EHOs pointed out that peoples` awareness will be raised by a controlled-burn decision, public and media interest will be greater and more questions will be asked (often stretching the local authority). Experience has shown that the public *perceives* the risk to be higher with controlled burn and they are more likely to attribute ill health to a controlled-burn incident than if the fire is put out in the normal way.

EHOs believed the public expectation is that a fire should be put out. There is little awareness of what goes on afterwards. However the public should accept controlled burn if it is explained and used more widely as a tactic. Public acceptance is dependent on trust. It is important that all parties involved agree operationally on the decision, ensure the decision is based on a robust BPEO assessment and stand side by side at, for example, the press conference. Though getting the message over might be difficult, the Agency pointed out that if the BPEO was not taken then pollution could result and this would itself lead to adverse publicity. EHOs would like to see better guidance and co-ordination for briefing the public and the media.

The HSE drew attention to the social context: peoples` livelihoods are at risk (a point also made by the LPC), and the BPEO decision cannot be made in isolation. It would be difficult to sell to the public a principle that might allow the fire brigade to watch-on while premises go up in smoke. The HSE also believed there would be difficulty in getting the Fire Brigades to buy-into any guidance of this sort as their reflex action would be to put it out.

5. CASE STUDIES OF SELECTED INCIDENTS

5.1 Objective

A case study is a detailed study into the background of one incident or group of incidents. It involves looking at past records, and asking people about past or present experiences and behaviour relevant to controlled burn. Advantages of a case study are that it gives a detailed picture of the individual incident, and it can form the basis for future research. Disadvantages are that it relies on memory or records that may be poor or distorted, and it can only tell you about one incident so the information cannot always be generalised to others.

The project specification required the following core issues to be covered in the case studies:

- to carry out a review of incidents involving fire and their environmental impacts of fires at sites storing polluting material and of allowing fires to burn;
- to include considerations of the impact on man (both physically and emotionally), controlled waters, air and the terrestrial environment (land);
- to consider the balance of protecting the environment versus possible impacts on man; and
- to consider what were the legal and financial consequences of such fires and particularly any decision to allow a building to burn.

5.2 Selection of Incidents for Study

All the interested parties in Chapter 4 were asked for details of any incidents they were aware of. Additionally, the Institute of Environmental Management and Assessment was contacted and details were requested of any relevant case studies. Incidents were categorised into a manageable number of model controlled-burn or put-out scenarios. To enable as large a number of incidents as possible to be examined within the constraints of the study, incidents were catalogued, then screened according to the amount of information available. The screening categories are shown in Table 5.1. This enabled, at a glance, the identification of the incidents most likely to produce a valid impact assessment. Only those incidents for which reasonable amounts of data were available were taken to the next stage, the full assessment of impacts. These incidents are shown as shaded rows in Table 5.1. Seven incidents were studied in detail and these represented a range of fire types and fire-fighting tactics.

5.3 Summary of the Main Features of the Case Study Fires

The following are some of the main lessons found from the case studies.

- The key players are clearly the Fire Service and Environment Agency
- Local authority environment health departments appear not to be considered key players, though their role is recognised (sometimes as an afterthought).
- Communications between all involved parties does not seem to be co-ordinated; though it seemed to work okay for the two key players.
- Categorisation of fires, while interesting intellectually, does not seem important operationally.

Table 5.1 Screening of incidents according to information available

Incident Reference	Information contained in incident report on:							
	Fire size	substances/ quantities	operational response	Impacts on water, air, land	Physical & emotional impacts on people	Financial/ insurance costs	Legal implications	further details available
Allied Colloids, Bradford	✓	✓	✓	✓(w)	✓	✓	✓	✓
Lorry fire at South Mimms, M25		✓	✓	✓(w)	✓	✓	✓	✓
Harcross Timber, Woking, Surrey	✓	✓		✓(w)		✓	✓	
Bolloms, Kent	✓	✓	✓	✓(w)		✓		✓
Garner Osborne electroplating, Newbury	✓	✓	✓	✓(w)	✓	✓	✓	✓
Capital Counties, Basingstoke			✓			✓	✓	✓
Telford military storage fire								
Pet-food fire, Croydon	✓	✓	✓	✓(w)		✓		✓
D&L Plastics, Thetford	✓	✓	✓	✓(w)	✓	✓	✓	✓
Sun Chemicals, Slough	✓	✓	✓	✓	✓	✓	✓	✓
BDH, Poole, Dorset								
Octel, Ellesmere Port	✓	✓	✓	✓	✓	✓	✓	✓
Wokingham fire, Berkshire								
Sainsbury`s, Chichester								
Basel, Switzerland								
Molloy Group, Ipswich	✓	✓	✓	✓		✓	✓	✓
Keymast Chemicals, Bletchley	✓	✓	✓	✓	✓	✓	✓	✓
Grimescote Metals,	✓	✓	✓	✓(w)	✓	✓	✓	✓
CROP Ltd., Wolverton, Bucks.		✓	✓	✓(w)				✓
Undergound storge facilty, Cleveland		✓						✓
Tanker carrying nitrobenzene, Cleveland		✓						✓
Toluene tanker, Cleveland		✓	✓	✓(w)	✓			✓
Scrapyard, Northants.	✓	✓	✓					✓
Warehouse, Poole, Doreset	✓	✓	✓					✓
Warehouse fire, Hemswell, Lincs.	✓	✓	✓	✓(w, l)	✓	✓	✓	✓
Pender Plating, Poole, Dorset								✓
Tyre Fire, SE England								✓
Ruberoid bitumen factory fire, Wigan, Lancashire								✓

- The Agency and Fire Service appear to be good at quoting the nature and quantities of substances involved
- Many of the case studies (e.g. the South Mimms lorry fire) showed the need for (and arguably the lack of) readily available environmental data on substances involved in fires. The Agency may like to review whether the existing mechanism for disseminating this information is adequate: in particular, who has responsibility for it? Is the communications route well established? Are the relevant data there? If controlled burn guidance make self-assessment emergency plans the way to go, where will the site operator get this information? Published sources of information are available on the behaviour of chemicals in fires.
- There is no serious recognition of financial implications, in terms of fighting or managing the fire and in terms of cost of consequences of the fire to people, environment, property or business. There are many areas of the financial impact of fires where there are insufficient data on costs, e.g. for closure of M25. These are possible areas for further work.
- Plume tracking and health assessment seem to be haphazard and difficult to carry out.
- It could be useful to extend the idea of HAZCHEM signs to, say, "ENVIHAZ" for potentially environmentally hazardous sites.

5.4 Details of Individual Case Studies

5.4.1 Hemswell Airfield incident, Lincolnshhire, May 1998

- This was a warehouse fire involving 10 000 tonnes of palletised sugar beet.
- The main potential pathways for environmental impact were: via air and groundwater (vulnerable underlying aquifer, Soil Class H1 which readily transmit liquid discharges because they are either shallow or susceptible to rapid flow directly to rock, gravel or groundwater).
- Firewater was contained within the building.
- There was good co-operation between the Fire Service, Environment Agency, EHOs and the police.
- After about 24 hours, the decision was made (based on BPEO) to cease spraying and allow the fire to burn out in a controlled manner.
- Contaminated firewater was tankered away by the manufacturer for treatment.
- The site was handed back to the owners after 6 days.
- Impacts on people physically – no injuries.
- Impact on people emotionally – some media interest, but final impact neutral.
- Impact on air quality – lots of smoke, but wind direction took it away from populated areas.
- Impact on surface water – none: contaminated firewater contained within the building.
- Impact on groundwater – none: contaminated firewater contained within the building.
- Impact on land – none: contaminated firewater contained within the building.
- Financial impact on owner and/or insurer - a newish building was destroyed, value unknown. The sugar beet was worth "hundreds of thousands of pounds". British Sugar paid for the tankering and treatment of waste. There were no fines or third-party claims.
- Financial impact on local community - no knowledge of any adverse impact on local business through closures or loss of trade.
- Financial impact on Fire Service - reported to be £17 500 (more than 50 fire fighters attended).

- Financial impact on Environment Agency - staff costs about 16 man-hours, recouped by back-charging the warehouse owner; materials (sandbags) £310.
- Legal – no legal action was taken because the fire was started by arson.
- Lessons learned – meteorological conditions are an important factor in the balance of impacts via air versus impacts on water, land, etc. This is an example where the fire-fighting tactic was the best option for health and safety as well as environmental reasons.

5.4.2 D&L Plastics fire, Thetford, Norfolk, October 1991

- Large fire at a plastics-recycling site, involving bales of plastic from a variety of sources.
- Fire fighting hampered by insufficient water supplies. Site abandoned on day two because of low fog and highly acid mist.
- The former National Rivers Authority (NRA), EHOs and Emergency Planning Officer involved. Internal communications within NRA poor initially.
- Impact on people physically – approx. 70 firemen sent to hospital because of the effects of the fire; about three kept in overnight. Local GPs did not report any increases in respiratory disorders in the weeks following the incident.
- Impact on people emotionally – resulted in much media interest and public concern and protests.
- Impact on air quality – acid precipitation of pH1-2 was being deposited. Samples of dust and vegetation from a number of locations (gardens and open areas under the path of the plume) up to a mile from the site were analysed for dioxins. All proved negative.
- Impact on surface waters - the direct surface water discharge into the River Thet from the culvert was well diluted and no significant effects from contamination were noted. The River Little Ouse downstream of Thetford is regularly monitored biologically and no effect on the river water was found. Following elevated levels of dioxins found in soils on site, the NRA analysed water samples for dioxins: none was found in river water. So much water was being taken from the river Thet in a low-flow period, that the river stopped flowing. This could have had very serious implications downstream, and illustrates the importance of informing the NRA.
- Impact on groundwater - firewater analysis of runoff and puddles on the site showed major components (high $\mu g\ l^{-1}$ to low mg l^{-1} level) were toluene and styrene, with lesser concentrations ($\mu g\ l^{-1}$ levels) of ethyl benzene, xylenes, other alkyl benzenes, naphthalene, 2-methylnaphthalene, 2-methyl naphthalene, benzene butanitrile and heavy oil fraction. It was feared that contaminated water soaking into the ground would reach the aquifer and become the water being drunk by the residents of Thetford. However, monitoring at nearby boreholes showed there was no significant impact on these. A medical products company located 500 m down the slope at the bottom of the hill (i.e. the direction contaminated water was likely to go) abstracted water for their process from an industrial borehole. Six months after the incident, the manager found chlorinated hydrocarbons in the supply were gradually increasing. The NRA then sampled boreholes in the area regularly and the contaminants gradually disappeared. Chemicals in groundwater were at high $\mu g\ l^{-1}$ to low mg l^{-1} levels. Following elevated levels of dioxins found in soils on site, the NRA analysed groundwater samples for dioxins: some were found in watercourses.
- Impact on land –the HSE found “significantly elevated levels” of dioxins in soil and closed the site with a Safety Order. The site laid derelict for 4-5 years, then was decontaminated.
- Financial impact on owner and/or insurer - the operator went out of business and also had no insurance. Lots of parties wanted to make claims against the operator, but these had to

be written-off. However, when new owners took over the site they carried out ground remediation at their own cost. (The Council was quoted £100k.)

- Financial impact on local community - closure of the nearby shopping centre (Sainsburys, Great Mills, etc.) for two days led to considerable loss of trade, but no information is available on the exact cost.
- Financial impact on Fire Service - quite considerable: 600 men were deployed over three days, and lots of equipment (hoses, etc.) was ruined, costing about £40-50k.
- Financial impact on Environment Agency - cost to the NRA was small (about one man-week plus analysis costs). The Waste Regulator spent quite a bit more time (approx. two man-weeks).
- Legal – The NRA didn't prosecute under Section 85 of the Water Resources Act 1991 in this case, because pollution wasn't apparent at the time. The HSE managed to close the site down using a Prohibition Order issued under part 1 of the HSAW Act, on the basis of the risk posed by the dioxins they found. In parallel, Breckland District Council issued an Abatement Notice under Part III of the Environmental Protection Act 1974, requiring the owners to secure the site from the public. The local authority didn't prosecute for statutory nuisance under Sections 79-85 of EPA 90 because vandalism was the claimed cause.
- Lessons learned – effective communications in the early stages of an incident are crucial; meteorological conditions are an important factor in the balance of impacts via air versus impacts on water, land, etc.; in the event, the firefighting tactics can be heavily influenced by practical factors; short- and long-term pollution monitoring has an important role; costs cannot always be recovered, especially when the site owner is underinsured.

5.4.3 South Mimms lorry fire, M25 Motorway, March 1994

- Fire on M25 involving a lorry carrying 3600 kg of an azo dye, 10 000 kg of water-based vinyl emulsions and 2000 kg of a non-hazardous fluorescent orange pigment.
- Initial confusion on how hazardous the load was because details of the lorry load were destroyed in the fire, and the driver's information was inaccurate.
- Water was sprayed on the fire, but after a while it went bang! The area was covered in orange dye. The fire brigade decided to let it burn. The fire lasted only a couple of hours. This resulted in partial closure of M25 on the lorry side.
- Water and a cocktail of chemicals, including combustion products, were beginning to emerge from the motorway drains into the brook by the time the NRA arrived on site. The brook was dammed to prevent pollution of nearby swallow holes and boreholes.
- Permission was sought from the local water company, Thames Water Utilities (TWU) Ltd, to pump the polluted water to foul sewer, and this was obtained only after protracted discussions and negotiations.
- After about 24 hours, heavy rain caused the dam to be breached.
- Impact on people physically – no injuries to driver, emergency services or public.
- Impact on people emotionally – no local interest.
- Impact on air quality –most of the 3600 kg of azo dye was thought to have combusted, and would have formed tetramethyl succinonitrile (TMSN). It is quite possible that the HSE 8-hour time-weighted average (TWA) occupational exposure limit was exceeded leading to a significant exposure of any unprotected operational staff. The evolution of sulphur dioxide (SO_2) could also have resulted in significant exposure. The quantities of formaldehyde and vinyl acetate present, and hydrogen cyanide (HCN) and nitrogen oxides (NOx) generated are less likely to have resulted in significant exposures

- Impact on surface waters - dissolution in firewater and ingress into waterway of TMSN, SO_2 to give sulphates, and HCN to give cyanides, formaldehyde and vinyl acetate. The polymer emulsions are fully miscible with the firewater and could lead to persistent milky discoloration and biological oxygen demand (BOD) harmful to aquatic organisms. It is thought that over the 10.5 h pumping period, around 90% of the pollutant was transferred to the foul sewer and that the remainder, in much diluted state, passed to the swallow holes. There were no problems at the Blackbirds/Maple Lodge STW. Samples taken on day two of the incident showed the following: at dam breach, showed 39 $\mu g\ l^{-1}$ TMSN in brook *c.f.* Suggested No Adverse Response Level (SNARL) of 0.18 $\mu g\ l^{-1}$; only very low levels of vinyl acetate and chloride were found. At STW, low levels of TMSN (max. 1.75 $\mu g\ l^{-1}$) but flows (x 50 dilution) would have provided adequate margin of safety. Low concentrations of the emulsions in water were reportedly unlikely to reduce sludge activity at the STW; the polymer is largely absorbed on the sludge and thus eliminated from the waste stream. This was confirmed by observations at the STW. Maple Lodge STW had achieved full treatment and with dilution available in the Colne and Thames, the resulting levels of TMSN were about 10 times less than the water company's "sensitive" level of 0.3 $\mu g\ l^{-1}$. A micro-invertebrate study was also carried out on the same day, at one point close to the point of the incident, one about 4 km downstream and a third above the pollution point of entry. No dead micro-invertebrates were found at any of the sites. One dead stickleback was found immediately downstream of the incident, none at the other sites. Biological water quality scores were similar for all sites sampled, indicating that there was no effect on the macro-invertabrate fauna present in the river, attributable to the pollution. It was noted that the river was turbid and flow was high. It was suggested that heavy rainfall had probably assisted the dispersion of any chemical remaining in the watercourse after pumping to foul sewer. In conclusion, there was no significant environmental impact on the receiving watercourse.
- Impact on groundwater - fairly significant impact on potable groundwater. Samples showed the following: at dam breach, showed 39 $\mu g\ l^{-1}$ in brook which could have entered the aquifer and might result in approx. 0.1 $\mu g\ l^{-1}$ on abstraction. Only very low levels of vinyl acetate and chloride were found. Time of travel to boreholes estimated 1-3 days. Picked-up at one of the boreholes, and shut down for a week or so and pumped to waste. TMSN at 0.35 $\mu g\ l^{-1}$ with increased turbidity.
- Impact on land – no details.
- Financial impact on owner and/or insurer – TWU Ltd tried to claim costs not recovered from the Agency back from the lorry driver. The motorway recovery company also tried claim their costs for recovery and storage. However, none of the parties or the police managed to track down the owner-driver.
- Financial impact on local community – no information on costs for police.
- Financial impact on Fire Service - no information on costs.
- Financial impact on Environment Agency – TWU Ltd had costs of £18 666. These were initially all invoiced to NRA, but after negotiations the NRA agreed to pay £10 178 and TWU Ltd agreed to seek the balance from the lorry driver. NRA pollution staff spent 31 hours totalling £400; microinvertebrate study cost £154; analysis costs not known; costs for dam were £955 material costs and £880 labour costs.
- Legal – treated as an accident. No one could prove negligence due to insecure load. HSE took no further action after confirming that there was no requirement for the load to be labelled hazardous. However, the police were pursuing the owner-driver on the issue of insurance and documentation and traffic violations.
- Lessons learned – there can be difficulties identifying what hazardous substances are involved in road incidents. Communications with the water company over diversion of

polluted water to foul sewer were difficult. For road incidents, there is a big problem balancing the environmental impact with the impact of shutting the road. The latter has not been costed. The fire-fighting tactic was based on the physical safety of the emergency services and other road users, rather than BPEO. The reported total costs for this incident were £21k (although there were almost certainly hidden costs that would add to this total) and none of these costs appears to have been recovered.

5.4.4 Sun Chemicals fire, Slough, June 1997

- A major fire at 100 m x 50 m single-storey ink production/storage site, involving varnishes and inks composed of highly purified paraffin mixed with dye, mostly red in colour. Quantities involved were:100 tonnes ink pigment; 90 tonnes ink vehicle (clear lacquer); 30 tonnes solvents (paraffins) equivalent to 27 000 litres.
- Difficulties were experienced in identifying the precise substances involved and one component was temporarilly confused with a similarly named, but much more dangerous, substance. The local authority Head of Environmental Protection Services (HEPS) contacted ICI Paints who had a site nearby for advice on likely hazardous substances; ICI were very helpful.
- Large number of fire-fighting personnel and equipment were used to contain the fire, using water jets followed by a massive smothering with foam; this limited the volume of water flowing to the outfall. Solvent tanks ignited and the building collapsed.
- Details of drainage system of the area were known: outfalls went into 1 m wide ditch and then into the Thames; outfall was black, with visual evidence of paraffin and red dye, and a strong odour. Ditch dammed to prevent polluted water from reaching the River Thames.
- Removed 0.5 million gallons by tanker from ditch in addition to firewater from site of fire, and discharged to local sewage works. Water stored in storm tanks at the STW and gradually bled through the sewage system.
- Fire brigade advised on arriving on site that it was “a big one” and alerted the relevant organisations including Environment Agency and local council's Emergency Planning Officer, Area Health Authority (AHA) and police. Local authority Environmental Protection Services also involved. The AHA obtained advice on the toxicity of substances from the Chemical Incident Response Service (CIRS) at Guys Hospital. The local authority Environmental Protection Services crosschecked this advice with information given in his own reference sources. Emergency Planning Officer decided to activate Emergency Operation Centre (EOC) at the Town Hall. A local help line was set up with two phones; there were lots of calls from the public (dozens rather than hundreds) over a few hours. Two nearest residential streets said to have been evacuated. The only omission seems to have been that no one advised the rail services of the potential dangers and trains continued to run passing through thick clouds of smoke.
- Impact on air quality – the most obvious pathway was a dense plume of smoke moving northeast from the site. Once solvent storage tank ignited there was also thick smoke at ground level on the building's east face. Fallout of smoke was not considered to be a problem. In the opinion of the HEPS there was no great immediate threat to human health, although schools were advised that if the plume did ground, people should go inside and shut the windows. The plume was tracked and it did not ground.
- Impact on surface waters - firewater runoff at risk of reaching open watercourses. Environment Agency supplied equipment to Fire Service, which helped reduce the amount of foam released to the environment. Ditch successfully dammed to prevent polluted water from reaching the River Thames. Foam protein may have had an

environmental impact, but its use was better than the alternative (using large volumes of water, which would have been environmentally catastrophic).

- Impact on groundwater – no details.
- Impact on land – no details.
- Impact on people physically – fire fighters suffered minor burns. Some crew were blown to ground by blast wave and were taken to hospital by ambulance. One received bruising of leg. Three members of the public suffered from smoke inhalation.
- Impact on people emotionally – there was obvious concern from local people phoning the help line.
- Financial impact on owner and/or insurer – no details.
- Financial impact on local community – no information on costs for police. As far as the Borough was concerned, eight senior officers were involved in the incident for a day. Some local businesses disrupted.
- Financial impact on Fire Service - no information on costs.
- Financial impact on Environment Agency – staff costs £4371; material costs £1649; contractor costs £17 271; sample and analysis £678. Local helpers did not charge for provision of resources. The above cost were all recovered from Sun Chemical's insurance. In addition the water company (TWU Ltd) had its own costs relating to water treatment, but did not make a claim.
- Legal – there was technically a Statutory Smoke Nuisance. But as this was an accident the Council took no action. The Agency does not tend to prosecute in the case of fires. It is not known what action was taken by the HSE in respect of possible infringements.
- Lessons learned - difficulty encountered in knowing immediately the nature of the chemicals involved. Difficulty in ascertaining precise health risks of the chemicals involved. This should have been covered in a COSHH assessment. There was no formal environmental impact assessment made prior to the incident. Access to online toxicity information helped the decision making process. When site drainage plans are held in advance, it is possible to quickly identify pathways for potentially contaminated water reaching sensitive watercourses and take the necessary corrective action. The actions in this incident effectively protected the River Thames. Environment Agency, Fire Service and Local Authority all opened their own separate emergency incident rooms; but the public required an integrated response on questions straddling these divides.

5.4.5 Garner Osbourne Circuits Ltd fire, Newbury, January 1996

- A factory (electroplating) fire requiring attendance of *c*.50 firefighters.
- Difficulty encountered by Fire Service in knowing immediately the nature of the chemicals involved and appreciating their potential environmental impact.
- Subsequently found that chemicals and quantities involved were 1200 litres copper sulphate (30%), 1200 litres sulphuric acid (20%), 100 litres nitric acid (20%) and 500 litres ammonium hydroxide ("etching strength").
- Environment Agency provided immediate telephone support and, later, one officer on site. Agency then appeared to quickly identify pathways for potentially contaminated water reaching sensitive watercourses, and recommend the necessary corrective action.
- Initial concern that there may have been cyanides and solvents present (this was unfounded), so building was allowed to burn for both health and safety reasons and environmental reasons. Fire Officer in Charge then contained most of chemicals within the floor working area. Minimal quantities of water used. The water company (TWU Ltd) would not accept the contaminated water to foul sewer. Some effluent did escape via

drains and was lifted into portable containment (Fire Service emergency plastic tank). Environment protected by using drain blockers and a plastic containment dam. Contaminated water pumped into containment dam. Fire Service supervised removal of acidic contaminated water (approx 3000 litres) from the site by special tanker. Fire Service said to have been on site for 18 hours from when the alarm was raised.

- Pathway to receptors - some chemical effluent escaped and entered the River Kennet via drains.
- Impact on air quality – not quantified.
- Impact on surface waters – some fish (10-100) were killed in a minor tributory which has an overspill to the River Kennet about 500 m downstream.
- Impact on land – no details.
- Impact on people physically – no reported injuries.
- Impact on people emotionally – Some media interest, but generally favourable towards the operational response. No major impact.
- Financial impact on owner and/or insurer – loss of a factory building and loss of stock. No firm figures available. Production said likely to commence within a week.
- Financial impact on local community – no information on costs for police or job losses.
- Financial impact on Fire Service - no information on costs.
- Financial impact on Environment Agency – staff costs £250; material costs £140. Not known if costs recovered.
- Legal – no action taken, though if the incident had resulted in major pollution the company could have been prosecuted.
- Lessons learned – there is potential for the wrong fire-fighting tactic to be used when the Environment Agency and Fire Service do not have all the relevant information on the substances stored at the site. This example again shows the necessity for good communications with the local water company to ensure inappropriate effluent is not pumped to foul sewer.

- **Associated Octel Fire, Ellesmere Port, Merseyside, February 1994**

- Fire at large chemical site (*c*.87 acres) producing motor fuel anti-knock compounds, i.e. tetra ethyl lead, tetra methyl lead, sodium, chlorine and ethyl chloride. Located in a large industrial complex with several major chemical plants nearby. Accidental release of ethyl chloride release was followed by ignition and fire.
- The crude ethyl chloride reactor liquor was approximately 90-95% ethyl chloride, up to 2% hydrogen chloride, 0.5-2% polymer oil and 0.1-1.5% aluminium chloride catalyst. The main hazard was ethyl chloride with flammable risk, although hydrogen chloride is a toxic and corrosive substance and readily forms hydrochloric acid (HCl) mist on contact with moisture in the air. Octel estimated that 5 tonnes of ethyl chloride reactor liquor was lost prior to ignition. 1.5 % of this was HCl, the main toxic hazard.
- Emergency services informed as soon as release occurred. Initial information given to the Fire Brigade was interpreted as "toxic" and responded accordingly. One works fire tender, followed by many fire brigade appliances (23 in total) called to the scene as the incident and response progressed. An hour and a half was needed to isolate the leak to suppress further releases of vapours and prevent the cloud spreading. Arrival of the first Octel manager one hour and 10 minutes after the release changes the tactics of the fire brigade from "toxic" response (playing jets of water on the pool of liquid) to "flammable" response (laying down a blanket so as to suppress the release of flammable vapours). The laying of foam began 1 hour 35 minutes after the release. Ignition occured 1 hour and 45 minutes

after the initial release. NRA in attendance from this point. A medical officer from the local authority attended the incident and made contact with local hospitals. Flammable vapours of ethyl chloride ignited creating a major pool fire and jet flames. The foam attack progressively reduced the fire to two main areas: the base of the reactor and the tops of the horizontal vessels. Approximately 3 hours later, the fire was contained and control was achieved within these areas. The fire was allowed to burn at a reduced scale and declared extinguished some 10 hours after its start.

- Pathway to receptors - foam and large quantities of firewater run off released into nearby watercourse.
- Impact on air quality – cloud of crude ethyl chloride reactor vapour spread in air for first one and a half hours before ignition occurred. Thereafter, combustion product.
- Impact on surface waters – 225 000 litres of foam and large quantities of firewater run off were discharged into the nearby watercourse (South Boundary Ditch). The NRA assessed that South Boundary Ditch discharged into the River Gowy at such a low rate that any contamination would be diluted out, and the existing condition of the watercourse made it of little concern. Visual checks by the NRA after the incident showed no lasting effects. No damage occurred to the Site of Special Scientific Interest (SSSI) located in the Mersey Estuary.
- Impact on land – no details.
- Impact on people physically – one Octel employee and 17 firemen received treatment during the night of the incident. The employee, who had been struck and contaminated by process liquids, became ill and was detained in hospital overnight. His subsequent absence from work for more than three days was formally notified to HSE. Two firemen were taken to hospital but not detained. Off site, there were a small number of complaints of ill health. Some of those working at the adjacent Shell refinery displayed symptoms consistent with exposure to HCl and there was one formal notification of ill health to HSE. There is a residential development within 250 metres, within 1.5 km of the site there are: large residential areas, main shopping and public amenities such as schools and council premises. The local authority was not aware of any further instances of members of the public being affected.
- Impact on people emotionally – emergency services and local authorities were swamped with telephone enquiries from anxious residents. Local residents, councillors and residents associations made their concerns known to HSE either in meetings or by correspondence.
- Financial impact on owner and/or insurer – The plant was extensively damaged and was subsequently demolished. A new plant has been built at an estimated cost of £6.1 million. Ethyl chloride was imported by road, rail and sea to make-up for the loss of production. The company estimates the costs of transport and of the disruption to the process may have been several times the rebuild cost.
- The company was also fined £150 000 for contravening the HSAW Act and was ordered to pay full costs of £142 655.
- Financial impact on local community – site employs approximately 1650 people. The adjacent roadways, Oil Sites Road and Bridges Road were closed as well as the nearby M53 motorway junctions 9 and 10. A roadworks gang on the M53 was evacuated and there was also partial evacuation of two local factory sites: Zeneca, and the North side of Shell UK Ltd.
- Financial impact on Fire Service – no details.
- Financial impact on Environment Agency – no details.
- Legal – HSE served a Prohibition Notice preventing Associated Octel Company from restarting production of ethyl chloride until the company had demonstrated improvements. The company pleaded guilty in Chester Court to contravening Sections 2 and 3 of the

Health and Safety at Work etc Act 1974 for failing to provide and maintain plant and systems of work which were safe and without risk to health. As a result, the company put at risk the health and safety of employees and other people, in particular the fire fighters involved. The company was fined £150 000 (£75 000 on each of the two charges) and were ordered to pay full costs of £142 655. Payment of costs was subject to Appeal by the company at the time HSE published its report in 1996.

- Lessons learned – a good example of a fire incident that could have either been avoided or its consequences reduced with improved emergency planning and provision for emergency response, risk assessments and safety management systems. The response/ tactics of the Fire Service were hampered by lack of information on the main risks from the substances. The lack of significant environmental impact suggests that with hindsight the chosen option of controlled burn was BPEO, but the course of action was to a large extent determined by circumstances.

5.4.7 Toluene road tanker fire, Cleveland, November 1986

- A chemical tanker carrying 4800 gallons of toluene involved in an road accident resulting in spillage and fire. Road was not provided with water mains or hydrants, and the nearest adequate supply of water was located in a trading estate, half a mile away, across a field.
- Considerable time before fire-fighting resources could be deployed due to severe traffic congestion. The fire crew's initial action concentrated on the fire-fighting search and possible rescue from the several cars involved, and the control of the tanker fire. Tanker driver advised chemical involved was toluene, and Fire Service obtained information from ChemData chemical database. A passing motorist with expert chemical knowledge gave considerable advice and informed the Fire Service's decision to extinguish the burning cars, but to leave the tanker fire to burn under controlled conditions until the toluene level dropped below the ruptured manlids. At this point, seven hours after the initial incident and with approximately 1800 gallons remaining in the tanker, the fire was extinguished using foam compound. The area affected by toluene, fire spread and the amount of foam compound used, was minimised by this combination of controlled burn and put-out tactics. Other services attending the incident included police, ambulance, environmental health, electricity board, water board and an ICI Chemsafe team.
- Pathway to receptors - the burning toluene on the road entered road drains, resulting in localised drain fires, extinguished using water and foam compound. The road at that point is close to the Stainsby Beck stream.
- Impact on air quality – toluene has a moderate toxicity level and a moderately high volatility, giving noxious fumes which would only be prevalent in the immediate area of the incident. The vapour irritates the eyes and respiratory system. It is highly flammable and when burning, produces a high level of carbon deposits (soot), as well as carbon dioxide and water. Fall out from the flames and smoke would be soot, and is unlikely to cause any irritation.
- Impact on surface waters – the Stainsby Beck was examined at the Mandale road junction, but no evidence of pollution was found. Further inspection of the Beck after the fire had been extinguished using firefighting foam was conducted, as some of the foam had entered road gullies. No further pollution was found, and this was attributed to the higher than normal water level of the Beck at the time of the incident diluting out any pollutants. the Water Authority Pollution Prevention Department and the Environmental Health Officer monitored the water, and no significant impact was found.

- Impact on land – 300 m^2 of road surface was contaminated with toluene. That the incident occurred on the central reservation limited the land contamination.
- Impact on people physically – two people sustained injuries: the tanker driver had a bruised back and minor burn to the hand, and was kept in for observation overnight; and the driver of the original vehicle in collision sustained a cut to the hand.
- Impact on people emotionally – the combustion of toluene gives a high output of carbon, releasing considerable amounts of dense black smoke. Residents were alarmed by this, and by inaccurate news coverage (despite press releases by the Local Authority and Chief Fire Officer).
- Financial impact on owner and/or insurer – road tanker and 3000 gallons of toluene were destroyed, and the remaining 1800 gallons were contaminated by foam compound and water.
- Financial impact on local community – severe damage was sustained to five cars, one cargo tanker, 300 m^2 road surface and 20 m roadside furniture. Considerable disruption to traffic due to closure of the road for two days due to the incident and damage sustained in the fire.
- Financial impact on Fire Service - high personnel and equipment costs to the Fire Brigade, including 67 fire fighters (14 at Station Officer rank or above), ten major pumping appliances, one decontamination unit, one emergency tender and one foam tender (which were tied up for 12 hours).
- Financial impact on Environment Agency – no details available.
- Legal – no details of any prosecutions.
- Lessons learned – events developed quickly. In this instance there was an element of good fortune in that a passing motorist had expert knowledge on the effects of toluene and offered his advice. This allowed decisions to be made more quickly than would otherwise be the case. No active measures had been taken to prevent pollutants reaching receptors, by, for example, blocking drains. The chosen fire-fighting tactic probably prevented more serious pollution impacts. Emotive news coverage can heighten the perceived impact when it is not (or chooses not to be) informed by official news releases.

5.5 Assessment of Impacts in Case Studies

5.5.1 Method of environmental assessment

An assessment has been made of the environmental impacts of each of the incidents in the case studies. The assessments include consideration of impacts on human health, on controlled waters, air pollution and the terrestrial environment. A rigid, quantitative approach has not been possible because of the lack of measurements and quantitative data from the incidents. Therefore a semi-quantitative "risk-ranking" approach has been used. The assessment is based on the relationship:

Impact $\propto$ Dose x Sensitivity

The dose is determined by the environmental hazard and the rate of transport to the receptor. The sensitivity depends on the location of the site and the characteristics of the receptors. Simple matrices have been used to estimate dose and sensitivity by placing the hazard, transport, location and receptors into broad categories. This procedure has been based on similar straightforward approaches used by the Environment Agency (e.g. OPRA Scheme[89]), Royal Society of Chemistry (e.g. COSHH in Laboratories[93]) and the HSE (e.g. COSHH Essentials[92]).

5.5.2 Estimation of Dose

To estimate the dose, it is first necessary to estimate the *environmental hazard* and then the rate of transport to the receptor. Figure 5.1 shows how the substance hazard is assigned a ranking between low and high, taking into effect the following:

- The inherent hazardous nature of the substance: a score has been applied (based on OPRA attribute PHA1) ranging from: 1 (low level of harm); 2 (slightly harmful); 3 (moderately harmful, not persistent); 4 (highly harmful effects but not persistent; or moderately harmful and persistent); up to 5 (highly harmful effects and persistent); and
- The scale of the release: a score has been applied based on similar schemes[75, 90] ranging though: 1 (very small, i.e. g, ml scale); 2 (small, i.e. kg, litre scale); 3 (medium, i.e. hundreds kg, hundreds litres scale); 4 (large, i.e. tonnes, m^3 scale); and 6 (very large, i.e. hundreds tonnes, hundreds m^3 scale).

The second factor determining the dose, the *transport rate* to the receptor via this pathway, must be ranked between low and high. The following were taken into account:

- Duration of the release;
- Flow rate through this pathway, e.g. is there a pathway through fissured rocks to an underlying aquifer?
- Distance and direction to receptor, e.g. is smoke blowing towards or away from residential area? and
- Mitigating effects of dilution or dispersion, e.g. will a river's flow rate sufficiently dilute contaminants?

The estimates of environmental hazard and transport rate were next looked at together in a matrix (Figure 5.2) to estimate the dose category.

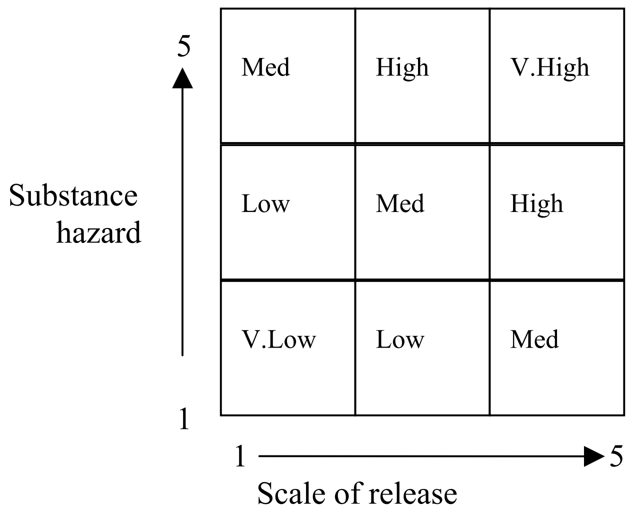

Figure 5.1 Matrix to estimate environmental hazard

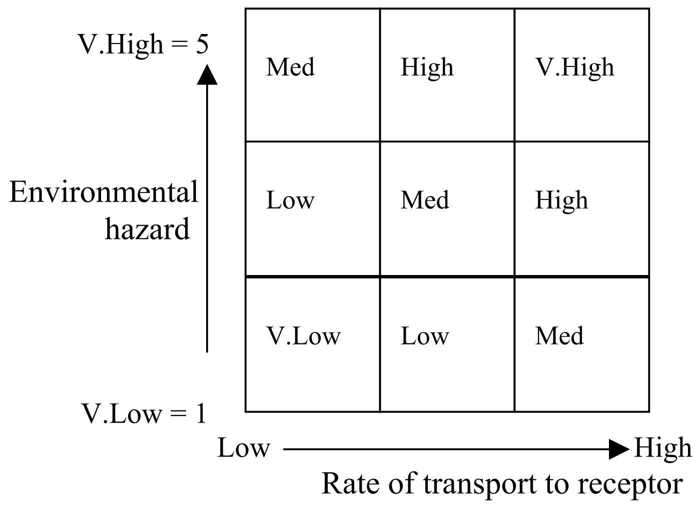

Figure 5.2 Matrix to estimate dose category

5.5.3 Estimation of Sensitivity

Now the dose has been established, it is necessary to estimate the sensitivity of the receptor to be able to assess the impact of the release on the chosen receptor via the particular medium and pathway. In assessing the sensitivity, both the location and the nature of the receptors were taken into account. Location sensitivity depends on the following questions:

- How close is the site to residential communities, schools, hospitals?
- Is the site in an area with sensitive groundwaters, particularly those used for public drinking supply purposes?
- Is the site is within river catchments above potable water supply intakes and/or reservoirs
- Could the site pose a threat to aquatic ecosystems of particular ecological value such as an SSSI?
- How close is the site to rivers, natural breeding grounds of fish, birds, etc?
- Could the site pose a threat to fisheries, fish farms and agriculture?
- Could the site affect areas used extensively for water-based amenities, e.g. waterways, canoeing, windsurfing and other sports?
- Does the site surface runoff discharge to a foul sewerage system and where the receiving STW may be damaged or otherwise seriously affected by the contaminants?

It is also necessary to take into account the sensitivities of the receptors themselves. The following questions are important[94]:

- Do any of the sites have "designated" status?
- What habitats/species are present?
- Are there any habitats or species that may be particularly sensitive to emissions to air, water, land?
- What proportion of a particular habitat/species would be lost or significantly disturbed (for a particular pollution incident)?
- Are there similar habitats or populations in the region or locally?
- How valuable are the potentially affected environments in nature conservation/ecological terms?
- Have any species/habitats reached the limits of viability (or are they near these limits)?

In these case studies, the importance of location of the process has scored 1 to 5, based in part on the Agency's OPRA scheme.

- Score 1. Low sensitivity area, e.g. heavily industrialised, low quality surface waters, not used for abstraction, absence of designated areas, remote from populations (including other industry workforces) and amenity locations. Additional pollutant releases not likely to cause significant deterioration in environment or exceedance of environmental quality criteria. Low sensitivity receptor: poor environments in nature/ecological terms (e.g. no rare or special habitat/species); habitats/species relatively insensitive to emissions; area does not include habitat/species at or near limits of viability.
- Score 3. Medium sensitivity environment, mixed industrial/residential area, low-density populations nearby, or highly sensitive areas at some distance but potentially in effect range. Medium sensitivity receptor: environments with a fair degree natural and ecological value; but no rare or special habitat/species or habitat/species at or near limits of viability.
- Score 5. Close proximity downwind/downstream of high population and/or highly sensitive environment, e.g. river used for water abstraction, groundwater, designated areas, etc. Further pollutant releases may exceed critical levels or lead to further harm. High

sensitivity receptor: very valuable environments in nature/ecological terms (e.g. SSSI); habitats/species very sensitive to emissions; habitat/species at or near limits of viability.

5.5.4 Assessment of impacts

The previously obtained estimates of dose and sensitivity were then combined in a matrix (Figure 5.3) to assess the importance of the impact of the incident on air quality, water and land. These impacts are shown summarised in Table 5.2, together with an indication of the financial impact.

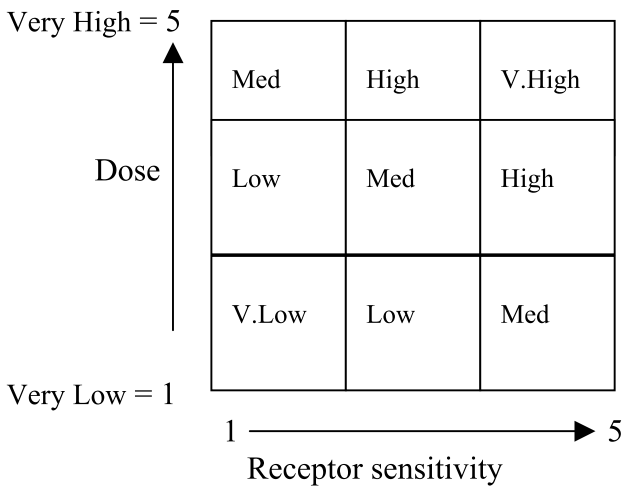

Figure 5.3 Matrix to estimate environmental impact

Table 5.2 Summary of environmental impacts of case-study fire incidents

Incident	Tactic	Type	Medium	Hazard	Scale	Transport	Dose	Sensitivity	Environment Impacts	Financial impact[1]
Hemswell Airfield, Lincolnshire	Controlled burn	Warehouse fire	Water	4	1	1	2	3	Low	Medium
			Land	1	5	2	2	3	Low	
			Air	1	5	3	3	3	Medium	
D&L Plastics, Thetford	Put out, containment	Plastics recycling site	Water	4	4	3	4	4	High	High
			Land	4	4	4	5	3	High	
			Air	4	4	2	4	3	Medium	
South Mimms M25	Controlled burn	Lorry accident And fire	Water	3	3	2	2	5	High	Medium
			Land	2	3	3	3	2	Low	
			Air	3	3	3	3	3	Medium	
Sun Chemicals, Slough	Put out, containment	Ink manufacture site	Water	3	5	1	2	3	Low	High
			Land	3	5	3	4	1	Low-medium	
			Air	2	5	2	3	3	Medium	
Garner Osborne Ltd, Newbury	Controlled burn, containment	Electroplating factory	Water	3	4	2	3	3	Medium	Medium
			Land	2	4	2	2	2	Low	
			Air	1	4	3	2	3	Low-medium	
Associated Octel, Elsmere Port	Put out, Controlled burn	Large chemical complex	Water	3	5	2	2	3	Low-medium	Very high
			Land	1	5	2	2	1	Very low	
			Air	3	2	3	2	2	Low	
Toluene tanker, Cleveland	Controlled burn	Road tanker accident and Fire	Water	3	2	2	1	4	Low	Medium
			Land	3	2	3	2	1	Very low	
			Air	2	4	2	2	3	Low-medium	

[1] Approximate financial impact categorisations as follows: Very low <£10k; Low £10k-50k; Medium £50k-200k; High £200k-500k; Very high >£500k

6. GUIDANCE ON CONTROLLED BURN

6.1. Introduction

This Section provides advice on minimising the environmental impact of fires, at sites storing materials hazardous to the environment. The Environment Agencies believe the issue is one of significant importance, illustrated by the number of recorded pollution incidents following fires.

The environmental impact of extinguishing a fire may be different (sometimes better, sometimes worse) to the impact of allowing a fire to burn out in a controlled and contained way. The latter tactic has become known as "controlled burn", and may be defined as "*a restricted or controlled use of water/ foam on fires where chemical or contaminated runoff may be a risk to the environment*". The "environment" here includes not just the natural environment (flora and fauna) but also human health and public water supplies. As well as being the best environmental option in some circumstances, controlled burn may also reduce risks to fire fighters. This must be balanced against possible legal and financial consequences of allowing a fire to burn out. It should be noted that some of the legal issues are not presently resolved completely and are likely to be so only following case-law decisions.

The Agencies` guidance on industrial sites (PPG11) provides basic advice on pollution prevention. Further information is given in other guidance notes, for example PPG 2 covering primary containment (i.e. bunding), PPG18 on major spillages and secondary (i.e. remote) containment and PPG21 on pollution incident response planning. This guidance document describes how environmental risk assessments and other factors (e.g. legal and financial) should be used within an emergency fire plan to ensure the fire-fighting tactics take account of the potential environmental impact.

6.2 Why Fire-Fighting Tactics are an Important Issue

When pollutants are released into the environment as part of a controlled process, the principle of Best Practical Environmental Option (BPEO) should used to minimise their impacts. The BPEO is the option having the smallest *overall* environmental impact over all media (air, land and water).

The same principle can be applied to fires, i.e. whether the BPEO option is to put the fire out with water or foam (with perhaps a risk to surface or goundwater from contaminated firewater runoff); or to let the building burn (with the possibility of both short-term air pollution and longer-term pollution of land and water from deposition of airborne contaminants).

However, BPEO is concerned overwhelmingly with minimising environmental impact, whereas in practice the decision is complicated by other important factors (illustrated in Figure 6.1), such as:

- whether immediate action is needed to prevent injury to people in or around the building;
- the legal and financial consequences of allowing fires to burn;

- the requirements of the site owner, insurance company and other organisations involved;
- the legal liability of the Fire Service when allowing a building to burn; and
- social factors, including perceived risk.

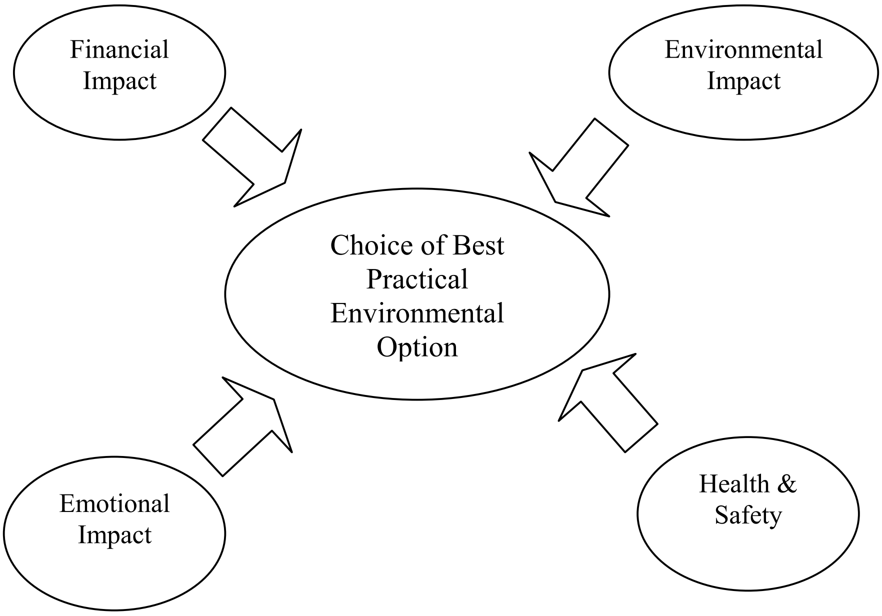

Figure 6.1 Factors involved in deciding BPEO for fires

6.3 Which Sites Pose a Risk?

Nearly all sites storing environmentally hazardous materials that do not have adequate runoff containment facilities pose a risk to the environment. Some substances normally considered non-hazardous to humans, such as milk and beer, can nonetheless pose serious threats to the environment if spilled in large quantities due to, e.g. their biological oxygen demand.

Joint Environment Agency-Fire Service contingency plans for fires have begun with all British Agrochemical Standards Inspection Scheme (BASIS) sites. Some large chemical sites covered by the COMAH Regulations 1999 already have emergency plans that cover fires. A limited number of large warehouses and sites with storage tanks have fire plans; and codes of practice have been drawn up by the timber-treatment industry, BASIS and the metal-finishing industry. The Environment Agencies are working with the Fire Service to identify other at-risk sites. Any site storing polluting material can cause a problem, but there is particular concern that certain premises, sites and processes can pose a significant environmental risk. These include, but are by no means restricted to:

- IPC/IPPC processes;
- COMAH Regulations sites (both the rigidly controlled top-tier sites and also the lower-tier sites);
- Sites storing or processing hazardous waste as defined under The Special Waste Regulations 1996;
- Planning (Hazardous Substances) Act sites;

- Regulated waste movement and disposal;
- Some contaminated land sites;
- Timber-treatment plants;
- Tyre dumps;
- Metal finishers;
- Plastics manufacturing and recycling sites;
- Petrochemicals sites;
- Chemicals, pharmaceutical and veterinary products warehouses;
- Agrochemical stores;
- Pesticides stores;
- Farm buildings;
- Large DIY superstores and garden centres;
- Sites storing substances not hazardous to human health but which can have a serious impact if spilled into surface waters, e.g. milk, orange juice, beer, sugar, mollases; and
- mobile potential pollution sources, e.g. road tankers.

To carry out a full BPEO fire risk assessment at every site would not be practicable or desirable, and could lead to prohibitively large amounts of effort being spent on small quantities of substances, which may present a negligible risk. Therefore a simple, rapid screening assessment should be conducted to assess the environmental sensitivity of an individual site. This would reduce the number of sites requiring a full risk assessment. This rapid screening assessment requires the risk to be subjectively assessed against certain headline issues (Figure 6.2), grouped into the following categories:

- type of site/activity – see sites of particular concern, above;
- type and quantity of substances;
- incident history and management practices;
- whether adequate containment exists;
- location of site relative to receptors; and
- sensitivity of receptors.

If the substance threshold is not exceeded, and the site is not sensitive, then the risk of environmental damage from accidental fire is considered low and no further risk assessment need be carried out. Similarly, the presence of ample and effective containment that would prevent the spillage of substances and firewater in the event of a fire would result in a low environmental risk towards low and medium-sensitivity sites even if somewhat larger quantities were stored[*].

If the site is in or close to a highly sensitive area but the industry is not one of high concern, there is no poor record of incidents, quantity thresholds are not exceeded and secondary containment is adequate, then a full risk assessment would not usually be necessary. In such cases, the advice of the Environment Agency should still be sought.

This screening process is shown schematically in Figure 6.3. Further notes on substances thresholds and receptor sensitivities are given in Sections 6.6 and 6.7, respectively.

[*] This refers to impact on water only. Impact on air always needs to be considered.

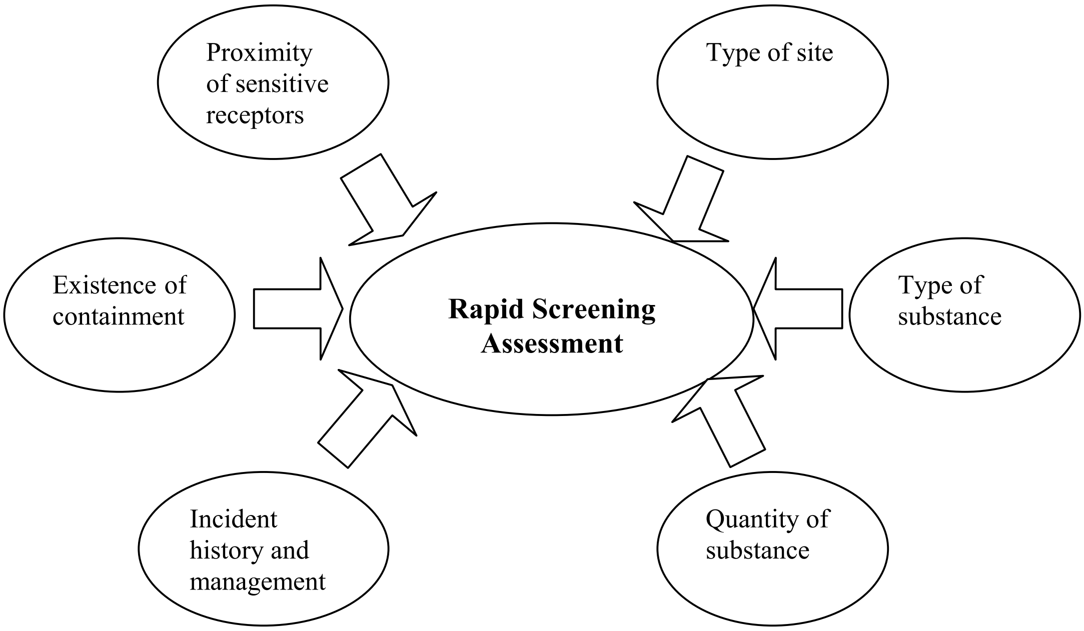

Figure 6.2 Factors influencing whether a full BPEO fire assessment is required

The area may be classed as high sensitivity if, for example:

- the site is within or close to residential communities, important buildings, schools, hospitals or other institutions;
- the site drains directly to a river or watercourse;
- the site is within river catchments above potable water supply intakes and/or reservoirs;
- the site is in an area with sensitive groundwaters, particularly those used for public drinking supply purposes;
- the site surface runoff discharges to a foul sewerage system and where the receiving sewage treatment works (STW) may be damaged or otherwise seriously affected by the contaminants.
- the site could pose a threat to ecosystems of particular ecological value such as sites of special scientific interest (SSSIs);
- the site is close to sensitive natural breeding grounds for fish, birds, etc;
- the site poses a threat to fisheries, fish farms and agriculture; and
- the site affects areas used extensively for water-based amenities, e.g. waterways, canoeing, windsurfing and other sports.

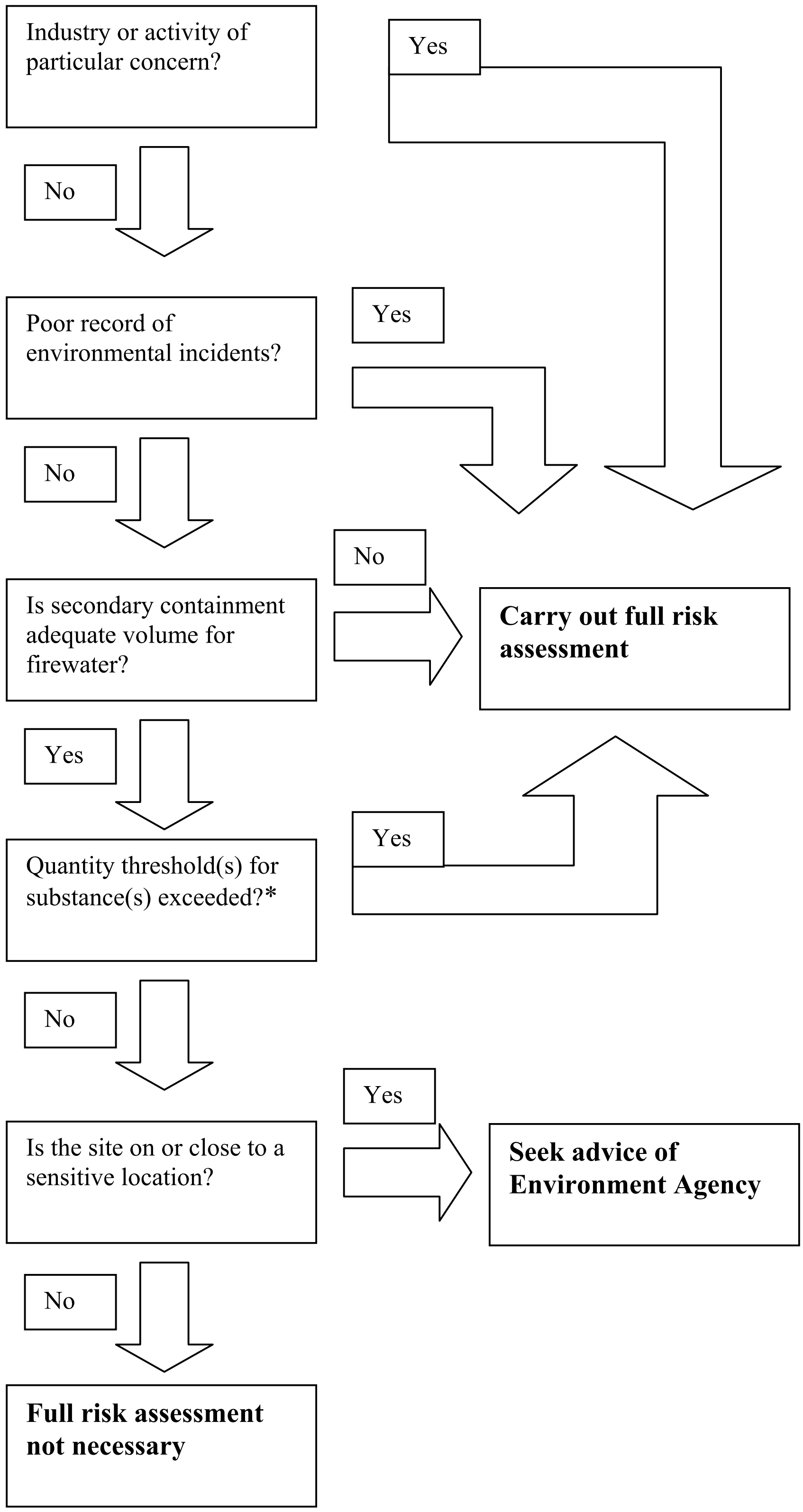

Figure 6.3 Rapid Screening Assessment process

* At this stage, risks of runoff pollution are small and the screening concentrates on air pollution. Quantity thresholds should be relevent to air pollution.

6.4 Producing a Risk Assessment

6.4.1 Who produces the risk assessment?

If the rapid screening assessment shows that there is a significant potential risk of environmental damage from a fire, a full risk assessment should be carried out (Figure 6.4). The risk assessment should be carried out by the site operator or owner, who should consult with and seek guidance from:

- the Fire Service;
- the Environment Agency; and
- the insurer of the site.

In some cases it will be necessary to consult other parties, such as the local authority Environmental Health Officer and (in cases where pollution could affect a sewage treatment works) the local sewerage provider. The Environment Agency will advise on whether this is necessary.

6.4.2 The basics of the risk assessment

This guidance uses the following definitions of terms when discussing risk assessments:

- *Hazard* - the substance's or physical situation's inherent **potential** to cause harm;
- *Risk* - an estimation of the **likelihood** of that potential being realised, within a specified period or in specified circumstances, and the consequence; and
- *Environmental* - referring to the routes of exposure for both humans and wildlife.

For example, a storage area containing an ecotoxic liquid adjacent to a watercourse would be a hazard; the corresponding risk might be that there was a 1 in 100 chance per year that an accidental fire would lead to spillage or runoff and kill 500 coarse fish. Some hazards are less readily identifiable than others because as well as the direct hazard posed by ecotoxic substances, other substances may be mobilised or formed during the course of the fires, because the combustion products may have significantly different properties to those of the materials burnt.

The purpose of carrying out the risk assessment is to establish which fire-fighting tactic (extinguish or controlled burn) is the best practicable environmental option. This would then form the basis of an emergency fire plan, after taking into consideration other relevant factors (e.g. legal and financial implications). BPEO is the option which provides the most benefit (or in this case, least damage) to the environment as a whole, at acceptable cost, in the long term as well as the short term. The risk assessment should cover the following stages:

1. Define the objective;
2. Evaluate the options (extinguish or controlled burn);
3. Summarise and present the evaluation;
4. Select the BPEO;
5. Review the BPEO; and
6. Implement and monitor effectiveness.

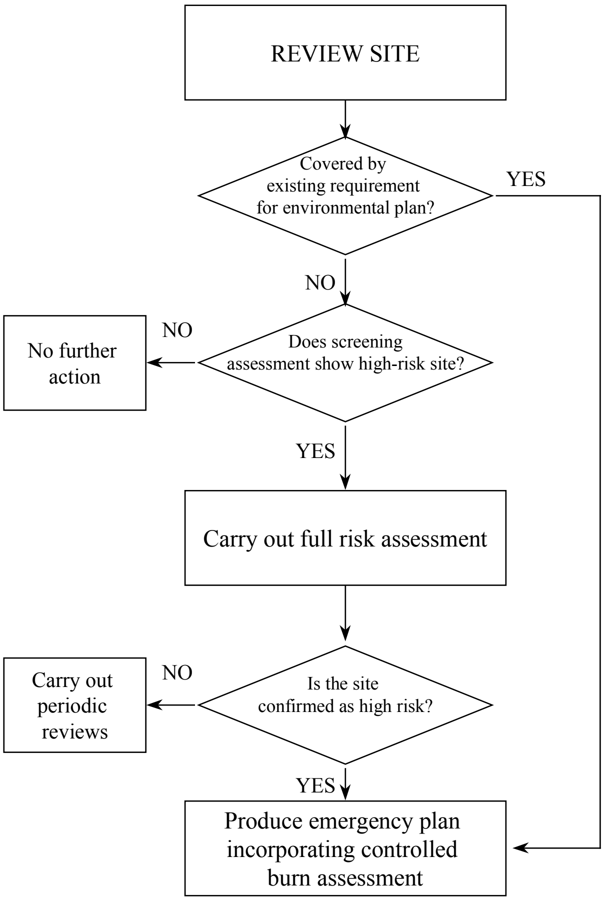

Figure 6.4 Overview of the risk assessment procedure

6.4.3 What makes up a suitable risk assessment?

Three components need to be present before a risk exists, namely:

Figure 6.5 Essential components creating a risk

If any parts of the source-pathway-receptor link (Figure 6.5) are missing then there is no risk. However, care must be taken to ensure that a risk is not dismissed on the grounds that one of the components is missing, if there is the chance that this omission is because of a system/barrier that might in fact fail. For example, a bund might be considered as a method of removing the pathway between the source and the receptor; this would not be a valid reason for concluding that there was no risk since there is a finite probability that the bund would be ineffectual. Similarly, pollution-prevention management procedures can significantly reduce the risk, but do not eliminate it altogether because of the possibility of a failure in the management system. Further notes on pathways are given in Section 6.8.

There is no single risk assessment method that will be suitable for every site. The depth and type of risk assessment will vary from on site to another (site operators should seek guidance from the Environment Agencies as to the complexity of risk assessment required for their site), but is likely to be proportionate to:

a) the scale and nature of the environmental hazards presented by the sites and activities on them;
b) the risks posed to neighboring populations and the environment and the extent of the possible damage; and
c) the complexity of the process and activities, and difficulty in deciding and justifying the adequacy of the risk-control measures adopted.

However, most environmental risk assessments will contain certain common features and will be based on the relationship:

Impact $\propto$ Dose x Sensitivity

The dose is determined by the environmental hazard and the rate of transport to the receptor. The sensitivity depends on the location of the site and the characteristics of the receptors. The assessments should include impacts on human health, on controlled waters, air pollution and the terrestrial environment. The key stages in a risk assessment of an accidental release of contaminants are summarised in Table 6.1.

Table 6.1. Key stages in a risk assessment of an accidental release of contaminants

Step	Stage	Information
1	Identify the environmental hazard	The inherent hazardous nature of the released substance, taking into account its chemical and physical properties.
2	Estimate the potential scale of release of pollutant(s)	The amount and rate of release of each substance in the fire
3	Estimate the scale of the hazard	This is a function of the previous two factors
4	Estimate the likely rate of transfer to the receptor(s)	Predicting the dispersion and deposition of the release (sometimes by modelling). Must take into account: • duration of the release • flow rate through this pathway, e.g. is there a pathway through fissured rocks to an underlying aquifer? • distance and direction to receptor, e.g. is smoke blowing towards or away from residential area? • Mitigating effects of dilution or dispersion, e.g. will a river's flow rate sufficiently dilute contaminants?
5	Estimate the potential dose	The amount of pollutant the receptors receive. The dose is a function of the environmental hazard and then the rate of transport to the receptor.
6	Estimate the sensitivity of receptors	The degree of sensitivity of these receptors to the released substances (refer to notes on sensitivity)
7	Estimate the impact	What are the environmental consequences? Impacts of the incident on air quality, water and land are functions of dose and sensitivity.

It is recognised that some of the information required may be difficult to obtain, for example the amounts and rates of releases of each substance in the fire and the dispersion and deposition of the releases. Where information is not available, estimates will need to be made. In all cases the Best Available Technique Not Entailing Excessive Cost (BATNEEC) principle shall be used, to ensure the cost and effort expended in the assessment is proportionate to the environmental benefit.

Information on the nature of released substances is available from a number of sources, including:

- Bretherick`s handbook of Reactive Chemical Hazards (www.bretherick.com, and publ. Butterworth Heineman);
- Croner`s Environnmental Management & Environmental Case Law and Substances Hazardous to the Environment (www.croner.co.uk);
- Dictionary of Substances and their Effects (DOSE) available online from the Royal Society of Chemistry (www.rsc.org);
- EINECS Plus, a CD-ROM containing the EINECS and ELINCS inventories; and
- CHEM-BANK, a CD-ROM containing databanks of potentially hazardous chemicals including HSDB (Hazardous Substances Databank), RTECS (Register of Toxic Effects of Chemical Substances), CHRIS (Chemical Hazard Response Information System) and IRIS (Integrated Risk Information System).

Also, new interactive CD-ROM based environmental risk assessment software systems are now commercially available, which include substance databases profiling many common chemicals.

A particularly difficult problem with accidental fires is that at some sites releases can consist of a cocktail of chemicals. The COMAH guidance recognises this and suggests two relatively simple approaches that may be applicable for some risk assessments of fires. These approaches consist of:

a) Instead of trying to consider the full cocktail of chemicals, choose a suitable representative "marker" chemical as an indicator of environmental effects. The Precautionary Principle should govern the selection of the marker, hence it may be:
    - the most toxic, persistent and mobile;
    - the most prevalent in terms of amount and concentrations; and
    - the substance transported to the most sensitive receptors.
b) Review information on accidents to see what the effects have been and where they have occurred. Use this information to identify any similarities with the situation of concern, which may enable a judgement to be made on its likely effects.

6.4.4 An example environmental risk assessment

An example assessment has been given in Section 6.9. This example is one from a site where a fire had occurred and has been the subject of a research and development case study. In this instance, a rigid, quantitative approach was not possible because of the lack of measurements and quantitative data and a semi-quantitative "risk-ranking" approach was used. The depth and type of risk assessment will vary from on site to another and site operators should seek guidance from the Environment Agencies as to the complexity of risk assessment required for their site.

6.4.5 Further considerations

If the risk assessment points to controlled burn as the tactic likely to be the BPEO, then consideration needs to be given to financial and legal issues. This will require effective discussions between the interested parties, especially the site owner, the insurer, the Environment Agency and the Fire Service. The main legal and financial issues have been covered in Sections 4.3.6 and 4.3.8, respectively.

6.5. Communications between Interested Parties

6.5.1 Who is involved?

There are a number of parties that may have an interest or involvement during an fire. Their interests may be regulatory, public safety or financial/contractual. These are summarised in Table 6.2.

The Fire Service Officer in Charge makes the final decision on fire-fighting tactics, but this decision will be informed by the advice of the other parties (Figure 6.6). Site owners, operators and insurers should pre-plan for accidental fires and their consequences, and take action to install pollution-prevention measures. This will reduce the numbers of decisions being made "on the hoof" during an incident and avoid the danger of arguing for hours at the incident about whether or not to put out the fire. Pre-planning will also ensure all parties have the opportunity to be consulted, and will reduce the potential for wrong decisions if one or another of the interested parties cannot attend the incident.

The emergency fire plan should be communicated to all the relevant interested parties involved: the Environment Agency, the Fire Service, the local authority and where appropriate BASIS and HSE. Sites covered by certain specific legislation (e.g. COMAH) will have definite procedures for public involvement (e.g. the system of advertising and notification) which need to be followed.

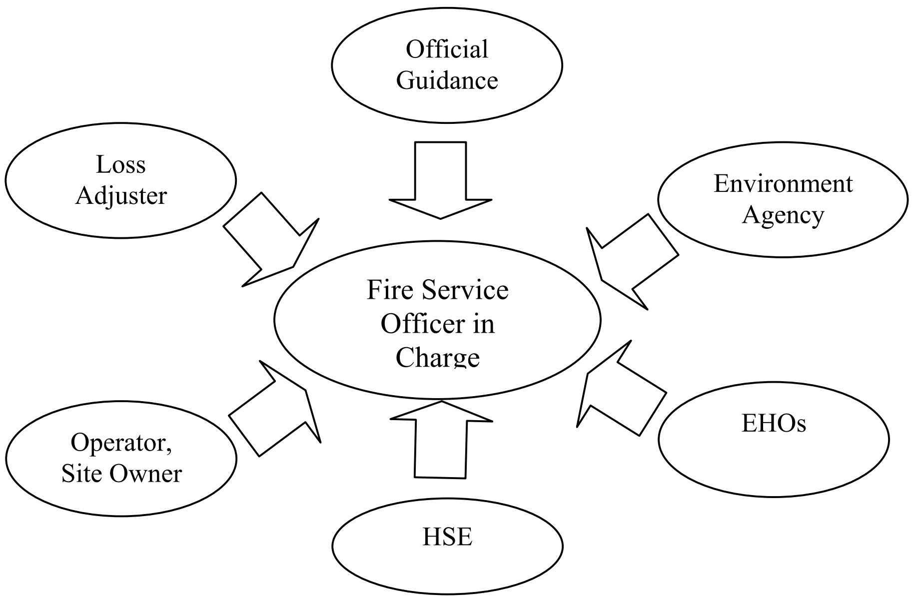

Figure 6.6 The final tactical decision is informed by expert advice.

Table 6.2 Main roles and responsibilities

Party	Main roles and responsibilities
Fire Service incident commander	Makes the final decision on whether the tactic of controlled burn is used or not. Will consider advice from experts, including the Environment Agency, the local EHO, site operators and emergency services.
Environment Agency	Will provide advice to Fire Service where appropriate. Has responsibility for enforcing environmental protection, e.g. the Water Resources Act 1991, the Environmental Protection Act 1990, and the Environment Act 1995. Where a fire poses a risk to the environment, the Environment Agency would expect the company to take appropriate control measures and follow applicable legislation and guidance and provide relevant information on substances, quantities, etc.
HSE	Will provide advice to Fire Service where appropriate. Operates under the HSAW Act 1974. The HSE, together with the Environment Agency/SEPA, forms the joint competent body for implementation of COMAH Regulations at industrial sites.
Local Authority	Will provide advice to Fire Service where appropriate. Also has the power under EPA 90, to take action in respect of statutory nuisances, including premises that are in such a state as to be prejudicial to health. Other responsibilities include: role as the relevant enforcing authority for Petroleum Licensing Regulations, responding to spillages of petroleum, and liaising with council services for COMAH sites, e.g. to trigger the emergency plan, evacuation.
BASIS	Operates in an advisory capacity only, under an approved code of practice (the MAFF Yellow Code).
Operator/ Site Owner	Responsible for making the emergency fire plan, in consultation with the Environment Agency and Fire Service, installing appropriate control measures, following applicable legislation and guidance and providing relevant information on substances, quantities, etc. The operator may need to consult and seek advice from his insurers and, where appropriate, the local authority EHO and Emergency Planning Officer.
Police	Responsible for public order and safety. The Agency and the Association of Chief Police Officers have recently signed a memorandum of understanding which sets out how they will ensure effective co-operation, communications and liaison during incidents in which the environment is at risk of harm.

6.5.2 Steps to take if there is a fire

The controlled-burn decision should be informed by the pre-planning, but in reality (particularly at small sites) the response may be incident-specific and the final decision may well need to be made on the fireground by the Fire Service Incident Commander.

Preventing immediate risk to life and limb is of paramount importance and overrides environmental implications (refer to Figure 6.7). If there is no immediate threat to life and limb, the decision on whether to apply controlled burn will need to be assessed individually for each situation, taking into account the emergency fire pre-plan (where available), the health impacts, the environmental impacts and the financial implications of

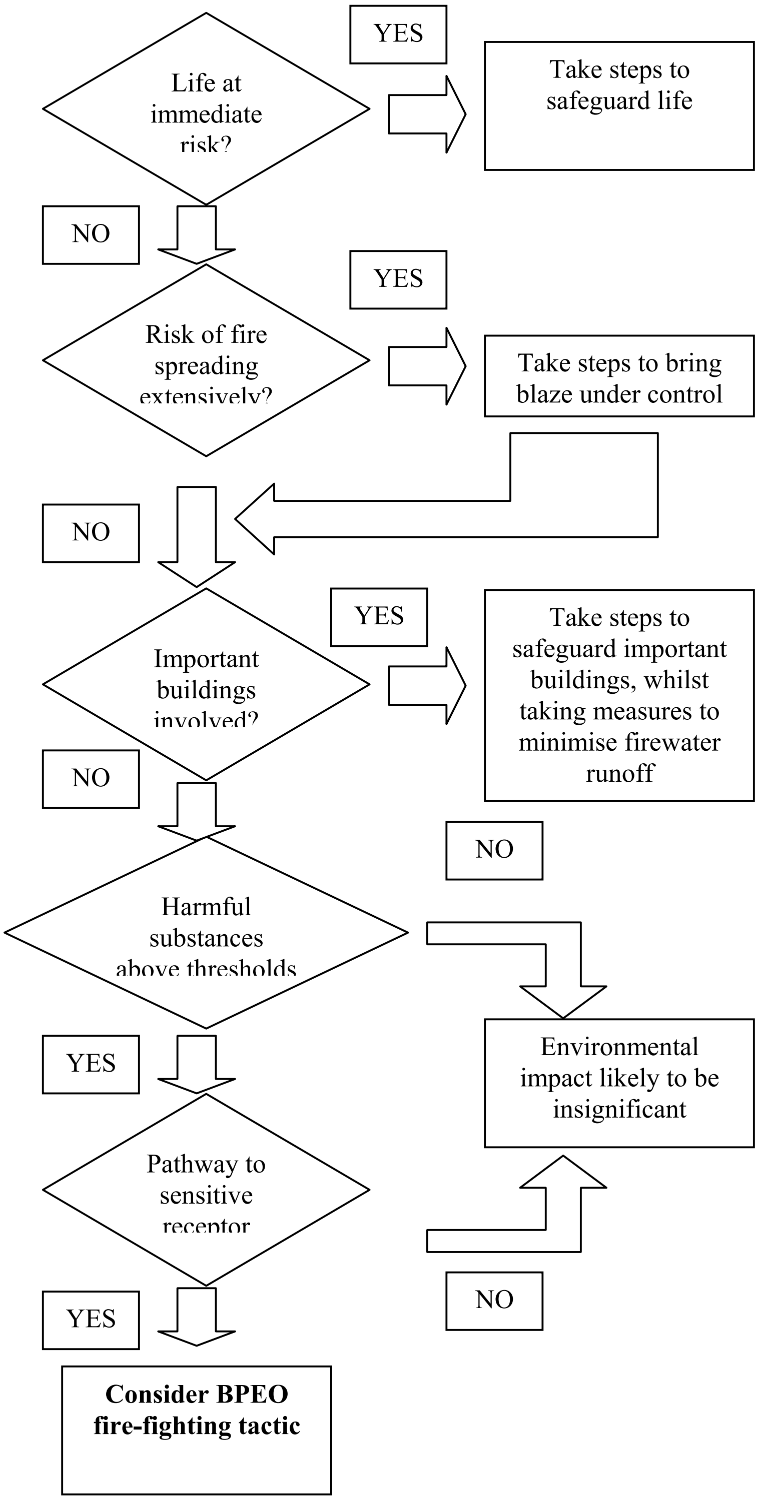

Figure 6.7 Incident assessment of whether controlled-burn tactic is appropriate

each option. The latter may require a decision to be made on, for example, whether saving 500 fish is worth the loss of a building, business and jobs.

Some buildings have particularly high value, not just in rebuilding costs, but because of their architectural, cultural or historical significance. The value placed on the loss of such important buildings must be weighed against the environmental benefit of a controlled burn (should this be shown to be the BPEO), but it is likely that attempts to save some important buildings will always be made. These firefighting efforts to employ other measures to protect the environment, e.g. containment of firewater runoff.

The decision on whether or not to use a controlled-burn tactic should take on board the principles of BPEO risk assessment, as described in Section 5.4. Each fire is different and the tactic should be decided on a case-by-case basis. However, some general examples of situations when controlled burn is and is not likely to be an appropriate option are given in Table 6.3.

Table 6.3 Examples of when controlled burn is and is not likely to be appropriate

Controlled burn may be inappropriate	Controlled burn may be appropriate
Life is at immediate risk	Life is not at risk;
There is a high success forecast for extinguishing the fire with minimal environmental impact	There is a low success forecast of extinguishing the fire
There is a risk of the fire spreading extensively*	Fighting the fire with other tactics would pose a significant risk to fire fighters;
Important buildings are involved.	Property is beyond salvage;
	Weather conditions are appropriate (wind strength and direction taking the plume away from population centres)
	Drainage from the site leads to an environmentally sensitive area
	Firewater runoff would impact on a potable supply intake and other abstractions
	Firewater runoff could knock out a STW

* In such a situation, it may be possible to employ a controlled-burn tactic once the initial blaze is under control.

6.5.3 Communicating decisions

The decision to use a controlled burn tactic should be communicated by the Fire Service Officer in Charge to all the relevant interested parties involved:

- the operator/ site owner (who should inform his insurer),
- Environment Agency;
- BASIS (if relevant); and
- the local authority Environmental Health Department and (depending on the severity of the incident) health agencies.

The public should have no direct involvement at the fire incident itself, but should be kept informed of decisions and developments. The Environment Agency presently relies on local authorities to give public-health advice during incidents and to liaise with emergency services. The communication of the decisions is summarised in Figure 6.8.

The present means of informing the public about a fire incident in progress is site-specific and can range from press briefings and announcements on television and radio, to police vans issuing public-address warnings or even door-knocking. Dissemination of information during an incident should be agreed as part of the emergency plan. Points to be borne in mind are:

- Care needs to be taken not to cause unnecessary alarm;
- The media and local press can be a big help, or a big problem, in influencing public perception of an incident; and
- Joint press briefings by the Fire Service and the Agency have in the past been found to be an effective medium for giving out public information.

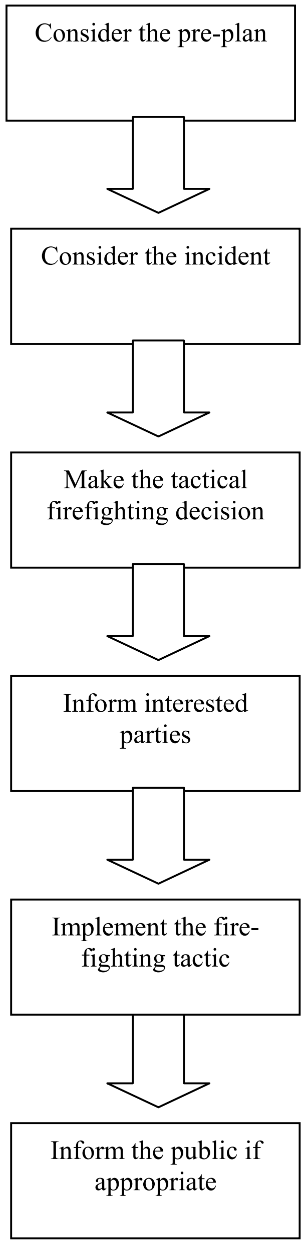

Figure 6.8 Communications within the decision-making process

6.6 Further Notes on Substance Threshold Quantities

Though desirable for practical reasons, there are difficulties in setting size/quantity thresholds for sites/substances to be covered by this guidance. In reality the risk depends on the sensitivity of the receptor: for example, whether it is a small, sensitive watercourse, or a large, less-sensitive watercourse.

Information and guidance on substance thresholds may be obtained from various sources, including:

- Substances and quantities specified under the COMAH Regulations 1998.
- Controlled substances and quantities listed on Schedule 1 of The Planning (Hazardous Substances) Regulations 1992 made under the Planning (Hazardous Substances) Act 1990.
- Sites (other than those already notified under COMAH, or the Planning (Hazardous Substances) Regulations) that hold more than 25 tonnes or more of dangerous substances, and require notification to the local fire authority and the enforcing authority (HSE or local authority) under The Dangerous Substances (Notification and Marking of Sites) Regulations 1990.
- Sites storing 200 kg or more of pesticides under the Control of Pesticides Regulations 1986.
- The Comité Européen des Assurances (CEA) Commission Incendie has published recommendations with the aim of the limiting the hazard generated by fire at stores that contain hazardous substances in quantities exceeding those listed in Table 6.4. The recommendations cover block and rack stores in single and multi-storey buildings; and high-rack stores and outdoor stores for solid, liquid and gaseous substances in mobile vessels and packages. The recommendations do not cover tanks, silos and bulk-goods stores. This scheme is already in operation (in Europe as well as the UK) and much of the information should be readily available to site operators as it is already required for insurance purposes. The list of materials and goods covers about 1400 materials, each given a classification and hazard grade for combustibility and explosibility, toxicity to humans and the environment, followed by the UN number and Chemical Abstracts Service (CAS) number where available. Some substances not hazardous to humans but hazardous to the aquatic environment (e.g. sugar, molasses, milk) are included in the list. Only pure materials or clearly defined mixtures of materials are covered: the influences of packaging or impurities are not taken into account, nor is the fact that the properties of materials can change considerably in a fire.

Table 6.4 CEA hazardous substances thresholds

Threshold	Risk category	CEA Classification
100 kg	substances posing a serious threat to air	Z1
1 tonne	substances posing a serious threat to water	PN1
10 tonne	substances posing a threat to water	PN2
100 tonne	substances posing a slight threat to water	PN3
100 tonne	substances posing a threat to air	Z2

Spillages exceeding the following threshold quantities have been used as trigger levels for fire brigades to reported spillages to the Environment Agencies. This does *not* mean that spillages below these quantities are acceptable or of insignificant environmental impact: the latter will depend on local factors such as the vulnerability of the individual site and should be discussed the officers of the local Environment Agency regional office.

Table 6.5 Threshold quantities[1] provided to fire brigades for reporting spillages

Substance Type	Spill Threshold	Example
HazChem-listed chemicals	Varies	As a rule all spillages should be notified to the Agency.
Special Waste Regulations substances	Varies	As a rule all spillages[2] should be notified to the Agency.
CHIP-listed chemicals	Varies	As a rule all spillages should be notified to the Agency.
List I and List II substances	Varies	As a rule all spillages should be notified to the Agency.
Pesticides	Varies	As a rule all spillages should be notified to the Agency.
Oil	25 litres	Mineral oils
Detergents	25 litres	Washing powder, washing-up liquid, shampoos, soaps and car-cleaning products.
Disinfectants	25 litres	Includes household bleach.
Food Stuffs	250 litres	Most of concern, but particularly sauces, sugars, salt, syrups, milk/cream, yoghurt, vinegar.
Beverages	250 litres	Beers, lagers, wines, spirits, softdrinks.
Fertilizers	25 kg	All
Paints and dyes	50 litres	All
Inorganic powders	500 kg	Silt, sand, cement, chalk, gypsum, plaster.
Organic liquids/ slurries	Varies	Blood, offal, farmyard slurry, fire-fighting foam, sewage sludge, antifreeze, oils (cutting, lube and cooking), glycerine, alcohols, latex, water-soluble polymers.

Note 1: Thresholds refer to amounts spilled rather than amounts stored. The potential for spillage should be assessed from the amount stored.

Note 2: Includes: agricultural, horticultural, hunting, fishing and aquaculture primary production, food preparation and processing; wastes from wood processing and the production of paper, cardboard, pulp, panels and furniture; wastes from the leather and textiles industry; wastes from petroleum refining, natural gas purification and pyrolytic treatment of coal; wastes from inorganic chemical processes; wastes from organic chemical processes; wastes from manufacture, formulation, supply and use of coatings, adhesives, sealants and printing inks; waste from the photographic industry; inorganic wastes from thermal processes; inorganic waste with metals from metal treatment and the coating of metals and non-ferrous hydro-metallurgy; wastes from shaping and surface treatment of metals and plastics; oil wastes; construction and demolition wastes; wastes from human or animal health care/research; waste from waste-treatment facilities, off-site waste water treatment plants; and municipal wastes

6.7 Further Notes on Sensitivity

A site could be screened out if it was a low-medium sensitivity area and if relevant substance thresholds were not exceeded. Guidance on categorising sensitivities is given in Table 6.6.

Table 6.6 Guidance on categorising environmental sensitivity

Category	Area characteristics	Receptor characteristics
Low sensitivity	Heavily industrialised, low quality surface waters, significant flow leading to adequate dilution, not used for abstraction, absence of designated areas, remote from populations (including other industry workforces) and amenity locations. Additional pollutant releases not likely to cause significant deterioration in environment or exceedance of environmental quality criteria.	No sensitive human receptors in, e.g. hospitals and schools. Poor environments in nature/ecological terms (e.g. no rare or special habitat/species); habitats/species relatively insensitive to emissions; no habitat/species at or near limits of viability.
Medium sensitivity	Mixed industrial/residential area, low-density populations nearby, or highly sensitive areas at some distance but potentially in effect range.	Environments with a fair degree natural and ecological value; but no rare or special habitat/species or habitat/species at or near limits of viability.
High sensitivity	Close proximity downwind/downstream of high population and/or highly sensitive environment, e.g. river used for water abstraction, groundwater, designated areas, etc. Surface waters with small flow leading to limited dilution. Further pollutant releases may exceed critical levels or lead to further harm.	Sensitive human receptors in, e.g. hospitals and schools. Very valuable environments in nature/ecological terms (e.g. SSSI); habitats/species very sensitive to emissions; habitat/species at or near limits of viability.

6.8 Further Notes on Exposure Pathways

A chain of events must occur to result in exposure, and this chain in a collective sense is termed an exposure pathway. The pathway is the complete environmental route by which chemicals from the site can reach receptors, and consists of the following elements:

- Source;
- Chemical release mechanisms (e.g. leaching);
- Transport mechanisms (e.g. groundwater flow);
- Transfer mechanism (e.g. sorption);
- Transformation mechanism (e.g. biodegradation);
- Exposure point (e.g. residential well);
- Receptors (e.g. residents consuming potable water from the well); and
- Exposure routes (e.g. ingestion of water).

Pathways for impacts on human receptors can be summarised as follows:

- *Air inhalation* - inhalation of contaminants emitted from a site as dust and inhalation of gases and aerosols;
- *Dermal contact* – skin contact resulting from exposure to airborne dust;

- *Soil/dust ingestion* - ingestion of dust or soil as a result of contamination of hands while playing or working outdoors. Soil and contaminated pasture is also ingested by grazing animals and may enter the human food chain via milk or meat;
- *Water ingestion* - groundwater and surface water containing chemicals can be ingested directly as potable water, it can support fish consumed by humans or it can be used as irrigation water for market gardens, etc;
- *Ingestion of local fish* - the consumption of fish from local streams and rivers is a potentially significant source of indirect exposure to releases from a site; and
- *Ingestion of local produce and crops* – this is a major route of exposure for some pollutants, such as dioxins, lead and fluoride.

Depending on the nature of the activity or on the vicinity of the site, receptors can be exposed via one or a combination of these pathways (see Table 6.7). Some pathways are likely to be more important if a controlled-burn tactic is employed than if the fire is extinguished.

Table 6.7 Some possible pathways for pollutant releases from fires

Release medium:	Route	Exposure
Emissions to air	suspended/dispersed in air	via inhalation of contaminants
	deposited onto soil followed by uptake by crops	via ingestion of crops
	deposited onto soil followed by contamination of aquifers	via drinking water
	deposited onto surface waters	via drinking water, ingestion of fish
Aqueous releases (e.g. firewater runoff)	direct to surface waters and ground waters	via drinking water, ingestion of fish
	to drains then surface waters	via drinking water, swimming and recreation and ingestion of fish
	to drains, STW, then surface waters	via drinking water, swimming and recreation and ingestion of fish

6.9 An Example Environmental Risk Assessment

6.9.1 Incident details

This example assessment is one from a site where a fire had occurred and has been the subject of a research and development case study. A summary of the details is given in Table 6.8. The tactic of controlled burn was applied (albeit after a period of conventional fire fighting) and probably accounted for the quite limited environmental impact. An assessment has also been carried out of the environmental impact of the alternative tactic that could have been employed – extinguishing the fire with large quantities or water and foam.

Table 6.8 Summary of details of South Mimms lorry fire

Substances	Fire on M25 involving a lorry carrying 3600 kg of an azo dye, 10,000 kg of water-based vinyl emulsions and 2000 kg of a non-hazardous fluorescent orange pigment.
Tactical response	Initially water was sprayed on the fire, but polluted firewater was beginning to emerge from the motorway drains into the nearby brook. The fire brigade decided to let it burn. The fire-fighting tactic used in this incident was based on the physical safety of the emergency services and other road users, rather than BPEO. The fire lasted only a couple of hours and resulted in partial closure of M25 on the lorry side. The brook was dammed to prevent pollution of nearby swallow holes and boreholes (although after about 24 hours, heavy rain caused the dam to be breached).
Subjective description of impact on air quality	Most of the 3,600 kg of azo dye combusted, and formed tetramethyl succinonitrile (TMSN). Possible that the HSE 8-h TWA was exceeded leading to a significant exposure of any unprotected operational staff . Evolution of SO_2 could also have resulted in significant exposure. The quantities of formaldehyde and vinyl acetate present, and HCN and NOx generated were less likely to have resulted in significant exposures
Subjective description of impact on surface waters	Dissolution in firewater and ingress into waterway of: TMSN, SO_2 to give sulphates, and HCN to give cyanides, formaldehyde and vinyl acetate. The polymer emulsions are fully miscible with the firewater and could lead to persistent milky discoloration and BOD harmful to aquatic organisms. It is thought that over the pumping period, around 90% of the pollutant was transferred to the foul sewer and that the remainder, in much diluted state, passed to the swallow holes. There were no problems at the nearby STW. Samples showed STW had achieved full treatment and with dilution available in the Colne and Thames, the resulting levels of TMSN were about 10 times less than the water company's "sensitive" level . A micro-invertebrate study was also carried out and no dead micro-invertebrates were found and there was no effect on the macro-invertabrate fauna present in the river. It was noted that the river was turbid and flow was high. Heavy rainfall had probably assisted the dispersion of any chemical remaining in the watercourse after pumping to foul sewer.
Subjective description of impact on groundwater	Fairly significant impact on potable groundwater. Samples showed the elevated levels of TMSN with increased turbidity at one of the boreholes, which was shut down for a week or so and pumped to waste.
Subjective description of impact on land	No details of any significant impacts.

In this instance, a rigid, quantitative risk assessment approach has not been possible because of the lack of quantitative data and a semi-quantitative "risk-ranking" approach was been used. Simple matrices have been used to estimate dose and sensitivity by placing the hazard, transport, location and receptors into broad categories. This procedure was based on similar straightforward approaches used by the Environment Agency (e.g. OPRA scheme), Royal Society of Chemistry (e.g. COSHH in laboratories) and the HSE (e.g. COSHH Essentials). The impacts of the two alternative fire-fighting options on air quality, water and land are summarised in Table 6.9. This tends to confirm that the chosen response – a controlled burn – was the best practicable environmental option. Details are given in the remainder of this section on how the dose, sensitivity and impacts were estimated.

Table 6.9 Summary of environmental impacts of alternative firefighting tactics

Incident	Tactic	Medium	Hazard	Scale	Transport	Dose	Sensitivity	Impacts
South Mimms M25 lorry accident and fire	Controlled burn	Water	3	3	2	2	5	Medium
		Land	2	3	3	3	2	Low
		Air	3	3	3	3	3	Medium
	Put out	Water	3	3	5	4	5	Very high
		Land	2	3	2	2	2	Low
		Air	3	3	1	2	3	Low-med

6.9.2 Estimation of dose

To estimate the dose, it is first necessary to estimate the *environmental hazard* and then the rate of transport to the receptor. Figure 6.9 shows how the substance hazard was assigned a ranking between low and high, taking into effect the following:

- The inherent hazardous nature of the substance: a score was applied ranging from 1 (low level of harm), 2 (slightly harmful), 3 (moderately harmful, not persistent), 4 (highly harmful effects but not persistent; or moderately harmful and persistent), up to 5 (highly harmful effects and persistent); and
- The scale of the release: a score was applied ranging though 1 (very small, i.e. g, ml scale), 2 (small, i.e. kg, litre scale), 3 (medium, i.e. hundreds kg, hundreds litres scale), 4 (large, i.e. tonnes, m^3 scale) and 6 (very large, i.e. hundreds tonnes, hundreds m^3 scale).

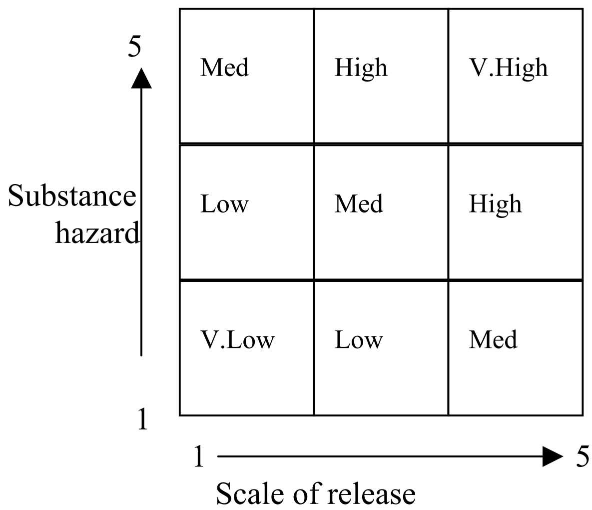

Figure 6.9 Matrix to estimate environmental hazard ranking

The second factor determining the dose, the *transport rate* to the receptor via this pathway, was ranked between low and high. The following were taken into account:

- Duration of the release;
- Flow rate through this pathway, e.g. is there a pathway through fissured rocks to an underlying aquifer?
- Distance and direction to receptor, e.g. would smoke blow towards residential area? and
- Mitigating effects of dilution or dispersion, e.g. would the river's flow rate sufficiently dilute contaminants?

The estimates of environmental hazard ranking and transport rate were next looked at together in a matrix (Figure 6.10) to estimate the dose category.

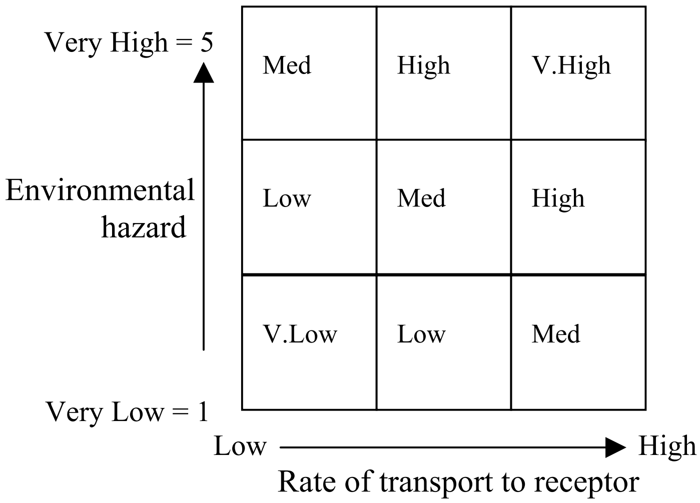

Figure 6.10 Matrix to estimate dose category

6.9.3 Estimation of sensitivity

Having estimated the dose, it was necessary to estimate the sensitivity of the receptor to be able to assess the impact of the release on the chosen receptor via the particular medium and pathway. In assessing the sensitivity, both the location and the nature of the receptors were taken into account. In this assessment, the process is scored 1 to 5, based in part on the Agency's OPRA scheme.

- Score 1: low sensitivity area as defined by Table 6.6.
- Score 3: medium sensitivity area as defined by Table 6.6.
- Score 5: high sensitivity area as defined by Table 6.6.

6.9.4 Assessment of impact

The estimates of dose and sensitivity were then combined in a matrix (Figure 6.11) to assess the importance of the impact of the incident on air quality, water and land.

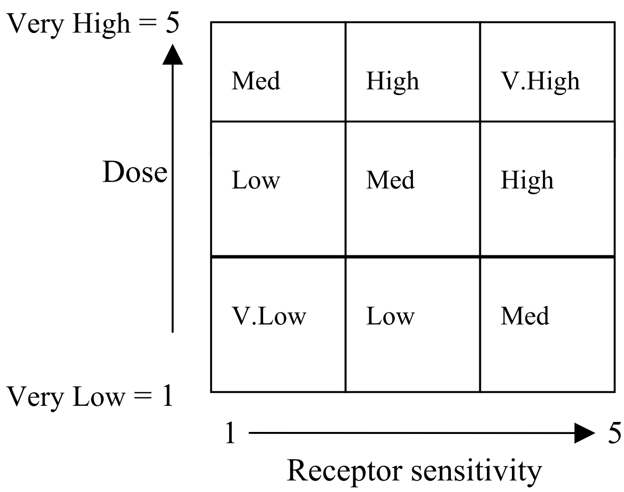

Figure 6.11 Matrix to estimate environmental impact

7. RECOMMENDATIONS AND FURTHER WORK

This report contains sufficient guidance to enable the Environment Agency to modify Pollution Prevention Guidance (PPG) Note 18 to cover controlled burn. A number of areas require development and further work (listed below) and can be added as appendices to future revisions of the PPG Note.

7.1 Develop Substance Threshold Quantities

Without substance threshold quantities, an unmanageable number of sites would require risk assessments, including sites where there is an insignificant environmental risk. The sources of guidance on thresholds for other, related applications summarised in Section 6.6 should be reviewed for their relevance to environmental impacts from fires on all three environmental media (air, land and water). In the absence of any relevant, existing thresholds, new threshold quantities will need to be developed.

7.2 Introduce a Warning Symbol and Sign System

A warning symbol should be developed, complementing those used under the Chemicals (Hazard Information and Packaging for Supply) (Amendment) Regulations 1999[103], to inform the user if a substance is particularly hazardous to the environment.

Sites and mobile sources (e.g. road tankers) storing, transporting or using substances in excess of defined threshold levels should display warning signs in a similar manner to HAZCHEM signs. This will enable emergency services to have some forewarning of what to expect when attending a fire. Progress is already being made in this area: a joint initiative between the Environment Agency, emergency services, haulage industry and other industries aims to develop a low-hazard marking scheme.

7.3 Accelerate Identification of At-Risk Sites

It is important that action is taken now to identify the highest-risk sites. This can be carried out in advance of development of specific substance thresholds, based on the professional judgement of Agency staff and Fire Service staff.

7.4 Develop Financial Impact Assessment Procedure

The assessment of financial impacts in the case studies was hampered by a lack of available information on costs. It is important that the Agency defines which of the cost categories should be included in any balance between financial impact and environmental impact. Liaison with the Home Office and insurers is required to develop this. The costs may include some or all of the following:

- contingent costs, e.g. litigation and legal expenses, personal injury, natural-resource damage, and remediation costs;
- conventional up-front costs, e.g. staff costs, capital equipment, materials and supplies.
- partially-hidden environmental costs, e.g. site studies, planning, reporting, records keeping, permitting, training and audits; and

- image and relationship costs, e.g. corporate image, relationship with industry, relationship with investors, relationship with insurers, relationship with staff, relationship with lenders and relationship with host communities.

Once the costs categories have been agreed, the Agency and Fire Service should ensure they have mechanisms in place to record the costs of incidents, to build-up a body of knowledge of their costs.

Guidance should be provided to operators on which of the above cost categories they may incurr can be included in the balance between financial impact and environmental impact.

Further research and information-gathering is required to enable the estimation of costs not "owned" by the Agency, Fire Service and operator. For example, the cost of 100 dead coarse fish, the cost of closing a motorway for 1 hour, or the approximate cost to the retail industry of 10,000 square feet of premises closed for a day because of a smoke plume.

7.5 Define Important Buildings and Clarify their Treatment

Some buildings have particularly high value, not just in rebuilding costs, but because of their architectural, cultural or historical significance. The value placed on the loss of such an important building must be weighed against the environmental benefit of a controlled burn (should this be shown to be the BPEO), but it is likely that attempts to save some important buildings will always be made. Further guidance is needed on how the risk assesments should treat this issue. At one extreme, a list of special buildings could be excluded from BPEO condiderations. The other approach would be to assign a monetary value to the architectural, cultural or historical significance and incorporate this in the balance between financial impact and environmental impact.

7.6 Improvement of Communications between Organisations

Contacts between interested parties (especially the Agency and Fire Service) are already generally good, but with some regional diffrences. If the production of emergency fire plans and BPEO assessment of firefighting tactics is to develop properly, these communications should be improved to a consistent level across the regions. This would include consitency of policies towards use of types of pollution-prevention equipment, e.g. drain blockers.

Consideration should be given to developing links between Agency staff and local authority Emergency Planning Officers, to ensure opportunities are taken to include BPEO considerations in off-site emergency plans for relevant (e.g. COMAH) sites.

7.7 Promotion of Emergency Fire Plans and BPEO Assessments

Success will depend heavilly on getting the message effectively to the small-medium enterprises currently unregulated by existing, specific environmental law. Industry and local authorities are not all aware of the existence of the current PPG 18; the profile of any new PPG Note on controlled burn must be better. The message may be by, for example, advertisments in jounals and posters.

7.8 Legal Issues

Some of the legal issues are not at present resolved completely, and are likely to be so only following case-law decisions.

APPENDIX 1

ENVIRONMENTAL IMPACT AND RISK ASSESSMENT SCHEMES

A1.1 Environment Agency BPEO Impact Assessment

The simplified approaches[104,105,106,107,108] used in many countries are based on the concentration of the polluting substance in the environment in comparison to a reference concentration. The environmental effect of a substance released to a particular medium is quantified as the Environment Quotient (EQ) for that substance in that medium. The EQ is the ratio of the process contribution (PC) – for the purposes of this study a fire incident - to the reference level. Provisional values for the latter have been published by the Agency in the form of Environmental Action Levels (EALs) for a wide range of substances in air, water and on land.

$EQ_{(substance)} = PC / EAL$

The guidance contains details on when substance releases can be considered insignificant. Where there are several substances released to more than one environmental medium, a broad indication of the overall direct effects on the environment of all these releases can be obtained by summing the EQs. The sum over all releases to a single medium is given by:

$EQ_{(medium)} = EQ_{(a)} + EQ_{(b)} + ... EQ_{(i)}$

The overall effects in water, air and land can be expressed as the sum of the three Environmental Quotients and the quantity so obtained is known as the Integrated Environmental Index (IEI).

$IEI = EQ_{(air)} + EQ_{(water)} + EQ_{(land)}$

The final stage of the process is to compare both the costs and environmental benefits of each option. This assessment process is summarised in Figure A1.1.

The Agency guidance also proposes an indicator for waste arisings, i.e. solid or liquid material not released to air or water, but the treatment and disposal of which may have some effect on the environment. The method[109] compares waste arisings from different environmental options and is based on that developed by the UK Government Industry Working Group on Priority Setting and Risk Assessment.

As well as the direct environmental effects for which the EQs and IEI provide indicators, released substances can have indirect environmental effects such as climate change and subsequent chemical transformations in the atmosphere. Though methods have been developed for assessing these, such indirect effects are not within the scope of this study.

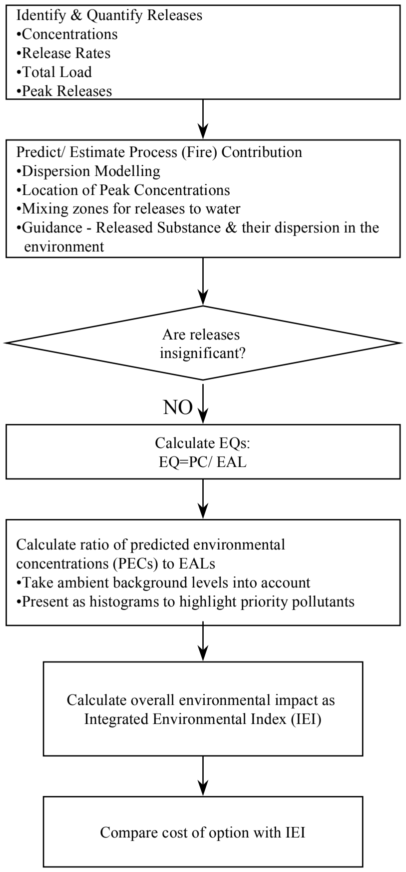

Figure A1.1. The BPEO process

A1.2 COMAH Safety Report Environmental Risk Assessment

One of the major differences from the predecessor regulations (CIMAH) is the increased emphasis under COMAH on major accidents that may affect the environment. The Environment Agency, on behalf of the COMAH Competent Authority, has produced practical guidance[79] on a structured approach to undertaking environmental risk assessment (ERA) under COMAH. The main issues covered by this guidance refer to risks to flora and fauna, rather than the direct impact on people (though it does include indirect risks to people, for example, via contamination of drinking water or crops). The non-prescriptive guidance contains descriptions of the principles and likely information requirements of the environmental risk assessment.

There is a hierarchy of risk assessment approaches of increasing complexity ranging from simple qualitative estimates through semi-quantitative assessments to fully-quantitative risk analyses. For compliance with the COMAH regulations, the depth and type of risk assessment required will vary from installation to installation, but is likely to be proportionate to:

- the scale and nature of the major accident hazards presented by the installations and activities on them;
- the risks posed to neighbouring populations and the environment and the extent of the possible damage; and
- the complexity of the major accident hazard process and activities, and difficulty in deciding and justifying the adequacy of the risk-control measures adopted.

The guidance recognises that even though the techniques for ERA are generally available, there is sometimes a paucity of associated quality environmental data. This means that pragmatic, but justified, choices may need to be made during the ERA process. When data are deficient the "Precautionary Principle" should be applied, i.e. choices should overestimate rather than underestimate the risks.

The main processes involved in undertaking an ERA for COMAH are summarised in Figure A1.3. The basic philosophy is to adopt screening and prioritisation tools at an early stage and reserve more sophisticated risk assessment techniques for high priority, more complex risks. The choice of approach will depend on a variety of factors such as:

- the extent to which the risk assessment is to be used to influence risk management decisions beyond the requirements of the COMAH Regulations; and
- the degree of understanding of the dispersion and dilution processes affecting a pollutant between its point of release on-site and its transport to receptors.

Accident risks should be screened-out as early as possible: there are different points in the processes (denoted A, B and C in no order of preference in Figure A1.2) at which criteria can be used to screen-out risks from further consideration within the risk assessment on the basis that they are not significant. Where assessment is undertaken purely for demonstrating compliance with the COMAH Regulations, and there is a good understanding of the effects of dilution/dispersion, then the "A" path should result in less effort since it allows early screening-out of non-major accident hazards.

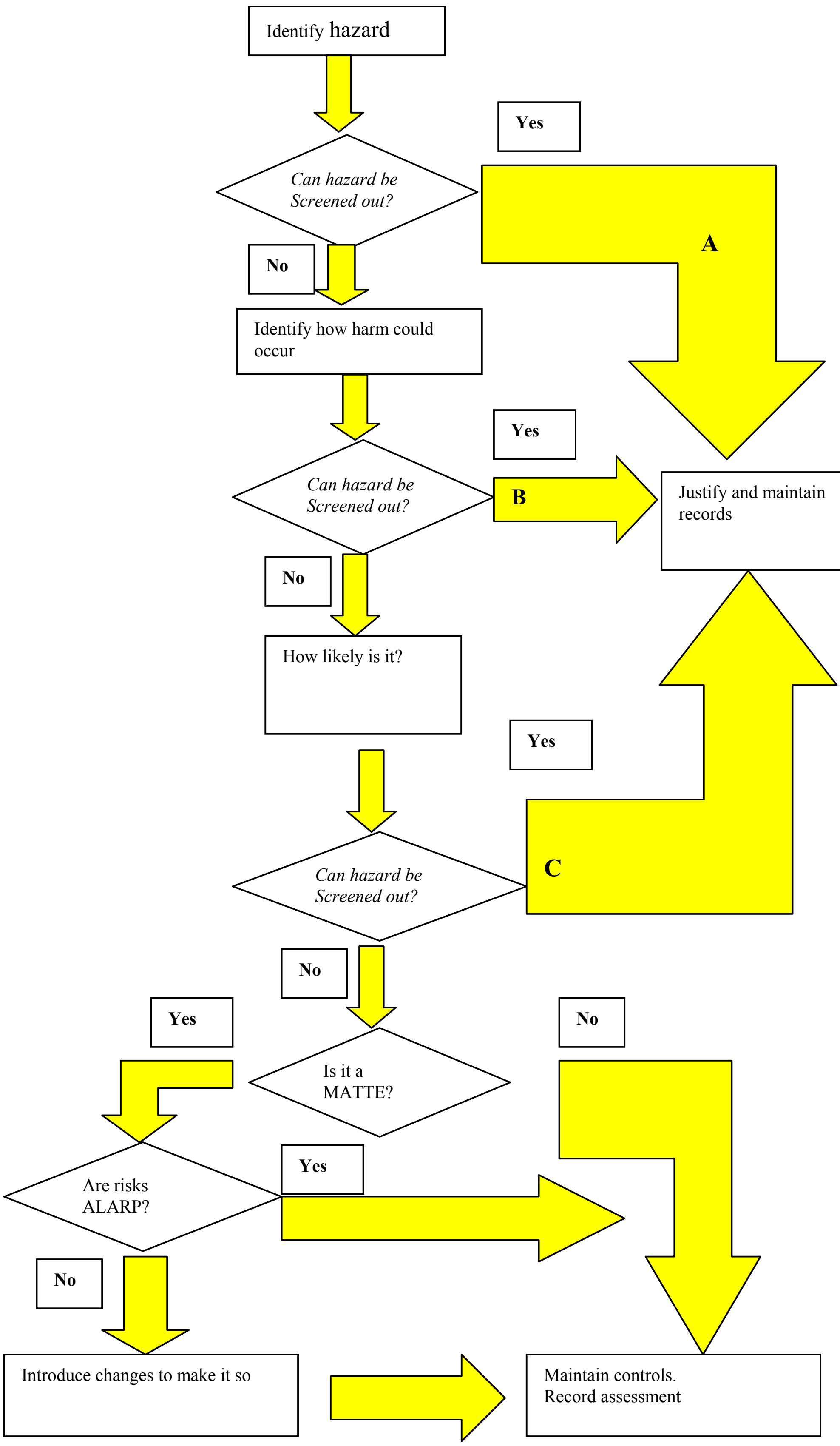

Figure A1.2 The basic processes involved in undertaking an environmental risk assessment for the COMAH Regulations[79]

Risk rating/ranking schemes can be valuable in identifying risks of primary concern so that these can be investigated first and the results used to focus subsequent investigation of lesser risks; where the risks of primary concern can be shown not to be important, then there is no need to consider the lower priority risks.

One of the basic criteria used to determine if the hazard is to be considered further, is whether the accident is a Major Accident To The Environment (MATTE). Operators may chose to use a less severe accident than a MATTE as the threshold determining whether or not the hazard is considered further; however, all accidents that are at least as severe as a MATTE *must* be considered. The definition of a "major accident" in the Regulations is: *"an occurrence (including in particular, a major emission, fire, or explosion) resulting from uncontrolled developments in the course of the operation of any establishment and leading to serious danger to human health and the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances".* Specific guidance lists the key parameters influencing the judgement of the scale of events that would be classed as MATTEs as a combination of:

- the recovery time; the spatial extent of the damage; and
- the severity of the damage (e.g. numbers affected).

If comparison of the Predicted Environmental Concentration (PEC) resulting from the fire is below the Environmental Quality Standard (EQS) or No Observed Effect Concentration (NOEC), then the impact on the environment is to be too small to be considered a MATTE. The accident hazard can then be eliminated from the risk assessment. For accident hazards which cannot be screened out, the easiest next step is generally to review the data and assumptions used to see if either there is an undue degree of conservatism in any of the values/choices selected; and whether the models used are too simplistic and do not properly take into account factors that would reduce the PEC. However, at some point no further screening out of hazards will be justified, and it may be necessary to consider the effect on ecosystems and indirect effects on people, taking into account the concentration-time profile of exposure, and the area affected.

The COMAH guidance recognises that releases during accidents (especially fires) at some installations can consist of a cocktail of chemicals. In such cases there is the additional need to predict the composition of the release, taking into account the presence of combustion or reaction products, including those not normally present in the process, and any other materials mobilised during the accident. It should be possible to identify these compounds, although there will generally be some uncertainty concerning the quantities involved. The guidance suggests the following two relatively simple approaches which may provide sufficient confidence in the predictions from the risk assessment:

a) Instead of trying to consider the full cocktail of chemicals, choose a suitable representative "marker" chemical as an indicator of environmental effects. The Precautionary Principle should govern the selection of the marker.
b) Review information on accidents to see what the effects have been and where they have occurred. Use this information to identify any similarities with the situation of concern, which may enable a judgement to be made on its likely effects.

It is important, however, that the uncertainties in the predictions from these (and indeed any other) approaches are properly recognised in making any decisions.

In some circumstances, the two simplified approaches described above will not be suitable. This may be when there are possible antagonistic or synergistic effects of chemical mixtures on the environment. In these and some other circumstances, there may be no practicable alternative to either undertaking a detailed environmental risk assessment or, alternatively, reducing the risks by introducing physical systems or risk management practices. The essential information that is expected in a COMAH environmental risk assessment is:

- Hazardous substances information;
- Site description;
- Description of the local environment;
- External factors (e.g. geology, earthquakes, subsidence, flooding, weather, air traffic);
- Hazard identification and quantification;
- Frequency assessment;
- Consequence assessment;
- Risk management; and
- Off-site emergency planning.

The guidance contains advice on carrying out all the above elements of the risk assessment. The guidance has clearly been developed with accidental releases, including fires, as one of the intended applications. The top-tier COMAH sites should already have in place an on-site emergency plan based on an assessment of major accidents (including fires) that takes the ERA into account. For lower-tier COMAH sites and sites not covered by COMAH, the ERA approach is still valid: the guidance on cocktails of reaction and combustion products would be especially useful in any simplified guidance developed for these sites. Similarly, the essential information referred to in the preceding paragraph applies to all sites, although some components (e.g. hazard identification, frequency assessment and consequence assessment) may need to be simplified.

A1.3 Environment Agency Risk Assessments for Water Protection Zones

A "catchment inventory" of hazards (stored chemicals or chemicals in reaction vessels) is compiled to enable initial screening, prior to more complex assessments. A threshold quantity is applied to avoid including prohibitively large amounts of data on very small quantities of substances, which will usually present a negligible risk. The cut-off quantity is determined by consideration of the most toxic substances that might be found, and the initial dilution that might be afforded if they were accidentally released.

A Rapid Risk Assessment is then carried out. This quick, practical risk assessment tool makes use of readily available data, and does not require the use of a computer and can be used by non-specialists. There are three levels in this suite of checklist-type assessment, which provided a point-of-entry to the risk management process. The first stage, known as Initial Hazard Assessment, required the hazard to be subjectively assessed against 15 possible issues, divided into categories of:

- type of site/activity;
- substances;
- incident history;
- vulnerability of watercourse/groundwater; and
- use of watercourse/groundwater.

The second-level assessment, known as Primary Risk Assessment, uses a scoring system to reduce subjectivity, and considers the same issues in more detail and with greater emphasis on site management, but the need for detailed toxicity and flow information is kept to a minimum.

The third-level assessment has greater data requirements, requiring both river flow and toxicity information. It overlaps with a simple PRAIRIE assessment (see below), but can still be undertaken without the use of a computer. This hierarchy of assessment levels acts as a screen, ensuring that only the sites or activities that appear unsatisfactory in the simpler assessments were considered by the more complex techniques. The cost-benefit assessment is also considered at each stage of the assessment (see Figure A1.3).

For a full risk assessment, prediction of the consequence element of the risk management process in rivers is carried out using PRAIRIE (Pollution Risk from Accidental Influx to Rivers and Estuaries), a piece of PC-based software consisting of:

- DYNUT - a one dimensional aquatic dispersion model applicable to non-tidal rivers or streams;
- a substance database, including physico-chemical data and toxicity information (currently on 250 substances);
- a hydrogeological database, containing information on river flows and weirs;
- a tabular and graphic output; and
- a standards database, containing limits relevant to potable water and the environment.

The model requires data on distances, flows, velocities and the longitudinal dispersion coefficient, and is capable of representing the situation where a chemical is spilt into a tributary, which subsequently enters the main river. As an option the model is able to predict the reductions in river concentrations caused by various sink processes which may occur such as volatilisation, photolysis, oxidation, adsorption to sediment and hydrolysis.

The spill-risk assessment is the part of the risk management process that is most specialised and involves the assessment of the probability of various release scenarios occurring. Again, a screening process is used to eliminate chemical stores which, even in a realistic worst-case spill scenario, could not result in concentrations of concern being exceeded in the receiving water. When a spill risk assessment is required, it is necessary to identify all of the possible scenarios that might result in the substance entering the watercourse. In many cases this will depend on a chain of events occurring, with a probability attached to each stage. The chain of events for each scenario will include the failure of containment devices, such as bunds. Generic failure rate data are used to calculate the probability of each alternative combination of events occurring. When PRAIRIE is run in its probabilistic mode for the series of possible combinations of events producing spills of varying size, each with a related probability, it produces a frequency versus concentration curve for assessment against the relevant risk criteria.

Potable water risk criteria have been developed to decide whether the risks to the potable water supply from hazardous substances are acceptable. These are based on the philosophy that a plot of frequency versus severity contains three regions:

- a region associated with low risks which are considered “acceptable”;
- a region of high risks which are considered “intolerable”; and
- an intermediate region, where risks may be “tolerable” providing that they are As Low As Reasonably Practicable (ALARP).

In determining whether the consequences from accidental releases are acceptable, it is necessary to consider a range of effects from minor impacts such as taste and odour complaints, through to health effects which in some circumstances might be potentially severe.

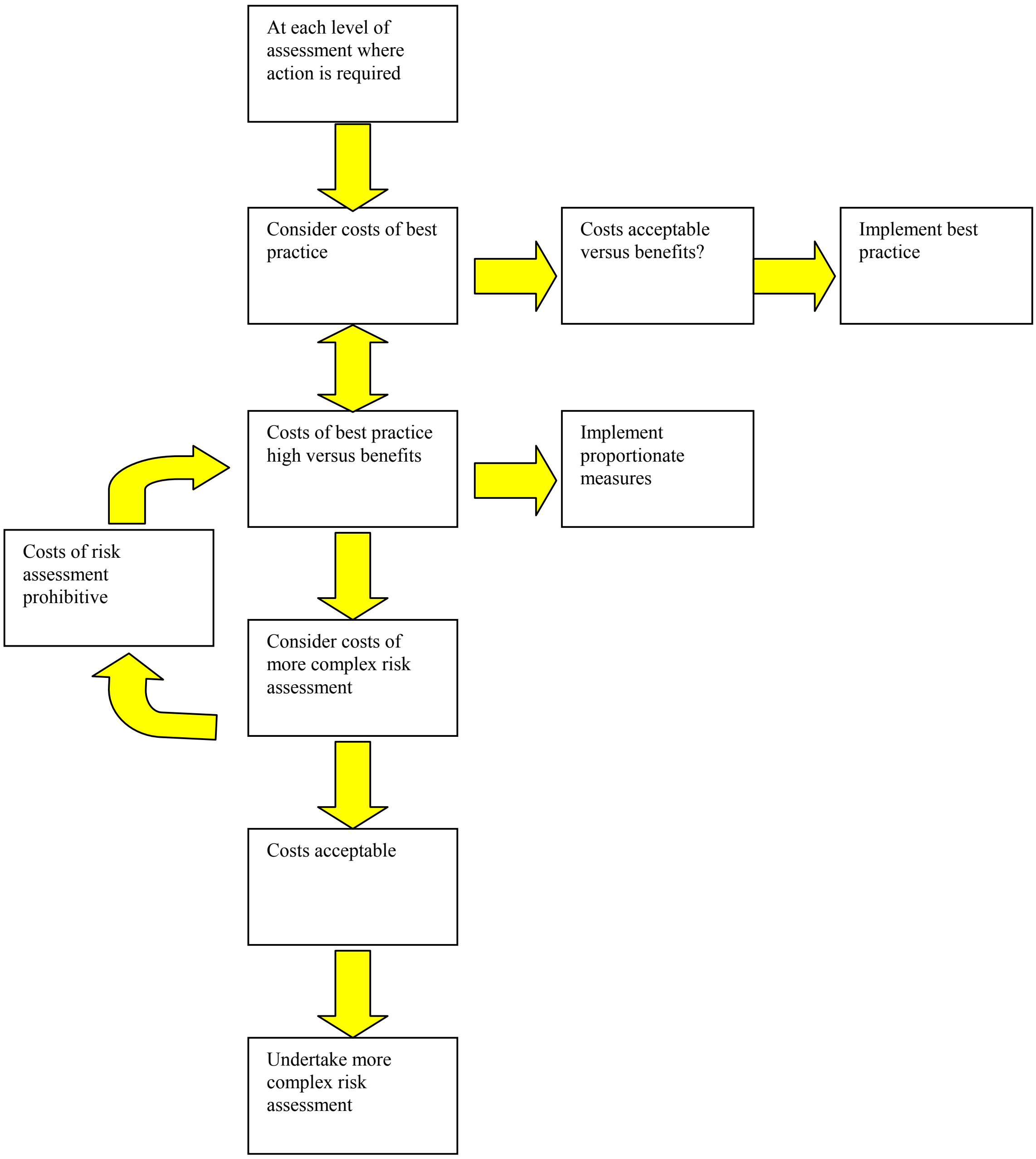

Figure A1.3 Risk assessment cost-benefit protocol[12]

A1.4 Environment Agency Risk Assessment for Landfilling of Household Wastes

The framework procedure for the risk assessment comprises of the following elements[80]:

Hazard identification - consideration of the properties and concentrations of the chemicals on the site that could give rise to harm, their spatial distribution and how they could move in the environment from the site to potential receptor points. The data are consolidated to stress the chemicals of concern (i.e. those representing the majority of risk posed by the site). The surrogate chemicals are selected on the basis of which compounds best represent the risk posed by the site:

- the most toxic, persistent and mobile
- the most prevalent in terms of frequency of detection and concentrations; and
- those exposed in the most significant exposures.

Release and transport of contaminants - the concentrations of contaminants at the exposure points via all relevant pathways must next be estimated. Mathematical models are used to calculate the transport of chemicals through air and water. For groundwater contaminants, hydrogeological models can be used to estimate the concentration downstream. The LANDSIM bespoke computer package uses a Monte Carlo simulation technique to sample randomly the model variables within a defined probability distribution. This was used to model the attenuation of organic and inorganic chemicals as the leachate passes vertically through the unsaturated zone beneath the landfill and the subsequent lateral transport of leachate via groundwater to an offsite receptor. For dust and gaseous chemicals released to the atmosphere, diffusion models can be used with representative meteorological conditions to predict downwind concentrations on and off the site.

Exposure assessment - a wide range of exposure pathways is considered. Estimation of dose at the point of exposure is calculated as a function of the estimated concentrations of the released chemicals in the environmental media with which individuals come into contact (i.e. exposure point concentrations) and the duration of contact. Exposure-dose equations are used to combine exposure factors (based on activity patterns of sub-groups within the population) with exposure point concentrations to estimate the received dose. These dose equations are dependent on the route of exposure (i.e. ingestion, inhalation and dermal contact).

Toxicity assessment - the next stage establishes the dose-response relationship for each of the indicator chemicals. For the purposes of quantifying human health risks, chemicals are typically characterised as carcinogens and non-carcinogens. The latter have threshold doses below which they fail to elicit any discernible adverse health effect. Applying safety factors to account for inter-species variability and sensitivity among different members of the population, this threshold is converted to an Acceptable Daily Intake (ADI) or Tolerable Daily Intake (TDI).

Risk estimation and evaluation - the steps in risk evaluation are:

- from the exposure-assessment stage, the total intake of each chemical into the body is estimated; then
- the intake of each chemical is compared against an appropriate TDI or reference dose, to obtain a Hazard Index (HI).

Thus the criterion for "acceptable" air or water quality in relation to a pollutant released from the landfill is the ratio of the modelled exposure concentration for that pollutant to its air or water quality standard (i.e. the HI). The ratio should not exceed 1.0, since this would indicate that the exposure concentration is equal to the standard for air or water quality. The lower the ratio, the less impact the emission has on air or water quality. There is no agreed method for the assessment of health risks from exposure to mixtures of chemicals. The criterion for acceptability is that the summed Hazard Index should not exceed 1.0, which demonstrates that the safety standard is not exceeded for a mixture of chemicals. Thus:

$HI_{total} = HI_a + HI_b + HI_c + ... < 1.0$

APPENDIX 2
GLOSSARY

ABI: Association of British Insurer
ACL: Approved Carriage List
ACTS: Advisory Committee on Toxic Substances
ADR: (French abbreviation for) European Agreement Concerning the International Carriage of Dangerous Goods by Road
AHA: Area Health Authority
ALARP: As Low As Reasonably Practicable
BASIS: British Agrochemical Standards Inspection Scheme
BAT: Best Available Techniques
BATNEEC: Best Available Techniques Not Entailing Excessive Cost
BIA: Biodiversity Impact Assessment
BOD: Biological Oxygen Demand
BPEO: Best Practicable Environmental Option
CACFOA: Chief & Assistant Chief Fire Officers` Association
CAS: Chemical Abstracts Service
CDCRoad: Carriage of Dangerous Goods by Road Regulations
CDGCPL2: Carriage of Dangerous Goods (Classification, Packaging and Labelling) and Use of Transportable Pressure Receptacles Regulations
CEA: Comité Européen des Assurances
CHIP: Chemicals (Hazard Information and Packaging for Supply) (Amendment) Regulations
CIA: Chemical Industries Association
CIEH: Chartered Institute of Environmental Health
CIMAH: Control of Industrial Major Accident Hazards Regulations
CIRS: Chemical Incident Response Service
COMAH: Control of Major Accident Hazards Regulations
COSHH: Control of Substances Hazardous to Health
DETR: Department of the Environment Transport and the Regions
EAL: Environmental Assessment Level
EC: European Community
EHIA: Environmental Health Impact Assessment
EHO: Environmental Health Officer
EIA: Environmental Impact Assessment
EINECS: European Inventory of Existing Commercial Chemical Substances
ELINCS: European List of Notified (New) Chemical Substances
EOC: Emergency Operation Centre
EPA90: Environmental Protection Act 1990
EPO: Environment Protection Officer
EQ: Environment Quotient
EQO: Environmental Quality Objective
ERA: Environmental Risk Assessment
EU: European Union
HDNI: Heritage Department of Northern Ireland
HI: Hazard Index
HPV: High Production Volume (chemicals)
HSAW: Health and Safety at Work (Act 1974)
HSC: Health and Safety Commission

HSE: Health and Safety Executive
ICCA: International Council of Chemical Associations
IEI: Integrated Environmental Index
ILGRA: Inter-Departmental Liaison Group on Risk Assessment
IPC: Integrated Pollution Control
IPPC: Integrated Pollution Prevention and Control
ISO: International Standards Organisation
LAAPC: Local Authority Air Pollution Control
LPC: Loss Prevention Council
MAPP: Major Accident Prevention Policy
MAFF: Ministry of Agriculture Fisheries and Food
MATTE: Major Accident To The Environment
MoU: Memorandum of Understanding
NONS: Notification of New Substances Regulations 1993
NIMBY: Not In My Backyard
NIRS: National Incident Reporting System
NGO: Non-Governmental Organisation
NRA: (the former) National Rivers Authority
OEL: Occupational Exposure Limit
OECD: Organisation for Economic Co-operation and Development
OiC: Officer in Charge
OPA: Operator Performance Appraisal
OPRA: Operator and Pollution Risk Appraisal
PC: Process Contribution
PEC: Predicted Environmental Concentration
PHA: Pollution Hazard Appraisal
PNEC: Predicted No Effect Concentration
PPG: Pollution Prevention Guidance (note)
PRA: Probabilistic Risk Assessment
PRAIRIE: Pollution Risk from Accidental Influx to Rivers and Estuaries
QRA: Quantitative Risk Assessment
R&D: Research and Development
RID: (the French abbreviation for) the European Agreement Concerning International carriage of Dangerous Goods by Rail
RSC: Royal Society of Chemistry
SEA: Strategic Environmental Assessment
SEPA: Scottish Environmental Protection Agency
SHH: Substances Hazardous to Health
SIA: Social Impact Assessment
SME: Small and Medium Size Enterprise
SNARL: Suggested No Adverse Response Level
SSSI: Site of Special Scientific Interest
STP: Sewage Treatment Plant
STW: Sewage Treatment Works
TWU: Thames Water Utilities Ltd
TDI: Tolerable Daily Intake
TWA: Ttime-Weighted Average
UK: United Kingdom
UK PIA: UK Petroleum Industry Association
UN: United Nations

WPZ: Water Protection Zone

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