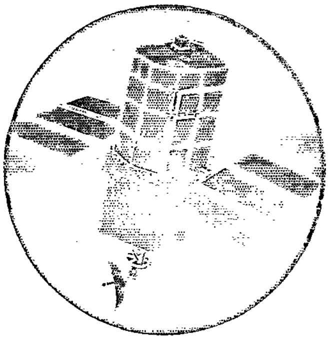
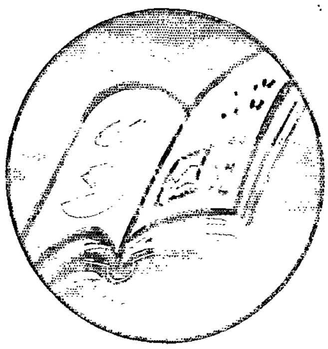
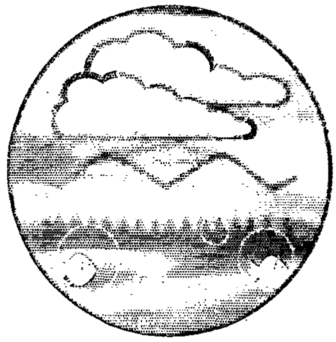
Strategic Risk Assessment: Further Developments and Trials







Research and Development

Project Record
E2-001/1

Environment Agency

Strategic Risk Assessment: Further Development and Trials

R&D Project Record E2-001/1

Research Contractor:

RPS Clouston

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Tel: 01454 624400 Fax: 01454 624409
ISBN 1 85705 184 X

Dissemination status
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Statement of Use
This Technical Report provides a strategic risk assessment methodology which can be used to enable the Agency to incorporate risk into its decision making at both a regional and strategic level. The method may be used with the assistance of the National Centre for Risk Analysis and Options Appraisal to prioritise issues in the LEAP process. The Project Record (E2-001/1) document is available for reference at Agency Libraries and includes the full background to the work.

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This document was produced under R & D Project E2-001:

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Preface

This Project Record (E2-001/1) contains the Appendices which support R&D Technical Report E70.

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APPENDICES

ENVIRONMENT AGENCY
R & D PROJECT

Strategic Risk Assessment
Stage 1 Report
Risk Assessment Model

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July 1997

CONTENTS

1. INTRODUCTION

1.1 General

The Environment Agency Act 1995 describes the duties and functions the Environment Agency will be expected to discharge. In protecting, maintaining and improving the environment, the Agency may wish to evaluate the severity of the risks, and the effects that these may have on the environment. In so doing, the Agency will have to operate at a series of levels from the site-specific assessment of risk, through the evaluation of risks at a regional scale, to the determination of national risk priorities. This will provide a sound basis from which to determine the relative importance of those issues, factors and activities facing the environment, and will result in greater confidence in setting environmental priorities.

1.2 Approach

It is the intention of the Environment Agency to be successful in introducing a strategic risk assessment approach where the resources required for practical implementation of the approach are sufficiently low to permit its use on a regular basis. Such an approach will ensure consistency in assessing risks across a range of environmental issues of decisions which are to be defensible.

2. OBJECTIVES

2.1 General

Reference 1 (Risk Assessment and Risk Management Portfolio, Chapter 5 - Strategic Risk Assessment, Part B - The Approach to Strategic Risk Assessment) refers to Primary Risk Indices and Risk Indices based on the Risk Expressions which must be addressed.

Based on the information referred to in each of these 'risk expressions', a measure of risk is to be assigned to each expression to assess the measure of risk of each Risk Index. The measures of risk of the risk indices are then rolled-up to assign a measure of risk to the Primary Risk Indices which set out the basis upon which the Strategic Risk Assessment approach will provide a Risk Priority for a given risk, effect and receptor as defined in the boundary conditions, see Reference 1.

2.2 Aim

This paper addresses the 'risk expressions' associated with the Risk Indices and the Primary Risk Indices referred to above, see Reference 1, and formalises a methodology that is robust and transparent to the User.

Due to the content and format in which Reference 1 is documented there is a requirement to examine the definition and content of the risk expressions and the structure in which these expressions have been structured to generate the Risk and Primary Risk Indices. Based on this examination, a proposed methodology is formalised in which the expressions (and indices) can be integrated into a flow diagram to which risk methods can be applied under various scenarios.

As the risk expressions refer to a diverse range of issues and dimensions e.g. harm occurrence, duration of source etc., there is a requirement to consolidate each risk expression and the dimensions in which it operates. In so doing, the various issues and dimensions will be normalised at the various stages of the analysis to enable the level of harm due to the effect of risks on each receptor to be quantified. The significance of the various risks on the different receptor types will be quantified in a similar manner.

The normalising factors for source and receptor risk expressions will be held in look-up tables. The normalising factors for **source risks** refer to the magnitude of the source i.e. the target value, above which the source is responsible for the environmental hazard, and the normalising factors for **receptor risks** refer to the tolerable number of receptors within the defined space and the period of time over which the receptors can be exposed to the environmental hazard without significant cause for concern.

2.3 Output

The aim of the analysis is to quantify the level of harm of each receptor above a tolerable level due to the associated environmental hazard(s) exceeding their target value. The results of the analysis are ranked with respect to their impact on the media as a whole and the frequency of the risk occurring.

3. MODEL

3.1 Methodology

The model for determining Risk Significance of a receptor against a particular hazard is based on the following methodology:

Step 1 - determine the **% of Space Exposed** to the Hazard (α_h)

$$\alpha_h = \frac{\{\text{Harm Space of one Source}\}_h \times \{\text{No. of Sources} > \text{Target Level}\}_h}{\{\text{Space}\}_h}$$

where:

Space = the area (or volume) of the environment under consideration

Harm Space of one Source = the area (or volume) of harm an average source generates in which the hazard is greater than a target level

No. of Sources > Target Level = the average number of sources which generate a hazard in excess of the target level

Step 2 - determine the **Period of Exposure** (β_h)

$$\beta_h = \{\text{Duration of Source}\}_h + \{\text{Shelf Life}\}_h$$

where:

Duration of Source = average length of time over which a source generates the hazard in excess of the target level

Shelf Life = average length of time in which a hazard will remain in excess of the target level once the source has ceased to generate the hazard

Step 3 - determine the **Number of Receptors Exposed to Hazard** (γ_{hr})

$$\gamma_{hr} = \alpha_h \times \{\text{No. of Receptors in Space}\}_{hr}$$

where:

No. of Receptors in Space = Estimated number of receptors in the area (or volume) of the environment under consideration

Step 4 - determine the **Level of Harm** (δ_{hr})

$$\delta_{hr} = \frac{\gamma_{hr} \times (\beta_h + \{\text{Recovery Time}\}_{hr}/2)}{\{\text{Tolerable Period}\}_{hr} \times \{\text{Tolerable No. of Receptors in Space}\}_{hr}}$$

where:

Recovery Time = Average length of time it takes the receptor type to return to a state of being uninfluenced by the hazard

Tolerable No. of Receptors in Space = Number of receptors that can be affected by the hazard without significant cause for concern

Tolerable Period = Estimated length of time under which the Tolerable Number of Receptors in space can be regarded as low priority

Step 5 - determine the **Risk Significance** (ε_{hr})

$$\varepsilon_{hr} = \delta_{hr} \times \{\text{Receptor Classification}\}_{hr} \times \{\text{Probability of Occurrence}\}_{hr}$$

where:

Scientific Weighting = A High/Medium/Low impact ranking to normalise one hazard/receptor combination dependant on scientific environment issues

Political Weighting = A High/Medium/Low impact ranking to normalise one hazard/receptor combination dependant on political/social/commercial issues

Probability of Occurrence = Probability of a source exceeding the target level in a given time period

{Note: Subscript h and r refer to Hazard and Receptor respectively e.g. δ_{hr} is the level of harm for receptor "r" against hazard "h".}

The Steps 1 to 5 are represented in Figure 1 under the following colour codes:

Step 1:	% of Space Exposed	Light Blue
Step 2:	Period of Exposure	Red
Step 3:	Number of Receptors Exposed to Hazard	Green
Step 4:	Level of Harm	Purple
Step 5:	Risk Significance	Dark Blue

3.2 Input Data

The input data to support the above methodology is itemised in Figure 1 in **black** script. The tables used for data entry into the model are presented in Appendix A .

Data Sheet	Description	Step No.
A.3	Hazard Number, Name	Step 1
A.3	(Hazard) Target Level, Units	Step 1
A.3	Receptor Number, Name	Step 3
A.4	Space Co-ordinates X, Y and Z (or override space) of the space under consideration	Step 1
A.4	Number of Sources in Space	Step 1
A.4	Number of Sources > (Hazard) Target Level	Step 1
A.4	Harm Space per Source x, y and z (or override space)	Step 1
A.4	Tolerable Period under which the Tolerable Number of Receptors in Space can be regarded as low priority, Units	Step 4
A.4	Duration of Source (Units as above)	Step 2
A.4	Shelf Life of the Source (Units as above)	Step 2
A.4	Probability of the Source Occurring	Step 5
A.5	Number of Receptors in Space (for each Receptor Type/Hazard)	Step 3
A.5	Tolerable Number of Receptors in Space that can be affected without cause for concern (for each Receptor Type/Hazard)	Step 4
A.5	Recovery Time for the Receptor to return to a state of being uninfluenced by the Hazard, Units	Step 4
A.8	Receptor Classification (High, Medium or Low impact ranking with Weightings to normalise one Receptor Type against another)	Step 5
A.8	Scientific/Political Classification (High, Medium or Low impact ranking with Weightings to normalise one Receptor Type against another)	Step 5
A.9	'Traffic Light' coding where the Danger Level and Warning Level can be entered	Step 5

3.3 Output Data

Based on the above data input the following output data is generated, see Appendix A and Figure 1 for reference to the Colour Coding.

Data Sheet	Description	Step No.	Colour Code
A.4	Space (in which the Hazard(s) are being considered)	Step 1	
A.4	Harm Space per Source in which the Hazard exceeds the Target Level	Step 1	
A.6	RESULT = % of Space Exposed to the Hazard	Step 1	Light Blue
A.6	RESULT = Period of Exposure of the Hazard	Step 2	Red
A.6	RESULT = Number of Receptors Exposed to the Hazard	Step 3	Green
A.7	RESULT = Level of Harm imposed on the Receptors as a result of Exposure to the Hazard. **See Figure 2**	Step 4	Purple
A.9	RESULT = Risk Significance of the Level of Harm on the Receptor as a result of Exposure to the Hazard	Step 5	Dark Blue

4. APPLICATION

4.1 General

The methodology enables the User to analyse the effects of the environmental hazards due to sources in a defined area (or space) and to assess the level of harm, above a tolerable level, on the various receptors as a result of these hazards.

4.2 Sources

The model enables the User to select the location under consideration, be this at local, regional or national level, and to estimate the number of 'sources' that are capable of generating the hazard(s) which can impose harm on the various receptors. Based on statistical evidence etc., the User has to assess the number of these sources that are responsible for the environmental hazards that produce an unacceptable level of harm on the receptors.

For normalisation a tolerable period of time needs to be defined. If this period of time is exceeded with the tolerable number of receptors exposed to the hazard then an unacceptable level of harm results

4.3 Receptors

4.3.1 Tolerable Number of Receptors

In the above discussion, the receptor has been referred to as the 'object' of the hazard. In the methodology, however, the 'receptor' must be defined as it is the receptor on which the level of harm is imposed. With reference to the Description Sheet, see Appendix A page A.3, the various receptors identified may have totally different levels of harm when subjected to the same environmental hazard e.g. for humans exposed to carbon monoxide, death will not be accepted as a tolerable level of harm, whereas for birds, death (up to a certain % of the bird 'population') may be tolerated as an acceptable level of harm. Hence the type of receptor must be clearly defined as it is critical in assigning a tolerable number of receptors to the environmental hazard from which the level of harm is measured. In the above example, had humans been exposed to aromatic chemicals (not carbon monoxide), the tolerable number of humans that can be subjected to the level of harm may be 1% of the population within the defined space as the effect of the aromatic chemicals, although long term, may not be fatal.

4.3.2 Receptor Classification

When conducting the analysis it is necessary to classify the receptor types based on the levels assigned to the 'tolerable number of receptors' and the 'tolerable period of time' based on defined criteria. With reference to the examples discussed above (see para 4.3.1), 'humans' are classified differently from 'birds' when assigning the tolerable number of receptors that can be subjected to a defined level of harm. Other issues that may have to be considered when assigning a level of classification to a receptor may be based on political factors, financial constraints, commercial costs and benefits, social costs and benefits at local, regional or national level etc..

4.4 Level of Harm

The User must also consider the time period over which the effects of the environmental hazards generated by the sources continue to impose a level of harm on the receptors. The three factors, therefore, that must be considered are:

- the length of time in which the sources are 'active' and, therefore, directly responsible for the hazard
- the 'passive' effects of the sources due to the retention of the environmental hazard when the sources are no longer active
- the time taken by the receptors to reach an acceptable level of recovery from the level of harm imposed by the sources.

4.5 Risk Uncertainty

The input data to support the analysis will, in many cases, be based on statistical data and information from the locality, be it local, regional or national, in which the analysis is being conducted. In some cases the information may also be effected by other factors e.g. wind direction, rainfall etc., which are external to the parameters necessary to run the model but which may have some impact on the results of the analysis. Many of the parameters associated with 'data input', see Paragraph 3.2, may, therefore, be affected in this way.

In a similar manner, the probability associated with the environmental hazards affecting the tolerable number of receptors over the tolerable period of time must also be considered in the analysis as these are critical parameters in the measurement of harm on the receptors. Other input parameters may also be affected in this way.

Hence, there is a strong requirement to consider data uncertainty and probability on the input data where such data can generate 'risk' on the value/significance of output data. For this purpose, the model has been developed to consider such risks by the User applying an uncertainty/probability curve to the input data to the relevant parameters. A goal seek function can also be performed to determine values of input parameters which are needed to produce defined levels of harm or risk - see Appendix A page A.9. The model is then run iteratively using Monte-Carlo simulation techniques and the probability of certain receptors exceeding the assigned level of harm can be analysed risk - see Appendix A page A.10.

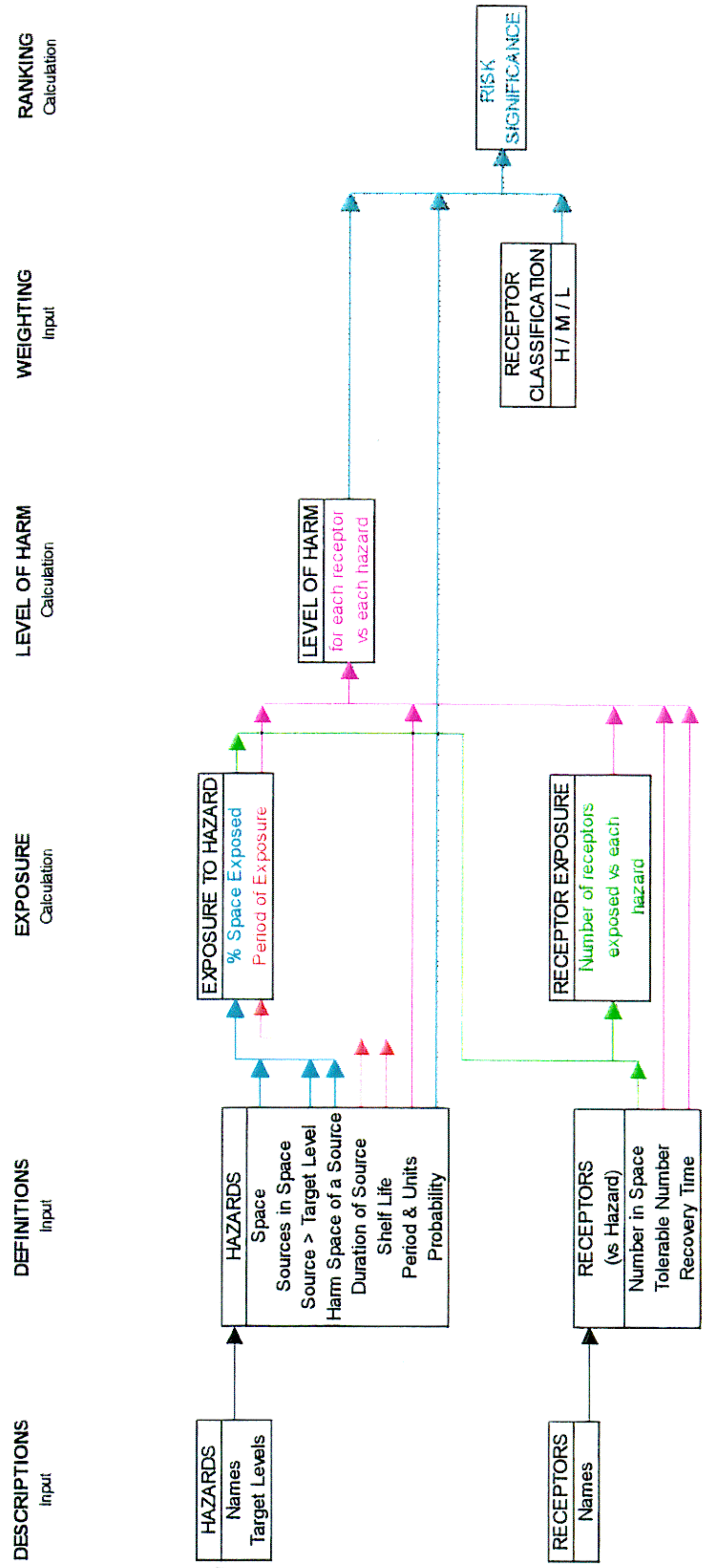
5. CONCLUSIONS

The proposed methodology is in the early days of development and needs further research to establish a more 'scientific' process in assigning values to the finite input variables e.g. the target level associated with each environmental hazard, the harm space of one source etc., and to the less definite input variables such as 'receptor classification', and other issues. Such research would need more detailed examination of environmental data and discussions with those people more closer affiliated with environmental studies.

Nevertheless, with reference to the terms of contract, the methodology conforms closely with the requirements of Reference 1 and presents a robust model which is User friendly. The model is, as yet, the result of a pilot study and needs several levels of examination to assess the viability of the model when exposed to the User in a 'live' situation.

At this stage of the study, it is felt that the progress to date presents a sound foundation on which to develop a structured procedure for Strategic Risk Assessment to be used by the Environment Agency.

Figure 1 - Model Structure



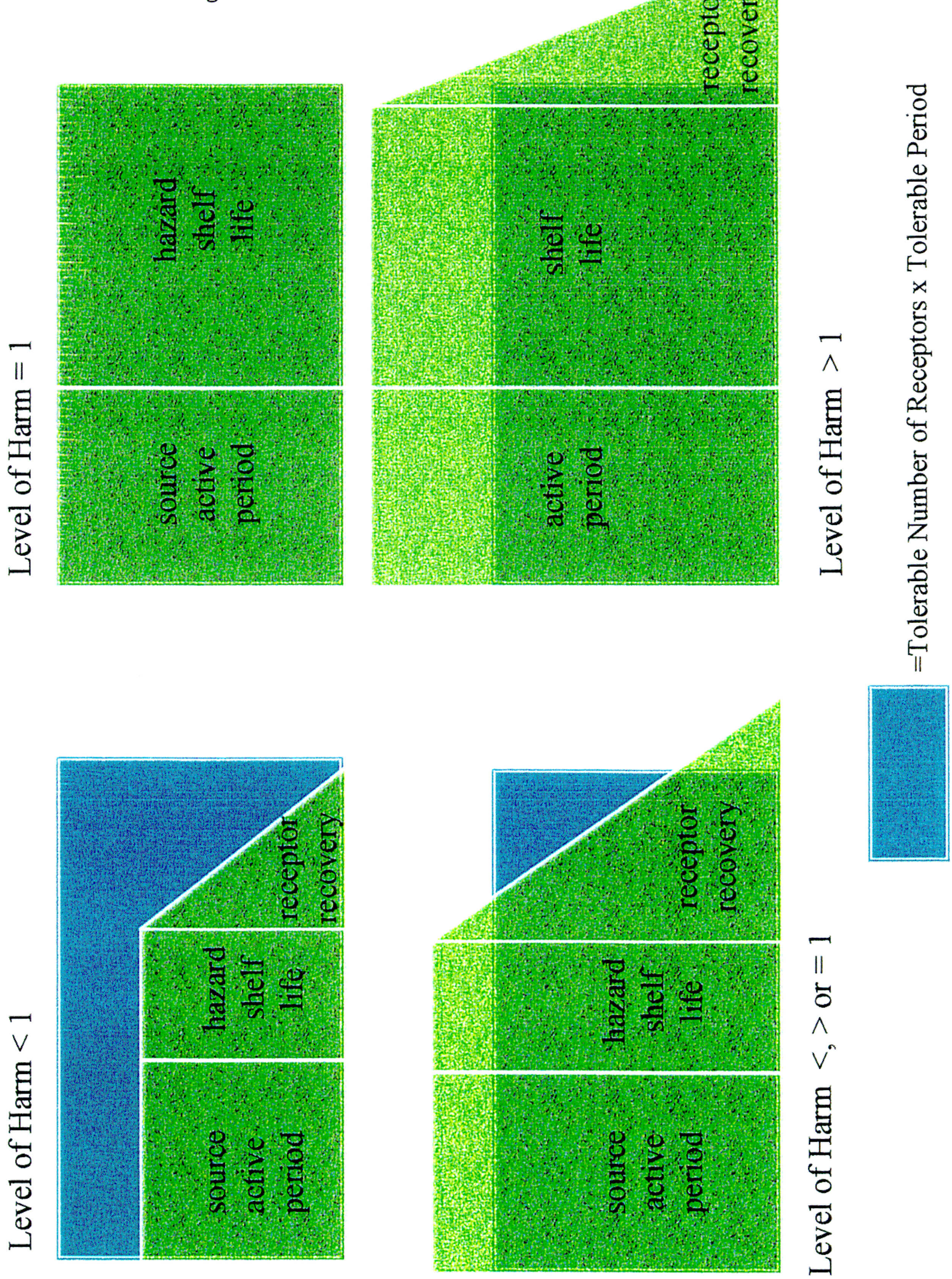


Figure 2 - Level of Harm Calculations

Our Ref: WJS/SAH/R3126B

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SCIENCE
PLANNING
DESIGN

4 July 1997

The Institute of Terrestrial Ecology
Monks Wood
Abbots Ripton
Huntingdon
PE17 2LS

FAO: Stuart Dobson

Dear Stuart

Ref: EA R&D Project: Strategic Risk Assessment: Receptors

Please find enclosed the first draft of the hazard description sheet.

Hopefully you are now in a position to commence work on the receptor definition sheet for each hazard. The receptors should be examined with regard to:

- the concentration level of each hazard above which harm is caused;
- the tolerable length of time a receptor may be exposed to each type of hazard before harm occurs; and
- the tolerable number of receptors harmed before the receptors population is critically damaged.

I assume you have been able to progress the other aspects in the brief. I have arranged a meeting with the EA for the week beginning 21 July 1997. Perhaps we should meet the week beginning 14th July 1997.

If you have any queries please contact me on the number provided.

I look forward to hearing from you soon.

Yours sincerely
for RPS Clouston

John Steele
Technical Director
Enc

ABERDEEN
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EA R&D RISK ASSESSMENT: HAZARD DESCRIPTION SHEET (FIRST DRAFT)

HAZARD :- '*The potential to create an adverse effect to flora, fauna, soil, water, atmosphere, crops and other material goods*'

HAZARD	POSSIBLE SOURCES	EA TARGETS	SOURCE
Acids (Precipitation)	Industrial By-Products, Chemical Reaction in Air	*Land* *Domestic Gardens, allotments, landscaped areas* pH<5 Threshold pH<3 Action	ICRCL
Ammonia	Industrial and Commercial Effluent and By-Products	*Air* Long Term - 100 ug/m^3 Short Term (1hr Ref: 2400 ug/m^3	EPA
Benzene	Vehicle Emissions, Industrial Processes	*Air* *Long term (annual average)* 3.25 ug/m^3 *Short term (1h reference period)* 960 ug/m^3 *Land* *Maximum deposition rate* 2.6 mg/m^2/day	EALs - Health and Safety Executive
Butadiene	Vehicle Emissions, Feedstocks and Landfill	*Air* *Long term (annual average)* 2.21 ug/m^3 *Short term (1h reference period)* 1320 ug/m^3	EALs - Health and Safety Executive
Carbon Dioxide	Energy Consumption (Industrial, Commercial and Domestic), Vehicle Emissions (Air and Terrestrial), Combustion (Commercial and Industrial)	N/A	EA (HMIP)
Carbon Monoxides (air)	Energy Consumption (Industrial, Commercial and Domestic), Vehicle Emissions (Air and Terrestrial), Combustion (Commercial and Industrial)	*Air* *Long term (annual average)* 550 ug/m^3 *Short term (1h reference period)* 99 ug/m^3	EA (HMIP)
CFC - Halons (Ozone Depleters)	Industrial and Commercial Emissions	N/A	EA (HMIP)
Chlorines and derivatives	Industrial and Commercial Effluent (Land, Air and Water)	*Air* *Long term (annual average)* 1.5 ug/m^3 *Short term (1h reference period)* 300 ug/m^3	EALs - Health and Safety Executive Health & Safety Executive

HAZARD	POSSIBLE SOURCES	EA TARGETS	SOURCE
Cyanides (Complex)	Industrial and Commercial Effluent and Emissions	*Land* *Soil Concentrations (1)* *Domestic Gardens, Allotments* 250 mg/kg air dried soil (threshold) 1000 mg/kg air dried soil (action) *Landscaped areas* 250 mg/kg air dried soil (threshold) 5000 mg/kg air dried soil (action) *Buildings, hard cover* 250 mg/kg air dried soil (threshold) *Maximum Deposition (2)* 0.2mg/m^2/day	(1) ICRCL 59/83 (2) EA (HMIP)
Cyanides (free)		*Air* *Long term (annual average)* 50 ug/m^3 *Short term (1h reference period)* 1500 ug/m^3 *Land* *Domestic gardens, allotments, landscaped areas* 25 mg/kg air dried soil (threshold) 500 mg/kg air dried soil (action) *Buildings, hard cover* 100 mg/kg air dried soil (threshold) 500 mg/kg air dried soil (action) *Maximum deposition rate* 0.04 mg/m^2/day	(1) ICRCL 59/83 (2) EA (HMIP)
Dioxins - dipenzo-p-dioxins, and - polychlorinated dipenzoflurans	Industrial Emissions, chemical reactions with air impurities	N/A	N/A
Flood Water - Fresh	Watershed	*Land use Return Period* A 1:50-1:100 B 1:25-1:100 C 1:5-1:50 D 1:1.25-1:10 E <1.25	New Works - MAFF CBA Maintenance - EA
Flood Water - Saline	Coastal	Land use Return Period A 1:100-1:200 B 1:50-1:200 C 1:10-1:100 D 1:2.5-1:20 E <5	New Works - MAFF CBA Maintenance - EA

HAZARD	POSSIBLE SOURCES	EA TARGETS	SOURCE
Hydrocarbons	Industrial Emissions, Transport, Contaminated Land	N/A	N/A
Metals - Cadmium	Industrial Emissions, Transport, Contaminated Land	*Air (1)* *Long term (annual average)* 0.005 ug/m^3 *Short term (1h reference period)* 1.5 ug/m^3 *Cadmium* *Land (2)* *Domestic gardens, allotments* 3 mg/kg air dried soil *Parks, playing fields, open space* 15 mg/kg air dried soil *Maximum deposition rate* 0.008 mg/m^2/day	(1) EALs - Health and Safety Executive (2) EA - HMIP
Metals - Copper	Industrial Emissions, Transport, Contaminated Land	*Air (1)* *Long term (annual average)* 2 ug/m^3 *Short term (1h reference period)* 200 ug/m^3 *Land* *Any uses where plants are to be grown* 130 mg/kg air dried soil Phytotoxic effects of copper, nickel and zinc may be additive. Trigger values given here are those applicable to the 'worst case': phytotoxic effects may occur at these concentrations in acid, sandy soils. In neutral alkaline soils phytotoxic effects are unlikely at these concentrations. *Maximum deposition rate* 0.32 mg/m^2/day	(1) EALs - Health and Safety Executive (2) ICRCL
Metals - Lead	Industrial Emissions, Transport, Contaminated Land	*Air* 2ug/m^3 *Land* *Domestic gardens, allotments* 500 mg/kg air dried soil *Parks, playing fields, open space* 2000 mg/kg air dried soil *Maximum deposition rate* 0.52 mg/m^2/day	EQS ICRCL National EC Standard

HAZARD	POSSIBLE SOURCES	EA TARGETS	SOURCE
Metals - Mercury	Industrial Emissions, Transport, Contaminated Land	*Air* *Long term (annual average)* 1 ug/m^3 *Short term (1h reference period)* 15 ug/m^3 *Land* *Domestic gardens, allotments* 1 mg/kg air dried soil *Parks, playing fields, open space* 20 mg/kg air dried soil *Maximum Deposition Rate* 0.006 mg.m2/day	EALs - Health and Safety Executive and EA (HMIP)
Metals - Nickel	Industrial Emissions, Transport, Contaminated Land	*Air (1)* *Nickel with Compounds* *Long term (annual average)* 0.2 ug/m^3 *Short term (1h reference period)* 6 ug/m^3 *Nickel (Organic)* *Long term (annual average)* 10 ug/m^3 *Short term (1h reference period)* 300 ug/m^3 *Land (2)* *Any uses where plants are to be grown* 70 mg/kg air dried soil Phytotoxic effects of copper, nickel and zinc may be additive. Trigger values given here are those applicable to the 'worst case': phytotoxic effects may occur at these concentrations in acid, sandy soils. In neutral alkaline soils phytotoxic effects are unlikely at these concentrations. *Maximum deposition rate* 0.2 mg/m^2/day	(1) EALs - Health and Safety Executive (2) EA - HMIP

HAZARD	POSSIBLE SOURCES	EA TARGETS	SOURCE
Metals - Zinc	Industrial Emissions, Transport, Contaminated Land	*Land* *Any uses where plants are to be grown* 300 mg/kg air dried soil Phytotoxic effects of copper, nickel and zinc may be additive. Trigger values given here are those applicable to the 'worst case': phytotoxic effects may occur at these concentrations in acid, sandy soils. In neutral alkaline soils phytotoxic effects are unlikely at these concentrations. *Maximum deposition rate* 1.6 mg/m^2/day	EALs - Health and Safety Executive EA - HMIP
Nitrates	Agriculture Sewage Processing Sludge Application	Env.A NSA and NVZ Limits - EC Drinking Water Guidelines	N/A
Nitrogen Dioxide	Energy Consumption (Industrial, Commercial and Domestic), Vehicle Emissions (Air and Terrestrial), Combustion (Commercial and Industrial)	*Air (1)* 200 ug/m^3 (annual 98%ile from mean values per hour or lesser period) *Air (2)* *Short term (1h reference period)* 400 ug/m^3	(1) National EQS (2) EALs - Health and Safety Executive
Nitrogen Monoxide	Energy Consumption (Industrial, Commercial and Domestic), Vehicle Emissions (Air and Terrestrial), Combustion (Commercial and Industrial)	*Air* *Long term (annual average)* 300 ug/m^3 *Short term (1h reference period)* 4500 ug/m^3	EALs - Health and Safety Executive
Nutrients and Organic Compounds	Slurry Application, Livestock Effluent, Spillage's	N/A	A/A
Ozone	Chemical Reactions	N/A	N/A
Pesticides - variety	Agriculture, Commercial Spraying	*Land -(Targets for Organochlorides Pesticides)* The maximum deposition rate is the quantity of pollutant which can be added to the soil over 50 years before the selected soil quality criterion is exceeded. *Maximum deposition rate* 0.07 mg/m^2/day - individual pesticide 0.14 mg/m^2/day - total pesticides	EALs - Health and Safety Executive
Phosphates	Industry, Domestic, Farming	N/A	N/A
Radioactive Discharges - Caesium -137 - Plutonium - 239/240/241 - Americium - 241 - Radon	Liquid waste and air borne sources	*Dose limit* 5mSv/year (from all man-made sources of radioactivity other than medical exposure)	Legal dose limits are set by the Euratom Basic Safety Standards Directive and IRR 85. Recommendations of the ICRP (ICRP 26). 1977 [1]

HAZARD	POSSIBLE SOURCES	EA TARGETS	SOURCE
Solids in Suspension	Agriculture, Urban Runoff, Industrial and Commercial Effluent, Waste	*Air* 80 ug/m^3 (annual median of daily means) 130 ug/m^3 (winter (1Oct-31Mar)median of daily means) 250 ug/m^3 (annual 98%ile of daily (24hr) means) *Water* N/A	Air quality standard arising from EC Directive (80/779/EEC) [4]. Implemented in England and Wales by The Air Quality Standards Regulations 1989 [5].
Sulphur Dioxides	Energy Consumption	*Air* Suspended particles (ug/m^3) / Limit value (ug/m^3) >40 / 80 <=40 / 120 (annual median of daily means) Suspended particles (ug/m^3) / Limit value (ug/m^3) >60 / 130 <=60 / 180 (winter (1Oct-31Mar) median of daily means) Suspended particles (ug/m^3) / Limit value (ug/m^3) >150 / 250 <=150 / 350 (annual 98%ile of daily (24hr) means; not to be exceeded on more than 3 days) *Cyanobacterial lichens* 10 ug/m^3 (annual) *Forest ecossytems & Natural vegetation* 20 ug/m^3 (annual and half year (Oct-Mar) *Agricultural crops* 30 ug/m^3 (annual and half year (Oct-Mar *Short term(24h reference period)* 125 ug/m^3	National EQS EALs - Health and Safety Executive
Volatile Organic Compounds	Industrial Processes	N/A	N/A

Glossary of Terms

EALs - Health and Safety Executive	Environmental Assessment Levels
ICRCL	Interdepartmental Committee on the Redevelopment of Contaminated Land
EQS	Environmental Quality Standard
EPA	Environmental Protection Agency

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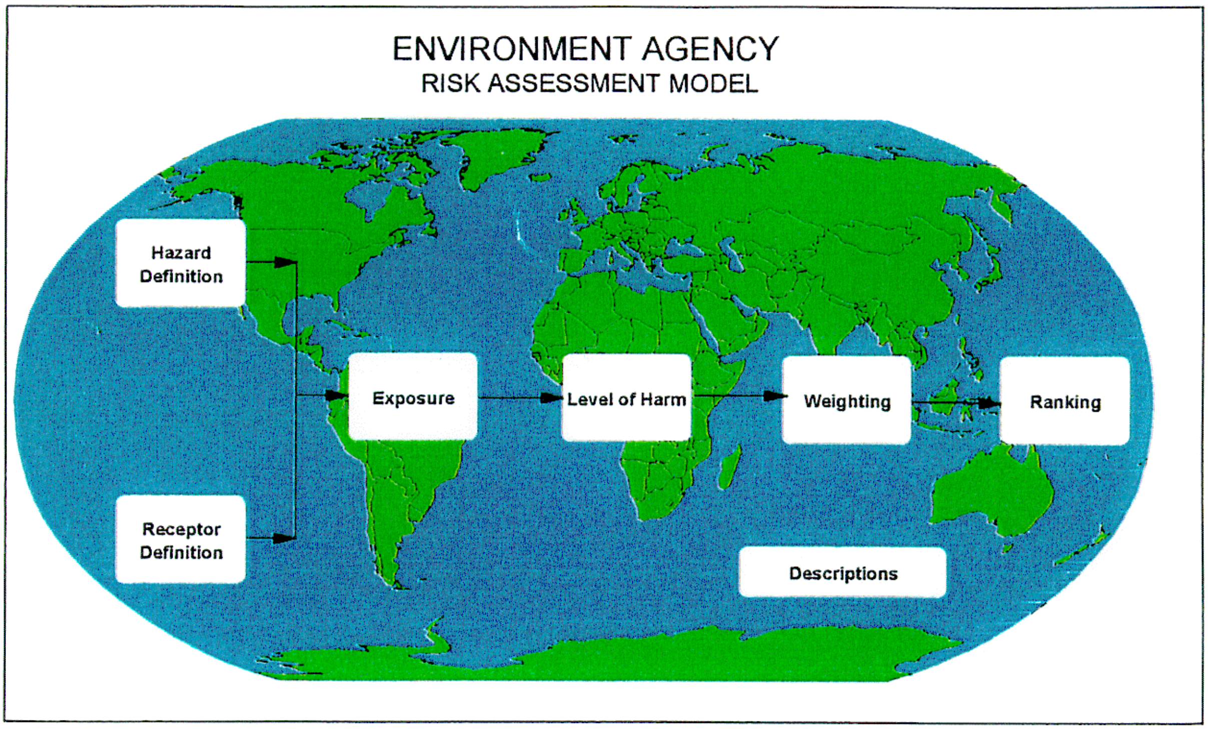
Dr R.J Pentreavth (1997) *The Environment of England and Wales - A Snapshot (**as updated on the internet**)* Environment Agency

Department of the Environment (1996) *Digest of Environmental Statistics Vol. no. 18 1996* Government Statistical Service

APPENDIX A

USING THE SPREADSHEET MODEL



On start up the model displays the above navigation screen which uses buttons to access the individual spreadsheets which present the input and results of the modelling. Inputs can be made on the Description, Hazard Definition, Receptor Definition and Weighting sheets and results of calculation are shown on the Exposure, Level of Harm and Results and Ranking sheets. The arrows represent the flow of information which the model uses to build the final ranking table of risks for Source vs Receptor.

The remainder of this appendix describes the individual spreadsheets and outlines some of the analysis tools which are available through Crystal Ball and Excel for performing analysis, and proposes some of their likely uses.

On the following sheets and in the model all input cells are shown in yellow. Calculated cells are shown grey on all but the final ranking sheet.

<

DESCRIPTION SHEET

	Name	Target Level	Units
Hazard 1	Nitrate Pollution		
Hazard 2	Carbon Dioxide		
Hazard 3	Flooding		
Hazard 4	Radioactivity		
Hazard 5	Oil Pollution		
Hazard 6	Hazardous Waste		
Hazard 7	Acid Rain		
Hazard 8	Sulphur Dioxide		
Hazard 9	Lead		
Hazard 10	Biological Water Contamination		
Hazard 11	Carbon Monoxide		
Hazard 12	CFC		
Hazard 13	Noise		
Hazard 14	Orthophosphate Levels		

Receptor 1	Rivers
Receptor 2	Human
Receptor 3	Flood Planes
Receptor 4	Reservoir
Receptor 5	Farm Land
Receptor 6	Roads
Receptor 7	Flora
Receptor 8	Fauna
Receptor 9	Bird Life
Receptor 10	Ocean

The "Description" sheet can be accessed either from the navigation sheet or from the sheet tabs displayed along the bottom of each screen. The sheet holds background information describing the Hazards and Receptors under analysis. This information consists of a description of each hazard along with a target level and a description of each receptor type.

It is assumed that a target level can sensibly be applied to each hazard. There is little advantage in assigning target levels to each Hazard/Receptor combination as in practice the policy of setting a target level will be influenced mainly by the most susceptible receptor.

This prototype system has initially been set to accommodate 14 Hazards and 10 Receptors which has been purely driven by the information that can be reasonably shown on single screens. Additions or deletions to this baseline requires the usual careful consideration when altering linked spreadsheets. The macros in the system would also need to be edited. It is therefore advisable not to delete or add Hazards or Receptors from or to the prototype unless absolutely necessary. Columns and Rows can be easily hidden to improve presentation if required by using the Excel Format Menu.

The exit button {<} at the top left of the screen returns the User to the navigation screen and updates the descriptions of hazards and receptors on all the other spreadsheets. If the User exits the screen by using the sheet tabs at the bottom of the screen then the descriptions on the other sheets will not be updated.

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HAZARD DEFINITION SHEET

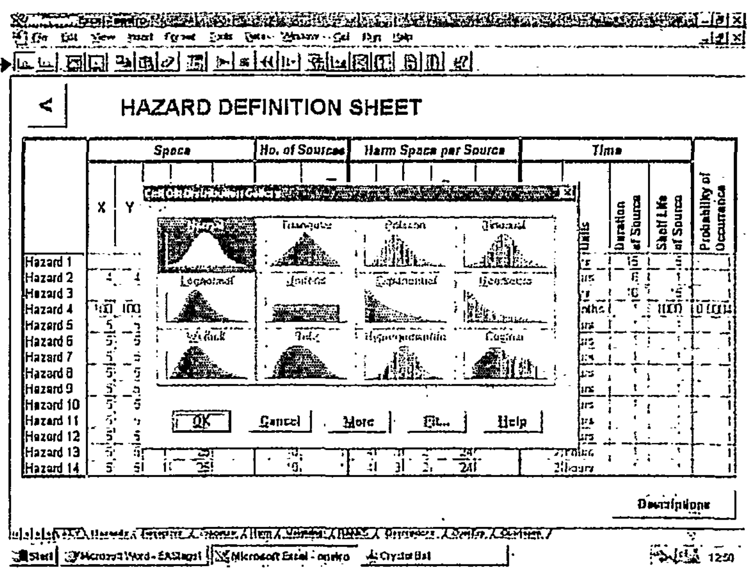
	Space					No. of Sources		Harm Space per Source					Time				
	X	Y	Z	Space	Override	Sources in Space	Sources > Target Level	x	y	z	Harm Space per Source	Override	Tolerable Period	Units	Duration of Source	Shelf Life of Source	Probability of Occurrence
Hazard 1				3000	3000	500	7	15	15	1	225		30	days	15	5	1
Hazard 2	4	4	1	16		6700	670	0.1	0.1	1	0.01		24	hours	6	1	1
Hazard 3				25000	25000	1	1	50	50	3	7500		50	days	10	15	1
Hazard 4	100	100	1	10000		1	1	80	70	1	5600		2	months	1	1000	0.0004
Hazard 5	5	5	1	25		10	1	4	3	2	24		2	hours	1	1	1
Hazard 6	5	5	1	25		10	1	4	3	2	24		2	hours	1	1	1
Hazard 7	5	5	1	25		10	1	4	3	2	24		2	hours	1	1	1
Hazard 8	5	5	1	25		10	1	4	3	2	24		2	hours	1	1	1
Hazard 9	5	5	1	25		10	1	4	3	2	24		2	hours	1	1	1
Hazard 10	5	5	1	25		10	1	4	3	2	24		2	hours	1	1	1
Hazard 11	5	5	1	40	40	10	1	4	3	2	24		2	hours	1	1	1
Hazard 12	5	5	1	25		10	1	4	3	2	24		2	hours	1	1	1
Hazard 13	5	5	1	25		10	1	4	3	2	24		2	hours	1	1	1
Hazard 14	5	5	1	25		10	1	4	3	2	24		2	hours	1	1	1

Descriptions

The "Hazard Definition" sheet can be accessed either from the navigation sheet or from the sheet tabs displayed along the bottom of each screen. The sheet holds the data which the system uses to calculate the area/volume of the analysis space which is (or could be) affected by a Hazard. These inputs are described at the table at section 3.2.

The input values may be single figure estimates or could come from current data such asaverages from known data sources, results from scientific simulation models, standard probability distributions or best fit distributions to a body of data. When the input is not a fixed value, Crystal Ball provides a facility whereby distribution can be assigned against any of the input values (i.e. the yellow cells). These are then referred to as "assumption cells" in Crystal Ball terminology. Assumption cells are defined by clicking the icon shown on the screen dump below which gives several distribution options.

Define Assumption Icon



RECEPTOR DEFINITION SHEET

Receptor	1			2			3			4			5			6			7			8			9			10			
	Number in Space	Tolerable Number	Recovery Time	Number in Space	Tolerable Number	Recovery Time	Number in Space	Tolerable Number	Recovery Time	Number in Space	Tolerable Number	Recovery Time	Number in Space	Tolerable Number	Recovery Time	Number in Space	Tolerable Number	Recovery Time	Number in Space	Tolerable Number	Recovery Time	Number in Space	Tolerable Number	Recovery Time	Number in Space	Tolerable Number	Recovery Time	Number in Space	Tolerable Number	Recovery Time	Time Units
Hazard 1	3	1	5																												days
Hazard 2				40	4	3																									hours
Hazard 3							40	2	30																						days
Hazard 4				10	1																										months
Hazard 5																			3	2	10	10	2	1							hours
Hazard 6																									2	2	10				hours
Hazard 7										2	2	10				2	2	10										3	2	10	hours
Hazard 8																			10	2	1										hours
Hazard 9													3	2	10				2	10	1				2	10	10				hours
Hazard 10																			3	2	10				2	10	1				hours
Hazard 11													2	2	10				2	10	10	3	2	10	2	10	1	2	2	10	hours
Hazard 12																															hours
Hazard 13																						3	2	10	3	2	10				hours
Hazard 14																															hours

Descriptions

The "Receptor Definition" sheet can be accessed either from the navigation sheet or from the sheet tabs displayed along the bottom of each screen. The sheet holds the data which the system uses to calculate the exposure levels of the receptors for the given Hazard parameters. A description of the data is given in the table at section 3.3.

Again the input values could come from a number of sources or may be defined as distributions using Crystal Ball. As the model is based on a spreadsheet these input cells can be linked to other spreadsheets or be defined as formulae referencing other cells. For example the tolerable number of receptors of a certain type in the relevant space may be a straight percent of the number of receptors in the space.

The Descriptions button at the bottom right opens up the Descriptions sheet as a reminder of the background details. Note that Users can see the details of Hazard and Receptors on any of the spreadsheets by placing the cursor over the relevant Hazard or Receptor number.

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EXPOSURE SHEET

Exposure to Hazard

	% of Space Exposed	Period Exposed
Hazard 1	52.5%	20 days
Hazard 2	41.9%	7 hours
Hazard 3	30.0%	25 days
Hazard 4	56.0%	1001 months
Hazard 5	96.0%	2 hours
Hazard 6	96.0%	2 hours
Hazard 7	96.0%	2 hours
Hazard 8	96.0%	2 hours
Hazard 9	96.0%	2 hours
Hazard 10	96.0%	2 hours
Hazard 11	60.0%	2 hours
Hazard 12	96.0%	2 hours
Hazard 13	96.0%	2 hours
Hazard 14	96.0%	2 hours

Number of Receptors Exposed

Receptor	1	2	3	4	5	6	7	8	9	10
Hazard 1	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hazard 2	0.00	16.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hazard 3	0.00	0.00	12.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hazard 4	0.00	5.80	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hazard 5	0.00	0.00	0.00	0.00	0.00	0.00	2.88	9.60	0.00	0.00
Hazard 6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.92	0.00
Hazard 7	0.00	0.00	0.00	1.92	0.00	1.92	0.00	0.00	0.00	2.88
Hazard 8	0.00	0.00	0.00	0.00	0.00	0.00	9.60	0.00	0.00	0.00
Hazard 9	0.00	0.00	0.00	0.00	2.88	0.00	1.92	0.00	1.92	0.00
Hazard 10	0.00	0.00	0.00	0.00	0.00	0.00	2.88	0.00	1.92	0.00
Hazard 11	0.00	0.00	0.00	0.00	1.20	0.00	1.20	1.80	1.20	1.20
Hazard 12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Hazard 13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.88	2.88	0.00
Hazard 14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Overwrite Descriptions

The "Exposure" sheet can be accessed either from the navigation sheet or from the sheet tabs displayed along the bottom of each screen. The sheet calculates and displays values for the level of the analysis space which is exposed to the Hazard and, from that, the number of receptors which are exposed to it.

In addition to the Exit and Descriptions buttons this screen has an Overwrite button which accesses the screen shown below. This overwrite sheet can be used as an input in cases where it is more pertinent to give the exposure level as a proportion of the space or the number of Receptors in the space exposed to a Hazard, rather than the parameters required by the Hazard and Receptor definition sheet. Note that probability distributions can be applied to these input fields in the same manner as described earlier.

<

OVERWRITE EXPOSURE SHEET

Exposure to Hazard

	% of Space Exposed	Period Exposed
Hazard 1		days
Hazard 2		hours
Hazard 3		days
Hazard 4		months
Hazard 5		hours
Hazard 6		hours
Hazard 7		hours
Hazard 8		hours
Hazard 9		hours
Hazard 10		hours
Hazard 11		hours
Hazard 12		hours
Hazard 13		hours
Hazard 14		hours

Number of Receptors Exposed

Receptor	1	2	3	4	5	6	7	8	9	10
Hazard 1										
Hazard 2										
Hazard 3										
Hazard 4										
Hazard 5										
Hazard 6										
Hazard 7										
Hazard 8										
Hazard 9										
Hazard 10										
Hazard 11										
Hazard 12										
Hazard 13										
Hazard 14										

Descriptions

<

LEVEL OF HARM SHEET

Receptor	1	2	3	4	5	6	7	8	9	10
Hazard 1	118 1%									
Hazard 2		157.0%								
Hazard 3			540.0%							
Hazard 4		280420%								
Hazard 5							144.0%	480.0%		
Hazard 6									96.0%	
Hazard 7				96.0%		96.0%				144.0%
Hazard 8							480.0%			
Hazard 9					144.0%		67.2%		28.8%	
Hazard 10							144.0%		33.6%	
Hazard 11					60.0%		42.0%	90.0%	18.0%	210.0%
Hazard 12										
Hazard 13								144.0%	144.0%	
Hazard 14										

Overwrite Descriptions

The "Level of Harm" sheet calculates and displays values for a level of harm as normalised by the tolerable period and tolerable number of receptors for the Hazard/Receptor combination. The level of harm is calculated as shown at Figure 2. A level of harm greater than 100% represents an 'intolerable' level and less than 100% represents a 'tolerable' level of harm. The actual value calculated gives an indication of the severity of any excess. Note that the level of harm by this definition is independent of 'concentration' of hazard unless this is accounted for in the recovery time or shelf life of the hazard.

This screen also has an Overwrite button which accesses the corresponding overwrite sheet if it is more appropriate to enter data at this point. Again, Crystal Ball could be used to give input assumptions.

<

OVERWRITE LEVEL OF HARM SHEET

Receptor	1	2	3	4	5	6	7	8	9	10
Hazard 1										
Hazard 2										
Hazard 3										
Hazard 4										
Hazard 5										
Hazard 6										
Hazard 7										
Hazard 8										
Hazard 9										
Hazard 10										
Hazard 11										
Hazard 12										
Hazard 13										
Hazard 14										

Descriptions

WEIGHTING SHEET

Receptor	1		2		3		4		5		6		7		8		9		10	
	Scientific	Political	Scientific	Political	Scientific	Political	Scientific	Political	Scientific	Political	Scientific	Political	Scientific	Political	Scientific	Political	Scientific	Political	Scientific	Political
Hazard 1	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Hazard 2	M	H	M	H	M	H	M	H	M	H	M	H	M	H	M	H	M	H	M	H
Hazard 3	L	H	L	H	L	H	L	H	L	H	L	H	L	H	H	H	L	H	L	H
Hazard 4	L	H	H	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Hazard 5	L	M	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Hazard 6	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
Hazard 7	H	H	H	H	H	H	H	H	H	H	H	H	H	H	M	H	H	H	H	H
Hazard 8	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Hazard 9	L	H	L	H	L	H	L	H	H	H	M	H	L	H	L	H	L	H	L	H
Hazard 10	L	H	L	H	L	H	L	H	L	H	L	H	M	H	L	H	L	H	L	H
Hazard 11	L	H	M	H	H	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Hazard 12	H	H	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H	L	H
Hazard 13	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H	L	H
Hazard 14	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

WEIGHTINGS

Scientific	
H	3
M	2
L	1

Political	
H	3
M	2
L	1

Descriptions

The "Weightings" sheet is an input sheet where weightings can be applied to the normalised level of harm figures and probability of occurrence to produce a ranking of Hazard/Receptor combinations. Provision has been made for two "flavours" of weighting. The first of these is called "Scientific" weighting which is to take account of relative importance of the Hazard/Receptor combination in environmental terms; whereas the "Political" weighting is intended to be used to take account of relative importance in terms of social issues independent of environmental issues.

As these types of weighting are necessarily subjective a coarse score system of High/Medium/Low has been adopted for the prototype. The relative importance of a High/Medium/Low weighting of each type in terms of the impact it has on the ranking marks for the Hazard/Receptor combination can be defined by the User. This is carried out in the boxes at the bottom left of the screen. In the example shown the 3/2/1 assigned to H/M/L means that a medium weighting reduces the ranking mark to 0.667 (2/3) of its unweighted value; whilst a low weighting reduces the ranking mark to 0.333 (1/3) of its unweighted value.

RESULTS AND RANKINGS

Receptor	1	2	3	4	5	6	7	8	9	10	Hazard Score	Sorted Hazard	Sorted Receptor
Hazard 1	118.1%										1.18	7	7
Hazard 2		104.7%									1.05	11	8
Hazard 3			180.0%								1.80	5	10
Hazard 4		100.0%									1.00	3	2
Hazard 5							48.0%	160.0%			2.08	9	3
Hazard 6									96.0%		0.96	8	5
Hazard 7				96.0%		96.0%				144.0%	3.36	1	9
Hazard 8							160.0%				1.60	10	1
Hazard 9					144.0%		22.4%		9.6%		1.76	2	4
Hazard 10							96.0%		11.2%		1.07	4	6
Hazard 11					20.0%		14.0%	30.0%	6.0%	70.0%	1.40	6	
Hazard 12												13	
Hazard 13								48.0%	48.0%		0.96	12	
Hazard 14												14	
Receptor Score	1.18	2.05	1.80	0.96	1.64	0.96	3.40	2.38	1.71	2.14	18.22		

WARNING LEVEL		80.0%
DANGER LEVEL		100.0%

Rank

Descriptions

The "Results and Ranking" sheet gives a score which is the product of the Probability of Occurrence, the Level of Harm and the Weighting Factors. When the User opens the Ranking sheet from the navigation sheet, the ranking scores are colour coded with either Red, Yellow or Green to indicate intolerably high, warning or low risk priorities. If the sheet is entered using the sheet tabs at the bottom of the screens then this will not be carried out until the Rank button is clicked.

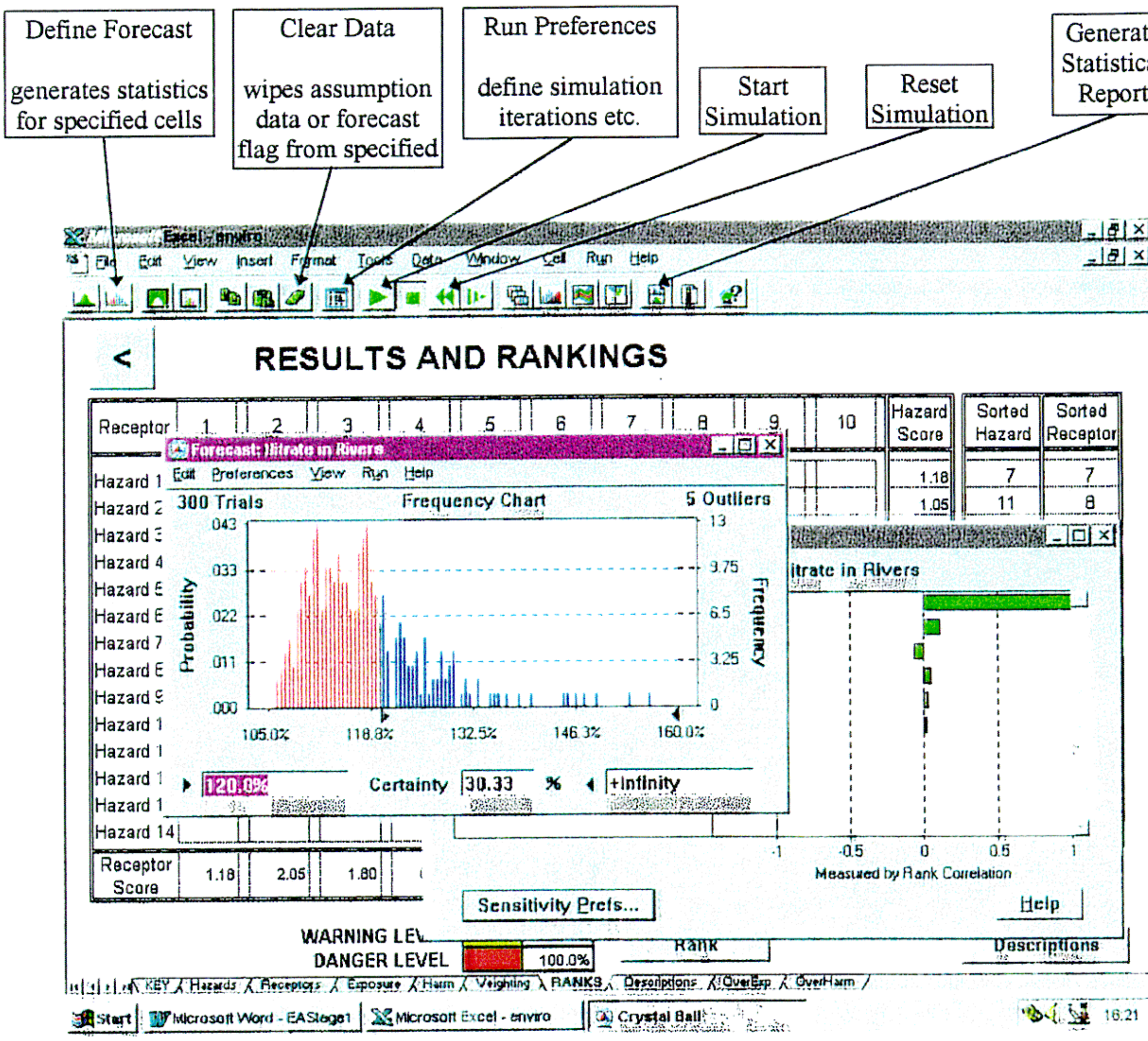
Users can set the breakpoints for the different colour indicators by using the codes for warning level and danger level at the bottom left of the screen. On changing these values the Rank button will need to be clicked so that any changes to the coding can take effect.

The screen also calculates a score for each Hazard and Receptor by summing the individual marks for the Hazard/Receptor combinations. These are then used to produced a sorted list ranking each hazard and each receptor which is displayed at the right of the screen. There are a number of different methods of calculating the scores for hazard and receptor which the user could choose by changing the summation formula in the current score cells if necessary. These ranked lists are produced when the screen is entered from the navigation screen or the Ranks button is clicked.

There are two in-built Excel functions which will be of value when analysing the results of the model:

1) The first is Goal Seek which can be used to find the value of an input cell which results in a given value for a calculation cell such as a Hazard/Receptor ranking mark (although this can be used for any calculated cell in the model). Thus the User can find the value of shelf life which results in a mark of 100% for the Hazard 5 / Receptor 8 combination given that the other parameters remain the same.
2) The second is Solver which can be used to find the values of a set of input cells which results in a given value for a calculation cell within a defined range for each of the input cells. For example you can determine whether a 100% score can be achieved for a shelf life greater than 10 days and a tolerable number of receptors less than 400.

In order to see the distributions on any of the ranking marks caused by input parameters with probabilistic distribution assumptions, a monte-carlo simulation can be run using Crystal Ball functions. The figure below describes some of the functions of Crystal Ball but full details can be gained from the Crystal Ball User Guide.



Once one or more "forecast" cells have been defined, the run preferences set (e.g. number of iterations) and the simulation has been run, a number of outputs and reports are available to the user. The first of these shown here is the forecast chart. This shows the distribution on the forecast cell which has been generated by the distributions (i.e. uncertainty) on the linked input cells. This chart can be used to determine probabilities and confidence levels of the resulting distribution. For example, the above chart has been set to show the probability that the Nitrates in Rivers ranking score is greater than 120%. The result is 30.33% probability. This sort of analysis could be carried out to test the robustness of a decision to concentrate on a particular risk rather than a counter option. It can also be used to build up look-up tables of levels of harm for given scenarios.

The second chart shown (partially hidden) presents a sensitivity analysis. This indicates how much of the spread of an output distribution can be attributed to the distributions on particular inputs and would be of value in deciding what extra information is sufficiently valuable to warrant further research. The tool can generate full reports for each forecast cell.

Received from ITE on 16.10.97 - see cover letter. Filed NJS.

Receptor definition sheets:

Concentration levels for receptors:

Agreed guidance values for both human health and environmental effects have been included preferentially for each defined receptor. In the majority of cases, only generic receptors can be used; forms have, therefore, been standardized to such generic receptors. In those cases where sub-division of receptors is possible, concentrations are tabulated for these divisions in the notes following the main form.

In addition to guidance values, lowest median toxicity values, no-observed-effect concentrations or lowest-observed-effect concentrations from national or international risk assessments have been included where available. In the absence of guidance values, these are included alone. In some cases, single studies are the only information available; this is stated along with the entry. In the majority of cases, these single studies have been reviewed and validated in national or international documents. A few single studies from general database literature searches have been included.

Care should be taken in equating these different types of information. Guidance values will have been derived from applying "uncertainty factors" to the lowest valid toxicity values identified from the literature. It is not always certain, without the original reports, how the guidance value was defined. Different receptors have guidance values defined differently. For example, critical loads are defined in terms of deposition rates whilst critical levels are in terms of air concentrations and aquatic EQSs in terms of concentration in water.

Tolerable time:

There is virtually no information in this area for general environmental exposure either for human health or effects on other organisms.

Long-term occupational exposure has often been studied for human health effects. Various syndromes associated with chronic human exposure have been described (for example, the neurotoxic effects of white spirit known as "painter's syndrome" the onset of which is about 20 to 30 years; WHO, 1996). Estimates for onset of effects of general environmental exposure can only be made by comparison with this, usually much greater, occupational exposure.

Environmental effects in the field are usually only studied after the event; research is, therefore, concentrated on recovery rather than onset. No quantitative information is generally available. Value judgments can be made on the basis of the persistence of the material in environmental media.

For both human health and the environment, classification terms of **acute, short-term** and **chronic** are given. The term "chronic" is usually defined as "approaching the life time of the organism" and is, therefore, relative.

Tolerable number:

Although this is the critical information required for ecotoxicological risk assessment, there are few published estimates. Measured values can only be made following extensive long-term field analysis of populations. This has been done over decades for populations of birds exposed to organochlorines but for few other pollutants. Models which extrapolate acute toxicity studies to a protection level for 95% of organisms have been explored but are not universally accepted. Field validation of such methods has not yet been done.

Measured or potential severity of the effect on populations is a more tractable approach. In some cases direct information exists to define severity, in others some value judgment is necessary. A matrix of severity scores is presented below tabulating geographical extent of the effect against ecotoxicological significance. An arithmetic progression of scores is used for distribution and a geometric progression for biological effect. This is arbitrary but crudely reflects importance to populations and communities. There is no suggestion that the multipliers reflect real relative ecotoxicological significance. Examples of hazards falling in each category are given:

Severity matrix:

		Contamination 1	***Incident 2***	***Population effect 4***	***Community effect 8***
Local	**1**	1[A]	2[E]	4[I]	8[M]
Regional	**2**	2[B]	4[F]	8[J]	16[N]
National	**3**	3[C]	6[G]	12[K]	24[O]
International	**4**	4[D]	8[H]	16[L]	32[P]

Notes:

Contamination: Presence of contaminants with no overt effect on organisms; possible source of human exposure, possible long-term effect on wildlife
Incident: Kills of limited numbers of organisms; likely recovery fast, effect readily reversible
Population effect: Kills of sufficient numbers to reduce populations of some organisms; recovery likely following end of exposure, timing of recovery medium term
Community effect: Changes in the community of organisms; recovery long-term or irreversible

Examples:

A: Dioxin residues in wildlife close to an incinerator
B: Radionuclides in vegetation
C: Polyaromatic hydrocarbons in aquatic sediment, solvents and pesticides in ground water
D: Residues of persistent pesticides and PCBs in environmental media and organisms at levels not producing overt effects; long-range transport to the arctic
E: Spill of toxic material or biodegradable organic into stream
F: Occasional emission of industrial effluent, leakage of land-fill site
G: Agricultural slurry release
H: Marine oil spill
I: Flood effect on non-mobile species
J: Competition or predation from alien species (eg. reduction of water vole populations by mink)
K: Secondary poisoning from rodenticide use, destruction of habitat by introduced species (eg. Muntjac deer)
L: Effects on marine mammals of PCB residues and disease
M: Removal of habitat (eg. Hedgerow)
N: Eutrophication of wetland, drought causing reduced river flow, incursion of salt water after storms/high tides
O: Competition from introduced plants (eg. rhododendron) with loss of native species
P: Acidification, climate change, deposition of nutrient nitrogen on nutrient-deficient biodiverse communities, erosion of salt marshes

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmo-sphere	Ground water
ACIDS (PRECIPITATION)	n/a	n/a	n/a	critical loads by classification of soil type (see notes for details) (Hornung et al., 1995) **SEVERITY SCORE 16 TO 32**		*pH>6 to <9 EAL for acidity for designated fisheries and aquatic life (based on salmonids and cyprinids) short-term exposure (EA, 1997)* **SEVERITY SCORE 16 TO 32**	*pH>6 to <8.5 for aquatic life pH>7 to <8.5 for shellfish EAL for estuarine and coastal waters (EA, 1997)* **SEVERITY SCORE ?**	n/a	no information

ACID PRECIPITATION:

Sources:

See individual components.

Environment:

The response of the environment to deposition of either acidic materials or chemical species which ultimately generate excess hydrogen ions (eg ammonia) is dependent on the buffering capacity of the receptor (soils or surface waters). Critical loads for deposition have been derived according to soil class in Britain as follows (Hornung et al., 1995):

Soil Class	Dominant weatherable material	Critical load (kmol H⁺ / ha/yr)
1	quartz, rutile, kaolinite, gibbsite	<0.2
2	muscovite, plagioclase, illite	0.2 - 0.5
3	amphipole, chlorite, biotite, epidote, glaucophane	0.5 - 1.0
4	olivine, garnets, pyroxenes, epidote	1.0 - 2.0
5	carbonates	>2.0

In addition, critical loads can be defined for materials (metals, stone, organic materials etc) (UNECE, 1996).

Time of onset:

The effect is cumulative over the medium to long-term (years) dependent on buffering capacity.

SCORE	SHORT TERM / CHRONIC

Severity:

Effects will occur at the population or community level over a wide area (international).

Distribution	INTERNATIONAL - SCORE 4
Degree of effect	POPULATION - SCORE 4/ COMMUNITY - SCORE 8
SCORE (Multiplied)	16 TO 32

Reversibility:

Reversibility will depend on the severity and chronicity of the original effect, the presence of populations to recover and the geochemistry of the site. Timing - years to decades.

SCORE	MEDIUM TO LONG-TERM

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
AMMONIA	*170 µg/m³ annual exposure 2400 µg/m³ 1 hr exposure EALs (EA, 1997)*	**18 mg/m³ 8 hr TWA 25 mg/m³ 15 min occupational exposure limit (HSE, 1997)**	1.5 mg/l perceptible to consumers (WHO, 1993a)	*8 µg/m³ critical level for all vegetation types over an annual exposure (EA, 1997)* **SEVERITY SCORE 16 TO 32**	as natural	*4 µg/l guideline 21 µg/l short-term EALs for designated fisheries; salmonids and cyprinids (DoE, 1988)* *15 µg/l draft EQS for aquatic life (DoE, 1988)* *20 µg/l chronic LOEC for fish (WHO, 1986)* **SEVERITY SCORE 16 TO 32**	*21 µg/l draft EQS (DoE, 1988)* **SEVERITY SCORE ?**		not expected to leach to groundwater (WHO, 1986)

AMMONIA:

Sources:

The major environmental release of ammonia is from natural biological processes such as the breakdown of organic waste matter. Anthropogenic emissions can result in local elevated concentrations.

Air: Ammonia may be released to the atmosphere from the use of ammonia fertilizers, from animal manure and biological emissions, and from municipal incinerators.

Water: Ammonia may be released to water via sewage treatment, meat processing or industries which manufacture fertilizers, inorganic chemicals, non-ferrous metals or ferroalloys. It may also enter the aquatic environment in both urban and rural runoff.

Soil: Ammonia may be applied as fertilizer or be deposited following short or long range atmospheric transport.

Levels:

MEDIUM	CONCENTRATION
AIR: RURAL	1.40 TO 21.70 $\mu g/m^3$
AIR: URBAN	0.80 TO 315.0 $\mu g/m^3$
PRECIPITATION	UP TO 13000 µg/litre measured in rain only
WATER: FRESHWATER	500 µg/litre (total ammonia - ammonia and ammonium ion)

Environment:

Ammonia, although alkaline, is utilized by plants as a nutrient with the net result of acidifying soil. The critical level tabulated is for damage to plants and is expressed as an air concentration based on fumigation experiments. Critical loads for acid precipitation and nitrogen deposition are expressed in term of all pollutants with acidifying or nutrient effects and, therefore, include ammonia deposition.

Time of onset:

Both nutrient and acidifying effects are cumulative; timing years to decades.

SCORE	SHORT TERM / CHRONIC

Severity:

Effects will occur at the population or community level over a wide area (international).

Distribution	INTERNATIONAL - SCORE 4
Degree of effect	POPULATION - SCORE 4/ COMMUNITY - SCORE 8
SCORE (multiplied)	16 TO 32

Reversibility:

Reversibility in terrestrial systems is dependent on severity and the capacity of leaching out from soil. Leached acid will subsequently affect local or regional surface waters. Timing years. Reduced biodiversity may be irreversible over decades.

SCORE	MEDIUM TO LONG-TERM

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Ground water
BENZENE	*3.24 µg/m³ EAL long-term exposure (EA, 1997) based on* ***EPAQS (DoE 1994a)*** *960 µg/m³ EAL short term exposure (EA, 1997)*	**16 mg/m£ maximum exposure limit (MEL) for 8 hour TWA occupational standard (HSE, 1997)** **EU limit in the course of being changed - this will be reflected in new UK limits in 1998. Details not available.**	10 µg/l guideline WHO (1993a)	2.5 *mg/m²/d maximum deposition rate to soil (EA 1997)* 32 mg/m³ lowest reported NOEC for inhalation exposure for mammals. (DoE 1991) **SEVERITY SCORE ?**	no data	*30 µg/l annual average (draft) EQS 300 µg/l MAC (DoE, 1997)* 5 mg/l lowest reported acute LC_{50} value for aquatic organisms 13 µg/l LOEC for most sensitive life stage (DoE 1991) **SEVERITY SCORE 2**	*30 µg/l annual average (draft) EQS 300 µg/l MAC (DoE, 1997)*	*33.4 photochemical ozone creation potential (relative to ethylene) (EA, 1997)* no reported stratospheric effects; likely $t_{1/2}$ in the troposphere is 5.3 days (WHO, 1993b)	no data

BENZENE:

Sources:

Air: Benzene is released to the atmosphere during combustion of fossil fuels and the production of domestic coal. It is also released during its manufacture and from industries such as oil refining and chemicals where it is extensively used as a solvent. It is added to non-leaded petrol and local air concentration may be high at service stations.

Water: Benzene may be released as effluent from industrial plants.

Soil: Benzene may be released to soil following its disposal in land-fill.

Levels:

MEDIUM	CONCENTRATION
AIR: RURAL	4.50 TO 2770.0 μg/m³
AIR: URBAN	1.60 TO 81500.0 μg/m³
AIR: INDUSTRIAL	0.40 TO 12710.0 μg/m³
PRECIPITATION	0.10 TO 87.2 μg/litre
WATER: FRESHWATER	0.00 TO 8.90 μg/litre
WATER: ESTUARINE	0.00 TO 18.0 μg/litre
WATER: GROUNDWATER	0.1 TO 330.0 μg/litre contaminated groundwater in the region of spills has reported levels up to 12 mg/litre
WATER: DRINKING	0.10 TO 50.0 μg/litre
SOIL	0.00 TO 0.19 mg/kg
SEDIMENT	0.00 TO 0.02 mg/kg

Human health:

Benzene is classified as a carcinogen and, therefore, attracts a Maximum Exposure Limit (MEL) for occupational exposure over an 8 hour working shift at 16 mg/m³ (HSE, 1997). Standard conversion of a MEL to an EAL for long-term exposure would give a value of 32.5 μg/m³ (EA, 1997). However, an EPAQS value was set a factor of 10 lower than this (DoE, 1994) and this has been adopted as the basis for the EAL.

Time to onset:

Carcinogenicity would require a prolonged period for development. Time to onset of other toxic endpoints has been estimated by WHO (1993); though the values are described as speculative. These are tabulated below:

Estimated percentages of worker population that might develop toxic endpoints after exposure to benzene

Duration	Exposure mg/m³	Bone marrow depression	Aplastic anaemia
1 year	320	90%	10%
	160	50	5
	32	1	0
	3.2	0	0
10 years	320	99	50
	160	75	10
	32	5	0
	3.2	<1	0

Environment:
A draft EQS has been suggested at 30 µg/litre for freshwaters and estuarine/marine environments with a Maximum Acceptable Concentration at 300 µg/litre (DoE, 1997). Values for lowest reported LC_{50} and LOEC for aquatic organisms have also been included. The most sensitive life-stage was hatching eggs for fish (DoE, 1991). There are inadequate data to set a terrestrial guidance value other than the maximum deposition rate to soil (EA, 1997) which has been based on remediation. The only values for toxicity to terrestrial organisms available are for earthworms in unrealistic exposure tests (DoE, 1991).

Some groundwater contamination occurs with benzene. This is thought to be due to "fast-track" movement through fissures into the aquifer. No values for concentrations leading to aquifer contamination are appropriate given this mechanism.

Time of onset:
The effects of benzene will be acute since the solvent partitions largely and rapidly to the atmosphere. Half-life in surface waters is about 11 days, longer than might be expected from its volatility because of some adsorption to sediment (DoE, 1991).

SCORE	ACUTE

Severity:

Acute exposure would lead to local kills.

Distribution	LOCAL - SCORE 1
Degree of effect	INCIDENT - SCORE 2
SCORE (multiplied)	2

Reversibility:

Reversibility will be rapid following cessation of exposure - timing weeks.

SCORE	READILY REVERSIBLE

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Ground water
1,3-BUTADIENE	2.21 *μg/m³* *annual exposure (based on EPAQS) EAL* *1320 μg/m³* *1 hr exposure EAL (EA, 1997)*			no information	2.2 mg/m^3 NOEC for beans single study (Kane & Alaire, 1978)	no information	71 mg/l single reported acute LC_{50} for a marine fish (Versheuren, 1996)	may participate in photolysis reactions (EA-SIS profile in preparation)	

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
CARBON DIOXIDE		**9150 mg/m^3 8 hr TWA 27400 mg/m^3 15 minute occupational exposure limits (HSE, 1997)**						1 global warming potential; CO_2 is the reference material (EA, 1997)	

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Ground water
CARBON MONOXIDE	*550 µg/m³ annual average exposure* *2900 µg/m³ 1 hr exposure (based on EPAQS) (EA, 1997)* 11.45 mg/m³ 8 hr running average EPAQS (DoE 1994b) 100 mg/m³ (15 min) 60 mg/m³ (30 min) 30 mg/m³ (1 hr) 10 mg/m³ (8 hr) WHO (1987)	**58 mg/m³ 8 hr TWA 349 mg/m³ 15 min occupational exposure limit (HSE, 1997)**						photochemical ozone creation potential 2.7 relative to ethylene (EA, 1997)	n/a

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Ground water
CFCs	increased incidence of non-melanoma skin cancer and immune system effects following increased UV-B - estimated 16% increase in cancer for a 5% ozone depletion (WHO, 1990)	CFCs have low toxicity following inhalation. The no-effect-concentration for 165 minute exposure of human volunteers was around 19 g/m^3 (WHO, 1990)		**SEVERITY SCORE 16 TO 32**		**SEVERITY SCORE 16 TO 32**		*global warming potential relative to CO_2* *CFC11 - 4000* *CFC12 - 85000* *CFC13 - 11700* *CFC113 - 5000* *CFC114 - 9300* *CFC115 - 9300* *(EA, 1997)*	

ChloroFluoroCarbons (CFCs):

Sources:

Chlorofluorocarbons are released to the atmosphere during manufacture and from use and disposal in refrigeration equipment.

Human health:

CFCs have very low acute toxicity to mammals and no known chronic effects. Indirect effects through global climate change resulting from atmospheric effects of CFCs have been estimated.

Environment:

Time of onset:

Climatic effects are cumulative.

SCORE	SHORT TERM TO CHRONIC

Severity:

Population and community effects expected on a global scale. Severity score is based on indirect effects of atmospheric change.

Distribution	INTERNATIONAL - SCORE 4
Degree of effect	POPULATION - SCORE 4/ COMMUNITY - SCORE 8
SCORE (multiplied)	16 TO 32

Reversibility:

Reversibility is difficult to assess. Given the continued effect for decades even assuming no further release, adverse conditions will persist for at least this period. The possibility of local or global extinctions means that some effects could be irreversible.

SCORE	LONG TERM TO IRREVERSIBLE

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Ground water
CHLORINE	*15 µg/m³ annual exposure* *300 µg/m³ 1 hr exposure* *EALs (EA, 1997)*	**1.5 mg/m³ 8 hr TWA** **2.9 mg/m³ 15 minute** **occupational exposure limit (HSE, 1997)**	5 mg/l drinking water guideline (WHO, 1993a)			*5 µg/l at pH6 short-term EAL for designated fisheries (as HOCl) 6.8 µg/l if measured as Cl_2; higher concentrations allowed if pH>6 (EA, 1997)* **SEVERITY SCORE 2**			

CHLORINE:

Sources:

Air: Chlorine is released to the atmosphere during its manufacture and use in chlorination processes in industry and water chlorination.

Water: Chlorine is added to drinking water during purification. It is also released in wastewater from cellulose production.

Levels:

MEDIUM	CONCENTRATION
AIR: RURAL	1.00 TO 3.70 $\mu g/m^3$
AIR: URBAN	UP TO 58.0 $\mu g/m^3$
WATER: DRINKING	UP TO 2.70 µg/litre

Human health:

Severe irritant of respiratory tract. Effect is acute at high exposure and may be irreversible.

Environment:

Time of onset:

The effects of chlorine will be acute since exposure is unlikely to be prolonged except in situations of chronic release.

SCORE	ACUTE

Severity:

Acute exposure would lead to local kills.

Distribution	LOCAL - SCORE 1
Degree of effect	INCIDENT - SCORE 2
SCORE (multiplied)	2

Reversibility:

The reversibility score is based on the assumption that exposure will always be short and that organisms will remain to recolonize locally affected areas. Time to recovery - weeks.

SCORE	READILY REVERSIBLE

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
CYANIDES (FREE)	*50 μg/m³ annual exposure* *1500 μg/m³ 1 hr exposure* *EALs (EA, 1997)*	**5 mg/m³ 8 hr TWA (except HCN, cyanogen and cyanogen chloride)** **occupational exposure limit (HSE, 1997)**	0.07 mg/l drinking water guideline (WHO, 1993a)	no information		0.05 to 0.16 mg/l range for LC_{50}s for fish in flow-through tests (US-EPA, 1976) **SEVERITY SCORE 2**			

CYANIDES:

Sources:

> **Water:** Cyanides may be released in effluent from the chemicals industry. A range of chemicals are cyanogens, releasing cyanide during breakdown (eg. the solvent acetonitrile); generally the rate of production of cyanide is low.

Levels:

No data. However, levels would be expected to be low because of rapid dissipation.

Human health:

Cyanides are acutely toxic and short lived.

Environment:

There are problems in toxicity testing of cyanides in water which make it difficult to interpret results of published studies and set guideline values. The figures given are restricted to flow-through tests where the concentration of the toxicant is maintained throughout the test period.

Time of onset:

The effects of cyanides will be acute since the material is short lived.

SCORE	ACUTE

Severity:

Acute exposure would lead to local kills.

Distribution	LOCAL - SCORE 1
Degree of effect	INCIDENT - SCORE 2
SCORE (multiplied)	2

Reversibility:

The reversibility score is based on local exposure, short persistence of the material and the presence of organisms to re-colonize locally affected areas. Time to recovery - weeks.

SCORE	READILY REVERSIBLE

Receptors	HUMAN Outdoor air	Indoor air	Drinking water/food	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
DIOXIN **2,3,7,8-tetra chloro *dibenzo-p-dioxin***			1 to 10 pg/kg body weight tolerable daily intake in humans (WHO, 1989d)	**SEVERITY SCORE ?**		<1 pg/l water quality standard based on application of uncertainty factor of 100 to LOEC for fish at 0.1 ng/l (Malcolm et al, 1993) **SEVERITY SCORE 4 TO 8**			

DIOXINS:

The only available information in term of guideline concentrations are based on 2,3,7,8-tetrachloro dibenzo -*p*- dioxin, the most toxic of the series.

Sources:

Air: Dioxins may be released to the atmosphere during the combustion of fossil fuels and the incineration of chemical and domestic waste. All burning of organic material can give rise to dioxin production though generation of 2,4,7,8-tetrachlorodibenzodioxin is rare except from the incomplete incineration of organochlorine material such as PCBs.

Water: Contamination of aquatic sediment can result from long-term effluents from the chemical industry.

Soil: Dioxins may be deposited on soil locally to incineration plants, be applied with sewage sludge or in contaminated products (older pesticides for example).

Levels:

MEDIUM	CONCENTRATION
AIR: RURAL	<1 TO 540 fg/m^3
AIR: URBAN	0.003 TO 6.4 pg/m^3
AIR: INDUSTRIAL	<0.02 TO 1100 pg/m^3
AIRBORNE DUST	0.17 TO 0.50 pg/m^3
	TCDD only in air following the Seveso incident
WATER: FRESHWATER	UP TO 1.1 pg/litre
SOIL: RURAL	<2.1 pg/kg
SOIL: INDUSTRIAL	0.8 TO 65 pg/kg
SOIL: WASTE DISPOSAL SITE	31.8 TO >40 mg/kg
SOIL: NEAR INCINERATORS	UP TO 3.5 mg/kg
SOIL: SEVESO AREA	0.01 TO 15 mg/kg

Human health:

WHO (1989) found no basis for derivation of human health guideline values for dioxins but quoted several attempts to derive tolerable daily intakes based on chronic effects. Acutely, dioxin exposure leads to chloracne which is usually readily reversible.

Environment:

There are very few studies because of the difficulties in handling the material. Only acute effects have been assessed though dioxins persist in the environment bound to sediments.

Time of onset:
The effects of dioxin will be local to contaminated sediments. Since the material will persist, population effects are possible from the longer-term exposure.

SCORE	ACUTE to SHORT-TERM

Severity:

Exposure could lead to local population and community effects given the persistence in sediment and high toxicity.

Distribution	LOCAL - SCORE 1
Degree of effect	POPULATION - SCORE 4/ COMMUNITY - SCORE 8
SCORE (multiplied)	4 TO 8

Reversibility:

The reversibility score is based on the assumption that contaminated sediment will be gradually dispersed in river systems and/or covered with new, uncontaminated material reducing its availability to organisms. There is no direct measurement of this for dioxins but it has been shown to be the case for other persistent materials. Timing - years.

SCORE	MEDIUM TERM

Receptors	HUMAN Outdoor air	Indoor air	Drinking water/food	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Ground water
METALS **CADMIUM**	*0.005 µg/m^3* *annual exposure* 1.5 *µg/m^3* *1 hr exposure* *EALs* *(EA, 1997)* based on WHO air quality guideline; a factor of 10 lower than calculated EAL would be 0.01 - 0.02 µg/m^3 annual exposure based on non-carcinogenic endpoints (WHO, 1987)	**25 µg/m^3** **8 hr TWA maximum exposure limit** **cadmium and cadmium compounds** **(HSE, 1997)**	3.0 µg/l drinking water guideline (WHO, 1993a) 400-500µg weekly intake in food for human adult (WHO, 1989a)	*0.009 mg/m^2/d maximum deposition rate to soil (EA, 1997)* 5 mg/kg soil lowest reported LC_{50} for invertebrates <20 mg/kg leaf litter LOEC for effect on micro-organisms (WHO, 1992) **SEVERITY SCORE** **16**	214 mg/kg soil; EC_{50} on yield (WHO, 1992)	***5 µg/l annual mean EQS for total soluble and insoluble cadmium (EA, 1997)***	2.5 ***µg/l coastal*** ***5 µg/l estuarine annual mean EQS for dissolved cadmium (EA, 1997)***	n/a	no information

METALS CADMIUM:

Sources:

Cadmium exists naturally in the earth's crust.

> **Air:** Cadmium may be released to the atmosphere following combustion of fossil fuels such as coal or petrol.
>
> **Soil:** Cadmium is deposited in the region of smelters (zinc) and may be added to soil via sewage sludge or as a contaminant in phosphate fertilizers.

Levels:

MEDIUM	CONCENTRATIONS
AIR: RURAL	UP TO 0.04 μg/m^3
AIR: URBAN	UP TO 0.70 μg/m^3
AIR: INDUSTRIAL	0.01 TO 5.00 μg/m^3
WATER: FRESHWATER	UP TO 0.01 μg/litre
WATER: ESTUARINE	UP TO 0.10 μg.litre
WATER: GROUNDWATER	UP TO 3200 μg/litre
SOIL	150 mg/kg soil irrigated with cadmium-rich water

Human health:

Human exposure is largely through the diet; an estimated tolerable daily intake is given. Cadmium is taken up from soil into plants; vegetable consumption would be the main dietary source. Kidney damage is the major short-term effect.

Environment:

The most serious environmental effect reported for cadmium is on leaf-litter degradation where communities of microorganisms (and invertebrates) are affected long-term. A value for leaf-litter concentration producing this effect is included. This effect is regional in the vicinity of zinc smelters.

Time of onset:

The effects of cadmium are cumulative in leaf litter, the most sensitive end point.

SCORE	SHORT-TERM TO CHRONIC

Severity:

Acute exposure would lead to regional population and community effects.

Distribution	REGIONAL - SCORE 2
Degree of effect	COMMUNITY - SCORE 8
SCORE (multiplied)	16

Reversibility:

Since cadmium cannot be broken down and has low mobility, effects will not be reversed without remediation.

SCORE	IRREVERSIBLE

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
METALS **COPPER**	*10 µg/m³ annual exposure 200 µg/m³ 1 hr exposure EALs (EA, 1997)*	**1 mg/m³ 8 hr TWA (dusts and mists) 2 mg/m³ 15 minute exposure** **occupational exposure limits (HSE, 1997)**	2 mg/l drinking water guideline (provisional) (WHO, 1993a)	*0.25 mg/m²/d maximum deposition rate for soil (EA, 1997)* 4 mg/kg soil lowest reported effect on soil biota (WHO, 1997b) **SEVERITY SCORE 16**	150 mg/kg soil chronic effects threshold for plants 500 to 1000 mg/kg reduced plant diversity (WHO, 1997b)	*5 to 112 µg/l (dependent on hardness) guideline EQS for designated fisheries* *1 to 28 µg/l (dependent on hardness) EQS for aquatic life (EA, 1997; DoE, 1989)* **SEVERITY SCORE 16**	*5 µg/l EQS for estuary and coastal waters (EA, 1997, DoE, 1989)*	n/a	n/a

METALS COPPER:

Copper is an essential trace element for both humans and other organisms. Its toxicity has, therefore, to be balanced against its essentiality. Bioavailability of copper to both humans and other organisms is related to its speciation and adsorption.

Sources:

Air: Copper may be released as a result of natural processes such as weathering of rocks/ soil, windblown dust, sea sprays, decaying vegetation and volcanic activity. Antropogenic release includes copper, zinc or lead smelters, iron foundries, power stations and municipal incinerators.

Water: The majority of copper entering the aquatic environment is the result of soil run-off. The major anthropogenic sources include industrial and domestic wastewaters and sewage sludge.

Soil: The major release of copper to land is from tailings and overburdens from copper mines. Other sources include municipal refuse and industrial waste. Agricultural uses of copper products account for 2% of copper released to soil.

Levels:

MEDIUM	CONCENTRATIONS
AIR: RURAL	UP TO 0.28 μg/m³
AIR: URBAN	UP TO 0.27 μg/m³
WATER: FRESHWATER	0.50 TO 1000 μg/litre
WATER: ESTUARINE	0.6 TO 3.00 μg/litre concentrations up to 600 μg/litre have been reported in an estuary receiving drainage from a copper mine
WATER: GROUNDWATER	UP TO 5.00 μg/litre
WATER: DRINKING	UP TO 2450 μg/litre
SOIL	1.0 TO 250.0 mg/kg typical background level; concentrations between 2480 and 6912 mg/kg have been reported close to smelters

Human health:

Both deficiency and toxicity states occur in humans though both are rare. Several genetically determined sensitivities to both deficiency and excess of copper are known. Exposure is largely through the diet (WHO, 1997b).

Environment:

Guidance values for the aquatic environment are related to water hardness which affects bioavailability. This can also be affected by pH.

Concentration ranges associated with the severity of copper toxicity in aquatic systems have been defined by WHO (1997b):

TOTAL DISSOLVED COPPER CONCENTRATION RANGE	CHARATERIZATION OF EFFECTS IN HIGH BIOAVAILABILITY WATER*
1-10 μg/litre	Significant effects are expected for diatoms and sensitive invertebrates, notably cladocerans. Effects on fish could be significant in freshwaters with low pH and hardness.
10-100 μg/litre	Significant effects are expected on various species of microalgae, some species of macroalgae, and a range of invertebrates, including crustaceans, gastropods, and sea urchins. Survival of sensitive fish will be affected and a variety of fish should have sublethal effects.
100-1000 μg/litre	Most taxanomic groups of macroalgae and invertebrates will be severely affected. Lethal levels for most fish species will be reached.
>1000 μg/litre	Lethal concentrations for the most tolerant organisms are reached.

* Sites chosen have moderate to high bioavailability similar to water used in most toxicity tests.

Time of onset:

The effects of copper would be cumulative following regular release from industrial sources such as smelters.

SCORE	SHORT-TERM TO CHRONIC

Severity:

Long-term exposure would lead to regional population and community effects. Such exposure could be from deposition onto terrestrial communities or from leaching of waste into aquatic systems.

Distribution	REGIONAL - SCORE 2
Degree of effect	COMMUNITY - SCORE 8
SCORE (multiplied)	16

Reversibility:

Since copper cannot be broken down, effects will not be reversed without remediation in heavily polluted areas. Development of copper-resistant vegetation has been shown on chronically polluted sites.

SCORE	IRREVERSIBLE

Receptors	HUMAN			BIOTA				ABIOTIC	
	Outdoor air	Indoor air	Drinking water	Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	Atmosphere	Ground water
METALS **LEAD (inorganic)**	**2 μg/m^3 limit value; annual mean exposure EQS (EA, 1997; EEC, 1980; statutory instrument, 1989; no 317)** 0.5 - 1.0 μg/m^3 recommended for children (WHO, 1987)	**0.15 mg/m^3 8 hr TWA occupational exposure limit (under review) (HSE, 1997)**	0.01 μg/l drinking water guideline (WHO, 1993a)	*1.1 mg/m^2/d maximum deposition rate to soil (EA, 1997)* insufficient information to quantify effects on soil invertebrates (WHO, 1989b) lowest reported dietary LC_{50} for birds at 100 mg/kg (WHO, 1989b) **SEVERITY SCORE 16**	100-1000 mg/kg soil LOECs for plant growth (WHO, 1989b)	*4 to 20 μg/l EAL for aquatic life based on salmonid fish (EA, 1997; DoE, 1989)* 124 μg/l lowest reported LC_{50} for aquatic invertebrate 1.32 mg/l lowest reported LC_{50} for fish (WHO, 1989b) **SEVERITY SCORE 16**	*25 μg/l EAL for estuary and coastal waters (EA, 1997; DoE, 1989)* 0.27 mg/l lowest reported LC_{50} for invertebrate 4.5 mg/l lowest reported LC_{50} for fish (WHO, 1989b)	n/a	

METALS LEAD:

Sources:

Air: The major release of lead to the atmosphere is from motor fuels, although the amount released is declining; 90% of lead released from fuel combustion is inorganic and 10% organic. Lead is also released to air from mines, smelters and refineries. Natural lead from the earth's crust may be released from weathering.

Soil: Lead may be released to soil by deposition, particularly close to smelters, and following disposal to land-fill of lead products.

Levels:

MEDIUM	CONCENTRATIONS
AIR: RURAL	0.02 TO 0.14 μg/m^3
AIR: URBAN	0.25 TO 25.0 μg/m^3 organic lead accounts for between 2 and 17%
AIR: INDUSTRIAL	UP TO 80.0 μg/m^3
PRECIPITATION	0.4 TO 34.0 μg/litre in rain
WATER: FRESHWATER	1.0 TO 100.0 μg/litre
WATER: ESTUARINE	0.03 TO 0.40 μg/litre
WATER: DRINKING	UP TO 3000 μg/litre for lead pipes, though lead stearate in some plastic pipes can leach out
SOIL	10.0 TO 127.0 mg/kg typical; near lead smelters soil concentrations ranging from 16000 to 40000 mg/kg have been reported
SEDIMENT	47.0 TO 106.0 mgkg

Human health:

There is a well established link between exposure of children to lead in air and water and irreversible central nervous system effects. The lowest guidance values reflect this sensitive sub-population.

Environment:

Severely contaminated areas from industrial emission or contaminated mine wastes show effects on populations of plants and animals locally. Population effects on birds (swans in particular but also other waterfowl) were related to lead shot intake; powdered lead and lead salts are substantially less toxic.

Time of onset:

The effects of lead would be cumulative following industrial release.

SCORE	SHORT-TERM TO CHRONIC

Severity:

Medium to long-term exposure would lead to local or regional population and community effects.

Distribution	REGIONAL - SCORE 2
Degree of effect	COMMUNITY - SCORE 8
SCORE (multiplied)	16

Reversibility:

Since lead cannot be broken down, effects will not be reversed without remediation in severely polluted areas.

SCORE	IRREVERSIBLE

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
METALS MERCURY (inorganic)	*1 µg/m³ annual exposure 15 µg/m³ 1hr exposure EALs (EA, 1997)*	**25 µg/m³ 8 hr TWA occupational exposure limit (HSE, 1997)**	1 µg/l drinking water guideline for total mercury (WHO, 1993a)	0.004 mg/m²/d maximum deposition rate to soil (EA, 1997) insufficient information on soil invertebrates to set a value (WHO, 1989c) lowest dietary LC_{50} for birds at ~3000 mg/kg (WHO, 1989c) **SEVERITY SCORE 2**	insufficient information	*1 µg/l annual average EQS total soluble and insoluble Hg (EA, 1997)* **SEVERITY SCORE 2**	*0.3 µg/l coastal 0.5 µg/l estuarine (dissolved Hg) (EA, 1997)*	n/a	

METALS MERCURY:

Organomercury tends to show significantly higher toxicity than inorganic. EQS values are for total mercury. Formation of organomercury from inorganic salts can occur in the environment, particularly in aquatic systems with high content of organic matter.

Sources:

Air: Mercury is released to the atmosphere during combustion of fossil fuels. It is also released from mercury mines, smelters and by vapourization from soil.

Water: Mercury is released in effluent from the paint, electrical and chloralkali industries.

Soil: Soil contamination may result from mine tailings.

Levels:

MEDIUM	CONCENTRATIONS (TOTAL)
AIR: RURAL	UP TO 0.01 µg/m^3 atmospheric mercury tends to be metallic mercury vapour; some organomercury has been reported. Particulate mercury accounts for <4% and tends to be found in precipitation
AIR: URBAN	UP TO 0.01 µg/m^3
AIR: INDUSTRIAL	UP TO 15 µg/m^3
PRECIPITATION	UP TO 0.10 µg/litre
WATER: ESTUARINE	0.0 TO 0.02 µg/litre dissolved mercury
WATER: GROUNDWATER	1.00 TO 1000 µg/litre
WATER: DRINKING	UP TO 0.60 µg/litre
SOIL	0.02 TO 0.63 mg/kg
SEDIMENT	0.2 TO 0.10 mg/kg values for ocean sediments

Human health:

Poisoning incidents to humans have invariably involved exposure to locally high concentration of organomercury. Toxicity is acute but symptoms may persist indefinitely.

Environment:

Time of onset:

The effects of organomercury are acute. Contamination of the environment with inorganic mercury may lead to long-term problems following methylation.

SCORE	ACUTE TO SHORT TERM

Severity:

Acute exposure could lead to local incidents (mainly pesticides)

Distribution	LOCAL - SCORE 1
Degree of effect	INCIDENT - SCORE 2
SCORE (multiplied)	2

Reversibility:

SCORE	SHORT TERM

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
METALS **NICKEL**	*0.2 µg/m³ annual exposure 6 µg/m³ 1 hr exposure EAL for nickel and its compounds (EA, 1997)*	**0.1 mg/m³ 8 hr TWA occupational exposure limit for nickel and its inorganic compounds (HSE, 1997)**	0.02 mg/l drinking water guideline (WHO, 1993a)	*0.11 mg/m²/d maximum deposition rate to soil (EA, 1997)* no reported studies on terrestrial animals except earthworms; LC_{50} at 757mg/kg soil (WHO, 1991) population and community effects (plants) at >2000 mg/kg soil (WHO, 1991) **SEVERITY SCORE 16**	50 mg/kg soil NOEC for toxicity to plants (WHO, 1991)	*50 to 200 µ/l according to water hardness; annual average EAL for aquatic life (EA, 1997; DoE, 1989)* 0.5 mg/l lowest reported LC_{50} for aquatic invertebrates 4 mg/l lowest reported LC_{50} for fish (WHO, 1991)	*30 µg/l annual average EAL for estuary and coastal waters (EA, 1997; DoE, 1989)*	n/a	

METALS NICKEL:

Sources: Nickel occurs naturally as the 24th most common element in the earth's crust and has a ubiquitous distribution.

Air: Nickel is released to the air from primary nickel industries and from the combustion of fossil fuels. It may also be released from waste incineration.

Soil: Nickel may be added to soil with sewage sludge.

Levels:

MEDIUM	CONCENTRATIONS
AIR: RURAL	UP TO 0.01 μg/m³
AIR: URBAN	0.02 TO 0.04 μg/m³
AIR: INDUSTRIAL	0.12 TO 0.15 μg/m³
WATER: ESTUARINE	0.10 TO 0.50 μg/litre
WATER: DRINKING	4.80 μg/litre higher concentrations reported from nickel plumbing at 75 to 490 μg/litre
SOIL	3.0 TO 1000 mg/kg

Human health:

The only reported human health effects of nickel relate to high occupational exposure with the exception of skin effects from contact with metal alloys containing nickel. There is evidence for carcinogenicity with high occupational exposure though risk varies considerably according to bioavailability.

Environment:

Nickel is an essential element for many microorganisms, a variety of plants and some vertebrates (WHO, 1991).

Time of onset:

The effects of nickel would be cumulative from industrial emissions.

SCORE	SHORT-TERM TO CHRONIC

Severity:

Long term exposure would lead to regional population and community effects.

Distribution	REGIONAL - SCORE 2
Degree of effect	COMMUNITY - SCORE 8
SCORE (multiplied)	16

Reversibility:

Since nickel cannot be broken down, effects will not be reversed without remediation. However, effects are only seen at very high soil concentrations.

SCORE	IRREVERSIBLE

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
METALS **ZINC**				*0.48 mg/m²/d maximum deposition rate to soil (EA, 1997)* 560 mg/kg soil threshold for reproductive effects on earthworms (WHO, 1997c) **SEVERITY SCORE 8**	200 to 300 mg/kg dry wt in leaves threshold for adverse effects on plants (WHO, 1997c)	*30 to 500 µg/l for different water hardness; short-term EAL for designated fisheries (salmonids) (EA, 1997)* *8 to 125 µg/l total annual average for different water hardness; EAL for aquatic life (salmonids) (EA, 1997; DoE, 1989)* **SEVERITY SCORE UP TO 8**	*40 µg/l (dissolved; total annual average); EAL for estuary and coastal waters (EA, 1997; DoE, 1989)*		

METALS ZINC:

Zinc is an essential element and *in vivo* levels are regulated by most organisms. Only dissolved zinc tends to be bioavailable.

Sources:

Air: Zinc is released to the atmosphere from combustion of fossil fuel in both domestic and industrial situations. It is also released during production of zinc, copper and lead and also from secondary copper and lead industries.

Soil: Zinc may be present in sewage sludge and is added to soil as organozinc pesticides (mainly fungicides and bird repellents).

Levels:

MEDIUM	CONCENTRATIONS
AIR: RURAL	UP TO 0.03 µg/m^3
AIR: URBAN	UP TO 0.84 µg/m^3
WATER: FRESHWATER	10.0 µg/litre
WATER: ESTUARINE	0.01 TO 1800 µg/litre
WATER: DRINKING	10.0 µg/litre drinking water from zinc plumbing reported at less than or equal to 2 mg/litre
SOIL	10 TO 300 mg/kg soil sampled close to a smelter had levels up to 5000 mg/kg
SEDIMENT	1.1 TO 2980 mg/kg values for marine sediment

Human health:

There are numerous health effects associated with zinc deficiency but toxicity is rare except in occupational exposure (WHO, 1997c).

Environment:

Environmental risk assessment for zinc, as an essential element, must be conducted on a site-specific basis. Thresholds for effects of dissolved zinc on aquatic organisms have been suggested by WHO (1997c):

Concentration of dissolved zinc (µg/l)	Freshwater	Marine
20 - 50	chronic effects on cladocerans in soft water	
50 - 100	chronic effects on cladocerans in hard water; acute effects on cladocerans in soft water; acute and chronic effects on fish in soft water; chronic effects on aquatic insects	acute effects on mysids
100 - 200	acute effects on algae; acute effects on cladocerans in hard water; chronic effects on fish in hard water; chronic effects on molluscs	acute effects on fish
200 - 1000		acute effects on amphipods and decapods
1000 - 10000	acute effects on molluscs, amphipods and copepods; acute effects on fish in hard water	

Time of onset:

SCORE	SHORT-TERM TO CHRONIC

Severity:

High concentrations of zinc can be found locally to deposition from smelters.

Distribution	LOCAL - SCORE 1
Degree of effect	COMMUNITY - SCORE 8
SCORE (multiplied)	8

Reversibility:

Since zinc cannot be broken down, effects will not be reversed without remediation. High local concentrations needed for community effects.

SCORE	IRREVERSIBLE

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
NITRATES			50 mg/l drinking water guideline (WHO, 1993a)						

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
NITROGEN DIOXIDE	200 µg/m³ exposure duration 1 yr (EA, 1997; EEC, 1985; Statutory Instrument, 1989; no 317) *400 µg/m³ (WHO 1987) exposure duration 1 hr* 200 µg/m³ (WHO 1997a) exposure duration 1hr 40µg/m³ (WHO 1997a) exposure duration 1 yr based on asthmatic children	**5.7 mg/m³ 8h TWA 9.6 mg/m³ 15 min exposure STEL** **occupational exposure limits (HSE 1997)**		SEE NITROGEN OXIDES (NO_X)					

NITROGEN DIOXIDE

The range of guidance values for nitrogen dioxide reflects different exposed populations of humans. An occupational exposure limit of 5.7 mg/m^3 refers to fit workers exposed for the course of an 8 hour working shift and is a time-weighted average over that period. The 1 hr exposure period guidance value set by WHO (1987) at 400 µg/m^3 refers to normal adults; this was listed by EA (1997) as a target value for EALs based on the 1989 recommendation. WHO (1997a) has subsequently revised this value down to 200 µg/m^3. A further guidance value for the most susceptible section of the human population, asthmatic children exposed indoors, has been suggested by WHO (1997a) at 40 µg/m^3.

All guidance values are entered for indoor air, where concentrations tend to be highest following release of nitrogen dioxide by gas appliances. The same values would apply to outdoor air for human exposure.

Environmental guidance values are expressed in terms of total nitrogen oxides (No_x) and are listed separately.

Time to onset:

Nitrogen dioxide acts as an irritant to the upper respiratory tract. It would be expected that sensitization would take some time to develop but this has not been quantified nor has a direct relationship between exposure to NO_2 and sensitization been determined. Onset of symptoms can be rapid in sensitized individuals. Asthma, once developed, persists and patients may respond to materials other than the original sensitizer.

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
NITROGEN MONOXIDE	*300 μg/m³ annual exposure EAL 4500 μg/m³ 1 hr exposure (EA, 1997)*	**31 mg/m³ 8 hr TWA 44 mg/m³ 15 minute STEL occupational exposure limit (HSE, 1997)**		SEE NITROGEN OXIDES NO_X					

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
NITROGEN OXIDES (NO_x)				**30 µg/m³ (UNECE 1993; WHO 1997a) critical level**	>30 µg/m³ (WHO 1997a)		No value available	2.8 photochemical ozone creation potential (EA, 1997)	
				5 to 10 kgN/ha/yr (UNECE 1993; WHO 1997a) critical load for most sensitive ecosystem		5 to 10 kgN/ha/yr critical load for soft water lakes; single study cited by WHO (1997a)			13 to 21 kgN/ha.yr single study for exceedence of NO_3 concentrations cited by WHO (1997a)
				15 to 20 kgN/ha/yr (WHO 1997a) critical load average value for ecosystems					

Values in **bold** are internationally agreed; values in *italic* have been selected as the basis for EALs ; other values are guidance.

NITROGEN OXIDES (NO_x)

Sources:

Air: Nitrogen oxides are released to the atmosphere as byproducts of nitrate decomposition. Combustion of fossil fuels in power plants and vehicles mainly produces nitric oxide but may also produce nitrogen dioxide. Nitrogen oxides are also released during the manufacture / use of nitric acid, explosives and in electroplating.

Nitrous oxide is released from anaerobic soil processes, the ocean surface layer and lightning.

Nitric oxide may derive from high temperature combustion processes.

Environment:

Guidance values for terrestrial habitats are expressed in terms of "critical levels" (the concentration in air leading to adverse effects) or "critical loads" (the deposition rate leading to adverse effects). Both values are based on exposure over a full year. A critical level of 30 μg/m^3 is based on fumigation experiments and converts to 5 to 10 kgN/ha/yr as a critical load. A range of critical load values has been derived from direct observation in the field for different ecosystems with actual deposition of nitrogen (see table below). Critical loads values derived this way cannot be used to calculate corresponding critical levels.

Ecosystem	Critical load	Indication
Mesotrophic fens	20-35[b]	increase in tall grasses; decline in diversity
Raised bogs	5-10[b]	decrease in *Sphagnum and subordinate species*
Calcareous grassland	14-19[a]	increase in tall grasses; decline in diversity
Neutral/acid grassland	20-30[b]	increase in tall grasses; decline in diversity
Montane grassland	10-15[c]	increase in tall grasses; decline in diversity
Lowland dry heath	15-20[a]	transition of heather to grass
Lowland wet heath	17-22[a]	transition of heather to grass
Heaths/acid grasslands	7-20[b]	decline in sensitive species
Coniferous trees	11->50[b]	nutrient imbalance
Deciduous trees	15-20[b]	nutrient imbalance
Acidic coniferous forest	15-20[b]	changes in ground flora
Acidic deciduous forest	15-20[b]	changes in ground flora
Calcareous forests	15-20[c]	changes in ground flora

[a]- reliable estimate; [b]- reasonably reliable estimate; [c]- best guess (WHO, 1997a)

Values for the most sensitive ecosystem studied are included together with an average value for ecosystems. All such studies have been based on effects on plants; there is little or no information on effects on animals. For No_x, the terrestrial receptor can be sub-divided into a range of habitats and critical load values applied (WHO, 1997a).

A value of >30 µg/m^3 is given for crops on the basis that the initial reaction of plants to low levels of NO_X deposition is increased growth. This would be a beneficial effect for crops. The concentration for onset of adverse effects has not been defined.

No guidance values have been set for aquatic freshwater or groundwater contamination. Critical load values for both of these receptors have been entered on the basis of single studies cited in the WHO (1997a) review and evaluation. This is the best available information.

It is highly likely that nitrogen deposition causes adverse effects in marine environments. Studies have concentrated on the Baltic Sea and Chesapeake Bay in the USA. Effects relate to both nitrogen and phosphate release into the marine environment. No concentration guidance values have yet been derived from these studies.

Nitrogen oxides (specifically N_2O) are greenhouse gases and participate in the formation of ozone and smogs at low levels of the atmosphere. The chemistry is complex and budgets for both the lower and upper atmosphere have been generated. However, because of the complex pattern of release into the environment, values in terms of emission and atmospheric effects have not been generated and the participation of released NO_2 in N_2O formation cannot be easily quantified. The calculated ozone creation potential relative to ethylene is given.

Time to onset:

Values cannot be placed on this parameter. The major initial effect of deposited nitrogen is as a nutrient. It would be expected that the effect would be progressive over time and field evidence supports this.

SCORE	MEDIUM TERM/CHRONIC

Severity:

Effects are severe with changes to natural ecosystems at the population and community level; species are eliminated from species-rich communities and replaced with those few species which respond well to high nutrient levels.

Distribution	INTERNATIONAL - SCORE 4
Degree of effect	COMMUNITY - SCORE 8
SCORE (multiplied)	32

Reversibility:

Reversibility has been estimated as long-term to very long term in most cases with some irreversible effects if physical breakdown (for example erosion) occurs with loss of critical species (WHO, 1997a). Timing - years to decades.

SCORE	LONG TERM / IRREVERSIBLE

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Ground water
OZONE	*2 µg/m³ annual exposure 100 µg/m³ 8 hr exposure (based on EPAQS) EALs (EA, 1997; DoE, 1994c)*	**0.4 mg/m³ 15 min STEL** **occupational exposure limit (HSE, 1997)**	n/a	10 ppm h (AOT40; accumulated exposure over a threshold of 40 ppb for 6 months) based on forest trees (UNECE, 1996) 200 µg/m³ 1 hr exposure; vegetation protection threshold (EA, 1997; EEC, 1992 statutory instrument 1994; no440) **SEVERITY SCORE 16 TO 24**	3000 ppb h (AOT40; accumulated exposure over a threshold of 40 ppb for 3 months) based on wheat (UNECE, 1996)	no information	no information	n/a	n/a

OZONE:

Human health:

The effect of ozone on humans is largely respiratory irritation following inhalation. The onset is acute but effects may persist longer than exposure.

Environment:

Ozone affects growth of plants adversely and guidance values are placed on this effect. Guidance concentrations are expressed in term of accumulated exposure above a threshold of 40 ppb over varying time periods. Monitoring is conducted at hourly intervals to calculate exposure. Exposure is only assessed during daylight hours when ozone is formed by photochemical oxidation.

Time of onset:

The effects of ozone are cumulative though exposure is not constant.

SCORE	SHORT-TERM TO CHRONIC

Severity:

Long term exposure would lead to regional or national population and community effects.

Distribution	REGIONAL - SCORE 2/ NATIONAL - SCORE 3
Degree of effect	COMMUNITY - SCORE 8
SCORE (multiplied)	16 TO 24

Reversibility:

Community effects are difficult to reverse in the short-term and may be irreversible. Timing - years to decades.

SCORE	LONG TERM

Receptors	HUMAN Outdoor air	Indoor air	Drinking water	BIOTA Terrestrial natural	Terrestrial crops	Aquatic freshwater	Aquatic marine	ABIOTIC Atmosphere	Groundwater
SULPHUR DIOXIDE	*267 µg/m³ 15 min exposure EAL (based on EPAQS) (EA, 1997)* **80 to 120 µg/m³ annual median of daily means 130 to 180 µg/m³ winter 250 to 350 µg/m³ 98th percentile of daily means (annual) (EA, 1997; EEC, 1980 statutory instrument 1989; no317)**	5.3 **mg/m³ 8 hr TWA 13 mg/m³ 15 min STEL** **occupational exposure limits (HSE, 1997)**		*10 µg/m³ annual mean critical level for lichens* *20 µg/m³ critical level for forests and natural vegetation* *(EA, 1997)*	*30 µg/m³ annual mean critical level for crops (EA, 1997)*				

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Definition of Receptors

General considerations

Receptors are resources which are susceptible to damage by one or more sources of hazard. For the concept to be useful, they must be amenable to being quantified in space and time, and mapped. They are not units of space, though their magnitude may be measured in units of space.

The recovery time, for a receptor to return to a state of being uninfluenced by the hazard, is a function of the receptor and the mode of action of the hazard. Sometimes, data are available for the period of recovery of normal status or functioning of individual organisms, following exposure to a hazard. For populations, the duration of effect may depend on the population dynamics, as well as the effect on individual members of the population. For example, if the hazard leads to death of a proportion of the population but leaves the rest unaffected, the recovery may be very different from that in a case where all individuals are affected sublethally. Local extinction of a species may be followed by rapid recolonisation from nearby populations and, consequently, rapid recovery. On the other hand, a population which suffers chronic, sublethal effects may resist colonisation, yet fail to reproduce.

At higher levels of organisation, such as communities or ecosystems, full recovery may be limited by the slowest-recovering component. As many communities are structured by competition or other interactions between species, there may be many possible routes and rates of recovery, dependent on which species are lost, when, and for how long.

If a species is extinguished completely from an area, opportunity for recolonisation may be more influential than rate of population growth in determining the time to recovery.

A scheme for identifying receptors

A structured list of receptors is given in Table 1. Receptors are first classified as terrestrial, aquatic or atmospheric. This division reflects the ways in which most standards are currently set. In practice, the environment cannot be compartmentalised so distinctly. For example, airborne contaminants may be deposited on land and water, and the quality of surface waters is influenced by catchment characteristics. Nevertheless, land, water and air represent a series of increasing potential for mobility and dilution which is pertinent to the risk assessment process.

For the purpose of this study:
1. **Land** extends to the high-water mark along coasts and estuaries.
2. **Water** includes groundwater, surface waters on the land, and coastal waters.
3. **Air** includes all parts of the atmosphere, which is a global resource.

These broad categories of resource are subdivided into smaller units which meet the criteria of being definable in space and time, having intrinsic value and being susceptible to damage. The nature of the value varies among receptors - some have overt commercial value, whereas others are valued primarily for aesthetic or other reasons. Receptors with commercial value, such as buildings or arable farmland, may be assigned a monetary value and ranked accordingly. Receptors whose value resides in their biodiversity or scenic beauty, for example, are not so readily ranked, either among themselves or against other types of receptor. One possible means of ranking receptors with "conservation value" is through designations (e.g. international > national > local). However, there is resistance within the conservation organisations to ranking receptors on this basis because the criteria for designation vary a great deal in breadth and stringency. Some designated areas are merely examples of more widely-occurring resources. Nevertheless, where designation confers a degree of protection in law, any strategy for protecting receptors from hazard should at least be consistent with legal requirements. For that reason alone, designated areas are listed.

Land

Urban areas are mapped at various scales by the OS and in the ITE Land Cover Map of Great Britain (Fuller *et al.* 1994). More detailed classifications of buildings and urban land are carried out by local authorities. The extent to which this information is digitised varies from one authority to another. Non-built land within urban areas might be classified using land cover maps.

Very little of England and Wales escapes any sort of management with an agricultural element. Land subject to low-intensity agriculture is sometimes considered to be of high conservation value, in which case it is difficult to allocate it to one category. In this case, the agricultural and non-agricultural categories are defined by the sum of their component parts.

Habitats and species are "natural" receptors. Some habitats are defined or recognised largely on the basis of their physical attributes (e.g. sand dunes and shingle beaches), others on the basis of component species. The terrestrial habitat types listed under 1.3.2 are derived from the ITE Land Cover Map of Great Britain and the occurrence of indicative groups of species (Osborn *et al.,* 1997).

As in the case of designated areas with statutory protection, protected species ought not to be put at risk as a result of any strategy for prioritising effort on environmental protection. Therefore, the distributions of protected species ought to be of special concern. This should not divert attention from non-protected species. Particular assemblages of otherwise unremarkable species are sometimes valued highly.

Water

Fresh waters are divided into surface waters and groundwater, owing to the profound difference in biota. Both may be sources of potable water supplies. River flow is recorded in >1000 stations in England and Wales daily, using permanent gauging structures. General Quality Assessments of surface waters include chemical, biological and aesthetic quality, plus nutrient status. River Habitat Surveys were carried out at 4500 sites during 1994-96.

Estuarine waters have distinctive physico-chemical attributes and species which distinguish them from freshwater or marine systems, though they occur at the boundary between the latter.

Marine habitats (listed under 2.4.2) are relatively distinct and coastal habitats, in particular, are well-characterised by tidal zones. There were 433 designated bathing beaches in England and Wales in 1996.

Air

The atmosphere is a medium for the transport, dispersal and dilution of potentially hazardous materials. Its physical properties are also important in determining the radiative environment and the climate.

The focus on the troposphere (up to 10 km) and stratosphere (up to 50 km) reflects concern for (a) air quality at ground level and (b) increased penetration of UV-B radiation due to ozone depletion.

Radiative forcing refers to enhancement of the greenhouse effect by emissions of so-called greenhouse gases (carbon dioxide, methane, nitrous oxide, CFCs, etc.), a probable cause of climate change.

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Fuller, R.M., Groom, G.B. & Jones, A.R. 1994. The Land Cover Map of Great Britain: an automated classification of Landsat Thematic Mapper data. Photogrammetric Engineering & Remote Sensing. 60, 553-562.

Osborn, D., Roy, D., Hankard, P., Treweek, J.R., Eversham, B. & Manchester, S.J. 1997. The Comparative Environment Index: a handbook of information requirements and a protocol. ITE Report to the Department of the Environment. 61 pp.

Table 1. Receptors and availability of data

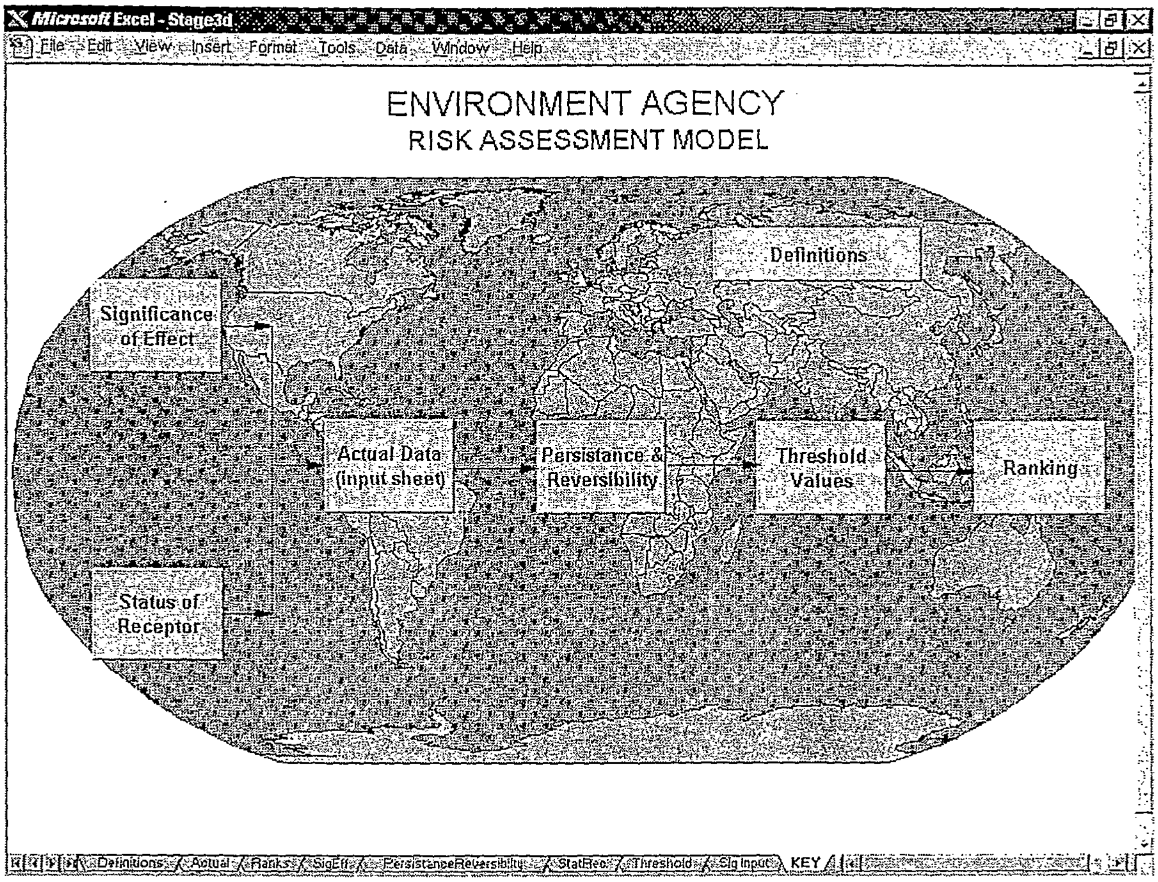
Receptor			Type of data	Digital data ?	Data source	Data in CIS ?
1. Land						
1.1 Urban			Land Cover Map of GB, Land Cover of Scotland, 1:250,000 Strategi data.	YES	ITE, MLURI, OS	YES
	1.1.1 Buildings				H.M. Land Registry	
		1.1.1.1 Residential	Population Census	YES	Office for National Statistics	NO
		1.1.1.2 Commercial	Population Census	YES	Office for National Statistics	NO
		1.1.1.3 Listed buildings			English Heritage, Local Authorities	NO
	1.1.2 Amenity land		Land Cover Map of GB, Land Cover of Scotland, Countryside Survey, 1:250,000 Strategi data	YES	ITE, MLURI, OS	YES
		1.1.2.1 Gardens	Countryside Survey, OS maps	YES	ITE, OS	?
		1.1.2.2 Parks	Countryside Survey, OS maps	YES	ITE, OS	?
		1.1.2.3 Woodland	Countryside Survey, OS maps, Land Cover Map of GB, Land Cover of Scotland	YES	ITE, MLURI, OS	YES
		1.1.2.4 Protected trees (TPO)		?	Local Authorities	NO
	1.1.3 Transport					
		1.1.3.1 Roads	Countryside Survey, 1:250,000 Strategi data	YES	ITE, OS	YES
		1.1.3.2 Railways	Countryside Survey, 1:250,000 Strategi data, Land Cover Map of GB, Land Cover of Scotland	YES	ITE, MLURI, OS	YES
		1.1.3.3 Airports			Civil Aviation Authority	NO
		1.1.3.4 Docks			Associated British Ports & Harbour Authorities	NO
1.2 Agricultural						
	1.2.1 Cultivated land		Land Cover Map of GB, Land Cover of Scotland, Countryside Survey	YES	ITE, MLURI	YES
		1.2.1.1 Agricultural grades	MAFF Agricultural Land Classes (5 major classes, plus sub-classes), 1:25,000	YES	FRCA, Local Authorities	NO
		1.2.1.2 Soil types	Various categories	YES	SSLRC	NO
	1.2.2 Grazed land		Land Cover Map of GB, Land Cover of Scotland, Countryside Survey	YES	ITE, MLURI	YES
		1.2.2.1 Agricultural grades	MAFF Agricultural Land Classes	YES	MAFF, FRCA	NO

		1.2.2.2 Soil types	Various categories	YES	SSLRC	NO
	1.2.3 Woodland		Land Cover Map of GB, Land Cover of Scotland, Countryside Survey	YES	ITE, MLURI, Forestry Authority	YES
		1.2.3.1 Farm woodland	Ditto	YES	Ditto	YES
		1.2.3.2 Forestry	Ditto	YES	Ditto	YES
		1.2.3.3 Hedgerows	Ditto	YES	Ditto	YES
	1.2.4 Crops		Countryside Survey	YES	ITE, MAFF, FRCA	YES
		1.2.4.1 Seasonal (e.g. cereals)	Countryside Survey	YES	ITE, MAFF, FRCA	YES
		1.2.4.2 Perennial (e.g. orchards)	Countryside Survey	YES	ITE, MAFF, FRCA	YES
	1.2.5 Livestock				MAFF, FRCA	NO
		1.2.4.1 Indoor			MAFF, FRCA	NO
		1.2.4.2 Outdoor			MAFF, FRCA	NO
1.3 Non-agricultural						
	1.3.1 Designated areas					
			Ramsar sites, SPA, SAC, NNR, SSSI, ESA, AONB, National Parks, Heritage Coast, Community Forests, Nitrate Areas, Natural Areas (England), Countryside Character Areas (England)	YES	EN, CCW, SNH, DETR, EA, FRCA, Countryside Commission, RSPB, English Heritage, MAFF, National Parks Authorities	YES
			Biosphere Reserves, World Heritage Sites, RSPB reserves, MNR, Forest Nature Reserves, Country Parks, Wildlife Trust NR, Urban Conservation Areas, Green Belts, LNR, Woodland Trust reserves, Nature Conservation Review Sites, Geological Conservation Review Sites, Limestone Pavement Areas, Norfolk Broads, New Forest, Heritage Coasts, Ancient Monuments	SOME	EN, CCW, SNH, Wildlife Trusts, Woodland Trust, Forestry Authority, Local Authorities, RSPB	NO
	1.3.2 Habitats		Phase 1 Surveys, Countryside Survey, Key Habitats, Habitat Quality, Habitat Potential Map, Land Cover Map of GB, Land Cover of Scotland	YES	ITE, SSLRC, EA, EN, CCW, SNH	SOME
		1.3.2.1 Chalk grassland	Ditto	YES	Ditto	YES
		1.3.2.2 Neutral grassland	Ditto	YES	Ditto	YES
		1.3.2.3 Acid grassland	Ditto	YES	Ditto	YES

		1.3.2.4 Sub-alpine grassland	Ditto	YES	Ditto	YES
		1.3.2.5 Lowland heath	Ditto	YES	Ditto	YES
		1.3.2.6 Broad-leaved woodland	Ditto	YES	Ditto	YES
		1.3.2.7 Coniferous woodland	Ditto	YES	Ditto	YES
		1.3.2.8 Moorland	Ditto	YES	Ditto	YES
		1.3.2.9 Raised and blanket bog	Ditto	YES	Ditto	YES
		1.3.2.10 Fens	Ditto	YES	Ditto	YES
		1.3.2.11 Saltmarsh	Ditto	YES	Ditto	YES
		1.3.2.12 Sand dunes, shingle beaches	*Ditto*	YES	Ditto	NO
	1.3.3 Protected species			YES	BRC, JNCC, EN, CCW, SNH, RSPB, BTO, LRC	SOME
	1.3.4 Other species			YES	BRC, JNCC, EN, CCW, SNH, RSPB, BTO, LRC	SOME
2. Water						
2.1 Surface waters			Countryside Survey, Land Cover Map of GB, Land Cover of Scotland	YES	ITE, MLURI	YES
	2.1.1 Potable water sources					
		2.1.1.1 Reservoirs			Water Companies	NO
		2.1.1.2 Rivers (points of abstraction)		YES	IH, EA	NO
	2.1.2 Habitats					
		2.1.2.1 Rivers	River Habitat Survey	YES	EA, IFE	NO
		Quality categories	Environmental Quality Indices, SERCON		EA, IFE, SNH	NO
		2.1.2.2 Streams	Environmental Quality Indices, SERCON	YES	EA, IFE, SNH	NO
		2.1.2.3 Lakes			IFE, EN, CCW, SNH, EA	NO
		2.1.2.3.1 Oligotrophic				
		2.1.2.3.2 Dystrophic				
		2.1.2.3.3 Eutrophic				
		2.1.2.4 Ponds	Countryside Survey 1990, Lowland Pond Survey 1996		ITE, DETR	
		2.1.2.5 Canals			British Waterways	
	2.1.3 Protected species		Invertebrate Site Register	YES	BRC, JNCC, EN, CCW, SNH, IFE, LRC	SOME
	2.1.4 Other species		*Invertebrate Site Register*	YES	BRC, JNCC, EN, CCW, SNH, IFE,	*SOME*

					LRC	
2.2 Ground water			Groundwater Protection Zones		EA, IH, BGS	
	2.2.1 Sandstone					
	2.2.2 Limestone					
	2.2.3 Chalk					
2.3 Estuarine			Land Cover Map of GB, Land Cover of Scotland, Countryside Survey	YES	ITE, MLURI	YES
	2.3.1 Habitats				EA	NO
	2.3.2 Protected species					NO
	2.3.3 Other species					NO
2.4 Marine						
	2.4.1 Amenity (bathing)				Local Authorities, EA	NO
	2.4.2 Habitats					
		2.4.2.1 Saline lagoons	Land Cover Map of GB, Land Cover of Scotland, Countryside Survey	SOME	BGS, EN, CCW, SNH, PML	NO
		2.4.2.2 Intertidal hard substrata	Ditto	Ditto	Ditto	NO
		2.4.2.3 Intertidal sediment	Ditto	Ditto	Ditto	NO
		2.4.2.4 Sublittoral hard substrata	Ditto	Ditto	Ditto	NO
		2.4.2.5 Inshore sublittoral sediment	Ditto	Ditto	Ditto	NO
		2.4.2.6 Offshore sediment	Ditto	Ditto	Ditto	NO
		2.4.2.7 Coastal waters	Ditto	Ditto	Ditto	NO
	2.4.3 Protected species		Ditto	Ditto	Ditto	NO
	2.4.4 Other species		Ditto	Ditto	Ditto	NO
3. Air						
3.1 Troposphere			Air quality, emissions & deposition data; *exceedances* of UK targets	YES	DETR, EA, AEA NETCEN (http://www.aeat.co.uk/netcen/airqual/)	NO
	3.1.1 Indoor air					
	3.1.2 Outdoor air		N_2O at 1km resolution over UK		AEA NETCEN (http://www.aeat.co.uk/netcen/airqual/)	
3.2 Stratosphere					DETR	NO
	3.2.1 Ozone				AEA NETCEN (http://www.aeat.co.uk/netcen/airqual/)	
3.3 Radiative forcing					DETR	NO

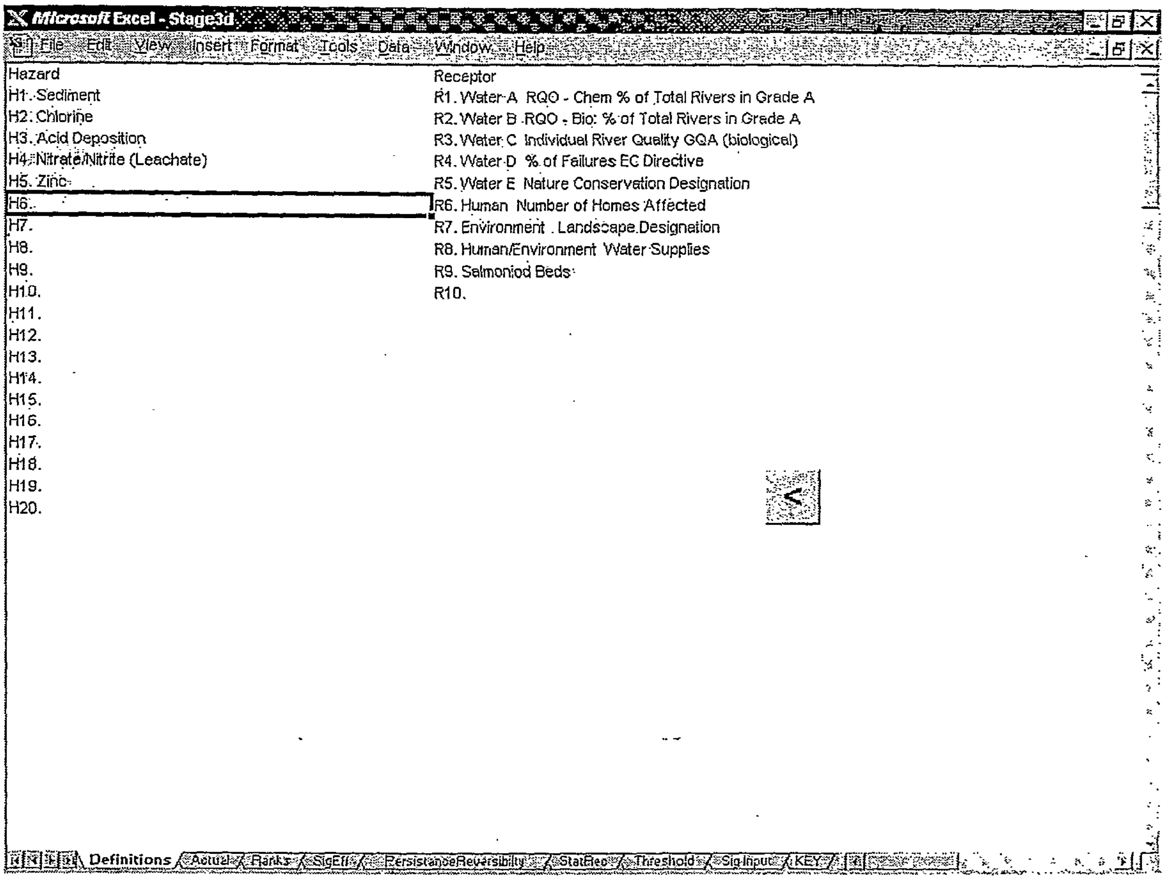
Abbreviations: AEA NETCEN = Atomic Energy Authority National Environmental Technology Centre; AONB = Area of Outstanding Natural Beauty; BGS = British Geological Survey; BRC = Biological Records Centre; BTO = British Trust for Ornithology; CCW = Countryside Council for Wales; CIS = Countryside Information System; DETR = Department of the Environment, Transport and the Regions; EA = Environment Agency; EN = English Nature; FRCA = Farming and Rural Conservation Agency; IFE = Institute of Freshwater Ecology; IH = Institute of Hydrology; ITE = Institute of Terrestrial Ecology; JNCC = Joint Nature Conservation Committee; LCMGB = Land Cover Map of Great Britain; LNR = Local Nature Reserve, ESA = Environmentally Sensitive Area; LRC = Local Recording Centres; MAFF = Ministry of Agriculture, Fisheries and Food; MNR = Marine Nature Reserve; OS = Ordnance Survey; PML = Plymouth Marine Laboratory; RSPB = Royal Society for the Protection of Birds; SAC = Special Area for Conservation; SNH = Scottish Natural Heritage; SPA = Special Protection Area; SSLRC = Soil Survey and Land Research Centre; SSSI = Site of Special Scientific Interest.



On start up the model displays the above navigation screen which uses buttons to access the individual spreadsheets which present the input and results of the modelling. Inputs can be made on the Description, Hazard Definition, Receptor Definition and Weighting sheets and results of calculation are shown on the Exposure, Level of Harm and Results and Ranking sheets. The arrows represent the flow of information which the model uses to build the final ranking table of risks for Source vs Receptor.

It should be noted that the system is not intended to be a bomb/fool proof piece of software but efforts have been made to make it as friendly as possible for a novice spreadsheet user. If cells are deleted or added or moved it is quite possible that the results table may be corrupted.

On the following sheets and in the model all input cells are shown in yellow. The input cells can be cleared or overwritten but should not be moved or deleted as this could result in failures of formulas or macros in any part of the spreadsheet system.

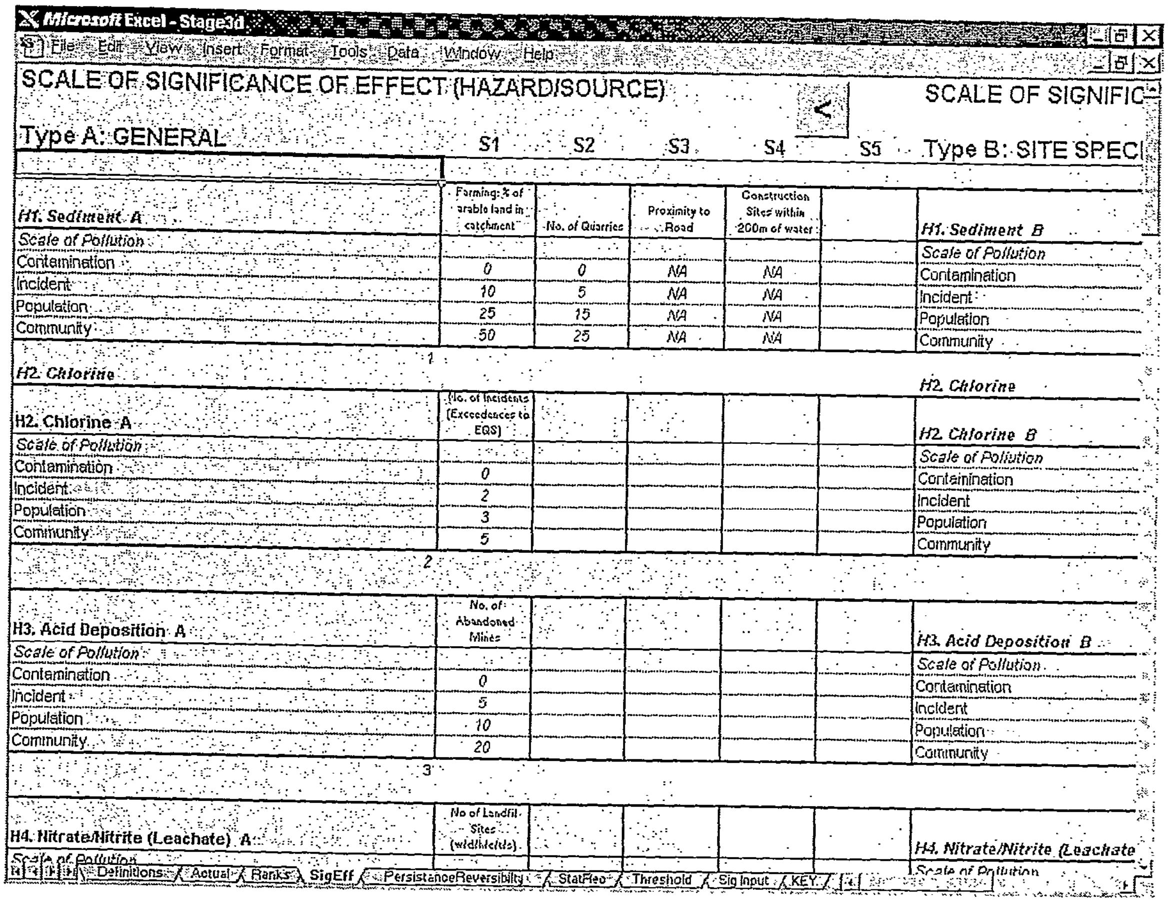


The "Definitions" sheet can be accessed either from the navigation sheet or from the sheet tabs displayed along the bottom of each screen. This describes the Hazards and Receptors under analysis.

The prototype system has initially been set to accommodate 20 Hazards and 10 Receptors which has been driven by the information that can be reasonably shown on single screens. Furthermore it was considered that this number of hazards and receptors is adequate for most reasonable analyses. As previously mentioned additions or deletions to this baseline requires the usual careful consideration when altering linked spreadsheets. The macros in the system would also need to be edited. It is therefore not advisable to delete or add Hazards or Receptors from or to the prototype unless absolutely necessary.

Columns and Rows can be easily hidden to improve presentation if required by using the Excel Format Menu.

The spreadsheet will automatically update the descriptions of hazards and receptors on all the other spreadsheets. The exit button {<} returns the User to the navigation screen.



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SCALE OF SIGNIFICANCE OF EFFECT (HAZARD/SOURCE) — SCALE OF SIGNIFIC

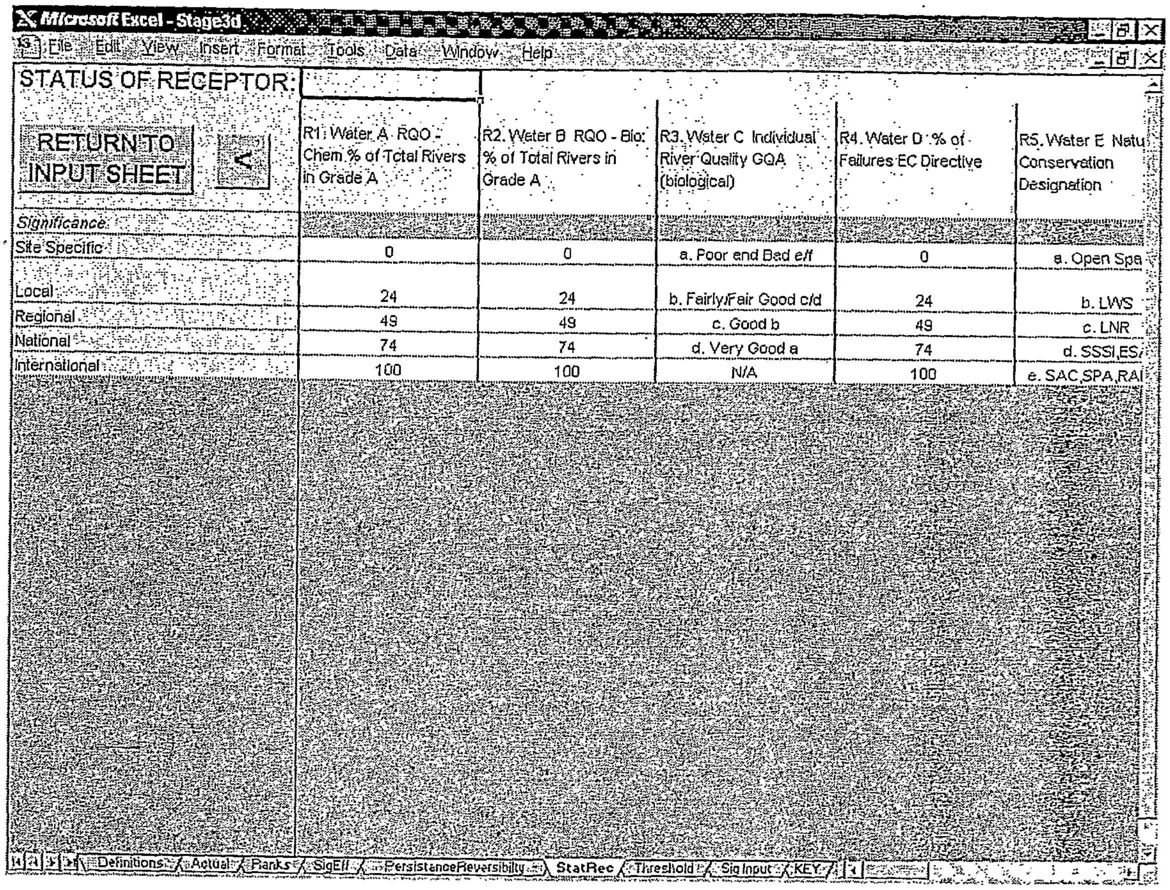
Type A: GENERAL	S1	S2	S3	S4	S5	Type B: SITE SPEC
H1. Sediment A	Farming: % of arable land in catchment	No. of Quarries	Proximity to Road	Construction Sites within 200m of water		H1. Sediment B
Scale of Pollution						Scale of Pollution
Contamination	0	0	NA	NA		Contamination
Incident	10	5	NA	NA		Incident
Population	25	15	NA	NA		Population
Community	50	25	NA	NA		Community
1						
H2. Chlorine						H2. Chlorine
H2. Chlorine A	No. of Incidents (Exceedences to EQS)					H2. Chlorine B
Scale of Pollution						Scale of Pollution
Contamination	0					Contamination
Incident	2					Incident
Population	3					Population
Community	5					Community
2						
H3. Acid Deposition A	No. of Abandoned Mines					H3. Acid Deposition B
Scale of Pollution						Scale of Pollution
Contamination	0					Contamination
Incident	5					Incident
Population	10					Population
Community	20					Community
3						
H4. Nitrate/Nitrite (Leachate) A	No of Landfil Sites (w/d/h/c/d/s)					H4. Nitrate/Nitrite (Leachate
Scale of Pollution						Scale of Pollution

Definitions / Actual / Ranks / SigEff / PersistanceReversibilty / StatReo / Threshold / Sig Input / KEY

The "Significance of Effect" sheet can be accessed either from the navigation sheet or from the sheet tabs displayed along the bottom of each screen. The sheet holds the data in the form of lookup tables which the system uses to assign a significance of effect score given an actual reading entered into the model. These inputs are described at the table at *(3 pages on from here)*.

The model operates by comparing measured data against lookup tables to calculate a risk level. The lookup tables relating to the source/hazard return a significance of effect index of Contamination {=1}, Incident {=2}, Population {=4} or Community {=8} (see para ??).

The lookup values should be populated with single entries giving the **top end** of the band of source proliferation which results in a significance of effect of the above categories. There are two lookup tables for each hazard. The first, *Type A*, relates to general pollution of the environment caused by the hazard for the area under consideration whereas the second table, *Type B* (positioned to the right of the Type A table), can be used for site specific sources of the hazard. The user is able to set up these tables to between 1 and 5 measurement types (S1 to S5) which should be sufficient to cover any analysis.



Significance	R1. Water A RQO - Chem % of Total Rivers in Grade A	R2. Water B RQO - Bio: % of Total Rivers in Grade A	R3. Water C Individual River Quality GQA (biological)	R4. Water D % of Failures EC Directive	R5. Water E Natu Conservation Designation
Site Specific	0	0	a. Poor and Bad e/f	0	a. Open Spa
Local	24	24	b. Fairly/Fair Good c/d	24	b. LWS
Regional	49	49	c. Good b	49	c. LNR
National	74	74	d. Very Good a	74	d. SSSI,ES/
International	100	100	N/A	100	e. SAC,SPA,RAI

The "Status of Receptor" sheet can be accessed either from the navigation sheet or from the sheet tabs displayed along the bottom of each screen. This sheet holds lookup tables relating to the defined receptors and returns a status of receptor index of Site Specific {=1}, Local {=2}, Regional {=3}, National {=4} or International {=5}.

As with the Significance of Effect tables these lookup values should be populated with single entries giving the **top end** of the band of receptor measurement which results in a Status of Receptor defined by the above categories. These lookup tables are found to the left of the sheet. Once they have been set up the user should scroll across to the right until a single column of one receptors lookup values can be seen. This column should not be tampered with. It is used by one of the macros to temporarily hold data for presentation to the user, while using the Actual data input sheet and is regularly overwritten.

As the model matures it is hoped that the lookup tables for Status of Receptor will become standard and fixed and will therefore not require setting up before the model can be used.

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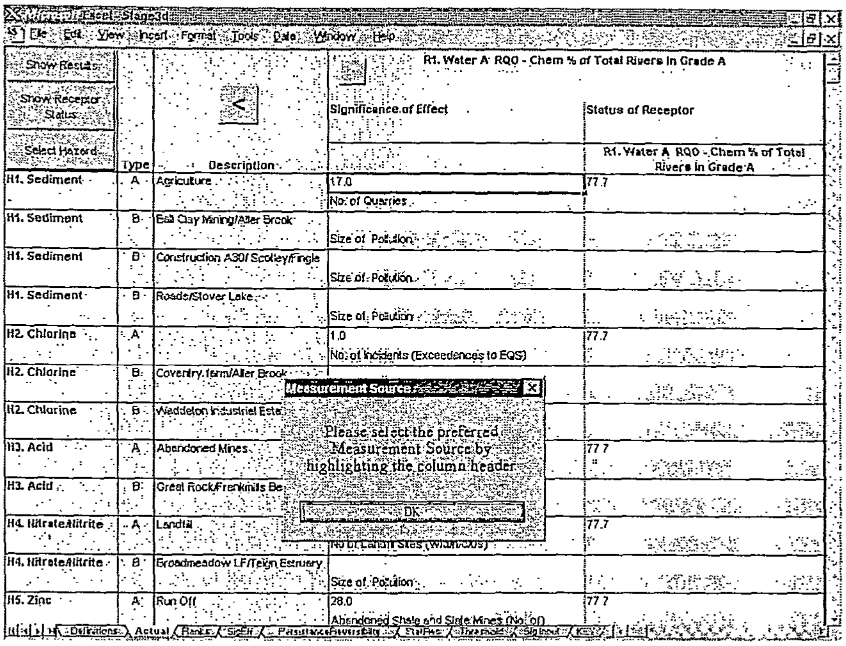
Show Results | Show Receptor Status | Select Hazard | <

	Type	Description	R1. Water A RQO - Chem % of Total Rivers in Grade A Significance of Effect	Status of Receptor R1. Water A RQO - Chem % of Total Rivers in Grade A
H1. Sediment	A	Agriculture	17.0 No. of Quarries	77.7
H1. Sediment	B	Ball Clay Mining/Aller Brook	Size of Pollution	
H1. Sediment	B	Construction A30/ Scotley/Fingle	Size of Pollution	
H1. Sediment	B	Roads/Stover Lake	Size of Pollution	
H2. Chlorine	A		1.0 No. of Incidents (Exceedences to EQS)	77.7
H2. Chlorine	B	Coventry farm/Aller Brook	Size of Pollution	
H2. Chlorine	B	Waddeton Industrial Estate/G	Size of Pollution	
H3. Acid	A	Abandoned Mines	58.0 No. of Abandoned Mines	77.7
H3. Acid	B	Great Rock/Frankmills Beadon	Size of Pollution	
H4. Nitrate/Nitrite	A	Landfill	2.0 No. of Landfill Sites (w/d/n/c/t/s)	77.7
H4. Nitrate/Nitrite	B	Broadmeadow LF/Teign Estruary	Size of Pollution	
H5. Zinc	A	Run Off	28.0 Abandoned Shale and Slate Mines (No. of)	77.7

Definitions / Actual / Ranks / SigEff / PersistanceReversibility / StatRec / Threshold / Sig Input / KEY

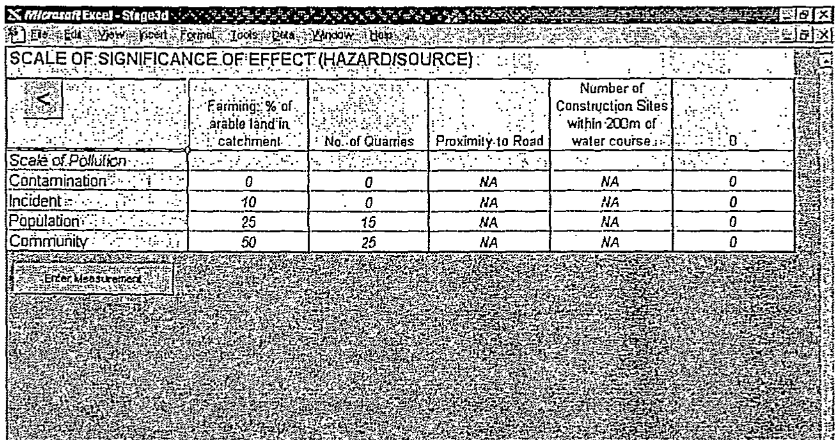
The Actual data input sheet can be accessed either from the navigation sheet or from the sheet tabs displayed along the bottom of each screen. The sheet holds the values against which the Significance of Effect and Status of Receptor lookup tables operate. This sheet is the control sheet for most of the user input tasks.

The first task is to set the hazards in the left hand column. As stated there can be up to 20 hazards entered but there can be multiple entries against each hazard type. For instance there are four entries against sedimentation in the example shown. To set up a hazard position the cursor box at the top of one of the entry fields and click the 'Select Hazard' Button with the mouse. A pick list then appears showing the hazards entered on the Definitions sheet. Choose a hazard from the list and then click the type A or B box to indicate whether it is a "general" or "site Specific" hazard. This will define which Significance of Effect lookup table will be used for this hazard. Note that hazards should always be input in this way rather than typing in hazards as a macro runs when the button is clicked to set up special parameters on the spreadsheet.

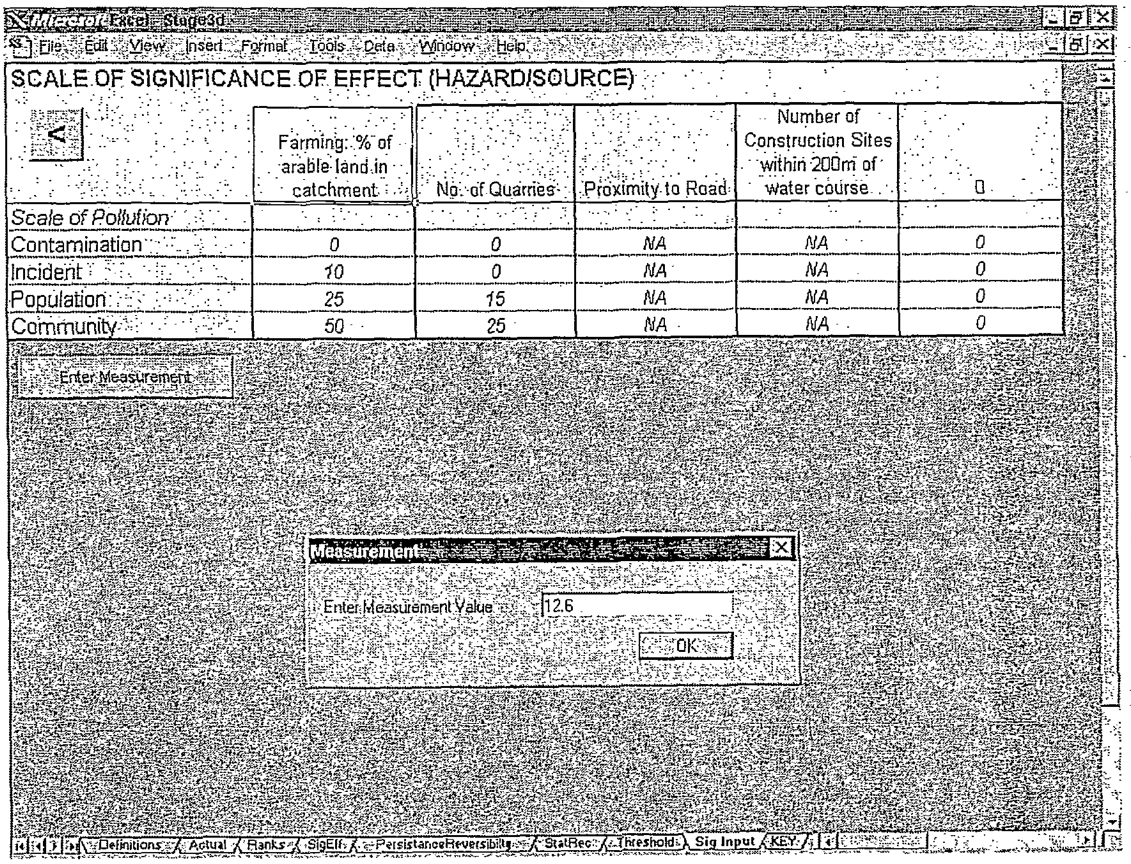


The remaining tasks are to input he actual hazard and receptor data into the yellow input fields. The receptors are automatically displayed along the spreadsheet and can be viewed by using the horizontal scroll bar. For each receptor hazard combination where there is a Hazard/Receptor interaction, input the actual data using the following procedure.

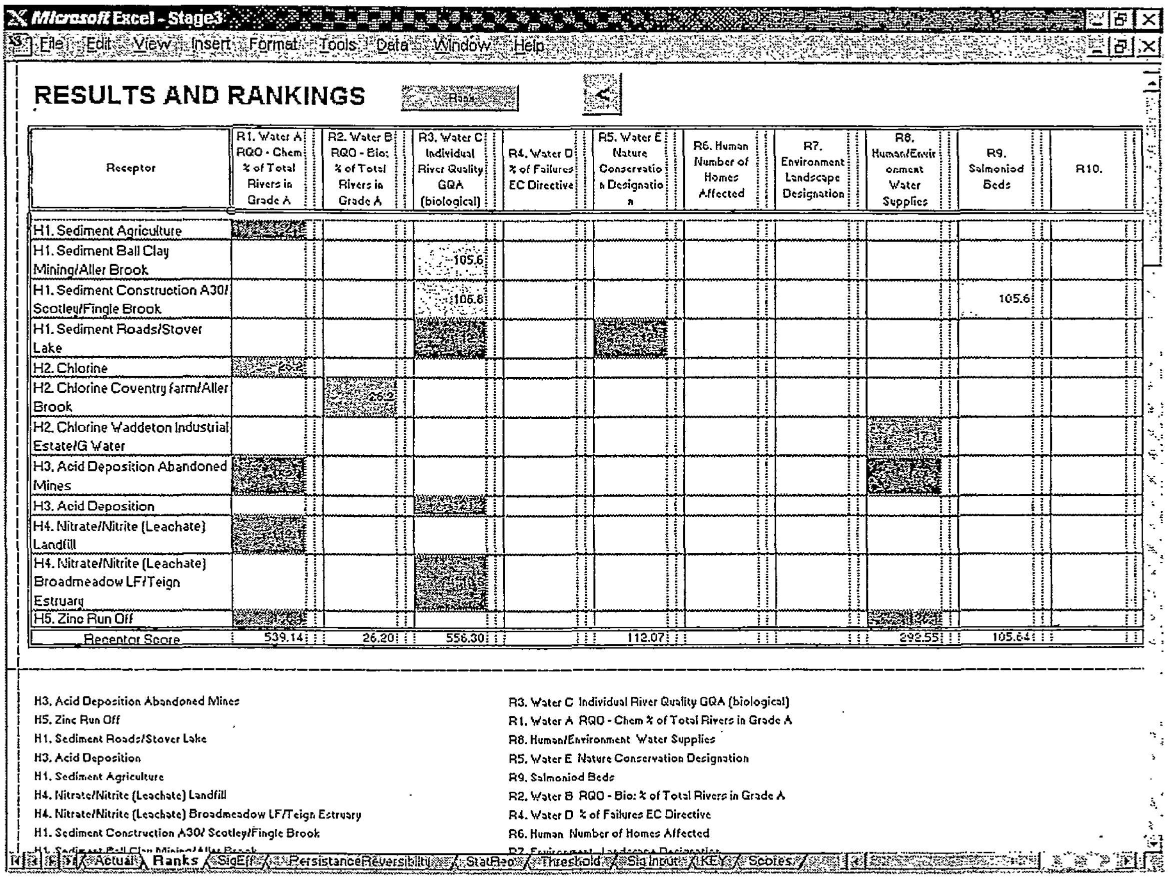
1) Select the Significance of Effect input box and click the small square button at the top of the page. The message box shown above will then appear. On clicking OK the system will present the user with the Significance of Effect lookup table determined by the hazard chosen. An example is given below.



The user should then chose the source type which fits the current scenario by placing the cursor box over the appropriate column heading. Next, click the Enter Measurement button and a small input box appears ready for data input.



Enter the actual data value and click OK. A macro will then run to set the appropriate values in the spreadsheet and return the user to the input sheet. Note that it is not possible to edit the lookup tables from this view. This can only be achieved using the procedure described earlier (i.e. on the Significance of Effect worksheet). This procedure must be used rather than just entering data onto the input sheet as other hidden parameters need to be set in order that the look functions operate correctly.



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RESULTS AND RANKINGS

Receptor	R1. Water A RQO - Chem % of Total Rivers in Grade A	R2. Water B RQO - Bio: % of Total Rivers in Grade A	R3. Water C Individual River Quality GQA (biological)	R4. Water D % of Failures EC Directive	R5. Water E Nature Conservation Designation	R6. Human Number of Homes Affected	R7. Environment Landscape Designation	R8. Human/Environment Water Supplies	R9. Salmoniod Beds	R10.
H1. Sediment Agriculture	[illegible]									
H1. Sediment Ball Clay Mining/Aller Brook			105.6							
H1. Sediment Construction A30/ Scotley/Fingle Brook			106.8						105.6	
H1. Sediment Roads/Stover Lake			[illegible]		[illegible]					
H2. Chlorine	[illegible]									
H2. Chlorine Coventry farm/Aller Brook		26.2								
H2. Chlorine Waddeton Industrial Estate/G Water								17.1		
H3. Acid Deposition Abandoned Mines	[illegible]							[illegible]		
H3. Acid Deposition			[illegible]							
H4. Nitrate/Nitrite (Leachate) Landfill	[illegible]									
H4. Nitrate/Nitrite (Leachate) Broadmeadow LF/Teign Estruary			[illegible]							
H5. Zinc Run Off	[illegible]							[illegible]		
Receptor Score	539.14	26.20	556.30		112.07			292.55	105.64	

H3. Acid Deposition Abandoned Mines
H5. Zinc Run Off
H1. Sediment Roads/Stover Lake
H3. Acid Deposition
H1. Sediment Agriculture
H4. Nitrate/Nitrite (Leachate) Landfill
H4. Nitrate/Nitrite (Leachate) Broadmeadow LF/Teign Estruary
H1. Sediment Construction A30/ Scotley/Fingle Brook

R3. Water C Individual River Quality GQA (biological)
R1. Water A RQO - Chem % of Total Rivers in Grade A
R8. Human/Environment Water Supplies
R5. Water E Nature Conservation Designation
R9. Salmoniod Beds
R2. Water B RQO - Bio: % of Total Rivers in Grade A
R4. Water D % of Failures EC Directive
R6. Human Number of Homes Affected

Actual | Ranks | SigEff | PersistanceReversibility | StatReo | Threshold | Sig Input | KEY | Scores

The "Results and Ranking" sheet gives a score which reflects the risk level. This can vary between 0 and 200. When the User opens the Ranking sheet from the navigation sheet, the risk level scores are colour coded with either Red, Yellow or Green to indicate unacceptable high {>110}, warning {90-110}or low risk {<90}priorities.

The screen also calculates a score for each Hazard and Receptor by summing the individual marks for the Hazard/Receptor combinations. These are then used to produced a sorted list ranking each hazard and each receptor which is displayed at the bottom of the screen. If the sheet is entered using the sheet tabs at the bottom of the screens then this will not be carried out until the Rank button is clicked. There are a number of different methods of calculating the scores for hazard and receptor which the user could choose by changing the summation formula in the current score cells if necessary. The ranked lists are produced when the screen is entered from the navigation screen, the Actual data input screen button or the Ranks button is clicked. Note that if the sheet is entered using the sheet tabs at the bottom of the screens then this will not be carried out until the Rank button is clicked.

The Persistence and Reversibility sheet can be accessed either from the navigation sheet or from the sheet tabs displayed along the bottom of each screen. This sheet holds the final lookup table giving persistence indices of Acute {=1}, Short Term{=2}, Long Term {=3} and Chronic {=4} and reversibility indexes of Readily Reversible {=1}, Medium Term {=2}, Long Term {=3} and Irreversible {=4} are available against. These indices are assigned for each Hazard/Receptor combination.

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	R1. Water A RQO - Chem % of Total Rivers in Grade A		R2. Water B RQO - Bio % of Total Rivers in Grade A		R3. Water C Individual River Quality GQA (biological)		R4 Water EC
	Persistence	Reversibility	Persistence	Reversibility	Persistence	Reversibility	Persistence
H1. Sediment	3	2	3	2	3	2	
H2. Chlorine	1	1	1	1	1	1	
H3. Acid Deposition	3	3	3	3	3	3	
H4 Nitrate/Nitrite (Leachate)	3	2	3	2	3	2	
H5 Zinc	2	4	2	4	2	4	
H6.	3	3	3	3	3	3	
H7.	3	3	3	3	3	3	
H8.	3	3	3	3	3	3	
H9.	3	3	3	3	3	3	
H10.	3	3	3	3	3	3	
H11.	3	3	3	3	3	3	
H12	3	3	3	3	3	3	
H13	3	3	3	3	3	3	
H14.	1	1	3	3	3	3	
H15.	3	3	3	3	3	3	
H16.	3	3	3	3	3	3	

Definitions / Actual / Ranks / Scell / PersistanceReversibilty / StatRec / Threshold / SiOut / KEY

The model also requires that a set of threshold values be input to be used to weight the result. These are state the maximum index applicable to each hazard and are shown below. Additionally the values at the foot of the table indicating minimum, acceptable and maximum scores is required to perform a scaling calculation to ensure that the results come out between 0 and 200.

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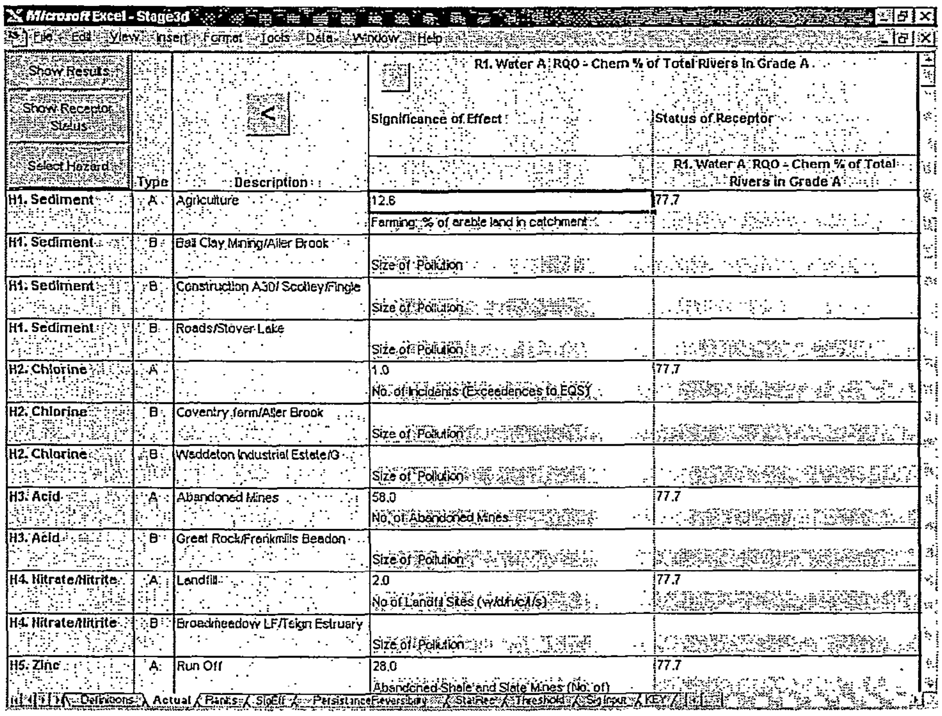
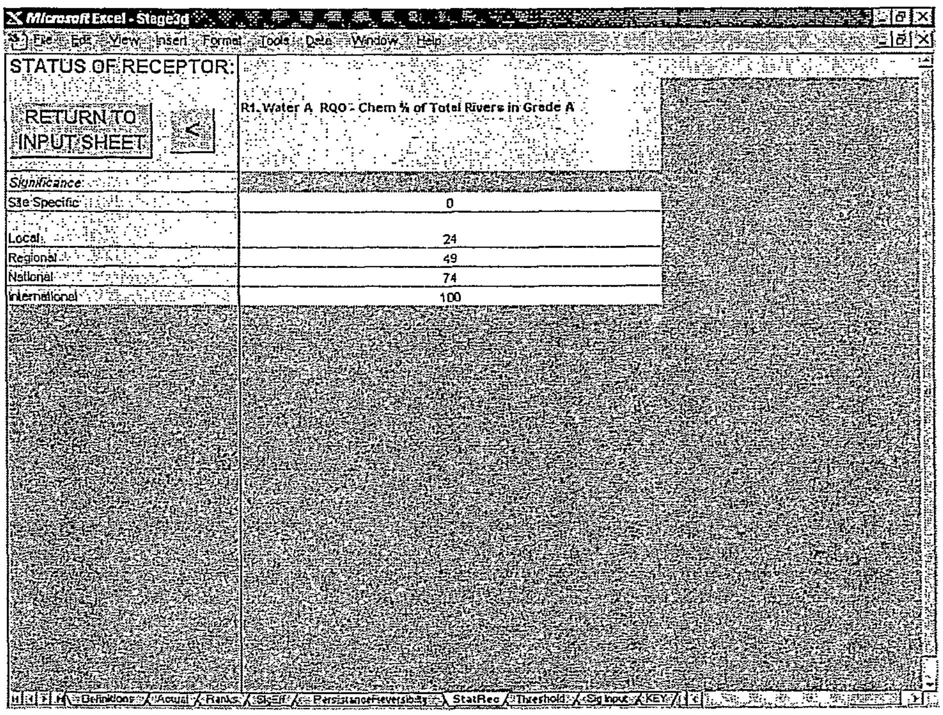
THRESHOLD VALUES	Significance of Effect	Status of Receptor	Persistence in Media	Reversibility
	a	b	c	d
H1. Sediment	3	2	3	2
H2. Chlorine	2	1	1	1
H3. Acid Deposition	4	4	3	3
H4. Nitrate/Nitrite (Leachate)	3	2	3	2
H5. Zinc	8	1	2	4
H6.	0	0	0	0
H7.	0	0	0	0
H8.	0	0	0	0
H9.	0	0	0	0
H10.	0	0	0	0
H11.	0	0	0	0
H12.	0	0	0	0
H13.	0	0	0	0
H14.	0	0	0	0
H15.	0	0	0	0
H16.	0	0	0	0
H17.	0	0	0	0
H18.	0	0	0	0
H19.	0	0	0	0
H20.	0	0	0	0
Max Potential Threshold	8	5	4	4
Level of Harm	4	2	1	1
Min Potential Threshold	1	1	1	1

Definitions / Actual / Ranks / Scell / PersistanceReversibility / StatRec / Threshold / SiOut / KEY

2) Once the Source/Hazard data has been input the Status of Receptor input box can be filled in. The user can type the actual value directly into the input sheet.



The lookup table can be viewed by clicking the Show Receptor Status button and ensuring that the right-hand column is viewed in the Status of Receptor sheet.



SCALE OF SIGNIFICANCE OF EFFECT (HAZARD/SOURCE)

Type A: GENERAL

	S1	S2	S3	S4	S5
H1. Sediment A	Farming: % of arable land in catchment	No. of Quarries	Proximity to Road	Number of Construction Sites within 200m	
Scale of Pollution					
Contamination	*0*	*0*	*NA*	*NA*	
Incident	*10*	*5*	*NA*	*NA*	
Population	*25*	*15*	*NA*	*NA*	
Community	*50*	*25*	*NA*	*NA*	
1					
H2. Chlorine					
H2. Chlorine A	No. of Incidents (Exceedences to EQS)				
Scale of Pollution					
Contamination	*0*				
Incident	*2*				
Population	*3*				
Community	*5*				
2					
H3. Acid Deposition A	No. of Abandoned Mines				
Scale of Pollution					
Contamination	*0*				
Incident	*5*				
Population	*10*				
Community	*20*				
3					
H4. Nitrate/Nitrite (Leachate) A	No of Landfill Sites (w/dh/ct/s)				
Scale of Pollution					
Contamination	*0*				
Incident	*2*				
Population	*4*				
Community	*5*				
4					
H5. Zinc A	Abandoned Shale and Slate Mines (No. of)				
Scale of Pollution					
Contamination	*0*				
Incident	*10*				
Population	*20*				

SCALE OF SIGNIFICANCE OF EFFECT (HAZARD/SOURCE)

Type B: SITE SPECIFIC

	S1	S2	S3
H1. Sediment B	Size of Pollution	No. of Quarries 2	Proximity to Road
Scale of Pollution			
Contamination	*a. Small*	*5*	*NA*
Incident	*b. Medium*	*15*	*NA*
Population	*c. Large*	*25*	*NA*
Community	*NA*	*50*	*NA*
1			
H2. Chlorine			
H2. Chlorine B	Size of Pollution		
Scale of Pollution			
Contamination	*a. Small*		
Incident	*b. Medium*		
Population	*c. Large*		
Community	*NA*		
2			
H3. Acid Deposition B	Size of Pollution		
Scale of Pollution			
Contamination	*a. Small*		
Incident	*b. Medium*		
Population	*c. Large*		
Community	*NA*		
3			
H4. Nitrate/Nitrite (Leachate) B	Size of Pollution		
Scale of Pollution			
Contamination	*a. Small*		
Incident	*b. Medium*		
Population	*c. Large*		
Community	*NA*		
4			
H5. Zinc B	Size of Pollution		
Scale of Pollution			
Contamination	*a. Small*		
Incident	*b. Medium*		
Population	*c. Large*		

Community	*50*				
5					
H6. A	% Change in Moorland Vegetation	No. of Recorded Algal Blooms			
Scale of Pollution					
Contamination	*0*	*2*			
Incident	*6*	*5*			
Population	*15*	*10*			
Community	*25*	*20*			
6					
H7. A	No. of Discharge Consents Exceeded	No. of Bathing Water Failures			
Scale of Pollution					
Contamination	*0*	*0*			
Incident	*5*	*5*			
Population	*15*	*15*			
Community	*25*	*25*			
7					
H8. A	Size of Pollution				
Scale of Pollution					
Contamination	*a. Small*				
Incident	*b. Medium*				
Population	*c. Large*				
Community	*NA*				
8					
H9. A	Flooding Problems in Land use Band A and B. No of Sites	Flooding Problems in Land use Band C. No. of Sites	Flooding Problems in Land use Band D and E. No. of Sites		
Scale of Pollution					
Contamination	*0*	*0*	*0*		
Incident	*5*	*5*	*5*		
Population	*10*	*10*	*10*		
Community	*15*	*15*	*15*		
9					
H10. A	Size of Pollution				
Scale of Pollution					
Contamination	*a. Small*				
Incident	*b. Medium*				
Population	*c. Large*				
Community	*NA*				

Community	*NA*		
5			
H6. B	RQO Failures: D Oxygen		
Scale of Pollution			
Contamination	*0*		
Incident	*5*		
Population	*15*		
Community	*25*		
6			
H7. B	No. of BOD/DO Failures		
Scale of Pollution			
Contamination	*0*		
Incident	*5*		
Population	*15*		
Community	*25*		
7			
H8. B	Size of Pollution		
Scale of Pollution			
Contamination	*a. Small*		
Incident	*b. Medium*		
Population	*c. Large*		
Community	*NA*		
8			
H9. B	Size of Pollution		
Scale of Pollution			
Contamination	*a. Small*		
Incident	*b. Medium*		
Population	*c. Large*		
Community	*NA*		
9			
H10. B	Size of Pollution		
Scale of Pollution			
Contamination	*a. Small*		
Incident	*b. Medium*		
Population	*c. Large*		
Community	*NA*		

STATUS OF RECEPTOR:

11

	R1. Water A. RQO - Chem % of Total Rivers in Grade A	R2. Water B. RQO - Bio. % of Total Rivers in Grade A	R3. Water C. Individual River Quality GQA (biological)	R4. Water D. % of Failures EC Directive	R5. Water E. Nature Conservation Designation	R6. Human. Number of Homes Affected
Significance						
Site Specific	0	0	a. Poor and Bad e/f	0	a. Open Space	0
Local	24	24	b. Fairly/Fair Good c/d	24	b. LWS	50
Regional	49	49	c. Good b	49	c. LNR	250
National	74	74	d. Very Good a	74	d. SSSI,ESA	1000
International	100	100	N/A	100	e. SAC,SPA,RAMSAR	10000

STATUS OF RECEPTOR

	R7 Environment Landscape Designation	R8 Human/Environment Water Supplies	R9 Salmoniod Beds	R10
Significance				0
Site Specific	a. Open Space	a.	0	0
Local	b. LWS	b. Groundwater Abstractoin	100	100
Regional	c. LNR	c. Resevoirs	500	500
National	d. SSSI,ESA	d.	2000	2000
International	SAC,SPA,RAMSAR	e.	20000	20000

	R1. Water A RQO - Chem % of Total Rivers in Grade A		R2. Water B RQO - Bio; % of Total Rivers in Grade A		R3. Water C Individual River Quality GQA (biological)		R4. Water D % of Failures EC Directive		R5. Water Conservatio
	Persistence	Reversibility	Persistence	Reversibility	Persistence	Reversibility	Persistence	Reversibility	Persistence
H1. Sediment	3	2	3	2	3	2	3	2	3
H2. Chlorine	1	1	1	1	1	1	1	1	1
H3. Acid Deposition	3	3	3	3	3	3	3	3	3
H4. Nitrate/Nitrite (Leachate)	3	2	3	2	3	2	3	2	3
H5. Zinc	2	4	2	4	2	4	2	4	2

	R5. Wate Conservatio	*R6. Human Number of Homes Affected*		*R7. Environment Landscape Designation*		*R8. Human/Environment Water Supplies*		*R9. Salmoniod Beds*	
	Reversibility	Persistence	Reversibility	Persistence	Reversibility	Persistence	Reversibility	Persistence	Reversibility
H1. Sediment	2	3	2	3	2	3	2	3	2
H2. Chlorine	1	1	1	1	1	1	1	1	1
H3. Acid Deposition	3	3	3	3	3	3	3	3	3
H4. Nitrate/Nitrite (Leachate)	2	3	2	3	2	3	2	3	2
H5. Zinc	4	2	4	2	4	2	4	2	4

THRESHOLD OF HARM DEFINITION SHEET

THRESHOLD VALUES	Significance of Effect	Status of Receptor	Persistence in Media	Reversibility
	a	b	c	d
H1. Sediment	3	2	3	2
H2. Chlorine	2	1	1	1
H3. Acid Deposition	4	4	3	3
H4. Nitrate/Nitrite (Leachate)	3	2	3	2
H5. Zinc	8	1	2	4
H6.	0	0	0	0
H7.	0	0	0	0
H8.	0	0	0	0
H9.	0	0	0	0
H10.	0	0	0	0
H11.	0	0	0	0
H12.	0	0	0	0
H13.	0	0	0	0
H14.	0	0	0	0
H15.	0	0	0	0
H16.	0	0	0	0
H17.	0	0	0	0
H18.	0	0	0	0
H19.	0	0	0	0
H20.	0	0	0	0
Max Potential Threshold	8	5	4	4
Level of Harm	4	2	1	1
Min Potential Threshold	1	1	1	1

	Type	Description	R1. Water A RQO - Chem % of Total Rivers in Grade A		R2. Water B RQO - Bio: % of Total Rivers in Grade A	
			Significance of Effect	Status of Receptor	Significance of Effect	Status of Receptor
				R1. Water A RQO - Chem % of Total Rivers in Grade A		R2. Water B RQO - Bio: % of Total Rivers in Grade A
H1. Sediment 1	A	Agriculture	12.6 Farming: % of arable land in catchment	77.7	Farming: % of arable land in catchment	
H1. Sediment 1	B	Ball Clay Mining/Aller Brook	Size of Pollution		Size of Pollution	
H1. Sediment 1	B	Construction A30/ Scotley/Fingle	Size of Pollution		No. of Quarries 2	
H1. Sediment 1	B	Roads/Stover Lake	Size of Pollution		Size of Pollution	
H2. Chlorine 2	A		1.0 No. of Incidents (Exceedences to EQS)	77.7	No. of Incidents (Exceedences to EQS)	
H2. Chlorine 2	B	Coventry farm/Aller Brook	Size of Pollution		a. Small Size of Pollution	95.4
H2. Chlorine 2	B	Waddeton Industrial Estate/G	Size of Pollution		Size of Pollution	
H3. Acid 3	A	Abandoned Mines	58.0 No. of Abandoned Mines	77.7	No. of Abandoned Mines	
H3. Acid 3	B	Great Rock/Frankmills Beadon	Size of Pollution		Size of Pollution	
H4. Nitrate/Nitrite 4	A	Landfill	2.0 No of Landfil Sites (w/d/h/c/t/s)	77.7	No of Landfil Sites (w/d/h/c/t/s)	
H4. Nitrate/Nitrite 4	B	Broadmeadow LF/Teign	Size of Pollution		Size of Pollution	
H5. Zinc 5	A	Run Off	28.0 Abandoned Shale and Slate Mines (No. of)	77.7	Abandoned Shale and Slate Mines (No. of)	

	Type	Description	R3. Water C. Individual Rive Significance of Effect
H1. Sediment 1	A	Agriculture	Farming: % of arable land in catchment
H1. Sediment 1	B	Ball Clay Mining/Aller Brook	b. Medium Size of Pollution
H1. Sediment 1	B	Construction A30/ Scotley/Fingle	a. Small Size of Pollution
H1. Sediment 1	B	Roads/Stover Lake	b. Medium Size of Pollution
H2. Chlorine 2	A		No. of Incidents (Exceedences to EQS)
H2. Chlorine 2	B	Coventry farm/Aller Brook	Size of Pollution
H2. Chlorine 2	B	Waddeton Industrial Estate/G	Size of Pollution
H3. Acid 3	A	Abandoned Mines	No. of Abandoned Mines
H3. Acid 3	B	Great Rock/Frankmills Beadon	a. Small Size of Pollution
H4. Nitrate/Nitrite 4	A	Landfill	No of Landfil Sites (w/d/h/c/t/s)
H4. Nitrate/Nitrite 4	B	Broadmeadow LF/Teign	a. Small Size of Pollution
H5. Zinc 5	A	Run Off	Abandoned Shale and Slate Mines (No. of)

	Type	Description	R3. Water C Individual Status of Receptor: R3. Water C Individual River Quality GQA (biological)	R4. Water D % of Failures EC Directive Significance of Effect	Status of Receptor: R4. Water D % of Failures EC Directive	R5. Water E Nature Con Significance of Effect
H1. Sediment 1	A	Agriculture		Farming % of arable land in catchment		No. of Quarries
H1. Sediment 1	B	Ball Clay Mining/Aller Brook	b. Fairly/Fair Good c/d	Size of Pollution		Size of Pollution
H1. Sediment 1	B	Construction A30/ Scotley/Fingle	c. Good b	Size of Pollution		Size of Pollution
H1. Sediment 1	B	Roads/Stover Lake	d. Very Good a	Size of Pollution		b. Medium Size of Pollution
H2. Chlorine 2	A			No. of Incidents (Exceedences to EQS)		No. of Incidents (Exceedences to EQS)
H2. Chlorine 2	B	Coventry farm/Aller Brook		Size of Pollution		Size of Pollution
H2. Chlorine 2	B	Waddeton Industrial Estate/G		Size of Pollution		Size of Pollution
H3. Acid 3	A	Abandoned Mines		No. of Abandoned Mines		No. of Abandoned Mines
H3. Acid 3	B	Great Rock/Frankmills Beadon	d. Very Good a	Size of Pollution		Size of Pollution
H4. Nitrate/Nitrite 4	A	Landfill		No of Landfil Sites (w/d/h/c/t/s)		No of Landfil Sites (w/d/h/c/t/s)
H4. Nitrate/Nitrite 4	B	Broadmeadow LF/Teign	d. Very Good a	Size of Pollution		Size of Pollution
H5. Zinc 5	A	Run Off		Abandoned Shale and Slate Mines (No. of)		Abandoned Shale and Slate Mines (No. of)

			R5. Water E Nature	R6. Human Number of Homes Affected		R7. Environment Lan
			Status of Receptor	Significance of Effect	Status of Receptor	Significance of Effect
	Type	Description	R5. Water E Nature Conservation Designation		R6. Human Number of Homes Affected	
H1. Sediment 1	A	Agriculture		Farming: % of arable land in catchment		Farming: % of arable land in catchment
H1. Sediment 1	B	Ball Clay Mining/Aller Brook		Size of Pollution		Size of Pollution
H1. Sediment 1	B	Construction A30/ Scotley/Fingle		Size of Pollution		Size of Pollution
H1. Sediment 1	B	Roads/Stover Lake	d. SSSI,ESA	Size of Pollution		Size of Pollution
H2. Chlorine 2	A			No. of Incidents (Exceedences to EQS)		No. of Incidents (Exceedences to EQS)
H2. Chlorine 2	B	Coventry farm/Aller Brook		Size of Pollution		Size of Pollution
H2. Chlorine 2	B	Waddeton Industrial Estate/G		Size of Pollution		Size of Pollution
H3. Acid 3	A	Abandoned Mines		No. of Abandoned Mines		No. of Abandoned Mines
H3. Acid 3	B	Great Rock/Frankmills Beadon		Size of Pollution		Size of Pollution
H4. Nitrate/Nitrite 4	A	Landfill		No of Landfil Sites (w/d/h/c/t/s)		No of Landfil Sites (w/d/h/c/t/s)
H4. Nitrate/Nitrite 4	B	Broadmeadow LF/Teign		Size of Pollution		Size of Pollution
H5. Zinc 5	A	Run Off		Abandoned Shale and Slate Mines (No. of)		Abandoned Shale and Slate Mines (No. of)

	Type	Description	R7. Environment	R8. Human/Environment: Water Supplies		R9. Salmon
			Status of Receptor	Significance of Effect	Status of Receptor	Significance of Effect
			R7. Environment: Landscape Designation		R8. Human/Environment: Water Supplies	
H1. Sediment 1	A	Agriculture		Farming: % of arable land in catchment		Farming: % of arable land in catchment
H1. Sediment 1	B	Ball Clay Mining/Aller Brook		Size of Pollution		Size of Pollution
H1. Sediment 1	B	Construction A30/ Scotley/Fingle		Size of Pollution		b. Medium Size of Pollution
H1. Sediment 1	B	Roads/Stover Lake		Size of Pollution		Size of Pollution
H2. Chlorine 2	A			No. of Incidents (Exceedences to EQS)		No. of Incidents (Exceedences to EQS)
H2. Chlorine 2	B	Coventry farm/Aller Brook		Size of Pollution		Size of Pollution
H2. Chlorine 2	B	Weddeton Industrial Estate/G		a. Small Size of Pollution	b. Groundwater Abstractoin	Size of Pollution
H3. Acid 3	A	Abandoned Mines		28.0 No. of Abandoned Mines	b. Groundwater Abstractoin	No. of Abandoned Mines
H3. Acid 3	B	Great Rock/Frankmills Beadon		Size of Pollution		Size of Pollution
H4. Nitrate/Nitrite 4	A	Landfill		No of Landfill Sites (w/d/h/c/t/s)		No of Landfill Sites (w/d/h/c/t/s)
H4. Nitrate/Nitrite 4	B	Broadmeadow LF/Teign		Size of Pollution		Size of Pollution
H5. Zinc 5	A	Run Off		28.0 Abandoned Shale and Slate Mines (No. of)	b. Groundwater Abstractoin	Abandoned Shale and Slate Mines (No. of)

			R9: Sal
			Status of Receptor
	Type	Description	R9: Salmoniod Beds
H1: Sediment 1	A	Agriculture	
H1: Sediment 1	B	Ball Clay Mining/Aller Brook	
H1: Sediment 1	B	Construction A30/ Scotley/Fingle	110.0
H1: Sediment 1	B	Roads/Stover Lake	
H2: Chlorine 2	A		
H2: Chlorine 2	B	Coventry farm/Aller Brook	
H2: Chlorine 2	B	Weddeton Industrial Estate/G	
H3: Acid 3	A	Abandoned Mines	
H3: Acid 3	B	Great Rock/Frankmills Beadon	
H4: Nitrate/Nitrite 4	A	Landfill	
H4: Nitrate/Nitrite 4	B	Broadmeadow LF/Teign	
H5: Zinc 5	A	Run Off	

RESULTS AND RANKINGS

Receptor	R1. Water A RQO - Chem % of Total Rivers in Grade A	R2. Water B RQO - Bio % of Total Rivers in Grade A	R3. Water C Individual River Quality GQA (biological)	R4. Water D % of Failures EC Directive	R5. Water E Nature Conservation Designation	R6. Human Number of Homes Affected	R7. Environment Landscape Designation	R8. Human/Environment Water Supplies	R9 Salmoniod Beds	R10.	Total
H1. Sediment Agriculture	[illegible]										112.07
H1. Sediment Ball Clay Mining/Aller Brook			105.6								105.64
H1. Sediment Construction A30/ Scotley/Fingle Brook			106.8						105.6		106.79
H1. Sediment Roads/Stover Lake			[illegible]		[illegible]						224.14
H2. Chlorine	99.7										99.68
H2. Chlorine Coventry farm/Aller Brook		99.7									99.68
H2. Chlorine Waddeton Industrial Estate/G Water								98.1			98.08
H3. Acid Deposition Abandoned Mines	[illegible]							[illegible]			299.69
H3. Acid Deposition			[illegible]								121.25
H4. Nitrate/Nitrite (Leachate) Landfill	[illegible]										112.07
H4. Nitrate/Nitrite (Leachate) Broadmeadow LF/Teign Estruary			[illegible]								110.55
H5. Zinc Run Off	[illegible]							[illegible]			264.51
Receptor Score	612.62	99.68	556.30		112.07			373.48	105.64		1754.15

H3. Acid Deposition Abandoned Mines
H5. Zinc Run Off
H1. Sediment Roads/Stover Lake
H3. Acid Deposition
H1. Sediment Agriculture
H4. Nitrate/Nitrite (Leachate) Landfill
H4. Nitrate/Nitrite (Leachate) Broadmeadow LF/Teign Estruary
H1. Sediment Construction A30/ Scotley/Fingle Brook
H1. Sediment Ball Clay Mining/Aller Brook
H2. Chlorine
H2. Chlorine Coventry farm/Aller Brook
H2. Chlorine Waddeton Industrial Estate/G Water

R1. Water A RQO - Chem % of Total Rivers in Grade A
R3. Water C Individual River Quality GQA (biological)
R8. Human/Environment Water Supplies
R5. Water E Nature Conservation Designation
R9 Salmoniod Beds
R2. Water B RQO - Bio: % of Total Rivers in Grade A
R4. Water D % of Failures EC Directive
R6. Human Number of Homes Affected
R7 Environment Landscape Designation
R10.

SCALE OF SIGNIFICANCE OF EFFECT (HAZARD/SOURCE)

Type A: GENERAL

H1. Lowering of Groundwater Levels

H1. Lowering of Groundwater Levels A	Climate Change effective rainfall % below average	Abstraction of ground water (volume) compared to regional total volume abstracted (Table 32 Key Facts)	0.000	0.000	0.000
Significance					
Low	0.000	0.000	0.000	0.000	0.000
Moderate	30.000	10.000	0.000	0.000	0.000
High	60.000	20.000	0.000	0.000	0.000
Very High	101.000	40.000	0.000	0.000	0.000

1

H2. Lowering of Surface Water Flows

H2. Lowering of Surface Water Flows A	Climate Change effective rainfall % below average (Fig 4.1)	Abstraction of surface water (volume) compared to regional total volume abstracted (Table 32 Key Facts)	No. of rivers in low flow compared to national figure (Fig 4.6)	0.000	0.000
Significance					
Low	0.000	0.000	0.000	0.000	0.000
Moderate	30.000	65.000	10.000	0.000	0.000
High	60.000	80.000	20.000	0.000	0.000
Very High	101.000	95.000	101.000	0.000	0.000

2

H3. Surface Water Pollution i) Sedimentation

H3. Surface Water Pollution i) Sedimentation A	Regional area of arable land * river drainage density	Substantiated transport pollution incidents compare d to national figure (Table 72 Key Facts)	No. of abandoned mines compared to national total	Length of roads by region compared to national total	0.000
Significance					
Low	0.000	0.000	0.000	NA	0.000
Moderate	50.000	10.000	5.000	NA	0.000
High	150.000	20.000	10.000	NA	0.000
Very High	350.000	30.000	20.000	NA	0.000

3

H4. Surface Water Pollution ii) Nutrient Enrichment - Nitrate

H4. Surface Water Pollution ii) Nutrient Enrichment - Nitrate A	Regional number of organic pollution incidents compared to river length	Population equivalents	0.000	0.000	0.000
Significance					
Low	0.000	0.000	0.000	0.000	0.000
Moderate	0.100	5.000	0.000	0.000	0.000
High	0.200	10.000	0.000	0.000	0.000
Very High	0.300	20.000	0.000	0.000	0.000

4

H5. Surface Water Pollution iii) Nutient Enrichment - Phosphate

H5. Surface Water Pollution iii) Nutrient Enrichment - Phosphate A	Length of Rivers classed as Grade 5 or 6 compared to total regional length (Table 63 Key Facts)	No. of substantiated farming + sewage pollution incidents by region compared to national total (Table 72 Key Facts)	% water bodies with blooms or alga (Table 66 Key Facts)	% of rivers with blooms or alga scum present (Table 66 Key Facts)	Population equivalents compared to river drainage density
Significance					
Low	NA	0.000	0.000	0.000	0.000

Moderate	NA	5.000	5.000	25.000	1.000
High	NA	15.000	10.000	50.000	3.000
Very High	NA	25.000	15.000	75.000	4.000

5

H6. Surface Water Pollution iv) Pesticides

H6. Surface Water Pollution iv) Pesticides A	Number of EQS failures by region compared to the river length*100	Area of arable land compared to national figure (NW data source unknown)	0.000	0.000	0.000
Significance					
Low	0.000	0.000	0.000	0.000	0.000
Moderate	0.050	10.000	0.000	0.000	0.000
High	0.100	15.000	0.000	0.000	0.000
Very High	0.200	101.000	0.000	0.000	0.000

6

H7. Surface Water Pollution v) Heavy Metal Contamination

H7. Surface Water Pollution v) Heavy Metal Contamination A	No. IPC and discharge consents for metal industries compared to national total (Table 45 Key Facts)	Number of EQS failures compared to river length * 100	No. of mines (used and disused) compared to national figure	0.000	0.000
Significance					
Low	0.000	0.000	NA	0.000	0.000
Moderate	15.000	0.250	NA	0.000	0.000
High	30.000	0.500	NA	0.000	0.000
Very High	50.000	0.750	NA	0.000	0.000

7

H8. Surface Water Pollution vi) Acidification

H8. Surface Water Pollution vi) Acidification A	No of IPC and discharge consents for acidic chemicals (HCl or sulphur compounds) compared to national figure	No. of EQS failures or poor pH records for pH compared to national figure (Fig4.29)	CL exceedences area as % of regional total	Area exceeding pH critical load compared to regional area	0.000
Significance					
Low	NA	NA	0.000	0.000	0.000
Moderate	NA	NA	5.000	10.000	0.000
High	NA	NA	15.000	20.000	0.000
Very High	NA	NA	30.000	35.000	0.000

8

H9. Surface Water Pollution vii) Hydro-Carbons

H9. Surface Water Pollution vii) Hydro-Carbons A	Number of fuel & oil incidents compared to river length	No IPC disharge consents for oil compounds compred to national total	0.000	0.000	0.000
Significance					
Low	0.000	NA	0.000	0.000	0.000
Moderate	0.250	NA	0.000	0.000	0.000
High	0.500	NA	0.000	0.000	0.000
Very High	0.750	NA	0.000	0.000	0.000

9

H10. Surface Water Pollution viii) Organic

H10. Surface Water Pollution viii) Organic A	Regional number of organic incidents compared to river length	Substantiated transport pollution incidents compred to national total (Table 72 Key Facts)	No. of abandoned mines compared to national total	Length of roads by region compared to national total	0.000
Significance					
Low	0.000	0.000	0.000	NA	0.000
Moderate	0.050	10.000	5.000	NA	0.000
High	0.100	20.000	10.000	NA	0.000
Very High	0.150	30.000	20.000	NA	0.000

10

H11. Groundwater Contamination - Nitrate

H11. Groundwater Contamination - Nitrate A	Area of NVZ compared to total regional area	NVZ area compared to total NVZ area (Fig 4.35)	No of drinking water failures due to nitrate compared to national total	Area of arable land compared to national figure	0.000
Significance					
Low	*0.000*	*0.000*	*NA*	*0.000*	*0.000*
Moderate	*5.000*	*5.000*	*NA*	*5.000*	*0.000*
High	*10.000*	*10.000*	*NA*	*15.000*	*0.000*
Very High	*15.000*	*30.000*	*NA*	*101.000*	*0.000*

11

H12. Groundwater Contamination - Pesticides

H12. Groundwater Contamination - Pesticides A	Regional area of arable land compared to major aquifer	Area of arable land compared to regional area	0.000	0.000	0.000
Significance					
Low	*0.000*	*0.000*	*0.000*	*0.000*	*0.000*
Moderate	*0.025*	*10.000*	*0.000*	*0.000*	*0.000*
High	*0.050*	*20.000*	*0.000*	*0.000*	*0.000*
Very High	*0.075*	*30.000*	*0.000*	*0.000*	*0.000*

12

H13. Groundwater Contamination - General

H13. Groundwater Contamination - General A	Percentage of regional number of Waste Disposal IPC authorisation compared to major aquifer density	No. of metal working sites compared to national total (Fig 3.24)	No. of chemical sites compared to national total (Fig 3.24)	No. of energy producing sites compared to national total (Fig 3.24)	0.000
Significance					
Low	*0.000*	*NA*	*NA*	*NA*	*0.000*
Moderate	*5.000*	*NA*	*NA*	*NA*	*0.000*
High	*10.000*	*NA*	*NA*	*NA*	*0.000*
Very High	*15.000*	*NA*	*NA*	*NA*	*0.000*

13

H14. Freshwater Flooding

H14. Freshwater Flooding A	Climate Change effective rainfall % below average (Fig 4.1)	Projected change in runoff rates (fig 3.2)	Increase in storminess	0.000	0.000
Significance					
Low	*0.000*	*-20.000*	*NA*	*0.000*	*0.000*
Moderate	*30.000*	*5.000*	*NA*	*0.000*	*0.000*
High	*60.000*	*10.000*	*NA*	*0.000*	*0.000*
Very High	*101.000*	*15.000*	*NA*	*0.000*	*0.000*

14

H15. Channel Disturbance

H15. Channel Disturbance A	% of region urbanised compared to national %	% river channeled compared to overall length	No. of days fished compared to national figure (NW data)	% of channel length obviously to heavily modified channels compared to national total (Fig 4.11)	Number of indentified "obviously to heavily extensive modified channels" compared to regional river length
Significance					
Low	*NA*	*NA*	*0.000*	*0.000*	*0.000*
Moderate	*NA*	*NA*	*40.000*	*5.000*	*5.000*
High	*NA*	*NA*	*101.000*	*10.000*	*10.000*
Very High	*NA*	*NA*	*102.000*	*15.000*	*15.000*

15

STATUS OF RECEPTOR:

	R1. Wetland Habitat : No. of SSSIs compared to regional area	R2. Freshwater Environment - Surface Water Quality (Biology) : Proportion of good quality streams (Grade ab GQA) compared to regional length	R3. Freshwater Environment - Surface Water Quality (Fish) : Proportion of catch size compared to regional river length*100	R4. Freshwater Environment - Groundwater Quality : Proportion of major aquifer compared to region area	R5. Groundwater Abstraction - Potable : Percentage of each regions built up area affected by freshwater flooding	R6. Groundwater Abstraction - Agriculture : % abstractions for agriculture supplies from groundwater compared to total groundwater abstracted (Table 33 Key Facts)
Significance						
Site Specific	0	0	0	0	0	0
Local	0	20	20	15	5	5
Regional	1	40	50	40	10	10
National	1	60	250	10000	15	20
International	1	101	10000	10000	101	101

R7. Groundwater Abstraction - Industry : % abstractions for industry supply from groundwater compared to total groundwater abstracted (Table 33 Key Facts)	R8. Surface Water Abstraction - Potable : % abstractions for potable supplies from surface water compared to total surface water abstracted (Table 32 Key Facts)	R9. Surface Water Abstraction - Agriculture : % abstractions for agriculture supplies from surface water compared to total surface water abstracted (Table 32 Key Facts)	R10. Surface Water Abstraction - Industry : % abstractions for industry supplies from surface water compared to total surface water abstracted (Table 32 Key Facts)	R11. Urbanisation within the flood plain : Urban area at risk from flooding as % of total urban area	R12. Freshwater Visual Value - Length of unmodified river channel as % of total
				0	0
0	0	0	0	0	0
5	20	5	20	0	0
10	50	10	50	5	35
20	80	20	80	8	55
101	101	101	101	10	70

THRESHOLD OF HARM DEFINITION SHEET

THRESHOLD VALUES	Significance of Effect	Status of Receptor	Persistence in Media	Reversibility
	a	b	c	d
H1. Lowering of Groundwater Levels	4	3	2	1
H2. Lowering of Surface Water Flows	4	4	1	1
H3. Surface Water Pollution i) Sedimentation	4	2	3	3
H4. Surface Water Pollution ii) Nutrient Enrichment - Nitrate	4	3	1	1
H5. Surface Water Pollution iii) Nutient Enrichment - Phosphate	4	3	2	1
H6. Surface Water Pollution iv) Pesticides	4	3	2	1
H7. Surface Water Pollution v) Heavy Metal Contamination	4	2	2	4
H8. Surface Water Pollution vi) Acidification	4	2	3	3
H9. Surface Water Pollution vii) Hydro-Carbons	4	2	1	1
H10. Surface Water Pollution viii) Organic	4	4	1	1
H11. Groundwater Contamination - Nitrate	4	3	4	3
H12. Groundwater Contamination - Pesticides	4	3	4	4
H13. Groundwater Contamination - General	4	3	4	3
H14. Freshwater Flooding	2	2	1	4
H15. Channel Disturbance	4	2	4	2
H16.	0	0	0	0
H17.	0	0	0	0
H18.	0	0	0	0
H19.	0	0	0	0
H20.	0	0	0	0
Max Potential Threshold	8	5	4	4
Level of Harm	4	2	1	1
Min Potential Threshold	1	1	1	1

HAZARD 1 - LOWERING OF GROUND WATER LEVELS

S1. PROJECTED CHANGES IN ANNUAL RUN-OFF (Fig 3.2)

	Projected Change in Run-off rates
Anglian	-11.1
Midlands	-3.0
North East	8.3
North West	7.0
Southern	-17.3
South West	-9.6
Thames	-13.8
Wales	-2.1

S2. ESTIMATED FRESH GROUNDWATER ABSTRACTION (MILLION LITRES A DAY) 1995 (Table 32 and 33 Key Facts)

	Groundwater	*Surface*	*Regional Total*	*GW as % of Total*
Anglian	1124.09	1309.52	2433.61	46%
Midlands	1275.75	3587.57	4863.32	26%
North East	516.31	3751.34	4267.65	12%
North West	372.78	2407.56	2780.34	13%
South West	722.48	3763.68	4486.16	16%
Southern	1379.73	1451.2	2830.93	49%
Thames	1592.71	3091.02	4683.73	34%
Welsh	178.5	6620.2	6798.7	3%
TOTAL	7162.35	25982.09	33144.44	

HAZARD 2 - LOWERING OF SURFACE WATER LEVELS

S1. PROJECTED CHANGES IN ANNUAL RUN-OFF (Fig 3.2)

	Projected Change in Run-off rates
Anglian	-11.1
Midlands	-3.0
North East	8.3
North West	7.0
Southern	-17.3
South West	-9.6
Thames	-13.8
Wales	-2.1

S2. ESTIMATED FRESH SURFACE WATER ABSTRACTION (MILLION LITRES A DAY) 1995 (Table 32 and 33 Key Facts)

	Groundwater	*Surface*	*Regional Total*	SW as % of Regional Total
Anglian	1124.09	1309.52	2433.61	54%
Midlands	1275.75	3587.57	4863.32	74%
North East	516.31	3751.34	4267.65	88%
North West	372.78	2407.56	2780.34	87%
South West	722.48	3763.68	4486.16	84%
Southern	1379.73	1451.2	2830.93	51%
Thames	1592.71	3091.02	4683.73	66%
Welsh	178.5	6620.2	6798.7	97%
TOTAL	7162.35	25982.09	33144.44	

S3. NUMBER OF RIVERS IN LOW FLOW COMPARED TO TOTAL NUMBER (Fig 4.6)

	Number Identified	*% of region compared to Total*
Anglian	5	16.0%
Midlands	7	22.0%
North East	8	25.0%
North West	2	6.0%
South West	2	6.0%
Southern	3	9.0%
Thames	4	13.0%
Welsh	1	3.0%
TOTAL	32	

S4. CURRENT RESERVOIR STOCKS COMPARED TO EACH REGIONS LIVE CAPACITY (Fig 4.4)

	1989-94 Reservoir Stocks Compared to Live Capacity
Anglian	85%
Midlands	81%
North East (inc. Northumbrian and Yorkshire)	80%
North West	76%
South West	71%
Southern (inc Wessex and South West)	72%
Thames	85%
Welsh	71%

S5. THE NUMBER OF DROUGHT ORDERS BY REGION COMPARED TO NATIONAL TOTAL 1996 (FIG 3.17)

	Total number of drought orders for last five years	*% of drought orders compared to national total*
Anglian		
North East	0	0%
North West	0	0%
Midlands	39	41%
Southern	23	24%
South West	1	1%
Thames	29	30%
Welsh	3	3%
TOTAL	1	1%
	96	

HAZARD 3 - SURFACE WATER POLLUTION - SEDIMENTATION

S1. ARABLE LAND COMPARED TO NATIONAL TOTAL

Region	*Total arable land*	*Regional area of land compared to national total*
Anglian	1106.34	22%
Midlands	1289.66	26%
North East	774.94	16%
North West	205.56	4%
Southern	395.38	8%
South West	717.56	14%
Thames	263.98	5%
Wales	208.89	4%
Total	4962.30	100%

NB. Yorkshire and Humberside amalgamated into the north east data, east midland data amalgamated into midlands. MAFFs southern region data is split into Thames and EA Southern. EA Thames region includes Berks, Bucks, Herts, Oxon and Greater

S2. NUMBER OF SUBSTANTIATED TRANSPORT POLLUTION INCIDENTS COMPARED TO NATIONAL TOTAL (Table 72 Key Facts)

	No. of Transport Incidents	*Regional compared to national total*
Anglian	361	19%
Midlands	450	23%
North East	167	9%
North West	158	8%
South West	253	13%
Southern	152	8%
Thames	201	10%
Welsh	173	9%
TOTAL	1915	

HAZARD 4 - SURFACE WATER POLLUTION II) NUTRIENT ENRICHMENT - NITRATE

S1. ARABLE LAND COMPARED TO NATIONAL TOTAL

Region	*Total arable land*	*Regional area of land compared to national total*
Anglian	1106.34	22%
Midlands	1289.66	26%
North East	774.94	16%
North West	205.56	4%
Southern	395.38	8%
South West	717.56	14%
Thames	263.98	5%
Wales	208.89	4%
Total	4962.30	100%

NB. Yorkshire and Humberside amalgamated into the north east data, east midland data amalgamated into midlands. MAFFs southern region data is split into Thames and EA Southern. EA Thames region includes Berks, Bucks, Herts, Oxon and Greater London.

S2. NUMBER OF SUBSTANTIATED FARMING AND SEWAGE POLLUTION INCIDENTS COMPARED TO NATIONAL FIGURE (Fig 72 Key Facts)

	Total farming and sewage pollution incidents	*Regional number of incidents compared to national total*
Anglian	661	8.6%
Midlands	1629	21.1%
North East	888	11.5%
North West	1076	14.0%
South West	1472	19.1%
Southern	393	5.1%
Thames	564	7.3%
Welsh	1027	13.3%
TOTAL	7710	

S3. NUMBER OF SUBSTANTIATED ORGANIC POLLUTION INCIDENTS COMPARED TO NATIONAL FIGURE (Fig 73 Key Facts)

	Number of substantiated organic incidents	*Regional number of incidents compared to national total*
Anglian	201	7.5%
Midlands	419	15.7%
North East	150	5.6%
North West	408	15.3%
South West	899	33.7%
Southern	84	3.2%
Thames	75	2.8%
Welsh	430	16.1%
TOTAL	2666	

S4. AREA OF NVZ COMPARED TO TOTAL REGIONAL AREA (Fig 4.35)
AND
S5. AREA OF NVZ COMPARED TO TOTAL NVZ AREA (Fig 4.35)

Region	*NVZ Area (ha)*	*TOTAL Region Area (ha)*	*S4 - Area of NVZ compared to TOTAL regional area*	*S5 - Area of NVZ compared to TOTAL NVZ area*
Anglian	387221	2700000	14.3%	67.6%
Midlands	124127	2100000	5.9%	21.7%
North East	23248	2338400	1.0%	4.1%
North West	1886	1444500	0.1%	0.3%
Southern	1614	2094500	0.1%	0.3%
South West	3151	1097000	0.3%	0.6%
Thames	29112	1300000	2.2%	5.1%
Welsh	2164	2076300	0.1%	0.4%
TOTAL	572523	15150700	3.8%	100.0%

S6. AMOUNT OF INORGANIC FERTILE APPLIED BY REGION (Fig A3.4 The Influence of Agriculture on the quality of natural waters ...RNA 1992)

	Est. of inorganic nitrogen (Tx1000/yr)	*EST proportion of inorganic nitrates applied to land*
Anglian	248.8	19.9%
Midlands	218.7	17.5%
North East	184.6	14.8%
North West	92	7.4%
Southern	91.1	7.3%
South West	194.2	15.5%
Thames	76.6	6.1%
Welsh	143.1	11.5%
TOTAL	1249.1	

S7. POPULATION EQUIVALENT FOR ORGANIC AND NITRATE LOADING (Source NW)

	Population Equivalents in Millions	*% of national total*
Anglian	3.6	7.7%
Midlands	14.5	30.9%
North East	8.6	18.3%
North West	8.1	17.3%
Southern	2	4.3%
South West	2.2	4.7%
Thames	6.7	14.3%
Welsh	1.2	2.6%
	46.9	

HAZARD 5 - SURFACE WATER POLLUTION II) NUTRIENT ENRICHMENT - PHOSPHATES

S1. LENGTH OF RIVERS CLASSIFIED AS GRADE 5 AND 6 (GQA NUTRIENT) COMPARED TO REGIONAL LENGTH (Table 63 Key Facts)

	Length of Grade 5 and 6 (km)	*Total Freshwater river length (WQ and Fisheries) KM*	*% Grade 5 and 6 Compared to Total Length of the River inc. survey*
Anglian	3091.3	4813.8	64.2%
Midlands	1938.3	6588.8	29.4%
North East	1314.5	5958.3	22.1%
North West	1500.2	5745.3	26.1%
South West	1654.1	2219.1	74.5%
Southern	920.8	6061.7	15.2%
Thames	2636.5	3797.1	69.4%
Welsh	314	5042.9	6.2%
TOTAL	13369.7	40227.0	

S2. NUMBER OF SUBSTANTIATED FARMING AND SEWAGE POLLUTION INCIDENTS COMPARED TO NATIONAL FIGURE (Fig 72 Key Facts)

	Farming and sewage pollution incidents	*Regional number of Incidents compared to national total*
Anglian	661	8.6%
Midlands	1629	21.1%
North East	888	11.5%
North West	1076	14.0%
South West	1472	19.1%
Southern	393	5.1%
Thames	564	7,3%
Welsh	1027	13.3%
TOTAL	7710	

S3. LENGTH OF SITES DESIGNATED AS 'EUTROPHIC' SENSITIVE COMPARED TO TOTAL EUTROPHIC LENGTH (Fig 4.6)

	Total length of river designated as eutrophic sensitive	Percentage of eutrophic rivers compared to national total
Anglian	3091.3	23.1%
Midlands	1938.3	14.5%
North East	1314.5	9.8%
North West	1500.2	11.2%
South West	1654.1	12.4%
Southern	920.8	6.9%
Thames	2636.5	19.7%
Welsh	314	2.3%
TOTAL	**13369.7**	

S4. NUMBER OF SUBSTANTIATED ORGANIC POLLUTION INCIDENTS COMPARED TO NATIONAL TOTAL (Fig 73 Key Facts)

	Number of substantiated organic incidents	*Regional number of incidents compared to national total*
Anglian	201	7.5%
Midlands	419	15.7%
North East	150	5.6%
North West	408	15.3%
South West	899	33.7%
Southern	84	3.2%
Thames	75	2.8%
Welsh	430	16.1%
TOTAL	2666	

S5. NUMBER OF RIVERS WITH BLOOMS COMPARED TO NATIONAL TOTAL (Table 66 Key Facts)

	Total number of rivers as identified with algae blooms	*Number of sites compared to national total*
Anglian	39	18.4%
North West	31	14.7%
North/Yorks	13	6.1%
Severn Trent	57	26.8%
South Western	22	10.3%
Southern	9	4.3%
Thames	33	15.5%
Welsh	8	3.8%
TOTAL	211	

S6. POPULATION EQUIVALENT FOR ORGANIC AND NITRATE LOADING (Source NW)

	Population Equivalents in Millions	*% of national total*
Anglian	3.6	7.7%
Midlands	14.5	30.9%
North East	8.6	18.3%
North West	8.1	17.3%
Southern	2	4.3%
South West	2.2	4.7%
Thames	6.7	14.3%
Welsh	1.2	2.6%
	46.9	

HAZARD 6 - SURFACE WATER POLLUTION - PESTICIDES

S1. NUMBER OF EQS FAILURES TO PESTICIDE LEVELS

	Number of EQS failures due to pesticide - grade I and II	*Number of EQS failures by region compared to the number of national failures*
Anglian	5	21%
Midlands	2	8%
North East	12	50%
North West	0	0%
South West	1	4%
Southern	3	13%
Thames	0	0%
Welsh	1	4%
TOTAL	24	

S2. ARABLE LAND COMPARED TO NATIONAL FIGURE (NW DATA SOURCE)

	Total arable land	*Regional area of arable land compared to national total*
North East	774.94	16%
North West	205.56	4%
Yorkshire and Humberside		0%
East Midlands		0%
Midlands	1289.66	26%
Eastern Region	1106.34	22%
Southern Region	659.35	13%
South West region	717.56	14%
Wales	208.89	4%
TOTAL	4962.30	100%

HAZARD 7 - SURFACE WATER POLLUTION - HEAVY METALS

S1. NUMBER OF IPC AUTHORISATIONS FOR METAL INDUSTRIES COMPARED TO NATIONAL TOTAL 1997 AND 1995(TABLE 46 KEY FACTS)

	No. of IPC consents for heavy metals	*Number of IPC Consents compared to national total*
Anglian	1	2%
Midlands	12	27%
North East	0	0%
North West	17	39%
South West	1	2%
Southern	1	2%
Thames	6	14%
Welsh	6	14%
TOTAL	44	

S2. NUMBER OF EQS FAILURES DUE TO METAL COMPOUNDS - GRADES I AND II (Source NW)

	No. of EQS failures due to Metals - Grade I and II	*% of EQS failures due to heavy metals compared to total*
Anglian	4	2.8%
Midlands	9	6.3%
North East	6	4.2%
North West	14	9.9%
South West	44	31.0%
Southern	7	4.9%
Thames	2	1.4%
Welsh	4	2.8%
TOTAL	142	

S3. NUMBER OF ABANDONED AND ACTIVE METAL MINES (Source NW)

	Total Number of Mines	*Percentage of Total*
Anglian	0	0.0%
Midlands	2	0.1%
North East	19	1.1%
North West	5	0.3%
Southern	0	0.0%
South West	1701	96.0%
Thames	0	0.0%
Wales	44	2.5%
Total	1771	

HAZARD 8 - SURFACE WATER POLLUTION - ACIDIFICATION

S1. NUMBER OF EQS BREACHES DUE TO LOW PH COMPARED TO NATIONAL TOTAL (Data - NW)

	Number of EQS failures due to low pH.	*Number of EQS incidents due to pH compared to national total*
Anglian		
Midlands	2	11%
North East		
North West	1	5%
South West	16	84%
Southern		
Thames		
Welsh		
TOTAL	19	

S2 and S3. VOLUME OF ACIDIC CHEMICALS (SO2, NOx) RELEASED COMPARED TO NATIONAL TOTAL (Table 49 Key Facts)

	SO2	*SO2 volume compared to National total*	*NOx*	*NOx volume compared to national total*
Anglian	144060	10%	46850	10%
Midlands	435620	31%	165300	34%
North East	273914	20%	94580	20%
North West	152882	11%	40450	8%
South West	85067	6%	29760	6%
Southern	112839	8%	34140	7%
Thames	69504	5%	24890	5%
Welsh	120204	9%	45100	9%
TOTAL	1394091		481070	

S4. ACIDIFICATION DATA SUPPLIED FROM THE 1995 GQA RESULTS

	Number of incidences where pH was recorded as below <6.49	*Proportion of the national number of acidification*
Anglian	0	0%
Midlands	2	2%
North East	11	10%
North West	8	7%
Southern	1	1%
South West	22	19%
Thames	0	0%
Welsh	71	62%
TOTAL	115	

S5. EXCEEDENCES OF CRITICAL PH LOADING (Source NW)

	Area exceeding pH critical load compared to regional area
Anglian	0%
Midlands	4%
North East	21%
North West	29%
Southern	6%
South West	8%
Thames	2%
Welsh	35%

HAZARD 9 - SURFACE WATER POLLUTION - HYDROCARBONS

S1. NUMBER OF SUBSTANTIATED FUEL AND OIL INCIDENTS COMPARED TO NATIONAL TOTAL (Table 73 Key Facts)

	Number of fuel&oil incidents	*Number of fuel&oil incidents compared to national total*
Anglian	734	12%
Midlands	*1197*	20%
North East	562	9%
North West	828	14%
South West	909	15%
Southern	470	8%
Thames	780	13%
Welsh	439	7%
TOTAL	5919	

HAZARD 10 - SURFACE WATER POLLUTION II) NUTRIENT ENRICHMENT - ORGANIC

S1. NUMBER OF SUBSTANTIATED ORGANIC POLLUTION INCIDENTS COMPARED TO NATIONAL FIGURE (Fig 73 Key Facts)

	Number of substantiated organic incidents	*Regional number of incidents compared to national total*
Anglian	201	7.5%
Midlands	419	15.7%
North East	150	5.6%
North West	408	15.3%
South West	899	33.7%
Southern	84	3.2%
Thames	75	2.8%
Welsh	430	16.1%
TOTAL	2666	

S2. POPULATION EQUIVALENT FOR ORGANIC AND NITRATE LOADING (Source NW)

	Population Equivalents in Millions	*% of national total*
Anglian	3.6	7.7%
Midlands	14.5	30.9%
North East	8.6	18.3%
North West	8.1	17.3%
Southern	2	4.3%
South West	2.2	4.7%
Thames	6.7	14.3%
Welsh	1.2	2.6%
	46.9	

HAZARD 11 - GROUNDWATER POLLUTION - NITRATES

S1. AREA OF NVZ COMPARED TO TOTAL REGIONAL AREA (Fig 4.35)
AND
S2. AREA OF NVZ COMPARED TO TOTAL NVZ AREA (Fig 4.35)

Region	*NVZ Area (ha)*	*Total Region Area (ha)*	*S1 - Area of NVZ compared to total regional area*	*S2 - Area of NVZ compared to total NVZ area*
Anglian	387221	2700000	14.3%	67.6%
Midlands	124127	2100000	5.9%	21.7%
North East	23248	2338400	1.0%	4.1%
North West	1886	1444500	0.1%	0.3%
Southern	1614	2094500	0.1%	0.3%
South West	3151	1097000	0.3%	0.6%
Thames	29112	1300000	2.2%	5.1%
Welsh	2164	2076300	0.1%	0.4%
TOTAL	572523			

S3. ARABLE LAND COMPARED TO NATIONAL TOTAL

Region	*Total arable land*	*Regional area of land compared to national total*
Anglian	1106.34	22%
Midlands	1289.66	26%
North East	774.94	16%
North West	205.56	4%
Southern	395.38	8%
South West	717.56	14%
Thames	263.98	5%
Wales	208.89	4%
Total	4962.30	100%

NB. Yorkshire and Humberside amalgamated into the north east data, east midland data amalgamated into midlands. MAFFs southern region data is split into Thames and EA Southern. EA Thames region includes Berks, Bucks, Herts, Oxon and Greater London.

S4. AMOUNT OF INORGANIC FERTILE APPLIED BY REGION (Fig A3.4 The Influence of Agriculture on the quality of natural waters ...RNA 1992)

	Est. of inorganic nitrogen (Tx1000/yr)	*EST proportion of inorganic nitrates applied to land*
Anglian	248.8	19.9%
Midlands	218.7	17.5%
North East	184.6	14.8%
North West	92	7.4%
Southern	91.1	7.3%
South West	194.2	15.5%
Thames	76.6	6.1%
Welsh	143.1	11.5%
TOTAL	1249.1	

NB. Est. based on 150kg/ha/yr for arable and 128kg/ha/yr for grass

HAZARD 12 - GROUNDWATER POLLUTION - PESTICIDES

S1. ARABLE LAND COMPARED TO NATIONAL TOTAL

Region	*Total arable land*	*Regional area of land compared to national total*
Anglian	1106.34	22%
Midlands	1289.66	26%
North East	774.94	16%
North West	205.56	4%
Southern	395.38	8%
South West	717.56	14%
Thames	263.98	5%
Wales	208.89	4%
Total	4962.30	100%

NB. Yorkshire and Humberside amalgamated into the north east data, east midland data amalgamated into midlands. MAFFs southern region data is split into Thames and EA Southern. EA Thames region includes Berks, Bucks, Herts, Oxon and Greater London.

HAZARD 13 - GROUNDWATER CONTAMINATION - GENERAL

S1. NUMBER OF IPC AUTHORISATIONS FOR WASTE DISPOSAL SITES COMPARED TO NATIONAL TOTAL 1993 to 1996 (TABLE 46 KEY FACTS)

	1993	*1994*	*1995*	*1996*	*Total*	*Percentage of national total*
Anglian	5	3	1	1	10	4.3%
Midlands	26	4	2	1	33	14.1%
North East	21	2	31	7	61	26.1%
North West	19	4	26	28	77	32.9%
South West	8	2	1	1	12	5.1%
Southern	10	1	1	0	12	5.1%
Thames	13	2	8	4	27	11.5%
Welsh	2	0	0	0	2	0.9%
TOTAL	104	18	70	42	234	

HAZARD 14 - FRESH WATER FLOODING

	Projected Change in Run-off rates
Anglian	-11.1
Midlands	-3.0
North East	8.3
North West	7.0
Southern	-17.3
South West	-9.6
Thames	-13.8
Wales	-2.1

HAZARD 15 - CHANNEL DISTURBANCE

S1. NUMBER OF SITES PREDOMINANTLY TO HEAVILY AND EXTENSIVELY MODIFIED (Fig 4.11)

	Total number obviously to heavily extensively modified	*Regional number modified compared to national total*	*Total Freshwater river length (WQ and Fisheries) KM*	*MLs Index of Modification (Density of Sites identified) *100*
Anglian	634	20%	4813.8	13.2
Midlands	426	14%	6588.8	6.5
North East	449	14%	5958.3	7.5
North West	312	10%	5745.3	5.4
Southern	226	7%	2219.1	10.2
South West	404	13%	6061.7	6.7
Thames	341	11%	3797.1	9.0
Welsh	317	10%	5042.9	6.3
TOTAL	3109		40227.0	

NB. number of sites identified compared to the length of the river

S2. NUMBER OF DAYS FISHED COMPARED AGAINST NATIONAL TOTAL (NW DATA)

	No. of days fished	*Number of days fished compared against national Total*
Anglian	0	0%
Midlands	14893	6%
North East	40654	17%
North West	65601	27%
Southern	2696	1%
South West	35853	15%
Thames	414	0%
Welsh	85107	35%
TOTAL	245218	100%

S3. NUMBER OF LIVESTOCK BY TYPE AND TOTAL (SOURCE UNKNOWN)

	Cattle and calves	*% of Total*	*Sheep and lambs*	*% of Total*	*Est. Livestock Units*	*% of Total*
North East	1007	12%	4861	16%	1736.54565	14%
North West	1163	14%	3685	12%	1715.54835	14%
Midlands	1552	19%	4276	14%	2193.7232	17%
Anglian	292	4%	447	2%	358.913	3%
Thames and Southern	627	8%	1708	6%	883.5738	7%
South West	2113	26%	3870	13%	2693.83695	21%
Wales	1349	17%	10767	36%	2964.47385	24%
TOTAL	8105		29614		12547	

NB - regions data does not match well

RECEPTOR 1 - WETLAND HABITAT

NUMBER OF WETLAND HABITATS COMPARED TO NATIONAL TOTAL (Source NW)

	Number of wetland SSSIs	*Proportion of SSSI compared to national total*
Anglian	157	17%
Midlands	130	14%
North East	138	15%
North West	131	14%
South West	54	6%
Southern	131	14%
Thames	69	7%
Welsh	134	14%
TOTAL	944	

RECEPTOR 2 - SURFACE WATER BIOLOGY

QUALITY OF THE SURFACE WATER BODIES (Source Internet site)

	Total a and b %	*Total Freshwater river length (GQA) km*	*Length of grade a and b compared to national total*	% grade a and b compared to national total
Anglian	65%	4813.8	3134	12.1%
Midlands	45%	6588.8	2985	11.5%
North East	64%	5958.3	3784	14.6%
North West	50%	5745.3	2890	11.1%
South West	88%	2219.1	1953	7.5%
Southern	77%	6061.7	4692	18.1%
Thames	63%	3797.1	2392	9.2%
Welsh	82%	5042.9	4145	16.0%
TOTAL		40227.0	25974	

RECEPTOR 3 - SURFACE WATER: FISH STOCKS

SURFACE WATER FISH STOCKS (source NW)

	Number of salmon, gills and trout caught	*Proportion of catch size compared to national total*
Anglian	0	0%
Midlands	380	1%
North East	4779	13%
North West	11353	30%
South West	512	1%
Southern	7812	21%
Thames	15	0%
Welsh	12557	34%
TOTAL	37408	

RECEPTOR 4 - FRESH WATER - GROUNDWATER

AREA OF GROUNDWATER CLASSIFIED AS MAJOR AQUIFER BY REGION (Source NW)

	Area of major aquifer	*Total regional area*	*Proportion of major aquifer compared to regional total*
Anglian	9925	26700	37.2%
Midlands	4350	21530	20.2%
North East	7525	22620	33.3%
North West	3725	14370	25.9%
South West	4350	10900	39.9%
Southern	5750	20610	27.9%
Thames	5900	12880	45.8%
Wales	1025	21175	4.8%

RECEPTOR 5 - GROUNDWATER ABSTRACTION - I) POTABLE

VOLUME OF GROUNDWATER ABSTRACTED FOR POTABLE MEANS (Key Facts Table 33)

	Volume of groundwater abstraction supplied for potable use	*Regional Total*	*% of groundwater abstraction supplied for potable use*
Anglian	869.76	1184.4	73.4%
Midlands	1135.5	1327.49	85.5%
North East	397.96	517.34	76.9%
North West	245.04	376.95	65.0%
South West	454.17	723.96	62.7%
Southern	1074.19	1395.52	77.0%
Thames	1384.19	1569.85	88.2%
Welsh	142.68	186.33	76.6%

NB all amounts are in millions of litres per day

RECEPTOR 6 - GROUNDWATER ABSTRACTION - I) AGRICULTURE

VOLUME OF GROUNDWATER ABSTRACTED FOR AGRICULTURAL MEANS (Key Facts Table 33)

	Volume of groundwater abstraction supplied for irrigation and agriculture use	*Regional Total*	*% of groundwater abstraction supplied for irrigation and agriculture use*
Anglian	84.98	1184.4	7.2%
Midlands	48.76	1327.49	3.7%
North East	37.16	517.34	7.2%
North West	9.03	376.95	2.4%
South West	176.56	723.96	24.4%
Southern	179.23	1395.52	12.8%
Thames	69.15	1569.85	4.4%
Welsh	9.99	186.33	5.4%

NB all amounts are in millions of litres per day

RECEPTOR 7 - GROUNDWATER ABSTRACTION - I) INDUSTRIAL

VOLUME OF GROUNDWATER ABSTRACTED FOR INDUSTRIAL MEANS (Key Facts Table 33)

	Volume of groundwater abstraction supplied for industrial use	*Regional Total*	*% of groundwater abstraction supplied for industrial use*
Anglian	229.66	1184.4	19.4%
Midlands	143.23	1327.49	10.8%
North East	82.22	517.34	15.9%
North West	122.88	376.95	32.6%
South West	93.23	723.96	12.9%
Southern	142.1	1395.52	10.2%
Thames	116.51	1569.85	7.4%
Welsh	33.66	186.33	18.1%

NB all amounts are in millions of litres per day

RECEPTOR 8 - SURFACE WATER ABSTRACTION - POTABLE

VOLUME OF SURFACE WATER ABSTRACTED FOR POTABLE MEANS (Key Facts Table 32)

	Volume of Surface Water abstraction supplied for potable use	*Regional Total*	*% of Surface Water abstraction supplied for potable use*
Anglian	1087.77	1309.52	83%
Midlands	1645.68	3587.57	46%
North East	2373.35	3751.34	63%
North West	1441.89	2407.56	60%
South West	921.11	3763.68	24%
Southern	270.92	1451.2	19%
Thames	2665.38	3091.02	86%
Welsh	1452.61	6620.2	22%

NB all amounts are in millions of litres per day

RECEPTOR 9 - SURFACE WATER ABSTRACTION - AGRICULTURAL

VOLUME OF SURFACE WATER ABSTRACTED FOR AGRICULTURAL MEANS (Key Facts Table 32)

	Volume of Surface Water abstraction supplied for irrigation and agriculture use	*Regional Total*	*% of Surface Water abstraction supplied for irrigation and agriculture use*
Anglian	129.2	1309.52	10%
Midlands	125.58	3587.57	4%
North East	446.41	3751.34	12%
North West	163.57	2407.56	7%
South West	1501.07	3763.68	40%
Southern	1108.66	1451.2	76%
Thames	321.93	3091.02	10%
Welsh	310.41	6620.2	5%

NB all amounts are in millions of litres per day

RECEPTOR 10 - SURFACE WATER ABSTRACTION - INDUSTRY

VOLUME OF SURFACE WATER ABSTRACTED FOR INDUSTRIAL MEANS (Key Facts Table 32)

	Volume of Surface Water abstraction supplied for industrial use	*Regional Total*	*% of Surface Water abstraction supplied for industrial use*
Anglian	92.55	1309.52	7%
Midlands	1816.31	3587.57	51%
North East	931.58	3751.34	25%
North West	802.1	2407.56	33%
South West	1341.5	3763.68	36%
Southern	71.62	1451.2	5%
Thames	103.71	3091.02	3%
Welsh	4857.18	6620.2	73%

NB all amounts are in millions of litres per day

RECEPTOR 11 - POPULATION PHYSICAL

BUILT UP AREA AFFECTED BY FRESH WATER FLOODING (Source NW)

	Percentage of each regions built up area affected by freshwater flooding
Anglian	14.4
Midlands	7.8
North East	5.2
North West	4.8
Southern	5.7
South West	3.8
Thames	8.6
Wales	7.3

RECEPTOR 12 - FRESHWATER AESTHETIC VALUE

NUMBER OF RIVERS WITH BLOOMS COMPARED TO NATIONAL TOTAL

	Total number of rivers identified with alglal blooms	*Number of sites compared to national total*
Anglian	39	18.4%
Midlands	31	14.6%
North East	13	6.1%
North West	57	26.9%
South West	22	10.4%
Southern	9	4.2%
Thames	33	15.6%
Welsh	8	3.8%
	212	

PROPORTION OF RIVER VISITED WITH SEMI_NATURAL OR PREDOMINATELY UNMODIFIED CHANNELS (Figure XX)

	Percentage of river channels visited with semi-natural or predominantly unmodified channels
Anglian	33%
Midlands	56%
North East	55%
North West	51%
South West	48%
Southern	62%
Thames	34%
Welsh	75%

Risk Assessment Post Processor Spreadsheet System

The post processing spreadsheet has been designed to provide users with a tool for analysing data from 8 regional risk assessment spreadsheet models in order to find the best ways of presenting and comparing the results. The system starts up with a control panel (Fig 1) which allows users to define general parameters for the system's graphical displays. Initially the system calculates composite results for 2 hazards and 3 receptors from the breakdown in the individual risk assessment models. The weightings section allows the user to weight the importance of the individual hazards/receptors to the composite hazards/receptors used in the post processor. The remaining input boxes relate to the selection of Red/Yellow/Green "traffic light" displays which can be applied to some graphs.

The traffic lights can be set by:

- counting the number of entries on the appropriate risk assessment spreadsheet which are above the base triggers for red and yellow and setting the result to red or yellow depending on whether the Number Off entry is met or exceeded
- assessing whether the percentage of entries on the appropriate risk assessment spreadsheet which meet or exceed the Base Triggers is greater than the Percentage values input
- using a points system where a defined number of points are scored for each red/yellow/green entry on the appropriate risk assessment and determining whether the point total meets or exceeds the inputted Point Score for yellow and red

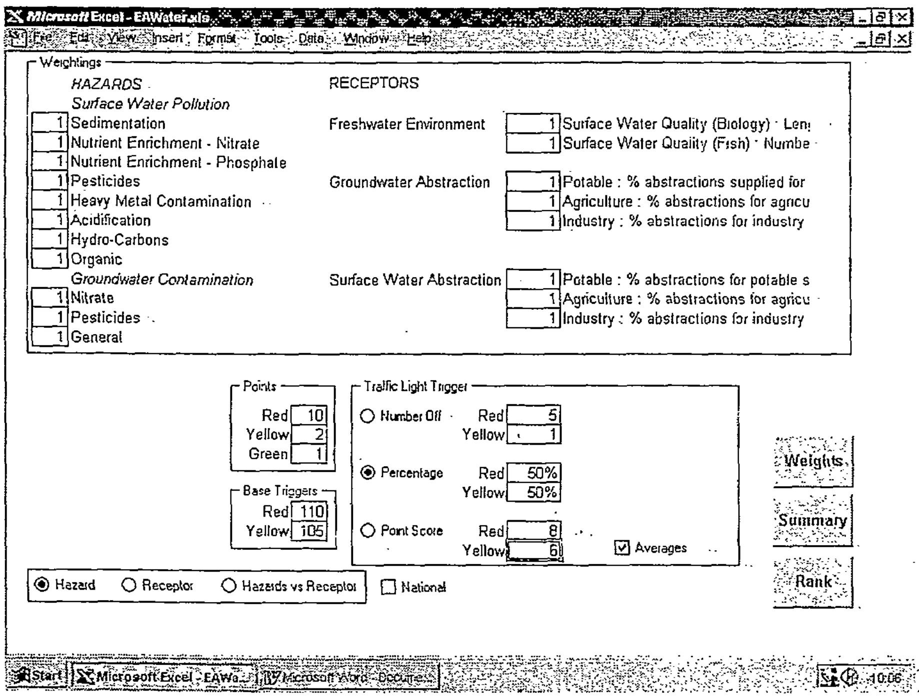


Fig 1

The buttons at the bottom left give access to a weights sheet which allows the user to adjust the relative importance of Hazards and Receptors for some displays and to displays giving an overview of the results. The option and check boxes at the bottom of the screen give access to more detailed breakdowns of the results.

The Weights sheet (Fig 2) allows the user to stress the relative importance of hazards and receptors for the displays which show hazard or receptor results separately. Displays which show hazard results vs receptor results are not affected by the weightings on this sheet. Weightings should be set by assigning a value of 1 to the lowest valued hazard/receptor as a base, then the relative importance of the other hazards/receptors can be e.g. a hazard considered to be twice as important as the base hazard would be assigned a weight of 2.

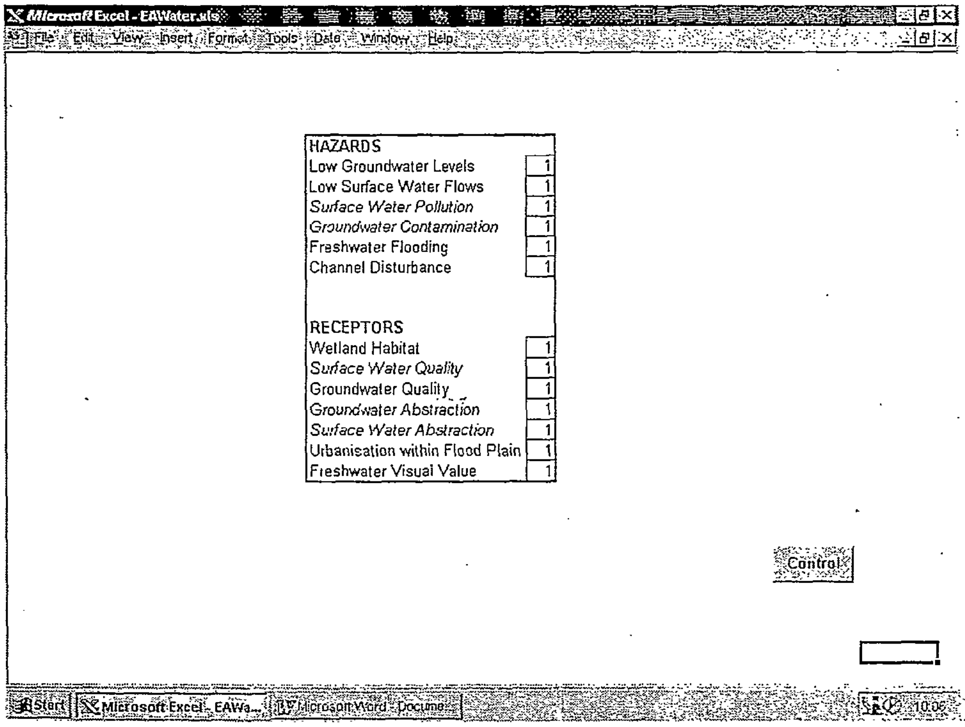


Fig 2

The Summary sheet (Fig 3) shows the relative scores for each hazard and receptor summed over the eight regions. The system allows the user to display either the total scores (which adds every entry in the individual risk assessment sheets) or an average score (which is the mean value of all the entries against each hazard or receptor).

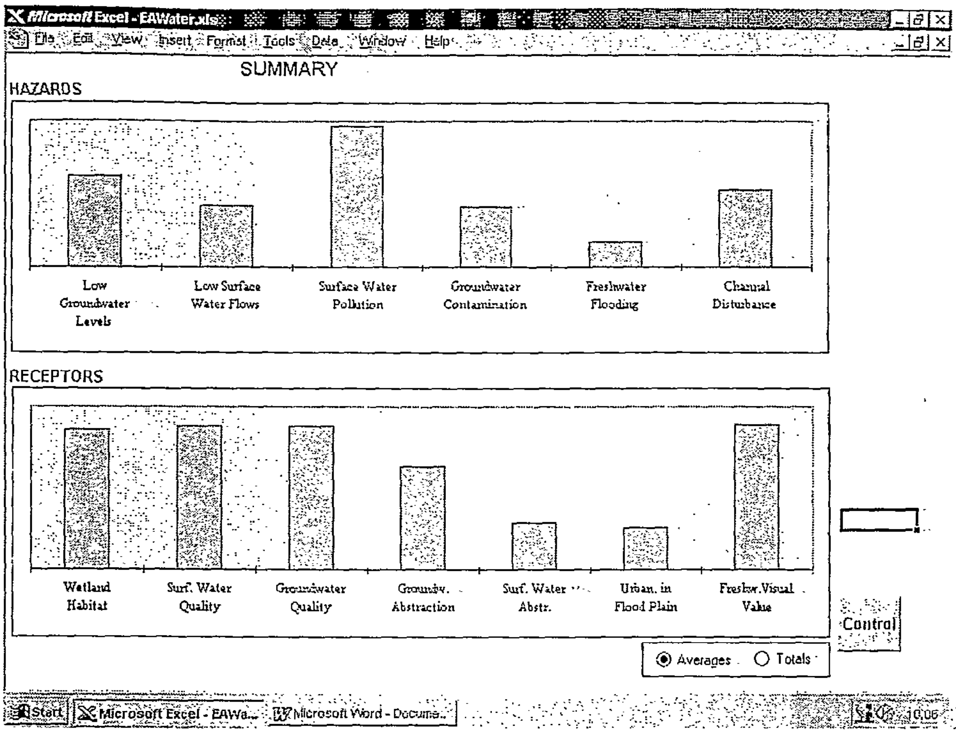


Fig 3

The Ranks sheet (Fig 4) gives a graphical representation of the rank order of each of the hazards and receptors across the regional areas. The highest risk appears at the top of the chart and the lowest at the bottom. By choosing different radio buttons the user can see how rank order changes if different scoring systems are used or average values or total values are used. Obviously receptors represented with multiple entries on the risk assessment sheets are likely to be ranked higher when totals are selected than when averages are selected.

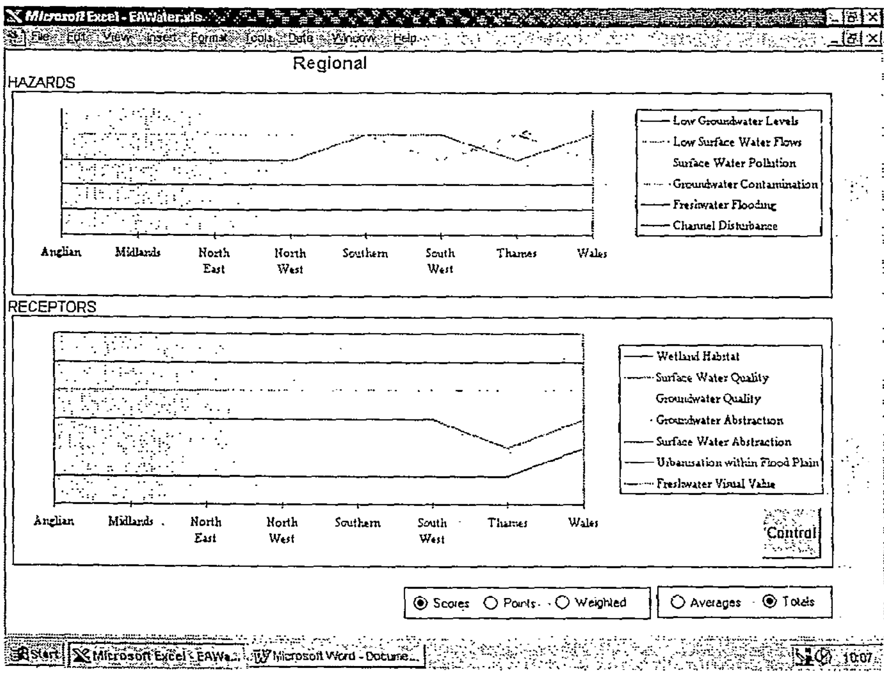


Fig 4

Hazard and receptor results can be displayed broken down over each regional area. An example is given at Fig 5 which shows the results for hazards relative to the highest and lowest scores nationally. Switching off the national check box presents the results relative to the highest and lowest scores within each regional area. The buttons at the right of the screen allows the same information to be shown in either line form (giving a similar representation to the rank graph be showing relative scores rather than simple order of ranking) or on a 3-D bar chart. The radio buttons at the foot of the chart allow access to all the data options available in the system.

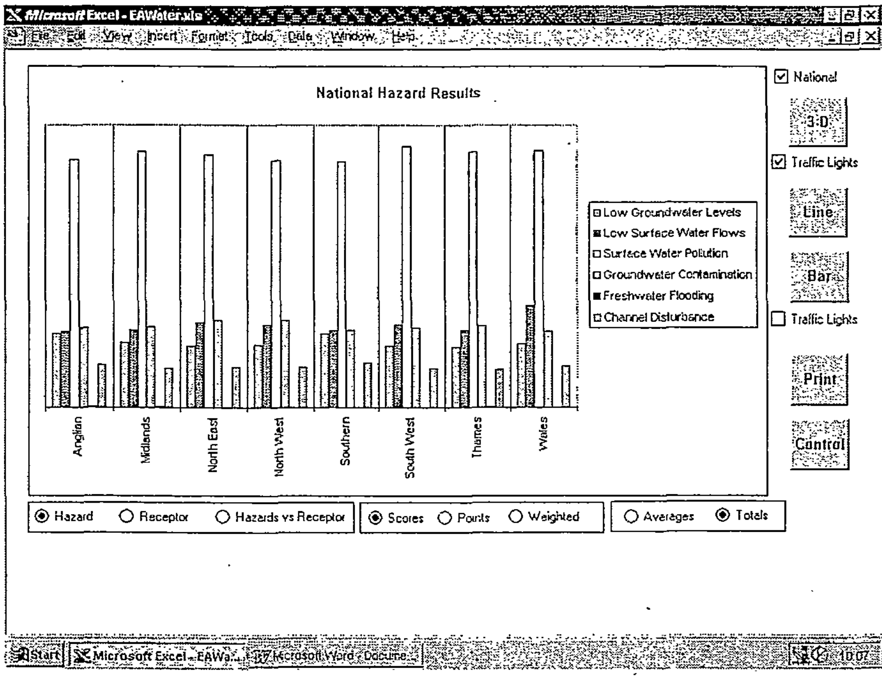


Fig 5

The traffic light switches paint the bars red/yellow/green depending on the system identified on the control sheet. An example is given at Fig 6.

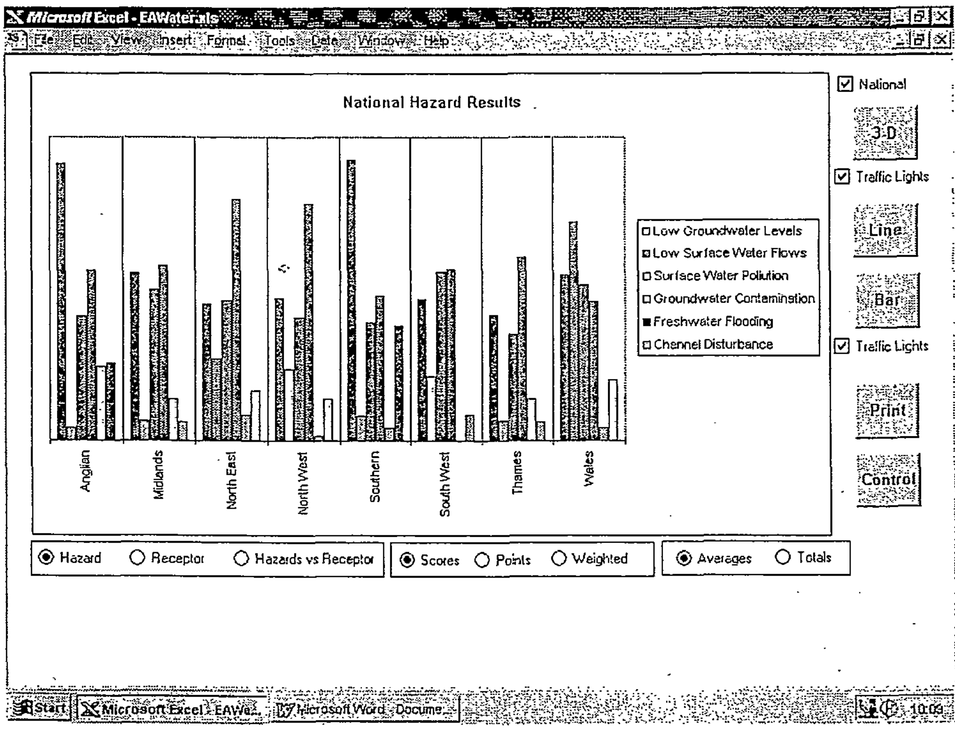


Fig 6

Displays showing the Hazard Vs Receptor results can be displayed either at national level (as shown in Fig 7) or for any of the individual areas (as shown in Fig 8). Any hazard or receptor weights entered on the weight sheet will be ignored for these graphs as their implications are felt to be confusing in this context.