NRA - Water Quality 42

Phil - copy for your file.
JW. 12/9.

629

NATIONAL RIVERS AUTHORITY

DIRECT TOXICITY ASSESSMENT

A step towards better environmental protection within the UK

BUSINESS STRATEGY

ETOX05

jrw/NC11/june94

NRA

CONTENTS

	Page
EXECUTIVE SUMMARY	5
ABBREVIATIONS USED IN THE TEXT	7
GLOSSARY OF TERMS	8
INTRODUCTION	11
1. PURPOSE OF THE DOCUMENT	11
2. BACKGROUND	11
THE BUSINESS NEED	12
3. GENERAL	12
4. CURRENT PRACTICE	14
5. THE DTA APPROACH	14
6. THE ROLE OF DTA IN ENVIRONMENTAL MANAGEMENT	17
THE BUSINESS ANALYSIS	19
7. GENERAL	19
8. OPERATIONAL ISSUES	19
9. POLICY ISSUES	20
10. CURRENT R&D INITIATIVES	20
A STRATEGY FOR THE WAY AHEAD	21
11. GENERAL	21
12. OPERATIONAL ISSUES	22
13. POLICY ISSUES	23
14. R&D STRATEGY	24
SUMMARY OF RECOMMENDATIONS	25

APPENDICES

APPENDIX 1 - US-EPA POSITION

APPENDIX 2 - EXTRACTS FROM THE US GENERAL ACCOUNTING OFFICE REPORT (FEBRUARY 1994)

APPENDIX 3 - US CLEAN WATER ACT

APPENDIX 4 - US CASE STUDIES (TOXICITY v INSTREAM IMPACT)

APPENDIX 5 - NRA ECOTOXICOLOGY GROUP AND TERMS OF REFERENCE

APPENDIX 6 - BUSINESS ANALYSIS (CURRENT NRA ECOTOXICOLOGICAL TESTING FACILITIES AND EXPERTISE)

APPENDIX 7 - CURRENT R&D PROGRAMMES

APPENDIX 8 - TBC LEAFLET

APPENDIX 9 - DTA LEAFLET

APPENDIX 10 - POLICY ISSUES (IMMEDIATE KEY TASKS)

APPENDIX 11 - MEDIUM TERM R&D STRATEGY

EXECUTIVE SUMMARY

This document defines the key role that Direct Toxicity Assessment (DTA) has in protecting the aquatic environment and proposes a National Strategy for the introduction of ecotoxicological procedures to help meet some business needs of the National Rivers Authority (and of Her Majesty's Inspectorate of Pollution) which are not being adequately met at present.

DTA has been applied successfully in the United States for almost a decade, as part of an integrated approach to pollution control and for the protection of aquatic life. In contrast to the current procedure of exerting control through chemical specific environmental quality standards, DTA provides a direct effects response whereby a whole sample (of effluent, receiving water, sediment etc.) is taken and a single measure of toxicity obtained.

An estimated 10,000 new chemicals reach the market each year. Currently, less than 0.1% of all available chemicals have an environmental quality standard (EQS) and those which do are often based on inadequate toxicological information. The derivation of EQSs cannot possibly keep pace with the production of new chemicals and the discharge of complex cocktails of chemicals presents analytical difficulties. Toxicity based consents (part of the DTA methodology) offer a better and more meaningful way of controlling complex effluents and directing investment on clean-up procedures. The wider application of DTA to the general quality assessment of controlled waters and its potential role in integrated pollution control (IPC) is presented.

Recent advances in method development and associated technology allow simple, robust, inexpensive tests to be applied to better assess effluent and exposure variability and to gain better control. Collaboration with other regulators, on co-funded R&D programmes, and consultation with industry, has allowed significant progress to be made toward the introduction of DTA procedures in the UK. The low level of expertise and facilities in the NRA is identified in a business analysis of the current national position.

A strategy for the way ahead is presented with twelve key recommendations which include the requirement for a business case to consider options to establish the necessary expertise and facilities for the introduction of the DTA as part of an integrated approach to water quality assessment and enhanced control of complex discharges.

ABBREVIATIONS USED IN THE TEXT

BPEO - Best Practical Environmental Option

DoE - Department of the Environment

DTA - Direct Toxicity Assessment

EPA - US Environmental Protection Agency

EQS - Environmental Quality Standard

FTE - Full Time Equivalent

GQA - General Quality Assessment

HMIP - Her Majesty's Inspectorate of Pollution

HMIPI - Her Majesty's Industrial Pollution Inspectorate (Scotland)

IPC - Integrated Pollution Control

IWEM - Institution of Water and Environmental Management

MAFF - Ministry of Fisheries and Food

NPDES - US National Pollutant Discharge Elimination System

NRA - National Rivers Authority

PARCOM - Paris Commission

R&D - Research and Development

RSC - Royal Society of Chemistry

SETAC - Society of Environmental Toxicology and Chemistry

SNIFFER - Scottish and Northern Ireland Forum for Environmental Research

SOEnD - Scottish Office Environment Department

SOAFD - Scottish Office Agriculture and Fisheries Department

SWQO - Statutory Water Quality Objective

TBC - Toxicity Based Consent

TRE - Toxicity Reduction Evaluation

WRc - Water Research Centre

GLOSSARY OF TERMS USED IN THE TEXT

Acute	a short period in the life span of the organism; this would be of the order of minutes for bacteria and usually $\leq$ 4 days for fish.
Antagonistic	a mixture of toxicants exhibiting less-than-additive total toxic effects.
Bioaccumulation	the process by which a compound is taken up by an aquatic organism, from water or through food and retained.
Bioassay	a test used to evaluate the relative potency of a substance or mixture of substances by comparing its effect on a living organism with the effect of a standard preparation on the same type of organism.
Bioavailability	a measure of the access that a toxicant has to the biological processes of an organism.
Bioconcentration	the process by which a compound is absorbed from water through the gills or epithelial tissues and is concentrated in the body.
Biological Assessment	an evaluation of the biological condition of a water body using biological surveys and other direct measurements of resident biota in surface waters.
Chronic	a relatively long period of exposure, usually a significant portion of the life span of the organism such as 10% or more.
Direct Toxicity Assessment	the use of bioassays to give a direct measure of effluent and environmental quality, expressed in toxicological parameters.
Lethal	causing the death of organisms by direct action.
Mixing Zone	an area where an effluent discharge undergoes initial dilution and is extended to cover the secondary mixing in the ambient water body. A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented.
Screening Tests	rapid toxicity tests used in routine monitoring and discharge control.
Sub-lethal	a stimulus below the level that causes death.
Substance Specific	the control and assessment of effluents and environmental samples using methods based on the analysis of individual substances or groups of substances.
Synergistic	a mixture of toxicants exhibiting greater-than-additive total toxic effect.

Toxicity	the inherent potential or capacity of a substance to cause adverse effects on living organisms.
Toxicity Reduction Evaluation (TRE)	a site-specific study conducted in a stepwise process designed to identify the causative agents of effluent toxicity, isolate the sources of toxicity, evaluate the effectiveness of toxicity control options, and then confirm the reduction in effluent toxicity.
Toxicity Test	a measure of the degree of effect on exposed test organisms of a specific chemical or effluent.
Whole Effluent Toxicity	the total toxic effect of an effluent measured directly with a toxicity test.

INTRODUCTION

1. PURPOSE OF THE DOCUMENT

1.1 The purpose of this document is to define the key role Direct Toxicity Assessment (DTA) has in protecting the aquatic environment and to establish a National Strategy for the introduction of ecotoxicological procedures to meet some business needs of the National Rivers Authority (NRA) (and of Her Majesty's Inspectorate of Pollution) which are not being adequately met at present.

2. BACKGROUND

2.1 As improvements in the quality of receiving waters are achieved by the more effective control of sanitary waste discharges (as measured by dissolved oxygen, biochemical oxygen demand and suspended solids) more attention is focused on those pollutants which cause damage by toxic effects.

2.2 There are currently in excess of 100,000 chemicals on the market with an estimated 10,000 new chemicals being produced each year. Relevant information on the toxicity of many chemicals is either poor or absent and their fate and behaviour in the aquatic environment is unknown. At present, only a very small number, less than 0.1%, have environmental quality standards (EQS).

2.3 The complex nature of receiving waters can result in high levels of a particular contaminant, often above the EQS, having no observable biological effect. By contrast, under different conditions, levels below the EQS can cause significant damage. Direct effects measures, such as DTA where a whole sample (effluent, receiving water, sediment etc.) is taken and a single measure of toxicity obtained, offer a better way of assessing real environmental impact and of prioritising investment on treatment processes.

2.4 The DTA approach has been used successfully in the United States to reduce both the volume and strength of toxic inputs from many waste discharges which enter the aquatic environment. It provides an important interface between chemical specific control and the biological assessment of receiving waters. Once established, it should reduce the need for the routine analysis of many complex determinands and better target the requirement for biological surveys. DTA is part of an integrated approach, there is a continuing need to reduce levels of particularly hazardous substances.

2.5 Currently, there are approximately twenty discharges regulated by the NRA (in Anglian, Welsh and Northumbria/Yorkshire Regions) which contain toxicity based criteria. The absence of an agreed national strategy and the limitation of available methodologies and associated quality assurance procedures, has meant that they have been only partially effective. Since 1989, following the formation of the NRA, R&D expenditure on ecotoxicological procedures has focused on the development and application of an improved methodology for direct toxicity assessment and control.

2.6 Toxicity measurements provide a direct effects based assessment of the health of the environment and, by employing the same methods, provide a mechanism for controlling those complex chemical discharges which cause damage (the toxicity based consent (TBC)). The application of toxicity based criteria to control waste discharges has been used extensively in the United States during the past decade, where toxicity testing is routinely implemented by regulatory agencies in a variety of effluent monitoring and toxicity reduction evaluation (TRE) programmes (Appendix 1).

2.7 In addition to point source discharges to both fresh and saline waters, the DTA approach can be applied to diffuse sources and episodic events and more widely to integrated pollution control (IPC).

THE BUSINESS NEED

3. GENERAL

3.1 Current UK practice relies predominantly on the application of EQSs and the determination of consented standards for the protection of aquatic life. For the sanitary determinands (with the exception of ammonia in some controlled waters) this has proven to be adequate although regimented sampling programmes take little account of real environmental effects of some determinands which are most lethal during hours of darkness. However, for the majority of chemicals, the substance specific approach cannot, on its own, provide satisfactory protection and an integrated approach including real effects measures is required.

3.2 To appreciate fully the value of DTA, it is necessary to understand its role in an integrated approach and to recognise the capabilities and limitations of each element for an assessment of the quality status of controlled waters (Table 1).

THE INTEGRATED APPROACH

1. SUBSTANCE SPECIFIC CONTROL (individual chemicals)

2. DIRECT TOXICITY ASSESSMENT (whole sample testing)

3. BIOLOGICAL ASSESSMENT (biological survey, bioconcentration/ bioaccumulation)

3.3 For the protection of aquatic life an integrated approach is required with each component providing valuable, but incomplete information. Reliance on chemical specific numeric criteria and/or biological criteria is only partially effective. To obtain the best information from monitoring programmes, for the cost effective control of waste discharges and for environmental impact assessment, it is important to understand the advantages and disadvantages of each.

Recommendation 1 - to accept the role of DTA, widely practised in the United States, in an integrated approach to water quality management.

TABLE 1 INTEGRATED APPROACH TO WATER QUALITY TOXICS CONTROL

CONTROL APPROACH	CAPABILITY	LIMITATION
Substance Specific	- protects human health	- does not consider all toxics
	- numeric standard can be set	- does not consider interactions of toxics
	- treatability data	- bioavailability not measured
	- less expensive if only few toxicants	- analysis can be expensive
		- cannot ascertain if a numeric standard is protective
Whole Sample Toxicity	- all toxics are addressed	- does not protect human health
	- aggregate toxicity measured	- no persistency data
	- bioavailability measured	- incomplete data on causative toxicant
	- can predict biological impact	
	- narrative standard can be applied	
Bioassessments	- measures biological impact	- impact has already occurred
	- all stressors measured	- cause of impact not identified
	- trend analysis	- standards limited
		- difficult to interpret data
		- can be expensive

4. CURRENT PRACTICE

4.1 Chemical-specific control of effluents of well defined composition and for which sound, scientifically based, environmental quality standards (EQSs) exist provides a simple, well understood measure of compliance against numerical criteria and is relatively inexpensive.

4.2 However, the derivation of many EQSs (metals and particularly organic chemicals) is often based on inadequate data, especially those relating to acute and chronic toxicological information on ecologically relevant species. An arbitrary safety factor is therefore applied which reduces the degree of certainty that protection is achieved at minimum cost to the discharger.

4.3 Even if a chemical has a sound EQS, there remains a number of problems (Table 1). It is rare for chemicals to be introduced into the environment singly or in pure form. In combination with other chemicals, in either the effluent or the receiving water, antagonistic and synergistic effects can radically alter the degree of toxicity. More importantly, in complex chemical discharges, there are many chemicals present for which no toxicological data exist and an EQS cannot be set. With an increasing number of new chemicals reaching the market each year it is unreasonable to expect the EQS approach to provide a sensible means of protecting the environment. Finally, there are analytical difficulties, with some EQSs being set below the current achievable limit of detection.

4.4 To help establish the level of protection afforded by the EQS approach, biological surveys provide information on community effects and reflect the overall health of the system. They are an integrated measure of all stressors, including the total toxic effect and provide additional information on the persistence and bioaccumulation of substances. However, biological surveys can be expensive and the data are often difficult to interpret, especially in saline waters. In cases where effects are clear, the impact has already occurred and the cause is rarely identified.

4.5 Inadequacies in the substance specific approach have been highlighted in a document published in February 1994 by the United States General Accounting Office, entitled "Poor quality assurance and limited pollutant coverage undermine EPA's control of toxic substances". Extracts from the document are provided in Appendix 2

Recommendation 2 - to accept the limitations of the substance specific approach and to support the need for new direct effects based measurements for the better control of complex chemical discharges and for more cost effective environmental impact assessment.

5. THE DTA APPROACH

5.1 Traditionally, a discharge consent is determined to ensure achievement of the relevant chemical specific EQS. Compliance is measured by the statistical evaluation of monitoring data which, together with information from biological surveys, is used to assess the protection of aquatic life.

5.2 DTA provides a better measure of the impact of complex waste discharges, and by using the same methods, establishes a means of control, thus reducing the need for chemical specific testing and bioassessment. Toxicity tests are not new; many are recognised internationally and are routinely employed to produce substance specific toxicological data. However, the duration and cost of these traditional tests severely limits their application to effluent monitoring and receiving water impact assessment. In recent years a number of abbreviated acute and chronic tests have been developed together with simple, more rapid screening tests. These allow the design of strategic sampling programmes to assess discharge variability and environmental impact and to achieve better control of complex chemical discharges. The NRA has invested in the development of these methods through its R&D programme and has produced a Methods Manual. New methods and their associated analytical quality control procedures will be added as they are developed.

5.3 In the United States both numeric and narrative criteria apply (Appendix 3). Such narrative criteria include:

"all State waters must be free from toxics in toxic amounts."

"all State waters must, at all times and flows, be free from substances that are toxic to humans or aquatic life."

Criteria are developed as national recommendations to assist States in interpreting narrative standards and consist of three components:

Magnitude - how much of a pollutant, expressed as a concentration, is allowable;

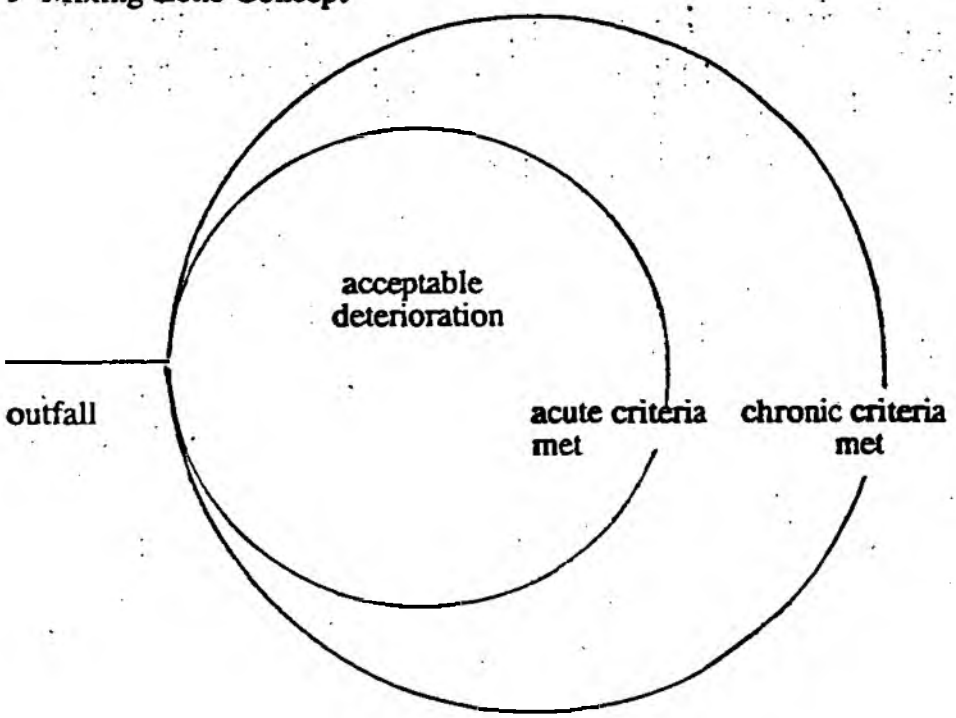
Duration - limits on the duration of exposure to elevated concentrations;

Frequency - how often the criteria can be exceeded

The procedure to implement the narrative criteria using whole sample testing should specify the testing procedure, the duration of the tests (acute or chronic), the test species and the frequency of testing required.

5.4 It is not always necessary to meet all criteria within the discharge itself to protect the integrity of the receiving water. Sometimes it is more appropriate to allow ambient concentrations to meet the criteria, using the concept of the mixing zone (Fig 1)

Figure 1 Mixing Zone Concept



Bioassay response at the point of application of the criteria should reflect ecological change (true impact). There have been a number of case studies, undertaken in the United States, to correlate effluent toxicity measurements to receiving water impact (Appendix 4).

5.5 There are three important sources of variability in water quality impact analysis, all of which cause considerable difficulty when analysing complex chemicals for substance specific control. Rapid toxicity tests and on-line monitoring can help overcome the difficulties:

Effluent variability - changes in composition can range from small (continuous processes), to quite dramatic (batch processes);

Exposure variability - caused by changes in flow rate of both effluent and receiving water;

Test variability - which, for whole sample testing, includes species sensitivity.

5.6 The development of rapid toxicity tests provides a more effective means of assessing effluent variability and enables the design of sound sampling programmes tailored to the toxic effect of concern (acute or chronic). This cannot be achieved easily by chemical specific analysis.

5.7 Exposure variability is best controlled by assuming steady state conditions at worst case exposure (an EQS based on an annual average, with little knowledge of the deviation about the mean or how it relates to real effects, is of little value).

5.8 Test variability is controlled by good analytical quality control and species variability can be assessed by testing a minimum of three species, representing different trophic levels. Batch cultures and good husbandry techniques also reduce biological variability and, when bacteria are the test organism, genetic engineering can be employed to evoke a specific test response. Toxicity testing is now sufficiently advanced to compare well with, and often exceed, the performance of chemical analytical methods.

5.9 The use of DTA to obtain a direct effects measure in the receiving water and deployment of the same method to effect control on the discharge provides an enormously powerful approach to the environmental management of complex waste waters.

Recommendation 3 - to gain a better understanding of the application of DTA procedures used in the United States, and other appropriate countries, particularly with respect to the effectiveness of narrative standards.

6. THE ROLE OF DTA IN ENVIRONMENTAL MANAGEMENT

6.1 The current chemical specific approach to controlling complex discharges is, in itself, inadequate. Of particular concern are those examples where the consent is breached, and where prosecutions are obtained, but where there is no demonstrable environmental impact as a result of the breached parameter. In contrast, but of equal concern, are those situations where all consent standards are met but where there is a clear environmental impact. An integrated approach (Section 3) is required to improve on current practice and provide better protection to aquatic life.

6.2 Discharge consent and compliance policy:

6.2.1 Recommendation 16 of the NRA Water Quality Series No. 1 (the Kinnersley Report) reads, "For environmentally significant discharges of complex composition where not all important constituents can be individually identified and numerically limited, consents should specify a clearly-defined toxicity limit, the appropriate form of toxicity test to be used, and the minimum frequency with which it should be applied".

6.2.2 In the United States, and in some European Countries, toxicity based criteria have been applied to many discharge regulations ranging from treated sewage effluents, which contain trade waste, to more complex industrial effluents. The introduction of simple, cost effective, robust screening measures of toxicity can provide valuable means of assessing discharge variability and thus better control.

6.2.3 The DTA approach also has a key role in the authorisation process administered by Her Majesty's Inspectorate of Pollution (HMIP). HMIP are co-sponsors of the TBC R&D programme and are represented on the Project Board.

6.2.4 A statement concerning the current position with regard to the TBC pilot study has been written for inclusion in the NRA Consenting Manual prior to establishing the necessary protocols for their implementation. It is unlikely that a single protocol will satisfy all complex discharge types but a framework to house the protocols should be established, and incorporated in the Consent Manual, by late 1995.

Recommendation 4 - to further develop protocols and procedural manuals for the implementation of TBCs for different complex discharge types and for all controlled waters. To achieve recommendation 16 of the Kinnersley report.

6.3 General Quality Assessment (GQA) and Statutory Water Quality Objectives (SWQOs):

6.3.1 The methodology used for effluent assessment and control can also be applied to receiving waters. This provides a strong cause-effect relationship and a more meaningful and better understood system of water quality management. This approach, using water column and sediment tests, is also being considered by the Ministry of Agriculture, Fisheries and Food (MAFF) with regard to their responsibilities for Dumping at Sea.

6.3.2 For some controlled waters, particularly estuaries and coastal waters, meaningful measures of the health of the system, usually provided by biological survey techniques, are difficult to obtain. The application of the DTA methodology can provide a direct measure of the health of the system, which in association with other measures (aesthetic and enrichment) can be used to assess the overall quality of the system. The inclusion of DTA in the GQA for estuaries is currently being investigated. DTA can also provide a better measure of protection for some SWQOs and it should become a fundamental part of an integrated approach to water quality assessment and the Catchment Management Planning process.

Recommendation 5 - to investigate current DTA methodologies and to develop toxicity based criteria for a general quality assessment of estuaries and coastal waters. To further consider the application of toxicity based criteria to all controlled waters.

6.4 Other Specific Discharges and Non-Point Source Inputs:

6.4.1 The DTA approach can be used to target the impact of specific discharges and, if appropriate, be used to effect control (examples include the use of disinfection agents to reduce the bacteriological content of domestic wastes discharging in the vicinity of recognised bathing waters and the discharge of tip leachates from landfill sites).

6.4.2 In addition to point source discharges, the DTA approach can be effective in assessing the impact of diffuse inputs or episodic incidents with the development of field tests. Because of its rapid deployment, it can also provide valuable data on the toxicity of a polluting influence in the event of an incident and be used to identify the source of the problem.

Recommendation 6 - to apply DTA procedures to priority point source and diffuse discharges (The first priority will be to consider the environmental implication of discharging disinfected sewage effluents to waters in the vicinity of recognised bathing waters).

6.5 Integrated Pollution Control:

6.5.1 The DTA approach can be applied to impact assessment and control in water, land and air environments and with the development of suitable techniques can be used to assess the best practical environmental option (BPEO) for waste disposal. These rapid techniques can also be used as a diagnostic tool and assist the identification of the source of the problem within the process plant (the TRE). Development of DTA thus offers, to a future Environmental Agency, a powerful means to identify real environmental effects and to establish effective control.

Recommendation 7 - in collaboration with other regulators, to promote the wider application of DTA procedures to IPC and the selection of the BPEO for waste disposal.

THE BUSINESS ANALYSIS

7. GENERAL

7.1 The business analysis considers the current position in the NRA regarding ecotoxicological expertise and facilities. It addresses current operational practice, policy issues and R&D initiatives.

7.2 Each Region is represented on the National Ecotoxicology Group (Appendix 5). The level of expertise nationally is low and resides with a few individuals only. Progress to date has been largely achieved through the Ecotoxicology Group and the National R&D programme. R&D investment has increased substantially since 1989 (from an inherited R&D budget of less than £100K in 1989 to a projected 1994/95 budget of £1.2M).

8. OPERATIONAL ISSUES

8.1 Details of Regional returns on the current level of activity on ecotoxicological testing are presented in Appendix 6.

8.2 Currently, there are approximately 10 full time equivalents (FTEs) engaged nationally on ecotoxicological issues with only 6 dedicated FTEs (primarily on testing). Even with the current low level of expertise there are large differences between the Regions.

8.3 The following key points have emerged:

8.3.1 The current estimated investment is;

Capital £692K Annual Revenue £306K

Of this almost 60% is centred in two Regions (Southern and Northumbria/Yorkshire) with less than 10% in four others (Thames, South Western, North West and Severn Trent).

8.3.2 The majority of Regions have Microtox, a relatively straightforward screening test. Only Southern and Northumbria/Yorkshire have sophisticated temperature control facilities with plumbed supplies of both fresh and sea water. Both facilities are small compared with those established by some of the major industrialists and contract laboratories (ZENECA, Shell, WRc). Anglian have an in-house facility but, due to lack of expertise, currently contract the work externally (approximately £50K).

8.3.3 There is currently a lack of consistent Quality Assurance and Quality Control procedures both within and between Regions.

8.3.4 The current level of testing, predominantly of effluents, is low. In a total of 2500 samples tested, in excess of 1000 employed the Microtox test. All Regions expressed a keenness to develop expertise and to improve on their current level of toxicity testing. There is currently no agreed National programme for toxicity testing in relation to either discharge control or receiving water impact assessment.

9. POLICY ISSUES

9.1 Sections 6.2.1 and 6.2.4 refer to the Kinnersley Report recommendation 16 and to the NRA Consents Manual respectively. Other business needs with respect to GQA Classification schemes, other discharge types and IPC are identified in Sections 6.3 to 6.5 inclusive. To date these issues have been progressed by the Ecotoxicology Group.

9.2 Proposals for the introduction and uptake of ecotoxicological procedures are the subject of papers which have been previously submitted to the Environmental Quality Committee (ETOX01, 02 and 03) together with proposals for a Controlling Business framework (ETOX04). Control of the further development of DTA initiatives and their implementation will now rest with a Toxics Project Board. The National Ecotoxicology Group is recognised as the expert group and will act in an advisory capacity providing a Regional focus.

9.3 There remain many unresolved policy issues which will need to be addressed if this potentially powerful approach to water quality impact assessment and discharge control is to be recognised. These are identified in the business strategy.

Recommendation 8 - to note the current position with respect to ecotoxicological expertise and facilities in Regions.

10. CURRENT R&D INITIATIVES

10.1 Current R&D initiatives in support of the DTA are summarised in Appendix 7.

10.2 Project plans for the three main areas of activity (Method development, TBC pilot study and the application of DTA to receiving waters) can be provided on request. The TBC programme is co-sponsored by HMIP and SNIFFER and is managed by a Project Board with representation from all parties and corresponding membership from other UK regulators (DoE, MAFF, SOEnD, SOAFD, HMIPI)

10.3 The following outputs have been delivered (either directly or as statements of progress):

NRA Ecotoxicology Methods Manual

TBC poster and leaflet (Appendix 8)

DTA poster and leaflet (Appendix 9)

TBC position statement in NRA Consent Manual

10.4 The implementation plan for DTA and TBCs includes initiatives to raise the general level of awareness of the procedures and to present progress reports. It is emphasised that development should be by consultation with interested parties. To date, papers/posters have been presented at the First World SETAC meeting held in Lisbon (March 1993), the SETAC UK Conference at Keele University (November 1993), a Hong Kong Government Workshop (December 1993) and a PARCOM Workshop held in Berlin (June 1994).

10.5 Presentations, by invitation, have been made to industry (the Petroleum Industries Association, The Chemical Industries Association, the Paper Industry Research Association and ZENECA); and to other UK regulators (River Purification Boards, MAFF, HMIP). International liaison has been established with contacts both in Europe and the United States.

10.6 Articles and briefings have been published in the ENDS Report (December 1992), Industrial Waste Management (April 1994) and Integrated Environmental Management (in press). Other papers (IWEM and RSC International Conference) are planned.

A STRATEGY FOR THE WAY AHEAD

11. GENERAL

11.1 The use of limit standards in discharge consents to ensure compliance with EQSs, which supposedly protect the aquatic environment, is inadequate for complex discharges and the role of DTA in an integrated approach has been identified (Sections 3 to 6).

11.2 Implementation of the DTA strategy requires a business plan leading to a phased introduction of the ecotoxicological techniques (real effects measures) and procedures for their application. Some methods can be applied immediately and could bring about rapid improvements in receiving water quality. Other methods need to be developed and applied in accordance with an agreed programme of R&D and associated uptake routes. This particularly applies to the role of DTA in IPC.

11.3 The strategy considers immediate and future needs, addressing operational and policy issues, together with a medium term plan for R&D.

12. OPERATIONAL ISSUES

12.1 The introduction of TBCs and the application of toxicity based criteria to provide real effects measures for environmental impact assessment will require appropriate ecotoxicological testing facilities. Current in-house facilities (Section 8) are limited and are considered to be inadequate to meet the likely demand whilst external testing houses are expensive and offer only some of the required test methods.

12.2 A few existing consents include a toxicity measure. These have proven to be difficult to administer because of inadequate standardisation of methods and quality control procedures. It is not acceptable to establish a TBC in the absence of documented test procedures, associated quality assurance and a well considered compliance monitoring programme which must be strictly applied.

12.3 New ecotoxicological methods offer a practical way forward for toxicity based consenting and provide direct effects measures for better waste management. Some of the currently available methods are established in the United States where the test requirements are met by a combination of EPA (US Environmental Protection Agency) internal laboratories and numerous testing houses. There are a number of options which need to be considered further in a business case to deliver the strategy. These include:

* Establish a national testing facility to meet all testing requirements and quality assurance procedures for the regulator and provide an independent assessment of discharger based testing programmes (self-monitoring).

* Establish one or more national testing facilities and regional facilities for the simple and rapid screening tests. Quality assurance to be delivered centrally together with an independent assessment of discharger based testing programmes.

* Establish full testing facilities in all regions with quality assurance being delivered either centrally by one location or by external contractor.

* All testing to be done by external contract laboratories.

* Provide testing facilities by a combination of in-house (national and/or regional) and external contract laboratories.

12.4 It is recognised that the DTA initiative, whilst offering a better means of control of complex chemical discharges and assessment of environmental benefit by real effects measures, is new to the NRA. Inevitably, to deliver real environmental benefit, initial investment will be high. However, a significant reduction in the number of chemical determinands measured and the frequency of chemical sampling could produce large savings. The procedures offer the prospect of a substantial improvement in the way sampling programmes are designed and executed.

Recommendation 9 - to produce a business case considering options to phase in the required resource and facilities for the introduction of ecotoxicological methods to establish DTA procedures.

13 POLICY ISSUES

13.1 Experience has shown that the application of new methodologies requires careful planning if consistency of approach is to be achieved. Current expertise is spread thinly in the Regions and is considered inadequate for proper development and promotion of policy issues for the successful implementation of the DTA approach.

13.2 The application of DTA to effluent control and to environmental quality assessment requires both method and procedural manuals which will need to be added to as methods are developed, and regularly updated as new procedures are adopted. It should be born in mind that the application of the direct effects measures approach to waste management and cost effective environmental benefit is not restricted to the aquatic environment. Procedures for the wider application of DTA for integrated pollution control and the choice of BPEO require close liaison with other regulators.

13.3 The following key tasks need to be addressed and sustained:

* Implementation - the introduction of DTA methods and associated procedures by a common and consistent approach nationally. Methods and procedural manuals to be written and updated in accordance with a client specification.

* Planning - the design of suitable sampling programmes with a target reduction of the analytical profile and frequency of analysis of specific substances. (The role of substance specific analysis for routine monitoring purposes and the achievement of EC directive needs is part of the integrated approach).

* Advice - provide expert advice for the selection of an appropriate protocol for TBC setting and the application of suitable ecotoxicological methodologies and the associated quality control procedures for environmental effects assessment.

* Archive - the compilation of information and data from DTA applications. The development of a database to archive all TBC consent data is considered essential for the wider application and development of protocols for many discharge types.

* Audit - the procedures, methods and data returns on DTA application. Direct effects measures provide a powerful approach to water quality management but the adoption of new procedures requires good quality assurance to meet the client specification.

* Development - of the DTA procedures, in collaboration with other regulators, for wider application to IPC and the BPEO approach. This issue should be further address by a medium-term R&D programme.

* Educate - learn by liaison with other professional staff, both nationally and internationally. Raise the level of awareness of direct effect measurements for water quality management and discharge control purposes with regulators, industry, research groups and the general public.

* Value for money - involving the continued review of procedures and their application to gain cost effective environmental benefit.

A summary of current initiatives and some of the more immediate tasks are identified in Appendix 10.

13.4 The current level of NRA expertise required to introduce and sustain the DTA approach is inadequate to address the key tasks. As with the need to address operational requirements (Section 12), a number of options to address those issues identified in Section 13.3 above need to be considered in a business case. These will include:

* Establish expertise in all Regions.

* Centralise the expertise.

* Employ contract expertise where available.

* Combine in-house and contract expertise.

Recommendation 10 - to include in a business case (Recommendation 9), options to establish the required expertise to undertake the key tasks identified in the strategy for the implementation of DTA procedures nationally.

13.5 The DTA approach is well established in the United States where more than 2500 discharges have toxicity based permits, and toxicity based criteria, are routinely monitored as part of an integrated assessment of environmental quality. It is important that UK regulators draw on this expertise and liaise with their counterparts in the United States and Europe to ensure effective and efficient application.

Recommendation 11 - to establish links with national and international groups and professionals. Within the UK and Europe particularly, better liaison with industry, other regulators and research organisations is required.

14. R&D STRATEGY

14.1 Current R&D initiatives (Section 10) are based on a three year planning cycle. This has restricted the commitment to introducing DTA procedures and, additionally, has caused difficulties for our main contractor which has threatened the valued expertise provided. It has also resulted in the premature demise of some work in order to advance more pressing needs. This is particularly the case in the development of new methods.

14.2 The application of the DTA approach for the continued development of more effective procedures for water quality management purposes, and the wider application to establish the most suitable route for the disposal of waste material, requires a longer term strategy.

14.3 A draft, medium-term strategy is shown in Appendix 11. Options and costings will be considered in a business case to introduce the strategy. The medium term strategy allows better planning and collaboration with other interested parties, particularly other regulators with common needs. It provides a firm indication of our intentions and, although offering no guarantees, does provide external expert groups and research organisations with a better idea of our needs.

Recommendation 12 - to adopt the medium-term framework R&D strategy and, as part of the business case, to produce a detailed plan with associated costs and timescales.

SUMMARY OF RECOMMENDATIONS

Recommendation 1 - to accept the role of DTA, widely practised in the United States, in an integrated approach to water quality management.

Recommendation 2 - to accept the limitations of the substance specific approach and to support the need for new direct effects based measurements for the better control of complex chemical discharges and for more cost effective environmental impact assessment.

Recommendation 3 - to gain a better understanding of the application of DTA procedures used in the United States, and other appropriate countries, particularly with respect to the effectiveness of narrative standards.

Recommendation 4 - to further develop protocols and procedural manuals for the implementation of TBCs for different complex discharge types and for all controlled waters. To achieve recommendation 16 of the Kinnersley report.

Recommendation 5 - to investigate current DTA methodologies and to develop toxicity based criteria for a general quality assessment of estuaries and coastal waters. To further consider the application of toxicity based criteria to all controlled waters.

Recommendation 6 - to apply DTA procedures to priority point source and diffuse discharges (The first priority will be to consider the environmental implication of discharging disinfected sewage effluents to waters in the vicinity of recognised bathing waters).

Recommendation 7 - in collaboration with other regulators, to promote the wider application of DTA procedures to IPC and the selection of the BPEO for waste disposal.

Recommendation 8 - to note the current position with respect to ecotoxicological expertise and facilities in Regions.

Recommendation 9 - to produce a business case considering options to phase in the required resource and faciilities for the introduction of ecotoxicological methods to establish DTA procedures.

Recommendation 10 - to include in a business case (Recommendation 9), options to establish the required expertise to undertake the key tasks identified in the strategy for the implementation of DTA procedures nationally.

Recommendation 11 - to establish links with national and international groups and professionals. Within the UK and Europe particularly, better liaison with industry, other regulators and research organisations is required.

Recommendation 12 - to adopt the medium-term framework R&D strategy and, as part of the business case, to produce a detailed plan with associated costs and timescales.

APPENDIX 1

US-EPA position statement (see also Appendix 3)

APPENDIX 1

US-EPA POSITION (EPA Technical Support Document for Water Quality-Based Toxics Control)

Development of Water Quality-Based Permit Limitations for Toxic Pollutants: National Policy.

Summary: EPA has issued a national policy statement entitled "Policy for the Development of Water Quality-Based Permit Limitations for Toxic Pollutants." This policy addresses the technical approach for assessing and controlling the discharge of toxic substances to the Nation's waters through the National Pollutant Discharge Elimination System (NPDES) permit programme.

Extract from Policy Statement:

The EPA will use an integrated strategy consisting of biological and chemical methods to address toxic and nonconventional pollutants from industrial and municipal sources. Where State standards contain numerical criteria for toxic pollutants, NPDES permits will contain limits as necessary to assure compliance with these standards. In addition to enforcing specific numerical criteria, EPA and the States will use biological techniques and available data on chemical effects to assess toxicity impacts and human health hazards based on the general standard of "**no toxic material in toxic amounts.**" EPA, in its oversight role, will work with States to ensure that these techniques are used whenever appropriate.

Where there is a significant likelihood of toxic effects to biota in the receiving water, EPA and the States may impose permit limits on effluent toxicity and may require an NPDES permittee to conduct a toxicity reduction evaluation. Where toxic effects are present but there is a significant likelihood that compliance with technology-based requirements will sufficiently mitigate the effects, EPA and the States may require chemical and toxicity testing after installation of treatment and may reopen the permit to incorporate additional limitations if needed to meet water quality standards. (Toxicity data, which are considered "new information" could constitute cause for permit modification where necessary).

APPENDIX 2

US General Accounting Office audit report on substance specific control under the NPDES permit scheme

APPENDIX 2

UNITED STATES GENERAL ACCOUNTING OFFICE

PAGE 1 OF APPENDIX - EXTRACTS FROM WATER POLLUTION REPORT ON SUBSTANCE SPECIFIC CONTROL (FEBRUARY 1994) "POOR QUALITY ASSURANCE AND LIMITED POLLUTANT COVERAGE UNDERMINE EPA's CONTROL OF TOXIC SUBSTANCES"

"We reviewed the information on actual toxic effluent discharges for 236 facilities and compared them to the facility's permits (substance specific). We found a large number of different pollutants being discharged by one or more of the 236 facilities. One hundred and eighty five different pollutants were reported to have been discharged from the 236 facilities. Whereas some pollutants were discharged from a single facility, others were reported from numerous facilities. For example, chloroform, a common by-product of industrial processes that EPA views a probable carcinogen, was reported to be discharged by 91 of the 236 facilities (but permitted in only 28).

We found that a large number of toxic pollutants being discharged (77%) were not listed on the NPDES permits of the facilities we studied. We also examined the discharge of uncontrolled toxic pollutants from the perspective of individual facilities. We found that for 200 of the 236 facilities (85%) the majority of the toxic pollutants they discharged were not controlled through the permit process.

In short, this finding makes clear that the permit application process emphasises the control of priority pollutants over others. To determine whether and to what degree that is important, however, one needs to examine whether or not controlling these pollutants actually results in human health or aquatic life risk."

PAGE 2 OF APPENDIX - CONCLUSIONS OF THE REPORT

CONCLUSIONS, A MATTER FOR CONSIDERATION, RECOMMENDATIONS, AND AGENCY COMMENTS

Conclusions

The discharge of toxic pollutants to the nation's rivers and streams poses both human health and aquatic health risks. This study has found that the current EPA water toxics control program has major problems in effectively controlling these risks. First, because the necessary steps to ensure that program activities are supported by information of acceptable quality are often not taken, the information produced is questionable and activities themselves are of uncertain usefulness. Second, a wide range of toxic pollutants posing both human health or aquatic life risk are not addressed by the permit control process. Further, the EPA program has not established human health or aquatic life criteria for many of the pollutants that are discharged to the nation's waters. Consequently, when developing permit limits for facilities, their risks cannot be assessed and they are not regulated.

Given that these problems have been long-standing for the EPA water quality program in general and that the likelihood of effectively addressing them is uncertain, we also conclude that it is time to question and reassess whether the basic strategy EPA uses to control toxic discharges can be expected to produce the results envisaged by the Clean Water Act. Therefore, we believe that the overall approach now used for controlling toxic discharges should be re-examined. This is especially important since controlling discharges of toxics from point sources, although an important water quality concern, competes with other causes of water quality impairment for scarce federal funds. In addition, EPA and the states run their water quality protection programs under stringent budgetary constraints. As a result, we cannot assume that the program will be funded adequately to effectively address the quality assurance and pollutant coverage needs identified in this report.

Consequently, we provide a matter for congressional consideration. In addition we make two recommendations specific to the problems we identified. The matter for congressional consideration suggests changing the general approach used for limiting discharges of toxic pollutants into the nation's water, emphasizing pollution prevention. Integrating pollution prevention principles into the current standards approach may yield an improvement in water quality without a significant increase in regulatory overhead.[1] A pollution prevention approach would encourage a reduction in toxic discharges by changing the system to make it in the interest of discharges themselves to limit the release of toxics.

---

[1] Pollution prevention is discussed in U.S. General Accounting Office, Pollution Prevention : EPA Should Re-examine the Objectives and Sustainability of State Programs, GAO/PEMD-94-8 (Washington, D.C.: January 25, 1994), and Water Pollution: Stronger Efforts Needed by EPA to Control Toxic Water Pollution, GAO/RCED-91-154 (Washington, D.C.: July 19, 1991).

APPENDIX 3

Statutory Authority for the use of Toxicity Testing and Whole Effluent Toxicity Limitations in NPDES Permits

CLEAN WATER ACT (33 U.S.A. 1251 SEQ.)

Statutory Authority for the Use of Toxicity Testing and Whole Effluent Toxicity Limitations in NPDES Permits:

Over the years, a development process has occurred regarding the use of biological techniques to assess effluent discharges and set permit limits. The acquisition of data and the development of new techniques has contributed to the refinement of toxicity testing methods, thus enabling EPA to more fully act in accordance with its mandates to implement statutory requirements relating to the attainment and maintenance of water quality.

Toxicity testing of Whole Effluents and Whole Effluent toxicity limitations in National Pollutant Discharge Elimination System (NPDES) permits are essential components in the control of the discharge of toxic pollutants to the nation's waters. The use of toxicity testing and Whole Effluent toxicity limitation in the NPDES program is clearly authorized by the Clean Water Act (CWA).

Relevant provision of the CWA that provide the statutory authority for using toxicity testing and Whole Effluent toxicity limitations include the following:

* Section 101(a) sets forth not only the goal of restoring and maintaining the "chemical, physical, and biological integrity of the Nation's waters" (emphasis added), but also in section 101(a)(3) the national policy of prohibiting the "discharge of toxic pollutants in toxic amounts" (emphasis added).

* As defined at Section 502(15), biological monitoring means that "determination of the effects on aquatic life, including accumulation of pollutants in tissue, in receiving waters due to the discharge of pollutants (A) by techniques and procedures, including sampling of organisms representative of appropriate levels of the food chain appropriate to the volume and the physical, chemical, and biological characteristics of the effluent, and (B) at appropriate frequencies and locations."

* Section 304(a)(8) requires EPA to develop information on methods, including biological monitoring and assessment methods, to establish and measure water quality criteria for toxic pollutants on bases other than pollutant by pollutant criteria.

* Section 303(c)(2)(B) states, "Nothing in this section shall be construed to limit or delay the use of effluent limitations of other permit conditions based on or involving biological monitoring of assessment methods..." (emphasis added).

* Section 302(a) provides the authority to establish water quality-based effluent limitations on discharges that interfere with the attainment or maintenance of that water quality which shall assure protection of public health, public water supplies, and the protection and propagation of a balance population of shellfish, fish and wildlife, among other uses. The effluent limitations established must reasonably be expected to contribute to attainment or maintenance of such water quality.

* Under section 301(b)(1)(C) and section 402, all NPDES permits must comply with any more stringent limitations necessary to meet applicable water quality standards, whether numeric or narrative.

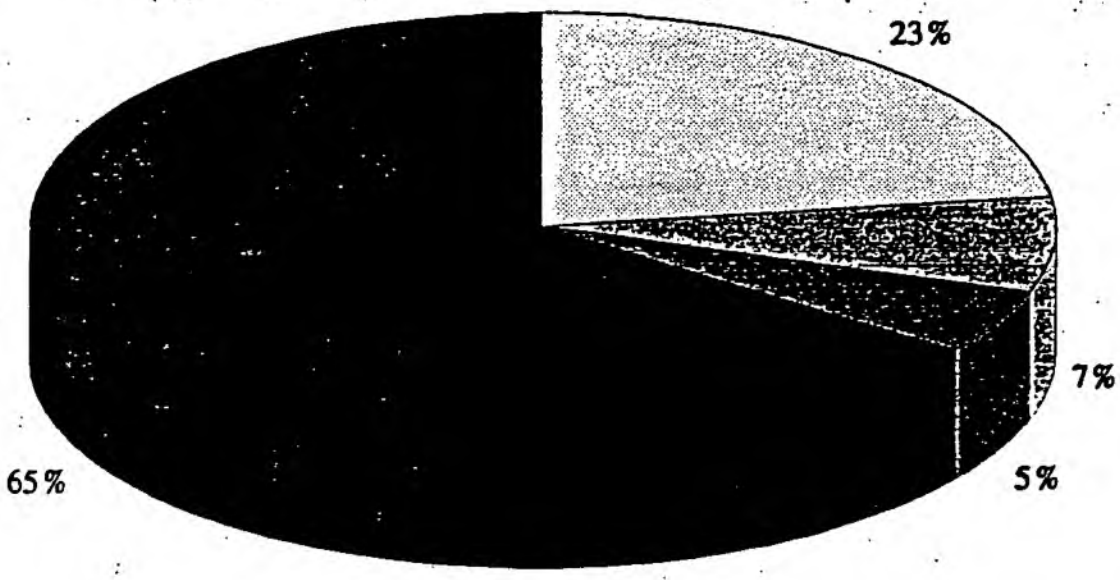
* CWA Section 308(a) and Section 402 provide authority to EPA or the State to require that NPDES permittees/applicants use biological monitoring methods and provide chemical, toxicity, and instream biological data where necessary for the establishment of effluent limits, the detection of violations, or the assurance of compliance with water quality standards.

* Section 510 provides the authority for states to adopt or enforce any standards or effluent limitations for the discharge of pollutants only on the condition that such limitations or standards are no less stringent than those in effect under the CWA.

APPENDIX 4

EXTRACT FROM US-EPA DOCUMENT "TECHNICAL SUPPORT DOCUMENT FOR WATER QUALITY-BASED TOXICS CONTROL"

Correlation of whole effluent toxicity measurements to actual receiving water impact.



☐ No instream toxicity predicted, no impact noted

☒ Instream toxicity predicted, no impact noted

■ No instream toxicity predicted, impact noted

■ Instream toxicity predicted, impact noted

US EPA: Comparison of Effluent Toxicity of Receiving Water Impact using *Ceriodaphnia* Chronic Toxicity Tests and Freshwater Receiving Stream Benthic Invertebrates at 43 Point Source Discharging sites in North Carolina

APPENDIX 5

NRA Ecotoxicology Group and Terms of Reference

APPENDIX 5

ESG/01

ECOTOXICOLOGY STEERING GROUP

TERMS OF REFERENCE

1. To provide a nucleus of expertise and a focus for ecotoxicological activities within the National Rivers Authority.

2. To consider and advise on ecotoxicological procedures and their introduction for operational and regulatory control purposes.

3. To provide technical advice, and input technical information, to R&D projects as required.

4. To develop and keep under review a long-term strategy for the development and implementation of ecotoxicological procedures.

5. To establish a satisfactory interface between the Ecotoxicology Steering Group, the National Centres for Marine Monitoring and Toxic & Persistent Substances and Regional Water Quality Officers and Scientific Staff.

6. To promote the general level of awareness of ecotoxicological procedures and their contribution to business needs within the NRA and to ensure the effective dissemination of information to Regions. To assist the implementation of R&D outputs into operational practice in the Regions.

7. To establish links and effective liaison with national and international experts, other UK regulators, industry and R&D groups.

ESG/02

ECOTOXICOLOGY STEERING GROUP

CONSTITUTION OF THE GROUP

Steering Group membership will comprise a single nominated representative from each Region, who will act as the contact point within the agreed Terms of Reference, and R&D Project/Package leaders associated with identified ecotoxicological programmes. Southern Region will provide the chair and technical secretary to the group.

Technical support and advice will be provided from in-house staff and by the main contractor (WRc), who will attend Steering Group meetings by invitation.

The Steering Group will retain the option to invite other regulators (DoE, MAFF, HMIP, SNIFFER and RPBs) to act as corresponding members on specific issues and to receive Steering Group minutes.

From time to time the constitution of the Steering Group will be reviewed to take account of changing R&D initiatives and Regional needs.

The Terms of Reference of the Steering Group are set out in paper ESG/01.

Current Membership:

J.Wharfe (Southern - Chair)
N.Holden/R.Boumphrey (Southern - Secretary/Package Leaders)

Technical

R.Sweeting (Thames - Project Leader)
D.Tinsley (Thames - Package Leader)
T.Crawshaw (Southern - Project Leader)
S.Killeen (Thames - ETAS)
C.Turner (Northumbria/Yorkshire - Project Leader)
E.Fisher (North West)
J.Dolby (Severn-Trent)
L.Waring (Anglian)
R.Milne (Welsh)
A.Frake (South-Western)
M.Foreshaw (Thames - R&D Coordinator)
G.Llewellyn (Head Office)

APPENDIX 6

THE BUSINESS ANALYSIS

Current NRA ecotoxicological testing facilities and expertise

APPENDIX 6

Ecotoxicology Business Analysis Questionnaire: Summary of Regional Returns

Introduction

This report summarises the current regional status of ecotoxicological procedures in the NRA. It is based on the returns from a questionnaire distributed to the eight regions. Where possible data has been collated into tables for ease of comparison; but other information and comments are outlined below.

1. Costs and Staffing.

Table 1 outlines the current estimated expenditure and capital costs of the Regional ecotoxicology programmes. In two cases an estimation of building costs was not supplied but these are thought to be small. The revenue costs for Anglian Region are solely for ecotoxicological testing that is contracted out. Anglian do have lab. facilities (this is reflected in their capital costs) but no in-house expertise.

Northumbria and Yorkshire, Welsh and North West Regions all report more than one facility. The costs for each area facility have been combined in table 1.

North West Region is buying two additional Microtox units (anticipated capital equipment costs £36k) and it is likely that there will be extra associated staffing costs.

Virtually all staffing costs reported are associated with Regional programmes. Thames Region reports £17k in staffing costs, but this includes approx. £7k for time spent on National initiatives. £40k of the £65k reported by Southern Region is for 2 full time staff employed on National initiatives.

Most Regions report some expertise in ecotoxicological test methods. Exceptions are Severn Trent and Thames where no qualified staff were reported.

2. Facilities

Table 2 summarises the facilities available in each Region. Anglian and the Northern area of North West Region do not use their facilities for ecotoxicological testing but can make them available should the need arise. Areas in North West, Thames and Welsh Regions report project licences for premises under the Animals (Scientific Procedures) Act, 1986.

3. Test Programmes

Table 3 shows the current test programmes in the Regions. Reported QA/QC arrangements were diverse and these are indicated by a simple 'yes/no' in the table.. However there is an obvious need for more rigorous quality protocols.

4. Other comments and conclusions

Toxicity based discharge consents have already been set in Northumbria and Yorkshire, Anglian and Welsh regions with Anglian having the majority (15 toxicity based consents). Toxicity based data have also been used successfully to support prosecutions although no Regions have yet reported breaches of Toxicity Based Consents.

All Regions with ecotoxicological expertise expressed a willingness to help progress national initiatives, however, no Regions were able to express this in terms dedicated staff resources.

The following points may be concluded from information supplied by this survey:

1. The NRA has considerable capital (£692k) invested in ecotoxicological testing facilities. However almost 60% of this is centred on two regions (Southern and Northumbria and Yorkshire). Whilst Anglian have a facility they contract all work out due to lack of in-house expertise.

2. Most regions use basic tests but are keen to improve their facilities and keep up to date with national and international advances.

3. There is a lack of consistent Quality Assurance and Quality Control between and within Regions.

4. There is no coherent national testing programme. Some Regions are far ahead of others in terms of test programmes, consents set and expertise.

TABLE 1. ECOTOXICOLOGY: CURRENT REGIONAL STATUS: COSTS (x £1000)

	REVENUE (k)			CAPITAL (k)		
REGION	STAFF	RUNNING	TOTAL	EQUIPMENT	BUILDING	TOTAL
Southern	65	52	117	151	85	236
Northumbria and Yorkshire	73	20	93	172	a	172
Thames	17	5	22	20	0	20
South Western	12	3	15	5	5	10
North West	0.8	2	2.8	22	b	22
Anglian	0	*50	*50	50	100	150
Severn Trent	0	0	0	0	0	0
Welsh	33	13	46	82	b	82

* All Anglian testing is contracted out

a Rental included in revenue costs

b No estimate supplied

TABLE 2. ECOTOXICOLOGY: CURRENT REGIONAL STATUS: FACILITIES

REGION	LAB FLOOR SPACE M^2	FACILITY DESCRIPTION	ADDITIONAL EQUIPMENT
Southern	105	3 constant temp. rooms; cold room; washing machine; growth cabinet; sink; benching; fresh and seawater on tap; reverse osmosis water; de-ionised water; fridge freezer; water purifier.	2 standard microscopes; 1 inverted microscope; Microtox & PCs; autoclave; 4 incubators; Coulter counter; vis/UV spectrophotometer; centrifuge; various WQ meters; orbital illuminated incubator.
Northumbria and Yorkshire			
(Washington)	58	General dry lab; 2 wet constant temp.labs; dechlorinated water; pure water; sink/waste disposal	Coulter counter; Microtox & PC;autoclave; orbital incubator; various incubators & water quality meters;water purifier;vis/UV spectrophotometer/plate reader.
(Olympia House)	19	General lab (fume cupboards/benches etc.);gas; tapwater and reverse osmosis water; weighing bench; fridge freezer.	Coulter counter; autoclave; Microtox & PC; centrifuge; orbital & illuminated incubators.
Thames	non-specific	non-specific	Microtox
South Western	11	Temp. controlled room with algal culture apparatus; general lab space and prep room with sinks and fume hood; fridge.	centrifuge; de-ioniser, spectrophotometer; incubator; conductivity / DO meters; compound microscope.
North West			
(Southern area)	3-4	Part of biology lab; fridge/freezer.	Microtox & PC.
(Northern area)	53	2 biology labs with refrigerated shelving unit.	aquaria; tanks; pumps; heaters; aerators.
Anglian	104	office; sample storage; 2 prep rooms (sinks etc); testing lab; test animal storage ($41m^2$) constant temp. units; fume cupboards.	fish storage tanks;sample tanks; Microtox & PC.
Severn Trent	none	none	none
Welsh			
(Caernarfon)	38	General lab; water; benches; sinks; fridge freezer.	3 x Microtox & PCs; centrifuge; fish tanks; 3 x incubators; 2 x balances; 3 x vacuum pumps; 2 x water baths; access to microscopes (between all 3 labs).
(Llanelli)	10		
(St. Mellons)	40		

TABLE 3. ECOTOXICOLOGY: CURRENT REGIONAL STATUS: TEST PROGRAMMES

REGION	TESTS UNDERTAKEN	QC	WORK PROGRAMME (approx.samples pa)
Southern	Microtox	yes	Water Quality Screening (300+)
	Daphnia	*	* * (110)
	Oyster embryo (OEL)	*	* * (340)
	Freshwater algae	*	Method Development (52)
	Corophium	*	Sediment Programme (200+)
	ECLOX	*	(to be determined)
	*Chironomus	NA	Method Development (52)
	*Acartia/ Tisbe	*	* * (52)
	*Marine algae	*	* * (52)
	*Toxkits (fresh and marine)	*	(to be determined)
Northumbria and Yorkshire			
(Washington)	Daphnia	yes	Pollution Incidents (12)
	G.Pulex	*	* * (10)
	*	*	Special Project (10)
	Microtox	*	Pollution Incidents (100)
	*	*	Operational Investigation DTA (24)
	OEL	*	* * (24)
	*	*	Special Project (24)
	Algae	*	Operational Investigation (10)
	Fish	*	* * (30)
	Corophium	*	Special Project (20)
(Olympia House)	Daphnia	yes	Screening (100)
	Microtox	*	* (100)
Thames	Microtox	yes	Effluent assessment (50)
	Gammarus	-	Occasional use to support prosecutions
South Western	Daphnia	no	Effluent assessment (50)
	OEL	*	* * (48)
North West	Microtox	yes	Testing on request (70)
Anglian	∞96hr Trout	yes	Contract(45)
	∞96hr Brown shrimp	*	* (30)
	∞Marine algae	*	* (4)
	∞Phytotoxicity (plant bioassay)	*	* (10)
Severn Trent	none		
Welsh	Microtox	yes	Effluent Assessment (84)
	*	*	Industrial Discharge Strategy (400)
	*	*	Pollution Incidents (60)
	OEL	*	Effluent Assessment (84)

* planned 94/95. QC procedures will be implemented.

- none specified

∞ contracted out

APPENDIX 7

CURRENT R&D PROGRAMMES

APPENDIX 7

CURRENT R & D PROGRAMMES

PROPOSAL/ PROJECT NUMBER	PROJECT TITLE OBJECTIVES	START END	PROJECT COSTS £k 1993/94 EXT IN	1994/95 EXT IN	1995/96 EXT IN	1996/7 EXT IN	CONTRACTOR /PROJECT LEADER	COMMENTS
A12(92)4 463	**Toxicity Based Consents - Phase 1** To define the programme of work necessary to undertake a pilot study for Toxicity Based Consents (TBC) and their implementation.	3/93 6/93	5 -				WRc Derek Tinsley T	output - f output - p
A06(94)6 493	To further develop toxicity criteria in regulatory control, to test the protocols and procedures necessary for the application of Toxicity Based Consents.	10/93 3/96	100 15	100 20	124 15		WRc Jim Wharfe S	Supports Developmental Initiative Kinnersley Report, Ref No WQ9, Rank 18. Reports to Ecotoxicology Working Group.
A01(94)1	**Toxicity based criteria for assessing receiving water quality.** To develop and assess toxicity based criteria in order to assess the general quality of receiving waters. **Phase 1:** scoping study for marine waters, to include a review of biomarkers.	94/95 94/95 95/96 96/97		40 10	100 10	100 10	Jim Wharfe S	output O & p Supports Developmental Initiative - SWQO Ref WQ11, Rank 16. Work to link to GQA project- Project 469 (Topic A1). Priority 1.
A12(92)2 494	**Method Development** To provide suitable selection tests for the ecotoxicological assessment of effluent and receiving water quality.	10/93 3/94 94/95	18 31	100 -	100 -		WRc R Sweeting T	Output M & O 91/011/S. Will absorb Project 420, (Topic A5) when let. Supports Developmental Initiatives - Kinnersley Report Recommendations and Programme of WQ Monitoring, Ref No WQ9 & WQ13. Reports to the Ecotoxicology Working Gp.
A12(92)3 420	**Methods Manual** To establish standard operating procedures for ecotoxicological techniques and to produce and update a methods manual.	9/92 8/95	7 -	7 -			WRc D Tinsley T	Output M & O Links with A12(92)2 as a group. Part funded by SNIFFER. Total project costs £50k. reports to Ecotoxicological Working Group. Project to be merged with A12(92)A5; (Topic A5).
A12(91)4 396	**Sediment toxicity test development - insoluble substances.** To develop internationally standardised toxicity tests for use with sediments contaminated with sparingly water soluble substances.	2/92 3/94	22 -				WRc T Crawshaw S	Output - E Part funded by EC STEP programme. Total project cost £106k. Reports to Ecotoxicology Working Group.

APPENDIX 8

THE TOXICITY BASED CONSENT LEAFLET

ABSTRACT

This leaflet describes the need for toxicity-based consents to help control complex effluents discharging to receiving waters in the UK and a 2 year R&D Project co-funded by the NRA, HMIP and SNIFFER set up to develop a strategy and procedures for formulating such consents. The project started in August 1993 and if successful, a consistent approach to the setting of toxicity-based consents will be introduced into current UK pollution control practice by the end of 1995. An outline of a protocol to be tested in a pilot study during the project is given in the leaflet. The potential value of rapid screening tests that calibrate well against established lethal and sub-lethal tests with indigenous species is also described. Ideas for new, innovative test methods for use in toxicity-based consents are required. Opportunities exist for collaborative project work and an NRA contact name is provided.

THE NEED FOR TOXICITY-BASED CONSENTS

Since the introduction of the 1974 Pollution Control Act, the release of potentially polluting liquid effluents into UK receiving waters has been controlled by means of discharge consents. The latter are legal agreements between the discharger and the regulatory authority which in many cases place limits on the concentrations of priority pollutants in the effluent. These limits are set to ensure that the Environmental Quality Standards (EQS) for individual priority pollutants are not exceeded in the receiving water. The EQSs are themselves derived to protect aquatic life living in the receiving water.

It is relatively easy to derive environmentally protective discharge consents for effluents which contain readily biodegradable non-toxic constituents or for effluents with a small number of constituents of known toxicity. However, some effluents are particularly complex mixtures of chemicals. The exact composition of these effluents is frequently unknown and even when such information is available, there is no data

on the toxicity of many of their chemical constituents. Furthermore, the likelihood of synergistic effects means that the actual toxicity can be markedly different from that predicted from a knowledge of the individual constituents.

One potential solution to this problem is to derive a consent which includes a direct toxicity assessment. The latter would allow the net toxic effect of the various constituents of complex effluents to be appraised. Such an approach has been used successfully in the USA and in a number of countries in Europe. A small number of toxicity-based consents have been in operation in the UK, but to date, there has been no nationally agreed strategy or procedures.

TOXICITY-BASED CONSENTS R&D PROJECT

The NRA, in collaboration with HMIP and SNIFFER, has commissioned an R&D project to develop a strategy and procedures for the use of a direct toxicity assessment to help consent complex effluents discharging into receiving waters within the UK. The project started in August 1995 and if successful it will result in the introduction of toxicity-based consents into current UK pollution control practices towards the end of 1995.

The project is divided into 3 clearly defined work areas :

WORK AREA 1. *FACT FINDING SURVEY AND DEVELOPMENT OF UK STRATEGY*

KEY FEATURES/OUTPUTS

- Review of use and experience of toxicity-based consents by regulatory authorities world-wide.
- Consultation paper on the proposed introduction of toxicity-based consents.
- Amendments to current UK pollution control practice.

WORK AREA 2. *PILOT STUDY INVOLVING SELECTED UK DISCHARGES*

KEY FEATURES/OUTPUTS

- A protocol for deriving and monitoring compliance with a toxicity-based consent fully tested in a pilot study with selected discharges.
- Use of rapid screening tests which calibrate well against lethal and sublethal tests with indigenous species to derive and monitor compliance with toxicity-based consents.
- The eventual development of on-line toxicity monitoring and hand-held toxicity meters.

The draft protocol to be tested in the pilot study is outlined below:-

STAGE 1.

SELECTION OF DISCHARGES - DESK STUDY AND TOXICITY SCREENING.

Tests to be used for screening discharges in pilot study :-

DISCHARGES TO FRESHWATERS	DISCHARGES TO ESTUARINE/MARINE WATERS
* Microtox	*Microtox
* 24 hr Daphnia lethality	* 24 hr Oyster embryo larval development/lethality

STAGE 2.

FULL TOXICITY ASSESSMENT

A suite of tests with mostly indigenous species from different trophic levels will be used in order to establish the most sensitive species.

Tests to be used in the full toxicity assessment :-

Discharges to freshwaters

- **72 hr/96 hr ALGAL GROWTH INHIBITION** *(Selenastrum capricornutum).*
- **48 hr *Daphnia* LETHALITY.**
- **96 hr FISH LETHALITY** *(Salmo trutta, Oncorhynchus mykiss, Cyprinus carpio).*

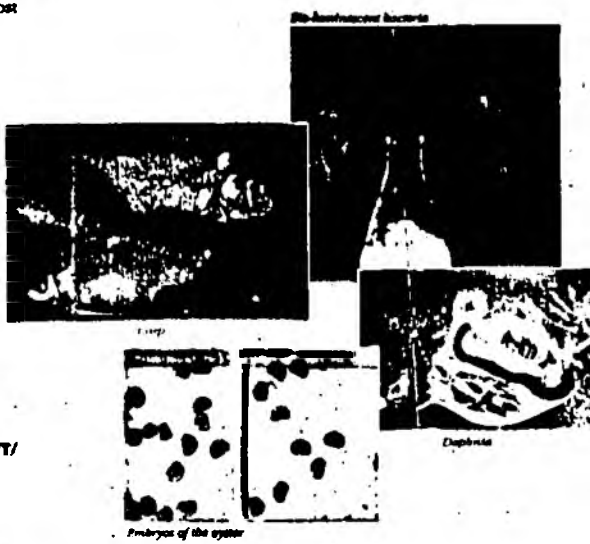
Discharges to estuarine/marine waters

- **72 hr/96 hr ALGAL GROWTH INHIBITION** *(Phaeodactylum tricornutum, Skeletonema costatum).*
- **48 hr OYSTER EMBRYO - LARVAL DEVELOPMENT/ LETHALITY**
- **96 hr FISH LETHALITY** *(Pleuronectes platessa, Scopthalmus maximus)*

STAGE 3.

TOXICITY REDUCTION/DERIVATION OF CONSENT

The need for toxicity reduction is then considered and a consent formulated using either a screening test, if this can be calibrated against the test with the most sensitive species in the full toxicity assessment or, if not, the most sensitive species test itself. The benefit of using a screening test to formulate the consent and monitor compliance is that the ease and cost of testing can be significantly reduced.



STAGE 4.

MONITORING FOR COMPLIANCE

Current pollution control procedures - tripartite sampling etc. will be followed where possible. The use of screening tests with the options of on-line toxicity monitoring or hand-held toxicity meters would be preferred.

WORK AREA 3. *PLAN FOR IMPLEMENTATION AND IN-HOUSE TRAINING*

KEY FEATURES/OUTPUTS

- **Implementation Plan - staff and facilities.**
- **Training Plan.**
- **Test Methods Manual**

THE POTENTIAL BENEFITS

The introduction of toxicity-based consents can provide considerable improvements to the way in which complex effluents are consented and as a result increase the degree of protection afforded to the aquatic environment. Toxicity-based consents may also reduce the need for difficult chemical analyses and as a result reduce the monitoring costs to both regulatory authorities and industry in the UK.

NRA
National Rivers Authority

Further details on the Toxicity-Based Consents R&D Project can be obtained from the NRA Project Leader, Dr Jim Wharfe.

Contact: Dr Jim Wharfe, NRA Southern Region, Guildbourne House, Chatsworth Road, Worthing, West Sussex BN11 1LD
Telephone: 0903 820692 Fax: 0903 821832

TOXICITY BASED CONSENTS

A STEP TOWARDS MORE EFFECTIVE CONTROL OF COMPLEX EEFLUENTS WITHIN THE UK

NRA
National Rivers Authority

APPENDIX 9

THE DIRECT TOXICITY ASSESSMENT LEAFLET

APPENDIX 9

(Poster and Leaflet in Press - UK-SETAC Conference Sept 1994)

DIRECT TOXICITY ASSESSMENT

A step towards better environmental protection within the UK

ABSTRACT

This leaflet describes the wider application of direct toxicity assessment (DTA) to enhance the control of toxic waste discharges and to provide a mechanism for assessing the environmental quality of controlled waters at both the acute and chronic level. It considers the capabilities and limitations of current practices and the role of DTA in water quality management and follows a leaflet previously issued describing the toxicity based consent (TBC) R&D pilot programme.

THE NEED FOR DIRECT TOXICITY ASSESSMENT

As improvements in the quality of receiving waters are achieved by the more effective control of sanitary waste discharges (as measured by dissolved oxygen, biological oxygen demand and suspended solids) more attention is focused on those pollutants which cause damage by toxic effects.

INDUSTRIAL DISCHARGE SLIDE/S

Toxicity measurements provide a direct effects based assessment of the health of the environment and, by employing the same methods, provide a mechanism for controlling complex chemical discharges (the toxicity based consent). The application of toxicity based criteria to control waste discharges has been used extensively in the United States during the past decade, where toxicity testing is routinely implemented by regulatory agencies in a variety of effluent monitoring and toxicity reduction evaluation programmes. The National Rivers Authority (NRA) is considering the wider application of direct toxicity assessment (DTA) to achieve better control of complex chemical waste discharges and to demonstrate cost effective environmental benefit.

THE TRIAD APPROACH

An assessment of the quality status of controlled waters requires an integrated approach, with each component providing valuable, but incomplete information.

1. **SUBSTANCE SPECIFIC CONTROL (individual chemicals)**
2. **DIRECT TOXICITY ASSESSMENT (whole sample testing)**
3. **BIOLOGICAL ASSESSMENT (biological survey, bioconcentration/ bioaccumulation)**

To obtain the best information from monitoring programmes, for the cost effective control of waste discharges and for environmental impact assessment, it is important to understand the advantages and disadvantages of each.

CURRENT PRACTICE

Chemical-specific control of effluents of well defined composition and for which sound, scientifically based, environmental quality standards (EQSs) exist provides a simple, well understood measure of compliance against numerical criteria and is relatively inexpensive.

However, the derivation of many EQSs is based on inadequate data, especially those relating to acute and chronic toxicological information on ecologically relevant species. This requires an extrapolation factor to be applied which reduces the degree of certainty that protection is achieved at minimum cost to the discharger. Even if a chemical has a sound EQS, there remain a number of problems. It is rare for chemicals to be introduced into the environment singly, in pure form. In combination with other chemicals, in either the effluent or the receiving water, additive and synergistic effects can radically alter the degree of toxicity. Additionally, in complex chemical discharges, there are many chemicals present for which no toxicological data exist and an EQS cannot be set. In such cases the total level of toxicity may be further compounded. There are also analytical difficulties with some EQSs which have been set below the current achievable limit of detection.

To establish the level of protection afforded by the EQS, biological surveys provide information on community effects and reflect the overall health of the system. They are an integrated measure of all stressors, including the total toxic effect, and provide additional information on the persistence and bioaccumulation of substances. However, biological surveys can be expensive and the data are often difficult to interpret. In cases where effects are clear the impact has already occurred and the cause is rarely identified.

Traditionally, a discharge consent is determined to ensure achievement of the relevant chemical specific EQS. Compliance is measured by the statistical evaluation of monitoring data, and together with information from biological surveys, is used to assess the protection of aquatic life.

ESTUARY SLIDE

THE DTA R&D PROJECT

DTA provides a better measure of the impact of complex waste discharges and by using the same methods establishes a means of control, thus reducing the need for chemical specific testing and bioassessment. Toxicity tests are not new; many are recognised internationally and are routinely employed to produce substance specific toxicological data. The duration and cost of these traditional tests severely limits their application to effluent monitoring and receiving water impact assessment. In recent years a number of abbreviated acute and chronic tests have been developed together with simple, more rapid screening tests. These allow the design of strategic sampling programmes to assess sample variability and environmental impact and to achieve better control of complex chemical discharges.

Examples of the methods the NRA considers suitable for DTA are shown. Each method has associated procedures for analytical quality control and, where more than one testing laboratory is used, independent audit will be neceesary.

METHODS DIAGRAM

To develop the DTA approach the NRA will field test the methodologies, particularly in the complex marine environment, and assess their value for both general water quality assessment and for targeted discharge impact assessment and control.

Further details on the Direct Toxicity Assessment R&D Project can be obtained from the NRA Project Leader, Dr Jim Wharfe.

Contact: Dr Jim Wharfe, NRA Southern Region, Guildbourne House, Chatsworth Rd, Worthing, West Sussex BN11 1LD. Telephone: 0903 820692 Fax: 0903 821832

APPENDIX 10

i) A summary of key events and current initiatives to progress the introduction of DTA procedures.

ii) Immediate key tasks required to be undertaken for the introduction of TBCs and DTA in receiving waters.

APPENDIX 10

i) A summary of key events and current initiatives to progress the introduction of DTA procedures.

* Sept 1994 UK SETAC Conference - Leicester. TBC poster presentation and launch of the TBC leaflet.

* Jan 1994 NRA/HMIP/SNIFFER TBC Prtoject Board established.
First meeting agreed to invite corresponding members from DoE, MAFF, SOEND, SOAF and HMIPI.

* Jan - Dec 1995 Level of Awareness presentations to industry based associations - CIA, CBI, PIA, PIRA etc.

* Mar 1994 Extended ecotoxicology testing facility completed at Waterlooville and recruitment of additional expertise in Southern Region.

* Apr 1994 River Purification Board Seminar - Stirling.

* June 1994 ETAS Seminar - WRc Medmenham.

* June 1994 OSPARCOM Workshop on the Organic Chemical Industry - Berlin. Joint NRA/HMIP presentation.

* Aug 1994 Toxics Policy Group established.
First meeting considered the DTA Business Strategy document.

* Sept 1994 UK SETAC Conference - Sheffield. DTA poster presentation and leaflet launch.

* Sept 1994 ZENECA DTA/TBC meeting for invited industrialists.

* Oct - Nov 1994 WRc meetings for industrialists.

* Oct - Nov 1994 Task Team trip to USA/American SETAC Conference.

ii) Immediate tasks requiring a consistent approach for the introduction of procedures nationally for TBCs and the wider application of DTA

POLICY ISSUES

1. EFFLUENT CONTROL

Discharge Control & Charging Gp

- develop protocol for TBCs and include in NRA consenting manual
- develop consenting framework
- design sampling/monitoring programme for effluents
- establish compliance measurement
- consent breach procedures
- develop protocol for toxicity reduction evaluation
- establish effectiveness of TBCs and wider application
- relate to environmental policy
- discharge charging scheme
- develop Client specification for testing
- update all documentation

2. RECEIVING WATER QUALITY

SWQOs Gp

- select relevant toxicity criteria for water quality assessment
- develop GQA classification scheme + other criteria
- coordinate national water quality survey

Monitoring Gp

- design sampling/monitoring programme for receiving waters
- advise on data evaluation methods
- relate to discharge control
- compile Client specification for testing
- EC Groundwater Directive toxicity requirements

All Gps

- progress the concept of Direct Toxicity Assessment and its application to discharge control and health assessment monitoring

- establish links with other national and international initiatives (CEC/EPA etc)

- establish formal and informal lines of communication with regulators, industry and research groups

- consider use and development of biomarkers as a measure of ecological effect

- develop water quality assessment at the sub-lethal level

- appraise current modelling initiatives to establish dose/effect related environment control measures (effluent/ambient/tissue standards)

OPERATIONAL REQUIREMENTS

- ecotox method selection

- ecotox method development
  i) ecologically relevant tests
  ii) screening tests
  iii) sub-lethal tests

- establish AQC/Audit/Accreditation procedures

- establish national testing facilities and compile a register of external contract laboratories

DATABASE DEVELOPMENT

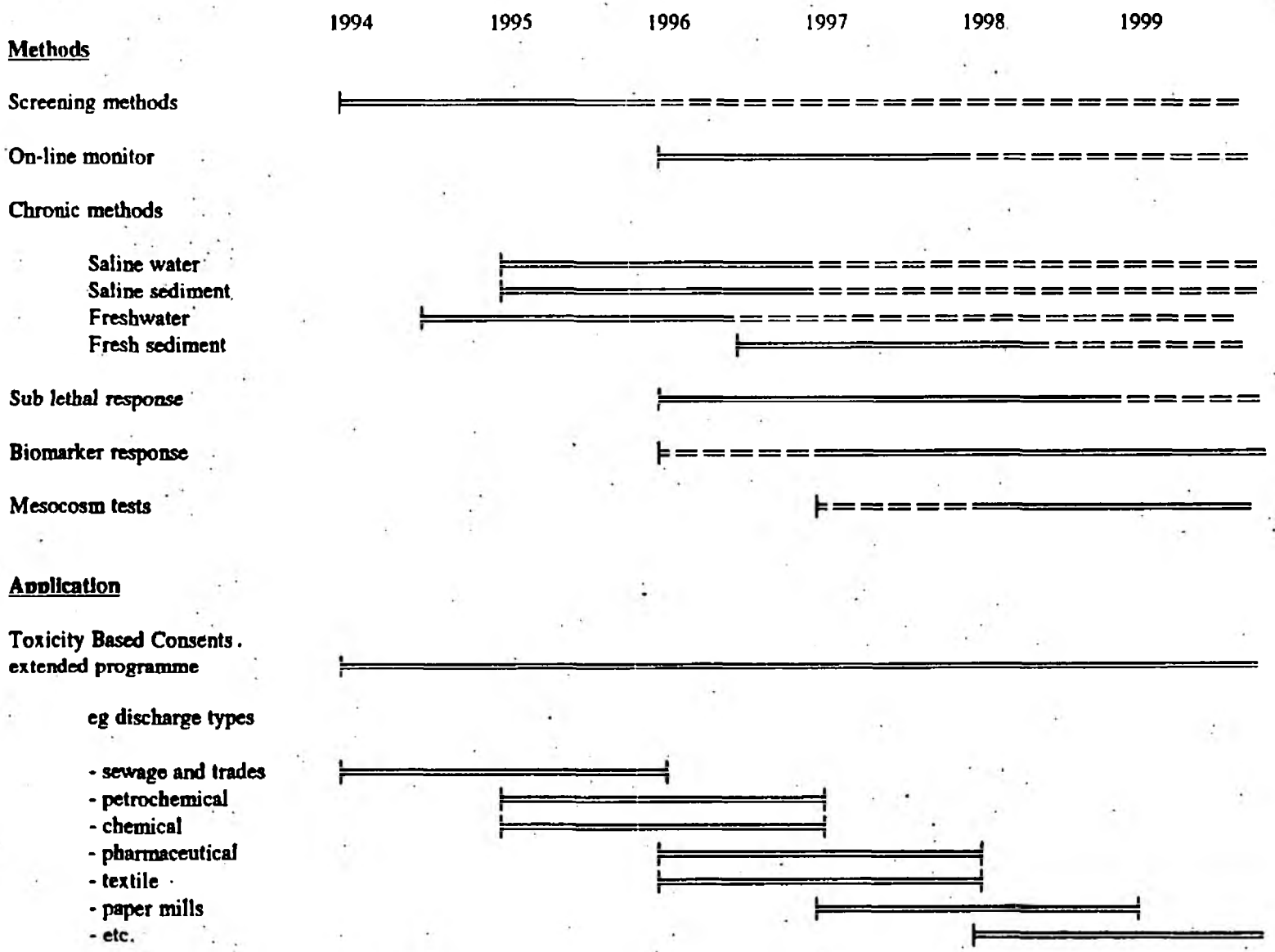
- develop database for case study assessment and establishment of TBCs via dummy consents

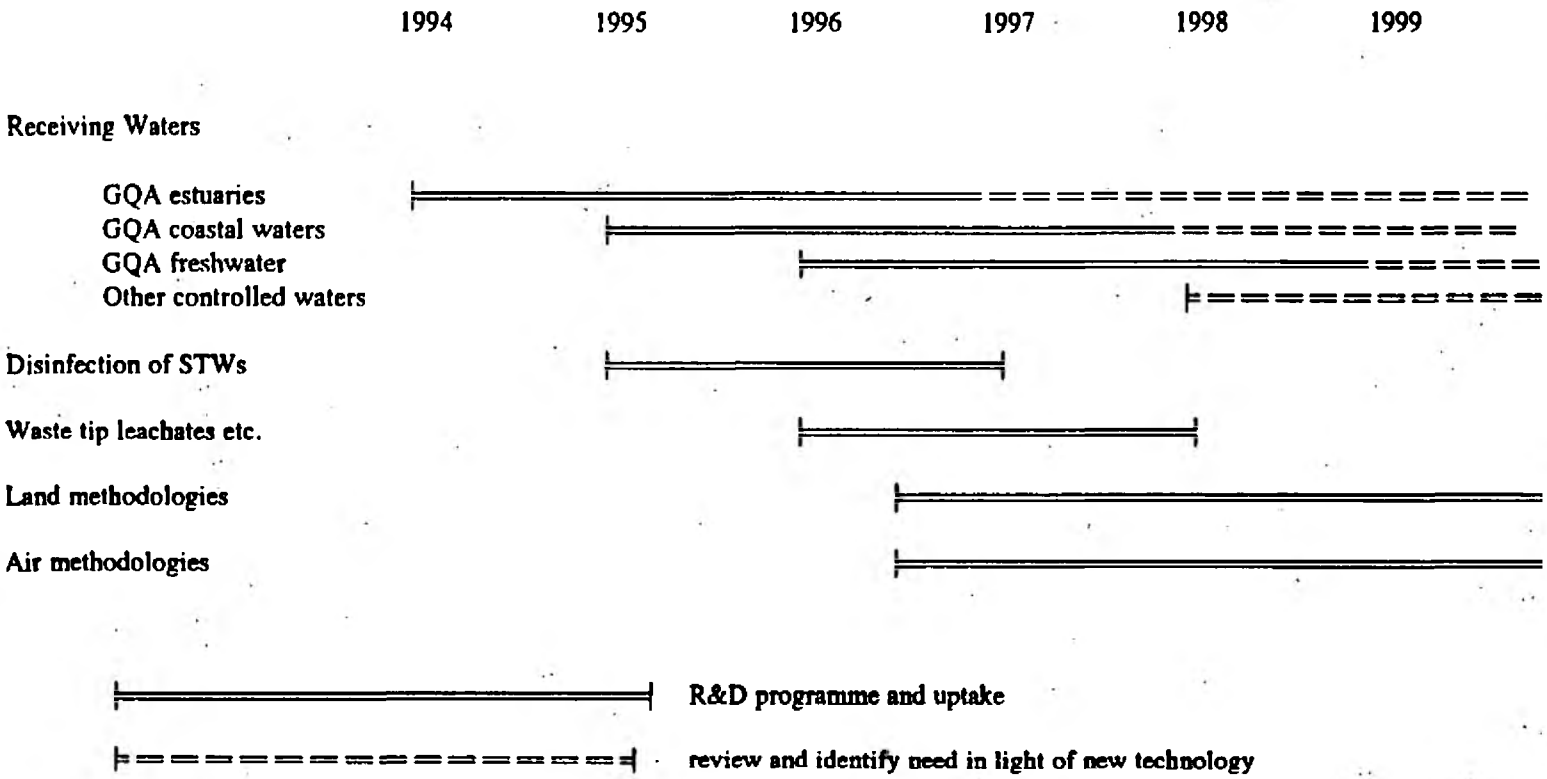
APPENDIX 11

MEDIUM TERM R&D STRATEGY

APPENDIX 11

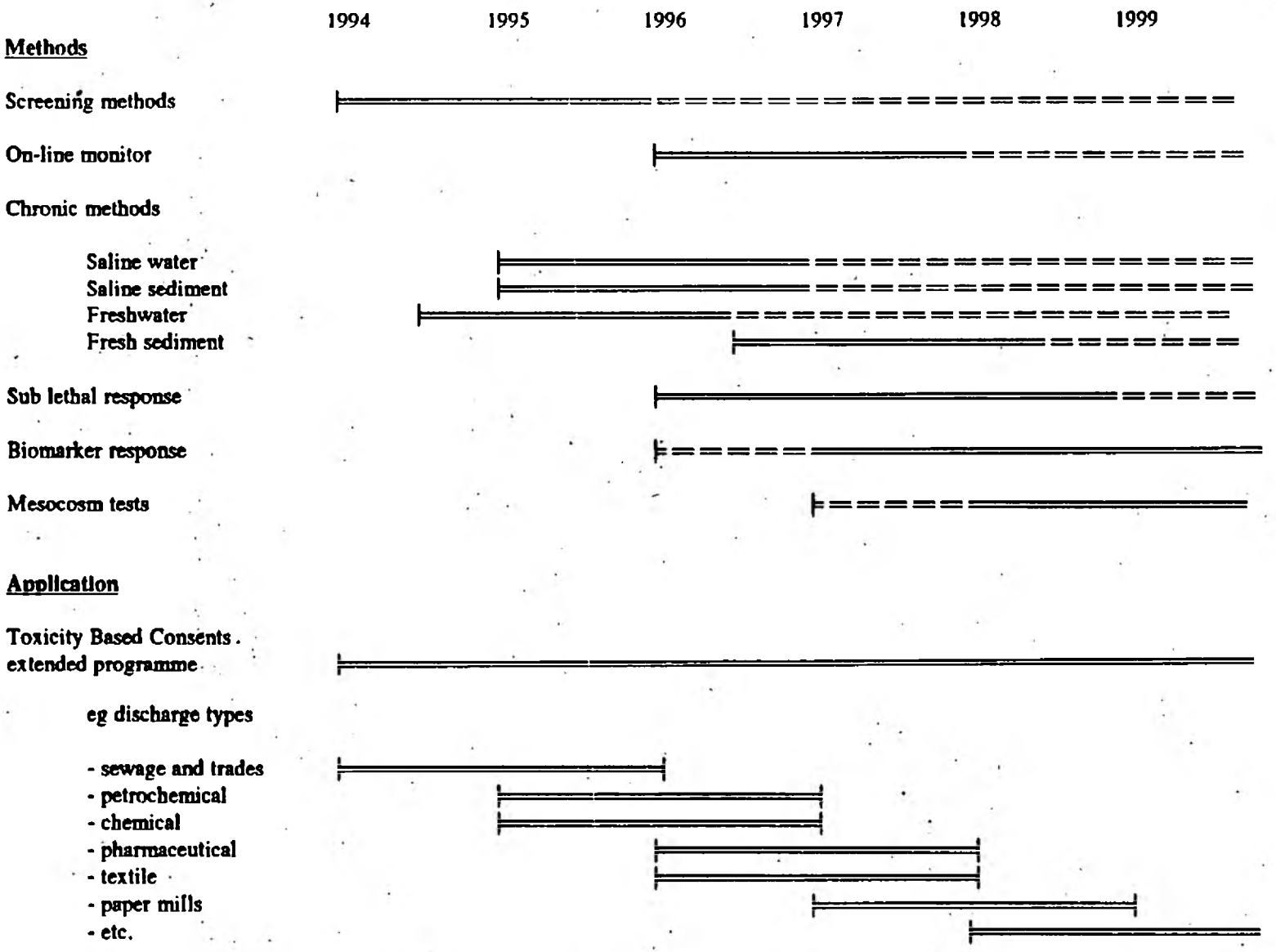
MEDIUM TERM R & D PROGRAMME

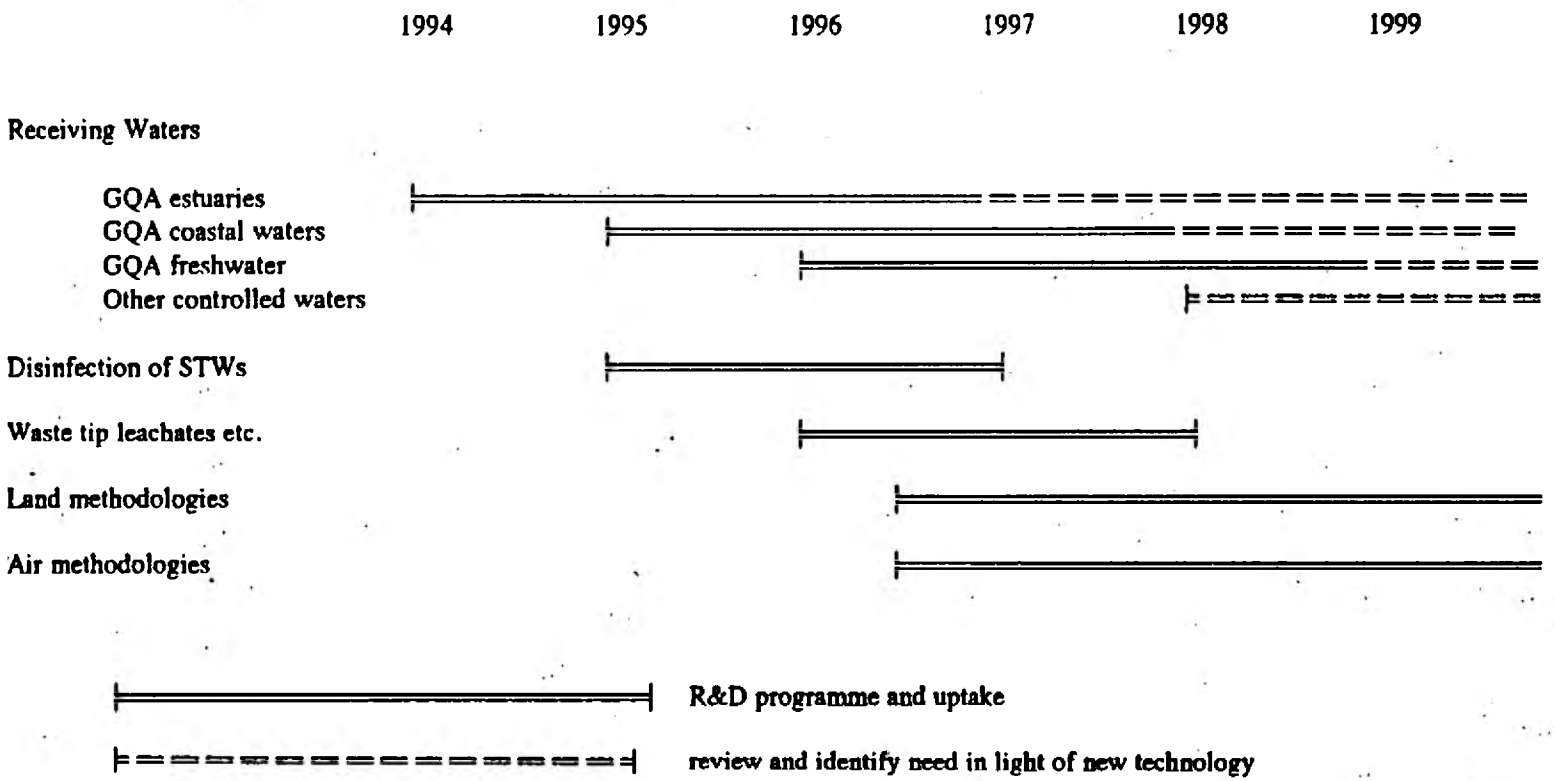



1994
1995
1996
1997
1998
1999
Receiving Waters
GQA estuaries
GQA coastal waters
GQA freshwater
Other controlled waters
Disinfection of STWs
Waste tip leachates etc.
Land methodologies
Air methodologies
R&D programme and uptake
review and identify need in light of new technology

APPENDIX 11

MEDIUM TERM R & D PROGRAMME




1994
1995
1996
1997
1998
1999
Receiving Waters
GQA estuaries
GQA coastal waters
GQA freshwater
Other controlled waters
Disinfection of STWs
Waste tip leachates etc.
Land methodologies
Air methodologies
R&D programme and uptake
review and identify need in light of new technology

MEMORANDUM

cc Brian Linkins
Phil Styles

To: Roger Saxon

From: David Sheriff, Area Regulation Officer
Extn: 5044

Your Ref:

Our Ref:

Date: 12th September 1994

Direct Toxicity Assessment - Business Strategy

I regret that the Area is unable to make a detailed response due to the short duration of consultation. However:

- DTA supported by area
- We question need for analysis facility in each region
- Regional expertise on understanding and interpretation of tests re. consents is vital.

I hope these comments are useful

David Sheriff