

**A STRATEGIC APPROACH TO THE
CONSIDERATION OF ENVIRONMENTAL
HARM**

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Report Number 36

June 2000

Title: A Strategic Approach to the Consideration of Environmental Harm		Report Number: 36
		Version: Final
		Issue Date: June 2000
Approval J. Irwin	Signature <i>JJ Irwin</i>	Date June 2000
Distribution: Internal, External, restricted		

ENVIRONMENT AGENCY



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EXECUTIVE SUMMARY

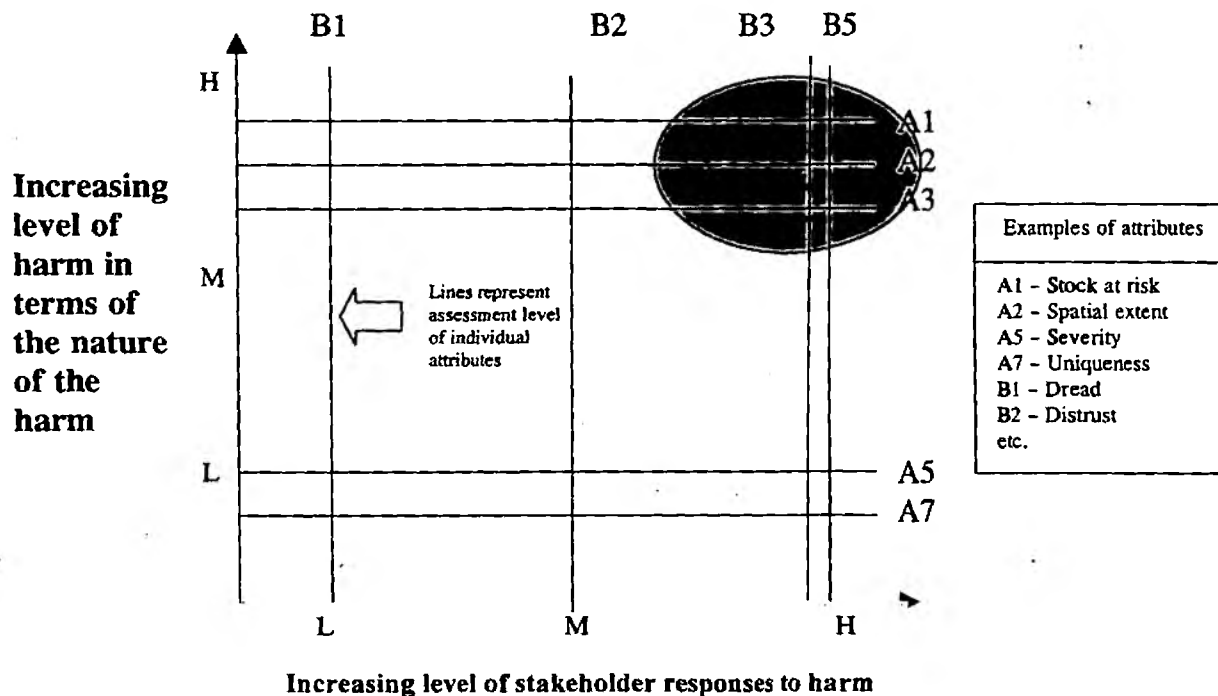
The Environment Agency's principal aim is to contribute to the goal of sustainable development. In working at the strategic level, a cyclical environmental management approach has been developed, as described in the Agency's Environmental Strategy. A key component of the approach is the consideration of 'risks and values'; this involves considering actual or potential environmental harm posed by various activities or natural pressures alongside the values society places on the components of the environment at risk. A central challenge to the practical application of a 'risks and values' framework is to develop an understanding of "environmental harm" that allows consideration of (a) the physical detriment to the environment; (b) the economic loss; and (c) the societal loss of value, within a single framework.

The National Centre for Risk Analysis and Options Appraisal (NCRAOA) and the Environmental Strategy Directorate have recently developed a qualitative framework for the prioritisation of environmental issues that highlights their multivariate nature and may facilitate comparison across different environmental pressures. Progress to date is presented in this Technical Report. It is essential, however, that its viability is thoroughly tested in an operational and strategic setting. Once a robust harm framework is developed, it should provide the Agency with a coarse, but defensible, prioritisation tool to assist in the screening of Area, Regional and National priorities.

This report has drawn on the work of the Environment Agency's predecessors in this area as well as from others working in the field of strategic risk assessment. The document is not intended as a substitute for technical assessments at the site-specific level or to replace the use of environmental standards as a means of assessing damage to the environment.

The approach involves capturing the key characteristics of environmental harm (magnitude, reversibility, spatial and temporal extent, latency etc.) using key words, or 'attributes', with meaning in a technical and socio-economic context. The various attributes may be grouped and represented graphically (as shown overleaf), so as to describe what we know collectively about the harm and the stakeholder reactions to it. Each of the attributes is presented on a qualitative scale so that attributes that have been plotted in the shaded area of the Figure will cause the highest overall impact in terms of the nature of the harm and/or the perception of that harm.

Graphical Representation of the Attributes of Harm



Keywords: Environmental harm, detriment, impact

Links to Agency Duties and Powers: Multivariate, addressed in text

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Status: Internal, External, Restricted

Acknowledgements: The NCRAOA acknowledge the valuable contribution of Gareth Llewelyn (Entec UK limited) and John Steele (RPS Clouston) as well as those of all those who took part in the workshops

Harm workshop, Heythrop Park, Oxfordshire, 30 June - 1 July 1999: Danielle Ashton, Nicky Ayscough (WRc-NSF Ltd), Chris Birks, Raquel Duarte- Davidson, Jonathan Fisher, Sue Herbert, Ashley Holt, Tom Horlick-Jones (University of Surrey), Richard Howell, Jimi Irwin, Ray Kemp (University of Surrey), James McTernan (SEPA), Daniel Osborn (ITE), Simon Pollard, Bob Smith, Clare Twigger-Ross, Jeroen Warner (Flood Hazard Research Centre), Neil Weatherley, Paul Whitehouse (WRc-NSF Ltd), Emma Wraige and Roger Yearsley.

Harm Workshop for State of the Environment Prioritisation, Steel House, London, 28 October 1999: Dan Archard, Rachel Brown, Raquel Duarte-Davidson, Jonathan Fisher, Jimi Irwin, Jane Kinneburgh, Linda Pope, John Seager, Clare Twigger-Ross, Ann Watts, Neil Weatherley, Anthony Williamson and Robert Willows.

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1. INTRODUCTION

1.1 Purpose, Scope and Audience

The Environment Agency's principal aim is to contribute to the goal of sustainable development. In working at the strategic level, a cyclical environmental management approach has been developed, adapted from the OECD 'pressure-state-response model' as described in the Agency's Environmental Strategy (Environment Agency, 2000a). A key component of the approach is the consideration of 'risks and values'; this involves considering actual or potential environmental harm posed by various activities or natural pressures alongside the values society places on the components of the environment at risk (Environment Agency, 2000b). A central challenge to the practical application of a 'risks and values' framework is to develop an understanding of environmental harm that allows a consideration of (a) the physical detriment to the environment; (b) the economic loss; and (c) the societal loss of value, within a single framework.

The purpose of this Technical Report is to present the Environment Agency's developing approach to the consideration of 'environmental harm'. This document should be of value as a decision-making tool for senior managers charged with prioritising environmental issues at the strategic level. As such, the Technical Report has drawn on the work of the Environment Agency's predecessors in this area as well as from others working in the field of strategic risk assessment. The document is not intended as a substitute for technical assessments at the site-specific level or to replace the use of environmental standards as a means of assessing damage to the environment.

1.2 Background and Business Impact

Harm to the environment is conventionally assessed by reference to the magnitude of the impact, often by reference to the exceedence, or otherwise, of environmental standards in air, water, soil and biota. However, the use of standards as surrogates for harm does not account for other important characteristics of the damage such as delayed onset, irreversibility and spatial or temporal extent. Neither do they necessarily account for the economic or social values society places on different components of the environment. These broader aspects are critical to strategic decision-making and become particularly important when prioritising issues at the area, regional, national or international scale.

The Agency and its predecessor bodies have long recognised the need for a strategic framework for considering the multidisciplinary aspects of environmental harm. This is highlighted by various pieces of work undertaken in recent years that have aimed to tackle the issue of environmental harm in a variety of decision-making contexts (see for example, DETR, 1998 and 1999, SEPA, 1998 and Environment Agency, 1999).

The National Centre for Risk Analysis and Options Appraisal (NCRAOA) and the Environmental Strategy Directorate have recently developed a qualitative framework for the prioritisation of environmental issues that highlights its multivariate nature and may enable comparability across different environmental pressures. Progress to date is presented in this

document. It is essential, however, that its viability is thoroughly tested in an operational and strategic setting. In order to progress this work, the Environment Agency is currently continuing its work on strategic risk assessment with a view to testing this framework in different case studies. Once a robust harm framework is developed, it should provide senior managers in the Agency with a coarse, but defensible, prioritisation tool to assist in the screening of Area, Regional and National priorities. It may, for example, assist in:

- preparing a defensible Agency response to the issues raised by State of the Environment Reports;
- the development of Local and Regional Environment Agency Plans (LEAPs and REAPs);
- providing input to the Environment Agency's response to the strategic plans of Regional Development Agencies, Unitary and Local Authorities; and
- supporting the prioritisation of issues in response to government Comprehensive Spending Reviews.

1.3 Structure

The structure of this Technical Report follows the chronology of the Environment Agency's developments in this area of work. Following this introduction, Section 2 presents a brief review and summary of some of the approaches developed in recent years; this is followed by a description of the Agency's approach (Section 3). Finally, Section 4 presents the conclusions drawn from this work which are key in progressing future developments in this field.

This report is a summary of progress to date and has benefited from a number of related activities and inputs, most notably:

- the Environment Agency's R&D project on Strategic Risk Assessment (Environment Agency, 1999);
- a two day workshop on 'Environmental Harm', held at Heythrop Park in July 1999, co-ordinated by the NCRAOA;
- discussions within the Environmental Strategy Directorate on the "State of the Environment" reporting; and
- the ongoing work programme of the NCRAOA.

Where appropriate, the reader is referred to other outputs from the Environment Agency that support this work.

2. REVIEW OF APPROACHES TO ENVIRONMENTAL HARM

2.1 Characterising Environmental Risks

A central problem when prioritising environment issues is the characterisation of risk, and specifically, attributing a level of significance to the probability and consequence of an adverse environmental impact. In particular, the value placed on the component at risk needs to be considered when assessing the significance of harm to the environment. That is, the significance of the harm must take into account the severity of the physical harm and the loss in economic and societal value that results from the damage.

At the strategic level, where data are often either sparse because the consequences may not be well understood, or conversely, too voluminous and focussed at the specific rather than the strategic level, 'coarse' assessments of probability and consequence are required to inform strategic decisions and prioritise regulatory effort. Here a broader view of the characteristics of harm is required that extends beyond the magnitude of the harm (e.g. the severity of a derogation in the quality of a potable water supply relative to a drinking water standard). This may include characteristics such as the irreversibility of the harm (e.g. whether the supply can recover), the delay in onset (when, in time, the derogation will start) or the spatial extent of the harm. These are important attributes of harm that are not dealt with by numerical environmental quality standards, yet they play an important part in determining the response to the potential or observed damage.

2.2 From Environmental Standards to Attributes of Harm

The adoption of standards has served regulators well in so far as it has provided clarity for the regulated community as to what environmental levels are considered acceptable in different environmental media. However, their derivation and adoption are surrounded by difficulties, as highlighted by the Royal Commission on Environmental Pollution (RCEP, 1998).

The use of standards to act as surrogates for environmental harm has, arguably, led to an implicit assumption that any exceedence of the standard will result in detriment. This is clearly not necessarily the case because the derivation of the standard involves 'margins of safety' in the form of uncertainty factors that may act in a precautionary fashion. In addition, if a standard is to be achieved in practice, it is important to take account of the cost of attaining the standard as well as the significance of the harm and the opportunities for reducing it. Standards are based on legislative/statutory requirements; the significance of harm; the regulator's discretionary options to reduce them, their technical feasibility and their costs; and environmental, social and economic implications.

Two particular situations bring the limitations of the current standard-based approach to the fore:

- Managing harm from low probability, high consequence events often requires an understanding of the characteristics of harm beyond its potential magnitude so that good contingency measures can be set in place, should the consequences be realised.
- At a strategic level, the comparison of risks is problematic because there is no accepted way of comparing the harm from say, flood damage to the contamination of soils, or from damage to a protected species to harm to an important aquifer. A purely technical approach often proves too restrictive, and monetisation, in isolation, fails to capture aspects of harm beyond an account of the 'stock at risk'. These difficulties are often encountered when prioritising seemingly disparate risks.

The above problems are well recognised and various attempts have been made to address them. Many approaches have proposed a core set of attributes of harm and have then attempted to develop qualitative or quantitative assessment criteria to assist in assessing the significance of each attribute. Sections 2.3 and 2.4 summarise a number of approaches that have been developed in the UK and elsewhere. Some of the common difficulties encountered include:

- providing clear definitions for the attributes of harm;
- the role and value of quantitative criteria for individual attributes;
- the applicability of attributes, such as irreversibility and latency, in the socio-economic context;
- the role of expert opinion and judgement in characterising harm according to the core attributes of harm; and
- reducing the complexity of environmental harm to a simple framework with broad applicability across the wide range of environmental impacts.

2.3 International Approaches to Strategic Risk Assessment

2.3.1 The German Advisory Council on Global Change

The German Advisory Council on Global Change (WGBU) has produced a broad classification of global environmental risks (WGBU, 1998). As part of this process a number of harm attributes were identified, which are considered of value for the methodology being developed here. The WGBU approach is briefly summarised in Box 1 and Figure 2.1.

This approach was considered the most appropriate for the development of the attributes of harm and the potential range of consequences arising and has therefore been taken forward by the NCRAOA as a workable framework.

2.3.2 The USEPA's approach to ranking ecological risks

Box 2 presents a brief summary of a semi-quantitative approach currently under development by the US EPA's Scientific Advisory Board who has established a sub-committee with the purpose of addressing risks to ecological systems (SAB, 1999).

Box 1: The German Advisory Council on Global Change (WGBU)

Problem Statement: Given the great number of risks inherent in global change, a systematic and strategic approach needs to be developed so that these can be estimated accurately and managed effectively.

Key Features of Approach: This approach relates a qualitative classification of global risks (e.g. risks of climate change, biodiversity loss, soil degradation, or issues associated with population growth or migration) to preferred risk management strategies. This is done by producing a categorisation of global risks linking the probability of the effects, the characteristics of the effects and the uncertainties in both, to regulatory responses for their management. The approach considers wider aspects of harm by having an attribute to measure social values (see below).

This can be illustrated graphically by plotting the probability of occurrence of a range of risks against the potential damage arising from such risks (Figure 2.1). In Figure 2.1 the normal area corresponds to an acceptable level of risk and the intermediate area is broadly comparable to the 'As Low as Reasonably Practicable' (ALARP) principle.

Application: This approach has been developed to influence the debate on global change at a strategic level and to devise national and international strategies for managing such change by

- identifying a taxonomy of globally relevant risks and highlighting the particularly relevant classes of risk; and
- linking both established and innovative risk assessment strategies and corresponding risk management to these classes, in order to define management priorities.

Attributes of harm: The Advisory Council provided a practical qualitative approach to relating the attributes of harm to the potential consequences or damage. This was designed to take into account probability of damage occurring and the certainty in an assessment of the probability of occurrence. The key attributes considered were as follows: the extent of damage, certainty in the assessment of the extent of damage, reversibility (defined as restoration potential), persistence (restoration rate), ubiquity (contaminants spread worldwide), delay effect and social and political mobilisation (severe conflict and dread among the general population).

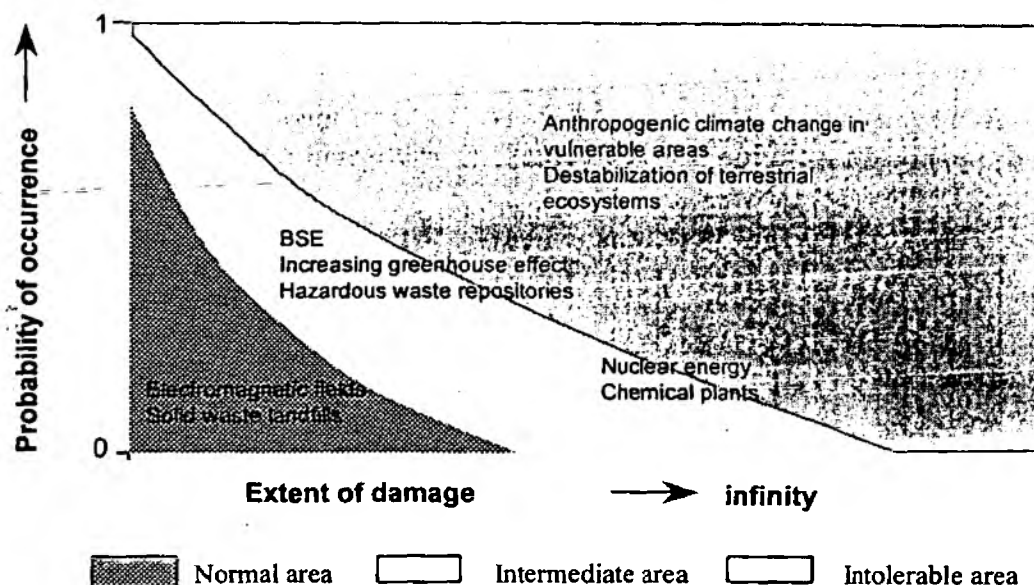


Figure 2.1: Classification devised by the German Council on Global Change

Box 2: The USEPA Approach to Ranking Ecological Risks

Problem Statement: Can an improved methodology be developed that compares and ranks the relative importance of various ecological risks?

Key Features of Approach: The approach addresses all types of ecological stressors: physical (e.g. climate change, fishing), chemical (e.g. air pollutants, persistent toxic organics) and biological (GMOs, waterborne microbes) affecting the important end-points (receptors) of ecological systems (e.g. forests, marine ecosystems). This requires consideration of the ecological stress (i.e. exposure regime) and the response (i.e. ecological effect) for each stressor. The approach is semi-quantitative and ecological risks can be ranked at the national, regional and local level. The outcome is a risk score for each stressor; stressors with similar levels of risk (i.e. similar scores) can be identified and classified into qualitative risk categories (e.g. high, medium and low relative risks).

Application: To be able to rank stressors into different categories to determine which are likely to represent a higher risk to various ecosystems in the United States at a local, regional and national scale. This information can be used by the USEPA and others regulatory and resource management agencies to reduce risks to ecological systems. It also allows for prioritisation of stressors that have been associated as posing the greatest risks to ecosystems.

Attributes of harm: Proportion of resource at risk, existence of 'hot spots', recovery potential, duration of stress effects, secondary stress induction, species depletion potential and special ecological significance.

2.4 National Approaches to Strategic Risk Assessment

2.4.1 Criteria for the Management of Unplanned Releases to the Aquatic Environment

The DETR (formerly Department of the Environment) commissioned AEA Technology to conduct a research programme to develop a practical and simple approach that may assist operators and regulators in screening and prioritising the management of risks to the natural environment (DETR, 1998). A brief summary of this approach is provided in Box 3. This approach is a useful attempt at quantifying the problem of relative environmental harm. Drawbacks include the applicability of the selection of a defensible "Reference

Accident" to a wider range of situations and the fact that only the aquatic environment is considered (i.e. no consideration is given to the terrestrial environment).

Box 3: DETR's Criteria for the Management of Unplanned Releases to the Aquatic Environment

Problem Statement: Can environmental risk criteria assist in the management of risks from accidental releases of hazardous substances to the aquatic environment?

Key Features of Approach: This approach uses three components of harm (see below) which have been associated with the consequences of an accident determining the harm from that event. These components of harm are normalised and then multiplied together to estimate an "Environmental Harm Index" (EHI) as shown below.

$$\text{EHI} = \frac{\text{Severity of effect in ecosystem}}{\text{Reference severity}} \times \frac{\text{Size of ecosystem affected}}{\text{Reference size}} \times \frac{\text{Time of ecosystem affected}}{\text{Reference time}}$$

The EHI is based on a "Reference Accident" concept, defined as an accident which has a significant impact on the environment. By plotting EHI values against annual frequency of accidents at a site, it is possible to identify broad areas of concern which are consistent with the German Scientific Advisory Council's approach illustrated in Figure 2.1. Although this approach focuses on ecological impacts only, it does recognise that other measures of harm such as financial considerations are of value in any risk management system.

Application: This approach is a useful attempt at quantifying the problem of relative environmental harm. It was developed to assist operators and regulators in screening and prioritising the management of risks to the natural environment.

Attributes of harm: severity (degree of harm, based on toxicity data and exposure time), size (extent of the harm) and time (defined as the timescale associated with the harm).

2.4.2 Assessment of harm to the environment following a major accident

The Institute for Terrestrial Ecology (ITE) have developed an approach on behalf of the DETR to define harm in terms of what constitutes a major accident to the environment (DETR, 1999; see Box 4). Although raised in the context of a major accident, some or all of these issues could equally apply to the impact of long-term discharges. Consequently, this approach provides some useful discussion on severity of impact which adds further considerations to the definition of harm being developed here.

Box 4: ITE's Assessment of Harm to the Environment Following a Major Accident

Problem Statement: Can numerical criteria be developed that adequately address harm to the biological environment following a major accident?

Key Features of Approach: A numerical criteria and associated thresholds were set out to address harm to the biological environment following a major accident. The severity of impact is considered only in terms of a major accident, which may result in persistent, extensive contamination; widespread damage to terrestrial fauna and flora; major effects on amenity sites; crop contamination; and a requirement for extensive clean-up measures.

Application: To provide guidance to regulators with respect to the interpretation of major accidents to the environment for the purposes of complying with the Control of Major Accident Hazards (COMAH) Regulations.

Attributes of Harm: The following criteria are used for addressing harm in the environment:

- ecosystem vulnerability (in terms of susceptibility to perturbation and fragility);
- potential effects arising (this term includes immediate and delayed effects as well as the habitat vulnerability/area affected);
- resource evaluation (ecological and socio-economic);
- scale of damage (in terms of resource variability and local scarcity);
- indirect damage;
- persistence of effects;
- the timing of the damage;
- population/habitat relationships and the extent of such damage; and
- recovery after environmental damage.

2.4.3 Strategic risk assessment ranking tool, phase I

A strategic semi-quantitative risk assessment ranking tool has been developed by the Environment Agency with assistance from RPS Clouston (Environment Agency, 1999) which includes a broader description of environmental harm. This was developed to address environmental impacts from different sources at the local, regional and national level. Details of this methodology are provided in Box 5 and Table 2.1.

Box 5: The Environment Agency's Strategic Risk Assessment

Problem Statement: Is it possible to identify key relationships that can be used to map different environmental impacts from a range of human and natural activities by reference to the *characteristics* of environmental harm?

Key Features of Approach: Following an initial feasibility study, a simple ranking system was developed using 'look up' tables, populated with elicited criteria for what were regarded as the key attributes of harm (see below). Indices were then ranked and scored as shown in Table 2.1 with the shaded areas indicating areas of unacceptable harm. A spreadsheet was then used to compute a normalised 'harm index' for each hazard-receptor combination, by estimating 'harm' as:

$\sqrt{[H^2 + R^2 + (T1 + T2)^2]}$ (See Attributes of Harm below for definitions.)

Application: A structured approach should provide a framework for improved objective setting, prioritisation and monitoring. The tool was piloted by the Environment Agency to provide a scaled ranking of issues and allow for meaningful comparisons and the prioritisation across a range of geographical scales (e.g. between and within regions). This approach may be used, for example, to help develop Local Environment Agency Plan (LEAPs are catchment-based local environmental strategies) or to prioritise issues within the Agency's "State of the Environment Reports" (which provide a national, strategic overview).

Attributes of Harm:

- the potential scale of the effect (H); ranging, for chemical contamination, from 'presence without overt effect' (low) to effects at the community level with 'long-term irreversible effects' (severe);
- the persistence of the hazard (acute to chronic relative to receptor life-time; T1) and reversibility of impact with respect to each receptor and/or media (readily to irreversible; T2); and
- the potential status of the receptor (R); sensitivity in terms of local, national or international designation.

Table 2.1: Severity Matrix for Ranking Environmental Harm

Criteria	Severity rank (and scores)			
H	Low (1)	Medium (2)	High (4)	Severe (8)
R	Low (1)	Medium (2)	High (3)	Severe (4)
T1	Acute (1)	Short-term (2)	Medium-term (3)	Chronic (4)
T2	Readily reversible (1)	Medium-term (2)	Long-term (3)	Irreversible (4)

2.5 Summary of the attributes of harm used by the different approaches

Table 2.2 presents a summary of the key attributes of harm used by the various approaches presented in this section. These attributes are defined in section 3 below. Please note that different approaches have used different attributes of harm and different definitions for these and as such they may not fit accurately into the classification presented here. Therefore, Table 2.2 is presented for illustrative purposes only. The purpose of this exercise is to develop the NCRAOA's approach further, rather than to discuss whether other classifications accurately fit the description provided in Section 3.

Table 2.2: Attributes of Harm Used by Different Approaches

Attribute	WGBU (1998)	USEPA (1999)	DETR (1998)	DETR (1999)	Environment Agency (1999)	NCRAOA (1)
Stock at risk	√	√	√	√	√	√
Spatial extent		√	√	√		√
Heterogeneity	√	√				√
Temporal extent	√	√	√	√	√	√
Severity	√	√	√	√	√	√
Reversibility	√	√		√	√	√
Uniqueness		√		√	√	√
Knock-on effects		√		√		√
Uncertainty	√					
Dread						√
Distrust						√
Equity						√
Imposition						√
Familiarity						√
Mobilisation potential	√					

(1) This Report

3. AN ENVIRONMENT AGENCY APPROACH

3.1 Description of the Approach

The Environment Agency has adopted an approach to considering environmental harm adapted from the German Council on Global Change but informed by the work of the Agency predecessors.

The approach involves capturing the key characteristics of environmental harm (magnitude, reversibility, spatial and temporal extent, latency etc.) using key words, or 'attributes', with meaning in a technical and socio-economic context. In the first instance, risk analysts from the NCRAOA considered attributes of harm and reviewed a number of candidate interpretations from the literature with the objective of forming a view on the value of the different approaches considered (Section 2). An initial set of attributes were developed and tested on an operational issue; a proposed extension to a domestic landfill which in the future may take special waste, but which was situated above a groundwater source protection zone.

This information was then presented to Agency colleagues to obtain feedback from a wider audience to include inputs from technical, social and economic expertise, with a view to drawing up a list of attributes of harm that would allow for technical, social and economic impact. Following on, a workshop was held¹ for the purpose of eliciting feedback from others in the Environment Agency as well as experts actively involved in this field. Based

¹ Environment Agency's workshop on "Environmental Harm", held at Heythrop Park, Oxfordshire, 29 June – 1 July 1999

on discussions held at the workshop the attributes were reassessed and a consensus reached on a core set of attributes (Duarte-Davidson *et al.*, 1999). These attributes were further refined following an internal workshop using the Environment Agency's State of the Environment Report as a case study for prioritising issues at the strategic level². Planned R&D work³ will now test this approach on a number of operational and strategic issues to consider further its usefulness as a qualitative tool for considering harm.

In summary, an iterative approach has been adopted which involves the following:

- identifying harm attributes;
- describing/defining attributes;
- classifying attributes in terms of applicability to technical, social and economic concerns (recognising these are not independent);
- providing examples of each; and
- qualitatively defining the potential scale of damage (low/intermediate/high).

The attributes of harm are presented in Tables 3.1 and 3.2. For each attribute a description, a qualitative scale and examples are provided. The list of attributes has been divided into those that 'objectively' describe the nature of the harm (what we know about the harm; Table 3.1) and those that describe 'subjectively' stakeholder reactions to 'harm' (i.e. how we feel about the harm; Table 3.2). Table 3.3 shows the potential scale of damage for each attribute. At this stage of development, a qualitative approach has been developed in the recognition that a greater understanding of the approach and the interactions between attributes would be required before any weighting system could be adopted.

One way of integrating the various attributes may be to consider them graphically, by plotting the attributes that describe what we know about the harm on the vertical axis and those that describe stakeholder reactions to 'harm' on the horizontal axis (Figure 3.1). Each of the attributes is scored on a qualitative scale (Table 3.3) so that attributes that have been plotted in the shaded area of Figure 3.1 will cause the highest overall impact in terms of the nature of the harm and/or the perception of that harm. This sort of approach can be used in decision-making to target the impacts which are causing the greatest technical and/or socio-economic concern.

² Harm Workshop for State of the Environment Prioritisation, Steel House, London 28 October 1999.

³ Strategic Risk Assessment, Phase 2: Development of Environmental Harm Framework. Environment Agency R&D Project E2-041

Table 3.1: "Objective" Attributes of Harm

Harm Attribute	Description	Examples
A1 Stock at risk	This term refers to how many people might be affected/ how much of a particular environment might be damaged/lost	Number of people affected / value of the stock (in financial terms)
A2 Spatial extent	Distribution of harm in geographical space	Harm may affect a localised area (e.g. siting of an industrial plant, incinerator or landfill site close to housing state or valuable ecological site) or could have widespread implications (e.g. global harm such as effects from climate change)
A3 Heterogeneity	Distribution of harm manifest. Some impacts may affect a wide geographic space but only certain communities/ receptors in that space	Acid rain deposition may cause harm at a number of localised sites even though the spatial extent of deposition may be more widespread (e.g. within a region). Radioactive deposition from Chernobyl was widespread, but in economic terms only localised farming areas were affected.
A4 Temporal extent	This describes the period over which harm occurs	The impact of a release may be short if a pollutant is readily degradable but much longer term for non-degradable (persistent) pollutants. Duration of an illness will affect the monetary value placed on the loss of quality of life of an individual (e.g. a higher monetary value will be given to an illness which causes a lingering death whilst a lower value will be placed on sudden death. This attribute includes <i>latency</i> so, for example, damage which becomes evident only after a period of time (e.g. asbestosis, cancer) would attract a high rating for this attribute.
A5 Severity of effect	Magnitude of damage to the receptor	Discomfort or irritation are less severe effects than death from cancer; this is reflected in the value given in economic terms as well as by the greater social acceptability of less severe effects of harm. A catastrophic event would attract a high rating for this attribute. For example, Publics perception of BSE had catastrophic consequences on the agricultural economy
A6 Irreversibility	The extent to which damage can be rectified.	Harm to the natural environment from flooding is reversible over time Harm is considered irreversible in economic terms where the costs and difficulties of restoring the damage are excessive. This attribute is important when remediation options are being considered; an activity or event given rise to substantial harm may actually be easier to remediate than one causing more modest impacts.
A7 Uniqueness	Availability of environmental resources to substitute damaged resources	The extent of harm arising from loss of a site where the only example of a particular species exists might be considered greater (in both social and economic terms) than loss of a site inhabited by more common species. For example, the loss of an area of salt marsh might be environmentally more damaging than loss of an equal area of pine forest.
A8 Knock-on effects	A secondary, indirect effect caused by an initiating effect. Harm may be manifest in the technical arena but has "knock" on social and economic effects.	Loss on income by affected population group may have an impact on other population groups through reduced spending by that group. Loss of resources may restrict ability to deal effectively with the cause of harm e.g. a major nuclear accident might result in loss of agricultural land and possibly industrial sites thus restricting the economy of the affected area.

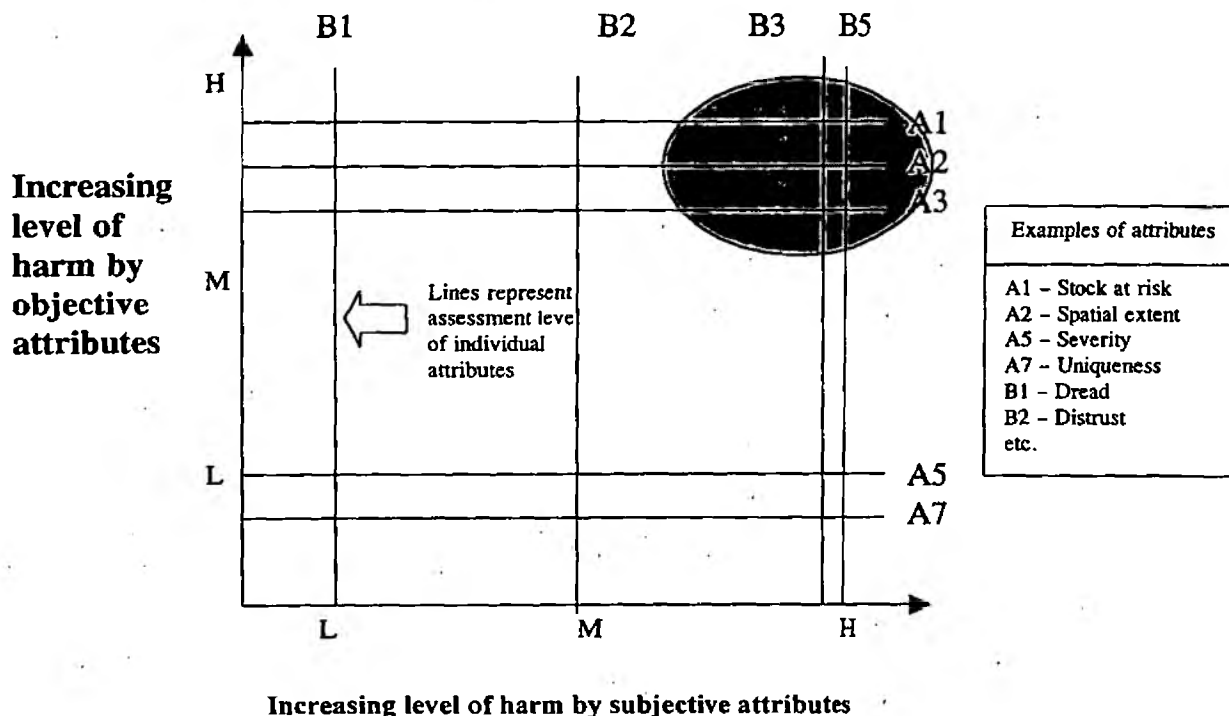
Table 3.2: "Subjective" Attributes of Harm

Harm Attribute	Description	Examples
B1 Dread	Fear of "harm"	There is a greater fear of cancer, relative to other sudden illnesses There is greater fear of death from a plane crash than from a car accident Greater fear of the nuclear industry than conventional chemical process plant.
B2 Distrust	Lack of trust of the characterisation of the impact by the messenger (e.g. scientist, politician).	
B3 Equity	Inequitably distributed – some benefit while others suffer the consequences (e.g. because they cannot meet costs)	Placing of a polluting factory near a deprived area – losses in economic terms (e.g. value of the land) may not be as significant relative to placing factory in land considered to be more value. Greenhouse gas emissions result in benefits to the present generation but may result in climate change which might harm future generations. Long-term effects in the Ukraine after Chernobyl .
B4 Imposition	Degree of personal control	There is greater aversion to harm that is outside our control and externally imposed on them. Smoking, rock climbing or knowingly living in a flood plain This factor has been used to adjust economic valuations of mortality risk reduction from one context (e.g. road accidents, cigarette smoking) to another (eg pollution hazards).
B5 Familiarity	Degree of knowledge and understanding of the harm	People are more comfortable with risks that they are familiar with (e.g. drinking alcohol) relative to novel risks such as the potential harm from exposure to genetically modified foods

Table 3.3: Qualitative framework for assessing attributes of harm

ATTRIBUTE	Low	SCALE Medium			High
A1 Stock at risk	None	Sensitivity in individuals			Sensitivity, general population/ environment
A2 Spatial extent	Point source	Local area	Region	National	International/ Global
A3 Heterogeneity	Single site		Multiple sites, regionally	Multiple sites, nationally	Widespread
A4 Temporal extent	Instant	Short/ Cyclical/ peak	Annual	Decades	Long-term to infinity; expanding over generations
A5 Severity of effect	No damage		Medium impact/ damage		High impact/ damage
A6 Reversibility	Reversible in short period/ Widespread resource and therefore less affected	Reversible in weeks	Reversible in years/ Widespread but replaceable resource	Reversible over decades	Irreversible/ unique resource and therefore irreplaceable
A7 Uniqueness	Widespread resource		Widespread but replaceable resource		Irreplaceable
A8 "Knock-on" effects	None		Indirect effects known reversibility/ad aptable		Interactions irreversible
B1 Dread	No obvious anxiety	Specific individuals affected		Groups of individual affected	Widespread
B2 Distrust	Acceptable	Tolerable, high degree of personal control/choice	Tolerable with respect to perceived benefit	Intolerable to some but a degree of personal control	Intolerable No degree of personal control
B3 Equity	Equality distributed		Few benefit/ few suffer		Majority benefit/ few suffer; few benefit / majority suffer
B4 Imposition	Voluntary		Avoided by taking personal precautions		Imposed
B5 Familiarity	Very familiar		Some degree of familiarity		Unfamiliar

Figure 3.1: Graphical Representation of Attributes



Representation of attributes as independent lines as opposed to co-ordinate positions represents independence of attributes. The shaded area (top right hand corner of figure) represents the overall assessment of harm according to the greatest concern in terms of both 'objective' (8) and 'subjective' (5) attributes.

3.2 Outcome from the workshop

The workshop confirmed the complexity of the subject and provided some valuable means of testing the fundamental premise for this work. Some questions raised for discussion at the workshop were:

- is the approach useful?
- is it applicable to the Environment Agency?
- is the approach clear and understandable to a technical and non-technical audience?
- is the list of 'attributes of harm' comprehensive (if not what attributes are missing)?
- are there any overlaps or cases where double counting would result?
- are the definitions clear and unambiguous?

Workshop delegates discussed the approach described above and considered various aspects of this framework. Below is a summary of the discussion on some of the themes that emerged during the workshop discussions.

- **'Harm' versus 'damage'.** It was suggested that 'harm' may be regarded as damage which cannot be reversed. The implication of such a definition is that we may be prepared to tolerate some damage but not irreversible harm. However, a more useful resolution emerged when reversibility was regarded as an 'attribute' of harm rather than something which is different to 'harm'. Nevertheless, there remains a question of how much harm can be tolerated and this is discussed in more detail below.

- **How much 'harm' is acceptable?** Amongst scientists there is no explicit acknowledgement of how much 'harm' is acceptable⁴. In standard-setting, protection objectives are usually unclear, and, even when these are explicitly defined (e.g. Dutch standard-setting schemes), the level of protection chosen (e.g. 95% of species exposed should be protected) is selected more on the basis of statistical considerations than on biological or social considerations. By definition, it could be argued that 'harm' is an unacceptable change. Ultimately, what is acceptable or not is a human value judgement. Although this obviously applies to issues that relate to human health and quality of life, it also extends to ecological considerations of harm as well. This is because, amongst other reasons, biological organisms cannot speak for themselves and there is no generally accepted technical basis for deciding what level of change is unacceptable (as this is a human value judgement).
- **What is subject to 'harm'?** The scope of what is meant by 'environmental harm' differed between delegates, at least initially. Delegates clearly recognised harm in terms of human health effects (e.g. air quality, livelihoods, or quality of life – for example access to the countryside). It was also clear that environmental harm should also include the protection of habitats and wildlife for its own sake, even if a direct effect on human welfare was unclear. In this respect, the protection of habitats and wildlife is similar to the protection of archaeological or architectural heritage. However, it was recognised that harm to the proper functioning of ecosystems could have a direct effect on human welfare and livelihoods (e.g. overfishing, deforestation, loss of botanical gene pool and associated potentially useful products).
- **Human responses to the threat of 'harm'.** There was general agreement that social changes would certainly be expected to result from cases of environmental change (e.g. a major house building programme). Whilst direct effects on the environment (e.g. loss of habitats) and quality of life (e.g. increased traffic noise) would be expected to result from such a programme, anxiety about these developments would be expected to precede them. It was generally accepted that this anxiety or dread was indeed an attribute of harm in its own right. It follows that 'harm' may result without any physical change to the environment.
- **Does 'harm' extend to the physical environment?** Whether or not changes to the physical environment constituted 'harm' was more contentious. Is the physical environment a receptor? Clearly, chemical contamination of the air would be regarded as 'harmful' but the 'harm' results from the biological effects of this contamination i.e. the receptor is a biological one. Nevertheless, protection against physical changes to the environment may be an effective (if precautionary) way of ensuring that other, more tangible, manifestations of 'harm' are prevented. A chemical analogy is the distinction between contamination and pollution. Current approaches to standard-setting imply that some degree of "contamination" above

⁴ In ecology, harm may be defined in terms of effects on the structure of biological communities (i.e. the number and diversity of species present) or the function of the supporting ecosystem (e.g. processes that define an ecosystem e.g. soil fertility, nutrient cycling). Rarely is this distinction explicit when standards are formulated.

background or nutritionally required levels (e.g. of water or soil) is allowable as standards are designed to prevent biological effects from occurring. A useful definition of pollution is the presence of toxic chemicals in toxic amounts. An approach that aims towards preventing chemical contamination would be highly restrictive and almost certainly impossible to comply with because it would amount to 'zero emissions'. The workshop failed to resolve this issue.

- The workshop participants agreed that harm should include effects on receptors which may be technically defined (e.g. human health, water quality, air quality, soil quality, ecosystems). In addition, it should also encompass harm as defined in social (e.g. the dread of harm) and/or economic (e.g. loss or impairment of economic resources) terms. A classification of attributes into technical (objective description of the nature of the harm) and those that describe how we feel (subjective description) was considered useful. This was an important outcome.
- In some circumstances, **beneficial changes** may result from human activities or natural occurrences (e.g. flooding may lead to increased population of certain waterfowl). In some circumstances, harm to one sector of the community or ecosystem may be balanced by benefits to another (flooding for example). However, it was agreed that 'harm' was concerned with only negative consequences and these were the subject of the workshop.
- **Scale of harm.** The scale over which harm might be expected to become manifest was raised as an issue. Some activities would be expected to result in very localised impacts (e.g. construction of a car park or factory), others may have more widespread effects (e.g. a national house building programme) whilst others may be truly pan-national (e.g. global warming, ozone depletion). It was not clear how this would be addressed when comparing the 'harm' resulting from an activity with entirely local effects and one where the resulting 'harm' is widespread.
- This in turn highlighted the issue that a unified framework may have little **impact on individual assessments**. For each individual assessment a sub-set of attributes of harm may be of greater relevance and may describe the harm more accurately, whilst consideration of all attributes may confuse rather than clarify what the key attributes of harm are. Although not fully resolved at the workshop, this was partly addressed by agreeing on some of the main attributes and by discussing the most appropriate means of presenting these. Further clarification should be obtained through testing this approach on individual case studies.

4 CONCLUSIONS AND FUTURE NEEDS

- Harm is a product of impact and receptor characteristics. As a result we can distinguish attributes that make a process, activity or development harmful and the receptor characteristics which give rise to the expression of harm.
- The classification of attributes into technical attributes and those describing how we feel is valuable. These latter categories describe the context in which harm is expressed.
- The approach developed has value as a coarse screening tool allowing assessment of various issues at a high level advisory role. For a regulatory role it needs further development, especially by working through case studies.
- It would be useful to develop a series of 'benchmark' scenarios for training and calibration purposes. A manual may be a means of achieving this.
- The development of indices for the two sets of attributes and ways in which they might be visualised requires consideration. This should include a consideration of the effects that a weighting scheme might have. Indeed, a weighting scheme might be developed empirically, to ensure that different scenarios give rise to contours that are intuitively correct.
- Socio-economic aspects need further consideration.

In general, the approach was thought to be potentially useful, but requires thorough testing using a number of case studies to improve and refine the framework. The diagram plotting 'what it is' against 'how we feel' was also thought to be useful, with potential for use in options appraisal.

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Version of 22 June 2000