GUIDING PRINCIPLES FOR THE DESIGN AND IMPLEMENTATION OF RISK RATING SYSTEMS IN THE ENVIRONMENT AGENCY

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MANAGEMENT SUMMARY

Background

In the Ministerial guidance to the Environment Agency on sustainable development[1], the Agency is required to adopt risk assessment to inform its decisions on the protection and enhancement of the environment. The Agency's Environmental Strategy[2] has stated an intent to develop risk-based tools for environmental regulation. The National Centre for Risk Analysis and Options Appraisal (NCRAOA) was established in 1997 to progress activities in this field and to develop risk-based tools and techniques for application within the Agency.

- This document provides internal guidance on the general principles for the design and implementation of risk rating systems and regulatory resource planning algorithms in the Agency. It is principally concerned with risks to the environment, rather than financial or corporate risks.

- The document has been developed in response to a need for a set of guiding principles for any risk-based resource planning system for the purposes of consistency and comparison between and within the Environmental Protection (EP) Directorate regulatory functions.

- The document is primarily intended for an internal audience of Agency staff involved in the design and implementation of risk rating systems, although others external to the Agency represent a potentially wider audience. The document assumes a familiarity with the principles of environmental risk assessment[3] and the Operator and Pollution Risk Appraisal[4] (OPRA) systems operated within the Agency's Operations Directorate.

- The guidance enables a flexible approach to risk-based resource planning. It sets out some core principles to be considered by all functions for the benefit of ensuring consistency and credibility across the Agency, and to enable fair comparisons and equitable resource planning across the functions.

- This guidance relates only to risk related aspects of resource planning at a cross functional level. It provides useful input to the Priority Planning Exercise, but it does not provide, in isolation, a basis for national priority planning, or address the full range of issues that need to be considered in national resource planning.

- In the interests of brevity, the document does not detail the Agency's existing work planning, charge setting or resource allocation process, although reference is made to these systems.

- This document refers to key issues on implementation of risk-rating systems and makes recommendations, but it does not represent a policy for the application of risk rating systems within the Environmental Protection or Operations Directorates.

[1] Environment Agency (1996) Introductory Guidance on the Agency's Contribution to Sustainable Development, Environment Agency, Bristol, 15pp.
[2] Environment Agency (1997) An Environmental Strategy for the Millennium and Beyond, Environment Agency, Bristol, 28pp.
[3] Department of the Environment (1995) A Guide to Risk Assessment and Risk Management for Environmental Protection. HMSO, London, 92pp.
[4] Environment Agency (1997) Operator and Pollution Risk Appraisal (OPRA), Version 2, Environment Agency, Bristol, 34pp.

It is recognised at the outset of this guidance that many Agency activities are not responsive to a risk-based approach. It would be misleading to imply here that risk rating systems can address all resource planning issues. However, for particular situations, considerable benefit can be achieved. As an illustration, the NCRAOA has successfully influenced implementation of a risk-based planning approach for ICI Chemicals and Polymers. Whilst the approach developed for ICI is at a level more complex than the risk rating systems referred to here, its impacts on ICI's investment programme for safety, health and environment (SHE) audits has illustrated the considerable benefit of screening and risk rating approaches.

Risk-Based Resource Planning

Risk-based resource planning requires the risks associated with regulated activities to be determined, based on a range of factors such as the nature of the hazard, the frequency of release, the nature of the receiving environment and the quality of the developer's, discharger's or operator's management systems. This information can be used to prioritise and allocate resources according to risk (Figure 1). Risk-based systems for undertaking this task may be developed at a variety of levels of sophistication according to national, regional or functional needs, and tools for this process could be regarded as being 'coarse' (high level; national priority, low precision) or 'fine' (lower level, site-specific, high precision). The risk-rating systems referred to in this document for functional resource planning are expected to sit in the middle of this range, and are aimed at facilitating inter- and cross-functional prioritisation within the Environmental Protection and Operations Directorates, rather than the establishment of corporate, national priorities.

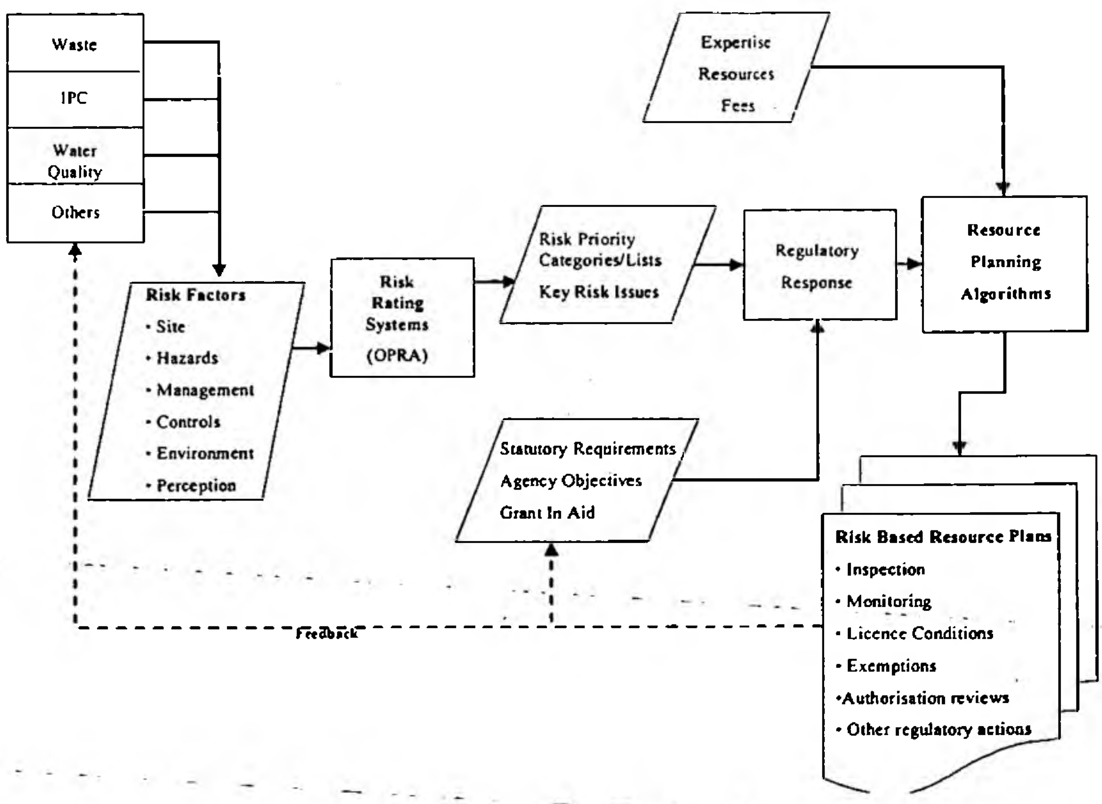

Figure 1: Risk-Based Resource Planning

Generally, where site-specific factors are taken into account, the assessment of risk and effectiveness of resource allocation can be improved. This has a clear benefit of enabling risk to be reduced and resource efficiency to be enhanced (Figure 2). Risk-based resource planning can be achieved either by apportioning the Agency's allocated resources according to risks across its statutory remit ('supply-led'); or by assessing risks and constructing a case for resources accordingly ('demand-led'). In practice, a combination of approaches will likely be in place, but critically, progressing from the former to the latter mode raises issues of fair comparison or "read across" within and between Agency functions. Where a demand led approach is desirable, "read across" issues need to be addressed early on.

Risk-based resource planning can apply at a functional level; for example by allocating waste regulatory resources to higher risk waste sites, or at a strategic level, by distributing total regulatory resources between functions according to levels of risk. Common systems are becoming important in the Agency with the harmonisation of certain functions at the Area level, the adoption of "multi-skilling" and consideration of combined visits. This activity will increase with the introduction of Integrated Pollution Prevention and Control (IPPC) and the summary information on key risks and issues at different sites provided by risk rating systems can potentially support this process. However, introduction of these systems will require training and it is recommended that functions consider how best to equip operational managers and staff with the skills to deliver risk-based resource management throughout the organisation.

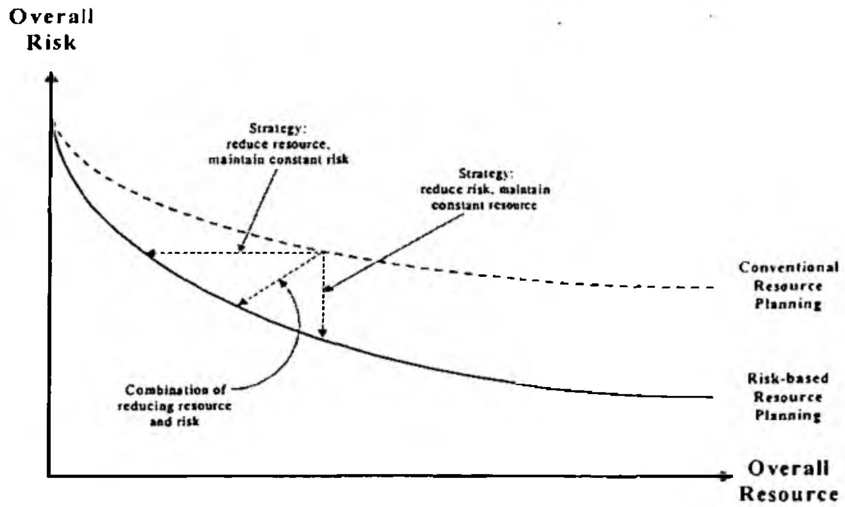

Figure 2: Reducing Risk and/or Resources

Key Principles for Risk-Based Resource Planning Systems

In simple terms, 'risk' can be regarded as a combination of probability and consequence; the likelihood of suffering harm from a hazard. The emphasis on various factors contributing to 'risk' may be specified according to the needs of individual functional risk-rating schemes, but it is essential that all systems incorporate the generic risk factors in Table 1. This indicates that the development, discharge or operation (i.e. the source of the hazard) and the characteristics of the receiving environment (the receptor) need to be considered to obtain a full assessment of the risk. The manner in which the contributing factors are 'grouped' within a risk-rating system is reflected in the "type of factor" column in Table 1. For example, the Agency's OPRA risk-rating system[4] groups factors according to those associated with the inherent pollution hazard and the operator's performance in managing that hazard. Groupings may need to be tailored for the specific functions.

In the interests of effective regulation it is beneficial to identify which factors are within the control of the developer, discharger or operator or regulator, and which factors are less likely to be altered. This then indicates the sensitivity of a factor to operator control or regulatory intervention. The risk rating system should include all relevant factors that can be altered. Ultimately, the sensitivity of individual factors to intervention will affect regulatory priorities, post-authorisation, and individual site responses to different risks and intervention.

Risk-based systems usually incorporate a numerical scoring system that reflects the magnitude of the probability or consequences of adverse effects occurring at a location. At this level of assessment scoring systems are arbitrary. The benefit of a scoring system over a qualitative assessments of risk (that is a risk characterised as 'high', 'medium', or 'low') is in allowing the *prioritisation* of risks and in distinguishing between probability and consequence contributions.

Scores can not reflect absolute risk and scoring systems need to be simple, clear, easy to follow and reproducible. Critically, they should never assume a degree of sophistication in their design beyond what they can deliver in terms of distinguishing between risks. More sophisticated tools are available for detailed estimates of risk, and scoring systems implying high levels of precision should not be employed given the relative nature of risk rating as an prioritisation activity. Where different scales are used for scoring (e.g. 1-5 vs. 1-30), these should be properly justified and taken into account when deciding on the weighting factors adopted for different risk attributes. In practice, scoring, weighting factors and guidance will evolve with increasing experience or as a result of changing conditions. This is acknowledged, for example by the Agency's proposed 'OPRA for Waste' scheme[5] and has been the experience with OPRA within process industry regulation.

[5] Environment Agency (1998) 'OPRA for Waste', Waste Inspection Frequencies by Risk Assessment, Version 7A, Environment Agency, Exeter, 20 pp.

No	***Factor description***	***Type of Factor***	***Sensitivity of Factor: Extent to which factor is in discharger's control***
1	*Severity of the hazard posed by the properties of the substances present; the potency of hazard source*	*Inherent hazard; source*	*Partially*
2	*Magnitude of the hazard posed by amount of substances present*	*Inherent hazard; source*	*Mostly*
3	*Frequency of the operation under study, including variabilities in operation*	*Inherent frequency; pathway*	*Mostly*
4	*Existing physical measures (technologies) to prevent, minimise or render harmless releases*	*Inherent hazard and frequency; pathway*	*Mostly*
5	*Pathway: extent to which the source of the hazard and the receiving environment are connected; the probability of exposure following release*	*Inherent frequency; pathway*	*Partially*
6	*Spatial extent of the potential impact in the receiving environment if release occurs*	*Inherent hazard and frequency; receptor*	*Partially*
7	*Temporal extent of potential impact in the receiving environment if release occurs, including permanence*	*Inherent hazard and frequency; receptor*	*Partially*
8	*Sensitivity of the receiving environment*	*Inherent hazard and frequency; receptor*	*Mostly outside discharger's control*
9	*Recording and use of information*	*Management factor*	*Completely*
10	*Knowledge of compliance requirements*	*Management factor*	*Completely*
11	*Operation of process or site*	*Management factor*	*Completely*
12	*Maintenance of process or site*	*Management factor*	*Completely*
13	*Management and training*	*Management factor*	*Completely*
14	*Historical record of incidents, complaints and non-compliance events*	*Management factor*	*Completely*
15	*Recognised environmental management systems*	*Management factor*	*Completely*
16	*Offensive characteristics of operation*	*Inherent hazard and frequency and management; source*	*Partially*
17	*Public perception of risk associated with operation*	*Inherent hazard and frequency and management*	*Partially*

Table 1: Generic Risk Factors within Risk Rating Systems

As is the case with risk rating systems, resource planning algorithms will also evolve as risk data are obtained, and feedback on the effectiveness of the Agency's actions is monitored. Initially, resource planning algorithms may be characterised as operating in "risk targeting" mode – here resources can be allocated simply in proportion to the risk levels assessed. As the risk levels change over time, the Agency can assess *where* its resources are having greatest effect, and, where a resource surplus exists. This is, in part, determined by the *sensitivity* of individual risk factors to intervention. Resource algorithms can then adopt an element of "risk *reduction* targeting" – whereby resources are allocated to addressing the factors (Table 1) where risk reductions are most achievable. Here, it would be important to continue targeting high risks, in order to establish that the developer, discharger or operator is maintaining or improving the level of control, and to address public concerns over these risks. It is also important that resource allocation reflects an appropriate balance of priorities to *anticipate* risk and *avoid* harm as well as reducing risk, for example in expending resource to prevent an environmental quality standard being breached. The above approach inevitably represents a 'trade-off' situation whereby attention on low risk activities is released for focusing on higher risk activities.

Risk-based resource planning can be applied to a number of different regulatory activities, e.g. inspection, monitoring, reviews of authorisations and reviewing licence conditions. Specific issues, such as setting individual authorisations, cannot be based solely on risk *rating* systems as these often require a more detailed evaluation and examination of site-specific, BATNEEC, BPEO and/or cost-benefit issues. The consideration and setting of authorisations and discharge permits, of course, plays an essential role in controlling both hazard (source-related aspects, potential releases) and risk at any facility. The emphasis of this document is largely with respect to post-authorisation regulatory control.

In terms of application, risk rating systems are likely to be used initially as modifiers for the existing function-specific resource planning algorithms. For example, they may be used to determine the proportion of the available resource (as in the case of waste function), or to modify the existing inspection frequencies (as in process industry regulation). Once "read across" or comparison between systems is possible through benchmarking between the different functions, it will be possible to apportion resources between functions according to risk. Furthermore, it should be possible then to develop the resource planning systems to help determine the desired amount of resource, based on risk. This will be achieved in practice by evaluating how 'sensitive' risk levels are to operator or regulatory intervention by different resource allocations.

Risk-based resource planning provides a more transparent and effective means of allocating resource to target risk. However, it is likely that a risk-based approach itself will require resources in itself to explain and implement, compared with current techniques. It is therefore important to consider the resource implications of introducing risk-based resource planning systems and to design and implement these with the objective of minimising the time and effort required to run such systems.

Proposed Way Forward

Risk-based resource planning systems exist in various stages of development in the Environmental Protection Directorate, notably waste, process industry regulation and water quality. These systems are being developed in response to differing pressures and according to varying deadlines. They are tailored towards the specific functions but are broadly based on the forerunner OPRA system. Different legal, resourcing and charging constraints apply in the different functions and grant in aid for individual functions may constrain the resource available for wider use. Currently, "read across" *within* functions is relatively straightforward within sectoral limitations and can be progressed. However, "read across" *between* functions is currently difficult but will improve with data feedback. The implementation of IPPC may provide an opportunity to address this difficulty.

It is recommended that each function continue to develop and implement its own function-specific system, using this guidance to work towards a common approach. These functional systems should be progressively harmonised, based on experience and feedback, including development of a strategic system which supports cross-functional resource allocation. Progressing this may require statutory constraints to be reviewed based on the information provided from the risk-based resource planning systems. Implementation of IPPC may provide an opportunity for harmonisation.

It is recommended the development of risk-based resource planning systems be dovetailed with other related initiatives in the Agency, notably the Priority Planning Exercise (PPE). This guidance relates only to risk aspects of resource planning and should therefore provide a useful input to PPE, but does not cover the full range of issues which need to be considered in resource planning. For example, a particular problem or issue requiring special regulatory attention could be identified through risk rating, but the risk-based resource planning system would not indicate how much extra resource is needed; this requires separate consideration.

In the short term, it may be desirable to run risk rating systems disengaged from resource planning, purely to gather data and test systems. Over the longer term, iteration of the resource planning system should identify areas where more or less resource is necessary. The process of implementing full risk-based resource planning may reasonably take around 3 - 5 years. Full risk-based resource planning must consider risk to the Agency's business as well as risk to the environment.

The strategic risk-based resource planning system will be challenging to develop and will need to be based on benchmarking and calibration between the different functional systems. The immediate need is for consistent systems to be developed and implemented within individual functions. Normalisation of scores from systems of different architectures will be more difficult than for similar systems, which would hamper comparison between functions. However, following this guidance will facilitate the delivery of a strategic resource planning system. In acknowledgement of the Board's approval of NCRAOA's corporate lead in risk assessment, such systems should be developed in consultation with the National Centre for Risk Analysis and Options Appraisal.

Acknowledgements

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CONTENTS

1. INTRODUCTION

1.1 Background

The Environment Agency has a statutory duty, under the Environment Act 1995[6], to contribute to sustainable development. In the Ministerial guidance provided in support of this duty, the Government has indicated that the Agency should use risk assessment and other tools in reaching decisions that contribute to sustainable development. The Agency's Environmental Strategy sets out a commitment to implement risk-based tools in support of the regulation of major industry.

In 1995, the former Department of the Environment (DoE) published a "Guide to Risk Assessment and Risk Management for Environmental Protection" and indicated that its sponsored bodies would be expected to implement the guidance. In 1997, the Agency's Board established the National Centre for Risk Analysis and Options Appraisal (NCRAOA) to lead efforts in implementing the requirements being placed upon it. It is against this background that the contents of this document should be viewed.

The Environment Agency of England and Wales (hereafter, the Agency) is committed to adopting risk-based management systems into all relevant areas of its business as part of a drive towards risk-based regulation. Increasingly, there are resource constraints on existing and new regulatory burdens that necessitate a new way of working. The prioritisation of regulatory activity on the basis of environmental risk, along with others factors, provides a sound, rational and structured way forward. A similar philosophy is being adopted in private sector and regulatory organisations elsewhere. This Guidance Note sets out some core principles for the design of risk rating and regulatory planning systems in the Agency, identifies where flexibility exists for the development of new schemes, and provides guidance for such cases. There is general guidance herein relating to the development of any risk rating system.

The Agency released its revised Operator and Pollution Risk Appraisal (OPRA) system in August 1997 for all Integrated Pollution Control (IPC), Part A processes. Day to day regulation of IPC processes now resides within the Operations Directorate as 'process industry regulation' (PIR). Based on the experience of OPRA for PIR, the Agency wishes to extend application of risk rating systems within, and between, the environmental protection (EP) regulatory functions. In future, consideration may be given to the design, development and implementation of similar schemes in other areas of the Agency's work. To progress this objective, the Agency held a workshop in June 1998, 'OPRA - Taking it Further,' hosted by the Environmental Protection National Service (EPNS) to establish the general principles, disciplines, implications and benefits of EP-wide risk rating and resource planning systems.

A clear outcome of the June workshop was the need for a set of guiding principles for the design of any risk-based resource planning system. These will ensure consistency and a fair comparison within and between the EP functions. NCRAOA has developed this Guidance within the remit of its corporate lead on risk assessment. The principles referred to here apply to the development of any risk-based resource planning system intended for Environmental Protection or Operations Directorates and, in keeping with similar best practice guidance, will be kept under review with

[6] Environment Act 1995, Chapter 25, HMSO, London, 394pp.

opportunities made for continuous improvement. Where readers are considering the development of risk-based schemes beyond these Directorates, they are referred to the NCRAOA for assistance in scheme design, because the assignation of risk attributes requires careful consideration to ensure compliance with the fundamental principles of risk assessment.

1.2 Purpose and Scope

The purpose of this document is to provide best practice guidance on the principles of risk rating and resource planning systems, in order to support the development and implementation of such systems in the Agency. The immediate target audience is Agency staff involved in the design, development and implementation of such systems, although others external to the Agency with an interest in risk-based resource allocation may have an interest. Importantly, the PIR OPRA system is not regarded as a standard template for this exercise although the Agency's experience in design, consultation and implementation has been valuable in preparing this guidance. The objectives of the guidance are to:

- establish a coherent, robust and transferable set of guiding principles for the development of risk-rating schemes;
- facilitate the consistent development and implementation of such schemes based on past experience and "best practice" in this field;
- ensure such tools are as effective and accurate as possible in differentiating and ranking sites according to environmental risk;
- ensure the resulting risk information is used, in conjunction with other relevant information, to allocate resources in a consistent and optimal manner within a given regulatory function or activity;
- enable "read across" (i.e. fair comparison) between regulatory functions and activities, thus allowing for "top level" planning of the total regulatory resource across all functions; and
- collate accurate information that could inform existing and 'new burdens' submissions to central government.

The scope of this guidance covers all risk rating systems and resource planning for Agency regulatory functions. It does not at address financial risk rating. The guidance is based on experience gained from existing and developing systems within the PIR, waste and water quality[7] (pilot scale only) functions and from a survey of similar schemes in external organisations. The guidance has benefited from the extensive consultation undertaken for PIR OPRA. It is recognised that improvements can be made, and this Guidance Note therefore represents a collation of experience to date, together with some new thinking on risk rating and resource planning.

The NCRAOA's experience of developing and implementing a risk ranking approach for ICI Chemicals and Polymers has also been integrated within this guidance. Whilst a level more complex than risk rating systems, the results provide details regarding risks and how they can be used to refine risk rating scores. The NCRAOA's ICI work is an example of risk-based scores directly affecting industry's internal investment on environmentally-related matters.

[7] Environment Agency (1998) Operator and Performance Appraisal for Water Quality (internal paper, North East Region, Environment Agency), Environment Agency, Leeds, 5pp.

The June '98 OPRA workshop identified the following requirements for the implementation of risk-based resource planning systems within the Agency. Any scheme should:

- identify the level of resource required to regulate to a defined service level;
- employ a sound scientific basis for evaluating environmental risks, discharger or operator effectiveness and be responsive to social and political pressures;
- be a practical tool using simple consistent scoring systems and terminology wherever possible;
- be simple and transparent to both Agency staff and our customers;
- contain quality systems which aim to promote consistency; and
- be capable of development, in conjunction with our customers, through experience gained and for new legislative requirements.

This document provides guidance on the design and implementation of risk rating and resource planning systems for the Agency. The document does **not** provide the detailed architecture for any particular system. Issues relating to charging and statutory requirements are not discussed in detail here, other than to identify where they may impinge on resource planning.

2. BASIC PRINCIPLES

2.1 Risk Assessment

'Risk' is the probability of suffering harm from a hazard and is concerned with both likelihood (probability) and consequence. The 'hazard' is the adverse *effect* under consideration posed by the source of the hazard. Risks can not occur without *exposure* of a target or receptor to the source of the hazard. Risk assessment is a process for assimilating what is known and what can be reasonably inferred about an exposure situation for the purpose of managing risk. Risk assessment can be conducted at various levels of sophistication, ranging from the initial screening of risk using a simple 'source-pathway-receptor' approach through to a detailed analysis of complex risks using quantitative techniques to assess and express consequence and probability in numerical terms. Risk rating systems sit between these ends of the spectrum and, in essence, have more in common with qualitative risk assessment than quantitative methods.

2.2 The process of risk assessment typically involves the following stages:

- hazard identification: identification of the sources of the hazard and characterisation of the source and the hazard, including the identification of dose-response relationships (potency);
- exposure assessment: evaluating the plausibility of the hazard being realised at the target, and by which mechanisms, allowing an assessment of the probability, magnitude and duration of exposure;
- risk estimation: consideration of the consequences of exposure with reference to effects and dose, expressed as a likelihood or probability of the hazardous effects of exposure being realised; and expressed over a range of spatial and temporal fields;
- risk characterisation: evaluating the acceptability and significance of risk with reference to standards, targets, background risks or related acceptability and tolerability criteria.

There is often considerable uncertainty involved in assessing environmental risk, particularly in the assessment of environmental exposures and impacts. Assessment effort must therefore be targeted accordingly, where risks or uncertainties are high, or where the costs of the assessment are justified by the benefits to decision-making. The Agency has adopted a staged, tiered and iterative approach[8] to risk assessment that facilitates early risk prioritisation, avoids unnecessary detail and matches the level of approach adopted to the needs of the problem under investigation (Figure 3). Here, a simple "screening" approach is used first to determine the key risks and priorities. If the decision cannot be made based on this approach then more detailed approaches are used, focusing on the key risks identified at screening.

2.4 Risk Rating Systems: Capabilities and Limitations

Risk rating systems are amongst the simplest screening approaches; they do not address detail but are a simple and rapid means of identifying and prioritising key issues. As such, the expectations of these systems should be realistically appreciated. This is a critical concept in the design of scoring systems. A further issue for the use of risk rating systems is the distinction between:
(i) the inherent, immutable aspects of a hazard; and
(ii) the probabilistic elements of exposure.
The latter are usually dependent on the exposure situation in hand and, in a pollution context, often relate to developer's, discharger's or operator's performance in managing their site, discharge or facility. The fundamental basis of risk rating systems is that these aspects are assessed *independently* for the purposes of arriving at an overall risk to direct regulatory activity.

[8] Environment Agency (1997) A Guide to Risk Analysis at the National Centre for Risk Analysis and Options Appraisal, Environment Agency, London, 5pp.

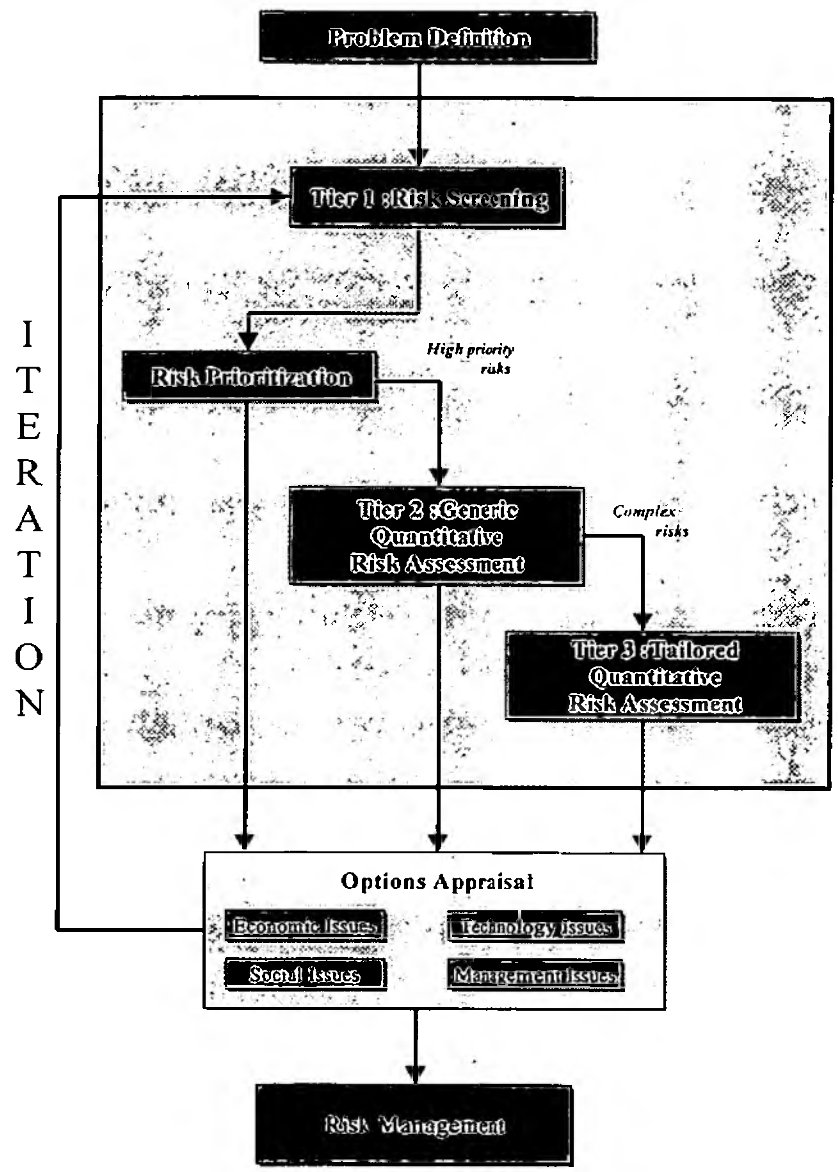

Figure 3: Staged, Tiered and Pragmatic Approach to Environmental Risk Assessment

The level at which risk rating systems operate is that of risk screening and prioritisation, whereby hazards and performance are being scored against a benchmark or reference point. Risk rating systems simply work by scoring various characteristics or "attributes" of risk and combining the scores to provide an overall assessment. The attributes relate to aspects such as the severity of the hazard, the sensitivity of the receiving environment, the probability of accidental release, and so on. Clear guidance is given on how to score over a predefined range but there are a number of over-riding capabilities and limitations of such schemes that must be recognised prior to their development and use (Table 2).

Risk rating systems have some specific advantages and disadvantages which place restrictions on their use. Such systems are used to prioritise sites and identify key risk contributions. They should not be used in attempts to infer 'absolute' levels of risk, to compare with risk criteria or to test the effectiveness of detailed risk management options. Other more detailed assessment systems are available for these purposes. These, where available, may be utilised as an input for the risk rating system. Similarly, detailed audits of management systems (such as large scale audits carried out for PIR processes) may provide information on operator performance which can be used in risk rating.

Capabilities: Risk rating systems can:	***Limitations: Risk rating systems can not:***
distinguish between risks posed by facilities or situations of a generic type	*provide absolute estimations of risk; scores are relative*
allow prioritisation of risks from risk scores, usually through the separation of probability and consequence	*provide a degree of resolution beyond that inherent to the subjectivity of the scoring system; scores are best 'banded' in ranges*
allow comparisons between situations with similar overall risk, but with different 'driving' factors	*be applied without training*
accommodate simple 'what if' questions	
allow fast screening of numerous facilities or situations	
prioritise and focus further risk assessment effort	
support the identification of high risk situations which may develop after authorisation or licensing	

Table 2: Capabilities and Limitations of Risk Rating Schemes

2.5 Resource Planning

Resource planning is the process of developing plans for the allocation of regulatory resources to specific tasks over a given period. Resource planning occurs primarily within individual Agency functions. Existing approaches to resource planning include Waste Management Paper 4[9] (WMP4), the Regulatory Standards Memorandum 41[10] (RSDM41) and the national Discharge Consents Manual[11]. These documents set targets for programmed activities such as inspection and monitoring.

In the context of achieving environmental protection and improvement, the primary aim of risk-based resource planning is to utilise regulatory resources in the most effective and efficient manner, taking into account the management of risk by the discharger, developer or operator and the concerns of stakeholders such as the public. These systems:

(i) explicitly recognise both the technical and procedural measures taken by industry to manage risk;
(ii) reduce unnecessary regulatory intervention; and
(iii) provide an incentive for dischargers to improve risk management by reference to changes in their risk scores over time, reflecting a greater degree of environmental responsibility.

3. GUIDANCE ON RISK RATING SYSTEMS

3.1 Overall Principles

The overall principles of risk rating systems are described in the Agency's revised OPRA guide. Critical aspects of the approach that set the context in which such schemes are being developed internally are:

- the primary purpose of a risk rating system is to provide an objective and consistent assessment of environmental risk;
- the Agency believes risk rating systems provide greatest benefit where they are used with full openness between the operator and regulator;
- these systems complement authorisations and support inspections, they do not replace them;
- overall risk levels are dictated by the balance between pollution hazard and operator performance; and
- risk rating systems have wide potential application within inspection resource planning, monitoring and environmental surveillance, pollution prevention planning, strategic planning, and the capture of environmental information.

The June '98 workshop 'OPRA-Taking it Further', identified a set of critical success factors for any risk rating system (Table 3).

[9] Department of the Environment (1994) Waste Management Paper 4: The Licensing of Waste Facilities, 3rd Edition, HMSO, London
[10] Her Majesty Inspectorate of Pollution (1991) Regulatory Standards - Memorandum 41, IPC Processes, Norms for Regulatory Effort; Application for Pre-IPC Application (internal Agency document)
[11] National Rivers Authority (1994) Discharge Consents Manual, Volume B, Chapter 8 (and subsequent Environment Agency updates), Environment Agency, Bristol

Factor	***Description / requirement***
Consistency	*Within a particular regulatory function, it is essential that risk rating systems work consistently, i.e. an operation in one part of the country is given a similar score to a similar operation elsewhere in the country; also, the same operation should be given the same score by different inspectors or at different times.*
Range Of application	*The risk rating system must be sufficiently flexible to enable evaluation of the wide range of operations and conditions within a given regulated area. Also the wide variety of types of risk on any site (different substances, media, point or diffuse sources, planned or unforeseen releases) need to be considered within the system.*
Use of Sound Risk Principles	*In order to be credible and to facilitate "read across" between different functions, each risk rating system should be based on a common philosophy and established principles of risk.*
Simplicity	*Systems should be simple to understand and use, with limited resource required to operate the system in the field.*
Transparency	*The risk rating system should be transparent, i.e. the basis for setting a score should be possible to follow and check.*
Judgement Factor	*There is a degree of expert judgement involved in assessing risk, which must be incorporated within the risk rating system and clearly identified as such.*
"Read across" between functions	*If risks from different functions are to be compared, it is important that the design and implementation of risk rating systems is controlled and based on common principles. It should be the presumption that systems are identical where possible and any differences in them are justified.*
Adds value	*Allows better decision-making (improved environmental protection and/or lower cost) than traditional approaches.*

Table 3: Critical success factors for Risk Rating Schemes

The scope of a risk rating system needs to be clearly defined. It will usually be applied to all regulated sites or activities within a particular regulatory regime. Specific issues need to be considered, such as whether "exempt activities" should be included, for example, particularly with reference to cost and resource implications.

3.2 What is measured by the risk rating system?

Risk rating systems assess overall risk to the environment from a regulated operation, discharge, site or facility, based on information known at the time of assessment. The term 'overall risk to the environment' reflects a need to assess risk:

(i) from routine and unplanned conditions;
(ii) to all parts of the environment affected by the operation;

(iii) over the short and long term; and
(iv) within the regulatory boundary defined by the authorisation only.

An assessment of risk can only be based on knowledge of the operation and its environment at the time of the assessment. Changes in conditions affect the risk level and will necessitate a reappraisal. In the case of landfill sites, for example, these stages are pre-operation, operation, closure and post-closure. For a process site, there may also be many different phases of an operation (e.g. different raw materials, throughput levels, etc.) as well as other stages to consider (e.g. decommissioning).

3.3 Generic Elements of Risk Rating System

Risks from an operation (a site, activity or process) are determined by a combination of risk factors or "attributes", including inherent physical or "hardware" factors (that is *technology*-associated factors) and so-called "software" factors (that is *management*-associated factors). The generic risk factors applicable to any type of operation or situation are shown in Table 4. Both the process (i.e. the source of the hazard) and environment (the receptor) need to be considered to obtain a comprehensive view of risk.

The generic factors represent the minimum information required to characterise risk levels. Existing Agency resource planning systems (RSDM41, WMP4 and the National Consents Manual) are unsophisticated tools based on simple considerations of a limited number of factors. For example, the effluent volume and the catchment size determine the frequency for sampling discharges and the permitted proportion of non-compliances. A risk rating system incorporating a wider range of risk attributes allows the regulatory workload and response to be targeted more accurately.

The "type of factor" in Table 4 describes the kind of risk information represented. "Inherent hazard" factors relate directly to the source, and reflect the potential *nature* of environmental harm that could result from an operation. "Inherent frequency" factors relate to 'pathway' (i.e. release) issues and the *likelihood* of events. Operator performance factors relate to the operator's systems for managing risks and controlling environmental performance, including measures in the event of catastrophic failure. The balance between inherent risk and operator performance determines the actual risk to the environment. This principle is used in the PIR OPRA system which divides attributes of risk into "hardware" (pollution hazard appraisal or PHA) and "software" (operator performance appraisal or OPA) factors. There are, however, several other valid categories of attribute (Table 5). For example:

- between those *within* the operator's *control* and those *outside* the operator's *control*;
- between those affecting the *frequency* of events and those affecting the *consequences* of events; or
- by specific reference to *source*, *pathway* and *target* (Figure 4).

The risk-rating systems developed in the Agency to date place an emphasis on different aspects of the process-risk-performance 'chain' (Figure 4).

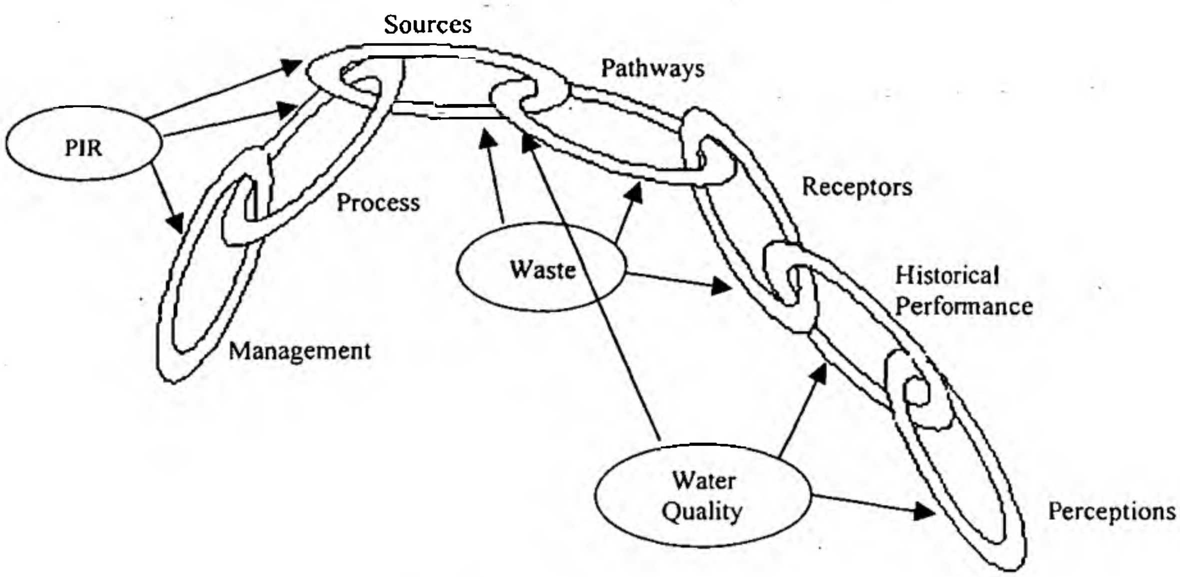

Figure 4: Emphasis of Existing and Developing Risk-Rating Systems in the Environment Agency

The term 'sensitivity of factor' relates to the ability of the operator (or the regulator) to control each factor through intervention. This becomes important in determining what the regulator will seek to influence when trying to reduce risk and through what mechanism. Some factors are completely within the operator's control, others less so. Some factors are best controlled during the initial authorisation, others post-authorisation.

The weighting of factors is a further issue because it reflects the relative importance of each attribute. Weighting factors may vary considerably from one industry sector to another. It may be necessary to derive weighting factors specific to each type of regulatory action. For example, the nature and frequency of operations and operational procedures may be particularly important to monitoring of water discharge consents, which is concerned *inter alia* with the variability of discharges against consented limits. For simplicity, no weighting factors are suggested in Table 4.

Each system of dividing attributes and expressing risk has different advantages and disadvantages (see Table 5 below). The different approaches are illustrated in Figure 5 below. The "balancing model" implies a level of operator performance in proportion to the inherent hazard. The "containment model" implies that over time, safeguards should be increased and risks decreased. The "risk model" is compatible with either of these and simply portrays risks as a conventional product of frequency and consequence factors, where risk management puts downward pressure on either or both frequency and consequence. The "risk model" is widely established (see for example, DETR[12], British Standards[13], Health and Safety Executive[14], Ministry of Defence[15] and Marine Safety Agency[16] approaches).

[12] Department of the Environment (1995) A Guide to Risk Assessment and Risk Management for Environmental Protection. HMSO, London, 92pp.

No	Factor description	Type of Factor	Sensitivity of Factor: Extent to which factor is in discharger's control
1	Severity of the hazard posed by the properties of the substances present; the potency of hazard source	Inherent hazard; source	Partially
2	Magnitude of the hazard posed by amount of substances present	Inherent hazard; source	Mostly
3	Frequency of the operation under study, including variabilities in operation	Inherent frequency; pathway	Mostly
4	Existing physical measures (technologies) to prevent, minimise or render harmless releases	Inherent hazard and frequency; pathway	Mostly
5	Pathway: extent to which the source of the hazard and the receiving environment are connected; the probability of exposure following release	Inherent frequency; pathway	Partially
6	Spatial extent of the potential impact in the receiving environment if release occurs	Inherent hazard and frequency; receptor	Partially
7	Temporal extent of potential impact in the receiving environment if release occurs, including permanence	Inherent hazard and frequency; receptor	Partially
8	Sensitivity of the receiving environment	Inherent hazard and frequency; receptor	Mostly outside discharger's control
9	Recording and use of information	Management factor	Completely
10	Knowledge of compliance requirements	Management factor	Completely
11	Operation of process or site	Management factor	Completely
12	Maintenance of process or site	Management factor	Completely
13	Management and training	Management factor	Completely
14	Historical record of incidents, complaints and non-compliance events	Management factor	Completely
15	Recognised environmental management systems	Management factor	Completely
16	Offensive characteristics of operation	Inherent hazard and frequency and management; source	Partially
17	Public perception of risk associated with operation	Inherent hazard and frequency and management	Partially

Table 4: Generic Risk Factors within Risk Rating Systems

[13] British Standards Institute (1996) BS8444 Part 3: Risk Management, British Standards Institute, London, 38pp.
[14] Health and Safety Executive (1989) Risk in Decision-Making, HSE Books, Suffolk, 36pp.
[15] Ministry of Defence (1996) Defence Standard 00-56 (Part 1) /2 Safety Management Requirements, 43pp.
[16] Marine Safety Agency (1998) Marine Guidance Note MGN 20 (M+F) Implementation of EC Directive 89/391 Merchant Shipping and Fishing Vessels (Health and Safety at Work) Regulations 1998, MSA, 16pp.

3.4 Iteration of Risks

Any assessment using a risk rating system must take place within the statutory remit of the Agency. For any type of operation, the attributes in Table 4 provide a basis for describing risk. Most regulated operations will have several, if not many, different sources of hazard. For example, an IPC process may have several well-defined point sources for releases of various substances to air and water. It may also have diffuse sources (e.g. fugitive emissions) and, for accidental releases, a potential for loss of containment in various sections of equipment. The risk rating system works by identifying (using iteration if necessary) the major source or sources of risk from the process 'as a whole' and basing the scores on the key sources. A similar degree of flexibility may be required for other regulated operations such as landfills. By 'processing' each potential risk through the same set of attributes, approximate comparison between different types of risk is possible.

System	***Advantages***	***Disadvantages***
'Software' vs. 'hardware' (performance vs. hazard)	*Allows balancing between inherent risk and management factors.*	*Frequency and consequence are not explicitly separated; more complicated than other approaches.*
Control vs. non-control	*Facilitates distinction between factors that can be controlled and those that cannot be easily controlled. Focuses on improvement.*	*Most factors can to some extent be controlled; hence system not easily balanced. Frequency and consequence are not explicitly separated.*
Frequency vs. consequence	*Most widely recognised approach. Simple.*	*Not sophisticated/powerful compared with above systems; sometimes difficult to fully separate frequency and consequence considerations.*

Table 5: Alternative Systems for Dividing Risk Attributes

Using iteration, it is possible to produce different risk rating scores for different media or substances. However, these must be integrated into a single representative score, and it is neither practicable nor desirable within the scope of risk rating to perform a complete assessment of every possible scenario as this is more the role of a detailed exercise e.g. a BPEO assessment. Instead, the overall risk rating is based on a single *representative* scenario which reflects the major risk issue for the process. The regulator's knowledge of the process and comparison with other similar processes should provide a basis for selecting a small number of candidate scenarios for iteration across the attributes in order to determine the main scenario of concern. It is essential that any set of scores is based on a single scenario. Other more detailed studies should be consulted to identify and characterise scenarios.

3.5 *Spatial Context*

In principle, it may be necessary to evaluate different spatial scales of risk, from localised impacts (e.g. water pollution) through to national or global impacts (e.g. acidification and global warming). The same set of attributes holds for any scale of effect. However, local effects are likely to be of greater interest within risk rating systems since the contribution of any one site to a global issue is low, and increasing regulatory attention in isolation of higher level changes in policy and legislation may not result in significant improvement. In principle, scores can represent any kind of release, from routine discharges to catastrophic loss of containment events (e.g. tank failure, liner failure). Proximity to receptors (particularly human dwellings) is an important spatial parameter considered in the assessment of vulnerability and sensitivity. There may be a need to normalise between different functions, as "close proximity" for a waste site and an IPC site, for example, may mean different things.

3.6 Consistency considerations

The basic attributes apply equally across different regulatory functions. For example, a rating of hazardous substances is based on the properties of substances present and is independent of the operation itself. This means that a rating of say '1' for hazardous substances has the same meaning for a waste site and an IPC process. Direct comparison or 'read across' for other attributes will be more difficult and needs to be undertaken carefully. For example, the magnitude of hazard may be difficult to calibrate for all IPC and waste sites, in which case a modification or weighting factor may be required. Similarly the basis for evaluating measures to prevent or minimize releases by reference to BATNEEC may not be easy to calibrate to a single scale for all types of regulated operation. Such differences need careful consideration as they will determine the regulatory balance, and may need to be developed using expert elicitation processes, as discussed below for weighting factors.

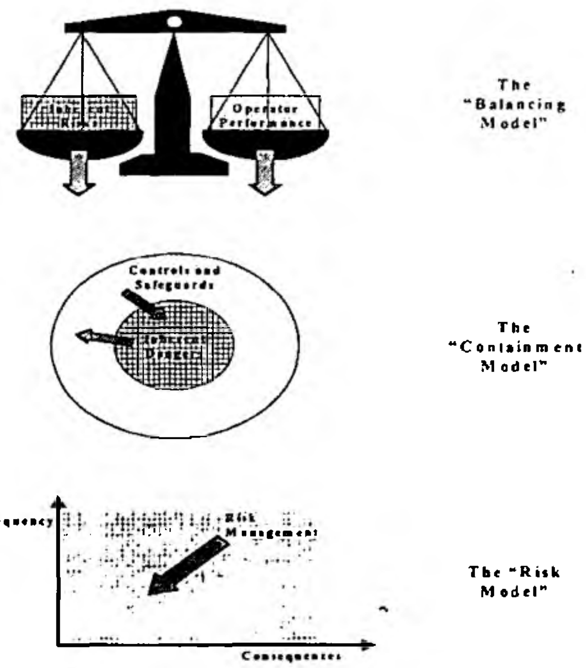

Figure 5: Alternative Models for Risk

Attributes can be split to clarify different issues (e.g. the PIR version has separate attributes for measures to *prevent* and measures to minimize releases). The nature of the surrounding environment is a complex attribute which may need to be split into further sub-attributes to facilitate proper characterisation. For example, the waste and water quality systems include several environment-related attributes, reflecting the complexity associated with any method of characterising the environment. The water quality rating system includes "nature of receiving water", "water quality considerations" and "location of process" and focuses more on the consequences of harm. Waste identifies three separate attributes for three main targets: humans, groundwater and surface water. PIR on the other hand contains one "location of process" attribute which reflects "overall" vulnerability and sensitivity. It is proposed that such differences are allowed, but it is important when attempting "read across" between functions that the splitting of attributes is recognised and any necessary recombining or weighting is undertaken to reconcile different functional approaches. Sub-attributes, as in the above examples, will require lower weighting factors to prevent individual attributes from having a disproportionate influence on the overall risk level.

It is conceivable that additional factors may be incorporated in order to capture specific issues. Similarly, non-applicable attributes can be deleted or "not scored". Deviation from the basic set of attributes in Table 4, however, needs strong justification because 'double-counting' is to be avoided. For example, operator monitoring is a part of recording and use of information. It may be necessary for the purposes of "read across" to establish such relationships and where appropriate, recombine non-generic factors into generic factors.

3.7 Environmental Management Systems

Including recognized environmental management systems (EMS) in risk rating systems provides a means for acknowledging the regulatory compliance and systematic improvements required of EMS standards. It also acts in support of policy objectives, as an incentive for operators to adopt EMS standards. Currently, PIR OPRA gives credit only for ISO14001 and EMAS systems, and does not reward internal company systems or those based on other standards such as ISO9001.

The weighting given to the EMS attribute reflects:
(i) the extent to which Agency is willing to reduce regulatory attention to sites with an EMS;
(ii) acknowledgement of the extra degree of effective management and "self-regulation" required by an EMS; and
(iii) the benefit of checking by independent certifying authorities.
PIR OPRA currently attaches a low weighting factor to this attribute, reflecting the inspectors' desire to verify for themselves the critical elements of management which dictate performance, e.g. maintenance, operation, training, etc. Here, the overall operator performance appraisal score sums up the inspector's view, and a recognised EMS is one small part of this. It is possible that the weighting given to a recognised EMS may increase over the long term, as confidence in recognised systems and demonstrable operation of these systems increases.

Effective management and awareness of risks is inherent to all 'software' (i.e. management) related scores. Presence or absence of a recognised EMS does not automatically guarantee high or low operator performance. An effective EMS is evidenced by demonstrable continuous improvement, an understanding of compliance status, and the demonstrable use of a management cycle (identify, evaluate, plan, implement, monitor and correct). These can be evident within or without a recognised EMS, although an operator unable to demonstrate these will probably be unable to acquire or maintain ISO14001 or EMAS. Thus an operator does not have to demonstrate the effectiveness of his EMS in order to obtain the score for the recognised EMS attribute; that is something which has to be done for all other performance-related attributes.

3.8 Integrating Perceived Risk

The "offensive characteristics" and "public perception" attributes in Table 4 are a requirement for all risk rating systems. They can be assessed independently from the more "objective" attributes (hence their separate designation in Table 4), but they can be a major factor in the amount of time spent on regulating an operation. The weighting factor adopted for these attributes reflect the Agency's desired split between response to public perceptions and response to the objective assessment of risk. In setting the weighting factors for these concerns, the Agency may consider the inherent level of perception of different industry sectors or operations. Consideration should also be given to the most appropriate response. For example, an inspection may be required in some situations, as it will often reassure the public and is seen as a valuable service to the operator. In other situations, for efficiency, it may be more appropriate to respond using public relations, education, R&D, operator communications or through the consultation processes.

Public and scientific perceptions are often quite different and, therefore, evaluation of these attributes is ideally undertaken separately from the objective evaluation of risk with reference to the other attributes. Offensive characteristics are determined by offences to human senses (e.g. visible plumes, heat and light, noise, odour, dust nuisance, traffic movements etc.). The risk perceived by a public may be dictated by the public image of the industry or company, the history of the site, related incidents, media and pressure group attention and whether the nature of effects are hidden or unknown. A public's perception of risk tends to be dominated by perception of the potential consequences, with less concern for probability issues. Repeated minor incidents may, however, heighten a perception of risk. An increase in perceived risk may be triggered by an incident, even if all measures are taken to prevent recurrence.

Many of the issues with respect to nuisance and perceived risk can be addressed at a planning stage or through local authority controls. However, it is acknowledged that the Agency often finds itself reacting to such concerns and there is, therefore, a legitimate role for assessment of these aspects at the outset. It is also widely acknowledged that some processes are inherently more "offensive" to the senses than others, such as seed-crushing and rendering plants, for example.

In summary, there are valid reasons for rating public perception issues alongside an assessment of an operation, facility or discharge:

- by evaluating perceived risk at the outset, it is possible to distinguish between sites on perception grounds and establish what likely resources may be necessary to undertake mitigative work, rather than relying solely on a reactive approach;

- understanding the perceptions of risk from various sites, operators, industry sectors, for example, can inform the Agency's public relations activity and help avoid confrontational situations developing[17]; and

- capturing information on risk perception over time may assist in assessing the merit of measures to address these issues; such as the establishment of formalised complaints procedures or the development of site liaison committees.

3.9 Historical Incidents

The historical record attribute enables real performance data to be included in the system, such as compliance statistics for the operation. This represents an "output" attribute; capturing measured performance rather than an "input" attribute (e.g. training or maintenance) to determine performance. A combination of input and output variables recognises that even high performance systems can have faults.

The weighting factor for historical incidents is an important parameter reflecting Agency policy. A high weighting factor implies great importance is attached to actual performance with respect to compliance, incidents and prosecutions. A low weighting factor implies importance is attached to the factors within the process and the management system itself which effectively dictates performance. The water quality function may attach a higher weighting to historical incidents than PIR does, due to the different emphases on "prosecution" versus "process control", for example. Whilst a consistent approach to considering past performance is preferred, it is recognised that this may be difficult to achieve in the short term although functions should work together to seek a common, consistent approach.

3.10 Guidance on Scoring and Weighting

The numerical expression of risk carries with it certain difficulties. The central one is what the numbers mean and the extent to which numbers accurately distinguish between different risks. A general rule is that systems for ranking or quantifying risk need be no more complex than is required to undertake the distinction between risks. A common error is the design of over-sophisticated schemes that invoke misplaced confidence in the scores, usually because of over-precision.

The existing risk-based rating systems use two very similar but not identical approaches to generating scores for attributes:

- points-based systems, e.g. score 1,3,5,10 or 20 points for specific conditions; and
- relative scale systems, e.g. 1 = lowest possible condition, 5 = highest possible condition.

It is easier to avoid bias within and between attributes if all scales within a particular system are simple and identical. This implies the PIR approach of using 1-5 for all attributes may be more robust than other scoring systems in this respect. However, it may be less flexible and not provide sufficient resolution. Currently, the PIR, waste and water quality systems have total

[17] Cm 4053, Royal Commission on Environmental Pollution (1998) Twenty-First Report: Setting Environmental Standards, The Stationery Office, London, 232pp.

points scales of 35/105 (PHA/OPA), 300 and 130 respectively. In general, it would be preferable for all risk rating systems to use the same scoring system. However it is possible to normalise different scales and modify scoring systems, for example by increasing the range of a relative scale system from 1-5 to say 1-10. This can provide additional statistical benefit and sensitivity, providing an expanded scale relates to observable increments in attributes 'in the field'. In practice, it is often preferable to produce "bands" of scores: 0-5; 5-15; etc.

Other forms of scoring are possible. For example, the American Petroleum Institute (API) risk-based inspection (RBI) approach[18] relies on an actual estimation of frequencies and consequences of releases on the basis of performance data. The frequency is calculated from a combination of generic (i.e. world-average) failure rates and site-specific modification (Mod) factors to reflect technical conditions, inspection regimes and management systems, that is:

Frequency of release = Generic Frequency x Technical Mod Factor x Management Mod Factor

RBI is being used by an increasing number of major companies to target inspection resources more effectively, enabling reduction in risk and/or cost. While some useful concepts could be extracted from RBI, it is unlikely that a similar approach could be developed in the near future for Agency's purposes. This is because the range of regulated industries is very wide, both accidental and routine releases need to be considered, and Agency's needs extend beyond the specific issue of inspection.

The direction of scoring also needs to be considered. The PIR OPRA scheme works on the basis that a low score corresponds to a low risk or performance; similarly a high score relates to high risk or performance. This encourages the view that operator performance and inherent risk should ideally be in balance (i.e. a high risk site should ideally have high operator performance), and reduces the undesirable impression that all sites should strive for the best overall 'score' in management performance. The water quality and waste schemes on the other hand score all attributes in the same direction, i.e. a low score is a low risk for all attributes. This is a more user-friendly system. From the point of view of "read across" between functions, differences in scoring direction can be normalised.

Guidance on how to allocate consistent scores based on tangible attributes of the regulated operation is essential. If a scoring system of 1-5 is used, the guidance can be derived based on the notion that the lowest possible value attracts a score of 1, the highest possible value attracts a score of 5 and the median for the entire range of values attracts a score of 3. The scores of 2 and 4 are self-defining as intermediates between 1-3 and 3-5 respectively. It is important to transpose the scale of 1-5 over the entire range of values so that scores of 1 and 5 may be encountered and the 'bunching' of scores avoided. The actual distribution of all operations across the scale of 1-5 may vary considerably. Distributions may be uniform, normal or skewed. The guidance for scoring should prevent artificial bunching of scores within the range of 2-4. Such systems, notably, do not accommodate 'zero' risk scoring.

It is also possible to reflect more than one type of risk in the final score by using the key risk issue as the baseline set of scores and incrementing relevant attribute scores to represent other risks which the inspector is concerned about. For example, the key risk is a large release rate to

[18] American Petroleum Institute (199) Risk-based Inspection, API, pp.

air of a slightly harmful substance, but the inspector also wishes to recognise a small inventory of a highly harmful substance which could accidentally spill to water. The hazard score would be based on the release to air and then incremented by 1 or 2 to allow for the spill to water. A large and complex operation can be split into subsystems and "mini" ratings performed, if evaluation of the total operation in one go is too difficult. It is necessary to combine the subsystem scores into an overall score for the whole operation. In essence, this represents a means of allowing for multiple inventories of hazardous substances. It is essential to carry out incrementing or combining scores transparently and consistently and the operation of any such allowance made clear in supporting guidance.

As well as recording scores it is critical to record the reasoning behind a score, and in particular, a change to a score. The basis for scoring should be summarised and include information on which substance(s) and types of risk are critical for that site and why scores have been allocated. It is not the intention of risk rating systems to drive all operators to the same levels of risk and performance (particularly in relation to operator performance scores). Low performance scores may not lead to serious environmental risk, for sites with low hazard scores. As discussed above, the intention is to strike a balance and drive dischargers, developers or operators towards at least a level of performance appropriate to the risks on the site.

Scores and overall score distributions are likely be different for each attribute and are likely to vary with time. Figure 6 illustrates this by showing a distribution of scores for two risk attributes across one business sector comprised of several individual process plant, e.g. bleaching plants in the pulp and paper sector. The shape of any particular distribution may be symmetrical or skewed, uniform or concentrated. It is important to understand these shapes and trends and to identify why changes are occurring. Scores may need to be re-evaluated when new information or technology for a sector becomes available. Such information provides valuable input to the assessment of specific sectors in any one function.

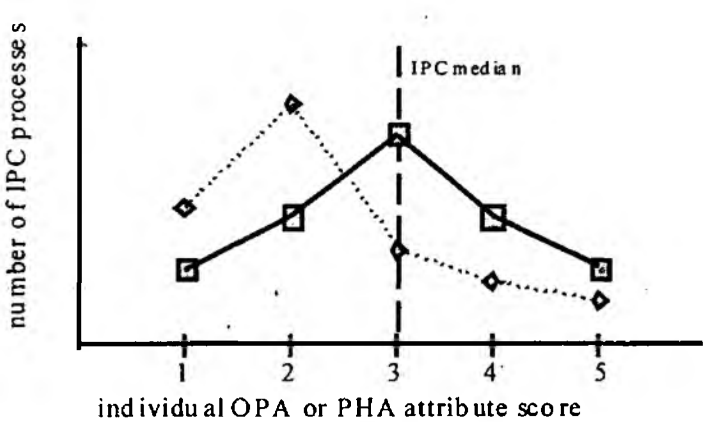

Figure 6: Example of Two Sectoral Distributions in Risk Rating Attribute Scores

Weighting factors represent the relative importance of different attributes with respect to the overall level of risk. Their use can often be controversial. This could include weighting to reflect the effect of extra regulatory resources in reducing risk. Weighting factors are used as "multipliers" for the "raw scores". This enables a summation of scores to be performed along the following lines. Weighting factors thus dictate the overall range of scores and need careful comparison for 'read across' purposes.

Total Score = Σ (weighted scores) = Σ (attribute raw score * attribute weighting factor).

For the purposes of assessing and discussing risk on a specific site, weighting factors may not need to be used, because they can often be controversial and are only relevant to the resource planning algorithm. It is possible to use the above equation to calculate overall scores. In the waste system, these are added together to obtain a total risk score for the site (given the operator and performance scores work in the same direction). The PIR equivalent would be to divide the performance score by the operator score (given hazard and performance scores work in opposite directions). The waste version is arguably more "user-friendly" but the PIR version enables a balance to be identified between performance and hazard. In either case, combining all the risk information into a single score enables production of a list of sites ranked according to risk.

An alternative approach is to not attempt to express risk by combining performance and hazard scores but instead to present them on separate axes of a matrix (Figure 7). The relative position of a site in the matrix is then an expression of the overall risk for that site. This approach is consistent with many other methods of expressing risk and avoids the controversy that may arise over expressing risk as a single number by combining scores.

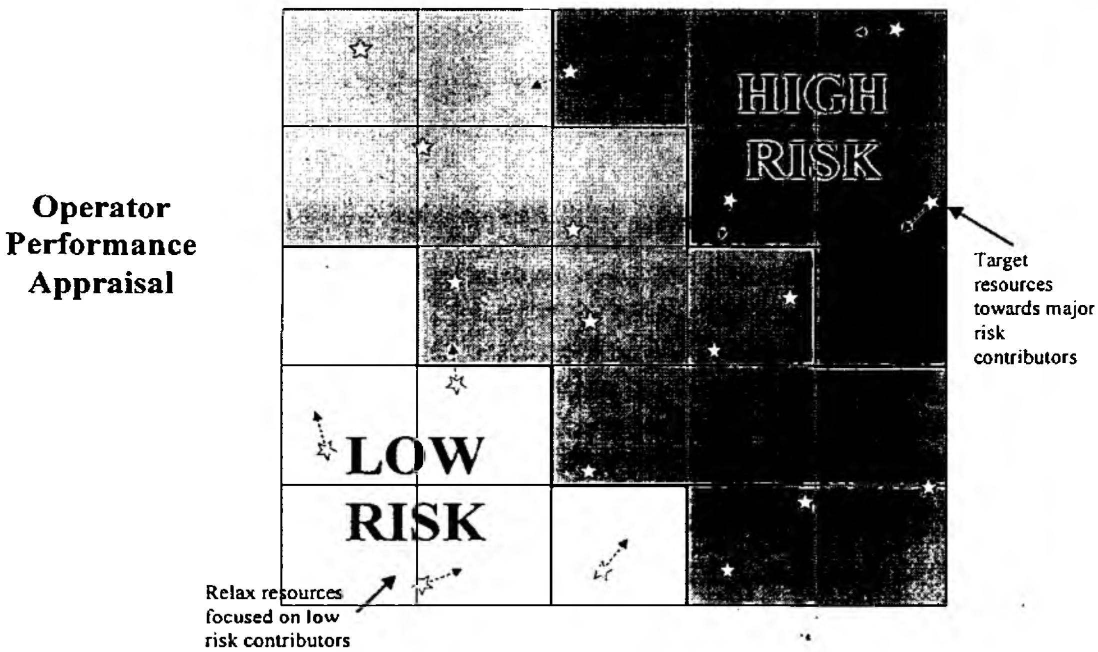

Figure 7: Example of a Risk Matrix

3.11 Expert elicitation for the derivation of weighting factors

Where weighting factors are needed, experience indicates that they can be readily derived using an expert elicitation or expert judgement process. This is a form of group exercise where individual experts provide their views on relative importance before an overall group consensus is established. The operation of such an exercise requires time and resources to be allocated in advance. The 'Delphi technique[19]' is one of many established protocols for expert elicitation. Only the highest and lowest individual views need to be explained. Individuals are then allowed to recast their views of the importance and ranking. Median values are then taken to represent the group's overall view. Rules for such exercises include the following:

- a group of experts from all relevant areas participate with a facilitator;
- common understanding of the different attributes and the system is established before discussion;
- individuals determine their own views on the relative importance and ranking of attributes;
- averaging of relative importance and rankings is applied;
- all information is recorded, with explanations;
- group discussion and reconciliation of scores.

It is important to distinguish when it is appropriate to introduce another risk factor, increasing the scoring scale, or increasing the weighting factor. Each has an effect on the overall risk profile. If any adjustments are made to any aspect, it is necessary to review and adjust the overall system to maintain proper balance. In general it is recommended that scoring scales are not adjusted.

4. GUIDANCE ON RESOURCE PLANNING SYSTEMS

4.1 Introduction

Corporate planning in the Environment Agency is a complex, multistage process involving the production of agreed activity lists and service levels, the collation of associated full-time equivalent inputs and financial resources, and the allocation of resources to the activity lists in a prioritised fashion. The development of a prioritised, risk-based resource programme represents a considerable shift in the manner in which this exercise is completed at present. However, it is acknowledged that resource planning can not be based solely on a risk as this would overlook the resources required in issuing the authorisation /consent/ licence, and the need to address environmental priorities in general.

4.2 Overall Principles

In the initial context of guidance on the use of risk rating systems, resource planning relates primarily to setting inspection and monitoring frequencies. Other potential uses of risk rating results are dealt with in the subsequent section. Table 6 shows the critical success factors for resource planning algorithms.

[19] See for example: Roberds, W.J. (1989) *Methods for Developing Defensible Subjective Probability Assessments*, Transportation Research Record, 1288, 183-190.

Consistency – Commonality	*It is essential that resource planning algorithms within different functions and activities are as consistent as possible in order to ensure rational allocation of resources both within a function (intra function planning) and between functions (inter function planning).*
Cover all relevant factors	*The resource planning algorithm must include all relevant factors which go into resource planning, as well as actual risk considerations. These include available inspector resource, total number of operations, statutory requirements, hours required for visits, programmed tasks, etc.*
Application range, Transparency, Judgement	*As for risk rating system.*
Effectiveness	*The resource planning algorithm should increase the effectiveness of inspection and other resources and be able to demonstrate this improvement.*

Table 6: Critical success factors for Resource Planning Algorithms

The development of resource planning systems should include consideration of the following:

- existing resource planning systems (e.g. WMP4 and RSDM41 for waste and PIR inspections respectively);
- total resource available for regulatory activity;
- total number of operations controlled within regulatory function;
- minimum statutory requirements;
- site-specific risk levels – performance and hazard attributes;
- weighting factors between different attributes, between hazard and performance and between different functions;
- desired rate of change of risk rating scores and inspection or monitoring frequencies;
- possible rate of change of risk following operator changes (e.g. an operator may agree to improve an aspect of management systems which requires 6 months to take effect);
- nature and duration of tasks required in regulatory activity (for example, if certain types of inspection task can only occur during certain operational phases, e.g. shutdown); and
- priorities and demands – incidents and complaints.

One purpose of resource planning is to produce *target* frequencies for inspection, monitoring and other regulatory activities. A wide range of issues and problems may arise which dynamically affect the available regulatory resource or the actual priority of work. For example, a major incident may occur on a high priority site, resulting in an increase in the actual frequency of inspections compared with the resource planning target. It may be appropriate to set upper and lower limits to the target frequencies calculated in the resource planning algorithm; for example if the target inspection frequency exceeds an override level then it is reset to that level and another activity (e.g. enforcement or review) is triggered.

At the outset, risk-based resource planning should be integrated with the existing resource planning system at least in the first period of application of a new system. For example, PIR inspection frequencies may be derived using risk ratings as modifiers for the established RSDM41 inspection frequencies. This can help avoid major discontinuities in resource allocation during the introduction of a system..

Risk-based resource planning is one component of the overall resource planning process. This may take into account factors beyond the scope of risk-based considerations, for example particular problems arising in a sector or on a particular site which may require additional regulatory resource. Risk-based considerations therefore should be integrated into overall planning initiatives such as the Priority Planning exercise.

In general risk-based resource planning in simple form takes a predetermined resource budget and apportions it according to risk, i.e. a "supply-lead" model. Current risk-based resource planning is based on this model.

4.3 Specific Principles

Weighting resources provides a means of reflecting the different importance placed on different demands – e.g. reacting to public perceptions of risk versus objective assessments of risk. This requires a policy decision to determine the relative importance of some factors. The split between reactive and programmed inspections may depend on historical experience within the function. For example, in waste regulation, generally 10% of inspections are reactive, whereas the proportion is much higher for PIR. It is possible to constrain risk rating systems to exclude reactive visits (e.g. due to complaints), effectively by setting the 'offensive characteristics' factor to 0. However, it may be preferable to retain all attributes within the resource planning algorithm, so that, for example, the planned inspection frequency includes a proportion for reacting to public complaints. This provides a comprehensive basis for resource planning including reactive and strategic priorities. It also reflects the reality that inspection visits may deal with both reactive and strategic issues.

The simplest technique for resource planning is based on the following equation:

$$BR_i = BR_t * (RS_i / RS_t)$$

Where RS_i = Risk Score for site i (= PHA/OPA or PHA+OPA)
RS_t = Risk Score total for all sites
BR_i = Budgeted resource for site i
BR_t = Budgeted resource total for all sites

Even this approach may be controversial because it requires a single value to represent the risk level. One solution is to use the risk matrix approach or similarly, a banding structure, whereby the effective risk and corresponding resource allocation for a site are dictated by the risk band or category the site falls into according to its score. The banding structure needs to be sufficiently sensitive so that significant changes, e.g. serious incident or major variation in conditions, lead to sites changing bands where appropriate.

Algorithms may work on the basis of frequencies or hours allocated to site visits. The "Oxford model"[20] derived internally by national waste managers for resource planning and adoption of 75% of the inspection frequencies recommended by Waste Management Paper 4 are both used in waste function to define the baseline total number of hours allocated to each site for a 3-month period. An average inspection time is then determined from the "Oxford model hours" and the total number of sites. It is assumed that 90% of the total available hours are used for programmed inspections. The remaining 10% is for reactive inspections. The total number of available programmed inspections is then calculated from the total hours available divided by average inspection time. An "inspection score per unit of risk" is then calculated by dividing the total number of available programmed inspections by the sum of all scores over all sites considered. This is then multiplied by the individual site score to obtain the individual site risk-based number of inspections over a 3 month period. This approach is entirely consistent with the generalised approach defined above.

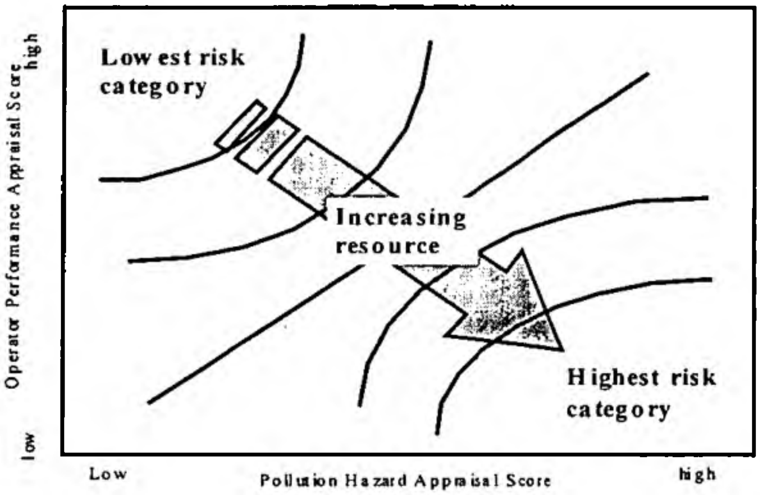

Figure 8: Philosophy of Risk-Based Resource Planning

Allocating resource in terms of inspection volume (hours/year) recognises the different duration of an inspection visit and can allow total journey time to be reduced which can be an important consideration for civic amenity sites in rural locations, for example. The duration of the visit may need to be linked to specific factors such as the issues identified in the last set of scores. PIR has proposed a minimum inspection frequency of once/year for all processes.

The general approach to allocating resources described above has limitations. It is relative. The resource allocated to any individual site is dependent on the total budget and the performance of other sites. Therefore resource allocation to a site will go up or down even if no change occurs on the site. Another limitation is the assumed linear relationship between risk score and inspection frequency implicit in the formula. It is more likely that a curved relationship is appropriate, reflecting *sensitivities* to change.

[20] An internal Agency agreement between National Waste Group members with respect to average inspection times, agreed at National Waste Group

The simple approach defined above assumes a "supply-lead" model. A "demand-lead" model, where the *risk* levels command the overall resource requirement could use the same equation but be based on "standard" resource requirements for particular regulatory tasks, multiplied by relative risk modification factors for each site to give the total resource required for each site.

The power of a risk-based approach can be illustrated by considering how, for example, inspection and monitoring activities might be optimised using a risk-based resource planning process. This can be viewed in two ways. First, the inspection frequency is set according to the risk level (Figure 8). Second, the inspection frequency *affects* the risk level since more inspection should result in reduced risk over time (Figure 9).

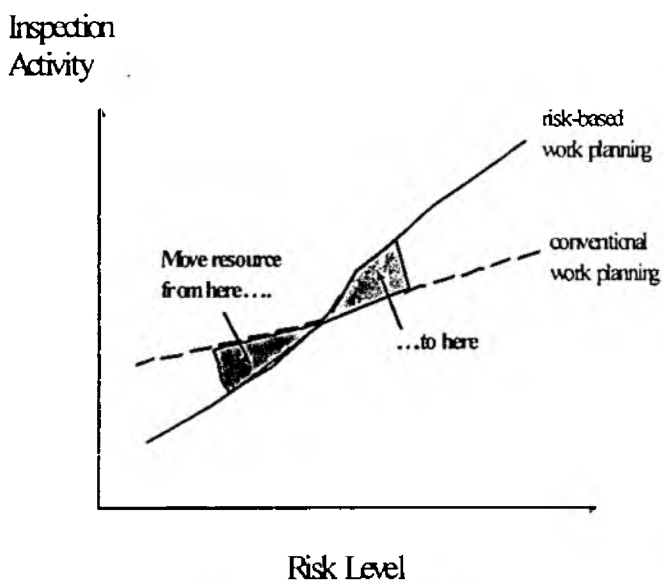

Figure 9: Benefits of Risk-based Resource Planning

In order to optimise the cost of regulatory effort with risk, resources are shifted from low risk towards high risk activities, and the particular level of inspection set according to how the risk varies as a function of inspection. There is no merit in increasing inspection if no significant reduction in risk occurs. Equally, reductions in inspection may result in some increase in risk. The aim is to set inspection frequencies for all sites so that *overall* reductions in risk outweigh any increases in risk. Sites where the gradient of risk vs. inspection frequency (i.e. the risk reduction opportunity per unit of inspection activity; Figure 9) is steep are in general likely to be candidates for reducing inspection activity, whereas sites where the gradient is shallow are likely to be candidates for increasing inspection activity. With experience, a predictive capability in "risk targeting" may emerge.

Information on the sensitivity of risk to regulatory attention is not available immediately and will take time to acquire. Therefore the initial phase of risk-based resource planning will be "risk-targeting", i.e. resources are allocated where the major risks exist (Figure 8). In time an element of "risk-reduction targeting" will develop whereby resources are allocated where the major risk reduction *opportunities* exist (Figure 10).

A balance of "risk-targeting" and "risk-reduction targeting" should be established in the long term. While opportunities to allocate resource to where risks can be reduced should always be sought, it is important to allocate some resource towards high risk operations, in order to establish that the operator is maintaining the appropriate level of control and to manage the public concern towards major risk operations. It is also important that resource allocation reflects an appropriate balance of priorities to anticipate and avoid risk as well as priorities to reduce risk, for example in expending resource to prevent an environmental quality standard being exceeded.

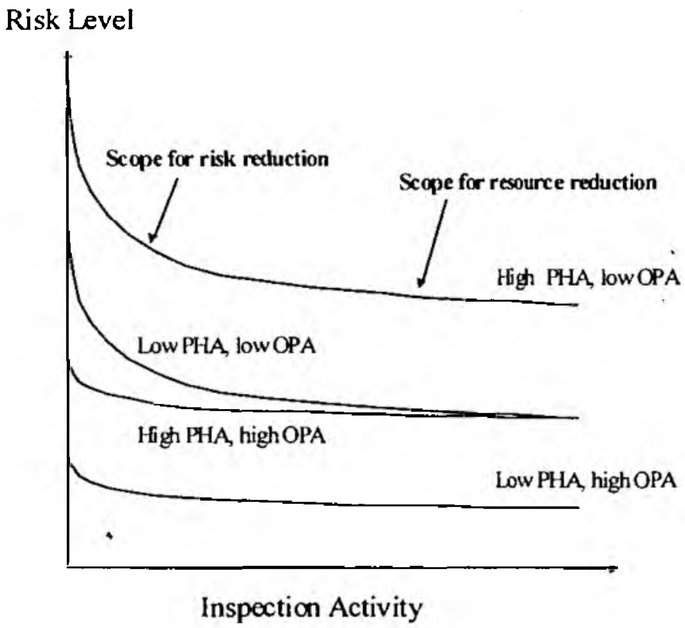

Figure 10: Response to Increased Inspection

Across all sites, the move to risk-based inspection should provide scope for reducing either the overall risks or the regulatory resource requirement, or both. The available reduction depends on the difference in accuracy of risk measurement and resource allocation, between the new and existing resource planning systems (Figure 10). For example, it is recognised that some consented discharges are over-monitored given the low level of risks. The available scope for reduction may vary from function to function. The risk-based inspection (RBI) system developed by the American Petroleum Institute (API) enables operators of processes to decide whether to reduce risk, or inspection cost, or both.

The required amount of inspection, and the effectiveness of varying inspection activity, for a given operation will depend on the balance between the pollution hazard and performance characteristics of that operation (Figure 7). Because of the design of the scoring system in this case, a site with a low hazard and high performance score will attract the lowest baseline inspection level. A site with a high hazard and low performance score will conversely attract the highest baseline inspection level. Sites with "high-high" and "low-low" are in balance and therefore fall in between.

Furthermore, sites with high performance scores are likely to be more amenable to reduction of inspection activity than those with low performance scores, irrespective of hazard scores (Figure 8). This is because a high performance score implies a well-run stable level of risk where the operator's basic management cycle is functioning and the implementation and audit processes result in improvements and corrections. Increasing regulatory inspection/monitoring results in little reduction in risk and the optimum inspection level is relatively low. Low performance operations, however, are more reliant on regulatory intervention to maintain performance and identify corrective action, because the internal management system is not advanced in relation to environmental performance. Increasing regulatory activity can result in significant risk reduction (or conversely, reducing regulatory activity may result in a significant upturn in risk); the optimum level of regulatory attention is therefore relatively high. Acknowledgement of the 'response profile' (Figure 9) is critical to obtaining the optimum profile within and between functions (Figure 10).

Depending on the industry sector, regulatory inspection and monitoring may in general have more effect on *performance* attributes than hazard attributes, whereas hazard attributes tend to be dealt with through authorisation and licensing. This reflects the fact that management factors may change relatively easily whereas the inherent hazards are generally less prone to variation once authorisation has been granted. Hazard attributes may be changed, but usually through variations to conditions or through the requirement for improvement programmes. The sensitivity of each attribute to different forms of regulatory action needs to be considered in resource planning.

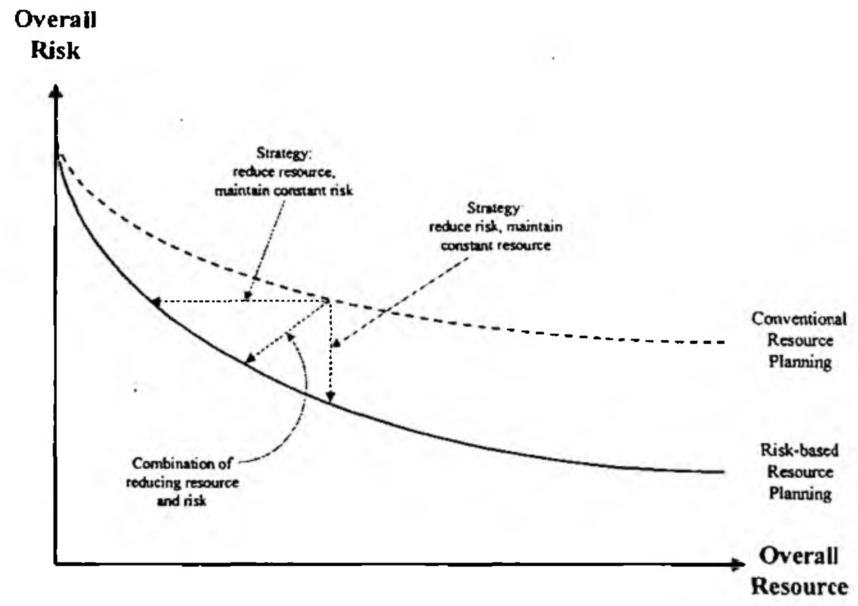

Figure 11: Reducing Risk and/or Resources

Uncertainty is an important concern in regulatory inspection and monitoring. Uncertainty may relate to variability (e.g. fluctuations in discharge conditions or accidental events), or to lack of knowledge. Either form of uncertainty may warrant greater regulatory inspection or monitoring effort. This factor is represented in part by the "frequency and nature of operations" attribute but uncertainty also plays an important role in determining a public's perception of risk. Uncertainty may need to be considered in the risk rating system and/or the resource planning algorithm. Uncertainties may vary considerably in nature and scale between different industry sectors. Seasonal variations may be one form of variability which needs to be considered in resource planning. For example, summer or winter conditions, changes in wind or river flows, or particular breeding periods, may affect risk levels. These may require inspection or monitoring to be programmed for certain times of year, rather than necessarily increasing resource allocation. Uncertainty also varies according to the life-cycle stage: at early operation and around closure, waste sites are subject to considerable uncertainty and may need additional regulatory resource.

In all cases, functions are initially developing risk-based approaches to inspection and monitoring. The approach may need to be extended to other elements of the regulatory system. For example, waste function is developing risk rating systems to cover the setting of licence conditions, financial provisions, exempt activities, charging, enforcement and standard inspection sheets, as well as the inspection and audit monitoring systems. It may be necessary to reproduce this in other functions so that consistency is achieved. In particular, risk rating systems may need to be considered in charging, in order to maintain the "polluter or *potential* polluter pays" principle, i.e. avoiding cross-subsidy between sites for risk-based inspection and monitoring levels. In some cases all that is needed is to ensure consistency; e.g. authorisation conditions and scores should be broadly consistent. In others, the issues will be far more complex.

As well as defining target resource allocations, it is important that the resource planning process reflects the necessary level of regulatory inspections, monitoring, etc. The use of risk rating scores in determining the scope of visits and the priority issues to address, is intended to cover the issue of quality. This also has implications to the level of expertise that may be required for different sites or visits. Currently, there is some flexibility in resource utilisation, for example water quality vary the proportion of specialist visits and routine sampling visits according to the perceived level of risk, within the existing monitoring frequency requirements given in the National Consents Manual. Risk rating systems may ultimately provide a valuable source of experience and information on risks from different operations and priority risk issues, which will assist in experience sharing and training of inspectors.

Compliance monitoring may be used to calibrate risk scores against impacts. To a certain extent this is achieved through including historical incidents in the rating system and also by triggering an update of the risk rating when a site has an incident. However it may be possible to further calibrate scores according to the results of environmental or end-of-pipe monitoring.

4.4 High Profile Sites

It is recognised that certain sites result in an extremely large demand on staff-time and other resources, often as a result of their having a very high public or political profile. In isolated instances, the additional resource demands resulting from regulating such sites will not have been identified by the usual resource planning within the Agency. In part, this is a consequence of the inherent difficulties involved in predicting which sites will fall into this category and the resource demands associated with regulating such sites.

In addition to the risk-based resource planning described above, it may be appropriate to develop a site-specific regulatory plan, defining the Agency's role in regulating such high profile sites. An aim of any such plan would be to bring the site back to routine regulation as soon as practicable and would provide an opportunity for more detailed examination of the additional resource demands until that is achieved.

5. OTHER USES FOR RATING SYSTEMS RESULTS

5.1 Dialogue with Operator

Scores for an activity should be discussed openly with the developer, discharger or operator concerned, to enable the operator to bring to the attention of the inspector any information which might be pertinent to the score and to promote a focused and constructive dialogue on the factors dictating risk. This ensures the scores are as robust and up-to-date as possible and the operator can identify opportunities to improve. However it is important to establish the principle that while operators are free to use risk rating scores for their own purposes, the scores are the responsibility of the inspector and there is currently no scope for self-assessment by the operator as the basis for setting scores.

5.2 Publication of Risk Ratings

Publication of risk rating scores has been discussed extensively within the PIR OPRA version. Both inspectors and industry were apprehensive that publishing such information might lead to misinterpretation, threaten credibility or inhibit open dialogue. However, it is recognised that publication of performance data can provide a powerful incentive to improve performance, and is an important part of the open relationship between regulator and public. Some of the information on which scores are based is in any case already in the public domain. In the longer term, it is envisaged that scores may be published, for example:

- by giving sector-specific results but not site-specific results;
- by showing trends in general results; or
- by allocating sites to broad-band categories.

5.3 Charging

Using risk rating scores in charging is seen as a logical extension to the system and IPC industry at least supports this proposal. Any charging system which takes into account the number of days spent on a site will in any case automatically vary according to inspection frequency. It is necessary to ensure that the risk rating system is robust before use in charging.

Charging is based on cost recovery for Agency resources allocated to industry sectors or specific industries. The charging basis varies from one function to another. Functions where charging is directly linked to inspection and monitoring frequencies (e.g. water quality) may not be able to fully implement a risk-based resource planning algorithm until the charging regime is updated. This depends on the rules regarding funding: revenue from some charging regimes goes to a national Agency fund for that regulated regime (e.g. charging for discharges in water quality). Also, some funds are 'ring-fenced' for use only within a given function (e.g. waste regulation).

5.4 Risk-Based Licence/Authorisation Conditions

Risk rating could also be used to derive risk-based conditions (e.g. discharge limits, waste storage requirements, monitoring), by addressing the areas of greatest concern identified by the scores. It is important to ensure conditions and scores are consistent where this is proposed.

5.5 Strategic information

It is reasonable to expect that a smooth running inter- and intra-functional risk rating system would yield powerful strategic information once there is enough reliable data available. Scores viewed over the long-term may be seen as one of many performance indicators for industry and the Environment Agency. Furthermore, it is likely that risk information gathered across functions will provide useful strategic information on statutory performance.

5.6 Application to Other Agency Work

A risk rating tool could similarly be used to prioritise risks and set workloads, for example in reviewing IPC/IPPC authorisations, COMAH safety reports, audits, permits under the Groundwater Regulations, special site investigations under Part IIA of the Environmental Protection Act 1990. Where joint competent authority status exists, risk rating may be used to determine the division of workload, e.g. between HSE and Agency in reviewing COMAH safety reports. The potential exists for simple risk rating and resource planning systems in any areas where risks exist and relative priorities need to be defined. Similar tools already exist in certain areas, for example, the water resource management screening tool used to identify priority surface waters. The "rapid risk assessment tool" was developed to assess the adequacy of measures to prevent pollution to surface waters. Risk rating may be a useful means of establishing risk-based monitoring programmes and could inform the basis for setting river stretches for biological and water quality classification.

Much of this document has considered reducing risk after permission to discharge or operate has been granted. However, it may also be desirable to consider risk-based approaches to assessing the Agency's effort in *authorising* a process, operation, development or facility. For example, in determining appropriate techniques or conditions, or in contributing to consultations under the planning system, or by identifying environmental sensitivities in connection with natural heritage designations. The tightening of conditions in the permission, or insisting on different techniques when carrying out the process, may be very effective. They have the added advantage of ensuring that the operator bears part of the cost of risk reduction. Similarly, increased involvement in the development stage of projects through the planning system may produce significant risk reductions at relatively low cost.

6. DEVELOPMENT AND IMPLEMENTATION OF SYSTEMS

Responsibilities for development and implementation need to be carefully defined and agreed internally. National implementation of the systems and gathering and interpretation of results will require technical assistance from NCRAOA, other National Centres and the EP functions.

Regional and Area managers use the results to ensure consistency across their regions and areas. Inspectors have responsibility for scores in their allocated sites.

6.1 The development of risk rating tools for the functions can progress in parallel or sequentially using one template. For consistency, the latter is preferable, although in practice the former is required in order to make good progress. This heightens the importance of following guidance and possibly using staff with previous experience in the development of new systems. A stepwise approach to development and implementation is advised based on preliminary testing, consultation and review before extending to different application areas. It is important to develop, test and gather data from the risk rating system before applying it in resource planning. A controlled process of review and improvement forms part of this stepwise process (e.g. annual review and modification of system). It is essential that refinement of the risk rating and resource planning system be allowed, based on a review of the results generated by the existing system. This may identify limitations in the system, which require improved guidance or other refinements.

Consultation, both with industry and inspectors, was carried out exhaustively for PIR OPRA. The system is more robust and accepted as a result of this effort. Consultation should be built into any project to develop such a system. This is consistent with the Agency's intention to be open and consult with stakeholders. Consultation works well when it is planned and deadlines set for comments and revisions.

Training will be required for inspectors and may be desirable for operators. Training should consist of both background and theory sessions, and practical sessions where inspectors work on case studies to generate risk rating scores both individually and in groups. The spread of results provides feedback on areas where guidance needs to be improved. Training should also cover the "why, when and how" aspects of employing the system, for example by demonstrating the procedures for use and indicating how long the assessment should take. Training of all inspectors should be carried out within a short timeframe and before the first official version of the system is finalised/published.

The amount of effort required in using the system needs to be considered and compared against the benefits of the system. While ratings systems are inherently simple and take little time to apply, one view has been that operation of a risk-rating system represents an additional burden. Some inspectors have also been concerned that such systems reduce regulation to a "checklist" approach, which potentially replaces or trivializes serious inspection. The key lessons for resource issues are illustrated in Table 7.

1	*Risk rating supports inspection and other regulatory activity – it does not replace these*
2	*Cost-benefit analysis of risk rating systems should indicate significant net benefit by targeting limited resource*
3	*Application of risk rating is always a short duration task; more comprehensive studies are separate exercises*
4	*Argument with operators is restricted by the procedures and review process – the inspector owns the scores*
5	*Frequency of updating risk rating scores is dictated by variability in site conditions and flexibility of resource planning*

Table 7: Resourcing Issues

Regulatory Procedures define practical issues such as when and how to apply a risk rating system. The PIR version contains definitions of when the inspector should consider carrying out an assessment. In addition, procedures define the process for completing and passing on information, informing the operator and allowing further comments, revision of scores, etc. Different functions will specify baseline frequencies for carrying out or updating risk rating exercises. For example, the waste version requires scores to be updated on a quarterly basis. Water quality proposes to carry out scores on an annual basis.

When to carry out an assessment of performance attributes	***When to carry out an assessment of hazard attributes***
At agreed de minimus frequency	*At agreed de minimus frequency*
New information comes to light potentially affecting scores	*Upon reauthorization*
Change of management	*Major variations resulting in changes to physical process*
In the event of an incident	*When new technology or information becomes available*
Any other reason stated by the inspector	*If there is a change to the receiving environment*
	Any other reason stated by the inspector

Table 8: Triggers for Attribute Re-appraisal

Trials and calibration should be carried out as part of the testing and development of the system. The primary purpose is to check consistency and reproducibility of scores, to eliminate anomalies and to identify improvements to the system. Calibration is aimed primarily at ensuring consistency at a national level, although it is clear that a degree of operational calibration may occur at area or regional levels. Both for intra- and inter- function planning and for actual risk scores, it is worth reviewing the results of the models to see if they reflect the Agency's expectations and priorities. Calibration of results will include modification of individual scores to calibrate with other scores for similar, e.g. to avoid inconsistencies from one region to another. However it is important to check why an apparently inconsistent score has been given, because this may be due to a site-specific factor. This is where the reason for giving a score is just as important as the score itself. Calibration of risk scores against actual performance, e.g. incident records or monitoring results, may also be possible, in order to target resources towards actual low performance. This in principle may be achieved by including actual performance as an attribute and using a suitable weighting factor for this attribute.

7. CONCLUSIONS AND RECOMMENDATIONS

Risk-rating systems are one mechanism for comparing risks across a number of operations. The adoption of a scoring system allows the assessor to separate risk according to its principal components (or attributes) but must be undertaken with care. Use of risk-rating systems in the Environment Agency has to date been confined to risk-based inspections for process industry and waste regulation, but a drive towards risk-based regulation as a whole presents an opportunity to extend their application to other areas. In the interests of consistency, this guidance should be followed in the design or development of schemes.

For the purposes of consistency, it is essential that all risk-rating systems incorporate the generic risk factors in Table 1. For the benefit of informing the resource planning process, it is also important to identify which factors are within the control of the developer, discharger or operator or regulator, and which factors are less amenable to alteration, post-authorisation.

The numerical expression of risk carries with it certain difficulties. The central one is what the numbers actually represent and the extent to which numbers accurately distinguish between different risks. Risk rating systems use subjective scales and generalised scoring systems. A general rule for their design is that systems for ranking or quantifying risk need be no more complex than is required to undertake the distinction between risks. The simple objective of providing a numerical, as opposed to a qualitative expression is to allow prioritisation. Given these caveats, the output of such systems are best "banded" into varying degrees of risk.

It is recommended that each function within EP continue to develop and implement its own function-specific system, using this guidance to work towards a common approach. Implementation of IPPC may provide an opportunity for harmonisation and consideration of "read across" issues.

It is recommended the development of risk-based resource planning systems be dovetailed with other related initiatives in the Agency, notably the Priority Planning Exercise (PPE). Functions should consider how best to equip operational managers and staff with the skills to deliver risk-based resource management throughout the organisation.

It is important to consider the resource implications of introducing risk-based resource planning systems and to design and implement these with the objective of minimising the time and effort required to run such systems.

In acknowledgement of the Board's approval of NCRAOA's corporate lead in risk assessment, risk-rating systems should be developed in consultation with the National Centre for Risk Analysis and Options Appraisal (NCRAOA).