Guidance on the Environmental Risk Assessment Aspects of COMAH Safety Reports

COMAH Competent Authority

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Preface

The Control of Major Accident Hazards Regulations bring into force in the UK the requirements of the Council Directive on the control of major accident hazards involving dangerous substances ('the COMAH Directive'). This requires operators of establishments where dangerous substances are present to take all measures necessary to prevent and mitigate the effects of major accidents to man and to the environment. Demonstration of the presence of adequate safety measures is a key part of this process.

This document has been produced, by the COMAH Competent Authority, to provide guidance on the requirements of the COMAH regulations, in so far as they relate to environmental risk assessments (ERA), and how these may be met. The document provides detailed environmental guidance to supplement Competent Authority documents such as 'How to prepare a Safety Report' and the 'Safety Report Assessment Manual'. The focus of attention herein is risks to flora and fauna and indirect risks to people, for example via contamination of drinking water or crops. It is intended that this document be available as guidance to those undertaking or evaluating environmental risk assessments under COMAH. The document will be continually reviewed and comments are welcome from industry as an input to this process.

The nature and variability of environmental risks at establishments subject to the COMAH regulations means that it is not possible, at present, to provide a definitive approach to an environmental risk assessment; nor is it currently possible to provide simple easily measurable criteria for assessing its adequacy. This guidance is non-prescriptive and contains descriptions of the principles and likely information requirements, accompanied by qualitative/descriptive criteria for assessing adequacy.

The overall approach required within an environmental risk assessment is the same as that applied to accidents affecting human safety. Under COMAH, safety and environmental risks are given equal importance and should be treated, where practicable, in an integrated way.

Since the risk assessment activity is linked to risk management it is generally an iterative process, starting with simple methods and cautious assumptions, and only proceeding to more complex methods with better defined input data where these are needed to meet the objectives of the assessment. In this instance, the objectives are to demonstrate that all necessary measures have been taken to prevent major accidents and limit their consequences.

It is acknowledged that whereas the requisite techniques for an environmental risk assessment are generally available, there is sometimes a paucity of associated quality environmental data; this situation can give rise to the need to make pragmatic, but justified, choices during the risk assessment process. Hence the depth of treatment achievable in risk assessments focussed on direct risks to people may not always be possible when evaluating wider environmental risks. Nevertheless, the risk assessment process is extremely valuable in facilitating the management of risks to the environment associated with major accident hazards and the absence of information cannot be used by operators as a justification for failing to complete a risk assessment.

There is a fundamental requirement as part of fulfilment of their duties under the COMAH regulations for operators to approach the environmental risk assessment in a systematic way and clearly to demonstrate that measures are in place to prevent major accidents and to limit their consequences if they occur. To aid operators in following a systematic approach guidance is provided on possible elements of a Safety Report together with an indication of the criteria that will be used by assessors (Appendices 1 & 2).

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Introduction

The Control of Major Accident Hazards (COMAH) Regulations (SI 1999/743) bring into force in the UK the requirements of Council Directive 96/82/EC on the control of major accident hazards involving dangerous substances ('the COMAH Directive'). This requires operators of establishments where dangerous substances are present to take all measures necessary to prevent and mitigate the effects of major accidents to man and to the environment. Demonstration of the presence of adequate safety measures is a key part of this process.

The Regulations are enforced by the Health and Safety Executive and the relevant environment agency[1] acting jointly as the Competent Authority. The environment agencies are principally concerned with assessment of the environmental aspects of COMAH. Operators who were previously subject to the control of industrial major accident hazards regulations (the 'CIMAH' regulations) will recognise similarities between these and the new COMAH regulations. However, one of the key differences between the two is the increased emphasis under COMAH on major accidents that may affect the environment. The document provides detailed environmental guidance to supplement Competent Authority documents such as 'How to prepare a Safety Report' and the 'Safety Report Assessment Manual'. Thus, this guidance has been written to provide practical advice on how to conduct an environmental risk assessment (ERA) in the context of the COMAH regulations. In this respect, the particular concern is events that do not have a direct impact on people. This means that the main issues discussed in this document refer to risks to flora and fauna and to indirect risks to people, for example via contamination of drinking water or crops.

The distinction between a risk assessment that addresses direct effects on people, as opposed to indirect effects on people and those on flora/fauna, is made to explain the basic purpose of this document. However, that is not to say that the techniques used for each are fundamentally different. The same basic methodology can be used irrespective of the receptor at risk. It can also be used for risk assessments undertaken for other purposes, although there may be a different emphasis on the level of risk which is of concern; for the purposes of the COMAH regulations, attention is focussed on major accidents.

This document sets out the requirements of the COMAH regulations, in so far as they relate to environmental risk assessments, and then discusses how these requirements may be met. However, it is recognised that the subject of risk assessment is one that is already well documented and that some of the techniques used are major subjects in their own right. This guide thus seeks to identify the Agencies' general expectations within the present context and to guide the risk assessor to suitable references wherein more detailed information on some of the requisite techniques can be found.

It is intended that this document be available as guidance to those undertaking or evaluating environmental risk assessments under COMAH. There is thus the expectation that there may be a range of pre-existing environmental risk assessment experience amongst readers. The guide therefore seeks to

[1] In England and Wales this is the Environment Agency. In Scotland it is the Scottish Environment Protection Agency.

strike a balance between providing detailed instructions on specific topics and a more general overview of the relevant issues that need to be addressed. It therefore starts with a general introduction to 'risk' and then moves into a more detailed discussion of specific aspects. Readers already experienced in either undertaking risk assessments or making judgements based on their results may wish to focus their attention on the latter part of the guide. Likewise, although the aim has been to make the guide reasonably self-contained, some readers may wish to refer to other documentation to assist them with understanding some issues or techniques in more detail than has been provided herein.

It is acknowledged that whereas the requisite techniques for an environmental risk assessment are generally available, there is sometimes a paucity of associated quality environmental data; this situation can give rise to the need to make pragmatic, but justified, choices during the risk assessment process. Hence the depth of treatment achievable in risk assessments focussed on direct risks to people may not always be possible when evaluating wider environmental risks. Nevertheless, the risk assessment process is extremely valuable in facilitating the management of risks to the environment associated with major accident hazards and the absence of information cannot be used by operators as a justification for failing to complete a risk assessment. Identification of the need for additional data should initiate a pro-active approach to its collection. When data are deficient the 'precautionary principle' should be applied, that is, choices should be made which overestimate rather than underestimate risks.

There is a fundamental requirement as part of fulfilment of their duties under the COMAH regulations for operators to approach the environmental risk assessment in a systematic way and clearly to demonstrate that measures are in place to prevent major accidents and to limit their consequences if they occur.

To help address this requirement, this guidance includes a list of possible elements that might occur in a COMAH safety report to address the Environmental Risk Assessment requirements (Table 2). A checklist for assessors of COMAH Safety Reports is provided in Appendix 1 and further suggestions as to what each section might contain, together with criteria for assessors are detailed in Appendix 2. These are not intended to be prescriptive, but to provide an indication of the type of approach that would be acceptable. If the operator wishes to follow a different structure and employ different approaches this may be acceptable, as long as it meets the requirements of the COMAH Regulations.

1 Concepts relating to risk assessment

This chapter provides an overview of some of the key issues associated with risk assessments. It begins by discussing what is meant by 'risk' and then gives an overview of the risk assessment process and what is required to comply with the COMAH regulations; subsequent chapters look at particular aspects in more detail.

1.1 HAZARD AND RISK

The COMAH Directive provides formal definitions of the above terms as follows:

> 'hazard' shall mean the intrinsic property of a dangerous substance or physical situation, with a potential for creating damage to human health and/or the environment;
>
> 'risk' shall mean the likelihood of a specific effect occurring within a specified period or in specified circumstances.

These definitions will be used by the Competent Authority in carrying out its duties under COMAH. However, it may be useful to consider the terms in less formal language whereby a 'hazard' is a situation with the potential to cause harm, and the 'risk' associated with that hazard is defined in terms of the potential level of harm and the likelihood of that harm occurring. Risk is thus a combination of a consequence and the probability of occurrence of that consequence. For example, a pipe-bridge carrying a toxic liquid across a watercourse would be a hazard; the corresponding risk might be that there was a 1 in 100 chance per year that the bridge would fail and kill 500 coarse fish.

Techniques for hazard identification are discussed later. However, some hazards are less readily identifiable than others, and it is important to recognise that, as well as a any direct hazards posed by dangerous substances, an establishment may also pose a hazard to the environment as a result of a release of other substances mobilised or formed during the course of the accident involving the dangerous substance. For example, a fire may lead to a release of asbestos from the building structure or the formation of combustion products with significantly different properties to those of the materials burnt.

1.2 RISK ASSESSMENT

Risk assessment involves understanding the nature of hazardous situations, what their outcome may be and how likely it is that adverse effects will occur. Allied to this procedure is the comparison of the results of a risk assessment with risk acceptability criteria and the determination of the need for risk management action. This is based on the concept of risk tolerability which requires that measures are taken to reduce the likelihood of hazards and to limit their consequences until further reduction of risks cannot be justified, that is, that the risks are 'as low as reasonably practicable' (ALARP).

The ALARP concept implies that ultimately there is a trade-off between the costs of risk reduction and the benefits obtained. This concept is often referred to as BATNEEC[2] (Best Available Techniques Not Entailing Excessive Costs) when applied to environmental risks. In general, the higher the scale of the hazard and the associated risks, the more the balance should tilt in favour of adopting further measures to control risks. This is unless the costs - in money, time and trouble - are clearly disproportionate compared to the benefits gained from the risk reduction. Operators will therefore need to define the basis of their decision making, when demonstrating that all measures necessary for controlling major accident hazards have been taken. For risks considered to be ALARP or BATNEEC, risk management action includes the monitoring and checking of risk minimisation procedures to ensure that the situation does not deteriorate.

The risk assessment process can be viewed as addressing seven basic questions:

i) **What Can Go Wrong?** i.e. identification of the sources of potential accidents and the ways they could happen (hazard identification);

ii) **How Often?** i.e. an estimate of the probability of their occurrence (source frequency);

iii) **What Gets Out and How Much?** i.e. evaluation of the size of the release from knowledge of the material(s) in question and release rate calculations;

iv) **Where Does It Get To?** i.e. dispersion (and deposition) predictions for the release;

v) **What Are The Consequences?** i.e. an estimate of the potential consequences of the accidents (consequence assessment);

vi) **What are The Risks?** i.e. determination of risk levels derived from the above analyses, and assessment of their significance; and

vii) **So What?** i.e. risk management action.

Different methods are used to address each of the above questions, although this is not always apparent in some integrated risk assessment tools. For example, fault/event trees may be used to investigate initiating events, dispersion/distribution models are used to predict concentration/time profiles and dose-response models may be used to predict levels of harm.

Predicted risks may then be compared with risk criteria to determine whether they are acceptable. Some examples of criteria which may be used to assist in this process are discussed later. Risk rating/ranking schemes may be used to help identify those risks which are priorities for further consideration. For those risks that cannot be shown to be acceptable on the basis of comparison with criteria, or which are

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[2] The term 'BATNEEC' originates in the Integrated Pollution Control legislation. This legislation will be modified to meet the requirements of the Integrated Pollution Prevention and Control Directive (the 'IPPC Directive' - 96/61/EC) in which the term 'BAT' (best available techniques), rather than BATNEEC, is used. At the time of writing, the details of this modification are not finalised. However, since the definition of 'best' in the IPPC Directive refers to the need to consider the costs and advantages of chosen techniques there is no fundamental difference of approach implied by the use of the term BAT rather than BATNEEC.

identified as priorities for consideration during risk ranking, it is necessary to decide what risk reduction measures may be introduced and whether or not they are practicable, bearing in mind the associated costs and benefits. A range of risk reduction methods may be envisaged in this context, for example, improved operator training, introduction of additional physical safety measures, or process modifications.

As an alternative to the above, which starts with a hazard and works towards a risk, it is also possible to take the reverse approach when criteria are available for defining impacts. This involves taking as a starting point an accident which just meets the criteria, that is starting with the result, and then working back to identify the corresponding initial release. Such a technique is useful for screening purposes, so that only the truly relevant scenarios are rigorously assessed in detail.

In broad terms, there is a hierarchy of risk assessment approaches of increasing complexity, ranging from simple qualitative analyses through semi-quantitative analyses to fully quantified risk assessment (see Table 1 for explanations). The depth and type of analyses required by the COMAH regulations will vary from installation to installation but is likely to be proportionate to:

(a) the scale and nature of the major accident hazards presented by the installations and activities on it;

(b) the risks posed to neighbouring populations and the environment - in other words, the extent of 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.

Table 1 : Types of risk assessment

Qualitative risk assessment is 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 is 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 or the environment. The importance of the results is judged by comparing them with specific examples, standards or results from elsewhere.

Quantitative risk assessment is the application of methodology to produce a numerical representation of the frequency and extent of a specified level of exposure or harm, to specified people or the environment, from a specified activity. This will facilitate comparison of the results with specified criteria.

Many of the parameters used in a risk assessment can take a number of values. For example, when modelling dispersion of pollutant in a river it is possible to envisage flow conditions ranging from low (or no) flow through to high flows or floods. In principle, there are an infinite number of such conditions and hence, in practice, it is usual to categorise them 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, so that a spectrum of possible outcomes is obtained each with an associated frequency of occurrence. Other parameters in the model may also be treated in this way. A risk assessment which takes this approach is termed 'probabilistic'.

An alternative to the above approach is to take one value for each parameter used in the risk assessment. Thus, the analogous case to the above would involve using one description of the river flow state, rather than allowing for the full range of flows which might occur. This type of assessment using single values for each parameter is termed 'deterministic'. The choice of parameter values is generally made so as to tend towards overestimation rather than underestimation of risks.

Any of the types of risk assessment described in Table 1 may, at least in principle, be either deterministic or probabilistic; however, in practice, quantitative approaches are generally only used for probabilistic assessments.

In general, for the purposes of the COMAH regulations it is expected that a deterministic risk assessment will be undertaken but, where appropriate, a probabilistic approach may be applied. However, in justifying the selection of descriptors/parameters used the operator should indicate associated probabilities and ranges where it is relevant to do so. Where judgmental words are used, for example, 'likely' or 'insignificant', then the meaning of these should be clearly explained.

1.3 RISK MANAGEMENT AND COMAH

The general duty on an operator under the COMAH regulations is to 'take all measures necessary to prevent major accidents and limit their consequences to persons and the environment' (regulation 4). All sites must also prepare a Major Accident Prevention Policy (MAPP). Operators of sites with the greatest potential risk to man and to the environment, known as the upper or top tier COMAH Sites, will have also have to submit a Safety Report. For new top tier installations a safety report must be submitted prior to construction and prior to operation with dangerous substances. Modification reports are required where there are to be changes to an existing site or after a review indicating significant safety implications.

The MAPP must take account of the principles specified in schedule 2 (paragraphs 1 and 2)of the regulations and include sufficient particulars to demonstrate that the operators has established a safety management system which takes account of the principles specified in paragraphs 3 and 4 of the schedule. It is advisable to read schedule 2 in detail (see Appendix 5). However, with respect to environmental risks, the key feature of the schedule is that the MAPP should include details of the aims and principles used to control major accident hazards and that the safety management system should refer to 'the adoption and implementation of procedures for systematically identifying major hazards arising from normal and abnormal operation and the assessment of their likelihood and severity'. There is the further intent that the requirements laid down in the MAPP should be proportionate to the scale of major accidents hazards.

The additional requirements placed on top tier sites do not differ in substance from those identified above in so far as they relate to the need to undertake environmental risk assessments. Thus, part 1 of schedule 4 (see Appendix 5) requires that the safety report should make a series of demonstrations. These are that:

(a) a Major Accident Prevention Policy (MAPP) and a Safety Management System (SMS) for implementing it have been put into effect;
(b) major accident hazards have been identified;
(c) the necessary measures have been taken to prevent such accidents and to limit their consequences for people and the environment;
(d) adequate safety and reliability have been incorporated into the design and construction, and operation and maintenance of any installation - and equipment and infrastructure connected with its operation - and linked to major accident hazards within the establishment; and
(e) on-site emergency plans have been drawn up.

In the context of environmental risks there is thus a fundamental requirement to identify major accident hazards, show how they are controlled, take all measures necessary to prevent major accidents and limit their consequences to persons and the environment. That is, to undertake an environmental risk assessment and consider risk management action.

Since the risk assessment activity is linked to risk management it is generally an iterative process, starting with simple methods and cautious assumptions, and only proceeding to more complex methods with better defined input data where these are needed to meet the objectives of the assessment. In this instance, the objectives are to demonstrate that all necessary measures have been taken to prevent major accidents and limit their consequences. Thus the risk assessment need not be quantitative provided that the criteria used to judge the significance of risk are generally accepted and appropriate for making decisions about major accident hazards. In many instances it is useful to start with a qualitative approach as a means of screening out risks which are clearly not of concern. This approach is illustrated in the Environment Agency's guide to risk analysis (1998).

Cost-benefit considerations are important in deciding upon the merit of potential risk reduction measures and, in particular, in demonstrating that risks are as low as is reasonably practicable. In addition to the actual costs of any proposed measure, the associated benefits need to be judged in terms of both the relative reduction in risks and the resultant residual risk. The merit of allowing for cost-benefit arguments in determining actions to reduce risks has been recognised within the Environment Act 1995, which states (para. 39)

'*Each new Agency –*
(a) in considering whether or not to exercise any power conferred upon it by or under any enactment, or
(b) in deciding the manner in which to exercise any such power,
shall, unless and to the extent that it is unreasonable for it to do so in view of the nature or purpose of the power or in the circumstances of the particular case, take into account the likely costs and benefits of the exercise or non-exercise of the power in the manner in question.'

The use of risk criteria to assist the decision-making process associated with management of environmental risks has been referred to above. Any such criteria are only one of the factors used in this process. The operator needs to justify to the Competent Authority the criteria used to make risk management decisions under COMAH. It is suggested that a general framework incorporating three broad categories of risk would form a suitable mechanism for helping this process. The three broad categories of risk may be summarised as:

- a lower level of risk beneath which risks are of minimal concern. These require continued monitoring to ensure they remain low;

- an intermediate level of risk between the above two regions within which risks require some further consideration but which do not necessarily require the instigation of risk reduction measures provided that it can be demonstrated that it is not practicable to reduce risks further (the area in which ALARP and BATNEEC considerations are particularly important); and

- an upper level of risk above which risks are priorities for further attention (for example, reviewing the assumptions and modelling used in the risk assessment, or implementing risk reduction measures). The action selected will depend on factors such as the relative costs, benefits and level of residual risk of the different approaches or of undertaking further risk assessments.

The above scheme is shown schematically on Figure 1 (HSE, 1992).

A risk management framework such as that outlined above has been discussed in a number of publications which the reader may wish to consult for further information (see Appendix 3, which contains a list of references and suggested further reading). Further information on production of a safety report can be found in HS(G)190, and information on major accident prevention policies for lower-tier COMAH establishments is contained in CHIS 3.

Guidance on all aspects of the COMAH regulations can be obtained from local HSE or the respective Environment Agency offices.

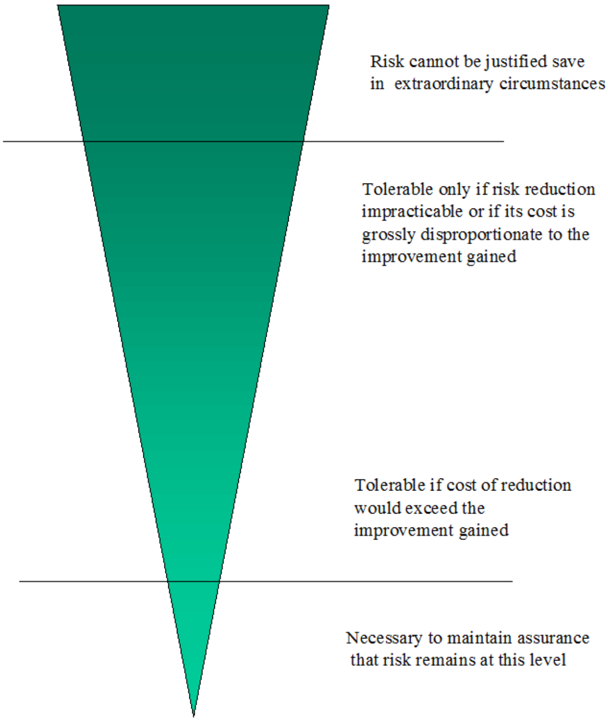

Figure 1 : Levels of risk (HSE, 1992)

2 Undertaking an environmental risk assessment

The basic processes involved in undertaking an environmental risk assessment are described below and are also shown on Figure 2. There are, as previously indicated, different points 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. The stages at which this is most commonly undertaken are shown on the Figure; these are denoted 'A', 'B' and 'C', although that should not be interpreted to imply any priority or preference. 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.

The basic philosophy is that one can adopt screening and prioritisation tools at an early stage and reserve more sophisticated risk assessment techniques for high priority, more complex risks. Where the assessment is undertaken purely for the purposes of demonstrating compliance with the COMAH regulations, and there is 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.

Each of the steps involved in undertaking an environmental risk assessment is considered below. The assessment is envisaged to be primarily a desktop exercise, which may be followed up by a more comprehensive verification exercise during inspection or if a potential serious deficiency is identified in the assessment. The guidance developed here is structured to assist both the initial assessment and subsequent verification.

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

A source → a pathway → a receptor

This recognition of the need for the presence of a source-pathway-receptor link can be valuable in both identifying that there is a risk and in managing that risk. If any of the above 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 the presence of a system/barrier which might 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 probability that the bund would be ineffectual.

Risk management techniques can, at least in principle, be applied to any of the above three components to reduce risks, although the practicalities and efficacy of doing so will depend on particular circumstances.

Although there are a number of ways of completing an assessment it is often beneficial to adopt an iterative approach to avoid unwarranted expenditure of time and effort; starting with simple methods and cautious assumptions and only proceeding to more complex methods with better defined input data where these are needed to demonstrate that the requirements of the COMAH regulations are met. Risks should be screened out as early as possible in the assessment process; for example, some accident scenarios may be disregarded relatively easily because it can be shown on the basis of source information (e.g. size of release or concentration) that they are not of concern. 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 risks which are of primary concern can be shown not be important then there is no need to consider lower priority risks.

Where a phased approach is adopted it may be beneficial formally to categorise and document the full spectrum of possible risk assessment techniques so that a structured and consistent approach can be applied in which the degree of conservatism/sophistication adopted is readily apparent.

No matter what method is adopted the operator should use a structured approach which demonstrates a systematic process of examining the installation to identify major accident hazards and demonstrating compliance with the requirements of the COMAH regulations. This should be transparent and include a mechanism for recording negative results (in the sense of risks which are screened out as not being of concern for COMAH purposes), as well as those which merit full consideration, so that an audit trail is available showing the process undertaken and the outcomes. Table 2 provides a list of possible elements which might occur in a COMAH safety report to address the Environmental Risk Assessment requirements. A checklist for assessors of COMAH Safety Reports is provided in Appendix 1 and further suggestions as to what each section might contain together criteria for assessors are detailed in Appendix 2. These are not intended to be prescriptive but to provide an indication of the type of approach which might be acceptable. If the operator wishes to follow a different structure and employ different approaches this may be acceptable as long as it meets the requirements of the COMAH Regulations.

Table 2 : Proposed List of ERA Aspects

Stage	No.	Environmental Aspect	Requirement
Introduction	1.	Objectives	Adds clarity
	2.	Resources and planning for assessment	Adds clarity
	3.	Background and previous studies	Useful
	4.	Layout and contents of report	Important
Approach	5.	Overall approach and justification	Adds clarity
	6.	Study Scope	Adds clarity
Information for Risk Assessment	7.	Hazardous substances information	Essential
	8.	Site description	Essential
	9.	Environment description	Essential
Accident Initiators	10.	Hazard identification techniques	Essential
	11.	Initiator events/cause analysis	Essential
	12.	Accident phenomena	Essential
	13.	List of potential accident scenarios	Essential
	14.	Screening	Essential
Accident Frequency Analysis	15.	Approach and modelling information	Important
	16.	Frequency estimation techniques	Important

Stage	No.	Environmental Aspect	Requirement
	17.	Onsite pathway analysis	Important
	18.	Accident elimination, prevention and control	Important
	19.	Screening	Important
Accident Consequences	20.	Approach and modelling information	Case-by-case
	21.	Offsite pathways analysis	Case-by-case
	22.	Hazard distances and other results	Case-by-case
	23.	Offsite emergency planning	Case-by-case
	24.	Screening	Case-by-case
Accident Impacts	25.	Approach and criteria	Case-by-case
	26.	Impacts to receptors	Case-by-case
Presentation of analysis/ Risk results	27.	Summary	Case-by-case
	28.	Data presentation	Case-by-case
	29.	Risk Acceptance Criteria	Case-by-case
	30.	Comparison of results with criteria	Case-by-case
	31.	Identification of risk management measures	Case-by-case
	32.	Evaluation of measures	Case-by-case

Section numbers in this table are also used in Appendices 1 & 2.

2.1 CRITERIA USED

One of the building blocks to demonstrating compliance with the COMAH regulations is the identification of **M**ajor **A**ccidents **T**o **T**he **E**nvironment (MATTEs). Assistance in this process is provided by the definition of a 'major accident' in the regulations, viz.,

'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 or the environment, immediate or delayed, inside or outside the establishment, and involving one or more dangerous substances'

Specific guidance to help judge the scale of events which would be classed as MATTEs has been provided by the DETR (1999a). The key parameters influencing this judgement are a combination of :

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

Although the guidance does not cover every eventuality it should facilitate decisions concerning the criteria used in screening out accidents which are not considered to warrant consideration as MATTEs. The rationale behind the screening out of hazards should be documented and discussed in any safety report.

In many situations it will be possible to eliminate hazards relatively early within a risk assessment because the concentrations in the environment can be shown to be too small to result in the effects considered to be a MATTE[3]. This may be done by comparing predicted environmental concentrations with concentrations associated with particular effects. For example, accidents predicted to result in

[3] Operators may choose to use a less severe accident than a MATTE as the threshold determining whether or not the hazard is considered further. However, all accidents which are at least as severe as a MATTE must be considered.

environmental concentrations less than EQSs (Environmental Quality Standards) or NOECs (No Observed Effect Concentration) are of no concern for the purposes of a risk assessment under COMAH, since such concentrations refer to levels of pollutant which will not cause harm if exposure to them occurs over very long time periods.

Where it is necessary to use concentrations associated with more severe effects as comparators against which to judge the importance of predicted environmental concentrations, then the most easily obtainable information is generally that on LC_{50}s (the concentration lethal to 50% of a population). LC_{50}s are specific to particular species and are determined from standard toxicity tests over set time periods (often of at least a 24 hours). Where a comparison of a predicted concentration with an LC_{50} is used to screen out hazards from further consideration, it will generally be necessary to consider both a range of species and the relationship between the test time period and that associated with the predicted concentration; for example, if a predicted concentration is close to the LC_{50} of a particularly sensitive species for a very short period of time in comparison with the test period used to determine the LC_{50}, then it might be possible to argue that the predicted concentration were not significant for the purposes of the COMAH regulations.

Data on LC_{50}s can be found in, for example, materials hazards data sheets, books of reference data on dangerous substances, and in databases of hazardous substance information. Some suggested sources of such information are provided in Appendix 3.

Species and ecosystems have different susceptibilities to different chemicals. When judging the importance of a particular chemical concentration in the environment it is therefore generally necessary to consider more than one species so as to have an appreciation of the overall environmental impact. The data used, including the species chosen, should be justified. Any screening out of hazards on the basis of comparison with reference concentrations should allow for the full range of effects which may be considered MATTEs.

The end point for most environmental risk assessment models is information on risks presented in the form of the likelihood of an environmental concentration occurring. Some suggestions from a research project on criteria to judge the significance of risks to the environment have also been published (DETR, 1998) and may assist in screening out risks which do merit further consideration in the context of the COMAH regulations.

For 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 selected values/choices. The models used may also be usefully reviewed at this stage to see if they are too simplistic and do not properly take into account factors which would reduce predicted environmental effects. The assessment may then be repeated using more refined, but justified, data and/or assumptions and/or models to investigate whether or not the changes result in lower consequences which then permit that accident to be screened out. However, at some point the risk assessor may find it difficult to justify further modification of either the risk model or the assumptions/data associated with it. If it is not possible to screen out a hazard then 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. This can be a relatively complicated process and operators may find it simpler to introduce additional risk management measures (including physical systems).

2.1.1 Chemical cocktails

Releases from some installations can consist of a 'cocktail' of chemicals. Such a situation is often associated with an exothermic reaction, such as occurred at Seveso in 1976, or a fire. This creates some difficulty for the risk assessor in knowing how to determine the environmental impact. In such cases there is the additional need to predict the composition of the release, taking due regard for the presence of combustion or reaction products, including those not normally present in the process, and any other materials mobilised during the accident; nonetheless, the compounds potentially produced by a fire should be readily identifiable, although there will generally be some uncertainty concerning the quantities involved.

Various approaches to addressing the above situation may be envisaged; however, two relatively simple approaches which may provide sufficient confidence in the predictions from the risk assessment are as follows:

- Instead of trying to consider the full 'cocktail' of chemicals, choose a suitable representative 'marker' as an indicator of environmental effects. The precautionary principle should govern the selection of the marker.
- Review information on accidents to see what the effects have been and where they 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.

The results from adopting either of the above approaches will be subject to uncertainty and the assessor should ensure that this is properly recognised in making any decisions concerning the predicted risks.

There will be some circumstances in which the use of a 'marker' as a surrogate for the full suite of chemicals is not suitable. For example, judging the effect of particular isomers on the basis of information on effects from that species of compounds is unlikely to be justifiable. Interactions between chemicals may also result in markedly different overall environmental effects from those associated with single chemical releases. It is therefore important explicitly to consider possible antagonistic or synergistic effects of mixtures of chemicals on the environment. For some combinations of chemicals and environmental conditions the effects may be so difficult to predict with confidence that it is necessary to undertake some toxicity testing of the chemical mixture.

Sources of further information on past accidents and their effects include: the environment agencies (particularly in respect of chemicals entering surface or ground water), MHIDAS, the Department of the Environment, Transport and the Regions (e.g. DETR,1999c), the Institute of Chemical Engineers, and journals such as 'Loss Prevention in the Process Industries', 'Loss Prevention Bulletin' and SIESO's 'Industrial Emergency Journal'.

In some circumstances there may be no practicable alternative to either undertaking a detailed assessment or reducing the risks via introduction of physical systems (or, possibly, via modified risk management practices).

2.1.2 Dioxins, furans and PCBs

Complex mixtures of dioxins, furans and PCBs may be released in some accidents. For these mixtures the overall toxic equivalency (TEQ) should be evaluated from the individual toxicity equivalency factors.

2.2 PRELIMINARY STEPS

2.2.1 Scope

It is important to identify the scope of the assessment in terms of which items of plant/site are included and their status; the boundaries of the assessment should be clearly identified. For almost all existing installations it will be necessary to divide the whole into a series of technical units so as to make the risk assessment process manageable. However, during the assessment it is important to take into account any effects on the units(s) being considered from neighbouring units (including those owned by different companies), as well as vice versa. The assessment should ultimately cover all units in which dangerous substances are produced, used, handled or stored. The regulations apply to an 'installation' which
'*means a unit in which dangerous substances present are, or are intended to be, produced, used, handled or stored, and it includes –*
(a) equipment, structures, pipework, machinery and tools,
(b) railway sidings, docks, and unloading quays serving the unit, and
(c) jetties, warehouses or similar structures, whether floating or not,
which are necessary for the operation of the unit.'
Thus, although it may be necessary for practical reasons to consider the installation as consisting of a series of individual technical units, it is important to ensure that these are not viewed as closed systems which do not have any influence on each other. The scope of the risk assessment for each unit should be sufficiently flexibly defined to allow for cross-unit interactions.

The COMAH regulations specify various items of information that should be included in either a safety report or, for lower tier sites, a notification to the Competent Authority. The following are relevant to the initial stages of an environmental risk assessment and should be obtained before commencing the main phases of an environmental risk assessment:

- Hazardous substances information;
- A map/description of the site; and
- A description of the local environment.

Some further details of what is needed are given in the next sections and in table 2 and Appendices 1&2. However, as with all aspects of the risk assessment, it may be necessary to revise the initial selection of data as the assessment proceeds. For example, the hazard identification exercise may show that data are required on some additional substances to those initially identified.

Installations designated as part of a 'Domino Cluster' will be notified by the Competent Authority. For such installations it is important to ensure that the effects of accidents on neighbouring COMAH establishments are included in the assessment.

2.2.2 Hazardous substances information

This information is required to allow an assessment of whether or not concentrations in the environment which might result from an accident are sufficient to result in a major accident.

The list of substances to be considered should be based on the scope. It should include substances occurring under normal and abnormal conditions; this includes substances generated during runaway reactions and any which may be mobilised or formed as a result of reactions once released into the environment. Given the generic nature of categories of harm in the COMAH regulations, and the corresponding limited list of named substances, the full list of substances which may need to be covered is potentially very large for some installations. However, it is probable that many substances can be excluded because they are only present in small quantities or do not have harmful environmental properties at the concentrations present on site (material moving off-site will be diluted as it disperses and hence the maximum concentration will be that found on site). Where substances are excluded from further consideration the basis for their exclusion should be justified. The precautionary principle should be applied, that is it should err on the side of caution, wherever there is some doubt about this process.

Information on the environmental behaviour of substances should be presented. Aquatic ecotoxicity data are particularly important in view of the emphasis on toxicity to the aquatic environment inherent in the references to R50/R51/R53 risk phrases in the definition of dangerous substances; however, other potentially harmful properties, for example, toxicity in the terrestrial or atmospheric environments, BOD/COD, blanketing/smothering, effects on potable water supplies may need to be considered. Data relating to immediate and delayed harmful effects should be presented. Other information that may be required includes persistence, bioconcentration factor, bioaccumulation potential, solubility, and density. The data required depend to a great extent on the complexity of the modelling used.

It may be most efficient to establish a list of key substances and associated data early in the assessment process and to add to that when it becomes clear that additional substances/effects need to be considered. For example, if the analysis of routes shows that there is no possibility of a substance entering surface waters then there is no merit in providing data on its possible effects in that medium.

The sources of the data presented should be identified. It must be relevant to the actual formulation used; for example, copper chrome arsenate has a range of formulations with a corresponding range of effects in the environment. For some substances there may be a range of effects data (e.g. lethal concentrations) reported in the literature, even for the same species/test. In that case the choice of data should be justified.

2.2.3 A description of the site

This is to help provide an overall appreciation of the site and its potential to cause a major accident to the environment.

It is important to include scaled plans or maps - usually at least 1:10000 - showing the establishment and its surroundings, as well as descriptions which clearly set out the internal geography of the establishment as a whole. Separate maps may be required to identify the surrounding population and the surrounding natural environment. The maps/descriptions required to support an environmental risk assessment are almost the same as those for the assessment of direct risks to people and hence the following list is common to all risk assessments, although the relative importance of the various items will vary according to the target at risk and the type of installation. The information required includes the:

- location of installations with major hazard potential;
- location of all other installations, including those that do not contain a dangerous substance, with an outline in general terms of what activity occurs there, or what substance is present there;
- numbers and locations of people, taking into account foreseeable fluctuations which could be due to shift working, maintenance activities, contractors, visitors, tourists.
- location of any activities which relate to the major accident scenarios given in the safety report - for example, include tanker filling points, storage tanks and forward emergency control sites;
- location of any key abatement systems preventing or containing major accidents, such as drainage and firewater retention, gas cleaning or liquid treatment works, explosive buildings traverses or mounds important for protection of people and the environment;
- location of any key control systems, such as computer control systems or isolation systems;
- location of roads, railways or docks, entrances to the establishment - including those for emergency vehicles only - or any other features relevant to the major accident scenarios in the safety report, such as flares or other open sources of ignition;
- sources of, and key features in, essential utilities which may be relevant to the prevention or containment of a major accident and details of any redundancy, diversity and segregation - for example, instrument, air, steam or electrical networks;
- matters relevant to emergency response, such as firewater supply, escape routes and communication systems;
- systems for monitoring and detecting toxic products in air, water or sewers;
- systems for fire detection and monitoring potentially explosive atmospheres; and
- systems for monitoring access and detecting intruders.

Data on management systems, control systems, procedures, operations and equipment are also required; it is anticipated that these will normally be the same as for those considered in the context of safety and direct risks to people. Any additional factors affecting control of environmental risk should be provided as input to the environmental risk assessment.

The above list summarises the information required. Although included in the list, particular attention is drawn to the need to provide the following information to support the environmental risk assessment:

- location, inventory and physical conditions of substances dangerous to the environment;
- layout and segregation of drainage system(s);
- collection areas for the drainage system and associated discharge points to watercourses/foul sewer/effluent treatment plants;
- details of abatement systems;
- location and capacity of sumps, penstocks, fire-water lagoons and any other barriers to off-site transport of liquids;

- location and characteristics of valves, bursting discs or other relief systems;
- any site features affecting runoff/dispersion of released materials; and
- the management systems associated with the above which demonstrate that MATTEs are properly managed.

2.2.4 A description of the local environment

This is to assist in identifying vulnerable elements of the environment (receptors) which may be affected by an accident, as well as routes (pathways) to them. The extent of the area described should take account of hazard ranges of the worst case events.

All environmental media are potentially relevant: surface water, ground water, soil and sediment, air. A description should be provided of relevant physical, chemical and biological receptors within those media, including onsite and offsite receptors. This should include all aspects of the environment and ecosystems at risk, in particular:

- Red Data Book species;
- Scarce or rare habitats (e.g. any area designated, or under consideration for designation, as a SAC, SPA, SSSI, AONB, Ramsar site, LNR, NNR, MNR);
- Locally identified nature reserves (e.g. managed by the RSPB or County Wildlife Trusts);
- Water bodies and groundwater;
- Water abstraction points;
- Ancient woodlands;
- Listed buildings, major archaelogical sites and historic monuments;
- Land of economic importance (e.g. urban or agricultural land); and
- Human populations.

It is recommended that the location of the above key environmental features be marked on a map of suitable scale (generally at least 1:10000). The area that needs to be covered will depend on the nature of the risks presented by the installation and the degree of dilution/dispersion of released material by environmental transport processes. As a general rule, it will be necessary to include information on the environment within about 10 km of most installations; however, this distance will need to be reviewed and may need to be varied once the hazards and associated consequences are known from subsequent phases of the risk assessment. Where it is possible for material to be transported a considerable distance with relatively little dilution, such as happens in some rivers and sewerage system, it may be necessary to include information on environmental features at much greater distances.

Particularly sensitive receptors within the area of interest should be identified; for example, those designated under the Directive on the conservation of natural habitats and of wild fauna and flora (92/43/EEC – 'the Habitats Directive'), the Directive on the conservation of wild birds (79/409/EEC – 'the Birds Directive'), and the Wildlife and Countryside Act 1981. Any information on the reasons for particular designations should be provided; for example, the basis for designation of an area as a SSSI. Attention should be drawn to any seasonal variations in the presence of vulnerable receptors as well as activities beyond the site boundary which may interact with the site, including neighbouring industrial facilities and water treatment plants.

The importance of sensitive receptors in either a national or international context should be discussed. Reference should be made to any formal classification schemes, such as those used by the Environment Agency to indicate groundwater vulnerability and river quality. The classification of any surrounding agricultural land and its corresponding use should be indicated.

Factors affecting the occurrence and behaviour of accidental releases in the environment should be described; for example, river or tidal flows, meteorology, hydrogeology, local topography (including man-made structures). Any features which may hinder emergency response or the effectiveness of containment measures should be identified and described.

Information sources to help in the above include;
- English Nature;
- Countryside Council for Wales;
- Scottish Natural Heritage;
- County Wildlife Trusts;
- The Royal Society for the Protection of Birds;
- The British Trust for Ornithology;
- World Wide Fund for Nature;
- Local environmental groups;
- Local authorities;
- The Meteorological Office;
- The Department of Environment Transport and the Regions (e.g. DETR 1999b); and
- The relevant environment agency.

Where these sources prove inadequate then it may be necessary to undertake a detailed site survey; it is expected that this will be unnecessary for most installations.

2.2.5 External factors

There may be some external factors which influence the nature of a major accident and which are not immediately obvious from a survey of the area. It is important that information on these is presented and that they are considered during the risk assessment. Some examples of factors which it is easy to overlook but which should be included are given below:

- when describing underlying geology, consider seismic events (earthquakes) and subsidence (for example, due to mining) that might cause accidents;
- consider past uses of the land on which the establishment is located, together with its surroundings; for example, include information on the history of mining or other mineral extraction activities or land reclamation in the area which may lead to subsidence, take into account previous land use which may be important in respect of contaminated land or water;
- consider the historical evidence of other external events that might cause accidents, such as flooding, and extreme weather conditions including temperature, rain, snow, wind, and lightning;

- take into account and describe any other activities in the area surrounding the establishment that might lead to, or exacerbate, a major accident. This information may include, for example: major hazard installations and pipelines in the area[4], land use under the establishment, air traffic movements over and around the establishment, transport activities that may have an impact, other human activities that might lead to major accidents, such as arson, vandalism, theft, and criminal damage, high voltage overhead electric power distribution lines, and radio transmission masts in the area that produce fields which could interfere with safety control systems or communication systems, or initiate electro explosive devices.

It is recommended that the presence of external factors, such as those identified above, is explicitly considered in the description of the environment. If none are relevant then a statement to this effect will consideration of the risk assessment by the Competent Authority.

2.3 HAZARD IDENTIFICATION

The first main stage in a risk assessment is identification of hazards, that is, identification of the initiating events which may ultimately result in a release of a dangerous substance. It is important that this is achieved in a transparent and comprehensive manner which covers both normal and abnormal events, including releases during maintenance and runaway reactions.

For an accident to be considered to be a 'Major Accident to the Environment' (MATTE) it is not necessary for the 'dangerous substance' as defined by the Regulations to cause the impact, but merely to have played some part in the chain of events leading to emission of a substance dangerous to the environment. For example, an accident sequence may begin by involving a 'dangerous substance', as defined by the COMAH regulations, but the ultimate main impact on the environment may be from a substance which is not identified in COMAH. In some circumstances the substance which causes the impact may be something which, from a COMAH 'dangerous substance' viewpoint, is relatively innocuous, such as glucose syrup or milk, present on either the COMAH site or one of its neighbours. These are termed 'consequential effects' of a COMAH Major Accident. This sequence of events is illustrated below:

Accident involving COMAH 'dangerous' substance	→	Release of non-COMAH 'dangerous' substance	→	Major accident to the environment caused by non-COMAH substance

Although several types of non-COMAH dangerous substances can cause consequential effects, those most likely to be overlooked are ones with a high BOD, extreme pH, or which cause smothering. Examples of such substances include milk, fruit juice, and oils.

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4 This requirement is limited to information which is clear to the operator. The Competent Authority will inform operators if they are part of a domino cluster. Once this is done, there is a duty placed on operators under COMAH to exchange information about major accident hazards.

The identification process should cover all the various different types of major accident hazards, including:

- loss of containment accidents due to vessel or pipework failures;
- explosions - batch reactors, tank explosion due to operator error - for example wrong contents and boiling liquid expanding vapour explosion (BLEVE);
- condensed phase explosions relating to explosives;
- large fires - for example, warehouses and pool fires;
- pressure relief valves lifting and venting to atmosphere;
- events influenced by emergency action or adverse operating conditions - for example, allowing a fire to burn rather than apply water, dump reactor contents to drain to avoid explosion, and abnormal discharge to the environment; and
- other types of major accident hazard or abnormal discharge.

The potential major accident scenarios should include the worst case scenarios - the most serious foreseeable events - taking into account what might happen **on site** as well as **off site**.

One way of approaching this would be to:

(a) identify the 'worst case events' – this may not be the absolute worst possible event but rather the worst event considered to be credible. Justification of the choice of event should be provided.

(b) assess the consequences - if they are trivial there is no need for further predictions, but if they are significant, a range of major accidents needs defining and analysing.

Guidance on the industrial screening for environmental risks is in preparation by the Environment Agency (1999).

A number of techniques can be used to assist in hazard identification. These seek to identify hazards in either a relative or absolute way. Relative methods use checklists or hazard indices based, in the main, on previous experience, whereas absolute methods are based on a systematic consideration of deviations from the design intent. A very brief description of each of these is given below. Other techniques also exist but are not in such widespread use. Further information and reviews of hazard identification techniques can be found in Lees (1980 & 1996), Kletz (1999). Whatever method is chosen it must be applied to the full range of potential problems – normal and abnormal operation, maintenance – and be fully documented. It must also make allowance for ‘common mode’ failures, that is, multiple failures of items as a result of a common event, such as a power failure or earthquake.

2.3.1 Checklists

Checklists consist of a series of questions, often of a general nature, which aim to identify hazards by providing a stimulus or focus for the assessor(s). Failure events are studied to determine whether particular failure types apply to the plant of interest. Typical checklists are derived from past experience and require critical appraisal of all aspects of operations on site, for example:

- Choice, situation and layout/division of site
- Process materials and by-products
- Reactions, process conditions and disturbance analysis
- Equipment
- Storage and handling of dangerous substances
- Handling and removal of hazardous waste products
- Fire protection and emergency planning

2.3.2 Hazard Indices

Hazard indices give a quantitative indication of the relative potential for hazardous incidents associated with a given plant or process. They are used to most effect at the early design stage of a new plant. The best known hazard indices are the Dow Index (1981) and the Mond Index (1979).

2.3.3 Failure Modes and Effects Analysis (FMEA).

A failure modes and effects analysis identifies the cause of a hazard from a knowledge of equipment failure and error modes. It considers all the causes of failure of each element of a system, and then records all the possible outcomes or effects of each failure scenario. An example of an FMEA for a typical chemical plant is described by King and Rudd (1972).

The basic stages of an FMEA are:

- Identify the system under study,
- Define the study objectives,
- Define the separate sub-systems for analysis,
- Identify failure modes, their causes and effects and the sequence in which they occur.

Faults can then be categorised by their effect along with probability estimates for each failure mode. Effect categories and their severity level will vary for different systems. An analysis usually proceeds to a level where failure data are available, but sometimes a qualitative judgement of the failure probability is required. Eventually it is possible to specify a severity level and probability of occurrence (quantitative or qualitative) for each failure mode that has been identified.

2.3.4 Hazard Studies.

Hazard studies are a widely used hazard identification technique in the chemical, petrochemical and nuclear industries; the methodology can be applied to a wide range of other processes and activities. Although the procedure, as described here, is for new plant, it can be applied retrospectively to existing plant.

Hazard studies can be carried out at various stages during the lifetime of a plant. The objectives and requirements vary with the point in the cycle at which they are undertaken; six hazard study levels are commonly used in industry, although this number is varied in some instances. The various levels provide a systematic way of managing the assessment of hazards, including the associated design process, during the life of a project. They also provide a series of 'gateways' which check that all relevant tasks have been completed before moving on to the next stage.

In particular, Hazard Studies 1 and 2 ensure adequate definition of the project and assessment of risk before any major capital expenditure has occurred. This contributes to the inherent safety of the design and avoids time consuming and expensive changes later in the project.

It is fundamentally important that the scope of a project is clearly defined and significant risks assessed; all projects should have a Hazard Study 1. Ideally, Hazard Study 2 should be carried out also, where appropriate. The fundamental aspects of each Hazard Study level are outlined below.

Hazard Study 1

This aims to ensure that the understanding of the project, the process and the materials involved is sufficient to ensure that safety, health and environmental issues may be properly assessed. It also contributes to key policy decisions (e.g. on site location) and ensures that contacts are established with the functional groups, site management and the authorities who may contribute to, or impose constraints upon, the development of the project.

Where there are no hazards inherent in the chemicals, process conditions, equipment, buildings, services, operations or their environment, the Hazard Study procedure may be curtailed at this stage. The appropriate individuals should agree and record the basis for curtailment.

Hazard Study 2

Helps identify significant hazards, providing the opportunity for their elimination by redesign. Where this is not practicable, it ensures any protective measures needed to meet the relevant criteria are provided. This establishes the basis of Safety for the operation of the plant.

The study also produces most of the information and assessments needed to meet the requirements of the regulatory authorities on health, safety and environment protection.

Hazard Study 3

A Hazard Study 3 is also known as Hazard and Operability Study (HAZOP). This reviews the design and/or procedures to identify any hazards or obstacles to operability which could arise, particularly through deviations from the design intent. For process plant, the study is based on the firm engineering diagrams and outline procedures/philosophy at the end of the project design stage.

HAZOP includes identifying the consequences of deviations and calls for appropriate corrective action where needed. This study also provides an opportunity to review potential maintenance and quality problems, to consider some implications of computer control and to assess possible deviations during commissioning.

With Hazard Studies 1 and 2 already completed, the HAZOP is better able to fulfil its real purpose of identifying deviations not foreseen during the design process. It should not have to deal with design concepts.

The results from a Hazard Study 3 are likely to input to a COMAH pre-construction safety report (PCSR) for a new plant.

Hazard Study 4

This checks that:
1. the plant or building has been constructed to the intended design;
2. actions from previous Hazard Studies have been completed and implemented in the design and installation;
3. the operating instructions and emergency procedures comply with any requirements identified by previous Hazard Studies and are satisfactory for Safe operation; and
4. training of appropriate people has been completed and validated.

The results from a Hazard Study 4 are likely to input to a COMAH pre-operational safety report (POSR) for a new plant.

Hazard Study 5

This provides a framework for those responsible for personal safety, employee health and environmental protection to check that the project, as implemented, meets Company and legal requirements.

Hazard Study 6

This checks that Hazard Studies 1 to 5 have been completed and that all relevant documentation is up-to-date and filed. This should be done immediately after commissioning to ensure no changes have been made which either change the assumptions made in earlier Hazard Studies or invalidate the basis of Safety.

Hazard Study 6 then includes a further review, a few months into early operation, to ensure the plant is consistent with the design intent with regard to safety, health and environmental issues. It also checks that assumptions defined in earlier Hazard Studies are borne out in actual operation, for example that corrosion rates assumed in the design are consistent with those found during maintenance. In the context of COMAH, it also confirms that the basic process assumptions within the risk assessment are not invalidated.

Further information on HAZOPs can be found in Kletz (1999) and CISHC (1977).

Where FMEA or hazard studies are being undertaken to facilitate demonstration of compliance with the environmental aspects of the COMAH regulations it is particularly important to ensure that the following are identified;

- consequential accidents;
- domino or escalation effects; and
- potential off-site effects, including those resulting from chemical transformations.

It is recommended that there is a hazard team member with specific expertise in identification of environmental hazards.

Many installations will have pre-existing FMEA or hazards studies. Most of these will have been undertaken with the primary objective of ensuring the safety of people. Where the results of such studies are used to feed into an environmental risk assessment it is important to undertake a review to ensure that environmental risks were not overlooked in the original study.

2.3.5 Hazard screening

Hazards identified as a result of the hazard analysis may be screened out and hence not considered further if they are inherently so small that they cannot cause a major accident or there is no pathway whereby the dangerous material (either one identified as such in the COMAH regulations or one which is dangerous to the environment and released as a consequence of the COMAH dangerous substance) can travel from its release point to the receptor. This is because, as discussed previously, a risk is only manifest if there is a source (the hazard), a pathway (a route to a receptor) and a receptor (on-site or off-site).

A pathway analysis is useful to check this latter possibility; hazards which are inherently too small to cause a major hazard should have been screened out during the main hazard assessment. The onsite pathway analysis will typically include looking at the following factors to see if the dangerous substance can travel towards one of the receptors already identified :

- Secondary containment design, position, capacity, condition
- Flow of spilled material across surfaces, into drains, etc.
- Distances between sources and pathways
- Site layout and drainage, capacity and condition of drains, etc.
- Barriers, e.g. interceptors and sumps
- Geographical/geological/hydro-geological features that may impede/facilitate pollutant escape
- Effect of varying weather conditions (e.g. storms)
- Firewater run-off
- Treatment plants (on or off-site)
- Location of pumps, valves, pipework
- Suitability, capacity of treatment plant

Pathways to receptors should have been identified previously. If there is a complete pathway from the source of the hazard to a receptor then that hazard cannot be screened out at this stage.

Where hazards are screened out the justification for doing so must be made clear.

2.4 FREQUENCY ASSESSMENT

Hazards taken forward for further consideration are known to have the possibility of reaching a receptor. The likelihood of this happening will depend on a number of factors such as:

- The frequency of containment failure;
- Release conditions;
- The presence of barriers which might 'cut' the pathway (and the probability of them operating correctly on demand); and
- Environmental fate, behaviour and transport conditions. This includes consideration of advection, dispersion, diffusion, and chemical partitioning using data on, for example, meteorology, river flow, hydrogeology and chemical/physical transformation/removal processes.

The frequency analysis investigates these factors with the objective of estimating the frequency with which dangerous substances reach each receptor.

Some of the above factors affect both the quantity of material reaching the receptor as well as the corresponding frequency. In some instances it may initially be worthwhile putting the question of how likely it is that a substance will reach a receptor to one side, in favour of considering what the effect on the receptor would be if <u>all</u> the released substance were transported to it without loss. In this way, any hazards which do not then result in a MATTE can be excluded from further consideration, at least with respect to demonstrating compliance with the COMAH regulations; that is not to say that less severe accidents would be of no concern to the Competent Authority for other reasons or that operators should not have systems in place to demonstrate adequate controls over them.

Screening out of a hazard in the above way will generally require some modelling so as to understand the correlation between the release and corresponding effects at the receptor. Operators may find it useful to produce generic guidance to be used by everyone on site on the degree of dilution/dispersion between typical release points and receptors; particularly for releases into site drainage system, this generic guidance may focus on pathways between the on-site discharge point and that at which the water discharges into other water systems (typically the site consented discharge point). The basis for such guidance should be made clear and the associated uncertainties and sensitivities explained.

Where it is necessary to undertake a frequency analysis the sequence of events between the initiating event (release of dangerous substance from primary containment) and the impact on the receptor should be documented. This should identify the pathway to the receptor. Both onsite and offsite factors affecting the transport of material to the receptor should be recorded. Examples of these include:

- operator error
- abnormal load (e.g. incorrect loading of tanks)
- extreme environmental conditions (e.g. flooding)

- failure of equipment to operate as expected on demand
- loss of service

Accident frequencies should be determined from the frequency of initial loss of containment combined with the conditional probabilities of relevant external factors. There are several basic approaches to evaluating accident frequencies, which may be used separately or in combination:

- Qualitative approach;
- Generic historical failure rate data;
- Company or site specific historical data;
- Direct quantification (for example, by the use of fault trees).

A qualitative approach may take the form of word- or number- based categorisation systems, e.g. LL, L, M, HH frequencies (L= low, M=medium, H=high), to input to a risk matrix such as that depicted in Table 3.

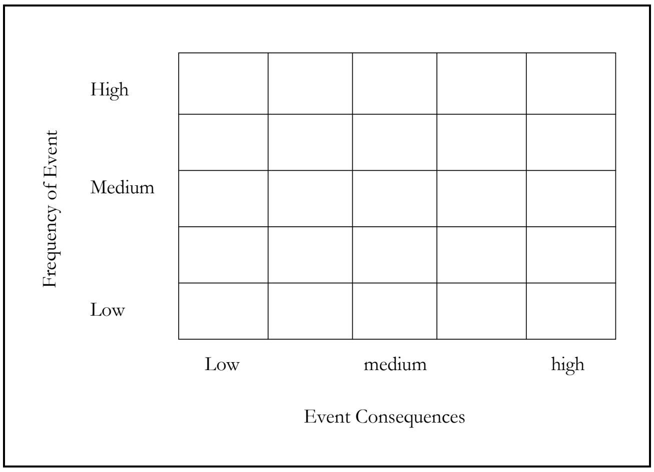


Table 3 : Example risk matrix.

Where generic or historical data are used, their source should be described and care should be taken to ensure that the data are from systems which are comparable to the one under consideration. Quantification is useful because it enables causes and measures to prevent or limit accidents to be explicitly handled; however, this may be a resource-intensive exercise and needs careful treatment. There is also the possibility that calculated frequencies can be significantly lower than the real values if common-mode failures are neglected.

The approach should include an evaluation of uncertainties in data used; e.g. alternative sources of equipment failure rates may be identified in order to derive a band of frequencies.

Allowance for factors affecting the transport of the dangerous substance to the receptor will require some modification of the initiating event frequency so that the probability of engineered barriers, management systems and environmental conditions are taken into account. A simple example of this process is shown in Figure 3, which is a hypothetical event tree for the liquid phase release of a dangerous substance to the environment and the conditional events that could potentially lead to pollution of the environment off-site. Some pathways lead to onsite containment. Although not shown on this figure, event trees may include operator actions as a factor which affects the probability of the various outcomes; justification of the probability for such actions is not always easy to demonstrate and it may be prudent to leave such factors off the event tree, at least until the magnitude of the risk is known. The effect of operators in mitigating the risks and consequences of accidents should be described to demonstrate that MATTEs are prevented or reduced.

The probability of a release reaching a receptor can be calculated by multiplying together the frequency of the initial event and the conditional event probabilities that lead to the spill arriving at receptor. In some instances more than one 'branch' of the tree may lead to the same outcome at the receptor, and in that case the probabilities of each branch are summed. Conditional event probabilities may be evaluated by using a fault tree model or by expert judgement, provided that this is fully justified.

2.4.1 Frequency screening

Some hazards may be screened out from further assessment on the grounds that the frequency of adverse effects is low enough for it not to be practicable to reduce them further. This ensures that resources are not wasted in evaluating risks that are insignificant.

Examples of screening criteria that may be used include:

- Offsite release frequencies less than 10^{-6} per year;
- Releases that become naturally diluted (e.g. through water in effluent treatment systems) to the NOEC (no observed effect concentration) or lower before entry to the environment;
- Small releases unlikely to cause a MATTE;
- Cost of further analysis not justified in terms of the benefits that may be provided.

Screening on the basis of a dilute (e.g. through applying firewater) and disperse risk management option is not an acceptable practice. As with all screening a conservative approach should be adopted.

2.5 CONSEQUENCE ASSESSMENT

The objective of this phase of the assessment is to determine which hazards may cause a MATTE. Hazards taken forward to this phase of the assessment are known to have a non-insignificant likelihood of occurrence and have not been ruled out on the grounds of being incapable of causing a MATTE. The actual likelihood will have been assessed in the previous phase of the assessment. The next step is to understand what the effect of the release will be. This requires both details of any changes in the released substance as it travels to a receptor (for example, dilution/dispersion) and an appreciation of the effect of the resultant exposure (concentration-time profile) at the receptor.

Once a spill enters the environment the main factors affecting its transfer to a receptor are environmental transport processes, such as the weather and/or water flow conditions, plus any chemical/physical transformations. These factors should be assessed using methods suitable for the distances involved and, ideally, able to allow for any transformations en-route; however, where it is known that any transformations would either be to a less hazardous substance or would remove the hazard from the environment then a model which neglects such effects would be acceptable since it would be conservative. Where a chemical may be transformed into a more environmentally hazardous form then the model should be able to allow for this. There are a number of models and software tools available, both in the public domain and on a commercial basis, which may be used to undertake these assessments.

The question of how to assess the consequences of a release has been discussed earlier. Quantitatively evaluating impacts on the environment involves considerable uncertainty and complexity. Some degree of quantification is possible but a large amount of qualitative judgement is usually necessary. The approach used should be described fully. In general the following may be used in combination or separately, for evaluating impacts:

- Toxicity relationships (e.g. dose-response relationships);
- Environmental harm criteria (e.g. LC_{50} data, critical loads);
- Negligible effect criteria (e.g. No Observed Effect Concentrations, Suggested No Adverse Response Levels);
- Past accident experience; and
- Population dynamics modelling.

If harm criteria are used then the relevant receptors must be clearly identified. Effects may be to individual species, a range of species (biodiversity), the community structure and the overall habitat or ecosystem. Very little information exists on community level responses to damage. In defining the expected level of change, natural variability needs to be considered as this can result in significant changes in receptors. If recovery is assessed then a distinction may need to be drawn between natural unassisted recovery and artificial recovery, particularly if contingency plans include cleanup and restoration which may affect the rate of recovery.

Immediate and delayed effects need to be considered in the approach to assessing impacts. The key uncertainties in the approach should be identified.

The predicted consequences of the various accidents considered may be compared with the guidance on situations which would be considered major accidents under the COMAH regulations to assess those which might be considered MATTEs. As explained previously, this assessment often requires some judgement to be made since it is not possible to provide a definitive list of everything which would be considered a MATTE; companies must make justified arguments concerning those accidents which they consider to be (or not) MATTEs.

2.6 RISK MANAGEMENT

For those events considered to result in MATTEs it is necessary to demonstrate that the risks are adequately managed. This requires a clear explanation of what measures are currently in place to manage MATTEs and why they are present. There is the further requirement to justify not introducing additional measures; the extent of this justification should be proportionate to the magnitude of the risks. This process should demonstrate the company's decision-making process regarding evaluation, adoption and rejection of risk management measures.

Management measures to prevent or reduce a MATTE fall into the following two categories:

- Frequency reducing measures (e.g. inspection and maintenance procedures)
- Consequence reducing measures (e.g. secondary containment)

Such risk management measures can be either 'hardware' (equipment) or management related. By way of example, hardware systems control the condition of the installation (the physical hardware or operating environment) whereas management systems affect the way in which people interact with the plant itself (the operating procedures, permit-to-work systems, training, etc.). For every risk there should be at least one of each type of control measure in place.

When considering the efficacy of existing measures or considering the introduction of new ones the following risk management hierarchy should be applied:

1. **Eliminate** by removing either the source, the pathway or the receptor.
2. **Prevent,** or **mitigate** by reducing either the likelihood of the harm occurring or its severity.
3. **Control** the level of harm once the accident has occurred through emergency planning/response.

Thus, all reasonable options should be considered for eliminating the risk before identifying prevention or mitigation measures and then control strategies. This procedure is linked to the point made earlier that three components – source, pathway, receptor – must be present before a risk can be manifest. Risk management can be directed towards affecting any one of these, although the priority should be to reduce or eliminate the risk at the earliest practicable opportunity in the accident sequence.

Measures to manage risks are extensive and may include the following:

- Management systems (e.g. training levels);
- Process design factors (e.g. inherently safe design principles);
- Process operation factors (e.g. control systems and operation procedures);
- Containment systems (e.g. double wall vessels, bunds, active containment, drainage design);
- Emergency response/contingency plans (e.g. external services, response equipment);
- Remediation plans (e.g. restoration, isolation and monitoring);
- Measures to monitor the risk levels to determine if risks are changing (e.g. near-miss data).

When seeking to identify suitable measures it may be useful to refer to Environment Agency Guidance Notes and HSE guidance documents, as well as publications from the DETR, IChemE, AIChE, CCPS and trade associations, including the CIA, CEFIC and CIRIA. Some examples of publications which may be of interest are provided in the reference list. The list should not be viewed as a complete.

It is not possible to provide more than general guidance concerning the process for identifying and selecting/rejecting further risk management actions since it is highly installation specific. Screening or ranking of the list of measures may be possible, in terms of cost, effectiveness, technical feasibility, safety implications, etc. The risks which the measures are intended to reduce should be clearly identified. Justification for selecting and rejecting measures should be based on some or all of the following considerations:

- Overall level of risk from the installation;
- Costs and benefits of individual measures;
- Relative merits of the range of measures considered;
- Company policy on management of risks (refer to MAPP);
- Safety, technical feasibility, other factors; and
- Guidance notes on how to determine BATNEEC[5] (best available techniques not entailing excessive cost) and industry practice.

The effects of individual or combinations of measures on risk levels may be presented in terms of the risks with and without these measures. An analysis of costs and benefits may be performed, comparing the risk reduction obtained against the cost incurred for a particular measure, or comparing between different measures (see Technical Guidance Note E1).

Measures to reduce MATTE risks may at the same time provide other benefits. For example, secondary containment systems for flammable or toxic materials may improve fire protection or prevent human exposure, and the recovery and recycling of spilled substances may improve waste minimisation. On the other hand, there may be scenarios where a higher environmental risk may arise due to measures to reduce the safety or occupational risk, and *vice versa*. The MAPP may provide information on the approach to be taken in this situation.

[5] At the time of writing, guidance on what is considered BATNEEC is provided by the Environment Agency for processes covered by the Integrated Pollution Control legislation. This regulatory regime will be modified when the Integrated Pollution Prevention and Control (IPPC) Directive is implemented in the UK later this year. Installations regulated under IPPC will be required to use BAT, rather than BATNEEC (although the basic philosophy is the same), and guidance will be available on what is considered BAT.

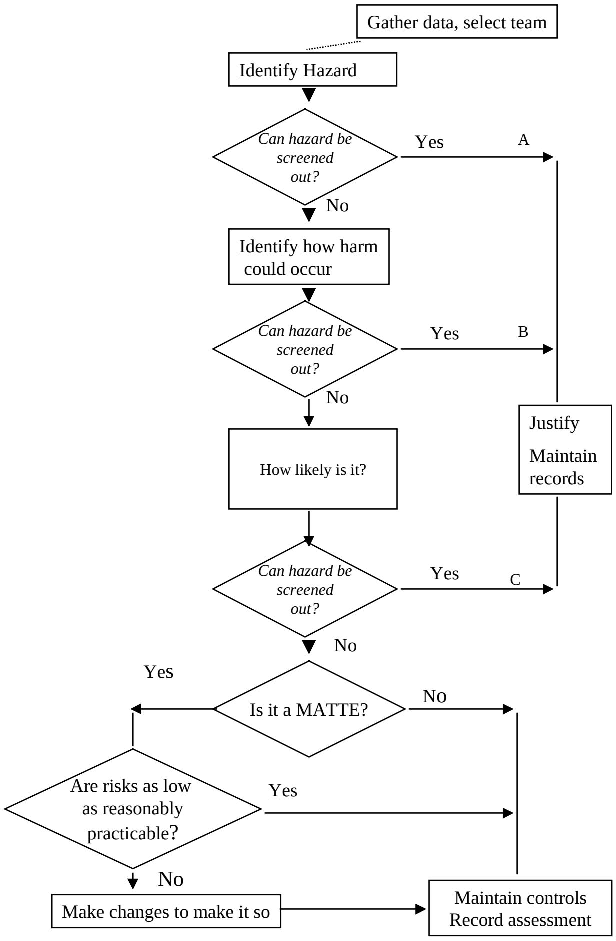

Gather data, select team
Identify Hazard
Can hazard be screened out?
Yes
A
No
Identify how harm could occur
Can hazard be screened out?
Yes
B
No
Justify
Maintain records
How likely is it?
Can hazard be screened out?
Yes
C
No
Yes
Is it a MATTE?
No
Are risks as low as reasonably practicable?
Yes
No
Make changes to make it so
Maintain controls
Record assessment

Figure 2

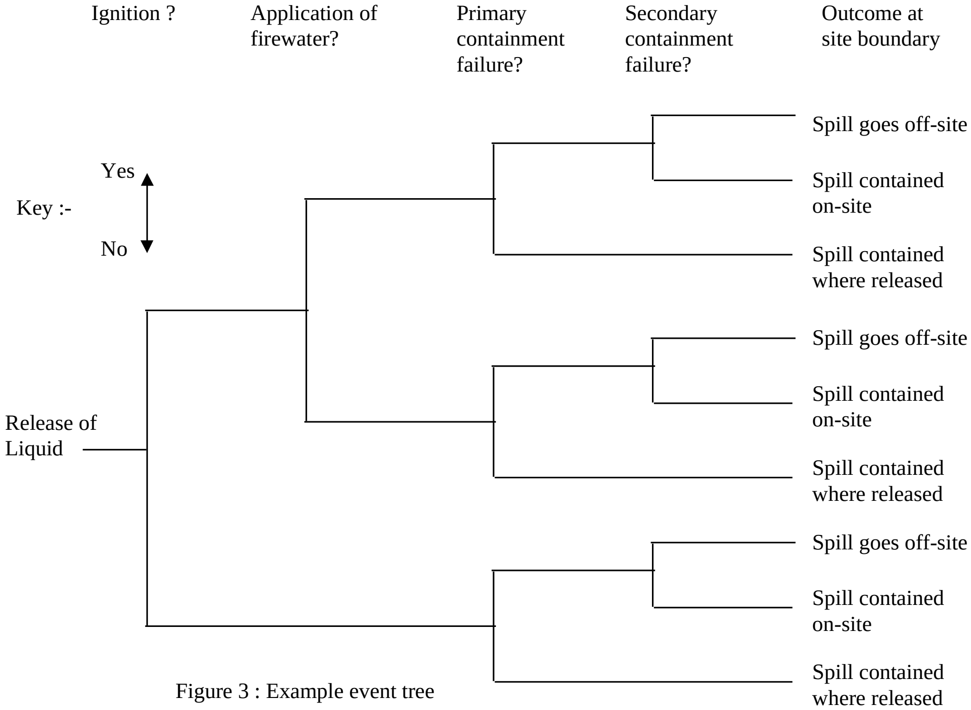


Figure 3 : Example event tree

3 Off-site emergency planning

The COMAH regulations place various requirements on operators in respect of emergency response arrangements. Such arrangements are also matters which should input to management of environmental risks. It might, for example, be possible to demonstrate that a particular fire cannot cause an off-site hazard to surface waters because all fire water will be collected on-site. The on-site and off-site emergency plans should complement each other and the requirements placed on operators include the provision of sufficient information to local authorities to allow this to happen.

Although operators are not expected to prepare the off-site emergency plan, much of the information gathered during the process of undertaking an environmental risk assessment is relevant to that process. For example, the offsite pathway analysis should provide information on where releases may go and hence allow third parties (e.g. water companies) potentially affected by any release to be identified so that measures can be put in place for them to be contacted in the event of a release from the COMAH site. Likewise, time of travel estimates can assist in determining how long emergency services have to respond and control an offsite emergency to vulnerable environmental receptors.

The Ministry of Agriculture, Fisheries and Food (MAFF) also have an interest in off-site risks in the context of potential impacts on the food chain.

It is expected that many of the results from the environmental risk assessment will be shared with the off-site emergency services and will assist operators in demonstrating that the on-site and off-site responses complement each other.

4 Presentation of risk assessment results

The COMAH regulations indicate what information must be included in a MAPP and in a safety report. Some guidance on the format of a safety report is provided in HS(G)190 (1999); this is not prescriptive and an operator may present the information required by the regulations in any written form. The suggested format in HS(G)190 is:

(a) site information common to all parts (Chapter 3)

(b) information on the management arrangements and safety management systems (Chapter 4)

(c) information about individual installations and processes, identification of major accident scenarios, assessment of their consequences and/or risk analysis and assessment linked to the measures provided (Chapter 5)

(d) information about the measures to prevent or limit the consequences of a major accident at each installation (Chapter 6)

(e) information about emergency response (Chapter 7).

The chapter numbers are those in HS(G)190 in which further guidance is provided. Suggested ERA elements are listed in table 2 and expanded in Appendices 1& 2 of this document. The information identified may be contained in sections within the HS(G)190 structure. There can be considerable mixing of the above categories of information, for example, for establishments covering more than one process it may easier to put as much common information in a 'core' report. If it necessary to refer to generic major accident scenarios or consequence assessment for more than one process, then it is probably simpler to separate these out to avoid repetition.

Each safety report will be evaluated by a team drawn from the HSE and the relevant environment agency, acting as joint Competent Authority. It will therefore be scrutinised by a number of different specialists to determine:

- if the report meets the obligations imposed by COMAH on operators; and
- whether the measures proposed to prevent and limit accidents to humans and the environment are seriously deficient.

Although it is likely that there will be an overlap between the interests of the team members, some parts of the report will be mainly of concern to those interested in safety and direct risks to people, whereas others will primarily be relevant to members concerned with the types of environmental risks discussed in this document. It is therefore recommended that some guidance on the structure of the report is provided to facilitate identification of relevant sections by team members and help increase the efficiency and speed with which it is assessed.

5 Summary and discussion

The environmental risk assessment should demonstrate the following aspects:

- that the operator understands the MATTE risks involved in the operation of the installation;
- that risks from MATTEs arising from the installation are at an acceptable level;
- adequate measures are being taken to prevent occurrence and limit consequences of MATTE;
- adequate information is provided for local authority purposes of developing offsite emergency plan;
- the effect of onsite and offsite emergency response plans on risk levels has been demonstrated; and
- there is sufficient information regarding domino risks with neighbouring sites.

The information provided in this document is intended to provide guidance for an assessment to be carried out on the aspects relating to an environmental risk assessment within a Safety Report. It may also be used to support a MAPP, although the degree of detail should be proportionally less, on the basis of risk, for a MAPP than for a Safety Report. Likewise, the basic techniques are equally applicable to other situations in which an environmental risk assessment is required, again with the proviso that the level of screening out of risk and of the degree of detail concerned will vary with the application. In the event that the assessment outlined in this guidance document concludes that the objectives of COMAH may not be met or that the measures taken are seriously deficient, further detailed verification may be required. The guidance provided here should also be used as a basis for such an exercise, to help identify and prioritise key areas of weakness; however, more detailed sources of information may need to be sought to support this process.

Given the nature and complexity of any risk assessment process and the particular difficulties associated with environmental risks, it is essential that this guidance be applied in a non-prescriptive manner. Evidence that the operator is using an effective environmental risk assessment process is itself as much of an important result as the actual risk level estimated, given the emphasis placed in COMAH on a systematic approach to identify, understand and manage risks.

It is particularly recommended that the steps taken to undertake an environmental risk assessment are set down in a simple and structured manner. An overview of the complete process may assist in this respect. As well as presenting information on MATTEs, operators should also document the methods and criteria used to identify those hazards and risks which are not considered to have the potential to cause MATTEs. This will facilitate the efficient regulation of the COMAH Directive by assisting the Competent Authority in understanding and judging the scope and thoroughness of the environmental risk assessment process.

It is expected that the risk assessment process will be more effective and streamlined if it addresses safety and environmental issues simultaneously where appropriate, for example in the hazard identification stage.

The Competent Authority can provide further advice on undertaking an environmental risk assessment.

Appendices

CONTENTS

Appendix 1
Checklist of ERA Aspects for Assessors of COMAH Safety Reports

Appendix 1 : Checklist of Aspects for a COMAH Safety Report (see Appendix 2 for further detail)

Stage	No.	Environmental Aspect	Objective	Present ?	Adequate ?
Introduction	1.	Objectives	Define objectives of environmental risk assessment carried out as part of COMAH Safety Report.		
	2.	Resources and planning for assessment	Demonstrate that adequate resources and planning are provided for assessment.		
	3.	Background and previous studies	To identify previous studies that could be used as to COMAH Safety Report.		
	4.	Layout and contents of report	To provide an overview of the structure of the COMAH Safety Report.		
Approach	5.	Overall approach and justification	To present and justify the overall approach adopted for the ERA.		
	6.	Study Scope	To define the scope of the ERA.		
Information for Risk Assessment	7.	Hazardous substances information	To present information concerning substances dangerous to the environment.		
	8.	Site description	To describe all aspects of the site relevant to the ERA scope.		
	9.	Environment description	To describe all aspects of the environment relevant to the ERA scope.		
Accident Initiators	10.	Hazard identification techniques	Specify techniques to be used for hazard identification.		
	11.	Initiator events/cause analysis	Identify and understand causes of accidental events.		
	12.	Accident phenomena	Understand how accidents develop.		
	13.	List of potential accident scenarios	Generate a comprehensive list of potential accident scenarios.		
	14.	Screening	Prioritise accidental events for further assessment and screen out lesser events.		
Accident Frequency Analysis	15.	Approach and modelling information	To describe the approach and modelling information used in evaluating source details for accident scenarios.		
	16.	Frequency estimation techniques	To estimate frequencies of initial release events.		
	17.	Onsite pathway analysis	To define pathways that an initial release may take to reach the site boundary.		
	18.	Accident elimination, prevention and control	To demonstrate source ERA information is used to identify measures to eliminate, prevent and control MATTE risks.		
	19.	Screening	To screen out insignificant risks based on source information.		

Appendix 1 : Checklist of Aspects for a COMAH Safety Report (see Appendix 2 for further detail)

Stage	No.	Environmental Aspect	Objective	Present ?	Adequate ?
Accident Consequences/	20.	Approach and modelling information	Demonstrate the approach taken to modelling exposures to the environment from MAH releases.		
	21.	Offsite pathways analysis	To describe the offsite pathway analysis.		
	22.	Hazard distances and other results	To determine the environmental range of exposure.		
	23.	Offsite emergency planning	To determine whether sufficient information has been generated for offsite emergency planning purposes.		
	24.	Screening	To determine whether further analysis is required and at what level of detail.		
Accident Impacts	25.	Approach and criteria	Demonstrate the approach taken to understanding the potential harm/damage caused to the environment by accidents.		
	26.	Impacts to receptors	Present results of impact assessment.		
Presentation of analysis/ Risk results	27.	Summary	Provide overall summary and conclusions with respect to risk results and ERA objectives.		
	28.	Data presentation	To present the results of the ERA.		
	29.	Risk Acceptance Criteria	To describe environmental risk acceptance criteria that may be used.		
	30.	Comparison of results with criteria	Assessment of acceptability.		
	31.	Identification of risk management measures	Produce a comprehensive list of relevant measures to manage MATTE risks.		
	32.	Evaluation of measures	Assess and justify selection of measures to manage MATTE risks.		

Aspects 7 to 14 are essential and should be included in all Safety Reports.
Aspects 15 to 19 are an important requirement of a Safety Report.
Aspects 20 onwards are dependent upon the operating environment and conditions.
Aspects 1 to 6 add clarity to the Safety Report – 4 is especially useful

Appendix 2
Further Technical Guidance and Assessment Criteria

Stage	**Introduction**
Aspect	**1. Objectives**
Objective	Define objectives of environmental risk assessment carried out as part of COMAH safety report
Details	The objectives of the safety report as defined in the COMAH regulations are to demonstrate the following: 1. A MAPP meeting the requirements of Schedule 2 and a management system for implementing the MAPP exist 2. Potential MAHs are identified and necessary measures implemented to prevent or limit them 3. Adequate safety and reliability are incorporated into the design/construction/operation/maintenance of related systems 4. Onsite emergency plans are drawn up and information provided for offsite plans to deal with MAHs 5. Information is provided to enable planning decisions to be made in terms of siting of developments The ERA part of the Safety Report should focus on item 2 but will also provide input to the remaining four items. Within item 2, the following specific objectives may be defined: • Identify all possible accident scenarios which may have the potential to lead to a MATTE • Understand the nature, causes, behaviour and consequences of these scenarios • Assess the risks to the environment from potential MATTE scenarios • Evaluate and select measures which are being or could be taken to minimise these risks • Determine whether the residual risks to the environment are acceptable
Links	Output to Presentation of Results, Approach
Criteria	1. Have the overall purpose and aims of COMAH been understood? 2. Are the objectives of the assessment clear and comprehensive? **SRAM Criteria 4.1/2/3**
References	COMAH Regulations Appendix 5 of this document

SRAM – Safety Report Assessment Manual

Stage	**Introduction**
Aspect	**2. Resources and planning for assessment**
Objective	Demonstrate adequate resources and planning provided for assessment
Details	It is generally accepted that the level of effort should be in proportion to the risk involved. However other factors need to be considered, e.g. previous experience with such assessment work, existing studies, complexity of the installation, degree of conservatism in selecting risk management measures, etc. The adequacy of resources in relation to risk can only be fully judged once the risks are assessed, therefore the plan should include a facility for iteration, i.e. carrying out further work if initial work indicates that this is necessary. Use of a tiered approach to ERA is fundamental to effective resourcing and planning of risk assessment. It may take considerable effort to demonstrate that a risk is very low for an installation which has numerous or complex safeguards. Therefore the level of effort should be judged in proportion to the inherent risk to the environment from the process.
Links	Input from Presentation of Results
Criteria	1. Is effort proportionate to the level of risk posed? 2. Has the planning included a facility for ERA iteration being used?
References	

<table>
<tr><td>Stage</td><td>Introduction</td></tr>
<tr><td>Aspect</td><td>3. Background and previous studies</td></tr>
<tr><td>Objective</td><td>To identify previous studies that could be used as input to COMAH application</td></tr>
<tr><td>Details</td><td>Demonstration of previous operational experience on sites with similar hazards to the environment is advantageous.

Transfer of data, information and expertise from sites with similar hazards to the environment is desirable.

Previous experience or assessments with related hazards could be used in support of the COMAH application. This could include previous CIMAH studies and any other work done relating to environmental accident risks from similar operations.

The interface to safety aspects and other legislative requirements should be identified as part of the background to the ERA. Other legislative requirements potentially relevant to the ERA may include:

• Environmental Protection Act 1990
• IPC/IPPC Directive
• EA Directive
• Habitats and Birds Directives
• Environment Act 1995
• Water Resources Act 1991
• Groundwater Regulations
• Notification of Installations Handling Hazardous Substances Regs (1982)
• Health and Safety at Work Act and 1992 Regulations

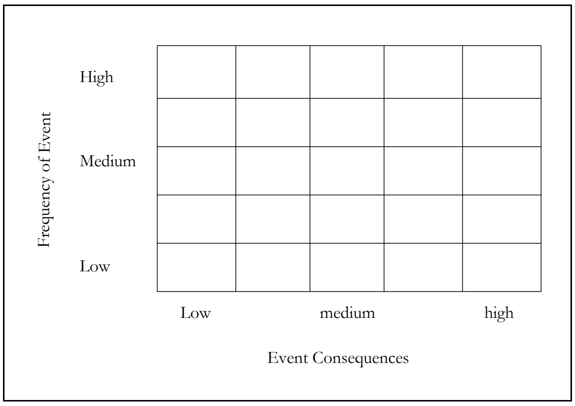
Agency policies may also be relevant, e.g. Groundwater Protection Policy.</td></tr>
<tr><td>Links</td><td></td></tr>
<tr><td>Criteria</td><td>1. Has the operator identified previous experience assessing environmental risks from similar operations?
2. Are related legislative requirements and interfaces defined?</td></tr>
<tr><td>References</td><td></td></tr>
</table>

Stage	**Introduction**
Aspect	**4. Layout and contents of report**
Objective	To provide an overview of the structure of the COMAH safety report.
Details	It is not possible for the regulator to prescriptively define COMAH safety report structure, It would be desirable for an operator to produce a route map of the COMAH safety report detailing the contents and where relevant information can be found.
Links	
Criteria	1. Is the report clearly laid out? 2. Is information easy to obtain?
References	

<table>
<tr><th>Stage</th><th>Approach</th></tr>
<tr><td>Aspect</td><td>5. Overall approach and justification</td></tr>
<tr><td>Objective</td><td>To present and justify the overall approach adopted for the ERA</td></tr>
<tr><td>Details</td><td>There are numerous methods for assessing environmental risks. It is not possible to prescribe a single approach for ERA. General guidance may be found from the following sources:
• DETR “Green Leaves”;
• Company standard methodologies;
• Standard references.

A tiered approach to ERA is recommended, starting with screening and using more detailed techniques only where necessary. This logic has been used elsewhere, e.g. by the Environment Agency for guidance on prevention of pollution. A tiered approach can be applied in either or both of two ways:
• start with simple qualitative methods and progress to greater levels of detail and quantification where necessary
• start by considering only source-related information (e.g. size and frequency of releases) and extend analysis where necessary to consider exposure/consequence information and finally impact/damage information

Refer to philosophy and approach contained within this document for further guidance. Some examples of ERA methods that may be used include:
• environmental checklists;
• risk matrix (e.g. DETR Green Leaves, see figure);
• scoring system;
• simple qualitative rating systems e.g. CIRIA approach which evaluates environmental risks based on rating of source, pathway, receptor and frequency in terms of Low/Medium/High categories.



The approach should include a clear definition of an environmental MAH and/or a major accident to the environment (MATTE). A MAH is defined in terms of the size and nature of a potential release (e.g. in relation to COMAH threshold inventories and criteria for substances dangerous to the environment). A MATTE is defined in terms of consequences and impacts to environment. This is contentious, but the following areas may provide guidance on what constitutes a MATTE:
• Management of Harm to Environment project;
• Historical accidents;
• Accident Reporting requirements in the COMAH Regulations;
• DETR “Green Book”.

Assessments of safety and environmental risks employ essentially identical structures and may therefore be done in conjunction. The interfaces between the assessment of safety and environmental risks should be made clear. It may be possible to treat environmental impacts from flammable events and atmospheric releases as for human impacts – specific focus of the environmental aspects may then be towards impacts to aquatic and groundwater/soil environments.

An operator should demonstrate an understanding of the risk-related terms presented in the approach (see Green Leaves Book for definitions).</td></tr>
<tr><td>Links</td><td>Output to all subsequent stages.</td></tr>
</table>

Stage	Approach
Aspect	**5. Overall approach and justification**
Criteria	1. Does safety report detail overall approach to ERA and interface to safety assessment? 2. Does description include definition of MAH/MATTE? 3. Is approach based on reasonable or recognised methods and techniques? 4. Is the approach structured, transparent and systematic? 5. Is level of quantification appropriate? 6. Is a tiered approach applied with iteration between assessment and evaluation of measures? 7. Does the approach reflect the MAPP? **SRAM Criteria 3.1, 4.1/2/3**
References	DETR 'Green Leaves Book': Guide to Risk Assessment and Risk Management for Environmental protection (1995, updated 1998) DETR 'Green Book' Definition of a MATTE (1991, updated 1998) DETR, 'Management of Harm to the Environment' HMSO 1998 JRC 'Guidance on the Preparation of a Safety Report to Meet the Requirements of Council Directive 96/82/EC (Seveso II)' (1997) Royal Society " Risk: Analysis, Perception and Management" (1992) Lees (1980): Loss Prevention in the Process Industries Guidance on EIA for Industrial Accidents (CIA/ICI Confidential?) CIRIA Design of Containment Systems to Prevent Pollution from Industrial Incidents

Stage	**Approach**
Aspect	**6. Study Scope**
Objective	To define the scope of the ERA
Details	Types of risk covered – immediate and delayed effects from uncontrolled releases arising from both normal and abnormal conditions on the installation. Includes commissioning, maintenance, operation and modification phases. The basic environmental risk issues for consideration are detailed in the Philosophy and Approach Section of this document. Range and type of effects to be considered – these should generally be local although there is a potential for long-range pollution e.g. via rivers. The study boundary (maximum size of area for analysis) should be defined taking into account the consultation distance but also considering the range of environmental impacts from the site. Substances dangerous to the environment that should be considered in the safety report are those that have been included within the upper tier limit under the Notification Scheme in the COMAH Regulations. Thus, the criteria for inclusion of a substance dangerous to the environment is an R50 or R51/R53 substance whose total inventory is greater than 2% of the upper tier threshold inventory for that substance class. Any systems, operations and equipment involved in the storing, processing, handling or transferring of substances within the scope of the safety report should be covered in the ERA scope. Definitions for MAH and MATTE (defined in the Approach) should be used to define the scope of ERA. In general environmental risks that do not constitute a MATTE may be screened out at the scoping stage if sufficient justification is provided. The basis behind MATTE screening is if a receptor does not exist within a reasonable distance from the site then an impact cannot occur. If the site also falls under IPC or IPPC then environmental risks controlled by those regulations issues (i.e. those risks that are less significant than MAH risks) should be screened out and reported under IPC/IPPC planning applications.
Links	Input to Philosophy/Justification of Approach Output from Hazardous substances information Output from Site Description Output from Environment Description
Criteria	1. Have all substances dangerous to the environment been included? 2. Have all potential MATTE been included? 3. Are all relevant systems, equipment and operations included? **SRAM Criterion 3.3**
References	COMAH Regulations (Notification Scheme)

Stage	**Information for Risk Assessment**
Aspect	**7. Hazardous substances information**
Objective	To present information concerning substances dangerous to the environment
Details	A list of substances to be considered should be generated based on the scope. The list should include substances occurring under normal and abnormal conditions. Given the generic nature of categories of harm in COMAH and the corresponding limited list of named substances, the onus should be on demonstrating that substances may be excluded on the basis of low inventories and harmful properties, rather than assuming a shortlist of relevant substances without justification. **Therefore, all substances should be assessed for potential environmental risk to justify exclusion, not just the substances with official documented risks.** The need to include substances other than R- substances and their COMAH Threshold Levels in the safety report may arise. However, this may be a difficult area due to concerns regarding over-interpretation of the requirements of the COMAH Regulations. Information on the environmental behaviour of substances should be presented. Aquatic ecotoxicity data are the most important given the emphasis on toxicity to the aquatic environment inherent in the R50/R51 criteria; however other potentially harmful properties (e.g. toxicity in the terrestrial or atmospheric environments, BOD/COD, blanketing/smothering) may need to be considered. Data relating to immediate and delayed harmful effects should be presented. Other information required includes persistence, bioconcentration factor, bioaccumulation potential, solubility, density, etc.
Links	Input from Scope
Criteria	1. Is the list of substances dangerous to the environment complete? 2. Is sufficient information available to understand the potential environmental behaviour and harm from each substance? 3. Is sufficient information available to demonstrate that the list is comprehensive? **SRAM Criteria 2.2-2.5**
References	EC Dangerous Substances Regulations Standard substance property data references

Stage	**Information for Risk Assessment**
Aspect	**8. Site description**
Objective	To describe all aspects of site relevant to scope of ERA
Details	Detailed guidance on site description requirements is provided in D6 guidance. Site data including management systems, control systems, procedures, operations and equipment which is relevant to the ERA but may not be covered in the safety aspect should be provided in the safety report. The type of information particularly relevant to the ERA includes the following: • Location, inventory and conditions of substances dangerous to environment • Layout and segregation of entire drainage system, barriers, valves etc. • Maps and plans of site features affecting runoff of spilled substances • Activities relevant to environmental risk • Onsite treatment plants Local areas of interest should be included in the Environmental Description.
Links	Input from Scope Output to List of Potential Accident Scenarios
Criteria	1. Are all environment-critical systems, operations and equipment described? **SRAM Criteria 2.8 – 2.11**
References	COMAH Competent Authority 'Safety Report Assessment Manual' (Part 2)

<table>
<tr><th>Stage</th><th>Information for Risk Assessment</th></tr>
<tr><td>Aspect</td><td>9. Environment description</td></tr>
<tr><td>Objective</td><td>To describe all aspects of the environment relevant to scope of ERA</td></tr>
<tr><td>Details</td><td>All environmental media are potentially relevant, and these include:

• surface water;
• ground water;
• soil and sediment;
• air.

A description should be provided of relevant physical, chemical and biological receptors within those media, including onsite and offsite receptors. This should include all aspects of the environment and ecosystems at risk, in particular:

• Red Book species
• Designated Areas (SAC, SPA, SSSI, AONB, Ramsar sites, Local Authority nature classification schemes, etc.)
• Water resources
• Drinking and industrial water abstraction points (ground and surface)
• Amenity areas
• Sites of architectural and historical importance
• Agricultural resources
• Human populations

Particularly sensitive receptors should be identified, e.g. EC Directive Priority Habitats/Species, EC Wild Birds Directive, special areas of conservation, etc. The environmental sensitivity of receptors needs to be gauged; for example surface/groundwater bodies are classified using Environment Agency classification schemes.

Information sources include English Nature, English Heritage, local environmental groups, Environment Agency, ITE Comparative Environmental Index, etc.

Factors affecting the occurrence and behaviour of accidental releases in the environment should be described, including: hydrology, meteorology, hydrogeology, geography, climate, etc.

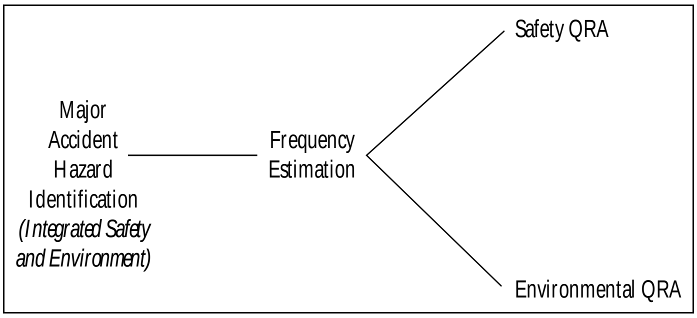
A detailed site survey may be needed to determine the nature of local ecosystems.

Activities beyond the site boundary which may interact with the site should be identified. These may include neighbouring industrial facilities, water treatment plants connected by rivers or sewer systems, upstream processes. Examples of interaction which should be considered within the ERA include spills from site causing damage to connected facilities, combinations of released substances which may react to produce an environmental hazard, and upstream processes transferring off-spec material leading to upsets on the installation.</td></tr>
<tr><td>Links</td><td>Input from Scope
Output to Offsite Pathway Analysis and Offsite Emergency Planning</td></tr>
<tr><td>Criteria</td><td>1. Are all relevant media considered?
2. Are all vulnerable receptors identified?
3. Is sensitivity of receptors to environmental accidents understood?
4. Is there sufficient information to describe occurrence and behaviour of releases in environment?
5. Have potentially interacting activities offsite been identified?

SRAM Criteria 2.6 - 2.7</td></tr>
<tr><td>References</td><td>ITE Comparative Environmental Index
Standard environmental information sources</td></tr>
</table>

<table>
<tr><td>Stage</td><td>Hazard Identification</td></tr>
<tr><td>Aspect</td><td>10. Hazard identification techniques</td></tr>
<tr><td>Objective</td><td>Specify techniques to be used for hazard identification</td></tr>
<tr><td>Details</td><td>Standard HAZID techniques include HAZOP, HAZAN, failure modes effects analysis (FMEA), etc. These are described in Section 3. However they are generally applied for safety purposes and evidence needs to be provided that they are extended to give proper consideration to environmental hazards. For example, HAZOP keywords can be developed specifically for environmental hazards, e.g. FIREWATER, DRAINS, ENVIRONMENTAL EFFECT.

The environmental HAZID can be combined with the safety HAZID (see figure). Divergence between the two arises at the stage where pathways and consequences are considered. If a separate safety HAZID has been performed, all events identified in that exercise should be checked to see if any have environmental implications, as there may be some overlapping events with both safety and environmental implications.


</td></tr>
<tr><td>Links</td><td>Input from Scope
Output to List of Potential Accident Scenarios</td></tr>
<tr><td>Criteria</td><td>1. Have hazards been identified using a structured approach?
2. Have environmental issues been fully considered within the HAZID?
3. Have safety hazards been screened for environmental implications?

SRAM Criteria 1.4 & 3.3</td></tr>
<tr><td>References</td><td>COMAH Competent Authority ‘Safety Report Assessment Manual’ (Part 2)</td></tr>
</table>

<table>
<tr><td>Stage</td><td>Hazard Identification</td></tr>
<tr><td>Aspect</td><td>11. Initiator events/cause analysis</td></tr>
<tr><td>Objective</td><td>Identify and understand causes of accidental events</td></tr>
<tr><td>Details</td><td>Basic loss causation theory applies equally between environmental and safety events. An understanding of how and why events occur is essential under COMAH in order to demonstrate an understanding of the risks and the appropriate measures to manage those risks.

The ERA should consider the following factors in order to understand why and how releases that lead to environmental accidents may occur:

• Direct, immediate causes – substandard conditions/acts/practices
• Basic causes – personal/system factors
• Loss of control – inadequate systems/standards/compliance

The ERA should identify all initiating events for accidental releases of substances dangerous to the environment, using historical incidents, fault trees, etc. as for safety analysis. Both onsite and offsite causes should be considered. Examples of causes include:

• operator error (80% of accidents are attributed to this cause alone)
• abnormal load (e.g. incorrect loading of tanks)
• extreme environmental conditions (e.g. flooding)
• loss of service
• sabotage</td></tr>
<tr><td>Links</td><td>Input from, and output to List of Potential Accident Scenarios</td></tr>
<tr><td>Criteria</td><td>1. Has an understanding of the causes of all events leading to environmental losses been demonstrated?

SRAM Criteria 1.4 & 3.3</td></tr>
<tr><td>References</td><td>COMAH Competent Authority ‘Safety Report Assessment Manual’ (Part 2)</td></tr>
</table>

Stage	**Hazard Identification**
Aspect	**12. Accident phenomena**
Objective	Understand how accidents develop
Details	Loss causation theory also applies to understanding why and how environment accidents progress from an initial release. For example, how and why is an interceptor unable to contain a spilled substance? The three main factors that need to be considered in order to understand accident phenomena are: • Behaviour of released substances • Onsite pathways analysis • Domino or escalation effects Substance behaviour upon release should be identified, e.g. reactions with air/water/other substances, changes of phase, dispersion characteristics (dense or buoyant behaviour), etc. Substance behaviour must be characterised before the types of pathway can be evaluated. Behaviour under normal conditions and foreseeable abnormal conditions should be considered. A pathway is the physical route, or routes, by which a released substance may be transported to (and subsequently through) the environment. Event trees may be used to present this process. The onsite pathway analysis for ERA will typically include the following factors: • Secondary containment design, position, capacity, condition • Flow of spilled material across surfaces, into drains, etc. • Management factors such as operator response, control procedures • Distances between sources and pathways • Site layout and drainage, capacity and condition of drains, etc. • Barriers, e.g. interceptors and sumps • Geographical/geological/hydro-geological features that may impede/facilitate pollutant escape • Effect of varying weather conditions (e.g. storm-water) • Treatment plants (on or off-site) • detection, shutdown • Location of pumps, valves, pipework • Suitability, capacity of treatment plant The safety report should consider Domino Effects in terms of the installation both causing and being affected by escalating accident scenarios, both within and outside the installation boundary. This section should take into account neighbouring activities which may interact with the installation. The report should identify if the installation is designated as part of a Domino Cluster (HSE). The effectiveness of existing and proposed measures on event frequencies and consequences should be possible to reflect in pathway analysis. Example event trees are detailed in the onsite and offsite pathway analysis sections.
Links	Input from AND Output to List of Potential Accident Scenarios Onsite pathway analysis, offsite pathway analysis
Criteria	1. Has the operator demonstrated an understanding of the onsite events and factors that could lead to release to the environment? 2. Does the operator understand why and how these events occur? **SRAM Criteria 1.4 & 3.3**
References	Competent Authority 'Safety Report Assessment Manual' (Part 2)

Stage	**Hazard Identification**
Aspect	**13. List of potential accident scenarios**
Objective	Generate comprehensive list of potential accident scenarios
Details	Scenarios should be developed from the release events identified in the HAZID. For example, safety and environmental consequence scenarios could be defined from the release of substance with the potential to effect safety and the environment. Further scenarios may then be developed to address all possible safety and environmental consequences. A comprehensive list of scenarios should be generated by taking into account factors such as: • accident phenomena and causes of accidents; • small and large failures in vessels, loading equipment, process equipment, pipelines within establishments, etc.; • mixtures of substances, unwanted by-products of chemical reactions, abnormal concentrations of substances or conditions; • MAH arising from normal operation and abnormal conditions; • systematic equipment failure cases; • operator error scenarios; • process upsets – uncontrolled chemical reactions; • domino scenarios; • commissioning, maintenance, operation and modification scenarios. As an example, a release event may have defined a catastrophic failure of storage vessel containing a flammable substance dangerous to the environment. Accident scenarios may include: • run-off to land; • entry to drainage system through; • application of firewater with run-off to the above. A particularly important scenario to consider is the potential for a release to be associated with firewater. This could be a direct result of firewater applied to the release, or indirectly firewater run-off from another part of the site (i.e. a domino effect).
Links	Input from HAZID Techniques Input from and output to Phenomena and Cause Analysis Output to onsite pathway analysis
Criteria	1. Have all potentially relevant accident scenarios been identified? 2. Are the scenarios developed consistent with accident phenomena and cause analysis? 3. Have firewater scenarios been developed for flammable substances? **SRAM Criteria 1.4 & 3.3**
References	Competent Authority 'Safety Report Assessment Manual' (Part 2)

Stage	**Hazard Identification**
Aspect	**14. Screening**
Objective	Prioritise accidental events for further assessment and screen out lesser events
Details	In order to focus the ERA on significant risk issues a screening stage may be introduced to screen out scenarios or events that may not lead to a MATTE. Screening may be done by coarsely ranking events and scenarios in order of potential significance and screening out insignificant events and scenarios. Screening is likely to be an iteration of the screening conducted at the scoping phase. At this stage of the analysis risks have not yet been evaluated. It is important that screening should be conservative follow the precautionary principle that if there is some chance that an event or scenario may constitute a MATTE then it should be retained for further analysis.
Links	Study scope
Criteria	1. Have events or scenarios from the HAZID been screened? 2. Has the operator provided sufficient justification for screening? 3. Are the screening criteria adopted reasonable? **SRAM Criterion 3.4**
References	

Stage	**Accident Frequency Analysis**
Aspect	**15. Approach and modelling information**
Objective	To describe the approach and modelling information used in evaluating source details for accident scenarios
Details	Source details need to be defined for each accident scenario, including all information necessary to determine the nature and frequency of the release at the site boundary. Source information should therefore include the following: 1. Substance released, size/release rate/duration of release 2. Conditions of release (pressure, temperature, phase) 3. Location, elevation, direction of release 4. External conditions (e.g. ignition, detection, secondary containment failure, drains, emergency procedures, etc.) 5. Frequency or likelihood of release Release details (1-3) should be derived directly from the hazard identification process. Discharge modelling may be used in order to quantify the initial release rate and any time dependent characteristics. The release duration needs to take into account detection and shutdown times plus the effects of potential blow-down or emergency emptying of vessels. Releases may be specified as catastrophic instantaneous or continuous releases. In either case an effective release rate and duration will generally need to be defined. Rates and durations for releases from further stages may also need to be defined, e.g. rate of release from secondary containment or from drainage system. Most site drainage systems will have a characteristic hold-up time which may dictate the effective release rate into the environment. Dilution or reactions of released material within drainage systems should also be considered in defining the release conditions. Based on the onsite conditions and behaviour of the release considered in Accident phenomena, it should be possible to characterise and present information regarding the external conditions relevant to each accident scenario. For any one scenario, a number of specific outcomes may arise depending on the onsite pathway which is followed. As discussed, event trees provide an effective means of describing these external conditions and determining the likelihood of each outcome. If a single outcome is selected to represent the range of possible outcomes, this representative outcome should be based on a worst-case assumption regarding each condition (e.g. detection fails, secondary containment fails, no blowdown, etc.). Accident frequencies will be determined from the frequency of initial loss of containment combined with the conditional probabilities of relevant external factors. There are several basic approaches to evaluating accident frequencies, which may be used separately or in combination: • Qualitative approach; • generic historical failure rate data based on e.g. HSE or other standard sources; • company or site specific historical data; • direct quantification (e.g. using fault trees). A qualitative approach may take the form of word- or number- based categorisation systems, e.g. LL, L, M, H, HH frequencies. Generic or specific historical data provides a more rigorous basis for frequency estimation. Quantification is very useful because it enables causes and measures to prevent or limit accidents to be explicitly handled; however this may be a resource-intensive exercise and needs careful treatment as calculated frequencies can be significantly lower than the real values if such things as common-mode failure are neglected. The approach should include an evaluation of uncertainties in data used; e.g. alternative sources of equipment failure rates may be identified in order to derive a band of frequencies.
Links	Accident cause analysis
Criteria	1. Has approach for estimating frequencies and modelling releases been described? 2. Does the approach use a recognised frequency estimation technique? 3. Does the approach cover all relevant information required to define source conditions? **SRAM Criteria 3.3 & 3.4**
References	Competent Authority 'Safety Report Assessment Manual' (Part 2)

<table>
<tr><td>Stage</td><td>Accident Frequency Analysis</td></tr>
<tr><td>Aspect</td><td>16. Frequency estimation techniques</td></tr>
<tr><td>Objective</td><td>To estimate frequencies of initial release events</td></tr>
<tr><td>Details</td><td>Irrespective of the actual approach adopted, event frequency estimation requires consideration of three issues:

1. Amount and type of equipment (e.g. no. of reactor vessels)
2. Task frequencies (e.g. frequency of maintenance shutdown or feed change)
3. Management system factors

An accident scenario will generally arise from a specific task or equipment, or group of tasks or equipment. In order to determine the frequency or likelihood of an event, a basic count of equipment or tasks is required.

It is widely recognised that the likelihood of an event occurring is determined by a combination of basic frequency information (e.g. relating to numbers of equipment/tasks) and management systems factors (e.g. degree of operator training). Although there is no easy way of combining this information in order to produce specific frequency data, it is necessary to reflect management factors in this aspect. Specific environmental aspects of the management systems need to be considered, e.g.:

• Documentation – procedures, information, records, etc.
• Use of information – hazard identification and assessment
• Implementation and Effectiveness of procedures and controls
• Commitment – aims, principles of action, roles, responsibilities defined
• Training, management of contractors
• Audit

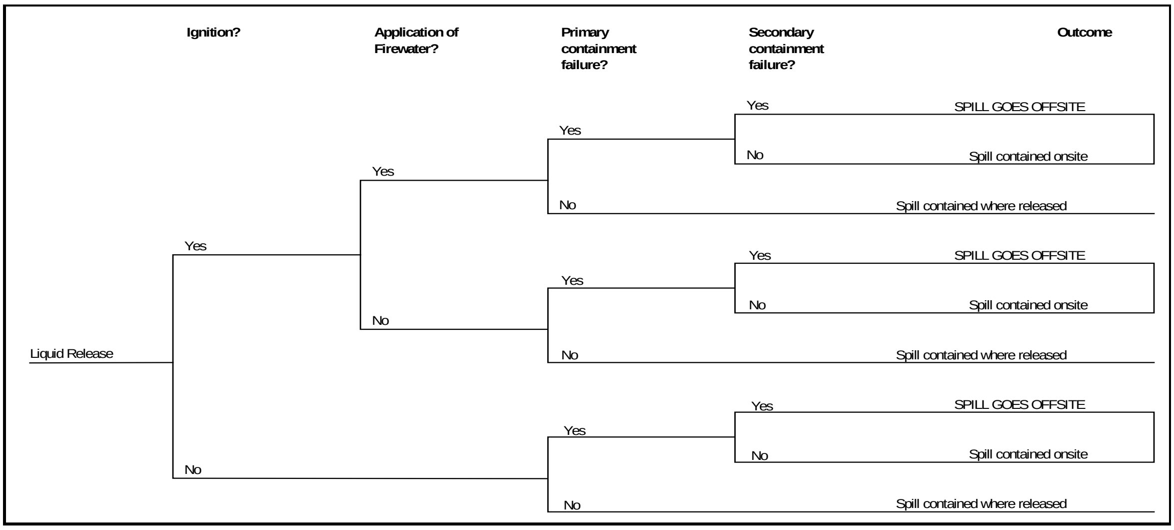
An evaluation of such factors may have been carried out for other purposes, e.g. a large-scale audit or an Operator and Pollution Risk Appraisal (OPRA) rating. Evidence that there is a management system specifically for environmental issues should be presented; this may include reference to recognised standards such as EMAS or ISO14001.

A clear distinction should be made between probability (e.g. 0.20, 20% or 1 in 5 chance) and frequency (e.g. 1/10,000 years, or 10^{-4}/year). Probability applies to the occurrence of one among a number of possible events given a precursor event or condition arises. Frequency is the rate of occurrence of a particular event in a given period of time.</td></tr>
<tr><td>Links</td><td>Input from Site description, List of Potential Accident Scenarios, Management Systems details</td></tr>
<tr><td>Criteria</td><td>1. Have frequencies been estimated using the stated approach?
2. Do the frequencies reflect relevant information on numbers of equipment, task frequencies, etc?
3. Has the influence of management systems factors been considered?

SRAM Criterion 3.4</td></tr>
<tr><td>References</td><td></td></tr>
</table>

<table>
<tr><td>Stage</td><td>Accident Frequency Analysis</td></tr>
<tr><td>Aspect</td><td>17. Onsite pathway analysis</td></tr>
<tr><td>Objective</td><td>To define pathways that an initial release may take to reach site boundary</td></tr>
<tr><td>Details</td><td>Onsite pathway analysis quantifies the factors identified in accident phenomena analysis in order to evaluate the likelihood or probability of an initial release going offsite. When a release occurs it does not necessarily go straight to the environment (e.g. surface water) but may go through an onsite sewer network before being released to the environment. In some cases an offsite pathway analysis may also need to be performed, e.g. for an external sewer network.

A relatively simple example of an onsite pathway analysis (presented as an event tree) is given in the figure.



The event tree describes the liquid phase release of a dangerous substance to the environment and the conditional events that could lead to a breach of the site boundary potentially leading to pollution of the environment. The accident phenomena section contains a summary of factors that should be considered in assessing the onsite pathways (some of which are provided in the figure).

The pathway analysis also describes the potential for a flammable substance to become ignited and to generate firewater as well as the transport of chemical spills. Some pathways lead to onsite containment. These pathways may be screened.

The probabilities of an offsite release can be calculated by multiplying together the conditional event probabilities that lead to a spill going offsite. Conditional event probabilities may be evaluated by using a fault tree model or by expert judgement. The frequency of an offsite release is given by multiplying the probability of an offsite release by the initial release frequency.</td></tr>
<tr><td>Links</td><td>Output from accident phenomena
Input to offsite pathway analysis</td></tr>
<tr><td>Criteria</td><td>1. Has an onsite pathway analysis been performed?
2. Is the onsite pathway analysis consistent with the factors identified in accident phenomena?

SRAM Criteria 3.4 & 3.5</td></tr>
<tr><td>References</td><td></td></tr>
</table>

<table>
<tr><td>Stage</td><td>Accident Frequency Analysis</td></tr>
<tr><td>Aspect</td><td>18. Accident elimination, prevention and control</td></tr>
<tr><td>Objective</td><td>To demonstrate source ERA information is used to identify measures to eliminate, prevent and control MATTE risks</td></tr>
<tr><td>Details</td><td>A source ERA (including onsite pathway analysis) enables an operator to identify the risk critical elements in eliminating, preventing and controlling the transport of a released chemical to the offsite boundary.

Onsite risk management options should be identified, tested and prioritised according to the following HSE risk management hierarchy:

1. Eliminate by removing either the source, the pathway or the receptor.
2. Prevent or mitigate by reducing either the likelihood of the harm occurring, or its severity.
3. Control the level of harm once the accident has occurred through emergency planning/response.

An operator should consider all reasonable opportunities to eliminate the risk before identifying prevention and then control strategies. Risk prevention options can be identified and tested using the accident cause analysis. Risk control options can be identified using the accident phenomena and onsite pathway analysis. These analyses provide information critical to developing effective onsite emergency plans.

Risk management options for prevention and control may be focused on:

• frequency reduction using hardware controls (e.g. detectors) and management controls (e.g. inspection and maintenance);
• release size (or consequence) reduction using hardware controls (e.g. bunding) and management controls (e.g. procedures for closing down parts of the onsite pathway in the event of an emergency).

At this stage of the ERA only release sizes not environmental exposures or impacts have been evaluated. Risk management options are therefore focused on reducing release sizes without any knowledge concerning the potential consequence or impact of the release.

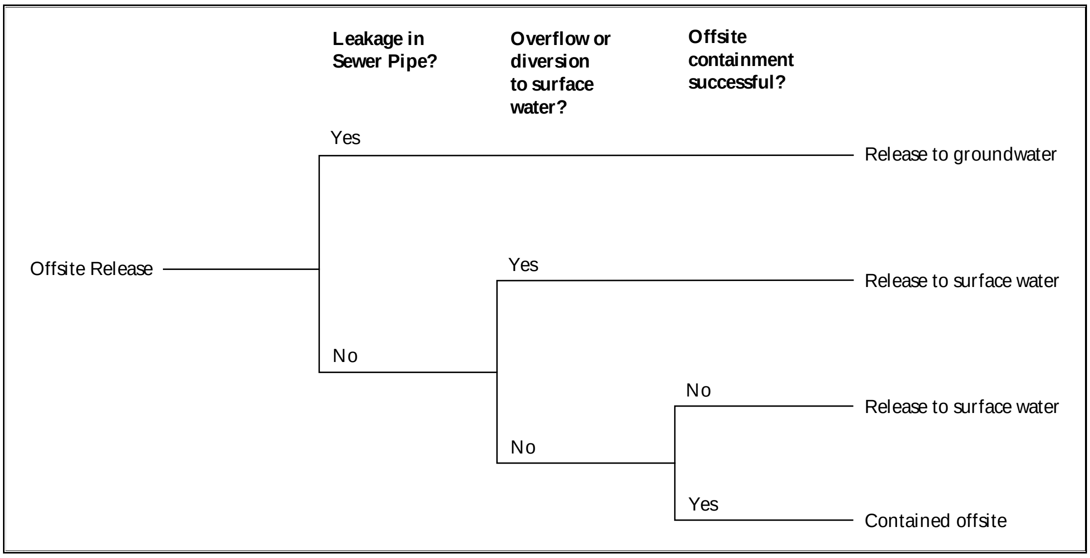
Risk management options can be tested for effectiveness by feedback into the source ERA model. Risk management options may be selected on the grounds of the costs, benefits and risks offered by each option.

Risk critical issues and their management could be used to develop the MAPP and environmental management system.</td></tr>
<tr><td>Links</td><td>Input from Accident Phenomena, Cause Analysis, Onsite Pathway Analysis</td></tr>
<tr><td>Criteria</td><td>1. Has the ERA been performed well enough to enable meaningful risk management decisions?
2. Has the operator satisfactorily demonstrated compliance with the HSE risk management hierarchy?
3. Has the operator used ERA results to develop and test onsite emergency plans?

SRAM Criteria 1.5 & 3.4</td></tr>
<tr><td>References</td><td>CIRIA Best Practice Guidance for Containment System Design
Chief Inspector Guidance Notes (BATNEEC) Requirements
Agency Best Practice Notes for Reducing Water Pollution
Other industry references on risk reduction measures</td></tr>
</table>

Stage	**Accident Frequency Analysis**
Aspect	**19. Screening**
Objective	To screen out insignificant risks based on source information
Details	Screening may be used at the end of a source ERA in order to reduce the number of release scenarios and events considered in the exposure ERA stage. This ensures that resources are not wasted in evaluating risks that are insignificant. Examples of screening criteria that may be used include: • Annual offsite release frequencies between 10^{-6} and 10^{-8} per year; • Releases that become naturally diluted (e.g. through water in effluent treatment systems) to the NOEL (no environmental effect level) or lower before entry to the environment; • Small releases unlikely to cause a MATTE; • Cost of further analysis not justified in terms of the benefits that may be provided. Screening on the basis of a dilute (e.g. through applying firewater) and disperse risk management option is not an acceptable practice. As with all screening a reasonably conservative approach should be adopted. Some operators may elect to complete an ERA at this stage on the basis of cost. If release events or scenarios exist that may constitute a MATTE then conservative measures may be imposed to ensure that risks are ALARP/BATNEEC. This may encourage an operator to perform an exposure ERA analysis in order to demonstrate that less expensive measures may be appropriate. There exists no specific guidance as to how to evaluate BATNEEC. Costs used in BATNEEC assessments could range from the operational and capital costs of risk control techniques to an operator up to the economic costs represented by willingness to pay. It may be useful for an operator to present costs versus risk reductions for the of risk management measures considered and to justify BATNEEC as that measure which provides the most cost effective or beneficial return on investment.
Links	
Criteria	1. Is screening process reported? 2. Is screening process realistic and justifiable? 3. Should operator progress to a more detailed analysis? **SRAM Criteria 3.4 & 3.5**
References	HMIPI, The Determination of BATNEEC, 1994 Environment Agency, E1 BPEO Assessment Methodology

Stage	**Accident Consequences**
Aspect	**20. Approach and modelling information**
Objective	Demonstrate the approach taken to modelling exposures to the environment arising from MAH releases
Details	The decision to perform environmental consequence or exposure modelling can only be taken if a release to the environment with the potential for a MATTE is demonstrated through the offsite pathway analysis. Assessing the consequences of accidental releases to the environment is a difficult task. The approach may be based on physical models, empirical information or qualitative analysis. Transport and fate models may be used for performing consequence or exposure analysis of releases to the environment. There are a large number of models of varying complexity which could be used in this context. The assessor should consider the reliability, applicability and availability of any models used in the assessment. The PRAIRIE (Pollution Risk from Accidental Influxes to Rivers and Estuaries) software has been developed in order to assess surface water pollution risks to rivers and estuaries. The transport and fate modelling should use the data contained with the environmental description. An operator may decide to perform deterministic or probabilistic modelling. The most sensitive probabilistic variables are the environmental flow field (i.e. wind speed, current speed, groundwater flow) and its direction. If deterministic modelling is used then scenarios should ideally be run to demonstrate the spatial range of impacts. The assumptions and limitations of the dispersion modelling should be clearly described. If difficulties arise a second opinion could be sought from modelling expertise within Agency or SEPA. Secondary atmospheric and aquatic chemistry reactions may be evaluated when MAH releases interact with releases (continuous or accidental) from neighbouring activities. This may be justified if the ecotoxicity of any chemical by-product is greater than that of the MAH substance or if interaction occurs close to vulnerable environmental resources. Persistence of MAH substances in the environment in terms of residence times may be modelled. Deposition and precipitation of material from MAH plumes onto vulnerable receptors may also be modelled. Environmental consequences of flammable events (e.g. explosion/radiation damage, smoke plumes from fire, etc.) may also be evaluated.
Links	Input from Environmental Description Input from Onsite Pathway Analysis
Criteria	1. Is approach consistent with offsite pathway analysis findings? 2. Does approach describe transport and modelling approach used? 3. Does approach detail modelling assumptions and highlight any limitations? 4. Does approach consider a reasonable range of environmental flows and flow directions? **SRAM Criteria 3.4 & 3.5**
References	EAC: RSDE Released Substances and their Dispersion in the Environment (1997). BRE Report on smoke plumes. PRAIRIE reports and literature. Environment Agency, River Dee Case Study. General environmental modelling literature.

Stage	**Accident Consequences**
Aspect	**21. Offsite Pathway Analysis**
Objective	To describe the offsite pathway analysis
Details	The principal reasons for performing an offsite pathway analysis are to: 1. Provide the local authority with information for preparing offsite emergency plans. 2. Provide a structure for performing exposure modelling. An example of a simple offsite pathway analysis and how a release to the offsite boundary can lead to a release to ground water and surface water is provided in the figure:  The offsite pathway figure describes how conditional events effect the transport of dangerous substances to the environment.
Links	Output to approach to modelling and information. Input from Environmental Description. Output to offsite emergency planning.
Criteria	1. Is offsite pathway consistent with offsite environmental details provided in the Environmental Description? 2. Are onsite and offsite pathways consistent with each other? **SRAM Criteria 3.4 & 3.5**
References	

Stage	**Accident Consequences**
Aspect	**22. Hazard distances and other results**
Objective	To determine the environmental range of exposure
Details	The environmental consequences of releases may be characterised using transport and fate modelling. Consequence results could be presented as follows: • Qualitative accident classification schemes (e.g. A-D); • Dose of released material to vulnerable receptors; • Time of travel to vulnerable receptors; • Extent of hazardous plume (to no environmental effect level); • Environmental Harm Index (EHI). If probabilistic transport and fate modelling has been performed then uncertainties in the above parameters may also be presented. Vulnerable receptors within the range of accident consequences should be identified by comparison of ecotoxicity level and predicted environmental concentrations. This may be supplemented by information on the extent of the effect, e.g. length, area or volume affected. Offsite emergency plan requirements are eliminated for installations where it can be demonstrated that no offsite effects can arise. EC Seveso TWG is developing criteria for this purpose.
Links	Input from Approach and modelling information, and Environment description
Criteria	1. Are environmental exposure levels evaluated to identify MATTE scenarios? 2. Are key results provided in terms of ranges to specified concentrations, etc? **SRAM Criteria 3.4 & 3.5**
References	EC Seveso TWG Criteria for Derogation regarding offsite emergency plans

Stage	**Accident Consequences**
Aspect	**23. Offsite emergency planning**
Objective	To determine whether sufficient information has been generated for offsite emergency planning purposes.
Details	The operator is not expected to prepare an offsite emergency plan under COMAH. However, the operator is expected to provide information to the local authority to assist in offsite emergency planning. This information will only be available if an operator has performed an offsite pathway analysis. The offsite pathway analysis can provide information concerning potentially affected third parties (e.g. water companies) that should be contacted in the event of a release from the COMAH site. Information concerning potentially affected receptors can be obtained from the exposure modelling analysis. Time of travel determinations from the exposure analysis can assist in determining how long emergency services have to control and offsite emergency to vulnerable environmental receptors.
Links	Offsite pathway analysis Hazard distance
Criteria	1. Is there enough relevant information in the COMAH Safety Report to assist in offsite emergency planning? **SRAM Criteria 1.9 & 6.6**
References	

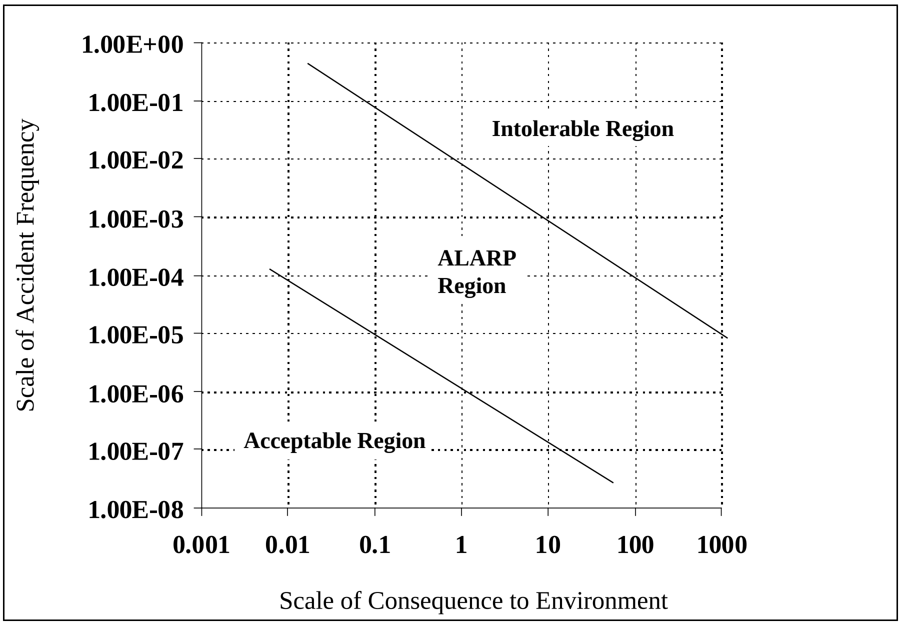
Stage	**Accident Consequences**
Aspect	**24. Screening**
Objective	To determine whether further analysis is required and at what level of detail.
Details	An exposure ERA that includes transport and fate modelling should provide sufficient information to perform at least a qualitative impact ERA. Screening between exposure ERA and impact ERA is similar to that between source ERA and exposure ERA. However, following an exposure ERA there will be significantly more information and confidence in whether there is the potential for a MATTE. The main argument for performing a quantitative impact ERA may be because of the perception of the risk posed. This could be for example that an isolated community of endangered or protected species might be permanently lost. Environmental risk acceptance criteria may be available with which to gauge acceptability. This is may be relevant if an exposure ERA has measured aquatic effects in terms of an EHI. It is likely that enough information will exist to suggest more realistic and therefore cost beneficial risk management options than at the source ERA stage. Costs for surveying biological receptors and their seasonal variations are likely to be expensive unless that data is already available. This may be a requirement before progressing to a quantitative impact ERA
Links	Input from risk acceptance criteria
Criteria	1. Is there a clear basis defined for screening events on the basis of consequence? 2. Does this basis properly relate to impact criteria and the definition of a MATTE? **SRAM Criterion 3.5**
References	DETR Management of Harm Project

Stage	**Accident Impacts**
Aspect	**25. Approach and Criteria**
Objective	Demonstrate the approach taken to understanding the potential harm/damage caused to the environment by accidents
Details	Quantitatively evaluating impacts on the environment involves considerable uncertainty and complexity. Some degree of quantification is possible but a large amount of qualitative judgement is usually necessary. The approach used should be described fully. In general the following may be used in combination or separately, for evaluating impacts: • Toxicity relationships (e.g. dose-response relationships). • Environmental harm criteria (e.g. LC50 data, critical loads). • Negligible effect criteria (e.g. No Observed Effect Levels, Suggested No Adverse Response Levels). • Past accident experience. • Population dynamics modelling. If harm criteria are used then the relevant receptors must be clearly identified. Effects may be to individual species, a range of species (biodiversity), the community structure and the overall habitat or ecosystem. Very little information exists on community level responses to damage. In defining the expected level of change, natural variability needs to be considered as this can result in significant changes in receptors. If recovery is assessed then a distinction may need to be drawn between natural unassisted recovery and artificial recovery, particularly if contingency plans include cleanup and restoration which may affect the rate of recovery. Immediate and delayed effects need to be considered in the approach to assessing impacts. The key uncertainties in the approach should be identified. DETR guidelines on Environmental Assessment should be followed where appropriate.
Links	
Criteria	1. Does the approach include consideration of different levels of impact on different components of the environment? 2. Is environmental recovery considered? 3. Are both immediate and delayed effects considered? **SRAM Criterion 3.5**
References	RPA Environmental Impacts of Explosion Events? DETR Guidance on Environmental Assessment IEA Guidelines on Environmental Assessment

Stage	**Accident Impacts**
Aspect	**26. Impacts to receptors**
Objective	Present Results of Impact Assessment
Details	Impacts should be defined in relation to the criteria given for MATTE, for all receptors potentially impacted as identified in the exposure assessment. Any potentially serious impacts not covered within the definition of MATTE should nevertheless be presented.
Links	Input from Hazard Distances and other results of exposure assessment, Overall approach, Risk Acceptance Criteria
Criteria	1. Are all potentially relevant impacts defined in relation to MATTE? 2. Are other potentially serious impacts not covered by MATTE presented? **SRAM Criterion 2.6 & 3.5**
References	

Stage	**Presentation of Analysis and Results**
Aspect	**27. Summary**
Objective	Provide overall summary and conclusions with respect to risk results and ERA objectives
Details	The ERA should contain a summary of the results and overall conclusions with respect to the ERA objectives, e.g. demonstrating the following: • operator understands the MATTE risks involved in the operation of the installation • the risks from MATTE arising from the installation are at an acceptable level • adequate measures are being taken to prevent occurrence and limit consequences of MATTE • adequate information is provided for land use planning and siting decisions by the competent authority • adequate information is provided for local authority purposes of developing offsite emergency plan • effect of onsite and offsite emergency response plans on risk levels demonstrated • provide for exchange of information regarding domino risks with neighbouring sites
Links	Input from Objectives
Criteria	1. Does safety report strike a balance between protection of workers, public and the environment?
References	

Stage	**Presentation of Analysis and Results**
Aspect	**28. Data Presentation**
Objective	To present the results of the ERA
Details	ERA results data could be presented in the following ways: • Overall risks from MATTE for the installation, with reference to appropriate criteria. • Identification of risk contributors, e.g. by ranking all events or identification of major contributors. There are numerous ways in which this information may be presented, depending on the nature of the assessment undertaken: • Qualitative descriptions (e.g. low/medium/high risk). • Simple relative scoring systems (e.g. 1-5, 1-100). • Quantitative modelling parameters (e.g. Environmental Harm Index). • Concentration/distance graphs. • Number of receptors affected vs. frequency of effect. • Recovery times. ERA results may be presented in similar formats to safety risk results, except that environmental damage units will replace fatality number. No consensus exists on consistent units for measuring different forms of environmental damage. Aquatic impacts may be represented by EHI formulated as part of the HARM R&D project. An EHI reflects the level of harm to the aquatic environment in terms of the ecotoxicity of the MAH substance, the environmental concentration, the extent of water effected (e.g. downstream effect distance for rivers) and the recovery time. Both the extent of contamination and recovery time are weighted by the MATTE definitions for those parameters for the aquatic environment affected. No EHI or equivalent yet exists for the terrestrial environment. Societal risk plots of cumulative frequency versus consequence/impact or EHI unit may be presented. Risk results may be summed over all events and scenarios to give the total environmental risk and breakdown in terms of the significant risk contributors. Uncertainties associated with ERA results may also be presented. This will allow an operator to determine the confidence with which risk management decisions can be made from the ERA results and/or focus data collection on sensitive and highly uncertain parameters.
Links	Input from Approach, Hazard distances and other results. Output to Evaluation of Measures
Criteria	1. Have ERA results been presented in the Safety Report? 2. Does ERA results presentation provide a basis for risk management selection?
References	DETR Management of Harm to the Environment

Stage	**Presentation of Analysis and Results**
Aspect	**29. Risk Acceptance Criteria**
Objective	To describe environmental risk acceptance criteria that may be used.
Details	Risk acceptance criteria provide information on what may be deemed negligible, acceptable or tolerable in terms of either or both the consequences and frequencies of accidents to the environment from an individual installation. Acceptability may therefore be judged by considering consequences in isolation, or by considering both consequences and frequency together. Risk acceptance criteria are not as well developed for environmental risks as for safety risks. Nevertheless a number of risk acceptance criterion exist. These may include: • DETR "Green Leaves Book"; • DETR 'Management of Harm to Environment' project; • Water Protection Zones (for the River Dee); • HSE tolerability of major accidents; • Company specific criteria; • Balancing cost, benefits and risks in option appraisal. Certain companies may have internal risk management criteria for environmental accidents which may be used to assess acceptability. A further dimension to consider is the public perception of what is an acceptable major accident risk to the environment. However there is little information on what frequency of MATTE would be acceptable to the public in general and local populations in particular. An example of risk assessment criteria prepared as part of the HARM project are given in the figure: 
Links	Evaluation of risk management measures
Criteria	1. Have any environmental risk acceptance criteria been described? 2. Are environmental risk acceptance criteria acceptable for COMAH purposes? **SRAM Criterion 3.5.4**
References	DETR Green Leaves Book. HMIP, River Dee Case Study. HSE publications. DETR 'Management of Harm to the Environment Project' HMSO (1998)

Stage	**Presentation of Analysis and Results**
Aspect	**30. Comparison of results with criteria**
Objective	Assessment of acceptability
Details	ERA results should be compared with environmental risk acceptance criteria used. Intolerable risks should identified and eliminated. Significant tolerable risks should be identified and made As low as reasonably practicable (ALARP) or BATNEEC. Tolerable risks should be identified and screened out.
Links	
Criteria	1. Has operator used the environmental risk acceptance criteria described in the Safety Report? 2. Have results of comparison been described? 3. Has comparison been performed correctly? **SRAM Criterion 3.5**
References	

Stage	**Presentation of Analysis and Results**
Aspect	**31. Identification of Risk Management Measures**
Objective	Produce comprehensive list of relevant measures to manage risks from MATTE
Details	An installation will typically have existing, planned or potential measures, which affect risks from MATTE. Risk management measures fall into the following two categories: 1. Frequency reducing measures (e.g. improved inspection and maintenance procedures) 2. Consequence reducing measures (e.g. improved secondary containment) Risk management measures can be either hardware or management related. Risk management measures should follow the HSE risk management hierarchy detailed in the Accident Elimination, Prevention and Control aspect. Measures to manage risks are extensive and may include the following: • Management systems (e.g. training levels); • Process design factors (e.g. inherently safe design principles); • Process operation factors (e.g. control systems and operation procedures); • Containment systems (e.g. double wall vessels, bunds, active containment, drainage design); • Emergency response/contingency plans (e.g. external services, response equipment); • Remediation plans (e.g. restoration, isolation and monitoring); • Measures to monitor the risk levels to determine if risks are changing (e.g. near-miss data). The identification of measures should refer to guidance notes on BATNEEC and industry practice, for example: • HSE guidance on prevention of accidents • IPC Process Guidance Notes • Environment Agency measures to prevent pollution to surface waters • CIRIA guidance on design of containment systems to prevent pollution from industrial incidents • Insurance industry recommended practice • Fire Protection Association recommended practice
Links	Accident, Elimination, Prevention and Control Output to Evaluation of Measures
Criteria	1. Have risk management measures identified been reported? 2. Are the risk management measures identified comprehensive? 3. Has the operator prioritised risk management measures in order of HSE risk management hierarchy? 4. Measures address major risks identified from risk assessment **SRAM Criteria 1.5, 1.6 & 3.6**
References	

Stage	**Presentation of Analysis and Results**
Aspect	**32. Evaluation of Measures**
Objective	Assess and justify selection of measures to manage risks from MATTE
Details	The Safety Report should contain a comprehensive evaluation of measures to manage risks from MATTE. This should include assessing the performance of existing or planned measures and justifying the rejection of other potentially relevant measures on clear grounds. This evaluation should demonstrate the company's decision-making process regarding considering, adopting and rejecting measures. Screening or ranking of the list of measures may be possible, in terms of cost, effectiveness, technical feasibility, safety implications, etc. The risks which the measures are intended to reduce should be identified with reference to the risk contributors identified in the risk assessment data presentation. Justification for selecting and rejecting measures should be based on some or all of the following considerations: • Overall level of risk from the installation • costs and benefits of individual measures • relative merits of the range of measures considered • company policy on management of risks (refer to MAPP) • safety, technical feasibility, other factors • guidance notes on BATNEEC and industry practice The effects of individual or combinations of measures on risk levels may be presented in terms of the risks with and without these measures. An analysis of costs and benefits may be performed, comparing the risk reduction obtained against the cost incurred for a particular measure, or comparing between different measures. Measures to reduce MATTE risks may at the same time provide other benefits. For example, secondary containment systems for flammable or toxic materials may improve fire protection or prevent human exposure, and the recovery and recycling of spilled substances may improve waste minimisation. On the other hand, there may be scenarios where a higher environmental risk may arise due to measures to reduce the safety or occupational risk, and *vice versa*. The MAPP may provide information on the approach to be taken in this situation. For those measures which are selected, adequate financial and resource provisions to implement and maintain these should be demonstrated. In particular, systems and equipment critical to achieving the stated risk levels should be possible to identify and the way in which their performance is to be ensured should be apparent. Measures to monitor the risk levels to assure performance is maintained over the lifecycle should be presented. The report will in particular need to demonstrate that adequate resources are available to respond to and cleanup/remediate damage from any accidents which may occur. This should include identification of what party carries out such actions and what party is responsible for costs incurred. The standards to which restoration of the environment is carried out should also be stated. The report should demonstrate that the risks have been re-assessed with all proposed measures in place. Tolerability and ALARP (As Low As Reasonably Practicable) concepts may be used to determine whether the proposed set of measures are adequate. Selected options should represent BPEO. It is not acceptable to directly transfer environmental risks from one environmental medium to another. For new installations the Safety Report should address site selection issues and justify the choice of site from a MATTE perspective.
Links	Input from Identification of Risk Management Measures, Data Presentation, MAPP

Criteria	1. Have all the identified measures been evaluated? 2. Has an iterative approach been taken to assessing risk and evaluating different measures? 3. Level of performance of risk management measures demonstrated? 4. Performance of risk-critical measures ensured over lifetime? 5. Basis for rejecting other potential measures is clearly stated? 6. Basis for rejecting other potential measures is acceptable? 7. Measures proposed reflect the inherent risk to the environment posed by the installation? **SRAM Criteria 1.5, 1.6 & 3.6**
References	CIRIA Design of Containment Systems to Prevent Pollution from Industrial Incidents

Appendix 3
References and Suggestions for Further Reading

REFERENCES AND SUGGESTIONS FOR FURTHER READING

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Chemical Industrial Safety and Health Council, 'A Guide to Hazard and Operability Studies', 1977.

Chemical Industries Association, 'Responsible Care Management Systems: Guidance and Self Assessment', 1998.

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Council Directive 79/409/EEC on the conservation of wild birds.

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Environment Agency, 'A Guide to Risk Analysis', NCRAOA, 1998.

Environment Agency, Pollution Prevention Series.

Environmental Analysis Co-operative, 'Released Substances and their Dispersion in the Environment', ISBN 0 11 702010 9.

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HSE, 'The Tolerability of Risk from Nuclear Power Stations', 1992.

HSE, 'Risk Criteria for Land Use Planning in the Vicinity of Major Industrial Hazards', 1989.

HSE, 'Successful Health and Safety Management', HS(G)65, ISBN 0 7176 1276 7, 1997.

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HSE, 'A Guide to the Control of Major Accident Hazard Regulations', L111, ISBN 0 7176 1604 5, 1999.

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Royal Meteorological Society (in collaboration with the DoE), 'Atmospheric Dispersion Modelling: Guidelines on the Justification of Choice and Use of Models, and the Communication and Reporting of Results', 1995.

Sax, 'Dangerous Properties of Industrial Materials'.

The Royal Society, 'Risk Assessment : A Study Group Report', 1983.

The Royal Society, 'Risk : Analysis, Perception and Management', 1992.

Verschueren K., 'Handbook of Environmental Data on Organic Chemicals', ISBN 0 442 28802 6, 1983.

Welsh S., 'Assessment and management of risks to the environment', in proc. 'Major Hazards Onshore and Offshore', I.Chem.E. Symposium Series No. 130, 1992.

Databases

There are a number of databases listing information on hazardous substances. These include:

- IRIS (Integrated Risk Information System)
- RTEC (Registry of Toxic Effects of Chemical Substances)
- HSDB (Hazardous Substances Data Bank)
- OHMTADS (Oil and Hazardous Material Technical Assistance Data)
- CHRIS (Chemical Hazard Response Information System)

This list is provided to assist in identifying possible sources of data. It is not comprehensive and the environment agencies neither specifically approve of use of data from one of the databases listed nor disapprove of data obtained from elsewhere.

Internet Sites

A considerable amount of information relevant to undertaking an environmental risk assessment is now available via the Internet. The following are some of the web sites available at the time of writing which the reader may find of interest. The list is not intended to be comprehensive or exclusive.

The Environment Agency's site:
http://www.environment-agency.gov.uk/

The Environment Agency's site for Wales:

http://www.environment-agency.wales.gov.uk/

The Scottish Environmental Protection Agency's site:
http://www.sepa.org.uk/

The Health and Safety Executive's site:
http://www.open.gov.uk/hse/

The Department of Environment, Transport and the Region's site:
http://www.detr.gov.uk/

The European IPPC Bureau's site:
http://eippcb.jrc.es/

Silverplatter's site (provider of databases):
http://www.silverplatter.com/

Appendix 4
Glossary

GLOSSARY

AIChE	American Institute of Chemical Engineers
AONB	Area of Outstanding Natural Beauty
BATNEEC	Best Available Techniques Not Entailing Excessive Costs
BOD	Biological Oxygen Demand
CCPS	Center for Chemical Process Safety
CEFIC	European Chemical Industry Council
CIA	Chemical Industries Association
CIMAH	Control of Industrial Major Accident Hazards
CIRIA	Construction Industry Research and Information Association
COD	Chemical Oxygen Demand
COMAH	Control of Major Accident Hazards
DETR	Department of Environment, Transport and Regions
EQS	Environmental Quality Standard
HSE	Health and Safety Executive
IChemE	Institute of Chemical Engineers
IPC	Integrated Pollution Control
IPPC	Integrated Pollution Prevention and Control
JNCC	Joint Nature Conservation Committee
LNR	Local Nature Reserves
MAFF	Ministry of Agriculture, Fisheries and Food
MAH	Major Accident Hazard
MAPP	Major Accident Prevention Policy
MATTE	Major Accident to the Environment
MHIDAS	Major Hazards Incident Database Service
MNR	Marine Nature Reserve
NNR	National Nature Reserve
NOEC	No Observed Effect Concentration
PCSR	Pre-construction Safety Report
POSR	Pre-operational Safety Report
Ramsar	Site listed under the Ramsar convention on Wetlands of International Importance (sites designated as Ramsar sites in the UK are also notified as SSSIs under the Wildlife & Countryside Act 1981)
RSPB	Royal Society for the Protection of Birds
SAC	Special Area of Conservation
SEPA	Scottish Environment Protection Agency
SIESO	Society of Industrial Emergency Services Officers
SPA	Special Protection Areas
SSSI	Site of Special Scientific Interest

Appendix 5
Schedules 2 and 4 of SI99/743

SCHEDULE 2

REGULATION 5(3)

PRINCIPLES TO BE TAKEN INTO ACCOUNT WHEN PREPARING MAJOR ACCIDENT PREVENTION POLICY DOCUMENT

(This schedule sets out the provisions of Annex III to the Directive)

1. For the purpose of implementing the operator's major accident prevention policy and safety management system account shall be taken of the following elements. The requirements laid down in the major accident prevention policy document should be proportionate to the major accident hazards presented by the establishment.

2. The major accident prevention policy should be established in writing and should include the operator's overall aims and principles of action with respect to the control of major accident hazards.

3. The safety management system should include the part of the general management system which includes the organisational structure, responsibilities, practices, procedures, processes and resources for determining and implementing the major accident prevention policy.

4. The following issues shall be addressed by the safety management system -

(a) organisation and personnel - the roles and responsibilities of personnel involved in the management of major hazards at all levels in the organisation. The identification of training needs of such personnel and the provision of the training so identified. The involvement of employees and, where appropriate, sub-contractors;

(b) identification and evaluation of major hazards - adoption and implementation of procedures for systematically identifying major hazards arising from normal and abnormal operation and the assessment of their likelihood and severity;

(c) operational control - adoption and implementation of procedures and instructions for safe operation, including maintenance of plant, processes, equipment and temporary stoppages;

(d) management of change - adoption and implementation of procedures for planning modifications to, or the design of new installations, processes or storage facilities;

(e) planning for emergencies - adoption and implementation of procedures to identify foreseeable emergencies by systematic analysis and to prepare, test and review emergency plans to respond to such emergencies;

(f) monitoring performance - adoption and implementation of procedures for the on-going assessment of compliance with the objectives set by the operator's major accident prevention policy and safety management system, and the mechanisms for investigation and taking corrective action in the case of non-compliance. The procedures should cover the operator's system for reporting major accidents or near misses, particularly those involving failure of protective measures, and their investigation and follow-up on the basis of lessons learnt;

(g) audit and review - adoption and implementation of procedures for periodic systematic assessment of the major accident prevention policy and the effectiveness and suitability of the safety management system; the documented review of performance of the policy and safety management system and its updating by senior management.

SCHEDULE 4

Regulations 5(6), 7(1),(5) and (7) and 8(1)

PURPOSE AND CONTENTS OF SAFETY REPORTS

PART 1

PURPOSE OF SAFETY REPORTS

(This Part sets out the provisions of Article 9(1) of the Directive)

The purposes referred to in regulation 7 are as follows -

1. demonstrating that a major accident prevention policy and a safety management system for implementing it have been put into effect in accordance with the information set out in Schedule 2;

2. demonstrating that major accident hazards have been identified and that the necessary measures have been taken to prevent such accidents and to limit their consequences for persons and the environment;

3. demonstrating that adequate safety and reliability have been incorporated into the -

(a) design and construction, and

(b) operation and maintenance,

of any installation and equipment and infrastructure connected with its operation which are linked to major accident hazards within the establishment;

4. demonstrating that on-site emergency plans have been drawn up and supplying information to enable the off-site plan to be drawn up in order to take the necessary measures in the event of a major accident;

5. providing sufficient information to the competent authority to enable decisions to be made in terms of the siting of new activities or developments around establishments.

PART 2

MINIMUM INFORMATION TO BE INCLUDED IN SAFETY REPORT

(This Part sets out the provisions of Annex II to the Directive)

The information referred to in regulation 7(1), (5) and (7) is as follows -

1. Information on the management system and on the organisation of the establishment with a view to major accident prevention.

This information shall contain the elements set out in Schedule 2.

2. Presentation of the environment of the establishment:

(a) description of the site and its environment including the geographical location, meteorological, geographical, hydrographic conditions and, if necessary, its history;

(b) identification of installations and other activities of the establishment which could present a major accident hazard;

(c) description of areas where a major accident may occur.

3. Description of installation:

(a) a description of the main activities and products of the parts of the establishment which are important from the point of view of safety, sources of major accident risks and conditions under which such a major accident could happen, together with a description of proposed preventive measures;

(b) description of processes, in particular the operating methods;

(c) description of dangerous substances:

(i) inventory of dangerous substances including -

- the identification of dangerous substances: chemical name, the number allocated to the substance by the Chemicals Abstract Service, name according to International Union of Pure and Applied Chemistry nomenclature;
- the maximum quantity of dangerous substances present;

(ii) physical, chemical, toxicological characteristics and indication of the hazards, both immediate and delayed for people and the environment;

(iii) physical and chemical behaviour under normal conditions of use or under foreseeable accidental conditions.

4. Identification and accidental risks analysis and prevention methods:

(a) detailed description of the possible major accident scenarios and their probability or the conditions under which they occur including a summary of the events which may play a role in triggering each of these scenarios, the causes being internal or external to the installation;

(b) assessment of the extent and severity of the consequences of identified major accidents;

(c) description of technical parameters and equipment used for the safety of installations.

5. Measures of protection and intervention to limit the consequences of an accident:

(a) description of the equipment installed in the plant to limit the consequences of major accidents;

(b) organisation of alert and intervention;

(c) description of mobilisable resources, internal or external;

(d) summary of elements described in sub-paragraphs (a), (b) and (c) necessary for drawing up the on-site emergency plan.