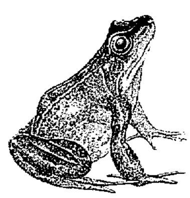
A Study of the Economics of Restrictions on the Use of Pesticides

Final Report to the Department of the Environment

DoE 3555/P
May 1995



A STUDY OF THE ECONOMICS OF RESTRICTIONS ON THE USE OF PESTICIDES

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WRc Authors: B Crathorne, M Fielding, D B Oakes, B F Hegarty, J Hart and J Buckland

Gould Rural Environment Authors: C H Mathias and J C Arnold

Contract Manager: B F Hegarty

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WRc plc, Henley Road, Medmenham, Marlow, Buckinghamshire SL7 2HD.
Telephone: 01491 571531

EXECUTIVE SUMMARY

Pesticides are used widely in agricultural and non-agricultural situations in the UK. Some pesticides are persistent in the soil and are leached into surface waters and groundwaters, including those which are abstracted and treated for public drinking water supplies. The maximum permitted concentration of individual pesticides in drinking water 0.1 $\mu g\ l^{-1}$ is specified in the Water Supply (Water Quality) Regulations 1989. Special (and expensive) treatment of contaminated source waters is often required to achieve this stringent limit. In August 1992, the Department of the Environment awarded a contract to WRc plc and Gould Rural Environment Ltd (Reference PECD 7/7/415) for a joint study of pesticide use and treatment, supervised by the Drinking Water Inspectorate. The purpose of the study was to investigate the relative economic costs of preventing pesticide contamination using a range of pesticide control mechanisms and installing processes for pesticide removal at water treatment works.

Benefits related to the reduction of pesticide concentrations in the environment, for example for the protection of aquatic life, were not studied.

Four specific pesticide control scenarios were studied in detail using case studies on two sources of drinking water: a surface water (River Leam, Warwickshire) and a groundwater (Colne Valley, Hertfordshire). The control scenarios were:

- no restriction on pesticide use, in which the market-place decides usage and water supply companies install treatment plant to reduce pesticide levels to below the prescribed level;

- a total ban on pesticides, in which an immediate withdrawal of all pesticides from the market is envisaged, with consequent reductions in pesticide levels in sources of drinking water;

- the use of protection zones, in which pesticide usage in locations designated as sensitive is prohibited;

- restricted usage, in which pesticide usage in the whole catchment is reduced by permitting applications of pesticides only up to certain specified quantities.

Other control methods (restrictions in timing of pesticide applications and the substitution of environmentally-friendly pesticides) were also examined but were not considered to be currently feasible and therefore not studied in detail.

Current agricultural land usage and cropping patterns, pesticide application and environmental occurrence data were obtained for the two catchments studied. Future land usage, cropping patterns and pesticide applications in agricultural and non-agricultural sectors were projected for each scenario for the ten-year period 1992-2002. Mathematical pesticide fate models were used to calculate future pesticide concentrations in the river and groundwater resulting from predicted pesticide applications. The costs of water treatment (by adsorption on granular activated carbon and/or ozonation) to reduce the predicted levels of pesticides to the prescribed level for drinking water were calculated from water treatment models.

The main conclusions to be drawn from the case studies are as follows:

- If no restriction is imposed on pesticide usage, water treatment to reduce pesticide levels would be necessary for both the surface and groundwater catchment.

- A total ban on agricultural and non-agricultural pesticide usage would have a significant negative impact on agricultural incomes and increase non-agricultural costs substantially.

- In the two catchments studied, water treatment costs to reduce pesticide levels were estimated to be considerably lower than the costs of a total ban on pesticide use.

- A protection zone 10 metres wide on each side of the river and tributaries of the Leam catchment should ensure compliance with the prescribed limit in drinking water.

- For the groundwater catchment, the application of protection zones and restricted usage should ensure compliance with the prescribed limit in drinking water.

- The costs of applying a policy of restricted usage and/or the use of protection zones were broadly the same as water treatment costs in both of the catchments studied.

The use of levies and tradeable permits as economic instruments to control pesticide usage was reviewed. Product levies appear to satisfy the criteria for effective economic instruments in pollution control.

The methodology required to extend the study to all of England and Wales is discussed. A less detailed analysis, concentrating on establishing the marginal costs of pesticide restrictions and the agro-economic implications, is recommended.

The limitations to the study and its conclusions are discussed. These are principally:

- the two catchments studied should not be considered as typical of the UK in general, as there are wide variations between catchments; all catchments must be considered on an individual basis and the results and conclusions obtained should be viewed in this context;

- the current lack of acceptable methods for quantifying environmental benefits;

- the uncertainties pertaining to future agricultural practice;

- insufficient knowledge of the environmental fate of pesticides and their degradation products, particularly their persistence in groundwater;

- paucity of data on pesticide occurrence in sources of drinking water.

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GLOSSARY

CAP	-	Common Agricultural Policy of the European Community
Financial Analysis	-	Analysis to demonstrate the effects of restrictions from the point of view of agents in the market place (i.e. in this study, the effects on farmers and the water industry) (cf, UK economic analysis).
Fixed Costs	-	Those costs which are unallocated when determining farm enterprise Gross Margins i.e. regular labour, power costs, other overheads and rent, finance charges etc.
GAC	-	Granular Activated Carbon, a treatment process for water.
Gross Margins	-	Enterprise output (including the value of production retained on the farm) less its variable costs. The latter are both specific to the enterprise and vary in proportion to the size of the enterprise. For arable crops these normally include fertilisers, seeds, sprays, sundry direct items, haulage, casual labour and specific contract charges.
IACS	-	Integrated Administration and Control System.
Key Pesticides	-	Pesticides which currently, or are predicted to, exceed the prescribed concentration or value (PCV).
Livestock Unit	-	A denominator to bring various numbers and ages of different classes of livestock to a common unit, based on the energy requirements of an average dairy Fresian cow (cow equivalent).
MAC	-	Maximum Admissible Concentration for substances in the EC Directive (80/778) on Water intended for Human Consumption. For pesticides, equivalent to the PCV.
MII	-	Management and Investment Income is the gross output less inputs excluding interest charges and the proportion of labour costs devoted to managing the farm. It therefore represents the return to management and tenant's capital, whether the latter is borrowed or not.
Ml/day	-	Mega litres per day.
NPV	-	Net Present Value, the difference between the Present Value of benefits and the Present Value of costs.
PCV	-	Prescribed Concentration or Value, the maximum permitted level for certain parameters under the UK Water Supply

		(Water Quality) Regulations 1989. The PCV for individual pesticides is 0.1 $\mu g\ l^{-1}$ (= 100 $ng\ l^{-1}$).
Pesticides	-	Herbicides, fungicides, insecticides and growth regulators used to control weeds, diseases, insects and other pests in agriculture and by non-agricultural organisations.
Present Value	-	PV, the discounted value of a stream of benefits or costs received or spent over a period of time.
PV	-	See Present Value.
Terminal Value	-	TV, the residual value of a capital asset at the end of the project's life.
TV	-	See Terminal Value.
UK Economic Analysis	-	Analysis of effects of restrictions using factors applied to agricultural commodity market prices and support payments, to indicate the effect from the point of view of the United Kingdom. (The appropriate factors were obtained from MAFF.) This analysis represents the effect of restricting pesticide usage from the point of view of the UK because the UK Exchequer costs of agricultural commodity support are excluded (cf, financial analysis).

1. INTRODUCTION

1.1 Background

Under reference PECD 7/7/415, the Department of the Environment awarded a contract to WRc plc and Gould Rural Environment Ltd for research relating to an Economic Study of Restrictions on the Use of Pesticides.

The research aims to compare, in economic terms, the different ways of ensuring that pesticide concentrations in drinking water comply with the standards prescribed in the Water Supply (Water Quality) Regulations 1989. The regulations set a Prescribed Concentration or Value (PCV) of 0.1 $\mu g\ l^{-1}$ for individual pesticides and 0.5 $\mu g\ l^{-1}$ for total pesticides in drinking water. Options for compliance include prevention, whereby control is exercised at source, and cure, in which problem pesticides are removed during water treatment. Both extreme scenarios have considerable economic implications. Other scenarios involving an element of both of these also need to be considered.

The issues are complex, involving pest control in the agricultural and non-agricultural sectors, impact on farm economy and on the consumers of farm produce, pesticide leaching into rivers and aquifers, regulatory requirements and the technology of water treatment. The assessment and quantification of environmental benefits (e.g. for aquatic life, conservation etc.) which might result from pesticide restrictions, were not within the scope of the study.

1.2 Structure of the study

The principle programme elements are shown in Figure 1.1 in flow-chart form, to indicate the overall structure of the work programme. This can be summarised as follows:

- representative sources of drinking water (a surface water and a groundwater) were selected for the study (Chapter 3);
- catchment data for pesticide usage (agricultural and non-agricultural) and occurrences in the sources of drinking water, land usage, meteorological records etc., were collected and assessed (Chapter 3);
- key pesticides were selected for modelling the impact of restrictions, from the usage and occurrence data (Chapter 4);
- specific scenarios for restricting pesticide usage were defined, with the aid of the models (Chapter 4);
- future pesticide usage over the next decade was estimated for each control scenario (Chapter 5);
- mathematical pesticide fate models were established and validated for each catchment (Chapter 6);

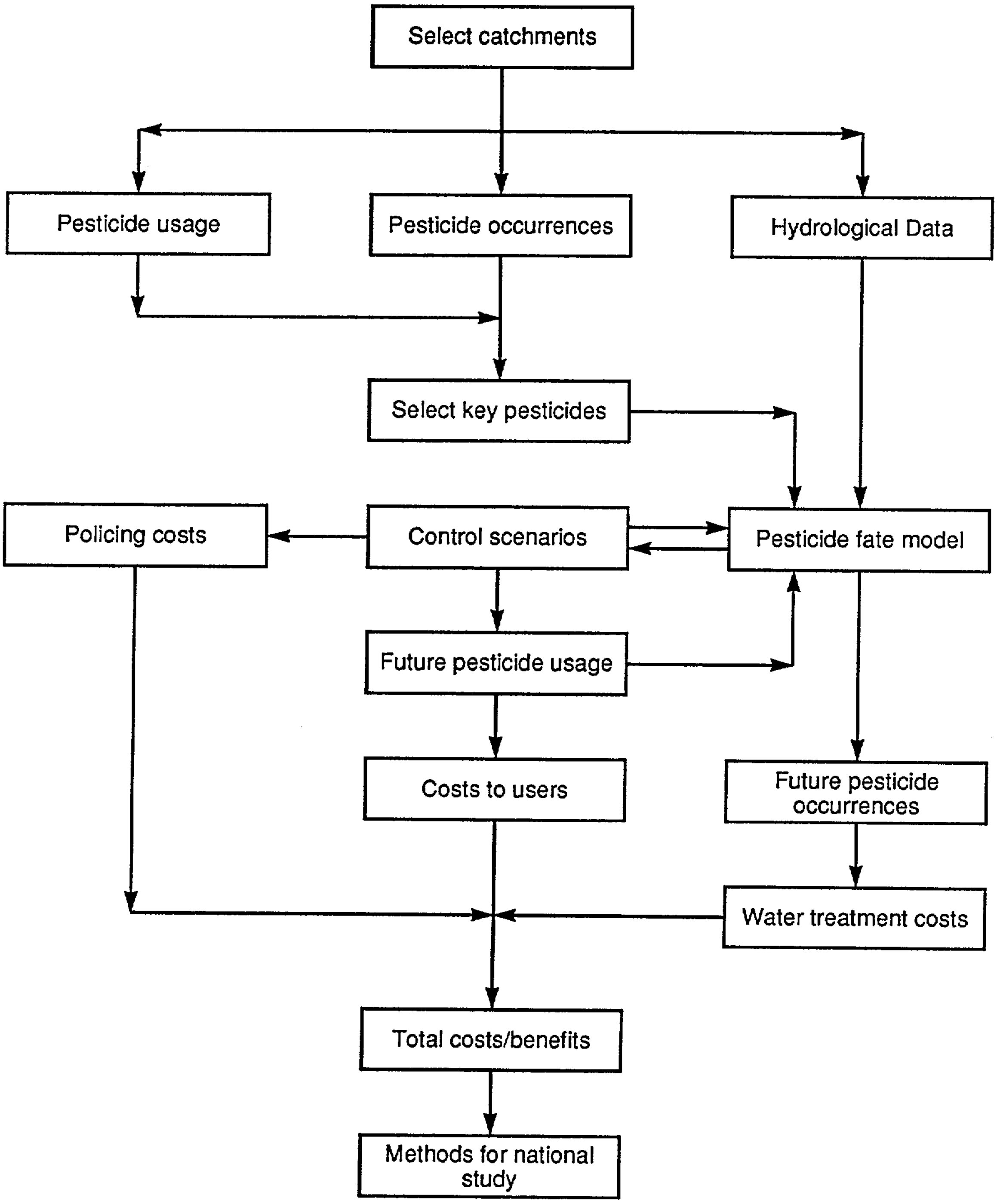

Figure 1.1 Flow-chart of programme

- future pesticide occurrences in the source waters were predicted using the pesticide fate model, based on the predictions of future usage (Chapter 7);

- costs of water treatment to reduce the predicted pesticide levels in the source water to comply with the PCV for pesticides in drinking water were estimated (Chapter 8);

- costs to agricultural and non-agricultural pesticide users of the restrictions were estimated (Chapter 9);

- costs of the policing required to enforce the restrictions were estimated (Chapter 10);

- the overall costs/benefits of the control scenarios were compared (Chapter 11);

- methods for extending the study to England and Wales were identified (Chapter 14).

The use of tradeable permits and levies to control pesticide usage is reviewed in Chapter 13.

2. OBJECTIVES

The objectives of the study as specified by the Department of the Environment were:

1. To compare the costs over ten years in two representative catchments:

   (a) to the water industry of reducing pesticides in water supplies; and

   (b) to agricultural and non-agricultural pesticide users of restrictions on the uses of pesticides.

2. To appraise critically the aggregate net benefit to be obtained from pesticide restriction regimes.

3. To propose methodology for extending the study to cover other relevant areas of England and Wales.

The terms of reference required that the following scenarios for restricted pesticide usage be examined:

- no restrictions;
- a total ban on pesticide usage throughout the catchments;
- the introduction of protection zones;
- restrictions on quantities and timing;
- the use of more acceptable pesticides;
- 'non-chemical' methods.

3. PESTICIDE USAGE AND OCCURRENCE IN THE SELECTED CATCHMENTS

3.1 Selection of catchments

Various catchments were considered as the two case studies planned for the project. The different characteristics ideally required of a catchment meant that no absolutely 'typical' one could be identified, although it was considered important to include a surface and a groundwater catchment in the study. The available data on pesticide monitoring and applications in catchments was an important criterion. Other criteria considered included the land use (urban/rural mix), the need to study both agricultural and non-agricultural pesticide applications, and the availability of hydrological information.

The River Leam catchment (Warwickshire) was selected as the surface water catchment. Data existed showing concentrations of agricultural and non-agricultural pesticides in the river and tributaries in excess of the PCV. The non-agricultural land consists of urban areas, roads, railways, etc., although land usage in the area is predominantly agricultural. Water is abstracted from the Leam by Severn Trent Water plc (STW) and treated at the Campion Hills water treatment works. STW kindly supplied pesticide monitoring and water treatment data for the period 1990 to 1993.

The Clay Lane borehole complex in the Colne Valley was selected as the groundwater catchment. This area encompasses a much larger proportion of urban usage compared to the Leam catchment. The Three Valleys Water Company kindly supplied pesticide monitoring data for the period 1990 to 1992. A map of the catchment has been constructed based on geological and hydrological information.

The catchment areas for the Leam, to the east of Leamington Spa, and the six boreholes serving the Clay Lane collection centre in the Colne Valley were identified and their respective areas digitally measured. Published parish statistics were used to establish the land use within each of the two catchments. A summary is given in Table 3.1. The catchment areas are shown in Figures 3.1 and 3.2.

Table 3.1 Catchment Areas and Land Use in 1992

Catchment	Leam ha	Colne Valley ha
Crops, Grass, Fallow and Set Aside	29564	7334
Woods and other land	815	443
Total Agricultural Area	30379	7777
Non Agricultural Land	6168	11546
Total Catchment Area	36547	19323

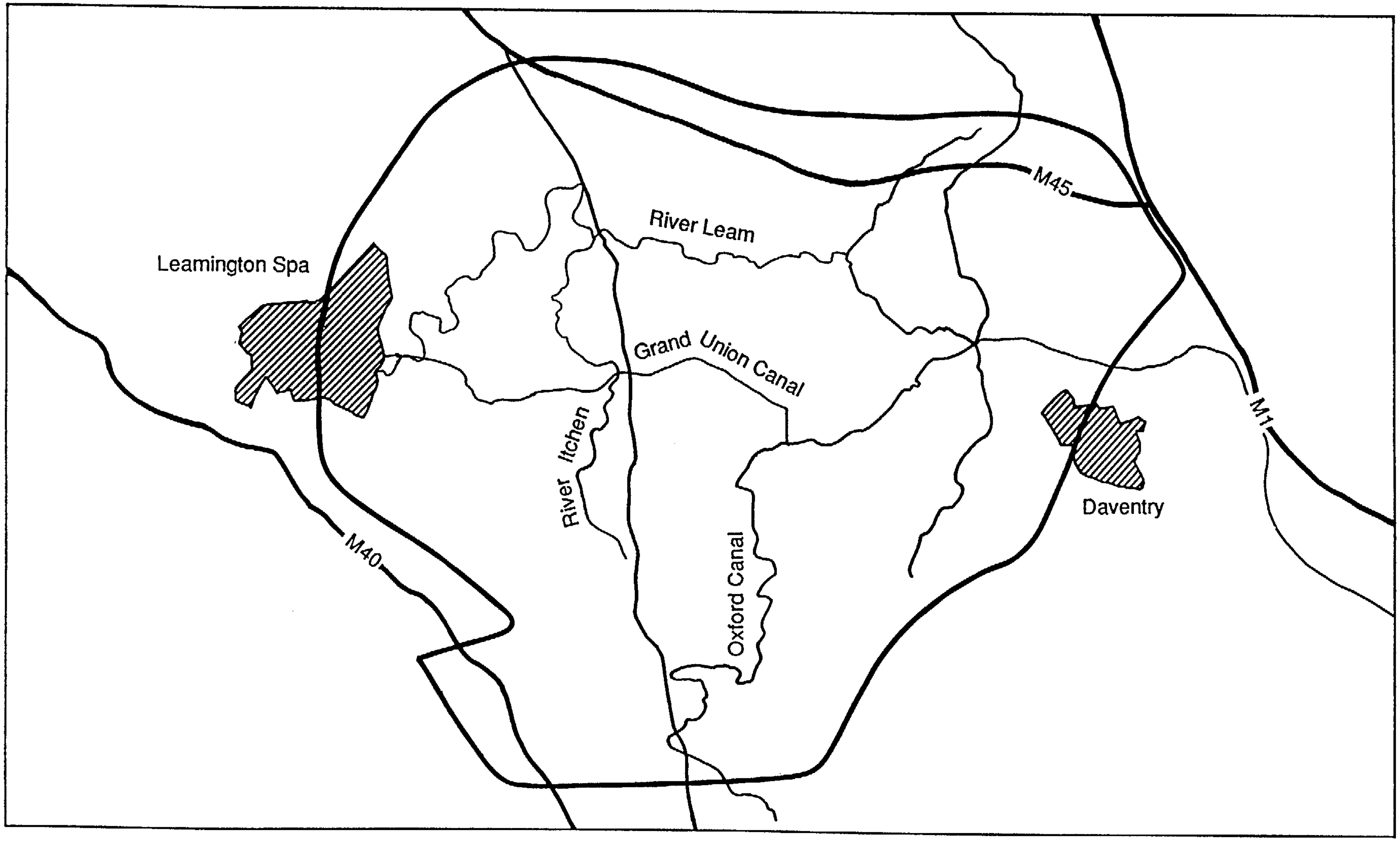

Figure 3.1 Leam Catchment

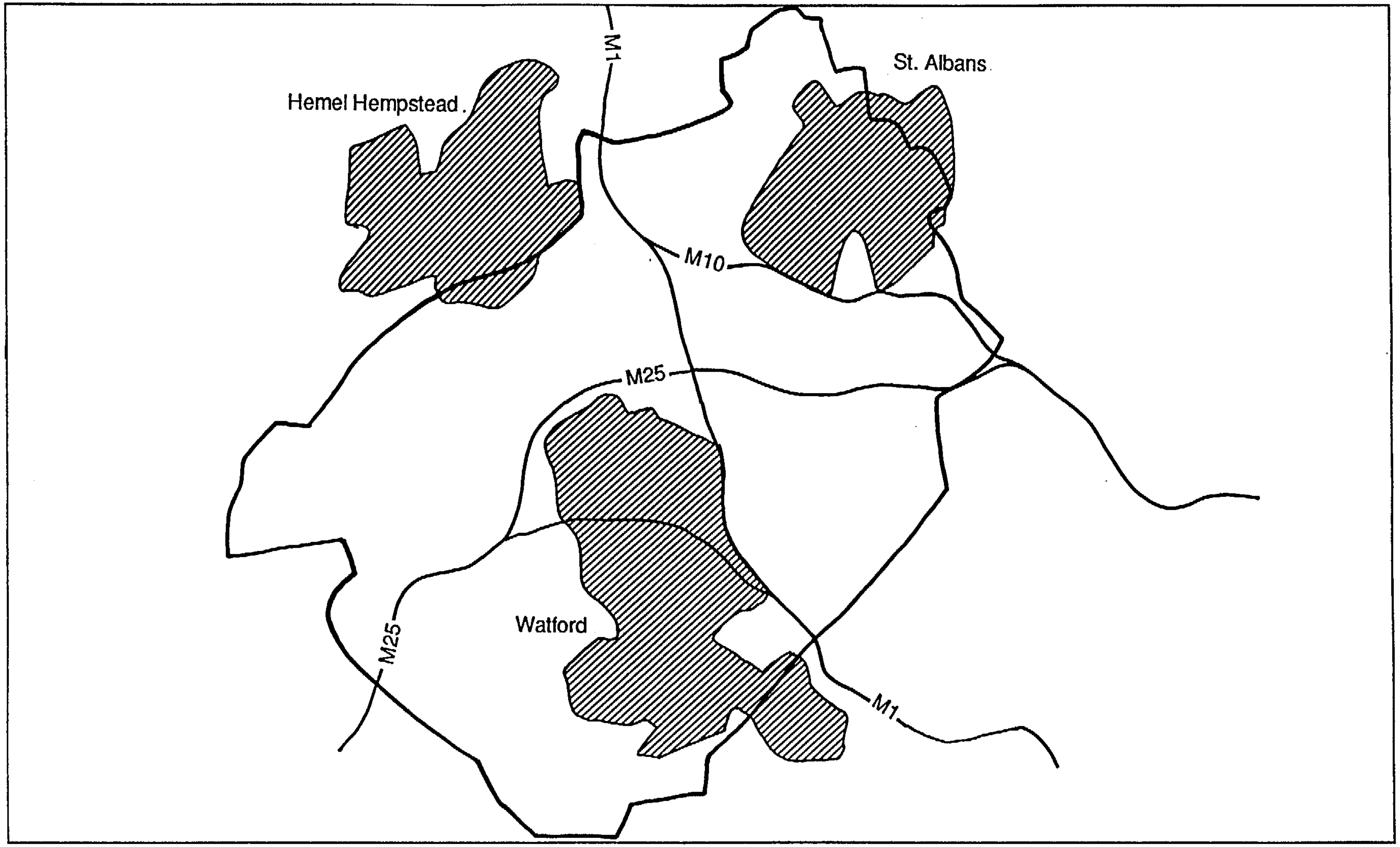

Figure 3.2 Colne Catchment

3.2 Historical and current pesticide usage

3.2.1 Historical and current cropping and stocking practices and levels of agricultural pesticide usage

The historical cropping and stocking practices in the two study areas have been estimated from published statistics for 1988 and 1992. These statistics were studied to correlate data on present pesticide occurrences in the drinking water sources (i.e. the surface and groundwater) with the historical record of pesticide use. Most applied pesticides should, if persistent and mobile in the environment, have worked through to the source waters after five years. Therefore a five year period (1988-1992) was considered appropriate for the agricultural statistics.

Pesticide usage in the Leam during the 1992 harvest year was established from a report on usage in the catchment prepared by Agricultural Development and Advisory Service (ADAS). For 1988 the pesticide application model was modified taking into account general trends in the usage of particular pesticides and the application records for that period of two large farms in the Leam catchment.

No data specific for the Colne study area were available. However, in 1992 Farmstat (Weddepohl, 1992) carried out a survey of pesticide usage throughout the Colne catchment. These results were adjusted using parish statistics, and the total active ingredients applied were published jointly by WRc and Farmstat (Weddepohl 1992). The pesticide application model used in our study was modified so that the total active ingredients of each pesticide applied agreed with the WRc/Farmstat results. The cropping for the catchment as a whole was then replaced by the cropping in the study area in order to derive an estimate of total usage in 1992.

Farmstat data for the Colne catchment did not exist for 1988; consequently, the results of a pesticide survey undertaken by Land Capability Consultants in the Granta catchment (Cambridgeshire) during that year were taken as being representative of the Colne because the soil type, cropping and climate are very similar in the two regions. A similar approach to that described for 1992 was undertaken to derive an estimate of total active ingredients applied in 1988.

A more detailed description of the methods used and the results obtained is given in Annex 1.

3.2.2 Historical and current use of non-agricultural pesticides

This topic is described in more detail in Annex 2.

Existing pesticide usage, means of application and the impact of alternative restriction scenarios on non-agricultural uses of pesticides was obtained from a series of postal and telephone surveys and personal interviews with appropriate officers of the following organisations in each catchment:

- District Councils;
- County Councils (who control weeds on major roads for the Department of Transport);
- British Rail;
- British Telecom;
- British Gas;
- Electricity Companies;
- Water Companies;
- Education Authorities;
- Municipal and private owners of golf courses;
- Specialist pesticide application contractors.

Reliable historic data on the use of non-agricultural pesticides in the two catchments was difficult to obtain from the survey respondents. Information on pesticide use in the catchment was supplemented by a report commissioned by the Department of the Environment "The Use of Herbicides in Non-Agricultural Situations in England and Wales" (Produce Studies, 1991). This information was compared with the results of the survey completed for this study, which recorded pesticide use by the respondents for 1992/93.

The major non-agricultural uses for pesticides in both catchments are golf courses, district and county councils (mainly for parks and amenity land) and British Rail. Only one usage of atrazine and simazine was noted during the survey (in the Leam catchment) by a contractor 'finishing off' his remaining small stock. The majority of respondents had planned, in response to the withdrawal of the license for the non-agricultural usage of simazine and atrazine, increased use of glyphosate supplemented, where required, with a residual (i.e. slow-acting) herbicide selected from the 'panel' of bromacil, dichlobenil, diuron and imazapyr.

Diuron was the favoured residual herbicide, although the majority of users were aware of diuron being found in drinking water. One respondent stated that "... diuron will go the same way as atrazine and simazine, and be banned". The manufacturers of diuron have reportedly expressed concern that a sustainable strategy for its use, involving voluntary restrictions on applications, be developed (Izat 1994). Users appeared to be very conscious of the need to be perceived as being 'environmentally-friendly' and, in the case of some local authorities and utilities, this concern has led to the development of an environmental charter. The majority of organisations now operating such a charter require that the environmental impact of particular pesticides on their own 'approval' list, should be satisfactorily appraised.

The water supply companies operating in both areas, Severn Trent (Leam) and Three Valleys (Colne), were perceived as one of the key influences on policy-making by the majority of users. The 'Spraysafe' initiatives of Severn Trent Water plc in particular was cited as an important contributor to raising the awareness of 'best practice' in the use and application of pesticides.

3.3 Pesticide occurrences

3.3.1 Pesticide occurrences in the River Leam

Table 3.2 summarises the results of an extensive pesticide monitoring programme of the River Leam and its tributaries (Cable *et al.* 1994). STW also supplied monitoring data for 1990-1993 at the inlet to their Campion Hills treatment works, which was summarised by Cable *et al.* (1994).

Table 3.2 Occurrence of pesticides in the Leam, 1991-1992 (Cable *et al.* 1994)

Pesticide and chemical type[1]	Maximum concentration in Leam or tributaries (ng l^{-1})	
Atrazine (T)	580	
Deethylatrazine	140	
Carbendazim (B)	170	
Chlorotoluron (U)	410	
2,4-D (PA)	250	
Diuron (U)	470	
Flutriafol (TR)	220	
Isoproturon (U)	7450[2]	(1520)
Linuron (U)	1940	
Mecoprop (PA)	110000[2]	(930)
MCPA (PA)	86400[2]	(1160)
Simazine (T)	400	
Trietazine (T)	170	

1 T - triazine; B - benzimidazole; U - uron; PA - phenoxy acid; TR - triazole.

2 These levels were exceptional transient peaks detected in the River Itchen (a tributary of the Leam); the next highest concentration observed is given in brackets.

3.3.2 Pesticide occurrences in the Colne groundwater

The catchment area includes both rural and urban zones (a third of the land usage is agricultural). Monitoring data for the borehole water was confined to that provided by the Three Valleys Water Company. The results indicated that, of the monitored pesticides, exceedances in the source water were limited to isoproturon, chlorotoluron, atrazine and simazine. The latter two pesticides are now no longer permitted for use in non-agricultural applications and their occurrence is expected to decline. Isoproturon and chlorotoluron are used agriculturally only. Therefore future pesticide exceedances in the source water should be limited to agricultural pesticide usage. This preponderance of agricultural pesticide contamination in the catchment proved important later when predictions of future pesticide occurrences indicated that, for scenarios involving protection zones for the boreholes and restrictions in the usage of pesticides, only agricultural pesticides needed control.

It should be noted that this pattern of pesticide occurrences in the Colne catchment is a feature specific to this catchment and may not therefore be observed elsewhere.

4. SELECTION OF PESTICIDES AND RESTRICTION SCENARIOS

4.1 Selection of pesticides

4.1.1 Introduction

A large number of pesticides are used, in both catchments. It was not feasible to model the leaching or treatment for all of them, so a selection of key pesticides was made. Eleven pesticides were selected from those applied in the catchments to represent those of special concern, due to a widespread occurrence in water sources, extensive current or future usage and the difficulty of removal during treatment. The selected pesticides were used for the mathematical modelling of the environmental transport and degradation of pesticides and for modelling pesticide removal during water treatment. Groups of pesticides that behave and are applied similarly have been represented by a typical example of that group.

4.1.2 Triazine herbicides

The triazine herbicides are important to include because of their presence (particularly atrazine and simazine) in both surface and groundwaters. Their physico-chemical properties are such that they are likely to leach into water sources and their non-agricultural usage for pre-emergent weed suppression increases their potential to enter the environment, as such applications may have direct drainage into water courses or aquifers.

Atrazine and simazine are sufficiently different in their properties, observed levels and uses that both were included in the modelling. Simazine has some agricultural usage on legumes and hops whereas atrazine is almost entirely of non-agricultural use in the UK. Their future levels in the environment are expected to decline following the recent withdrawal of their licences for use in non-agricultural situations, but many water companies are installing facilities (mainly granulated active carbon, GAC) to remove these contaminants from drinking water. Atrazine and its transformation product, deethylatrazine, have been observed in the River Leam (Cable *et al.* 1994).

4.1.3 Acid herbicides

Acid herbicides also have both non-agricultural and agricultural uses, the latter being in post-emergent control of broad-leaved weeds in cereals. The three phenoxy acids (mecoprop, MCPA and 2,4-D) are very similar in uses, structure and physico-chemical properties and one (mecoprop) was selected to represent the three. Most reported exceedances nationally have been for mecoprop, probably because its usage is the highest of the three, so this herbicide was selected.

4.1.4 Urea-based herbicides

Urea-based herbicides, or urons, are an important category of pesticides to study, from an agricultural and environmental point of view. Their selectivity for grass and broad-leafed weeds ensures their heavy use in cereal crops. The quantity of isoproturon alone applied in the parishes of the Leam in 1992 represents about 40% of the total herbicide applications in the catchment. The levels observed in both the Leam and Clay Lane waters reflects this high usage.

The phenyl ureas (chlorotoluron, isoproturon, diuron and linuron) are similar in structure and physico-chemical properties. Diuron is now being used as a non-agricultural replacement for atrazine and simazine and its occurrence in rivers and groundwaters is expected to increase over the timescale of this study. Therefore it has been included in the modelling. Isoproturon is generally observed in the catchment in much higher concentrations than chlorotoluron. Any legislated restriction in its usage could incur significant economic penalties and, consequently, it was included in the modelling. There is some evidence that chlorotoluron is more persistent in soil than isoproturon (see Table 6.2 for a comparison of their half-lives in soil) and its usage is large, so its behaviour was also modelled.

4.1.5 Non-selective herbicides

The main representative of this grouping of herbicides is the phosphonic acid compound glyphosate. It has a large number of applications in both the agricultural and non-agricultural sectors. It has also been extensively marketed in the domestic gardening sector as being non-persistent and 'environment-friendly'. The transport behaviour of this pesticide was therefore modelled.

4.1.6 Fungicides

The application data for fungicides is different from that of herbicides. The highest usage in the catchments is that of chlorothalonil on wheat and winter beans, followed by that of fenpropimorph on wheat and barley. Information on their levels in the water of either catchment was not available.

Flutriafol and carbendazim have both been observed in the Leam and its tributaries. Flutriafol is found at consistently higher levels and is more water-soluble than carbendazim. The latter however has a larger total usage in the catchment, including significant non-agricultural use on golf courses. Both are included in the modelling for this reason.

4.1.7 Growth regulators

Although these agrochemicals are not pesticidal in action, they are covered by the general definition of pesticides and consequently, they can be included in the selection as similar considerations apply to them. The high usage of chlormequat, both within the Leam catchment and nationally, warrants its selection. Its occurrence in the water is unknown (its determination is difficult). It has a strongly cationic nature, which suggests a correspondingly high adsorption to soil.

4.1.8 Insecticides

Modern insecticides do not generally present a problem in terms of contamination of water sources and water treatment. However chlorpyriphos, which has the highest usage in this category in the catchments, was included in the modelling as it was considered important to include an insecticide in our study. Chlorpyriphos is an organophosphorus compound which degrades slowly in soil.

4.1.9 Selection of pesticides

In summary, the resulting list of pesticides (key pesticides) which were studied for the two sites, was as follows:

> atrazine, simazine, mecoprop, isoproturon, chlorotoluron, diuron, glyphosate, carbendazim, flutriafol, chlormequat and chlorpyriphos.

Although this list was compiled to cover the pesticides used and/or observed in the catchments, it also includes many of those which are applied and which occur in water supplies nationally. This feature was important in consideration of the methodology for the extrapolation of the study to England and Wales (see Section 14.3).

4.2 Scenario definitions

4.2.1 Introduction

Various options are available for restricting future pesticide usage so as to ensure that pesticide levels in sources of drinking water comply with the PCV. The terms of reference of the study required that the following scenarios of restrictions be examined:

- no restrictions;
- a total ban on pesticide usage throughout the catchments;
- the introduction of protection zones;
- restrictions on quantities and timing;
- the use of more acceptable pesticides;
- use of 'non-chemical' methods.

These scenarios represent two extremes of pesticide restrictions and intermediate options. Variations within some of these scenarios are possible and the scope of some is greater than that of others. The scenarios are individually described in the following six sections.

4.4.2 No Restrictions

This scenario postulates that pesticide usage in the catchments continues at levels which are decided by the individual end-user, whether farmer, horticulturist or other. In effect, the scenario represents the current situation. This scenario is the 'baseline' with which the other scenarios are compared.

The prediction of future total agricultural pesticide usage was made through a combination of anticipated changes in pesticide usage and changes in cropping practices. Future non-agricultural use of pesticides was estimated based on knowledge of existing trends. The effects of the continued unrestricted use of agricultural and non-agricultural pesticides on the source water quality and hence on water treatment costs was calculated from catchment water flow and pesticide fate models developed for this study and from water treatment models.

4.2.3 Total ban

This provides the other extreme scenario and postulates a total ban on the marketing and usage of pesticides in the catchments.

The effects of total bans on agricultural and non-agricultural pesticide usages were studied separately as the effects and costs differ substantially.

It was not within the scope of this study to assess the political feasibility of this option. It is likely that considerable resistance would be met from a number of sources, particularly as a total ban would prevent the use of all pesticides, whether detected in drinking water sources or not. Non-agricultural pesticide usage may contribute to a greater extent to the current problem than agricultural pesticide usage: this could be cited as a reason why a total ban is unfair and unjustified.

4.2.4 Protection zones

In this scenario, the drinking water source is protected by defining a specified area as a Protection Zone in which the application of key pesticides is not permitted, but substitute pesticides could continue to be used. Such a scenario has several precedents, both in the UK and the rest of Europe (Horth *et al.* 1994). Schemes to protect groundwater resources from excess nitrate levels include the use of protection zones (Laurence Gould Consultants Ltd, 1985). The NRA have issued regional guides to protect groundwater ("Policy and Practice for the Protection of Groundwater").

The extent of protection required and the format of the protection zone for both non-agricultural and agricultural pesticide usage was defined with the aid of the mathematical pesticide fate models. In principle, each of the key pesticides would require a protection zone specific to itself. In practice, a system where each pesticide would have an individual protection zone would be impractical to implement, so the size of the protection zone has been set at that required to protect the source water from the most problematical pesticide in the catchment. It should be noted that these protection zones therefore overprotect for the other key pesticides.

Spraydrift into the watercourse from pesticide applications outside the buffer zone was ignored in this scenario. Present knowledge on this subject is insufficient to permit accurate calculations, but the likely effects were considered to be minor.

4.2.5 Restrictions on quantity and timing of application

Under this scenario, legislative restrictions are imposed on the amount of pesticide used in the catchment and/or the timing of application. Many different options exist within this framework; several were considered. During the analysis of the effects of this scenario, limitations on the scope for the practical implementation of these scenarios were identified. These limitations and the resultant definition of this scenario are described below.

Restrictions on quantities

The pesticide approval and registration system requires pesticide manufacturers to state explicitly the maximum rates of chemical to be applied and the timing of application. These may vary, depending on the crop, soil type and the type and level of infestation. The application rate(s) are clearly set out on the product label, together with details on timing, tank mixing and crop safety. Every product label also has a hazard rating, if appropriate, together with other safety, environmental and handling instructions that accompany each container. The Control of Pesticides Regulations (COPR) includes Approvals required before any pesticide may be sold, stored, supplied, advertised and used, and allows for general requirements to be set out in various 'Consents'. Consent C(i) relates to use and includes requirements for spray operators to operate within the constraints of the label. In theory, therefore, no scope exists to exceed the maximum recommended amount of pesticide per unit area of land.

Archivable data indicates that in the two areas being studies, dose rates are at the current recommended levels. Farmers can reduce the dose rates at their own risk, but this can only be achieved practically when climatic factors, the growth stages of weeds and crops and the crop population density mean that an effective kill can be achieved. As a result, this approach can only be adopted in very specific circumstances and may even be limited to one particular field in any one year.

Research is being undertaken to improve predictions of when farms can effectively utilise lower application rates and, as a result, the proportion of applications made below recommended rates may increase in the future. It has been difficult to assess what proportion of farms are currently adopting this approach and in any case, it will vary from year to year for the above reasons.

There is evidence to suggest that the continual use of below recommended application rates, while reducing costs in the short term, could well increase the long term costs because of the increase in the seed bank in the soil and the build-up of potential resistance to individual, and possibly groups, of pesticides.

In these two catchments, the existing pesticide usage would suggest that the key weed problems are blackgrass, wild oats and cleavers and the scope to reduce rates for these weeds is particularly limited. In other catchments, the scope may be greater; one survey, for example, reported that most farmers in the Bedfordshire Ouse catchment undercut the label application rates (Ward *et al.* 1993).

Restrictions on timing

Changing the time at which pesticides are applied (e.g. from autumn to spring) may reduce the environmental impact of the application. This option however was found to have only limited feasibility because most pesticides are only effective between certain weed or crop growth stages or below specific levels of disease or pest infestation. In addition, the development of weeds, diseases and pests will vary from year to year depending on climatic conditions. In order to illustrate the limitations on timing of applications, a brief discussion on this aspect for the key agricultural pesticides is given below.

Only one application of atrazine can be made per annum otherwise weed resistance may build up. It is preferable to incorporate the chemical into the soil before drilling, but if it is moist and the soils are light it can be applied after the crop has been planted. However, if it is dry when the crop is planted, atrazine can be applied to light soils when the weeds emerge but before they are 40 mm high.

Again, if repeated applications of simazine are made, weed resistance may build up but in any case there should be a minimum interval of seven months between applications. Simazine should be put on as soon as possible after drilling winter beans and no later than the end of February and the chemical should be applied within seven days of planting spring beans. For bush, cane and top fruit crops, simazine should be put on in February or March when the soils is clear of weeds, and should be applied to strawberries between July and December but not in the spring.

Mecoprop should be sprayed on winter cereals from the time the first leaf has unfolded but before the end of December. For spring cereals, the chemical can be put on after the first two leaves have unfolded but before the first node is detected. Isoproturon can be applied at any time in the autumn, subject to vulnerable weed growth stages, but not during extended frosts or when it is wet. It should not be put on before crop emergence if the crop has been planted after the end of November. To ensure weed control isoproturon should be applied to blackgrass before early tillering, before the three fully expanded leaf stage of wild oats or sterile brome and before annual broadleaved weeds are 50 mm high and 100 cm wide. Chlorotoluron can be put on in the autumn or spring but the former is preferable. It can also be applied pre- or post-emergence but before blackgrass and annual meadow grass reach the five leaf stage and wild oats the two leaf stage.

Glyphosate is a translocated non-residual phosphonic acid herbicide and kills most actively growing plants. The chemical cannot therefore be applied to crops which are growing. Its most common agricultural use is to control annual and perennial weeds in cereal stubble, sward destruction and as a pre-harvest application to control couch in cereals. However, the application must occur a minimum number of days before harvest, the time interval between applications and harvest depends on the crop.

Fungicides and insecticides are applied as a direct response to a particular problem and as indicated above, the development of diseases and pests is very dependent on climatic conditions. Carbendazim controls a wide range of fungal diseases but must be applied to winter wheat before flowering, to barley before the flag leaf sheath opens and to oilseed rape before stem extension. Flutriafol is also a broad spectrum fungicide for use in wheat and barley. It can be applied at all growth stages up to the onset of flowering but for best control it is preferable to put it on at an early stage of disease development. Chlorpyriphos should be applied in the spring or summer when aphids are first detected. It should be used against wheat blossom midge between ear emergence and flowering and against wheat bulb fly during the egg hatch in January/February. The chemical can be used to control fruit fly either pre-emergence, during or post-emergence or at the first sign of damage. Later applications will be less effective.

Chlormequat, a growth regulator, can be applied to actively growing winter wheat between the leaf sheath erect stage but before the second node is detectable, and to winter barley and spring wheat and barley from the fully tillered stage but before the first node is detectable.

In view of the above limitations on timing and quantities, the restrictions scenario has therefore been taken to be the introduction of restrictions on the total use of key pesticides in order that they remain within the PCV.

The use of economic instruments to reduce pesticide usage (primarily levies and tradeable permits for pesticide purchases) can be considered as a tool to implement this scenario. Economic instruments have been examined and are discussed in Chapter 13 and in more detail in Annex 5.

4.2.6 More acceptable pesticides

This scenario postulates the substitution of problem pesticides by more 'environmentally-friendly' products. Identifying these environmentally-friendly pesticides can be difficult. For example, the recent withdrawal of the permission to apply atrazine and simazine in non-agricultural cases was not accompanied by the recommendation of a substitute product of similar herbicidal efficacy but with a lower potential to contaminate water supplies. Both of these withdrawn herbicides caused chronic exceedances of the PCVs set in the Water Supply Regulations. In many cases, diuron has replaced the non-agricultural uses of atrazine and there is evidence that this pesticide is now occurring more widely in source waters.

In the Protection Zone scenario, the substitution of certain pesticides for those not permitted in the protection zone created additional and unpredicted problems in relating future occurrences of pesticides to future usage. These problems highlighted the difficulties in identifying more acceptable pesticides and the need for careful consideration of the effects of increased usage of the substitute pesticides on environmental occurrences of pesticides. For example, if mecoprop were to be replaced by fluoroxypyr, the pesticide transport model (described in Chapter 6) predicts that fluoroxypyr levels would also exceed the PCV; whereas if the substitute for mecoprop were metsulfuron-methyl, the model indicates that the PCV would not be exceeded in the river (See Annex 1). However these predictions could not be verified as neither fluoroxypyr nor metsulfuron-methyl are currently monitored in the catchment. The identification of more acceptable pesticides requires therefore catchment-specific studies of future pesticide usage and modelling of the fate and behaviour of the "more-acceptable" pesticides.

Other practical limitations to the implementation of this scenario and the costing of its effects were identified during the study. The agro-chemical market is worldwide and the numbers of companies involved are declining due to intense competition and the high costs associated with research and development. The success of the R&D will have a large impact on the future profitability of each company. Discussions with representatives of the agro-chemical companies, understandably, yielded no specific information about future developments. Although some general information is available about likely future developments in pesticides and genetic engineering, no detailed information could therefore be gained on when the introduction of new technology could be expected, its cost and mode of operation. Consequently, the impact in operational, environmental and financial terms of using new and more acceptable pesticides cannot be readily quantified. Examination of this scenario was therefore confined to modelling their ideal physico-chemical properties for each catchment (see Section 7.4). The value of such an exercise is that it indicates 'target' physico-chemical properties for pesticides that would minimise their potential to reach water sources in concentrations above 0.1 $\mu g\ l^{-1}$.

4.2.7 Non-chemical methods

Consideration of this scenario required assessment of techniques which are available or have been suggested for use as non-chemical pest control methods.

In the two catchments, non-chemical practices are not viable options, primarily because of the specific soil characteristics and farm systems; arable cropping is predominantly winter sown and hence the opportunity for non-chemical weed control is extremely limited. In order to achieve an increase in non-chemical practices, a significant shift to spring cropping would need to be achieved. In the two catchments, because of the big differential in yields and hence gross margins between spring and autumn crops, there would be high costs to individual farmers. Assuming that the latter can switch to an alternative chemical, they will adopt this as the preferred option because it represents the least costly alternative and hence minimises the impact on overall farm profitability.

The switch to spring cropping may not represent such a large cost in other catchments where, because of differing soils and farm systems, the differential in yields between winter/autumn sown crops is less marked. The differential in gross margins may also be further reduced in those areas where soils and other management factors enable premium crops (e.g. malting, barley and milling wheat) to be consistently produced.

Biological control techniques are currently in use for glasshouse crops. Although research is being undertaken into similar systems for field crops, none are currently available and it has not been possible to estimate when they may be introduced, what their final effectiveness may be, or their cost. Consequently, the main non-chemical methods available to both agricultural and non-agricultural users of pesticides are mechanical or manual methods. However, in agriculture there are no mechanical or manual means for controlling diseases or normal populations of weeds and pests. Consequently, for both agricultural and non-agricultural pesticide users, restrictions to 'non-chemical' methods effectively means a ban on pesticide usage. The financial effects of this scenario are therefore equivalent to those studied for the Total Ban scenario described above.

It should be noted that the limited scope for implementing this scenario is a feature of the two catchments studied and may not apply elsewhere.

4.2.8 Summary of scenario selection

The six original scenarios of pesticide restrictions were assessed.

The practical scope of one scenario (restrictions on quantities and timing) was found to be limited. Very little scope for varying the timing of pesticide applications exists. Application rates are fixed by operational factors, so this scenario is reduced to a restricted usage of total pesticides and hence restricted cropping levels.

Little information on 'more acceptable (environment-friendly) pesticides' was available, therefore the detailed effects were not quantifiable. Ideal properties for theoretical pesticides were derived from the mathematical pesticide fate model.

Although they may be appropriate in other catchments, non-chemical agricultural practices are not viable options in the two catchments studied because of the specific soil characteristics and farm systems.

The detailed economic analysis was therefore conducted for the following scenarios:

- No Restriction;
- Total Ban;
- Restricted Usage;
- Protection Zones.

5. FUTURE PESTICIDE USAGE

5.1 Future agricultural pesticide usage

A more detailed description of the methods used and the results obtained is given in Annex 1 of the report.

Pesticide usage projections were undertaken, assuming no restrictions, for each of the major crops in both catchments for the years 1997 and 2002. The following factors were taken into account when undertaking the predicted applications per hectare of crop:

- the range of available pesticides was restricted to existing and recently approved products;
- soil type;
- general trends in the usage of specific products, e.g. older chemicals becoming less popular and being replaced by newer products;
- the trend away from prophylactic treatments towards meeting the problems as they occur;
- changes in the agricultural support system in which the prices of most arable crops are being reduced but compensated by area payments.

It should be noted that, without detailed information on the weed spectrum in each catchment, the precise use of herbicides currently applied could only be estimated. Specific weed problems have had to be assumed in order that predictions on appropriate substitutes could be made. Future loadings in each catchment would be different from that anticipated if the initial assumption on the spectrum of weeds subsequently proved to be incorrect.

Cropping projections for the No Restriction case were made after taking into account past trends, the relative profitability of individual crops under the new agricultural support system and rotational constraints. In view of the difficulty of predicting the changes to the Common Agricultural Policy (CAP) and because farmers' ability to radically alter their farm system is now limited under the Integrated Administration and Control System (IACS), it has been assumed that no further changes in cropping occur after 1997. However, predictions of future pesticide usage, in terms of trends in use by chemical and application rate, were made for the ten-year period. To calculate the overall loading of active ingredients, the predicted cropping patterns for 1997 and 2002 were multiplied by the anticipated application rate of active ingredient for each pesticide applied to the major crops in both catchments. The results were then fed into the pesticide fate model so that the concentrations in water could be predicted (see Chapter 7).

A similar procedure was adopted for each of the pesticide restriction scenarios. For the Restricted Use and Protection Zone scenarios, it was assumed that substitute chemicals could be used to replace the restricted key pesticides. Suitable substitutes were chosen such that, providing the farm-management ability of farmers in the catchment is good, the yield potential of all but one crop (forage maize) should be unaffected. The main impact of these restrictions, providing substitutes can continue to be used, would therefore be changes in pesticide costs per hectare and, under some circumstances, the need to make additional passes with the sprayer. However, when Restricted Use loadings were run through the pesticide fate model, three of the substitute chemicals, which had not previously been a problem, exceeded the PCV. These chemicals were replaced with other less mobile substitutes and the models were re-run to check that the PCV was not exceeded. This highlights the practical problems that are likely to be experienced if partial restrictions are placed on the overall loading of a particular pesticide: the usage of other pesticides may increase to maintain crop yields to the extent that further contamination by the other pesticides may occur.

The most appropriate form of protection zone for agriculture in the Leam catchment would be to create a grass buffer zone on either side of the watercourses on farms. Normal pesticide application rates would continue to be applied to arable crops outside the zone. In the Colne catchment this approach is not possible and the protection zone required to protect the groundwater from pesticides above the PCV occupies a substantial portion of both the agricultural and non-agricultural land area. In view of the problems encountered with substitutes in the Leam, the final range of substitute pesticides used in the protection zone was the same as that assumed for the Restricted Use scenario.

A summary of overall loadings of the key pesticides used in agriculture in the two catchments is presented in Tables 5.1 and 5.2.

Table 5.1 Summary of key agricultural pesticide loadings in the Leam Catchment under the alternative restriction scenarios - kg active ingredients

Key	No Restrictions			Restricted Use		Protection Zone(s)	
Pesticide	1992	1997	2002	1997	2002	1997	2002
Atrazine	102	203	203	18	18	202	202
Simazine	750	1130	1129	162	162	1122	1122
Mecoprop	2795	2429	1545	327	293	2416	1538
Isoproturon	15524	9794	6351	482	457	9723	6306
Chlorotoluron	1341	1138	1120	239	220	1130	1111
Flutriafol	275	187	3	123	3	186	3
Carbendazim	110	119	176	119	176	118	174
Chlormequat	9297	6399	6399	6399	6399	6353	6353
Chlorpyriphos	988	367	367	367	367	367	367
Glyphosate	3464	3491	2826	3489	2824	3470	2809

Table 5.2 Summary of the key agricultural pesticide loadings in the Colne catchment under the alternative restriction scenarios - kg active ingredients

Key Pesticide	No Restrictions			Restricted Use		Protection Zone(s)	
	1992	1997	2002	1997	2002	1997	2002
Atrazine	41	41	41	5	5	5	5
Simazine	135	250	248	16	16	17	17
Mecoprop	748	729	698	729	698	729	698
Isoproturon	3765	2007	1697	1404	1407	200	169
Chlorotoluron	1181	575	373	292	230	57	37
Flutriafol	103	52	34	52	34	52	34
Carbendazim	343	76	87	75	87	89	100
Chlormequat	2027	1430	1527	1430	1527	1430	1527
Chlorpyriphos	94	95	158	95	158	95	158
Glyphosate	305	512	422	511	421	511	421

Note: Under the Total Ban scenario the loading of active ingredients is zero in both catchments.

5.2 Future non-agricultural pesticide usage

It is assumed that present levels of non-agricultural weed control will continue to be necessary, key users aiming to control weeds at least cost within legislative and policy parameters laid down by central government. Any policy changes are likely to have a significant effect on costs - as has been the case with the banning of simazine and atrazine - in this sector. Whilst there are alternative methods of weed control (as discussed in Annex 2, Section 3.8) it is not possible to predict future government legislation nor to accurately quantify the impact that such changes would have on the methods of weed control that would be adopted by different users.

The results of the data collation and predictions are described in detail in Annex 2 to the report.

The restriction scenarios carried out for non-agricultural pesticide usage have been applied to the Leam catchment. For the Colne ground water, neither of the pesticides (isoproturon and chlorotoluron, see Section 7.3) which the pesticide fate model predicted, on the basis of the projected No Restrictions usage, to occur at levels above 0.1 $\mu g\ l^{-1}$ in Colne borehole water was found to be used or is likely to be used in the non-agricultural sector. Therefore only the Total Ban restriction scenario was applied to non-agricultural pesticides in the Colne. However respondents in both catchments were requested to provide information on their expected future use of pesticides.

Evidence collected during the project confirmed that there had been a significant increase in the use of diuron up to the time of the research, due mainly to the withdrawal of the approval for non-agricultural usage of atrazine and simazine. However, the majority of respondents if they were changing to diuron had already done so by the time the fieldwork was carried out. None of the respondents expected to make any major changes to their approved range of chemicals.

None of the respondents were able to indicate their likely use of pesticides over the next five to ten year period. Comments made by the respondents when requested for their view normally indicated "... that legislation and budgetary pressures would probably require a reduction in the use of pesticides." However, as they were unable to quantify likely changes, no changes have been assumed.

The prohibition in the non-agricultural use of simazine and atrazine in August 1993 was incorporated into the calculation of the overall loading of active ingredients. The quantity being used (only in the Leam catchment) was so small as to be insignificant.

For the Restricted Use and Protection Zone options it was assumed that substitute chemicals could be used to replace the restricted key pesticides with negligible effect on efficacy, albeit at a small increase in cost.

Surface types used in considering the protection zone in the Leam catchment were sub-divided into three categories:

	Surface type	Protection Zone
1.	Roads and hard surfaces (assumed to have direct drainage into the water courses)	Total catchment
2.	Railways	50 m each side of bridges over watercourses
3.	Soft surfaces*	9.6 m strip on each bank of watercourse

* Grass verges, sports pitches, flower beds, etc.

A summary of the non-agricultural key pesticide loadings in each catchment is presented in Table 5.3.

Table 5.3 Leam and Colne catchments - summary of non-agricultural key pesticide loadings under alternative restriction scenarios - kg active ingredient

Key Pesticide	No Restrictions			Restricted Use		Protection Zone(s)	
	1992	1997	2002	1997	2002	1997	2002
Leam catchment							
Atrazine	1.5	0	0	0	0	0	0
Diuron	74	74	74	0	0	61	61
Glyphosate	120	120	120	120	120	120	120
Mecoprop	51	51	51	0	0	50	50
Colne catchment							
Diuron	215	215	215	na*	na	na	na
Glyphosate	372	372	372	na	na	na	na
Mecoprop	605	605	605	na	na	na	na

na Not applicable

* The Colne catchment would be unaffected by any of the restriction scenarios since none of the pesticides exceeded the PCV.

6. DEVELOPMENT AND VALIDATION OF PESTICIDE FATE MODELS

6.1 Introduction

In this section, the development and validation of mathematical models to predict future pesticide levels in the River Leam and the Colne groundwater are described. The models are specific to the two catchments. The models were validated by predicting the present pesticide levels in the source waters, based on the pesticide application data, and comparing the predicted levels with the observed levels.

The models used were developed from existing software to permit the particular requirements of the study to be included. The main objective was to construct physically based models, that is models which could simulate the processes controlling the movement of water and the fate of pesticides in the catchments. The alternative modelling approach, in which outputs (i.e. loads or concentrations in the water) are statistically related to inputs (i.e. applications), was rejected because such a model cannot extrapolate outside the bounds of the calibration phase, and so cannot give predictions of the effects of land-use controls on pesticide concentrations. Details are given in this section of the model construction, data requirements, the calibration process and the sensitivity exercises which were undertaken.

6.2 Pesticide fate models

The investigations have required the prediction under various usage scenarios of pesticide concentrations in the River Leam and in the Chalk groundwater of the Colne catchment. The predictions cannot be made in a straightforward way by extrapolation of past trends because the scenarios to be tested are complex, involving, for example, replacements of some pesticides and spatial restrictions on others. The available historic data on pesticide concentrations are also very limited, and do not reflect the full range of meteorological conditions which may occur in any year.

The problem of predicting future trends has been resolved by building computer models of the two catchments. Such models have been widely used in the past for simulating the transport and fate of agrochemicals in the environment (Onstad and Blake 1980, Laurence Gould Consultants Ltd 1986, Clark *et al.* 1992). Essentially, such models solve the equations of mass balance and continuity governing water and solute movement through a catchment, to calculate solute concentrations at selected points and times.

Models for pesticides in surface and groundwaters need to take account of the following factors:

- water flow rates dependent on catchment characteristics and effective rainfall (i.e. rainfall minus evaporation);

- pesticide application at any time of the year;

- adsorption of pesticides onto the soil matrix during transport;
- decay of pesticides.

Two models were developed for this study, one for surface runoff in the River Leam catchment, and the other for groundwater flow in the Colne Valley Chalk aquifer. The models were based on existing computer codes used in earlier studies, though significant enhancements were needed to handle the additional complexities of the current study.

6.3 River Leam catchment

The catchment to the Campion Hills water works intake on the River Leam covers an area of 37 000 ha. The soils are principally of the Denchworth, Evesham and Whimple Associations, heavy clays with permeabilities declining rapidly with depth which result in the generation of surface runoff in the top metre or less. The runoff flow paths through the catchment will depend on the topography, and to allow a model to simulate the runoff process, a digital terrain model (DTM) was used to generate topographic heights on a 250 m grid covering the catchment. The DTM also produced the river network and the watershed boundary to define the catchment area. An overland flow route to the river system is thereby provided for each 250 m grid square in the catchment, a necessary requirement for a pesticide transport model. It soon became apparent, however, that a 250 m grid was inadequate for the problem at hand because protection zones along rivers of a few metres width would need to be simulated and this is only feasible with a spatial resolution of similar magnitude. The 250 m model grid required 5900 mesh points which is a practical size for modelling purposes; a 2 m grid would require over 90 million mesh points which is, by a very large margin, impractical for the DTM and for a pesticide simulation model. It was therefore decided to model pesticide transport along a typical flowpath of width 1 m. The DTM generates flowpaths and was used to estimate the average flowpath length in the catchment area, 1350 m. A one-dimensional model of water and pesticide movement was therefore applied to the typical flowpath. Model simulation proceeded as follows:

The flowpath model was based on the method of Haith (1980), who developed a simulation procedure to predict pesticide runoff from a small field. The method has been adapted by subdividing the flowpath into 1 m^2 cells and undertaking a Haith type calculation for each cell.

1. The entire catchment was represented by a single, typical flow path, which may be considered as a 1 m wide strip running from high ground down to the river.

2. Pesticide applications were simulated as additions to each cell at the appropriate times of year. To simulate buffer zones, applications were reduced to zero in selected cells close to the river.

3. Water flows and pesticide loads were calculated cell by cell in the direction of flow (i.e. down hill). Calculations were undertaken with 73 time steps per year, each of five-day duration.

4. Water and pesticides were assumed to move through the upper zone of the soil under hydraulic gradients resulting from catchment topography and rainfall recharge.

5. Water flows through the soil were calculated from pentad (five-day) rainfall recharge (i.e. rainfall - evaporation) values over a 51 year period.

6. The processes of pesticide adsorption onto organic carbon and biochemical degradation were simulated to occur during movement through the soil.

7. At the river boundary water and dissolved pesticides fluxes out of the soil were multiplied by the total length to give the flow and mass of pesticide in the river.

Transport of pesticides on particles (sediment transport) was not included. This is not considered a significant feature for the pesticides modelled.

One important feature not covered in the conceptual model described above is land drainage, and its effect on water and pesticide movement. Data presented by Robinson and Armstrong (1988) indicates that under-drainage was installed on between 0 and 10% of the agricultural land in the vicinity of the Leam catchment in the period 1971-80. Furthermore, it was estimated that data for the 1971-80 decade represent about half of the two million hectares drained in England and Wales this century. A reasonable estimate for the percentage of agricultural land drained in the River Leam catchment is therefore about 10%. The effects of under-drainage on pesticide transport in the Denchworth clay soils at Brimstone Farm have been studied (Harris *et al.* 1994). Pesticide movement through two plots at Brimstone Farm, one undrained and the other equipped with mole drains at 60 cm depth, was analysed and modelled. It was concluded that the drainage system encouraged downward movement of water through the soil, which resulted in longer soil residence times for agrochemicals than occurred with runoff through undrained soils. Once the water reached the drain it would move very rapidly to the river, but the overall effect appeared to be that under-drainage does not necessarily provide a rapid by-pass route, and hence higher losses, to rivers. Drainage systems can vary enormously in their design and resulting hydrological impact on agrochemical movement, but without detailed field experimentation it was considered appropriate to base the Leam model on the findings from the Brimstone Farm experiments, which were on identical soils. It was therefore decided that under-drainage need not be explicitly included in the river Leam model formulation. In the context of the Leam catchment, simulation of the current situation with regard to pesticide occurrences in the river provided a test of whether the hydrological model is soundly based.

The use of a single flowpath to represent the catchment has been shown to be a valid assumption by comparing the flowpath method with a small two-dimensional model of a catchment. Essentially, the concentration of pesticide in water discharging to the river is relatively independent of the assumed flowpath length, so that the inclusion of all flowpaths in the simulation (equivalent to a two-dimensional model) would give a very similar prediction to that for a single flowpath. The sensitivity of the models to flowpath length is discussed in Section 6.5.

Runoff in the model is generated from five-daily totals of effective rainfall (defined as rainfall minus evapotranspiration). Because of the need to consider the impact of climatic variations on pesticide concentrations, all model runs were undertaken with a 51-year sequence (the duration of the climate sequence is not critical) of five-day effective rainfalls. The sequence is synthetic (Cole *et al.* 1991) but contains the statistical features of actual effective rainfall in southern England. The five-day values of effective rainfall were scaled to give a long-term average value appropriate to the Leam catchment, assumed to be 180 mm/a.

The model outlined above is physically based, and simulates all of the processes that are considered to be important. Data required to run the model comprise catchment characteristics and pesticide physico-chemical data and all of these items are measurable. Application of the best available data to simulate the current situation therefore provided a test of the viability of the model as a predictive tool. The catchment characteristics used in the model, and the sources of the data, are listed in Table 6.1.

Table 6.1 River Leam model characteristics

Property	Value	Source
Depth of soil	75 cm	Hall *et al.* (1977)
Soil bulk density	1.3 gm ml^{-1}	Hall *et al.* (1977)
Soil organic carbon	8%	McGrath and Loveland (1992)
Water content	40%	Hall *et al.* (1977)

The physico-chemical properties of pesticides were taken from Moore (1992) and Fielding *et al.* (1992). The values used in this study for both the River Leam and the Colne groundwater catchments are listed in Table 6.2. K_{oc} is the partition coefficient of the pesticide between water and organic carbon. The decay processes on soils are described by the exponential rate constant, k, or the equivalent half-life, t½.

For agricultural chemical usage the application rate applied to the model was calculated as the total application loading on the catchment divided by the catchment area, so that uniformity of usage was assumed. However, applications were excluded from the 1 m strip next to the river, on the assumption that this would be uncultivated.

Table 6.2 Properties of selected pesticides

Pesticide	K_{oc} (ml g^{-1})	t½ (d)	k (1/d)
Isoproturon	107	20	3.47e-2
Chlorotoluron	175	135	5.13e-3
Mecoprop	127	28	2.48e-2
Diuron	288	64	1.08e-2
Flutriafol	1200	600	1.16e-3
Carbendazim	129	52	1.33e-2
Chlormequat	68	1.3	5.33e-1
Chlorpyrifos	498	94	7.37e-3
Atrazine	140	50	1.39e-2
Simazine	118	60	1.16e-2
Glyphosate	28700	53	1.31e-2

For non-agricultural usage, the assumption of uniformity of application rates was tested and found to be inappropriate to predict pesticide occurrences from the application data. For example, application of diuron uniformly over the entire catchment gave predicted concentrations which were too small by a factor of about 200. A different approach was therefore used to simulate the very variable application regime typical of non-agricultural usage, and the significant threat posed to water sources: all of the chemical was assumed to be applied to a 10 m wide strip adjacent to the river. The value of 10 m was derived by calibrating the model against results for diuron. This was the only aspect of the Leam study in which a catchment characteristic (the spatial distribution of non-agricultural pesticide usage) was derived by calibration.

Data were not available on the temporal distribution of pesticide usage in the Leam catchment, and so the monthly patterns of usage were based on the Pesticide Use Survey results (Weddepohl *et al.* 1992) for the Warwickshire Avon catchment.

The model results for 1992 isoproturon usage are shown for 20 years of simulation in Figure 6.1. The remaining 31 years show very similar trends. Note that the years are notional as synthetic rainfall recharge data are being used. However, this does not preclude comparisons with STW's measured concentrations, as reported in Cable *et al.* (1994). The shape of the predicted trends agrees well with the STW measurements (shown in Figure 6.2), concentrations peaking in December or January and subsequently declining rapidly to values less than 100 ng l^{-1}. Variations in predicted annual peak concentrations, Figure 6.1, are due to variations in rainfall recharge from year to year, particularly the incidence of runoff immediately after the application. In those years when the peak concentrations are noticeably lower, for example years 10 and 16, there was little runoff at the time of application so that biochemical decay significantly reduced the loading on the catchment prior to transport into the river. Other pesticides show similar trends. The maximum measured concentrations in the River Leam at the STW Campion Hills intake are reasonably well simulated by the model, Table 6.3.

Table 6.3 Measured and simulated maximum pesticide concentrations in River Leam catchment at Campion Hills works

Pesticide	Maximum concentration ($ng\ l^{-1}$) Measured	Simulated
Isoproturon	2400	2630
Chlorotoluron	300	250
Mecoprop	680	440
Diuron	650	660
Flutriafol	220	20
Carbendazim	70	40
Chlormequat	nd	100
Chlorpyrifos	nd	30
Atrazine	490	20
Simazine	330	170
Glyphosate	nd	<1

nd: not determined

The application data used in the model were effectively 1992/93 rates. The non-agricultural usage for simazine and atrazine was very small, reflecting changes in anticipation of the ban from August 1993. The measured maxima were recorded in 1990/91 and it is likely that the model underpredictions result from this mismatch in inputs.

The simulations for flutriafol underpredict by a factor of about ten, but the physico-chemical properties database for this pesticide is very limited and must be considered suspect. For example, measured concentrations in the River Leam fluctuate significantly, between 220 $ng\ l^{-1}$ and $<10\ ng\ l^{-1}$. The value for half life given in Moore (1992) is 600 days which is inconsistent with the observed range of variation. In order to undertake predictive simulations for flutriafol the model was used to obtain suitable physico-chemical data by calibration against the observed trends. The observed trends were well reproduced when values of $K_{oc} = 35\ ml\ gm^{-1}$ and t½ = 60 days were used. These are significantly different from the reported values, Table 6.2.

Other simulations are reasonably good and certainly better than the majority of catchment scale predictions presented in recent publications (e.g. Brooke and Matthiessen, 1991).

The model of the River Leam catchment appears to be capable of providing predictions of future pesticide concentrations which are sufficiently accurate for testing catchment control options. Results of these predictions are given in Section 7.2.

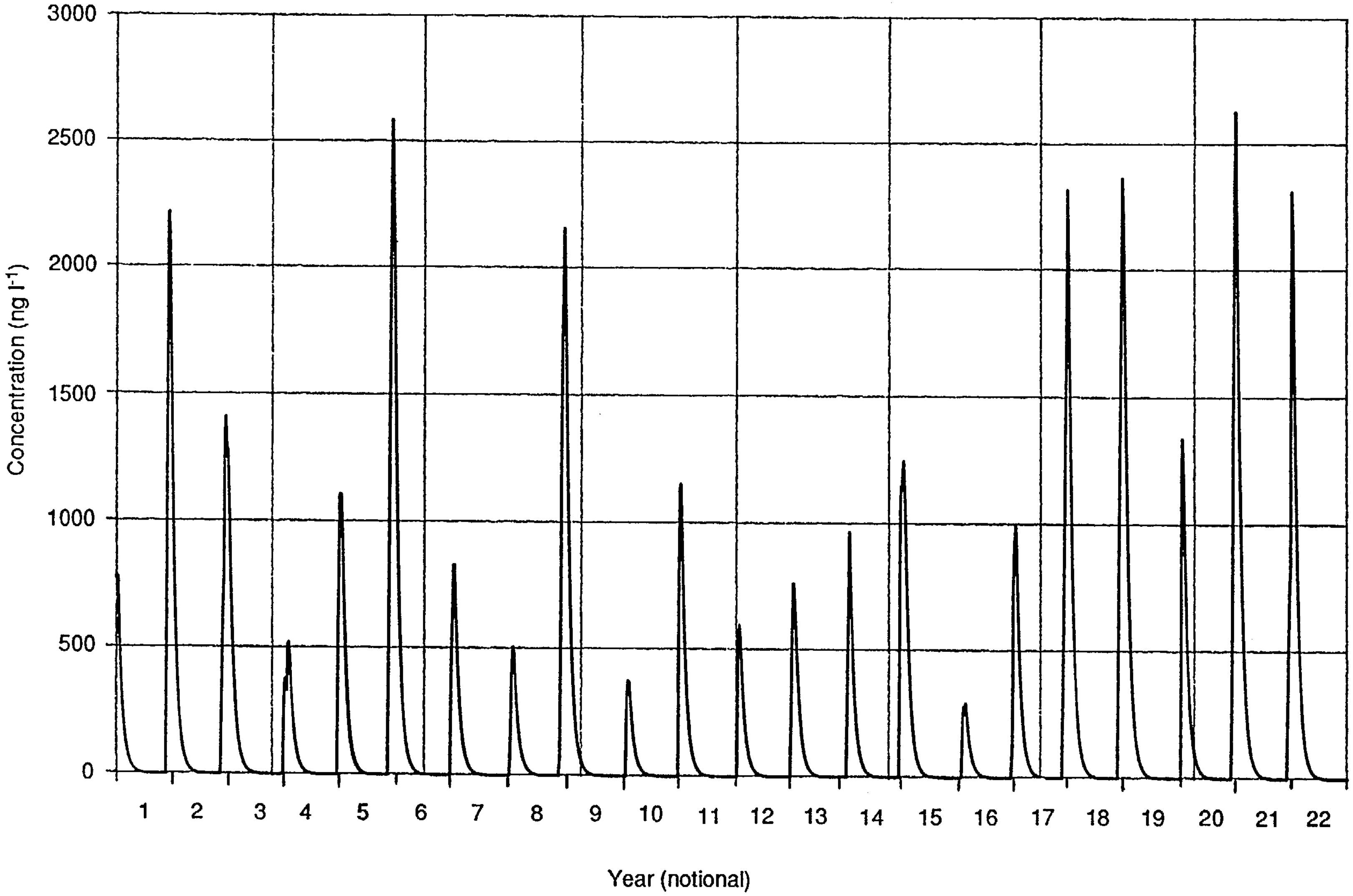

Figure 6.1 Predicted levels of Isoproturon in River Leam

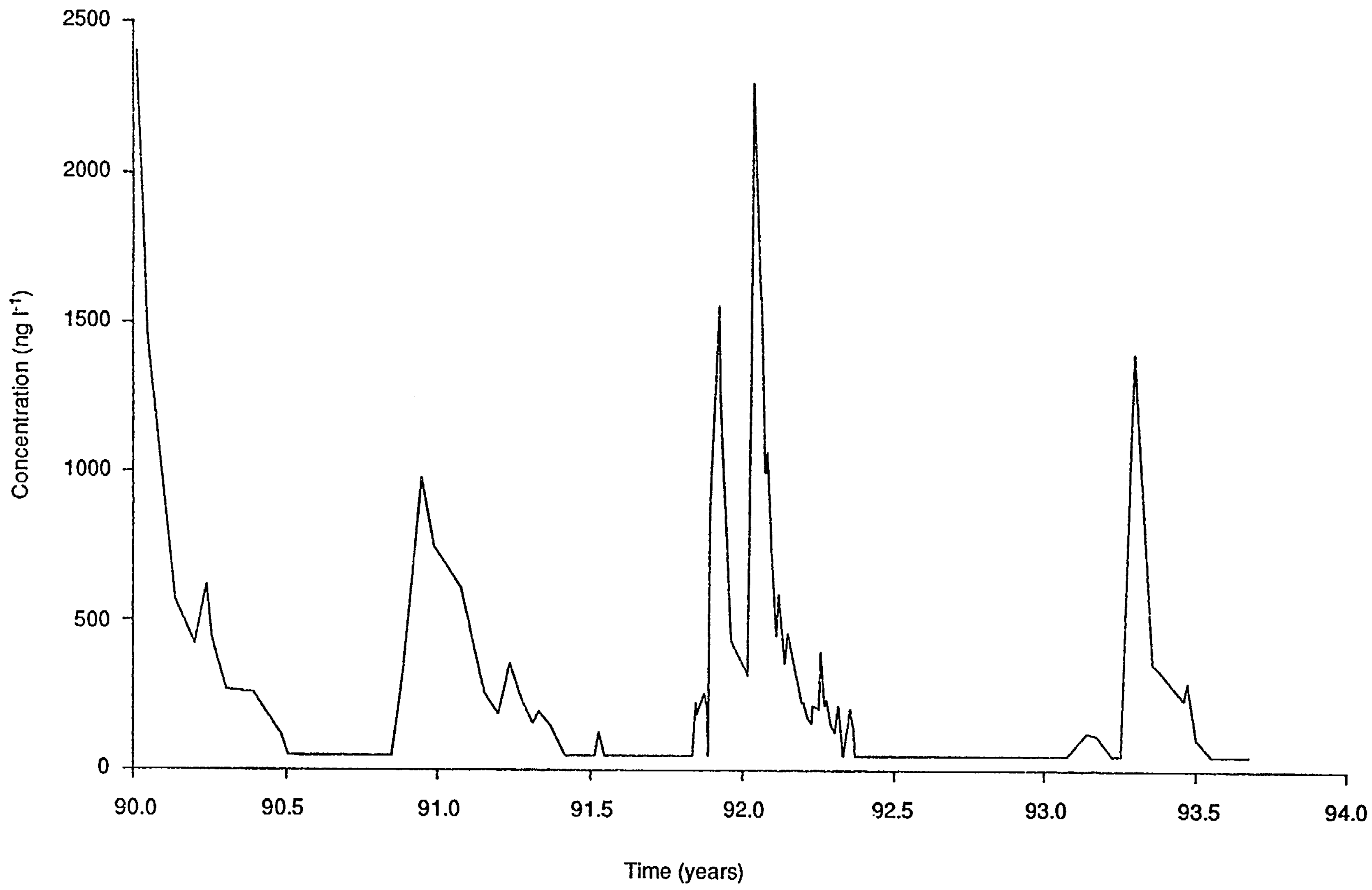

Figure 6.2 Measured levels of Isoproturon in River Leam, 1990-1993

6.4 Colne groundwater catchment

The catchment to the seven groundwater sources which feed into the Clay Lane treatment works covers an area of nearly 20000 ha. The soils are mainly of the Andover Series overlying Chalk, and are relatively thin and very permeable. Almost all of the rainfall recharge to the soils drains through rapidly to the Chalk. The area was studied extensively as part of a hydrogeological and modelling investigation into artificial recharge of the London Basin (Oakes 1988). Modelling for the present study was able to draw on the findings of the previous work. To facilitate the simulation of pesticides in the Chalk aquifer a model was constructed based on a 250 m grid. This level of spatial resolution was too coarse for the River Leam model but proved to be quite adequate for the Colne catchment. The method of simulation was that developed for the River Granta Chalk catchment (Clark *et al.* 1992). The method may be summarised as follows:

1. Groundwater levels and rates of flow are calculated with a finite difference groundwater flow model with a cell size of 62 500 m^2. Rainfall recharge and groundwater abstraction rates are the required inputs for the flow model, and aquifer transmissivity is the main parameter.

2. Pesticide applications were simulated as additions to each cell at the appropriate time of year. To simulate protection zones, applications were reduced to zero within a specified distance of the boreholes.

3. Rates of pesticide leaching through the soil were calculated from rainfall recharge over successive five day time steps, with inclusion of the processes of adsorption onto organic carbon and biochemical degradation.

4. Pesticide movement through the unsaturated zone was assumed to be confined to the fissure system. Clark *et al.* (1992) showed that pesticides moving slowly through the Chalk matrix would undergo rapid degradation, and hence not reach the water table by this route.

5. On reaching the saturated zone, pesticides move with groundwater flow through fissures towards abstraction sites.

The catchment characteristics for the groundwater model, and the data sources, are listed in Table 6.4.

Table 6.4 Colne groundwater model characteristics

Property	Value	Source
Depth of soil	50 cm	Hall *et al.* (1977)
Soil bulk density	1.1 gm ml^{-1}	Hall *et al.* (1977)
Soil organic carbon	3%	McGrath and Loveland (1992)
Water content	30%	Hall *et al.* (1977)
Fissure flow fraction in unsaturated zone	10%	Oakes (1982)
Effective depth of saturated aquifer	25 m	Oakes (1990)
Transmissivity of saturated aquifer	2500 m^2 d^{-1}	Whitmore and Oakes (1990)
Porosity of saturated aquifer	2%	Whitmore and Oakes (1990)

The question of pesticide decay in aquifers has received considerable attention, and various attempts have been made to measure degradation rates appropriate to groundwater. Agertved *et al.* (1992) reported *in situ* experiments in a sandy aquifer with atrazine and mecoprop (also known as MCPP). Atrazine appeared to be recalcitrant over the 160 day test period, but mecoprop did degrade slowly following a 50 day period of stability. Klint *et al.* (1993) reported laboratory experiments with aquifer materials in which atrazine did not degrade noticeably over a 540 day period, and mecoprop degraded completely after 80 days following a 40 day period of apparent stability. Lack of good, consistent data on degradation rates in aquifers is currently the main weakness of all groundwater pesticide modelling work. For the present study a conservative (or possible 'worst-case') approach was adopted whereby it was assumed that degradation would occur in the soils and upper regions of the unsaturated zone, but not in the saturated part of the aquifer.

Model runs were undertaken with a 5-daily time step using the same 51-year sequence of effective rainfall applied to the River Leam model. In the Colne catchment the long term average effective rainfall was assumed to be 210 mm/a (Whitmore and Oakes, 1990).

Model results for 1992 isoproturon usage are shown in Figure 6.3. As before the years are purely notional as synthetic data are being used. Nevertheless, a comparison with observed isoproturon concentrations from the Clay Lane raw water, Figure 6.4, demonstrates that the model predictions are quite good. Other pesticides show similar trends. The maximum measured concentrations in the Clay Lane raw water are shown in Table 6.5

Table 6.5 Measured and simulated maximum pesticide concentrations, Colne groundwater catchment

Pesticide	maximum concentration (ng l^{-1}) measured	simulated
Isoproturon	230	290
Chlorotoluron	270	150
Mecoprop	< lod	50
Diuron	< lod	10
Flutriafol	< lod	6
Carbendazim	< lod	40
Atrazine	820	20
Simazine	740	10
Glyphosate	nd	<1

lod: limit of detection
nd: not determined

As with the River Leam simulations, atrazine and simazine are underpredicted because the 1992 data used in the model include no non-agricultural usage for these herbicides whereas the maximum measured concentrations were recorded in 1990. Overall the predictions are reasonable and sufficiently accurate to validate the model for predictions of future trends.

6.5 Sensitivity analyses for pesticide transport model

The simulations and predictions of future trends obtained with the two models are dependent on the assumptions made and parameters selected. By comparing the model outputs with current concentrations it has been possible to demonstrate that the models appear to be viable tools for providing predictions of future trends. However, it is theoretically possible that equally good simulations of current concentrations could be obtained with different sets of parameters, and that these different parameter sets could give modified predictions under the various scenarios applied to the models. To minimise this possibility, all model parameters have been based on measured values, where available, and the models have not been subject to calibration by adjusting the parameters. Nevertheless, the effect of parameter variability on predictions is an important issue which must be taken into account when considering the robustness of the predictions and the transferability of the results to other catchments.

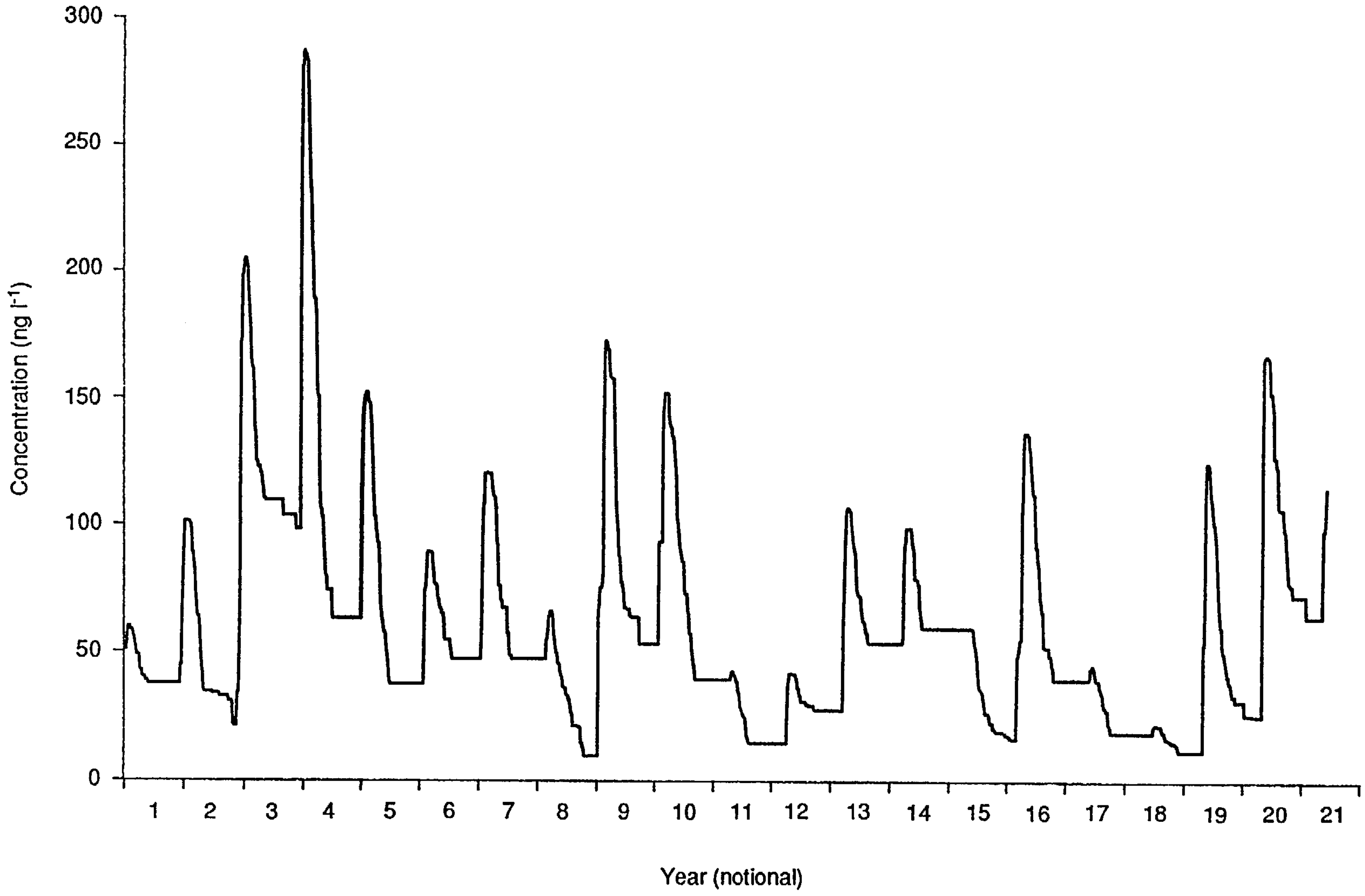

Figure 6.3 Predicted levels of Isoproturon in Colne groundwater

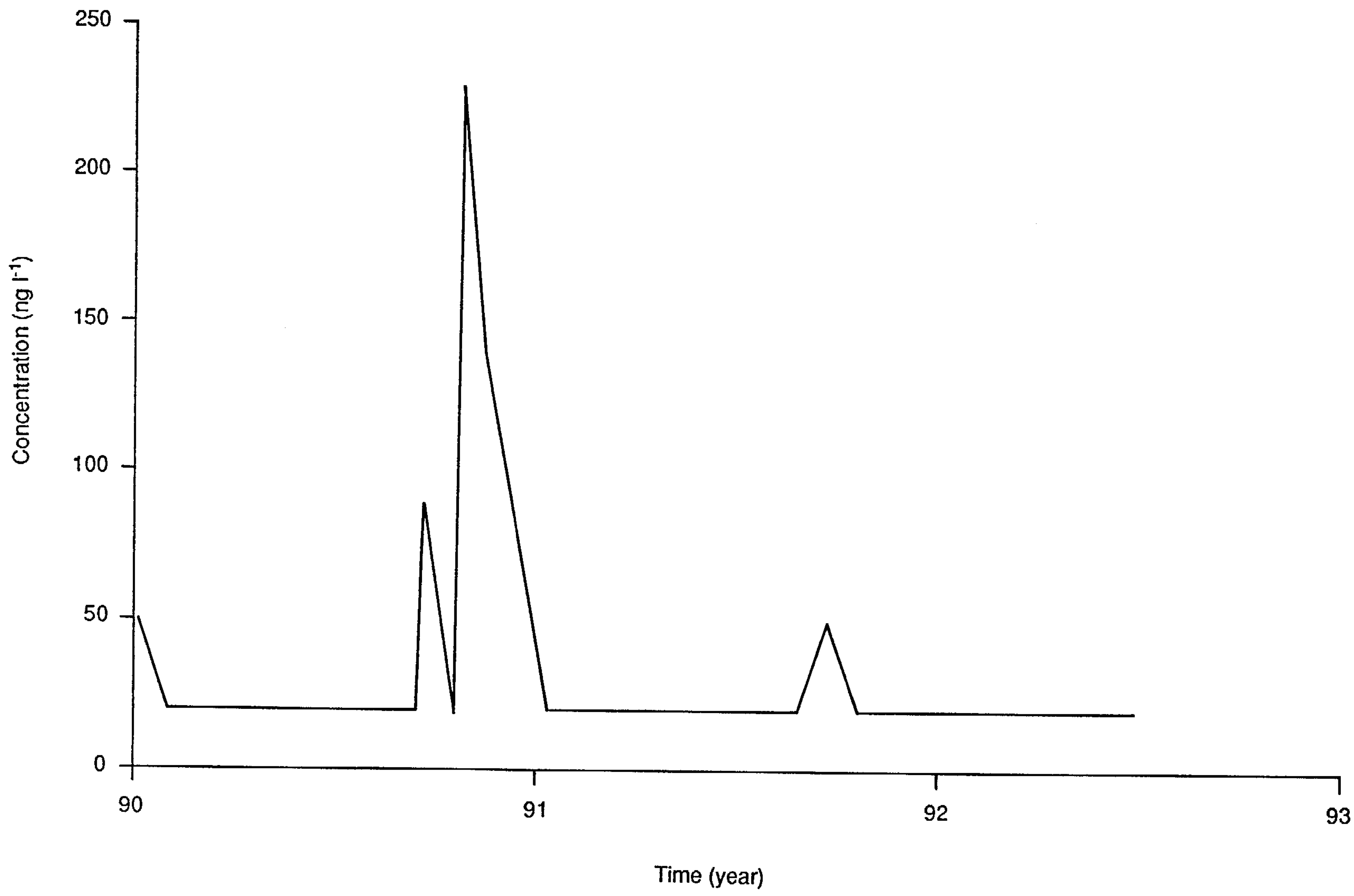

Figure 6.4 Measured levels of Isoproturon in Colne groundwater

To illustrate the sensitivity of the predictions to some of the key parameters, the River Leam model was run a number of times for isoproturon with a range of acceptable values used for those parameters. Table 6.6 shows the results in terms of the maximum values of concentration predicted over the 51-year period.

Table 6.6 Sensitivity of maximum predicted isoproturon concentrations

Flow path length (m)	Mean effective rainfall (mm/a)	Organic carbon (%)	Maximum isoproturon (ng l^{-1})
1350	180	8	2630
1000	180	8	2440
2000	180	8	2820
1350	150	8	2430
1350	200	8	2840
1350	180	6	3690
1350	180	10	2000

The results demonstrate that catchment flow path length is not of great significance, and validates the assumption that a single average flow path length may be used to represent the entire catchment.

Similarly, rainfall recharge variations do not have a major effect on the predicted maximum concentration of isoproturon. Higher values of rainfall recharge give rise to greater dilution of pesticide in runoff water, but the higher water flow rates result in lower soil residence times, and hence less biochemical degradation. The two effects combined result in only small changes in the predicted isoproturon concentrations.

Changes in soil organic carbon are predicted to have a greater effect on isoproturon simulations. The organic carbon content of the soil determines the extent to which pesticides are retained by adsorption, and hence affect degradation losses. Organic carbon content can vary significantly from catchment to catchment, and hence it must be recognised that predictions for other catchments may be quite different to those for the Leam.

The sensitivity of the predictive model used for the Colne groundwater catchment to the main catchment characteristics was also investigated. Similar findings to those for the Leam emerged: the model predictions are relatively insensitive to rainfall recharge, but are significantly affected by the organic carbon content of the soil.

6.6 Conclusions from the pesticide fate model

Mathematical models were developed for pesticide transport from the point of application to the source waters (River Leam and Colne Valley). The models are physically-based and were validated against previous pesticide application data and present occurrences in the source waters. Their sensitivity to key catchment characteristics was investigated. The models for both catchments appear to be capable of providing predictions of future pesticide concentrations which are sufficiently accurate for testing the pesticide restriction scenarios. Results of these predictions are given in the following Chapter.

7. FUTURE PESTICIDE OCCURRENCES IN DRINKING WATER SOURCES

7.1 Introduction

Model predictions were made for the No Restrictions, Restricted Use and Protection Zone scenarios in both catchments. The inputs to the scenarios were the future applications predicted in Chapter 5 for the eleven key pesticides.

In the Restricted Use scenario, model runs were also made for additional pesticides to ensure that those used as replacements would not themselves give rise to concentrations exceeding the PCV. The main problems with regard to replacement pesticides were encountered with bentazone and fluroxypyr. These were not on the original selected list for study but had to be severely restricted in usage as replacements, because the model predicted that their mobility was high enough to cause contamination of the source waters.

For the Protection Zone option, the models were run to determine the minimum size of zone around the river or the boreholes necessary to reduce the maximum pesticide concentrations predicted to less than 100 ng l^{-1} (the PCV).

7.2 Results of predictions for the Leam catchment

The results of the simulations for the River Leam catchment are presented in Table 7.1 for the six pesticides which the model indicates could contaminate the water at levels above 100 ng l^{-1}. The concentrations of the other five key pesticides (atrazine, glyphosate, carbendazim, chlormequat and chlorpyrifos) were predicted, on the basis of future predicted usage, not to exceed the PCV.

An important point to note is the prediction that isoproturon levels in the Leam raw water will, if no restrictions in pesticide usage are implemented, continue to regularly exceed the PCV for drinking water, reaching on occasion a maximum concentration that is 26 times the PCV. This finding highlights the need for future on-going control of pesticide levels, through water treatment or restrictions in pesticide usage, if the PCV for pesticides in drinking water is to be maintained.

The only non-agricultural pesticide predicted to exceed 100 ng l^{-1} in the Leam in future years is diuron.

As is clear from Table 7.1 (1), there is no simple correlation between the maximum concentration that a pesticide reaches in the river and the amount of time for which it exceeds the PCV. These differences are due to the different transport properties of the pesticides. Isoproturon in particular exhibits rapid changes in its predicted levels of occurrence and these changes are found also in measured levels (Figure 6.2).

Table 7.1 Predictions from pesticide fate model for River Leam scenarios

(1) Predicted pesticide levels for No Restrictions scenario

Pesticide	maximum concentration predicted (ng l^{-1})	predicted % of time exceeding 100 ng l^{-1}
Isoproturon	2600	25
Chlorotoluron	250	53
Mecoprop	440	23
Simazine	170	9
Diuron	660	99
Flutriafol	220	10

(2) Predicted required reductions in pesticide usage for Restricted Usage scenario

Pesticide	reduction required as % of 1992 application to achieve < 100 ng l^{-1}
Isoproturon	96
Chlorotoluron	67
Mecoprop	85
Simazine	41
Diuron	85
Flutriafol	54

(3) Predicted area of soft land along River Leam required as a Protection Zone

Pesticide	protection zone size (ha) to achieve < 100 ng l^{-1}	protection zone as % of total area
Isoproturon	255	0.7
Chlorotoluron	53	0.1
Mecoprop	133	0.4
Simazine	93	0.2
Diuron	74	0.2
Flutriafol	19	0.1

The protection zones required on farms in the River Leam catchment are assumed to be strips of grassland along both banks of the main water courses. For isoproturon this comprises a strip of approximately 10 m width on each bank. A relatively small strip is needed because pesticide retardation and degradation will continue during flow through the strip towards the river, and these processes are very efficient at attenuating pesticides.

7.3 Results of predictions for the Colne catchment

The results of the simulations are presented in Table 7.2 for the Colne groundwater catchment. Of the eleven pesticides modelled, only isoproturon and chlorotoluron were predicted to contaminate the groundwater in concentrations above 100 ng l^{-1}.

Table 7.2 Predictions from pesticide fate model for Colne groundwater scenarios

(1) Predicted pesticide levels for No Restrictions scenario

Pesticide	maximum concentration (ng l^{-1})	% of time exceeding 100 ng l^{-1}
Isoproturon	290	18
Chlorotoluron	150	64

(2) Predicted required reductions in pesticide usage for Restricted Usage scenario

Pesticide	reduction required as % of 1992 application to achieve < 100 ng l^{-1}
Isoproturon	57
Chlorotoluron	63

(3) Predicted area of land in Colne catchment required as a Protection Zone

Pesticide	protection zone size (ha) to achieve < 100 ng l^{-1}	protection zone as % of catchment
Isoproturon	11300	56
Chlorotoluron	12500	63

Perhaps the most significant of these predictions is that, without restrictions on usage, the continued normal application of two major use agricultural herbicides during the next decade will give rise to exceedances of the PCV in drinking water unless pesticide removal plant is installed specifically to treat the raw water.

Isoproturon is predicted to reach the higher concentration of the two pesticides, but it exceeds the PCV less often than does chlorotoluron. As noted for the surface water, this difference is due to their differing transport properties and persistence.

The aquifer is predicted to recover reasonably soon from the present contamination by atrazine and simazine. The transport of pesticides is dominated by fissure flow, rather than the slower matrix flow that is typical of groundwater contamination by, for example, nitrates. No non-agricultural pesticides were predicted by the model to exceed the PCV in the untreated groundwater, despite the moderate usage of persistent herbicides such as diuron.

The protection zones in the Colne catchment are large. As mentioned earlier, the model does not include any degradation in the aquifer and so the protection zone merely provides a degree of dilution. To provide a diluting factor of almost 3, necessary to reduce the isoproturon maximum (from Table 7.2) from 290 ng l^{-1} to 100 ng l^{-1}, requires a protection zone covering more than half of the catchment.

Groundwater catchments are particularly prone to contamination from persistent pollutants, including pesticides, and it was considered that even a protection zone of 63% of the catchment might not be adequate to protect the water source. In particular, there are doubts over the future non-agricultural pesticide usage (e.g. increased use of diuron and the extent of the threat it may pose to the water source). It is calculated, for example, that atrazine usage in the non-agricultural sector would, if usage had not been stopped, require a 90% protection zone in the Colne, based on the occurrence data. To allow for the possibility of a future pesticide problem of this magnitude emerging and in recognition of the serious threat to groundwater resources, it was therefore decided to assume that the protection zone in the Colne Valley would in fact occupy 90% of the catchment. The benefits and disbenefits of the Protection Zone scenario have been costed on this basis.

7.4 Ideal pesticide characteristics (more acceptable pesticides)

The models of the two catchments were also used to determine the general characteristics required of pesticides to achieve concentrations in the source waters less than the PCV.

For this purpose each model was run many times varying the pesticide specific properties, but not the catchment characteristics, in order to determine combinations of properties which gave maximum concentrations less than or equal to 100 ng l^{-1}. The properties which could be varied were:

- application rate in the whole catchment;
- soil organic carbon partition coefficient;
- degradation rate (or half life).

Each of these was varied independently but within sensible ranges. The results are plotted on Figure 7.1 for the River Leam catchment, and on Figure 7.2 for the Colne groundwater catchment. On each graph a curve of log(t½) versus log(K_{oc}) is plotted for a number of application rates. Points lying on these curves will give a maximum concentration of 100 ng l^{-1}. Combinations of parameters closer to the origin (i.e. under or to the left of the curves) will give rise to smaller maxima, and hence indicate acceptable properties. It should be noted that the application rate is here defined as the total annual load to the catchment divided by the catchment area, and is not as normally used.

Previous efforts to define the transport properties and acceptable leachability of pesticides include the GUS (Groundwater Ubiquity Score) indices, which incorporate t½ and K_{oc} (Gustafson, 1989). The GUS classification is as follows:

GUS index	GUS classification
<1.8	Improbable leacher
1.8 - 2.8	Transition
>2.8	Probable leacher

The curves on Figure 7.2 for the Colne catchment present results which are related to the GUS indices, except that the curves also include the effect of different application rates. For comparison the GUS indices 1.8 and 2.8 are also presented on Figure 7.2.

The GUS classification broadly agrees with the groundwater model results for applications of 100 g/ha, though at other rates of usage the GUS classification appears less useful.

The curves of Figures 7.1 and 7.2 may be used to test for compliance any other pesticides used in the catchment now or in the future.

7.5 Summary of future predictions of pesticide levels in sources of drinking water

The mathematical pesticide fate model developed and validated in the previous Chapter was used to predict future pesticide levels in the River Leam and Colne groundwater catchments. Predictions were made for the No Restrictions, Restricted Use and Protection Zone scenarios in both catchments. The inputs to the scenarios were the future applications predicted in Chapter 5 for the eleven key pesticides.

Pesticide levels under the No Restrictions scenario were predicted to exceed the PCV for drinking water. The reductions in pesticide usages required under the Restricted Usage scenario were calculated. The size of protection zones to protect the sources of drinking water was calculated; those in the Colne represent substantial amounts of the catchment area. The models of the two catchments were also used to determine the ideal properties required of 'environment-friendly' pesticides to achieve concentrations in these source waters less than the PCV.

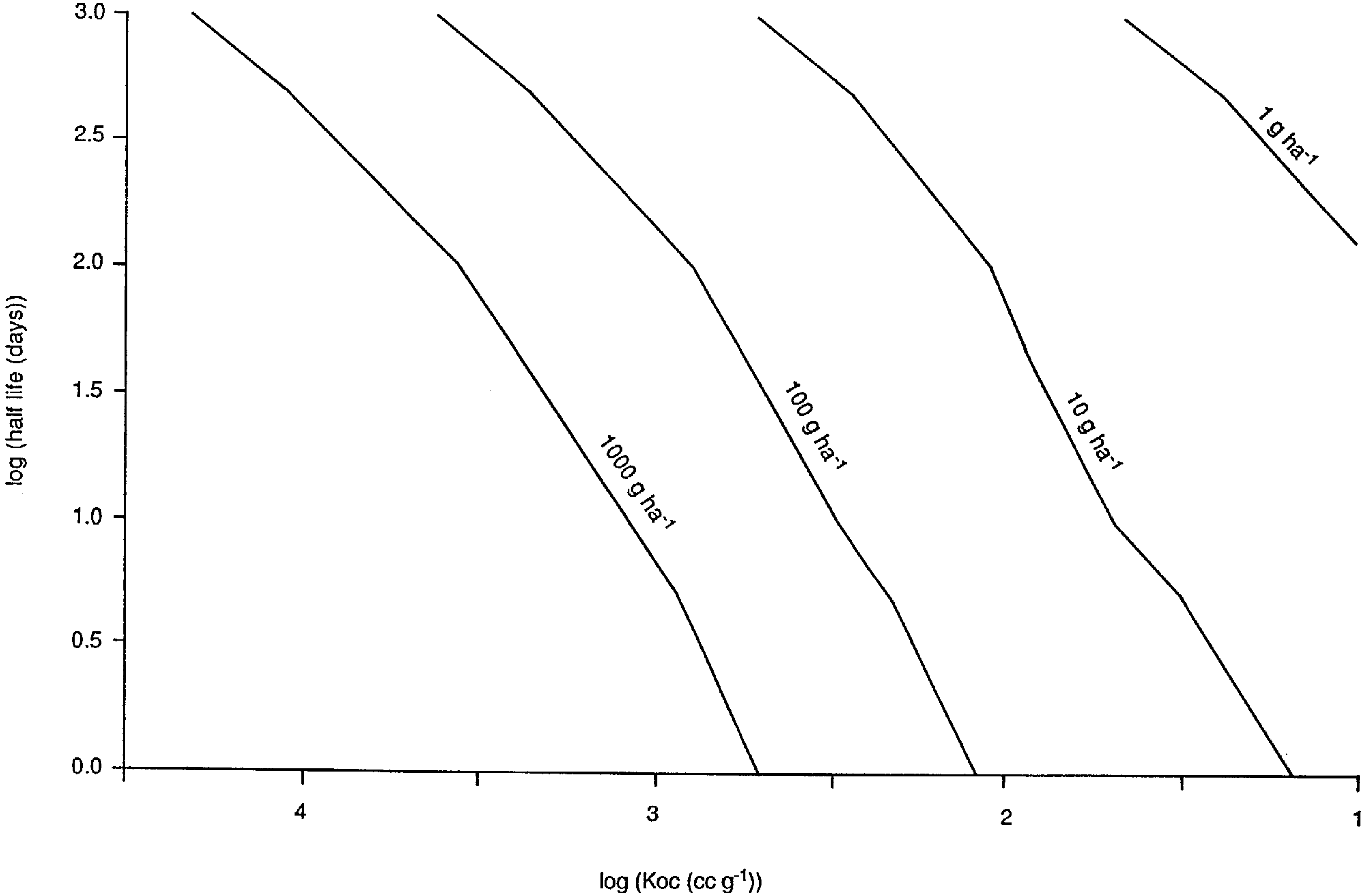

Figure 7.1 Ideal pesticide characteristics, River Leam catchment

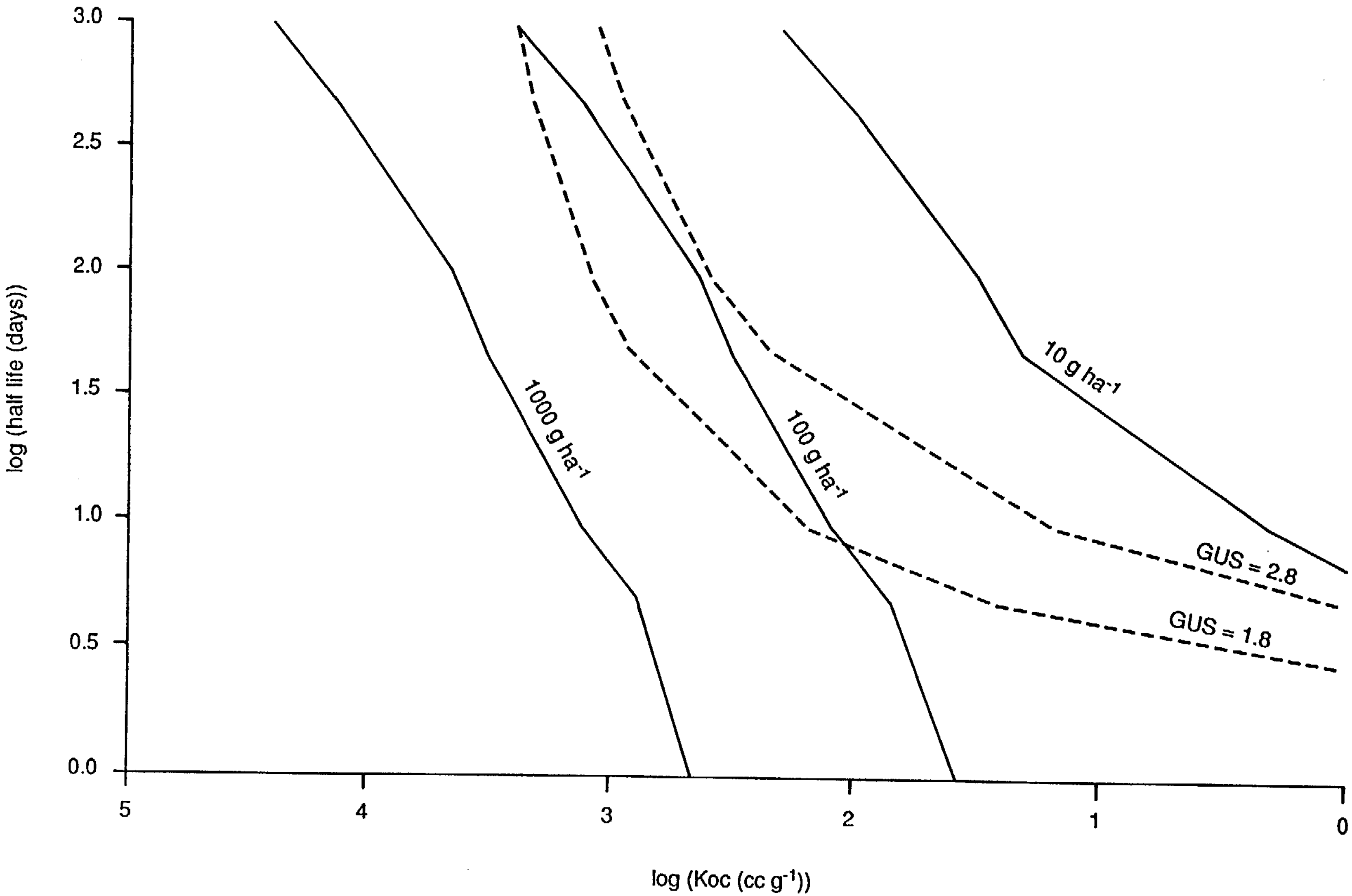

Figure 7.2 Ideal pesticide characteristics, Colne groundwater catchment

8. WATER TREATMENT MODELS AND COSTS

8.1 Introduction

The pesticide fate model established that, under the No Restrictions scenario, the future use of pesticides would result in pesticide contamination of sources of drinking water in both catchments. In this section, the technology for treating the raw water to reduce pesticide levels to below the PCV is discussed and estimates are made for the costs of the necessary treatment.

The two processes that are either currently installed, or are being installed, for pesticide removal, are granular activated carbon (GAC) adsorption and ozonation. Experience has shown these processes to be highly effective at removing, or reducing many pesticides, to below the PCV of 0.1 µg l^{-1}. These processes are thus proven technology, for which reliable estimates of costs can be made of their current and planned future use.

Other treatment options are available, such as membranes or advanced oxidation processes (AOPs). Research into the feasibility of these processes for pesticide removal is still underway. At the present time it is, therefore, difficult to predict process performance and plant design and consequently difficult to estimate the costs of using such processes. These advanced processes have, therefore, not being considered as options in this study for the two catchments.

The pesticide fate models generated maximum and mean pesticide levels in the raw water. The maximum concentration indicates the treatment efficiency required, which dictates the amount of ozone or bed contact time of the GAC. The mean pesticide level determines the expected life of the GAC before it becomes saturated with pesticides and regeneration becomes necessary.

WRc mathematical models have been used to estimate the treatment costs and to predict process performance, for each of the process options. It has been assumed that current abstraction rates of the existing water treatment plants for the two catchments are maintained in the future. The treatment costs were then confirmed by the consultants Cremer and Warner (a sister company of Gould Rural Environment), who also have experience in producing cost estimates for treatment processes. The detailed costings are shown in Annex 3.

8.2 Surface water catchment (Leam)

The conventional treatment process for surface water catchments such as the Leam would be coagulation, clarification, sand filtration and disinfection. If needed, pesticide removal processes would be added to this treatment train.

For the Leam catchment, treatment information is available for all the pesticides predicted to occur above the PCV, except flutriafol. The mean concentration for this pesticide is, in fact, predicted to be below the PCV. It has been assumed that flutriafol behaves similarly to other pesticides and can be adequately removed during treatment.

Three options have been considered for the treatment of the surface water. These are:

- the use of GAC alone;
- the use of ozone alone; and
- the use of the combined process of ozonation followed by GAC.

Each option has been assessed for a treatment works where 24 Ml/day of water is extracted for treatment (the current abstraction rate for the existing treatment plant on the Leam).

8.2.1 Process performance of GAC alone

Modelling of the GAC process was undertaken, using the seasonal variations in pesticide profiles, for each of the pesticides. The model predictions showed that the bed life (i.e. period before the PCV in the treated water would be exceeded) would be governed by diuron, primarily because it was predicted to occur more persistently and at a higher mean concentration than the other pesticides. To obtain a realistic bed life (more than one year), a contact time of 15 minutes would be necessary. The predicted GAC bed lives for each of the pesticides are shown in Table 8.1.

Table 8.1 Predicted GAC bed lives with a 15 minute contact time

Pesticide	Mean conc. ($\mu g\ l^{-1}$) in raw water	Bed life until PCV exceeded (weeks)
Chlorotoluron	0.17	>100
Diuron	0.44	62
Isoproturon	0.17	100
Mecoprop	0.06	73
Simazine	0.04	>100

The results in Table 8.1 show that the GAC would have to be regenerated after 62 weeks to ensure that diuron did not exceed the PCV. It is worth noting, that even though chlorotoluron and simazine were predicted to occur above the PCV in the raw water, GAC was predicted to remove these to below the PCV for more than the 100 weeks of operation simulated.

To ensure the long GAC bed life, a relatively long contact time (15 minutes) is required. This means that replacement of the sand in the existing filters with GAC is not a feasible option. Therefore, the GAC would have to be installed in purpose-built adsorbers, after sand filtration.

8.2.2 Process performance of ozone alone

There are several options for placement of ozonation in a conventional treatment works. It can be used to treat either the raw water (pre-ozonation), or the treated water (either clarified or clarified and sand filtered). Ozone is far more effective at destroying pesticides in clarified and/or sand filtered water than in raw water. Therefore, the option of using pre-ozonation has not been considered feasible for effective pesticide removal.

Pesticides vary in their susceptibility to ozonation. Ozonation is extremely effective at destroying urons (chlorotoluron, diuron, isoproturon), and relatively low ozone doses can produce significant removals (2 mg O_3 l^{-1} typically destroys between 90 and 99%). Mecoprop can be effectively destroyed by ozonation, but is less well removed than the urons (2 mg O_3 l^{-1} typically destroys about 80% of mecoprop). Of the pesticides listed in Table 8.1, simazine is least readily destroyed by ozone. Therefore the ozone dose for pesticide destruction would be the dose required to reduce the maximum simazine concentration to below the PCV.

The maximum simazine concentration in the raw water was predicted to be 0.17 µg l^{-1} (Table 7.1). Therefore, a dose to destroy more than 40% would be required. Typically, ozone doses of 2 to 3 mg l^{-1} can destroy 40-60% of simazine. For treatment of the surface water, an ozone dose of 3 mg l^{-1} has therefore been assumed to ensure effective pesticide removal. A contact time of 10 minutes has been assumed, as this is normally sufficient for pesticide removal and allows a high degree of ozone utilisation.

Ozonation produces assimilable organic carbon (AOC) which has the potential to lead to problems with regrowth of bacteria in distribution systems. Normally, therefore, ozonation is followed by a biological treatment stage, e.g. filtration, to reduce AOC. If ozonation alone were to be used for pesticide removal, it would have to be installed prior to sand filtration, after clarification. This would result in some AOC removal. More typically however, ozone would be installed after sand filtration, but prior to GAC. This ensures maximum pesticide destruction by ozonation and effective removal of AOC by GAC.

8.2.3 Process performance of ozone/GAC

Installation of ozone followed by GAC offers a secure means of ensuring that pesticides are removed to below the PCV. This can effectively be achieved by ozone alone, as noted above, but, should higher pesticide levels occur than had been used for the basis of the plant design (and the setting of the ozone dose), the PCV could be exceeded if the dose were not sufficient to obtain the required degree of removal. By having GAC after ozonation, such a scenario would be avoided as the GAC would remove any pesticides remaining after ozonation.

As with the use of ozone alone, an ozone dose of 3 mg l^{-1} has been assumed for the Leam catchment. This would mean that the GAC would primarily be used for AOC removal, and thus would not need to be regenerated as frequently as it would if it was used for pesticide removal. It has been assumed that the GAC would be regenerated after a period of three years as, after this time, it may become saturated with other organics present in the water. A GAC contact time of 15 minutes has been assumed, as this is what, typically, is being considered for waters similar to the Leam.

8.2.4 Costs of treatment for the Leam

A comparison between the costs of the three treatment options considered is shown in Table 8.2. The costs assume that GAC is installed in purpose-built adsorbers (pressure filters) after sand filtration, prior to final disinfection. Ozone is assumed to be dosed using a conventional bubble contactor, with the ozone being generated from air (as opposed to oxygen).

Table 8.2 Cost of removing pesticides from raw water from the Leam (24 Ml/day plant)

Process option	Capital cost (£'000)	Operating cost (£'000/year)
GAC	1101	127
Ozone	711	61
Ozone/GAC	1812	142

8.3 Groundwater catchment (Colne)

For the groundwater site, only the option of using GAC has been considered. This is because the low Total Organic Carbon (TOC) levels in groundwaters mean that GAC is highly effective at removing pesticides and that long bed lives can be obtained. Ozonation could be used to treat a groundwater but additional treatment would be required to remove any AOC produced: this would be more costly than using GAC alone. Combining ozone and GAC is also more expensive than GAC alone, even though the GAC bed life would be extended.

The only pesticides predicted to occur in the groundwater at levels above the PCV were isoproturon (mean 0.07 µg l^{-1}, maximum 0.29 µg l^{-1}) and chlorotoluron (mean 0.10 µg l^{-1}, maximum 0.15 µg l^{-1}). Modelling showed that a contact time of five minutes was sufficient to keep the pesticide below the PCV for a five year period before bed regeneration would be required. Cost estimates have, therefore, been made assuming this contact time. However, a ten minute contact time was also costed because this is more typical of the size of GAC plant installed at groundwater sites.

The GAC cost estimates assume that the GAC is regenerated after a five year period. The GAC is assumed to be installed in purpose-built pressure vessels, treating the current capacity of the Clay Lane borehole complex (114 Ml/day). Capital and operating costs are shown in Table 8.3.

Table 8.3 Cost of removing pesticides from the raw water from the Colne (114 Ml/day)

Process option	Capital cost (£'000)	Operating cost (£'000/year)
GAC (5 mins contact time)	1,359	120
GAC (10 mins contact time)	2,621	185

8.4 Summary of water treatment

The options regarded as the most technically appropriate to remove the key pesticides in each catchment are:

- Leam - ozonation followed by GAC (15 minutes retention time);
- Colne - GAC with 10 minutes retention time.

In each case the initial capital investment has been assumed to be undertaken in Year 0. The economic life of civil works, electrical and mechanical equipment has been taken to be 20 years and a terminal value has been calculated, assuming straight line depreciation, to reflect the residual value of the investment. The initial capital costs and annual operating and maintenance costs have been discounted at eight per cent. The detailed costs are presented in Annex 3.

The initial capital costs and the Present Value (PV) of capital and annual operating and maintenance (O&M) costs throughout the ten year period are as follows:

Catchment	**Initial Capital Investment £'000**	**Present Value Capital and O&M £'000**
Leam	1812	2430
Colne	2621	3364

8.5 Discussion of water treatment

It should be stressed that in the catchments, treatment measures are currently either in place or being installed for pesticide removal.

It should be noted that a number of factors not taken into account may have large impacts on the given costs for water treatment, and may limit the applicability of the methods and costs for these catchments to those for other catchments. Such factors include:

- Research is still underway concerning the effects of ozonation on the formation of by-products such as bromate (from naturally-occurring bromide in the raw water). No consideration has been given to any costs accruing from the presence of ozonation by-products in treated waters.

- It has been assumed in our analysis that GAC and/or ozone are being installed only for pesticide removal; in fact other organic pollutants would also be removed by these treatments, but no account has been made for these additional benefits.

- The costs are plant-specific and existing abstraction rates have been assumed to continue. In particular, it should be recognised that the Clay Lane borehole complex is of above average size for a plant treating groundwater.

9. COSTS TO PESTICIDE USERS

The impact of pesticide restriction scenarios are considered in this section for:

- future agricultural cropping and stocking patterns (9.1, detailed in Annex 1);
- effects on farm profitability (9.2, detailed in Annex 1);
- financial and UK economic costs to agriculture (9.3, detailed in Annex 4);
- changes to non-agricultural pesticide use (9.4, detailed in Annex 4);
- costs to non-agricultural pesticide users (9.5, detailed in Annex 4).

9.1 Agricultural cropping and stocking practices under pesticide restriction scenarios

9.1.1 Cropping predictions

A summary of the projected changes in cropping in both catchments under the alternative restriction scenarios is presented in Table 9.1 and 9.2.

In 1992 the cropping in both the Leam and the Colne catchments was dominated by arable crops, although grassland and fodder crops represented at least 40 percent of the agricultural area. Changes in the agricultural support system have meant that from 1993 onwards, farmers should set-aside 15 percent of their eligible crops in order that they can qualify for support. It has been assumed that all farmers with arable land will enter into the scheme and that from 1994 linseed becomes an eligible crop. Consequently, in both catchments the area of eligible crops is predicted to fall, with a compensating increase in the area of set-aside.

No Restriction, Protection Zone and Restricted Usage

In both catchments, it is forecast that, with no restriction on pesticide usage, the area of combinable break crops will increase in order that a more balanced rotation can be achieved. However, the relative profitability of linseed is expected to fall and the consequent decline in the area grown will be offset by the more profitable oilseed rape crop. Under the Restricted Use and Protection Zone scenarios, the ability to use substitute pesticides means that the relative profitability of each crop will remain unchanged and hence there is unlikely to be any significant change in cropping from the No Restriction case. The one exception is forage maize in which the area grown is predicted to increase in order to compensate for the reduction in yield.

Table 9.1 Leam Catchment - Projected Changes in Cropping Resulting from Restrictions in Pesticide Usage

	Percent of Agricultural Area				
Pesticide Restriction Scenario	No Restrictions		Total Ban	Restricted Usage	Protection Zone
Crops	1992	1997	1997	1997	1997
Grass, Fodder Crops	45	45	45	45	46
Cereals	37	27	29	27	26
Potatoes	1	1	-	1	1
Peas, Beans	4	8	4	8	8
Oilseed Rape, Linseed	8	9	11	9	9
Set Aside, Other Crops, Fallow, Other Land	5	10	11	10	10

Table 9.2 Colne Catchment - Projected Changes in Cropping Resulting from Restrictions in Pesticide Usage

Pesticide Restriction Scenario	Percent of Agricultural Area				
	No Restrictions		Total Ban	Restricted Usage	Protection Zone
Crops	1992	1997	1997	1997	1997
Grass, Fodder Crops	41	41	41	41	41
Cereals	41	28	29	28	28
Peas, Beans	2	5	4	5	5
Oilseed Rape, Linseed	9	12	12	12	12
Set Aside, Other Crops, Fallow, Other Land	7	14	14	14	14

Total Ban

Providing farming continues and the land is not allowed to revert to scrub, the introduction of a total ban in both catchments is likely to result in a more fundamental change in cropping because alternative crops vary in their ability to compete with weeds, pests and diseases. Weeds would be controlled by mechanical means, primarily by undertaking several passes with a combweeder. However, there are no known non-chemical methods currently available for controlling pests and diseases in field crops. In the Leam catchment, potatoes would cease to be a viable crop due to the risk associated with blight infestations. In both catchments, it has been predicted that there would be a reduction in the less competitive crops such as winter wheat, linseed and peas towards the more competitive spring barley, winter oats and oilseed rape crops.

9.1.2 Stocking practices

In the past, overall stock numbers have remained relatively stable and, as beef and sheep quotas have been recently introduced, no further change is envisaged in either catchment.

Consequently, no change is predicted in the area of grassland required, particularly as permanent pasture is the predominant grassland crop. Livestock production systems would remain largely unchanged under a total pesticide ban because very little pesticide is applied to grassland. Conventional livestock production systems have, therefore, been assumed to continue.

9.2 Effect on farm profitability

The restriction of pesticide usage would affect the profitability of farms in the two catchments. To illustrate this, typical farms have been constructed from an analysis of published statistics and farm management data for the two study areas. This is described in more detail in Annex 1.

Restriction of pesticide usage would result in a decline in farm profitability, the extent of the decline being dependent on the severity of restrictions imposed. If the fall in profits is significant, a prudent landlord is likely to accept a long-term reduction in rent to ensure that his or her land is effectively farmed and to prevent a reversion to scrub. The potential long-term fall in rental changes and the capital value of land is outside the scope of this study and it has, therefore, been assumed that the rental charge per hectare remains the same whether or not restrictions are imposed. It should be noted, therefore, that the estimated farm incomes, particularly where losses are shown, are for presentational purposes only and are unlikely to represent the outcome in the long term. It should also be noted that rents have been excluded from the cash flow analyses because they represent internal transfers between tenants and landlords.

The effect of restricting pesticide usage on the profitability of an average farm of 83 and 96 hectares in the Leam and Colne catchments respectively is summarised in Table 9.3.

Table 9.3 Summary of the impact of restricting pesticide usage on the profitability of an average farm in the catchment areas

Restriction Scenario		Leam M.I.I.* £	Colne M.I.I. £
No Restrictions	- 1992	670	6494
	- 1997	2917	6524
Total Ban	- 1997	(3040)	(1557)
Restricted Use	- 1997	2633	6372
Protection Zone	- 1997	2732	6041

* M.I.I. = Management and Investment Income
Note: brackets denote losses

The management and investment income (MII) achieved in 1992 represents the last year before the alternative restriction scenarios are imposed. Projected changes in cropping undertaken by the farmer in order to improve or maintain profitability under the No Restriction case or to partially overcome the financial impact of the restrictions is assumed to stabilise from 1997 onwards. The increase in profitability in the Leam, if no restrictions are imposed, is largely due to the fact that yields are below the national average and farmers are likely to benefit from the new support arrangements to a greater extent than their more efficient counterparts elsewhere. Conversely, farms in the Colne catchment are only likely to maintain MII because their overall yields are at or above average and the support system tends to discriminate against farmers who regularly achieve yields which are above the national average.

By 1997 the introduction of a total ban is likely to reduce the MII of farms in the Leam and Colne catchments by £71.8 and £84.5 per hectare respectively. Because of the ability to use substitute chemicals, the introduction of restrictions on the total usage of key pesticides is likely to have a more limited effect, providing the substitutes can continue to be used. Under this scenario the MII in the Leam and Colne catchments is reduced by £3.4 and £1.6 per hectare respectively. The model for the Protection Zone scenario assumes that the farm falls wholly within the protection zone. Under these circumstances the restrictions in the Colne catchment are more severe than the Restricted Use scenario because the key pesticides are banned; however, substitutes can still be used. Providing the latter can continue to be utilised, the introduction of a protection zone is likely to result in a fall in MII of £2.2 and £5.0 per hectare in the Leam and Colne catchments respectively.

It should be noted that the financial impact of introducing a protection zone in the Leam is based on that in the catchment as a whole. Consequently, on average, farmers would lose a relatively small proportion of their land. The effect on an individual farmer would depend on how much of his land was situated in a protection zone. For example, if it is assumed that a typical farm adjacent to a watercourse is square and that the watercourse runs alongside one boundary, the protection zone would amount to 0.9 hectares. Under these circumstances, the 1997 MII would be £2,501 rather than the average MII of £2732, an overall reduction compared to the No Restrictions 1997 MII of £5.0 per hectare.

9.3 Financial and UK Economic Costs to Agriculture

9.3.1 Introduction

Two main analyses have been undertaken to appraise the effects on agriculture of imposing restrictions on the use of pesticides, as follows:

- Financial Analysis - to demonstrate the effects from the point of view of farmers and the water-industry.

- United Kingdom Economic Analysis - using factors applied to agricultural commodity market prices and support payments, to indicate the effect from the point of view of the United Kingdom (appropriate factors were obtained from the Ministry of Agriculture, Fisheries and Food.) Thus, the UK economic analysis represents the cost of restricting pesticide usage to the UK, because the UK Exchequer costs of agricultural commodity support are excluded.

The long term impact on the structure of the agricultural industry in the areas where pesticide restrictions are imposed is difficult to determine and is outside the scope of this study. Consequently, three key assumptions have been made, namely:

- that farmers continue to farm and that under the Total Ban scenario the land is not allowed to revert to scrub;

- that the high capital investment, low return on capital and the recent introduction of IACS prevents expansion of livestock enterprises;

- that farm overhead costs remain at their present level.

It should be noted that farmers respond to actual prices and costs and their decisions are unaffected by the values used in the UK economic analyses.

The financial and UK economic analyses have been undertaken using early to mid 1993 prices and costs which have been assumed to remain constant in real terms. In view of the continuing evolution of the agricultural support system, other changes have since occurred, such as changes in the amount of area payments, but these have not been taken into account. However, these do not affect the results of the financial and UK economic analyses because any changes equally affect both the non-restriction area and each of the restriction scenarios. The incremental effect is, therefore, zero.

9.3.2 Costs to Agricultural Pesticide Users

Cash flows, in financial terms, of farm incomes and incremental capital expenditure were constructed for the No Restriction case and each of the restriction scenarios for the period 1992 to 2002. The former year has been assumed to be the year in which restrictions would be introduced and has therefore been taken as Year 0.

For each scenario, the anticipated cropping and stocking in each year was multiplied by the predicted enterprise Gross Margins to derive the overall Gross Margin for each catchment as a whole. From this was deducted the annual fixed costs, derived from published farm management survey results, and incremental capital expenditure. The PV was then obtained by discounting each cash flow at eight percent, which is the appropriate Treasury Real Discount Rate. The agricultural disbenefits for each restriction scenario were then obtained by deducting the PV of the No Restriction case from the PV of each restriction scenario cash flow.

The same calculations were undertaken using agricultural price data of relevance to the UK economy. Sensitivity analyses were undertaken at a five per cent discount rate, which represents the water service companies real cost of capital (see Chapter 12).

The methodology used for deriving agricultural costs is described in more detail in Annex 4.

The PV of the main financial agricultural cash flows and the UK economic cash flows, together with the PV of the agricultural costs for each restriction scenario are presented in Table 9.4 and Table 9.5.

Although the agricultural area of the Colne catchment is significantly below that in the Leam, the relative similarity of disbenefits under the Protection Zone option is explained by the fact that in the Colne the zone would occupy 90 percent of the agricultural area, whereas in the Leam it is less than one percent of the catchment.

9.4 Effects of restrictions on non-agricultural pesticide users

The key assumption has been made that present levels of pest (mainly weed) control would be maintained. Non-agricultural pesticide users would if pesticide usage were to be restricted, change to the cheapest available alternative means of controlling pests.

The organisations that would be most affected by the introduction of a total ban are the District Councils, British Rail, golf courses and the County Councils who carry out road maintenance on behalf of the Department of Transport. The District Councils would need to significantly increase expenditure on mechanical and manual methods to control weeds, while British Rail would need to reduce the time interval between re-ballasting the tracks by about half. Golf courses would be particularly affected because of the need to re-turf the greens on a regular basis which would also result in a loss of income while the greens are unplayable. Expenditure on motorway and trunk road maintenance would rise due to the need to increase the frequency of mowing and clearance operations, which in turn requires, for safety measures, the closure of carriageways. The analysis does not take into account any costs incurred as a result of rail and traffic delays.

Table 9.4 Financial analysis - summary of the Present Value of the agricultural cash flows and agricultural costs of the alternative restriction scenarios - £'000

	Leam Catchment - £'000		Colne Catchment - £'000	
Restriction Scenario	Present Value	Agricultural Dis-benefits	Present Value	Agricultural Disbenefits
No Restrictions	67454	-	17030	-
Total Ban	52306	15148	12818	4212
Restricted Usage	66829	625	16955	75
Protection Zone(s)	67072	382	16700	330

Table 9.5 UK economic analysis - summary of the Present Value of the agricultural cash flows and agricultural costs of the alternative restriction scenarios - £'000

	Leam Catchment - £'000		Colne Catchment - £'000	
Restriction Scenario	Present Value	Agricultural Disbenefits	Present Value	Agricultural Disbenefits
No Restrictions	25806	-	7022	-
Total Ban	17953	7853	4800	2222
Restricted Usage	25220	586	6957	65
Protection Zone(s)	25597	209	6701	321

Non-agricultural organisations in the Colne catchment would not be affected by the Restricted Use and Protection Zone scenarios because none of the pesticides used are predicted to exceed the PCV.

9.5 Costs to non-agricultural pesticide users

For each non-agricultural user of pesticides, information was requested on current pesticide usage, means of application, unit costs for each method of application together with the total length or area to which each pesticide is applied. Similar information was also requested for each of the pesticide restriction scenarios.

In the Restricted Use and Protection Zone scenarios, the results of the surveys suggest that there would be no change in the costs of applying substitute chemicals as this is largely undertaken by specialist contractors who win contracts through competitive tendering. For these services the incremental costs will therefore be the difference in purchase cost of chemicals.

Under the Total Ban scenario, the overall costs associated with achieving the same level of weed control through manual or mechanical means has been derived from the quoted unit costs per unit length or area supplied by respondents. The latter also provided similar unit costs, including the cost of pesticides, for each of the existing weed control regimes. The total annual expenditure for all organisations was assumed to remain constant in real terms and was discounted over a ten year period at a discount rate of eight percent. The incremental costs were again obtained by deducting the PV of the No Restriction usage from the PV of each of the restricted usage scenarios.

The methodology used for deriving non-agricultural costs is described in more detail in Annexes 2 and 4.

The PV of the financial cash flows for non-agricultural areas of pesticides in each catchment, together with the PV of the incremental costs for each restriction scenario are presented in Table 9.6.

Table 9.6 Financial analysis - Present Value of non-agricultural use cash flows and incremental costs of the alternative restriction scenarios - £'000

Restriction Scenario	Leam Catchment - £'000		Colne Catchment - £'000	
	Present Value	Non-Agric Disbenefits	Present Value	Non-Agric Disbenefits
No Restrictions	339	-	610	-
Total Ban	8447*	5623	15721*	10756
Restricted Usage	350	11	na**	na
Protection Zone(s)	340	1	na	na

* Includes application costs saved. These costs remain the same for all other scenarios
**na not applicable

10. POLICING COSTS

10.1 Approach

It can be seen from the preceding Chapter that the imposition of restrictions on the usage of pesticides in either catchment would have significant negative effects on farm incomes and would increase non-agricultural pest control costs significantly. There would therefore be strong financial incentives for pesticide users to disregard the regulations or legislation and apply pesticides. Moreover, imposing pesticide restrictions in just two catchments while pesticides would remain freely available outside the catchments would facilitate the purchase of pesticides outside the catchments for illicit use inside the catchment.

From the point of view of a water utility, which under the pesticide restrictions would be able to abstract water from a protected source, the absence of pesticides at levels above the PCV in the raw water would remove the need to install pesticide removal plant. However, the utility would remain under a regulatory requirement to supply drinking water complying with the PCV for pesticides. Any misuse of a pesticide that raises raw water and drinking water pesticide levels above the PCV would represent a breach by the utility of the regulations, albeit unintended and perhaps regarded as 'trivial' by DWI.

There would thus exist a situation where it would be difficult to enforce the restrictions and important to ensure the restrictions were obeyed. Enforcement therefore would, in our view, require strong policing, coupled with education of pesticide users, warnings on pesticide labels, etc. Analysis of river water would be required in the Leam catchment, along with farm inspections and soil analysis. The records of non-agricultural pesticide users would be regularly checked.

The input required effectively to police each restriction scenario will vary from case-to-case and catchment-to-catchment. For instance, a Total Ban represents the easiest restriction scenario to police while Restricted Use would be the most difficult. Estimates were undertaken of the man-power, sampling and analytical inputs required, together with any other associated costs for each restriction scenario in the two catchments. In doing so the following factors were taken into account:

- size of catchment;
- frequency of farm and site visits;
- existing level of monitoring undertaken;
- extent of water quality monitoring and analysis required, bearing in mind that one study area is a groundwater and the other a surface water catchment;
- extent of soil sampling and analysis required;
- type and seniority of personnel required to undertake each part of the policing operation.

The PV of policing costs was again obtained by constructing a ten year cash flow for each restriction scenario in the two catchments and applying a discount factor of eight percent.

The methodology used for deriving policing costs is described in more detail in Annex 4.

10.2 Costs of policing pesticide restrictions

The PV of the estimated policing costs required to ensure compliance with each of the restriction scenarios is presented in Table 10.1.

Table 10.1 Present Value of policing costs

Restriction Scenario	Leam Catchment £'000	Colne Catchment £'000
Total Ban	540	144
Restricted Usage	2477	878
Protection Zone(s)	494	803

Existing monitoring activities by the NRA have been taken into account when assuming the input required to effectively police the two catchments. The above PVs, therefore, represent the incremental costs incurred. Although the costs are based on those provided by the NRA for equivalent activities by pollution control officers, the policing may be undertaken by any nominated government body.

No additional water sampling or analysis would be undertaken in the Colne catchment because the abstracted water contains pesticides that were applied up to five years ago. Consequently, greater emphasis would be placed on field inspections and soil analysis. Apart from this, the level of policing costs under the Total Ban and Restricted Usage scenarios has been assumed to be primarily a function of catchment size. In the Leam, policing costs under the Protection Zone scenario is less than in the Colne because in the former catchment the zone is a grass strip adjacent to watercourses, whereas in the Colne 90 percent of the agricultural and urban areas would need to be protected.

11. COMPARISON OF COSTS

The financial and UK economic results for the two catchments are summarised in Tables 11.1 and 11.2 and are detailed in Annex 4. Under the UK economic analysis no change has been made to the non-agricultural, policing and water treatment costs as it has been assumed that the financial costs represent a true cost to the UK economy.

As stated in Section 1.1, the "costs" represent monetary benefits/disbenefits of restrictions on pesticide usage for pesticide users and the water industry. Impacts of pesticide restrictions on environmental concentrations of pesticides, and the resultant benefits for aquatic life, recreation, conservation etc. are not easily quantified. The consideration of such benefits were outside the scope of our study and are not therefore included in the economic comparison.

11.1 Leam catchment

In the Leam catchment the overall costs, in both financial and UK economic terms, of the Total Ban and the Restricted Use scenarios exceed the estimated cost of installing and operating a water treatment plant. In the Restricted Use scenario, the complexities of ensuring compliance are likely to result in policing representing about 80 per cent of total costs. In both analyses, the introduction of a protection zone adjacent to the water courses represents the least cost option and under this scenario the financial costs are likely to be almost equally borne by the agricultural and water industries.

11.2 Colne catchment

In the Colne catchment, the higher cost of treating water means that the financial and UK economic costs to agricultural and non-agricultural pesticide users exceed those incurred by the water industry only in the Total Ban scenario. Under the Restricted Usage and Protection Zone scenarios, the total agricultural and non-agricultural costs are about one third of that required to install and operate a water treatment plant and, again, in each case most of the expenditure would be incurred in policing costs. In view of the uncertainty surrounding the level of policing effort required, the total costs of the Restricted Use and Protection Zone scenarios should be regarded as approximately the same.

Table 11.1 Leam catchment - summary of financial and UK economic costs, in Present Value terms, associated with each restriction scenario - £million

(1) Financial Costs - £M

Restriction Scenario	Pesticide User Agric	Pesticide User Non-Agric	Water Treatment	Policing	Total Costs
No Restrictions	-	-	2.4	-	2.4
Total Ban	15.1	5.6	-	0.5	21.2
Restricted Usage	0.6	-	-	2.5	3.1
Protections Zone(s)	0.4	-	-	0.5	0.9

(2) UK Economic Costs - £M

Restriction Scenario	Pesticide User Agric	Pesticide User Non-Agric	Water Treatment	Policing	Total Costs
No Restrictions	-	-	2.4	-	2.4
Total Ban	7.9	5.6	-	0.5	14.0
Restricted Usage	0.6	-	-	2.5	3.1
Protection Zone(s)	0.2	-	-	0.5	0.7

Note: Discounted at 8%

Table 11.2 Colne catchment - summary of financial and UK economic costs, in Present Value terms, associated with each restriction scenario - £million

(1) Financial Costs - £M

Restriction Scenario	Pesticide User Agric	Pesticide User Non-Agric	Water Treatment	Policing	Total Costs
No Restrictions	-	-	3.4	-	3.4
Total Ban	4.2	10.8	-	0.1	15.1
Restricted Usage	0.1	-	-	0.9	1.0
Protection Zone(s)	0.3	-	-	0.8	1.1

(2) UK Economic Costs - £M

Restriction Scenario	Pesticide User Agric	Pesticide User Non-Agric	Water Treatment	Policing	Total Costs
No Restrictions	-	-	3.4	-	3.4
Total Ban	2.2	10.8	-	0.1	13.1
Restricted Usage	0.1	-	-	0.9	1.0
Protection Zone(s)	0.3	-	-	0.8	1.1

Note: Discounted at 8%

12. SENSITIVITY ANALYSES

12.1 Introduction

The comparison of costs in the previous Chapter shows that in some cases, the differences in total costs between various Restriction Scenarios are relatively small. In this section the impact of alterations in three factors (discount rates, water treatment costs and analytical costs) on the total costs are summarised. Details of these analyses are in Annex 4.

Many other technical, social and political factors may also affect the costs and these wider issues are discussed in Section 14.2. The sensitivity of the pesticide fate model to key parameters is examined in Section 6.5.

12.2 Use of lower discount rate

A sensitivity analysis was undertaken using a discount rate of five per cent (instead of eight) to reflect the real cost of capital to the Water Service Companies. The financial and UK economic results for the two catchments are detailed in Annex 4 and presented in Tables 12.1 and 12.2. The use of a lower discount rate increases the financial and UK economic costs of each scenario, as seen in Table 12.3.

12.3 Increase in water treatment costs

In the Leam catchment, the estimated cost of treating water in the main analysis is £700 000 below the total estimated costs of restricting the usage of pesticides. In practice, treatability studies and pilot plant trials may lead to the conclusion that water treatment costs could be higher than estimated. The percentage increase in investment and initial capital and annual operating costs required to bring the PV of water treatment costs up to those estimated for the Restricted Usage scenario are as follows:

	Financial %	**UK Economic** %
Initial Capital Investment	+50	+50
Capital and Annual Operating Costs	+28	+28

12.4 Reduction in analytical costs

The analysis of water and soil samples forms a significant part of the policing costs, particularly in the Leam catchment. Consequently, a reduction in the unit analytical costs, for three suites of pesticides from, say, £300 to £200 could significantly affect total costs. The possible impact of a one third reduction in analytical costs is set out in Table 12.4.

Table 12.1 Sensitivity analysis - Leam catchment - summary of financial and UK economic costs, in Present Value terms, associated with each restriction scenario - £million

(1) Financial Costs - £M

Restriction Scenario	Pesticide User Agric	Pesticide User Non-Agric	Water Treatment	Policing	Total Costs
No Restrictions	-	-	2.4	-	2.4
Total Ban	17.1	6.5	-	0.6	24.2
Restricted Usage	0.7	-	-	2.9	3.6
Protections Zone(s)	0.4	-	-	0.6	1.0

(2) UK Economic Costs - £M

Restriction Scenario	Pesticide User Agric	Pesticide User Non-Agric	Water Treatment	Policing	Total Costs
No Restrictions	-	-	2.4	-	2.4
Total Ban	8.6	6.5	-	0.6	15.7
Restricted Usage	0.7	-	-	2.9	3.6
Protection Zone(s)	0.2	-	-	0.6	0.8

Notes: Discounted at five per cent

Table 12.2 Sensitivity analysis - Colne catchment - summary of financial and UK economic costs, in Present Value terms, associated with each restriction scenario - £million

(1) Financial Costs - £M

Restriction Scenario	Pesticide User Agric	Pesticide User Non-Agric	Water Treatment	Policing	Total Costs
No Restrictions	-	-	3.4	-	3.4
Total Ban	4.8	12.4	-	0.2	17.4
Restricted Usage	0.1	-	-	1.0	1.1
Protection Zone(s)	0.4	-	-	0.9	1.3

(2) UK Economic Costs - £M

Restriction Scenario	Pesticide User Agric	Pesticide User Non-Agric	Water Treatment	Policing	Total Costs
No Restrictions	-	-	3.4	-	3.4
Total Ban	2.4	12.4	-	0.2	15.0
Restricted Usage	0.1	-	-	1.0	1.1
Protection Zone(s)	0.4	-	-	0.9	1.3

Note: Discounted at five per cent

Table 12.3 Effect of decreasing discount rate from eight to five per cent

	Financial		UK Economic	
	Leam £m	Colne £m	Leam £m	Colne £m
No Restrictions	-	-	-	-
Total Ban	+ 3.0	+2.3	+1.7	+1.9
Restricted usage	+0.5	+0.1	+0.5	+0.1
Protection zone(s)	+0.1	+0.2	+0.1	+0.2

Table 12.4 Total costs if expenditure on analyses for pesticides in water and soils is reduced by one third

Catchment	Leam - £m		Colne - £m	
Restriction Scenario	Financial	UK Economic	Financial	UK Economic
Total Ban	21.1	13.9	15.1	13.1
Restricted usage	2.4	2.4	0.7	0.7
Protection zone(s)	0.8	0.6	0.9	0.9

Note: Discounted at eight per cent

Apart from Restricted Usage, a reduction in unit costs of analysis would appear to have little effect on the Colne because analytical costs are likely to represent a relatively small proportion of overall expenditure in the other scenarios. In the Leam, the largest impact would be on the total costs of restricting pesticide usage. Under these circumstances the total UK economic costs for this scenario would fall to about the same as the estimated water treatment costs. However, in view of the complexity of policing restricted pesticide usage, it may not be possible to achieve an overall cost reduction of this magnitude.

12.5 Conclusions from the sensitivity analyses

The impact of varying three key factors on total costs would appear to be relatively small. Decreasing the discount rate led to an overall increase in costs. A significant reduction in analytical costs had in general only a relatively minor impact on total costs - the largest reduction being from £3.1m to £2.4m for the Restricted Use scenario in the Leam catchment.

13. TRADEABLE PERMITS AND LEVIES

13.1 Introduction

In this section, the potential use of levies and marketable permits to control the use of pesticides is discussed. As such the use of economic instruments to achieve environmental objectives within the agricultural and non-agricultural sectors represents a variation and extension to the Restricted Usage scenario. A more detailed discussion of levies (product charges) and marketable permits is presented in Annex 5.

Economic instruments have been defined as "instruments that affect costs and benefits of alternative actions open to economic agents (consumers and producers), with the effect of influencing behaviour in a way that is favourable to the environment" (OECD 1989) Economic instruments are therefore a means of implementing the Polluter Pays Principle which aims to allocate costs of pollution prevention and control measures to encourage rational use of scarce environmental resources.

13.2 Objectives

The precise objective of a policy to control the use of pesticides needs to be clearly defined as this will have significant implications on the effectiveness of the selected economic instrument. Possible objectives may be to:

- reduce the total inputs of pesticides; or
- reduce inputs by a given percentage; or
- control individual pesticides in order to ensure that the concentration of individual pesticides do not exceed the drinking water standard for the specified pesticides.

13.3 Approaches

OECD (1991a) distinguished three distinct approaches to the use of economic instruments; output/impact related, input-source related and process-technology related. The use of pesticides produces non-point source pollution which is difficult to monitor and suggests that an input or source related approach would provide the most appropriate framework for assessing the application of levies and marketable permits.

13.4 Product levies

The following assessment of levies focuses on product charges as opposed to emission charges, due to the emphasis of an input-source related approach and the difficulties associated with monitoring non-point source pollution which characterises the use of pesticides. It is recognised that product levies can function as a substitute for emission charges where these are not appropriate.

Fertiliser levies have been applied in several West European countries and empirical studies have suggested that the price elasticity of demand for fertilisers is low (i.e. low response in the change in quantity demanded in relation to changes in the price for fertilisers), suggesting that the benefits in terms of crop yield increase resulting from increased fertiliser use far outweighs the increased cost of fertilisers unless the taxes are very high. In contrast to marketable permits, product charges have been applied to pesticides within Europe, though the reasons for the charges may not be specifically to act as an incentive to reduce the use of pesticides. Charges have been introduced to raise revenue and recover administration and monitoring costs. A recent survey (OECD, 1993) of eco-taxes within the OECD is summarised in Table 13.1.

Pesticide levies could be based on either the amount of active ingredients or on the number of treatments. The main information requirements for setting product charges is the calculation of the appropriate charge rates in order to achieve what economists define as the optimal level of pollution. Baumol and Oates (1971) argued that taxes should be selected in order to achieve specific acceptability standards, rather than attempting to base the taxes on the unknown value of marginal net damages. While this may not achieve the optimal allocation of resources and level of pollution, it does achieve compliance with the standards at the least cost. This last point does highlight the complementary role of standards and economic instruments and the fact that they should not be regarded as substitutes.

Table 13.1 Pesticide and Fertiliser Product Charges in OECD Member States

Country	Product	Purpose
Denmark	Pesticides	Fund research programme as part of an Action Plan to reduce the total consumption of pesticides by at least 25% in 1990 and an additional 25% by 1997. The retail sale of pesticides is subject to 20% tax.
Norway	Fertilisers and pesticides levies	The pesticide tax is charged at 13% of the purchase price and was estimated to raise NKr 22 million (£1.96 million) in 1992.
Sweden	Pesticides charge	The fertiliser and pesticide charges raise over SKr 200 million (£19.28 million). Revenue raising policy and Incentive charging.
Netherlands	Pesticides	The levy imposed on pesticides is used to finance the action programmes in each of the sectors included in the Multi-Year Crop Protection Plan.

The Institute for Public Policy Research (Owens *et al.* 1990) conclude that excise type product charges could be applied to fertilisers and pesticides. The single stage tax would act as an incentive on both firms and individuals.

13.5 Marketable permits

The application of marketable permits involves the setting of environmental quotas, allowances or ceilings, typically based on emission levels, which can then be traded within a regulated market. The 'Bubble Concept' (see Annex 5) illustrates how a marketable permit system operates. It involves visualising several different pollution sources being contained within a 'bubble'. A total emission load is set for the bubble as a whole to ensure that the environmental quality standards are achieved and emissions from any individual source are allowed to rise as long as there is a corresponding reduction from other sources within the bubble.

The creation of pesticide bubbles, which would take into account soil type, available dilution and infiltration rate, would allow the targeting of the policy to protect the environment to reflect the diversity on regional and local characteristics. Environmentally sensitive areas, such as water protection zones, could be created within which the input bubbles could be more stringently defined than elsewhere in the country.

OECD (1991a) have reviewed the potential use of marketable permits to control the use of pesticides and concluded that the potential benefits that may accrue are outweighed by the practical difficulties associated with its implementation. The major practical difficulty stems from the monitoring and policing costs likely to arise from the implementation of the policy. The system would almost be impossible to police effectively. The practical difficulties arise not only from the variety of pesticide types and methods of application, but also from the seasonal fluctuations associated with pest control, as well as anticipated high transaction and administration costs.

13.6 Conclusions

A comparison of marketable permits and product charges against the five criteria (Environmental effectiveness, Economic efficiency, Equity, Acceptability and Administrative feasibility and cost) included in the Annex to the OECD's 'Recommendations of the Council on the Use of Economic Instruments in Environmental Policy' (OECD 1991b) shows that marketable permits only rate highly in terms of economic efficiency by promoting cost savings in meeting compliance requirements. Product charges rate highly for each of the five criteria and would appear to be the appropriate economic instrument to be used for controlling the use of pesticides, though it should be stressed that economic instruments should be regarded as complementary to other policy instruments such as regulation and the use of standards.

The relationship between the economic instrument and direct regulation needs to be clearly defined. For example, with certain products, bans would be desirable. The complementary nature of the two approaches would need to be emphasised. More specifically the precise objectives of the charge should also be stated, e.g. to reduce the consumption of pesticides by a given percentage within a period of time. This will help to define the precise nature of the product charge, i.e. revenue raising or providing incentives to change patterns of consumption.

The scope of any environmental tax needs to be well defined (including the scope of pesticide types and application methods etc.) and has to be formulated taking account of the features of the target groups. Clearly defined fields of operation would also allow users to identify environmentally friendly alternatives and switch consumption to these substitute goods.

The introduction of product charges on pesticides could be implemented in the form of excise duties (and Import Duties for imports), comprising single stage, non-deductible taxes. Charges would be set at fixed rates, which could be amended in future years as the effect on demand became known so that policy objectives could be achieved. There is a need to identify the appropriate rate at which the charges should be set.

It would be necessary for all users of pesticides to be consulted about the proposed introduction of taxes. The successful implementation and acceptance of pesticide charges would depend greatly on clearly defined objectives and fields of operation, simplicity of operation and overall equity. It may be appropriate for charges to be increased gradually over a period of time so that the users may respond to the imposition of additional financial burdens.

14. DISCUSSION

14.1 General comments on the cost comparisons

14.1.1 No Restrictions scenario

Imposing no restrictions on pesticide users in the catchments would result in pesticides reaching the sources of drinking water, which forces the water treatment and supply companies to treat the water to remove the pesticides to below the prescribed limit (the PCV). Treatment is expensive for both catchments studied but costs are greater for the groundwater plant.

The water company would also be obliged to continue existing monitoring activities for pesticides in the raw and treated water at the treatment plant. The costs of these activities are not included in the Tables 11.1 and 11.2 as only future incremental costs incurred are included.

14.1.2 Total Ban scenario

The imposition of a total ban on pesticide applications would be, by a large margin, the most expensive option for controlling pesticide levels in drinking water in either catchment. A total ban would not, therefore, appear to be justified in economic terms.

A total ban would have a very severe negative impact on the profitability of farms, which reflects the dependence of modern intensive agriculture on crop protection products. The agricultural support system does much to cushion the financial impact to individual farmers, but the costs of a ban to the UK economy are still substantial.

Non-agricultural usage of pesticides can be seen as cost-effective, from the large costs (principally due to increased labour and machinery) incurred by such users under a total ban. Costs to non-agricultural users in the Colne are greater than in the Leam catchment, reflecting the greater amount of urban land in this area.

Policing costs would also be incurred under a total ban, to ensure compliance of agricultural and non-agricultural pesticide users.

14.1.3 Restricted Usage scenario

For the surface water catchment (the Leam), the total costs of restricting usage of the key pesticides throughout the catchment would be greater than treating the water. It is assumed that substitute pesticides would be permitted: this reduces the financial impact of this scenario, especially for non-agricultural pesticide users.

Restricting pesticide usage appears to be less expensive in the Colne catchment than installing and operating water treatment. The total costs would be less in the Colne than in the Leam, as the agricultural area is smaller. Policing costs in this catchment are also lower than in the Leam, as fewer analyses of the groundwater for pesticides would be conducted. (Groundwater analysis would be of little practical help in policing the scenario.)

The scenario was not applied to the Colne catchment's non-agricultural pesticide users, as such usage was not predicted to cause pesticide levels in the raw water to exceed the PCV. This feature was specific to the Colne and may not apply in other catchments.

The difficulty of policing such a situation is reflected in the large costs for this activity: this scenario has the largest policing costs of all the scenarios, in both catchments.

14.1.4 Protection Zones scenario

For the Leam catchment, establishing protection zones has the lowest total costs of all the studied scenarios. The format of the protection zone was defined as a strip (about ten metres wide) on each bank of watercourses passing through agricultural land, all roads and hard surfaces, and, on railways, within 50 metres of bridges over watercourses. The impact on agricultural and non-agricultural pesticide users is relatively low. The impact on an individual farmer would depend on how much of his or her farm lay within the zone. Costs would be incurred for the policing activities undertaken.

For the Colne catchment, the protection zone is much larger than in the Leam as entry of contaminants to groundwater occurs over a wider area than entry to surface water. Therefore, costs to agricultural pesticide users are almost as large here as those in the Leam, despite the smaller agricultural area in the Colne. The total costs of the scenario here are approximately the same as those incurred under the Restricted Usage scenario, and are significantly less than the costs of water treatment.

As with the Restricted Usage scenario, this scenario was not applied to non-agricultural users of pesticides in the Colne.

One of the predictions of this scenario is that the financial costs would be shared between farmers and the 'water industry'. The water industry in this context includes the NRA (or any other organisation which might undertake policing activities, e.g. MAFF); this point is important because most of the costs to the water industry are for the extra policing and monitoring activities which the scenario requires. Therefore the costs do not actually accrue to a major extent to the water supply company.

14.1.5 Implications of revisions to EC Directive 80/778

The study has quantified the impact on pesticide users and the water industry of complying with the 0.1 $\mu g\ l^{-1}$ PCV for individual pesticides in drinking water, as specified in the Water Supply (Water Quality) Regulations 1989. The PCV is derived from Parameter 55 of the EC Directive 80/778, on Water Intended for Human Consumption, which sets a Maximum Admissible Concentration (MAC) for pesticides. This concentration is arbitrary: it has no scientific significance in terms of effects on consumers' health. It is worth noting that the economic impact of complying with other pesticide concentrations in drinking water, either arbitrary or toxicology-based, would be very different.

There has been speculation that Parameter 55 may be changed in a revised EC Directive, and, in particular, individual MACs set for each pesticide on the basis of toxicological data. This is the approach taken by the US Environmental Protection Agency (EPA). The UK Department of the Environment (DoE) has issued Advisory Values for pesticide concentrations in drinking water (Department of the Environment, 1989), based on advice from the Department of Health and, wherever possible, they follow values recommended by the World Health Organisation (WHO). Such toxicology-based limits are, in general higher than 0.1 $\mu g\ l^{-1}$. For example, the DoE Advisory Value for isoproturon is 4 $\mu g\ l^{-1}$. The maximum concentration of this pesticide in the River Leam during the decade is predicted to be 2.6 $\mu g\ l^{-1}$ (Table 7.1) with no restriction on pesticide applications. Obviously therefore the economic impact of compliance with a toxicology-based PCV for this particular pesticide would be non-existent.

The PCV for certain pesticides in the Water Regulations is lower than 0.1 $\mu g\ l^{-1}$ (e.g. 0.03 $\mu g\ l^{-1}$ for aldrin and dieldrin). However these do not normally pose a problem for water supplies.

14.1.6 Potential exceedances of the PCV

Exceedances of the PCV for pesticides in drinking water could still occur under the various pesticide restriction regimes because it is assumed that the measures adopted to protect the source of drinking water would be successful. In other words, the Protection Zone and Restricted Usage scenarios have been designed so that maximum pesticide levels in the source water remain below 0.1 $\mu g\ l^{-1}$ under normal conditions. Therefore no pesticide removal plant is installed. If levels of pesticides in the source water were to rise, no barrier to pesticide entry into the public water supply would be in place. The concentration of pesticides might increase transiently, due, for example, to a spillage or an illegal use of pesticide in a protection zone, or for an extended duration, due to an incorrect prediction of the transport properties of a pesticide or abnormal weather conditions. Transient increases in pesticide levels in source waters could be handled by temporarily shutting the inlet to the water treatment plant. Transient increases in pesticide levels above the PCV could be judged, by DWI, to be 'trivial' exceedances of the Regulations.

14.2 Assumptions, limitations and exclusions

In this section, some of the more significant underlying assumptions of the techniques used in the study, the limitations to the findings and items that, although considered, were excluded from the financial analysis, are discussed.

14.2.1 Agricultural costs

Although considerable effort has been put into quantifying the impact of alternative pesticide restrictions in agriculture in the two catchments, the results can only be regarded as indicative because:

- the agricultural industry is going through a period of significant change and new, but as yet unquantifiable, developments in both its structure and technology are likely to take place over the next 10 years;

- the lack of detailed information in the spectrum of weeds, diseases and pests in each catchment means that only best estimates could be made regarding the precise use of each pesticide. The actual use of pesticides in the future could differ significantly from that predicted;

- there is a lack of experimental data in the public domain regarding the impact of a total ban on pesticide usage on yields and, in particular, its effect on the build up of weeds, diseases and pests in the long term;

- the removal of certain pesticides from the farmer's portfolio may lead to increased pesticide resistance due to the higher use of the remaining alternatives, and it has not been possible to predict the associated long term effects.

Premiums for the prices of 'green produce' have been included in the analysis, although in fact the national market for such produce would probably be saturated by the produce from these two catchments. As inorganic fertilisers would probably still have to be used, the agricultural produce could not be classified as 'organic'.

14.2.2 Non-agricultural costs

As with the agricultural predictions, the impact of alternative pesticide restrictions in non-agricultural situations can only be regarded as indicative because:

- the policy of users is constantly being reviewed in the light of legislation and budgetary requirements;

- some users have no specific budget for pesticide application, instead allocating its costs within an overall departmental budget and carrying out a proportion of applications on a 'need to' basis, addressing a specific problem which may arise for one year only;

- the widespread use of contractors who are able to select from a group of approved pesticides, within a performance-related contract, meant that levels of active ingredient actually applied was sometimes difficult to obtain;

- application rates and unit lengths/areas were estimated when such information was unobtainable directly from the respondents.

The assumption has been made that present levels of pest control would be required and maintained in the future, by the most cost-effective means available to non-agricultural pesticide users.

14.2.3 Pesticide fate model

Degradation rates of pesticides in aquifers

In modelling pesticide occurrences in groundwater in the Colne catchment, it has been assumed that no degradation of pesticides occurs in the saturated zone. In fact, it is likely that degradation, particularly chemical hydrolysis, occurs. However the experimental data on pesticide degradation were too scarce and unreliable to permit realistic inclusion in the model. Therefore, a conservative approach was assumed (i.e. that no degradation occurred), so that pesticide levels in the aquifer are only reduced by dilution from incoming pesticide-free water.

Pesticide occurrence data

The availability of data on the occurrence of pesticides in the aquatic environment is limited, in terms of the frequency of analysis and the number of pesticides monitored. This can limit the extent to which the pesticide fate model can be validated. For example, the model predicted that levels of one pesticide in the Leam (chlormequat) should approach the PCV. No information on occurrence was available to confirm this prediction, as a sufficiently sensitive analytical method for this chemical in water was not available. Some key pesticides were not monitored in either catchment.

Transformation products (TPs) of pesticides

Attention is being increasingly focused on the chemicals formed from pesticides when they degrade due to chemical, biochemical or photochemical processes. It is possible that future legislation and EC Directives will set limits for TPs in drinking water and/or the environment. TPs can have different transport properties (i.e. be more or less leachable) and toxicities (towards humans, animals or plants) than the parent pesticides. It is possible, for example, that a pesticide having transport properties which would normally permit its use in a catchment, may degrade to a TP that is more leachable and likely to contaminate the source of drinking water. Information on TPs is scarce and their fates were not predicted with the pesticide leaching model.

Non-agricultural pesticide applications

No specific information was available on the spatial distribution of the non-agricultural usage of pesticides in the catchments, and there are uncertainties attached to the present and historical usage data. Therefore it was necessary to make broad generalisations about the spatial distribution of usage in the pesticide fate model and it must be considered doubtful if the historical usage data are reliable enough to calibrate the model very precisely for non-agricultural pesticides.

14.2.4 Water treatment

Effect of point sources

The costs of water treatment have been based on the future predicted levels of pesticides in the source waters. The predictions are based on normal agricultural use of pesticides, which represents a diffuse source of pollution with normal seasonal variations. There is evidence however that discontinuous point sources of pesticides, perhaps associated with pesticide abuse or spills, contribute to environmental pesticide levels, in surface waters especially. For example, a monitoring programme detected very high transient levels (up to 110 $\mu g\ l^{-1}$) of some herbicides in a tributary of the River Leam (Cable *et al.* 1994). The inherently unpredictable timing, nature and extent of such point sources precluded their inclusion in the modelling of water treatment and calculation of costs.

Additional benefits of water treatment to remove pesticides

The costs of treating raw water under the No Restrictions scenario so that pesticide levels comply with the PCV were calculated on the assumption that pesticide removal was the only reason to install processes such as GAC and/or ozonation. This assumption ignores the additional benefits which GAC and ozone treatment may have in improving water quality generally. For example, GAC may be installed for removal from raw water of colour and compounds which give rise to taste and odour problems. This may be relevant only for surface waters; it is not usual for groundwater to be treated for these problems.

Conversely, conventional water treatments such as sand filtration may reduce pesticide levels in raw water to some extent.

Effects on groundwater quality of pesticide restrictions

It has been assumed that no water treatment specifically to reduce pesticides would be necessary if a total or partial restriction were to be imposed. In fact the timescale for the recovery of aquifers to pollution on the surface may be of the order of years, and is subject to many factors. Therefore if pesticide levels in a groundwater used for public water supplies are currently above the PCV, it may still be necessary to install pesticide removal treatments even if the source of the pollution is removed.

The groundwater catchment studied appears to respond relatively quickly to seasonal variations in pesticide levels. It is unclear how other groundwater sources of drinking water would respond to pesticide restrictions.

14.2.5 Cumulative effects of uncertainties

There are uncertainties attached to all of the major elements of predicted cost in the economic comparison of costs. The sensitivity analysis in Chapter 12 examined the effects of variations in specific parameters. It is worth noting that while the individual uncertainties may be estimated, the cumulative effects of such uncertainties are less easy to estimate. This is particularly important in this study because of the dependency of some elements on other predicted elements. For example, predictions of the world economy over the ten-year period are incorporated into the predictions of agricultural land usage in the two catchments. Future cropping figures are the basis for the projected pesticide application data; these in turn are the inputs for the predictions of future environmental pesticide levels. Future pesticide levels in the source water determine the costs of treatment. Thus there is considerable potential for inaccuracies to accumulate in the chain of predictions.

14.2.6 Other exclusions

The study was confined to a comparison between the economic effects of restricting pesticide usage and the consequent savings in water treatment costs. The study has not therefore taken into account certain other issues:

- Environmental issues specifically related to the effects of current and likely future pesticide usage. For example, the NRA may wish to limit pesticide levels in the aquatic environment to avoid potential effects on aquatic life. Standards for this activity may be less than 0.1 $\mu g\ l^{-1}$.

- The costs of introducing legislation to restrict pesticide usage. These costs could be significant for the Protection Zone and Restricted Usage scenarios as complex regulations would be necessary. Costs of legislation could also be significant if the measures adopted to restrict pesticide usage proved controversial.

- The impact on manufacturers of pesticides of a total ban. The domestic and international agro-chemical production industry is likely to suffer if the market for its products is reduced. This factor may become significant if a national ban on pesticides is considered. The UK 1992 sales of pesticides represents about 2.4% of the total world market for pesticides (McDougall and Phillips 1993).

14.3 Methodology for extension to England and Wales

14.3.1 Agricultural Pesticide Use

In each catchment, the range and total application of agricultural pesticides will vary depending upon the:

- balance between cropping and stocking and, within the arable sector, the actual rotations adopted;
- soil types;
- climate;
- precise spectrum of weeds, diseases and pests.

There will therefore be significant differences in the loadings of individual pesticides in each catchment throughout England and Wales. The study has shown for example that relatively few pesticides are used on grassland; consequently, at the extreme, pesticide usage in the uplands will differ greatly from that applied in the intensive arable areas of East Anglia.

14.3.2 Non-Agricultural Pesticide Use

A number of key points have arisen as a result of the work carried out in this study. These include:

- The difficulties in obtaining information greater than one year old from the majority of users of non-agricultural pesticides, due to either records not being to hand or the resources necessary to procure the information not being available. Considerable time and effort was required to follow through initial contacts to the final providers of the information. Almost without exception, promised dates and timings for the provision of the requested information were unfulfilled.
- The use of performance-linked contracts has resulted in the devolving of responsibility for the day-to-day decisions on pesticide application rates to the contractors and away from the client/purchaser. Notable exceptions to this can be found in pesticide usage for roads and railways.
- The important contribution that legislation, budgetary constraints and public perception make to the overall use of pesticides. It has not been possible to accurately predict the impact that such factors will have on the likely future application of pesticides by non-agricultural users.

Use of pesticides in non-agricultural situations will be influenced by:

- population density;
- the extent of infrastructure which will influence the lengths of roads and railways;
- disposable income and the inclination of the local and visiting populations to spend money on sporting pursuits which require fine turf facilities, such as golf and bowls;

- climate. Weed growth will be more of a problem in the warmer and damper regions of England and Wales;

- local authority budgets.

There are, therefore likely to be significant differences in the applications of the individual pesticides in each of the catchments. The differences would be greater for 'area' users, such as local authorities, amenity departments and golf courses, than for 'linear' users, such as roads and railways.

14.3.3 Pesticide fate model

The river and groundwater quality models developed for the study were successfully applied to the two selected catchments. The applications were successful because:

- pesticide applications in both the agricultural and non-agricultural sectors were clearly identified and quantified;

- the principal physical and chemical processes controlling the movement of pesticides were incorporated in the models.

The models developed are general purpose and can be readily applied to different catchments. Some model calibration or validation may be required in other catchments, but in principle, model application should be relatively straightforward. Pesticide application data will be required to a similar level of accuracy as that obtained in the present study. In any further work, attention should be focused at an early stage on pesticides likely to be problematical now or in the future. The models could be used at an early stage to screen a wide range of pesticides used, to identify those which may fall into this category and would therefore warrant further investigation.

The results from the present study must be considered to be representative only of the particular local conditions prevailing. The models have demonstrated that the key catchment parameters which exert a significant influence on pesticide behaviour are:

- effective rainfall - in general, the higher the effective rainfall, the higher the pesticide concentrations, which is the reverse of the usual relationship between pollutants and flows;

- soil thickness - usually between 95% and 100% of applied pesticides are removed by degradation in the soil, with thicker soils providing higher removal rates;

- soil organic carbon - provides the means of retarding pesticide movement relative to water so giving rise to greater potential for degradation; can vary by a factor of 50 between soil types;

- aquifer fissures - provide the main route for pesticide movement from the soil to the water table and subsequently to abstraction wells; higher fissure densities will increase the potential for pesticide movement.

The variability of response of surface water and groundwater systems which results from the range of catchment properties, and the wide range of pesticide usage, implies that there can be no single 'best solution' for the whole of the UK. The pesticide problem has a very definite geographical dimension as revealed by their incidence in water supplies.

14.3.4 Suggested methodology

In principle, the methodology undertaken in this study could be applied throughout the other catchments in England and Wales. However, a detailed approach has been undertaken and it would be both time consuming and costly to repeat this for all catchments. A more suitable approach to extending this study to the whole of England and Wales might be as follows:

- Decide on a number (perhaps seven or eight) of generally homogeneous regions, having similar soils, rainfall, crops and current usage of pesticides. The regions could be identified by desk study using published information on the key parameters.

- Identify in each region two catchments (one surface water, one groundwater if appropriate) and establish the databases of cropping, pesticide usage and catchment characteristics.

- Undertake modelling and economic analyses of the feasible control options.

- Assess the sensitivity of the findings to variations in cropping, pesticide usage and catchment properties typical of the selected region.

- Consider only those pesticides which are either currently a threat or are predicted, on a national basis, to pose a future threat to sources of drinking water.

- Under the restricted usage and protection zone scenarios, the analysis should be limited to the marginal changes in pesticide usage and application costs.

- In agriculture, for those cases where suitable alternative pesticides exist and yield reductions are likely, the analysis should be restricted to the marginal changes in cropping, enterprise output, pesticide usage and application costs together with other associated changes in production costs. Regional or national yields and costs of production should be used throughout, and whole catchments or groups of catchments should be analysed. Priority should be given to those which are predominantly arable cropping.

- The financial and economic analysis of national restrictions on agricultural pesticide usage should develop methods for projecting the unknown international agro-economic repercussions of large-scale bans on pesticides. It is probable that cheaper imports of agricultural and horticultural produce from countries where no ban is operative would dominate the market. Tariffs on imported produce could compensate the countries' farmers but the introduction of protectionist tariffs is not likely to be acceptable to the international community.

- For non-agricultural usage, lengths of roads and railways and sizes of amenity areas should be taken from maps and the costs per unit length of pesticide application should be applied to obtain total usage. Golf courses should be categorised by likely pesticide use (high, medium and low users) and models developed to reflect such use. Consolidated regional or national data on average unit costs of application and control should be used throughout.

- The likely changes in land use from agriculture to non-agricultural purposes would be need to be estimated for each region.

15. CONCLUSIONS

The study has compared some of the costs, over ten years, in two representative catchments:

(a) to the water industry, of reducing pesticides in water supplies; and

(b) to agricultural and non-agricultural pesticide users, of restrictions on the uses of pesticides.

The aggregate net economic benefits and disbenefits to be obtained from pesticide restriction regimes were appraised critically. Consideration of the potential environmental benefits of reduced pesticide usage were not within the scope of the study.

Six scenarios for the future usage of pesticides were studied, ranging from the extreme cases (no restrictions and a total ban) to intermediate scenarios of partial restrictions. Two scenarios use of non-chemical methods and use of more-acceptable pesticides were found to be impractical or impossible to analyse in detail. Detailed predictions and economic analyses were therefore made for four scenarios: No Restrictions; Total Ban; Protection Zones; and Restricted Usage.

Uncertainties in the predictions were identified. For agriculture, these include uncertainty over the longer term changes in the structure of the industry, the adoption of future technology and climatic influences. In addition, there has been a lack of information on the spectrum of weeds, pests and diseases in each catchment, together with the effect of a total ban and uncertainty over the impact of restrictions on the build-up and changes in resistance of pests to a reduced number of acceptable pesticides. Difficulty was also experienced in obtaining data from non-agricultural organisations on historic, current and likely future pesticide usage. This was partially due to the letting of performance-related contracts, allowing contractors to select from a given range of pesticide brands without any obligation on the organisation letting the contract to keep detailed records on the actual volume of active ingredients applied. However, sufficient information was obtained to allow a reasonably accurate assessment to be undertaken.

There is a lack of experience in the UK of policing alternative types of restrictions. Consequently, uncertainty also surrounds the estimated costs of this activity. In addition, the final choice of water treatment technology and size of plant in the two catchments is likely to be dependent on further studies and pilot plant trials.

The following conclusions can be drawn; in general these are specific to the two catchments studied and it should not be assumed that they would apply in other catchments or to the UK in general.

1. Restriction of pesticide usage would lead to a decline in projected farm profitability, the extent of the fall being dependent upon the restriction scenario imposed. The introduction of a Total Ban would result in significant financial losses, assuming that farming continues. Providing suitable and effective substitutes can continue to be used, the imposition of Restricted Usage or Protection Zone scenarios will have a

much more limited impact on projected farm profitability. It should be noted that for both restriction scenarios, the recent change in the agricultural support system, in which area payments have been introduced to offset reductions in prices, does much to cushion the financial impact of pesticide restrictions on individual farmers.

2. The introduction of a total ban would have very serious cost implications for both agricultural and non-agricultural pesticide users. In the Leam catchment, total UK economic and financial costs are likely to be in the order of six and ten times the cost of installing and operating a water treatment plant respectively. In the Colne catchment, the higher cost of treating water means that a ban on pesticides would cost four or five times the cost of installing and operating a treatment plant.

3. In the surface water catchment of the Leam, the least expensive option, in both financial and UK economic terms, would be to establish a narrow protection zone on either side of the water courses associated with farmland. In financial terms, the costs of this option are likely to be borne almost equally by farmers and the water industry.

4. Non-agricultural users of pesticides in the Leam and Colne catchments are unlikely to be significantly affected by the Protection Zone or Restricted Usage scenarios, providing suitable and effective substitute pesticides can continue to be used.

5. The total costs of restricting pesticide usage or introducing protection zones in the Colne catchment are similar. In each case, providing suitable and effective substitute pesticides can continue to be used, the policing costs are likely to be significantly greater than the cost to agriculture. It is therefore difficult to determine which of these two options is likely to be the most attractive. In practice both options would be very hard to police, but enforcing compliance with the restricted pesticide usage scenario is likely to be more complex than that for protection zones.

6. The sensitivity of the costs to variations in some parameters was investigated. Using a discount rate of five percent increases the costs of the Total Ban, Restricted Usage and Protection Zones by some 10 to 18 per cent but has little effect on the cost of treating water. In the Leam catchment, a substantial increase in the initial capital investment and annual operating costs would be required to bring the cost of water treatment up to the total costs incurred by pesticide users under the Restricted Usage option. Apart from one scenario, a one third reduction in the cost of analyzing water samples has little impact on the overall results for both catchments. The exception is the Restricted Usage scenario. In the Leam, the policing costs incurred would fall to a level such that total costs are similar to the costs of treating water.

7. These studies have been based on two catchments, with different land use characteristics, where current and predicted future pesticide concentrations in surface and groundwater exceed the UK prescribed concentrations for pesticides in drinking water. These conclusions may not necessarily hold true in other areas where the level of urbanization, climate, soil type and farming systems differ. However, the techniques used in this study could be applied to other catchment areas and extended to cover England and Wales (or any other region).

8. The use of levies and tradeable permits as economic instruments to control pesticide usage was evaluated. Product charges appear to satisfy the criteria for effective economic instruments in pollution control. Tradeable permits are probably impractical.

16. RECOMMENDATIONS

Improving co-ordination of pesticide usage by different local authorities within catchments and raising awareness of the issues, by introducing educational campaigns, such as 'Spraysafe' in the Severn Trent region, to other water company regions, would do much to minimise the risk of pesticide pollution by non-agricultural users.

Although the techniques used in this study are applicable to other catchments, extending this approach to England and Wales as a whole would be both time consuming and costly. It is therefore recommended that a simplified methodology is developed before assessing the economic impacts of pesticide restrictions throughout the two countries.

Consideration should be given to the situation in other European Union countries, where the Directive on Water intended for Human Consumption and its MAC for pesticides of 0.1 $\mu g\ l^{-1}$ in potable water have also been incorporated into national law. Similar dilemmas, of restrictions in pesticide usage versus water treatment to reduce pesticide levels, are faced by other EU countries in complying with the MAC. Compromise solutions such as those identified in this study (protection zones and restricted usage) should be investigated in a Community-wide context.

The research has highlighted several areas where uncertainties exist. It is recommended that further research is undertaken to reduce these before the results of this study are considered for implementation. This applies, in particular, to:

- the impact on the aquatic environment of using substitute pesticides as replacements for those which are restricted;
- the persistence of pesticides in the aquatic environment, specially in aquifers where microbial and other degradation processes are assumed to be of negligible importance;
- the transport of pesticides (and, in particular, their environmental transformation products) from the point of use to sources of drinking water, which remains inadequately understood;
- the lack of suitable, sensitive analytical methods for some pesticides in the environment, which precludes monitoring of their occurrence;
- the practical effectiveness of protection zones to prevent pesticide contamination of water sources;
- the potential build-up in resistance of weeds, pests and diseases if the portfolio of approved pesticides is reduced;
- the applicability of policing regimes, introduced in other countries, to UK conditions;
- alternative water treatment technologies and their costs.

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ANNEX 1

HISTORICAL AND FUTURE LAND AND PESTICIDE USE AND THE EFFECT ON FARM PROFITABILITY OF RESTRICTING PESTICIDE USE

1. INTRODUCTION

This annex describes the method used to derive historical land and pesticide usage in the Leam and Colne catchment areas.

Land use projections for both areas were undertaken from 1993 to 1997. Land use beyond the latter date was assumed to remain constant, because of possible, but as yet unquantifiable, changes to the CAP.

Yield depressions under the Total Ban scenario or the substitution of alternative pesticides to replace the key pesticides restricted under the remaining restriction scenarios have been assessed.

Financial Gross Margins were then calculated for each of the restriction scenarios and applied to an average farm in each catchment in order to show the likely impact on profitability.

2. ANALYSIS OF PARISH STATISTICS - LEAM CATCHMENT

Parish statistics were analysed for all 55 parishes which fall wholly or partially within the catchment area of the water treatment works at Campion Hills in Leamington Spa. Although 27 parishes lie wholly within the catchment area, it was considered imprudent to calculate on a pro-rata basis the data for those parishes which lie partially within the catchment. In 1992 the total agricultural area was 42951 ha.

An analysis of cropping and stocking within the parishes was undertaken for the year 1988 and 1992. The former year was selected because it was considered that pesticide usage from that year should have entered the water supply during the subsequent period of time. The latter year represents the latest statistics available when the study commenced. At the time, these statistics were unpublished and MAFF undertook a special computer run to extract the data. It was also considered important that the 1992 parish statistics data was used because this represented the last year before the widespread introduction of set-aside. Because MAFF aggregated disclosive information, it was not possible to accurately breakdown land use data into sub-catchments.

A statistical analysis was undertaken of the 1992 cropping and stocking records of those parishes which fell entirely within the catchment. The results were compared to a similar analysis for the remaining parishes and no significant differences were detected. Therefore, the cropping within the total parish area can be considered representative of the cropping within the catchment.

The gross area of the parishes, totalling 53360 ha, was obtained by using a digitizer to measure the area within each parish boundary marked on the latest available maps. The difference between this and the agricultural area represents urban conurbations, industrial estates, roads, railways, etc.

The total catchment was measured as 36547 ha. The agricultural cropping and stocking area then proportioned down using 36547/53360 as a ratio.

Between 1988 and 1992 there has been a small increase in the percentage area of wheat grown, while the percentage of barley, beans and potatoes has fallen. The reduction in the latter crop is possibly due to the size of enterprise becoming unviable or the unsuitability of the soils on particular farms for the production of high quality produce that is now demanded. During the five year period linseed was introduced and in 1992 was a small but significant crop. A similar area of set-aside was also introduced under the old scheme which has now ceased to exist.

3. ANALYSIS OF PARISH STATISTICS - COLNE CATCHMENT

A similar approach was adopted for the Colne catchment to that described for the Leam.

A total of 16 parishes fall wholly or partially within the catchment area of the six boreholes supplying the Clay Lane collection point. In 1992 the gross area of these parishes amounted to 23 359 ha compared with 19 323 ha within the catchment area itself. A statistical analysis was undertaken between the eight parishes that lie wholly within the catchment and those which are partially within the catchment. Again, no significant differences were detected between the two samples.

The total agricultural area within the Colne and Leam catchments has declined by 1.4 and 3.3 percent respectively over the last five years. Visual observation has confirmed that in both areas there has been an increase in land taken for roads, new housing and industrial estates, together with private horse paddocks and equestrian centres.

4. LAND USE PROJECTIONS, ASSUMING NO RESTRICTIONS - 1992 TO 2002

4.1 Introduction

Land use projections have been based on a combination of past trends, rotational considerations, bearing in mind the soil types in each catchment, and enterprise performance at the Gross Margin level. In addition, the recent introduction of the Integrated Administration and Control System (IACS) leaves farmers with little room to manoeuvre because their total arable and grassland areas are now effectively fixed, and beef and sheep quotas have also been introduced. Milk quotas were already in existence, therefore all grazing livestock are now subject to quota schemes.

Area and headage payments under the new support arrangements are quoted up to 1995/96. However, it should be noted that payments in this period will relate to land use and stocking in 1994/95, i.e. the 1995 harvest. Gross Margin predictions can therefore only be made up to this point in time and it has been assumed that they remain constant thereafter. Uncertainty still surrounds the long-term impact of the recent General Agreement on Tariffs and Trade (GATT) agreement on the European Union's (EU) Common Agricultural Policy (CAP). Consequently, future price assumptions can only be based on the current and foreseeable situation.

Although the terms of reference request that predictions on land usage should be over a ten year period, no further changes have been assumed after 1997. The main reasons for this are as follows:

- as indicated above, farmers now have a limited ability to change their overall farm systems;
- the analysis of parish statistics indicates that over the last five years farm systems have been relatively stable with only minor changes in cropping taking place;
- farmer decision making is increasingly driven by financial considerations. Individual decisions on cropping patterns are based on soil type, other inherent farm resources and the financial attractiveness of the enterprise. Unless radical changes are made to the support system when the current arrangements come up for review, it is considered unlikely that the rankings, in terms of Gross Margin per hectare, will change.

The land use projections for both catchments are given in Appendix 1. The data are discussed for each catchment in the following two sections.

4.2 The Leam catchment

Intensive pig and poultry units have been ignored in the analysis because they appear to be all specialist units with small land areas. Consequently little or no pesticides would be applied. No change has been assumed in the overall numbers of beef and sheep. The main reasons for this are as follows:

- arable land is concentrated on the larger specialist holdings which appeared to have few or no facilities for livestock. In view of the investment required, these farms are unlikely to attempt to diversify;
- beef and sheep numbers are now subject to quota;
- although additional quota can be leased, visual observations indicated that additional investment in buildings, facilities and fencing may well be required to accommodate larger stock numbers. In view of the smaller size of livestock farms and the extensive overall stocking rate in both catchments, it would be difficult to justify additional investment to acquire extra quota or new facilities.

There are an estimated 29 dairy herds in the catchment all of which appear to belong to committed dairy farmers. Although the number of dairy cows has fallen over the last five years, the recent change in the support system means that this decline is likely to stop because:

- there are now significant advantages associated with retaining a diversified farm system;
- dairying is the most profitable farm enterprise.

Set-aside has been introduced for the 1993 harvest onwards. It has been assumed that all farmers set-aside 15 percent of their eligible land over the next ten years. Linseed becomes an eligible crop from 1994 onwards.

The area of fodder crops has fallen dramatically over the last five years and it has been assumed that these crops will be phased out by 1997. The area of potatoes is predicted to remain constant as visual observations suggest that the crop is now confined to the better land.

The initial change in the area of major combinable crops between the 1992 and 1993 harvest was based on the results of national surveys, undertaken by the industry at the beginning of 1993. This suggested an initial swing out of winter and into spring oilseed rape. However, it is predicted that, because of the better financial results from the former crop and the heavy soil type in the area, the spring crop will cease to be grown by 1997.

To date, the use of linseed has increased markedly because of the historical high levels of support. Under the new system it is anticipated that the financial attractiveness of the crop will decline and hence the area will fall.

As the relative profitability of linseed declines, field beans will appear more attractive to farmers as a break crop, thus the area of beans together with winter oilseed rape and peas is predicted to increase, subject to rotational constraints.

The area of spring barley has declined over the last five years, reflecting its relatively low Gross Margin and possibly the difficulty of establishing the crop on the heavy soils in early spring. It is anticipated that this trend will continue. Similarly, the areas of winter barley and oats are expected to continue their downward trend due to the relatively low Gross Margin compared with other crops.

Improved varieties has meant that forage maize has become an attractive source of livestock fodder and this has been reflected in the small but significant increase over the last five years. This trend is expected to continue.

The overall area of leys, permanent pasture and rough grazing is predicted to remain more or less constant. In 1992 the overall stocking rate was low at 0.68 ha per livestock unit ((LU or cow equivalent). Visual observations indicated that apart from the more intensive dairy farms, the general level of intensity of other livestock farms was low. This situation is not expected to change.

4.3 The Colne catchment

For the reasons described above, no change has been assumed in total livestock numbers. Similarly, the total area of leys, permanent pasture and rough grazing is not expected to alter significantly. Consequently, the overall stocking rate in 1992 of 0.77 ha per LU is predicted to remain unchanged. Again, this is a low stocking density but visual observations confirmed that, apart from the dairy units, extensive grazing appeared to be the norm. In part, this is due to the relatively high level of part-time/hobby farms in this commuter-dominated area.

Again, it has been assumed that all farms enter 15 per cent of eligible land in to the current set-aside scheme.

In 1992 the area was dominated by winter cereals with a relatively small proportion of land use devoted to break crops. In view of the financial attractiveness of the latter, it has been assumed that farmers will move towards a more balanced rotation by expanding the use of oilseed rape and beans. Linseed is expected to decline while harvest peas may well be introduced as the crop is ideally suited to light land. No allowance has been made for possible cereal yield increases that result from a higher proportion of break crops.

As in the Leam catchment, the use of winter and spring barley and oats is expected to decline and in the case of the latter two crops be phased out by 1997. The use of maize has declined over the last five years but is predicted to stabilise at its present level as the crop is now probably grown by only a few farmers.

A small area of horticultural crops is grown and has increased by 18 percent over the last five years. In view of the proximity of large urban conurbations, this trend is expected to continue.

5. HISTORICAL AND FUTURE PESTICIDE APPLICATIONS

5.1 Introduction

MAFF publishes, on a regular basis, the results of a survey in England and Wales on pesticide usage on a wide range of crops. While these results are of interest from a national point of view, it was considered that they are of more limited use when studying two specific catchments. The main reasons for this conclusion are that pesticide usage will vary depending on the spectrum of weeds, disease and pests found on the land in question and this, in turn, is largely influenced by the soil type, micro-climate and range of varieties within each crop grown, all of which vary from area to area.

5.2 Historical pesticide applications in the Leam catchment

To provide background information for other research work, WRc commissioned ADAS to prepare two reports on pesticide usage in the Leam catchment. These reports were entitled 'Evaluation of Herbicide Use in East Warwickshire 1991/92 and 1992'. The former covered pesticide applications in the autumn of 1991 and early spring of 1992, and the latter report covered pesticide usage in the late spring/summer of 1992. The information was based on ADAS officers' knowledge of farming practices in the area and was largely used as the basis for estimating the total application of pesticides applied per hectare of each of the major crops grown for harvest in 1992. No information for minor crops such as mixed corn, fodder crops, other crops and horticulture was available; consequently these were excluded from the analysis.

The format of the basic information for each major crop consisted of the following:

- the chemical and trade name of each straight and mixed pesticide applied;
- the total area, expressed as a percentage, to which each pesticide was applied;
- the application rate per hectare in litres or kilograms of formulated product;
- the active ingredient in grammes per litre or kilogram of product applied.

From this it was possible to derive the overall application per hectare of each active ingredient which, when multiplied by the crop area, gave the total kilograms of each active ingredient applied in the catchment area as a whole.

Comparable information for 1988 did not exist. Consequently, the approach adopted was to use the 1992 pesticide application data for each crop as a base but modify it in the light of detailed pesticide application records for the 1988 harvest year on two large farms in the area. Account was also taken of the difference in weather patterns between the two years and the fact that these two farms were above average in managerial ability. The per hectare results were then multiplied by the overall 1988 cropping pattern to derive the total kilograms of active ingredients applied in the catchment as a whole.

5.3 Future use of pesticides in the Leam catchments without restrictions

Again, the 1992 data set was used as a base and predictions were made for pesticide usage per hectare in 1997 and 2002. The following factors were taken into account when undertaking these predictions:

- the range of available pesticides was restricted to existing and recently introduced chemicals. Pesticides that were known to be at various stages in the registration process were ignored in case they subsequently failed to become approved;
- the soil type;
- general trends in usage of specific pesticides, e.g. older chemicals becoming less popular/effective and being replaced either by new chemicals or formulations;
- the general trend away from prophylactic treatment of weeds, pests and diseases towards reacting to problems as they occur;
- changes in the agricultural support system whereby product prices are being reduced but compensated by area payments. This reduces the incentive to attain ever higher yields through increasing inputs.

In many cases, individual herbicides can attack more than one species of weed. It should, therefore, be noted that without detailed information on the weed spectrum, the precise use of relevant pesticides currently used could only be estimated. It is therefore possible that, if the weed spectrum is different from that assumed, future loadings of active ingredient could be different from that predicted.

Again, for 1997 and 2002, the projected cropping programme was used to calculate the total application of active ingredients throughout the catchment as a whole.

5.4 Total Ban throughout the Leam catchment

No pesticides were assumed to be applied to crops or grass. The impact on yields and Gross Margins is discussed in Section 6 of this Annex.

5.5 Protection zone in the Leam catchment

The most effective form of protection zone in this surface water catchment is to establish a 9.6 metre wide grass strip on either side of the watercourses. The width of protection zone has been calculated on the basis of the area required to contain the most problematical pesticide (isoproturon) within the MAC. The main impact on farmers will therefore be a small loss of arable land. Pesticide usage and application rates on the remaining land would be unaffected.

5.6 Restrictions on the quantities and timing of pesticides in the Leam catchment

Most herbicides have to be applied between certain crop or weed growth stages, or a combination of these, if they are to be effective. For instance, Hytane 500 SC (isoproturon) can be applied either as a pre or post emergence spray but should be applied before the weeds reach the two or three leaf stage, depending on the weed to be controlled. Applications of the chemical after this drastically reduces the pesticide's effectiveness and therefore it ceases to be a financially viable proposition to apply the chemical. Similarly, the timing of chemical applications to control pests and diseases is critical. If a disease or pest is not controlled before it reaches a certain stage or population density, the application of chemicals will either be less effective or it will cease to be economic to apply it. The scope to vary the timing of specific agro-chemicals is not therefore considered to be a viable option because, for the above reasons, the introduction of time limits effectively means a ban. In addition, the development of weeds, diseases and pests will vary from year to year depending on the climatic conditions.

The pesticide approval and registration system requires pesticide manufacturers to explicitly state the maximum rates of chemical to be applied and the timing of application. These may vary, depending on the crop, soil type and level of infestation. The application rate(s) are clearly set out on the product label, together with details on timing, tank mixing and crop safety. Every product label also has a hazard rating, if appropriate, together with other safety, environmental and handling instructions that accompany each container. The Control of Pesticides Regulations (COPR) includes Approvals required before any pesticide may be sold, stored, supplied, advertised and used, and allow for general requirements to be set out in various Consents. Consent C(i) relates to use which includes requirements for spray operators to operate within the constraints of the label. In practice therefore, no scope exists to exceed the maximum recommended amount of pesticide per unit area of land.

Archivable data indicates that in the two areas being studied, dose rates are at the current recommended levels. Farmers can reduce the dose rates at their own risk, but this can only be practically achieved when climatic factors and the growth stages of weeds and crops mean that crop population density can bring about an effective kill. As a result, this approach can only be adopted in very specific circumstances and may even be limited to one particular field in any one year.

Current research is being undertaken to improve predictability when farms can effectively utilise lower application rates and, as a result, a proportion of applications made below recommended rates may increase over a period of time. It has been difficult to assess what proportion of farms are currently adopting this approach and in any case, it will vary from year to year for the above reasons.

There is evidence to suggest that the continual use of below-recommended application rates, while reducing costs in the short term, could well increase the long term costs because of the increase in the seed bank in the soil and the build-up in potential resistance to individual, and possibly, groups of pesticides.

In these two catchments, the existing pesticide usage would suggest that the key weed problems are blackgrass, wildoats and cleavers and the scope to reduce rates for these weeds is particularly limited.

Whilst it is recognised that it is Government policy to minimise the use of pesticides while maintaining efficiency, the use of lower application rates is not considered to be a viable system on a year-on-year basis. The most feasible option under discussion is therefore to restrict the area on each farm in the catchment to which key pesticides can be made.

The restriction of the key pesticides to a proportion of each crop does not mean that the farmer cannot combat particular weeds, diseases or pests elsewhere in the crop because alternative chemicals can be used. The pesticide model for the No Restriction scenario was modified using the substitutes indicated in Table A1.1 to reduce the level of active ingredients of the key pesticides to the required levels. The substitutes were chosen for their pesticidal efficacy from among the pesticides currently approved in the UK.

Table A1.1 Substitute Pesticides

Key Pesticides Restricted	Substitute Pesticides
Atrazine	Pyridate
Simazine	Propyzamide (Bentazone, Carbetamide)
Mecoprop	Metsulfuron Methyl (Fluoroxypyr)
Isoproturon Chlortoluron	Depending on crop and weed problem, the following may be used: Trifluralin-Fenoxaprop sequence; Diclofop-Fenoxoprop combination; Trifluralin-DFF mix
Flutriafol	Propiconazole (Maneb, Dithiocarb)

Note: It is recognised that trifluralin is on the Red List, but it is still an approved chemical for agricultural use and therefore remains, for the time being, a least-cost substitute for farmers

The total application of active ingredients applied to the catchment was then re-calculated and the results were run through WRc's pesticide fate model to check whether any exceeded the MAC. The initial objective was to replace the key pesticides with those from another family of chemicals. Consequently, bentazone, carbetamide and propyzamide were substituted for simazine, fluoroxypyr for mecoprop and maneb and dithiocarb for flutriafol. The WRc model showed that by replacing the key pesticides with other chemicals, the following substitutes also exceeded the MAC: bentazone, carbetamide, dithiocarb and fluoroxypyr. The latter exceeded the MAC by a large amount and when the WRc model was run, using the current estimated loading in the catchment, the MAC was also exceeded. Fluoroxypyr has not been monitored in the Leam catchment and therefore did not form one of the key pesticides to be considered in the study. The only conclusion that can be drawn is that, to date, it has not formed part of the range of pesticides which are routinely analysed. It was agreed with WRc that as it was not a named pesticide in the terms of reference, the usage of fluoroxypyr could remain but should not be increased.

Bentazone and carbetamide were then replaced solely with propyzamide and fluoroxypyr with metsulfuron methyl except on grass where isoxaben would be used. Although it is also a triazole, the mobility of propiconazole is low and it was subsequently used as a substitute for flutriafol. The catchment loadings were recalculated and run through the WRc model. None of the substitutes exceeded the MAC.

The above highlights the problems that are likely to be experienced in practice if partial restrictions are placed on the overall loading of a particular pesticide throughout a catchment. The use of substitute chemicals may well result in the substitutes themselves exceeding the MAC.

5.7 More acceptable pesticides in the Leam catchment

The above has demonstrated that all pesticides currently in use could potentially exceed the MAC depending on the size of the catchment, farm systems and the spectrum of weeds, diseases and pests. The newer pesticides are more environmentally friendly and target specific and this trend is set to continue.

Agro-chemical companies are multi-national organisations operating on a world-wide basis. In addition, the number of companies involved is falling due to a static or declining market in the developed world, increasing competition and the high costs associated with research and development and pesticide registration.

The major agro-chemical companies therefore regard the whole world as their market and, because of the high costs involved, develop pesticides that will have a large and wide-ranging market potential. Because individual countries represent a small market segment, the industry is unlikely to develop specific pesticides to solve specific national needs.

Apart from developing new chemicals, it has been reported that agro-chemical companies are actively developing new products or systems which involve genetic engineering.

Examples include the production of seed which is resistant to glyphosate and integrated crop production systems. Discussions were held with manufacturers' representatives about the likely future developments in the agro-chemical industry but they were, naturally, reticent to divulge details.

MAFF is also undertaking research into achieving safer and reduced pesticide use to ensure human and environmental safety commensurate with the minimum compatible with the efficient production of wholesome agricultural and horticultural produce. This includes increasing the efficiency of pesticide performance, the development of reliable forecasting systems for target diseases and strategies to prevent resistance to pesticides developing. The Ministry is also undertaking work in the field of genetic conservation and modification.

The consultants are not aware of any experimental results that are in the public domain which are of sufficient detail to predict the likely future characteristics of pesticides. Consequently, it has not been possible to assess whether and to what extent future pesticides or production systems will be more environmentally acceptable. As a result, the modelling and costing of this scenario has not been feasible. However, following discussions with the research team, it was concluded that it would be possible to model the ideal physico-chemical properties of pesticides necessary to reduce the pollution risk to the aquatic environment, bearing in mind the differences in soil type between the two catchments. This is discussed in Section 7.4 of the report.

5.8 Non-chemical methods in the Leam catchment

In the absence of definitive information on the likely future development in cultural techniques, the only means available to farmers for controlling weeds through non-chemical methods is to use mechanical implements such as comb weeders. Until new varieties are bred with even higher disease resistance, there is no alternative to chemicals for the control of fungal attacks.

Integrated pest control systems have been developed for glasshouse crops because resistance to pesticides has built up to such an extent that it has now become impossible to control pests by chemical means alone. Research work is being undertaken by MAFF into integrated pest control management systems in arable crops but the outcome, in terms of the practical implications to farmers, is not known.

Non-chemical agricultural practices are not a viable option, primarily because of the specific soil characteristics and farm systems; arable cropping is predominantly winter sown and hence the opportunity for non-chemical weed control is extremely limited. In order to achieve greater non-chemical practices, a significant shift to spring cropping would need to be achieved. In this catchment because of the big differential in yields and hence gross margins between spring and autumn crops, there would be high costs to individual farmers when the necessary additional investment and annual costs of labour and machinery are also taken into account. Assuming that farmers can switch to an alternative chemical, he/she will adopt this as the preferred option because it represents the least-cost alternative and hence minimises the impact on overall farm profitability.

The switch to spring cropping may not represent such a large cost in other catchments where, because of differing soils and farm systems, the differential in yields between winter/autumn sown crops is less marked. The differential in gross margins may also be further reduced in those areas where soils and other management factors enable premium crops (e.g. malting, barley and milling wheat) to be consistently produced.

5.9 Historical pesticide applications in the Colne catchment

WRc and Farmstat produce a series of joint reports in which the total annual application of active ingredients are estimated for key catchments throughout the country. In 1992 the two organisations produced a report for Three Valleys Water Services Plc entitled Service on Pesticide Loadings in Catchments, Report No UC 1783 (November 1992) which covered agricultural pesticide applications for the 1992 harvest year in the Colne Catchment. The base data for these estimates was derived from an ongoing farmer survey of pesticide usage on major crops and grass. The survey results are weighted up using parish statistics so that they are representative of the catchment as a whole.

To determine the overall application loads in 1992 the pesticide application model for the Leam was modified by varying:

- the percentage use of crop to which particular pesticides were applied;
- the range of pesticides applied;
- where appropriate, the application rates of pesticides in order that the difference in soil type could be taken into account;

so that the total active ingredients applied corresponded to that estimated by WRc/Farmstat for the Colne Catchment as a whole.

In order to estimate the pesticide loadings in the sub-catchment being studied, the pesticide application model was then further modified by inserting the sub-catchments 1992 cropping pattern.

WRc/Farmstat data did not exist for 1988. However, Land Capability Consultants undertook a detailed survey of pesticide usage in the Granta catchment in the same year. This catchment is close to the Colne and has similar cropping, soil types and climate and was therefore considered to be representative of the Colne. The pesticide application model was modified using this data so that the area of crops and total active ingredients of each pesticide matched the results of the survey. The 1988 cropping pattern in the Colne was then substituted in order to achieve the overall catchment loadings.

5.10 Protection zone(s) in the Colne catchment

The type of protection zone required in the Colne has more serious implications for farmers because in order to prevent pesticides exceeding the MAC it would be necessary to introduce either one large zone or a series of smaller protected areas. Within the protection zone the use of key pesticides would be banned although it has been assumed that farmers would be able to use substitute chemicals to achieve the same end result. The total area of protection zone has been calculated on that required to contain atrazine within the MAC.

A similar approach has been adopted to that described for the general restriction on the total application of specific pesticides described for the Leam Catchment. In the light of the problems experienced with some of the original substitutes exceeding the MAC, the final range of substitutes also remains the same as those assumed for the Leam. The only addition is the substitution of aziprotryne for a simazine-trietazine mix that is used on peas.

Outside the protection zone it has been assumed that no restrictions would apply.

5.11 Other scenarios in the Colne catchment

The methods adopted for the remaining scenarios in the Colne catchment are the same as those described for the Leam. Consequently, the impact of introducing more acceptable pesticides cannot be quantified. Although they may be appropriate elsewhere, non-chemical agricultural practices are again not viable options in the Colne catchment, because of the specific soil characteristics and farm systems.

6. IMPACT ON FINANCIAL GROSS MARGINS

6.1 No pesticide restrictions

Yield data for major crops in the two catchments was obtained from the following farm management survey reports:

Leam - Farm Business Data, Department of Agricultural Economics and Management, University of Reading, 1993.

Colne - Report on Farming in the Eastern Counties of England 1990/91, University of Cambridge.

The Cambridge and Reading University reports covered the 1990 and 1991 harvest year and accounting periods ending April 1991 and April 1992 respectively. The Reading University report covered the region, including Warwickshire, as a whole while the Cambridge University report sub-divides the region into eleven areas. Data for the south Cambridgeshire and Hertfordshire chalk was used to determine enterprise performance levels in the Colne catchment.

Not all major crops were covered by the University reports. Under these circumstances a composite yield for the quoted crops was compared with their respective national yields. The yields of non-quoted crops were then determined by multiplying the national yield by the overall ratio for quoted crops.

Improved varieties and better management has resulted in an average increase in crop yields of some 2 to 3 percent per annum. It can therefore be anticipated that inherent improvement in yield potential will continue in the future. However, no allowance for further yield increases have been made because under the new support system area payments will decline as national yields increase, thus Gross Margins are likely to remain constant.

Typical financial Gross Margins were constructed for arable crops in the no restriction case in both catchments. For minor crops such as horticulture, a range of enterprises were assumed to be grown and an overall average per hectare taken.

The parish statistics were used to estimate the number of livestock produced per annum in each catchment. The Gross Margin per livestock unit, before forage costs, was assumed to be the same in each catchment except for dairy cows and sheep where milk yield and lambing percentage differed. Forage costs in each catchment were derived from the overall mix of forage crops and the stocking rate. The latter was used to determine the likely inputs of inorganic fertilisers required to achieve the estimated stocking intensity. No further increase in stocking rate is anticipated.

6.2 Total ban on pesticides

Because of the lack of experimental data, Gross Margin predictions for this scenario represent the greatest area of uncertainty. Initially, the possibility of farmers converting to organic systems were investigated but it was finally concluded that this would not be possible because:

- for organic systems, producers must be registered as meeting the organic standards and their farms have to have undergone a period of organic production before they can benefit from any increase in prices. This conversion period represents a considerable cost to each farmer;

- most organic systems are heavily reliant on a high proportion of livestock in the overall enterprise mix in order that sufficient farmyard manure is produced to satisfy the manurial needs of the arable crops;

- a high proportion of grass would need to form an integral part of the overall cropping pattern;

- visual observation suggests that most mixed livestock/arable farmers are already maximising the use of livestock buildings, further investment in these facilities would be difficult to justify;

- the recent introduction of IACS means that it is difficult for farmers to radically alter their overall enterprise mix;

- successful conversion to organic farming requires a specific interest and commitment in the system. If this was already in existence, farmers would have already converted/started to convert.

Consequently, it is therefore believed that under a total ban farmers would attempt to maintain as many of the features found in conventional systems as possible because this represents the least deviation from their current knowledge of husbandry systems.

The next possibility to be investigated was conservation grade farming systems. These are similar to conventional production systems but inputs, particularly of inorganic fertilisers and pesticides, are restricted in order that the economic production of healthy crops and livestock can be achieved. However, because the use of certain pesticides is allowed, conservation grade farming systems as such could not be introduced under the total ban scenario.

It was therefore considered that the most practical production systems that could be introduced under the total pesticide ban would be a mixture of organic and conservation grade systems. However, as it would be necessary to apply inorganic fertilisers to make up for the shortfall in organic manures and allow the crops to compete effectively with the weed populations, price premiums for organic produce would not be achieved.

In June 1992, the Agricultural Economics Unit of Cambridge University produced a report entitled 'Organic Farming as a Business in Great Britain'. The report sets out the findings of a farm management survey of organic producers undertaken between autumn 1989 and early 1991. This report and press articles and reviews on conservation grade performance levels were used as the basis for estimating the likely yields and level of inputs under the total ban scenario. Yield data from organic and conservation grade systems were compared both with each other and conventional systems. After taking into account the technical impacts of reduced fertiliser usage and a total ban on pesticides, an overall yield estimate was made for each crop assuming a high level of management. This was then down graded by the percentage difference between the average yields of conventionally grown crops and those achieved by the top ten percent of farmers in order to derive an overall average yield for the area as a whole.

Yield levels for crops such as oilseed rape, peas, beans and linseed which are not quoted for either organic or conservation grade systems, were estimated using a composite yield depression factor derived from those crops for which sufficient data was available to make a realistic estimate together with an assessment of each crop's ability to withstand competition from weeds.

A comparison of the estimated yields under the No Restriction and Total Ban scenario is presented in Table A1.2:

Table A1.2 Comparison of estimated yields for major crops under the No Restriction and Total Pesticide Ban scenarios

Catchment	Leam			Colne		
Crop	No Restriction t/ha	Total Ban t/ha	% Reduction	No Restriction t/ha	Total Ban t/ha	% Reduction
Winter Wheat	6.10	3.42	44	6.70	3.76	44
Winter Barley	5.16	2.97	44	5.80	3.32	43
Spring Barley	4.20	3.36	20	4.60	3.60	23
Winter Oats	5.00	3.44	31	5.20	3.78	27
Beans	3.30	1.65	50	3.50	1.65	53
Peas	3.20	1.28	60	3.20	1.28	60
Winter OSR	2.70	1.69	37	3.00	1.69	44
Spring OSR	1.70	1.12	34	2.10	1.12	47
Linseed	1.75	0.54	69	1.90	0.54	72

The anticipated decline in the yield of winter oats and spring barley is much less than for that for winter wheat and barley because of their greater ability to compete against weeds. Peas and linseed are less able to compete and hence are likely to suffer serious yield reductions. Under a Total Ban scenario potatoes would cease to be grown because of the high risk of blight infestations. In a bad year the whole crop could be destroyed, thus farmers would switch to other crops which have a more certain outcome. Yield reductions and Gross Margins for minor crops have been based on the overall average reduction in yields for the major crops (see Table A1.3).

Table A1.3 Minor crop gross margins

Catchment	Leam	Colne		
Crop	Total Ban £/ha	Other Scenarios £/ha	Total Ban £/ha	Other Scenarios £/ha
Mixed Corn	315	466	343	517
Horticultural Crops	816	1454	621	1107
Other Crops	295	446	322	494
Set Aside*	267	267	267	267

* 1992 set aside payments = £180 per hectare

Weeds would be controlled by mechanical means, primarily by undertaking several passes with a combweeder. An allowance for this has been made by calculating a net increase in expenditure on labour and machinery costs after deducting the overhead costs saved through not being able to spray the crops. As they form part of a farm's fixed costs, this increase does not feature in the Gross Margin analysis.

Because of the need to use inorganic fertiliser, crops and livestock would not qualify as organic produce and hence the price premia obtained for this produce would not be achieved. Discussions were held with traders who specialise in the marketing of conservation grade produce. The typical premium obtained for crops grown under this production system is between 8 and 15 percent over that achieved for conventionally grown crops. However, currently there is no premium market for malting barley, beans, peas, oilseed rape, linseed, potatoes and vegetables. Thus premiums are largely confined to cereal crops.

Outline estimates were undertaken of the national production of conservation grade crops currently produced and this was compared with the likely future levels of production for the Leam and the Colne catchments. The production of wheat from the two catchments is estimated to at least equal that grown elsewhere while the production of oats is likely to rise to about half of that produced nationally. The increase in conservation grade barley is estimated to rise by about 70 percent. If all farmers in the two catchments tried to market their cereal crops as conservation grade produce the impact on price premia would be considerable due to the large increase in production and the relatively slow growth in this market. It could be argued that the current premia would be negated; however the following premia over conventionally grown crops has been, optimistically, assumed:

Crop	**% Price Premium**
Wheat	2
Barley	2
Oats	3

The introduction of a total ban would have very little impact on livestock systems because very little pesticide is applied to grassland. The main impact is likely to be increased expenditure on labour and machinery costs due to extra topping and hand pulling of grassland weeds, depending on the density of weed population found. The main impact would be felt by those farmers who grow forage maize as a ban is likely to reduce yields by 45 percent. However, because the replacement feed value of this crop is high, these farmers would expand the maize area at the expense of the lowest Gross Margin cereal crop in order to make up the shortfall.

In order to minimise the impact of a total pesticide ban on management effort and in view of its more limited impact on livestock production systems, it has been assumed that farmers with livestock enterprises would continue to manage them under conventional systems. Consequently, no price premia has been assumed and the Gross Margins, before forage costs remain the same as those under the No Restriction scenario.

6.3 Other restriction scenarios

Assuming farmers' management ability is high (within the constraints imposed by the soil type), the introduction of the Restricted Use and Protection Zone scenarios should have no impact on yield potential, providing the correct substitute pesticides are used. This has been assumed to be the case because most farmers now have a much more professional approach to managing their businesses than in the past and most farmers use specialist consultants or representatives to advise them on the overall pesticide programme that should be adopted. Consequently, the main impact of these scenarios on the Gross Margins would be the net change in cost of pesticides due to the replacement of the key pesticides by suitable alternatives.

As indicated earlier, the imposition of non-chemical methods on agriculture would equate to the Total Ban scenario.

Typical financial Gross Margins have been constructed for the No Restriction and each of the relevant restriction cases for the period 1992/93 to 1995/96 to reflect not only the impact of restrictions but also the predicted changes resulting from the recent introduction of the new agricultural support systems. The results for the 1993/94 marketing year are summarised in Tables A1.4 and A1.5. It has been assumed that the restrictions are introduced in the autumn of 1992, thus the Gross Margins for the 1992/93 marketing year are the same for all options.

Table A1.4 Leam catchment - Depression in financial gross margins caused by alternative restrictions in pesticide usage

Restriction Scenario	Predicted Financial Gross Margin - £ per hectare - 1993/94 Marketing Year									
	Winter Wheat	Winter Barley	Spring Barley	Winter Oats	Potatoes	Beans	Peas	Winter Oilseed Rape	Spring Oilseed Rape	Linseed
No Restrictions	554	462	405	486	966	539	512	566	517	493
Total Ban	399	349	402	410	324	434	374	562	519	444
Restricted Use	540	458	403	481	966	535	512	566	517	493
Protection Zone	554	462	405	486	966	539	512	566	517	493

Table A1.5 Colne catchment - Depression in financial gross margins caused by alternative restrictions in pesticide usage

Restriction Scenario	Predicted Financial Gross Margin - £ per hectare - 1993/94 Marketing Year								
	Winter Wheat	Winter Barley	Spring Barley	Winter Oats	Beans	Peas	Winter Oilseed Rape	Spring Oilseed Rape	Linseed
No Restrictions	634	537	452	514	553	505	620	584	526
Total Ban	436	385	427	445	434	374	562	519	444
Restricted Use	631	531	452	514	543	505	620	584	526
Protection Zone*	619	526	452	514	538	502	620	584	526

* Gross Margins for those crops wholly within the protection zone(s)

Certain points should be noted when considering Tables A1.4 and A1.5. These are as follows:

- the absolute reduction in the Gross Margins for certain crops between each restriction scenario and the No Restriction case will tend to decline over the next three years because;

- cereal prices are predicted to fall while compensatory area payments will increase;

- usage of certain of the key pesticides under the No Restriction case are predicted to decline anyway, thus the net increase in pesticide costs are expected to fall for some crops under the Restricted Use and Protection Zone scenarios. For example, in the Leam the use of chlorotoluron is predicted to decline by 15 percent between 1992 and 1997;

- where crop Gross Margins remain unchanged in the No Restriction, Restricted Use and Protection Zones scenarios, key pesticides are not used as part of the crop pesticide programmes;

- gross margins in the Leam protection zone option remain as in the No Restriction case because outside the grass strip adjoining the water courses normal pesticide applications can be made.

7. PROJECTION OF FUTURE LAND USE UNDER THE RESTRICTION SCENARIOS

7.1 Introduction

The cropping and stocking for each study area has been projected forward to 1997 and is assumed to remain constant thereafter. The projections have not been taken beyond this point due to the difficulty of predicting future technological developments and future changes in international trading conditions and price support mechanisms.

7.2 Leam catchment - Total Ban scenario

Cropping in the 1993 harvest year was assumed to remain the same as that under the no restriction area because farmers would have no experience of the husbandry and financial implications of a total ban. Thereafter, as the impacts of a total ban become known, farmers will respond by changing their cropping patterns in order to improve both the rotation and financial performance of their businesses.

The Gross Margins for each of the major crops were derived for the Total Ban scenario. Additional Gross Margins were constructed for spring wheat and oats but their financial performance was below that of the winter sown alternative. Consequently, these alternatives were not considered further. In addition, the heavy soil precludes a dramatic swing to spring cropping.

The relative profitability of the arable enterprises was compared and the points at which enterprises became more or less profitable in relation to the others was noted. This, together with rotational constraints, was used to predict future land use. The resulting projections of land use are given in Appendix 1.

Winter oilseed rape remains the most profitable break crop and is likely to be maximised at the expense of peas and linseed. These latter crops are therefore likely to be discontinued. The relative profitability of winter oats rises, primarily due to its competitive nature, above that of winter wheat. Consequently, it is assumed that the latter would decline in favour of oats. The relative profitability of winter barley also declines but the crop is likely to be retained as a partial entry into winter oilseed rape. Conversely, the financial performance from spring barley would rise, thus the area of this crop could be expected to increase while beans would also need to be increased to take the place of potatoes as a break crop.

The area of forage maize is predicted to rise by 45 percent to offset the reduction in yield. The cost of buying in alternative foodstuffs to replace the loss in yield per hectare far exceeds the Gross Margin derived from cereals.

The area of horticultural crops and other fodder crops is assumed to remain the same as in the No Restriction case because horticultural crops still represent a relatively high Gross Margin per hectare while other forage cropping is predicted to be discontinued.

7.3 Colne catchment - Total Ban

The approach adopted for the Colne catchment was the same as that described for the Leam. The projections are given in Appendix 1.

Apart from wheat, the changes in relative Gross Margins were the same as that found in the Leam catchment. Consequently, while oilseed rape would again be maximised at the expense of peas and linseed, the area of winter barley would fall but spring barley is likely to increase. Winter oats are also expected to increase but the rise would be constrained by limited demand. An increase is also expected in the area of beans in order that a balanced rotation can be achieved.

As in the Leam, the change in the area of horticultural crops and fodder crops is expected to remain the same as in the No Restriction case, while the area of fodder maize increases to offset the anticipated yield reduction.

Livestock numbers and the area of forage crops are not expected to change. Although livestock enterprises would be largely unaffected by a total ban, further expansion would not be viable due to the introduction of beef and sheep quotas and the difficulty of justifying further investment in buildings and waste storage facilities, fencing and water supplies.

7.4 Other restriction scenarios

The projected land uses for other scenarios are given in Appendix 1 for both catchments.

The relative profitability of arable crops under the Restricted Use and Protection Zone scenarios remains the same as that in the No Restriction case. Consequently, no difference in the projected cropping is anticipated except for forage maize which would be expanded by 30 percent in the affected areas to offset the reduced weed control achieved by pyridate which would be substituted for atrazine. In each catchment it has been assumed that forage maize would be expanded at the expense of those arable crops with the lowest Gross Margins per hectare. Again, livestock numbers remain unchanged.

8. THE EFFECT OF RESTRICTING PESTICIDE USAGE ON THE PROFITABILITY OF AN AVERAGE FARM

8.1 Introduction

The restriction of pesticide usage will have an effect on the profitability of farms within the catchment areas where restrictions are imposed. To illustrate the impact, 'model' farms were constructed based on an average farm in each of the two study areas.

The average farm size was derived from the analysis of parish statistics in the two catchment areas. The Gross Margins (described in Section 6 of this Annex) for the No Restriction case and each of the restriction scenarios were used to establish the total from Gross Margins. Typical fixed cost levels were obtained from the farm management survey data published by Cambridge and Reading Universities.

The detailed calculations are given in Appendix 2.

8.2 Farm size, cropping and stocking

In 1992 the number of farms in the Leam catchment was as follows: 29 specialist or mainly dairy farms, 20 pig or poultry farms, 11 horticultural units together with 179 lowland cattle/sheep, cropping cattle and sheep and 159 specialist or general cropping farms. There were also 56 farms which annually let grass for grass keep. Because of the difficulty in deriving a typical farm from such a wide range of farming systems, the following assumptions were made:

- the farms which regularly let grass keep are assumed to let the land to other farmers in the catchment and were therefore ignored;
- the horticultural units were assumed to occupy only land classified as being under horticulture;
- specialist pig and poultry farms were assumed to have no grassland or arable crops;
- the dairy farms were assumed to be specialist dairy units and hence would grow only grass and fodder crops.

The area occupied by the dairy farms was estimated by converting the number of dairy cows and dairy youngstock into Livestock Units and multiplying by the overall stocking rate (LU/ha) for specialist dairy farms quoted in the Reading University farm management survey. This was then deducted from the total agricultural area in the catchment and the balance divided by 338 (e.g. the total of 179 and 159) to arrive at the average farm size for a mixed arable, beef and sheep holding. Because these farms predominate in the catchment, they were taken as the typical farm 'model'. On the basis of the above estimates, it has been assumed that the typical livestock/arable farm extends to 83.0 ha, of which 47.7 ha are currently down to crops, 33.1 ha under grass and the balance, 2.2 ha, being woods and other land.

A similar approach was adopted for the Colne catchment. In 1992 there were 13 horticultural units, 11 pig and poultry units, 44 holdings which let grass keep, 13 specialist and mainly dairy units, 25 lowland cattle and sheep/cropping, cattle and sheep holdings and 42 specialist cereals or general cropping units. The average farm size of a beef, sheep and arable holding is estimated to be 95.6 ha, of which 61.5, 31.1 and 3.0 ha are arable, grass and woods and other land respectively.

8.3 Fixed costs

The fixed costs per hectare were derived from the Reading and Cambridge University survey reports and, apart from rent, rates and unpaid labour, were adjusted for inflation. The assumed fixed costs are as shown in Table A1.6.

Table A1.6 Assumed fixed costs

		Leam Catchment £/ha	Colne Catchment £/ha
Labour	- Paid	55.2	76.2
	- Unpaid	67.1	35.8
Power	- Fuel/Electricity	20.2	23.1
	- Repairs/Insurance	36.4	41.7
	- Depreciation	65.4	75.1
Occupier's Repairs		20.5	16.9
Miscellaneous		38.8	32.1
Rent and Rates*		88.9	82.8

*The rental charge was assumed to apply to all farms, even if owner occupied.

The assumed marginal cost per labour hour was £5.52, calculated as follows from the Agricultural Wages Board rates for 1992/93:

	£/Week
Minimum wage (non-craftsman)	137.33
NIC/Employers Liability Insurance	15.13
Overtime (8 hours/week @ £5.18/hour incl NIC/ELI)	46.01
Premium over basic wage (incl NIC/ELI)	31.09
Total Cost per Week	229.56
Total Cost per Year	£11,937.00
Cost per Hour (2162 hours/year)	£5.52

A premium has been incorporated to allow for the fact that farmers frequently pay over the basic rate.

Marginal changes in machinery repairs and fuel costs have been based on the average cost per hour for 43 to 49 kw and 56 - 65 kw tractors quoted in the 23rd edition of the Farm Management Pocketbook by J. Nix. A unit cost of £1.46 and £1.75 has therefore been taken for fuel/oil and repairs respectively. The tractor hours assumed for the major crops were as shown in Table A1.7.

Under the Total Ban scenario, it has also been assumed that in order to keep grass weeds under control an additional 10 percent of the ley and permanent pasture area would be topped and 20 percent pulled where weed densities were lower. The tractor and labour hours assumed were 2.8 and 4.8 hours respectively.

An allowance was also made for increased labour and machinery hours in the Protection Zone and Restricted Use scenarios for those relevant areas of crops where double spray passes with substitute chemicals would be necessary to obtain the same overall level of protection as that achieved by the restricted or banned key pesticides. The estimated increases in labour and machinery hours are shown in Table A1.8

Table A1.7 Tractor hours for major crops

	Standard Tractor Hours per Annum	
	Total Ban	Other Scenarios
Leys	11.0	11.1
Permanent Pasture	7.0	7.0
Maize	13.5	12.0
Winter Wheat	15.0	13.0
Winter Barley	14.2	13.0
Spring Barley	13.4	13.0
Winter Oats	15.0	13.0
Beans	13.2	12.0
Peas	13.2	12.0
Oilseed Rape	14.2	13.0
Linseed	13.6	13.0

Table A1.8 Increases in labour and machinery hours

	Labour Hours/ha	Machinery Hours/ha
Colne Protection Zone		
- Winter Wheat/	+0.24	+0.24
Winter Barley	+0.10	+0.10
Restricted Use (Leam and Colne)		
- Winter Wheat	+0.10	+0.10
- Winter Barley		

Future changes in cropping will affect the overall labour and machinery costs. The incremental changes in cropping per annum were determined and the above unit costs and tractor hours were used to calculate the annual changes in fuel and repair costs. Changes in labour costs were calculated on a similar basis.

Under the Total Ban scenario, farmers would need to invest in a comb weeder to control weeds and a pre-cleaner to remove weed seeds from the harvested crops. The average unit purchase price of these items together with the sale value of sprayers has been assumed to be as follows:

	£
Comb Weeder	2600
Pre-Cleaner	8000
Sprayer	1250

The economic life of the comb weeder and pre-cleaner, used to calculate depreciation charges, has been taken as 5 years.

8.4 Summary of results

A summary of the financial impact of restricting pesticide usage on an average farm in each catchment area is given in Table A1.9, with details in Appendix 2. The underlying assumption is that farming will continue even though losses may be incurred, and that the land will not be allowed to revert to scrub.

Table A1.9 Summary of the impact of restricting pesticide usage on the profitability of an average farm in the catchment areas

Restriction Scenario		Leam M.I.I.* £	Colne M.I.I. £
No Restrictions	- 1992	670	6494
	- 1997	2917	6524
Total Ban	- 1997	(3040)	(1557)
Restricted Use	- 1997	2633	6372
Protection Zone	- 1997	2732	6041

* M.I.I. = Management and Investment Income
Note: brackets denote losses

The management and investment income (M.I.I.) achieved in 1992 represents the last year before the alternative restriction scenarios are imposed. Projected changes in cropping undertaken by the farmer in order to improve or maintain profitability under the No Restriction case or to partially overcome the financial impact of the restrictions is assumed to stabilise from 1997 onwards. The increase in profitability in the Leam, if no restrictions are imposed, is largely due to the fact that yields are below the national average and farmers are likely to benefit from the new support arrangements to a greater extent than their more efficient counterparts elsewhere. Conversely, farms in the Colne catchment are only likely to maintain M.I.I. because their overall yields are above average and the support system tends to discriminate against farmers who regularly achieve yields which are above the national average.

By 1997, the introduction of a Total Ban is likely to reduce the M.I.I. of farms in the Leam and Colne catchments by £71.8 and £84.5 per hectare respectively.

Because of the ability to use substitute chemicals, the introduction of restrictions on the total usage of key pesticides is likely to have a more limited effect, **providing** the substitutes can continue to be used. Under this scenario the M.I.I. in the Leam and Colne catchments is reduced by £3.4 and £1.6 per hectare respectively.

The model for the Protection Zone scenario assumes that the farm falls wholly within the protection zone. Under these circumstances the restrictions in the Colne catchment are more severe than the Restricted Use scenario because the key pesticides are banned; however, substitutes can still be used. Providing the latter can continue to be utilised, the introduction of a protection zone is likely to result in a fall in M.I.I. of £2.2 and £5.0 per hectare in the Leam and Colne catchments respectively. It should be noted that the impact on farmers in the Leam catchment is under estimated because **on average** farmers would lose a relatively small proportion of land, while their counterparts in the Colne would be forced to introduce substitute pesticides on all of the affected crops. However, the model underestimates the likely impact of a protection zone on farmers with land adjacent to watercourses because the cropping is based on that in the catchment as a whole. It is difficult to be more precise without detailed information on the ratio of watercourse length to typical farm size.

9. APPENDICES

Appendix 1	Projected cropping patterns in the Leam and Colne Catchments
Appendix 2	Impact of restricting pesticide usage on the profitability of an average farm in the Leam and Colne catchments.

APPENDIX 1

PROJECTED CROPPING PATTERNS IN THE LEAM AND COLNE CATCHMENTS

LEAM CATCHMENT
NO PESTICIDE RESTRICTIONS

CROPPING	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Crops and Fallow	16119	16119	16120	16127	16135	16143	16143	16143	16143	16143	16143
Leys	2573	2573	2572	2565	2557	2549	2549	2549	2549	2549	2549
Permanent Pasture	10732	10732	10732	10732	10732	10732	10732	10732	10732	10732	10732
Rough Grazing	141	141	141	141	141	141	141	141	141	141	141
Woodland/Other Land	815	815	815	815	815	815	815	815	815	815	815
Sub-Total	30379	30379	30379	30379	30379	30379	30379	30379	30379	30379	30379
CROPPING											
Wheat	8162	7056	7127	7199	7270	7341	7341	7341	7341	7341	7341
Winter Barley	2502	2227	1854	1481	1107	734	734	734	734	734	734
Spring Barley	282	251	98	65	32	0	0	0	0	0	0
Oats	357	335	251	168	84	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Maize	68	75	90	105	120	135	135	135	135	135	135
Potatoes	262	262	262	262	262	262	262	262	262	262	262
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops excl mushrooms	73	73	72	72	71	70	70	70	70	70	70
Field Beans	1050	1174	1418	1662	1906	2150	2150	2150	2150	2150	2150
Harvest Peas	140	157	172	187	201	216	216	216	216	216	216
Fodder Crops	26	19	14	10	5	0	0	0	0	0	0
Winter Oilseed Rape	1876	1247	1635	2022	2410	2797	2797	2797	2797	2797	2797
Spring Oilseed Rape	0	238	179	119	60	0	0	0	0	0	0
Linseed	638	766	596	427	257	87	87	87	87	87	87
Other crops inc Triticale	13	0	0	0	0	0	0	0	0	0	0
Fallow	59	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	613	2239	2352	2352	2352	2351	2351	2351	2351	2351	2351
TOTAL CROPPING	16119	16119	16120	16127	16135	16143	16143	16143	16143	16143	16143

LEAM CATCHMENT
TOTAL PESTICIDE BAN

CROPPING	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Crops and Fallow	16119	16119	16120	16127	16135	16143	16143	16143	16143	16143	16143
Leys	2573	2572	2572	2565	2557	2549	2549	2549	2549	2549	2549
Permanent Pasture	10732	10732	10732	10732	10732	10732	10732	10732	10732	10732	10732
Rough Grazing	141	141	141	141	141	141	141	141	141	141	141
Woodland/Other Land	815	815	815	815	815	815	815	815	815	815	815
Sub-Total	30379	30379	30379	30379	30379	30379	30379	30379	30379	30379	30379
CROPPING											
Winter Wheat	8162	7056	6501	6066	5631	5197	5197	5197	5197	5197	5197
Spring Wheat	0	0	0	0	0	0	0	0	0	0	0
Winter Barley	2502	2227	2178	2128	2079	2029	2029	2029	2029	2029	2029
Spring Barley	282	251	280	309	338	367	367	367	367	367	367
Winter Oats	357	335	544	752	961	1169	1169	1169	1169	1169	1169
Spring Oats	0	0	0	0	0	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Maize	68	75	105	135	165	195	195	195	195	195	195
Potatoes	262	262	197	131	66	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops excl mushrooms	73	73	72	72	71	70	70	70	70	70	70
Field Beans	1050	1174	1219	1264	1308	1353	1353	1353	1353	1353	1353
Harvest Peas	140	157	118	79	39	0	0	0	0	0	0
Fodder Crops	26	19	14	10	5	0	0	0	0	0	0
Winter Oilseed Rape	1876	1247	1781	2314	2848	3381	3381	3381	3381	3381	3381
Spring Oilseed Rape	0	238	179	119	60	0	0	0	0	0	0
Linseed	638	766	575	383	192	0	0	0	0	0	0
Other crops inc Triticale	13	0	0	0	0	0	0	0	0	0	0
Fallow	59	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	613	2239	2360	2367	2374	2382	2382	2382	2382	2382	2382
TOTAL CROPPING	16119	16119	16120	16127	16135	16143	16143	16143	16143	16143	16143

LEAM CATCHMENT
RESTRICTED PESTICIDE USE

CROPPING	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Crops and Fallow	16119	16119	16120	16127	16135	16143	16143	16143	16143	16143	16143
Leys	2573	2573	2571	2565	2557	2549	2549	2549	2549	2549	2549
Permanent Pasture	10732	10732	10732	10732	10732	10732	10732	10732	10732	10732	10732
Rough Grazing	141	141	141	141	141	141	141	141	141	141	141
Woodland/Other Land	815	815	815	815	815	815	815	815	815	815	815
Sub-Total	30379	30379	30379	30379	30379	30379	30379	30379	30379	30379	30379
CROPPING											
Wheat	8162	7056	7127	7199	7270	7341	7341	7341	7341	7341	7341
Winter Barley	2502	2227	1854	1481	1107	734	734	734	734	734	734
Spring Barley	282	236	80	40	5	0	0	0	0	0	0
Oats	357	335	251	168	84	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Maize	68	93	112	133	152	171	171	171	171	171	171
Potatoes	262	262	262	262	262	262	262	262	262	262	262
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops excl mushrooms	73	73	72	72	71	70	70	70	70	70	70
Field Beans	1050	1174	1418	1662	1906	2150	2150	2150	2150	2150	2150
Harvest Peas	140	157	172	187	201	216	216	216	216	216	216
Fodder Crops	26	19	14	10	5	0	0	0	0	0	0
Winter Oilseed Rape	1876	1247	1635	2022	2410	2797	2797	2797	2797	2797	2797
Spring Oilseed Rape	0	238	179	119	60	0	0	0	0	0	0
Linseed	638	766	596	427	257	56	56	56	56	56	56
Other crops inc Triticale	13	0	0	0	0	0	0	0	0	0	0
Fallow	59	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	613	2236	2349	2348	2347	2346	2346	2346	2346	2346	2346
TOTAL CROPPING	16119	16119	16120	16127	16135	16143	16143	16143	16143	16143	16143

LEAM CATCHMENT
PROTECTION ZONE

CROPPING	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Crops and Fallow	16119	16007	16008	16014	16022	16030	16030	16030	16030	16030	16030
Leys	2573	2573	2572	2565	2557	2549	2661	2661	2661	2661	2661
Permanent Pasture	10732	10844	10844	10844	10844	10844	10732	10732	10732	10732	10732
Rough Grazing	141	141	141	141	141	141	141	141	141	141	141
Woodland/Other Land	815	815	815	815	815	815	815	815	815	815	815
Sub-Total	30379	30379	30379	30379	30379	30379	30379	30379	30379	30379	30379
CROPPING											
Wheat	8162	7007	7076	7145	7218	7288	7288	7288	7288	7288	7288
Winter Barley	2502	2211	1841	1470	1099	729	729	729	729	729	729
Spring Barley	282	249	97	64	31	0	0	0	0	0	0
Oats	357	333	249	167	83	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Maize	68	75	90	105	120	135	135	135	135	135	135
Potatoes	262	262	262	262	262	262	262	262	262	262	262
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops excl mushrooms	73	71	71	71	70	70	70	70	70	70	70
Field Beans	1050	1166	1408	1650	1893	2135	2135	2135	2135	2135	2135
Harvest Peas	140	156	171	185	199	214	214	214	214	214	214
Fodder Crops	26	19	14	10	5	0	0	0	0	0	0
Winter Oilseed Rape	1876	1238	1623	2008	2393	2777	2777	2777	2777	2777	2777
Spring Oilseed Rape	0	236	178	118	59	0	0	0	0	0	0
Linseed	638	761	592	424	255	86	86	86	86	86	86
Other crops inc Triticale	13	0	0	0	0	0	0	0	0	0	0
Fallow	59	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	613	2223	2336	2335	2335	2335	2335	2335	2335	2335	2335
TOTAL CROPPING	16119	16007	16008	16014	16022	16030	16030	16030	16030	16030	16030

COLNE CATCHMENT
NO PESTICIDE RESTRICTIONS

CROPPING	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Crops and Fallow	4166	4166	4165	4163	4162	4161	4161	4161	4161	4161	4161
Leys	820	820	821	822	824	825	825	825	825	825	825
Permanent Pasture	2105	2105	2105	2105	2105	2105	2105	2105	2105	2105	2105
Rough Grazing	243	243	243	243	243	243	243	243	243	243	243
Woodland/Other Land	443	443	443	443	443	443	443	443	443	443	443
Sub-Total	7776	7776	7776	7776	7776	7776	7776	7776	7776	7776	7776
CROPPING											
Wheat	1984	1712	1652	1593	1533	1473	1473	1473	1473	1473	1473
Winter Barley	851	758	739	720	700	681	681	681	681	681	681
Spring Barley	284	146	84	56	28	0	0	0	0	0	0
Oats	105	99	74	50	25	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Maize	27	27	27	27	27	27	27	27	27	27	27
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops excl mushrooms	53	53	56	58	61	63	63	63	63	63	63
Field Beans	126	139	172	206	239	272	272	272	272	272	272
Harvest Peas	0	0	34	68	102	136	136	136	136	136	136
Fodder Crops	5	5	4	3	1	0	0	0	0	0	0
Winter Oilseed Rape	480	345	463	581	698	816	816	816	816	816	816
Spring Oilseed Rape	0	77	58	39	19	0	0	0	0	0	0
Linseed	189	227	191	155	118	82	82	82	82	82	82
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	26	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	36	578	612	611	611	611	611	611	611	611	611
TOTAL CROPPING	4166	4166	4165	4163	4162	4161	4161	4161	4161	4161	4161

COLNE CATCHMENT
TOTAL PESTICIDE BAN

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CROPPING											
Total Crops and Fallow	4166	4166	4165	4163	4162	4161	4161	4161	4161	4161	4161
Leys	820	820	821	823	824	825	825	825	825	825	825
Permanent Pasture	2105	2105	2105	2105	2105	2105	2105	2105	2105	2105	2105
Rough Grazing	243	243	243	243	243	243	243	243	243	243	243
Woodland/Other Land	443	443	443	443	443	443	443	443	443	443	443
Sub-Total	7777	7777	7777	7777	7777	7777	7777	7777	7777	7777	7777
CROPPING											
Winter Wheat	1984	1712	1559	1439	1320	1201	1201	1201	1201	1201	1201
Spring Wheat	0	0	0	0	0	0	0	0	0	0	0
Winter Barley	851	758	698	639	579	519	519	519	519	519	519
Spring Barley	284	146	196	246	296	346	346	346	346	346	346
Winter Oats	105	99	118	136	155	173	173	173	173	173	173
Spring Oats	0	0	0	0	0	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Maize	27	27	30	33	36	39	39	39	39	39	39
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops excl mushrooms	53	53	56	58	61	63	63	63	63	63	63
Field Beans	126	139	191	243	294	346	346	346	346	346	346
Harvest Peas	0	0	0	0	0	0	0	0	0	0	0
Fodder Crops	5	5	4	3	1	0	0	0	0	0	0
Winter Oilseed Rape	480	345	475	605	735	865	865	865	865	865	865
Spring Oilseed Rape	0	77	58	39	19	0	0	0	0	0	0
Linseed	189	227	170	114	57	0	0	0	0	0	0
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	26	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	36	578	611	610	610	609	609	609	609	609	609
TOTAL CROPPING	4166	4166	4165	4163	4162	4161	4161	4161	4161	4161	4161

COLNE CATCHMENT
RESTRICTED PESTICIDE USE

CROPPING	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Total Crops and Fallow	4166	4166	4165	4163	4162	4161	4161	4161	4161	4161	4161
Leys	820	820	821	823	824	825	825	825	825	825	825
Permanent Pasture	2105	2105	2105	2105	2105	2105	2105	2105	2105	2105	2105
Rough Grazing	243	243	243	243	243	243	243	243	243	243	243
Woodland/Other Land	443	443	443	443	443	443	443	443	443	443	443
Sub-Total	7776	7776	7776	7776	7776	7776	7776	7776	7776	7776	7776
CROPPING											
Wheat	1984	1712	1652	1593	1533	1473	1473	1473	1473	1473	1473
Winter Barley	851	758	739	720	700	681	681	681	681	681	681
Spring Barley	284	146	84	56	28	0	0	0	0	0	0
Oats	105	93	74	50	25	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Maize	27	34	34	35	35	35	35	35	35	35	35
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops excl mushrooms	53	53	56	58	61	63	63	63	63	63	63
Field Beans	126	139	172	206	239	272	272	272	272	272	272
Harvest Peas	0	0	28	60	95	129	129	129	129	129	129
Fodder Crops	5	5	4	3	1	0	0	0	0	0	0
Winter Oilseed Rape	480	345	463	581	698	816	816	816	816	816	816
Spring Oilseed Rape	0	77	58	39	19	0	0	0	0	0	0
Linseed	189	227	191	155	118	82	82	82	82	82	82
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	26	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	36	577	611	610	610	609	609	609	609	609	609
TOTAL CROPPING	4166	4166	4165	4163	4162	4161	4161	4161	4161	4161	4161

COLNE CATCHMENT PROTECTION ZONES	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
CROPPING											
Total Crops and Fallow	4166	4166	4165	4163	4162	4161	4161	4161	4161	4161	4161
Leys	820	820	821	823	824	825	825	825	825	825	825
Permanent Pasture	2105	2105	2105	2105	2105	2105	2105	2105	2105	2105	2105
Rough Grazing	243	243	243	243	243	243	243	243	243	243	243
Woodland/Other Land	443	443	443	443	443	443	443	443	443	443	443
Sub-Total	7776	7776	7776	7776	7776	7776	7776	7776	7776	7776	7776
CROPPING											
Wheat	1984	1712	1652	1593	1533	1473	1473	1473	1473	1473	1473
Winter Barley	851	758	739	720	700	681	681	681	681	681	681
Spring Barley	284	146	84	56	28	0	0	0	0	0	0
Oats	105	93	74	50	25	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Maize	27	34	34	34	34	34	34	34	34	34	34
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops excl mushrooms	53	53	56	58	61	63	63	63	63	63	63
Field Beans	126	139	172	206	239	272	272	272	272	272	272
Harvest Peas	0	0	28	61	96	130	130	130	130	130	130
Fodder Crops	5	5	4	3	1	0	0	0	0	0	0
Winter Oilseed Rape	480	345	463	581	698	816	816	816	816	816	816
Spring Oilseed Rape	0	77	58	39	19	0	0	0	0	0	0
Linseed	189	227	191	155	118	82	82	82	82	82	82
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	26	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	36	577	611	610	610	610	610	610	610	610	610
TOTAL CROPPING	4166	4166	4165	4163	4162	4161	4161	4161	4161	4161	4161

APPENDIX 2

IMPACT OF RESTRICTING PESTICIDE USAGE ON THE PROFITABILITY OF AN AVERAGE FARM IN THE LEAM AND COLNE CATCHMENTS

LEAM CATCHMENT- NO PESTICIDE RESTRICTIONS
FARM MODEL

	1992 no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	5.7		
Permanent Pasture	27.4		
Rough Grazing	0.0		
Maize	0.2		
Fodder Crops	0.1		
DIVIDED BETWEEN STOCK ENTERPRISES (no.):			
Dairy	0	778.8	0
Dairy Replacements	0	295.9	0
Autumn Calving Single Sucklers	7	215.9	1511
Beef heifer Replacements	1	169.0	169
Fattening Suckled Calves	6	60.8	365
2.5 year Beef	8	167.0	1336
2 year Beef	5	204.4	1022
Sheep	124	27.7	3440
CROPPING			
Wheat	24.3	570.4	13860
Winter Barley	7.4	457.7	3387
Spring Barley	0.8	375.5	300
Oats	1.1	478.8	527
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.8	1622.3	1298
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	3.1	533.4	1654
Harvest Peas	0.4	493.8	198
W. Oilseed Rape	5.6	501.5	2808
S. Oilseed Rape	0.0	459.9	0
Linseed	1.9	552.6	1050
Other crops inc Triticale	0.0		
Fallow	0.2		0
Set-Aside Schemes	1.8	180.0	324
TOTAL CROPPING	47.4		
Woodland/Other Land	2.2		
TOTAL FARM AREA	83.0		
TOTAL FARM GROSS MARGIN			33248
Fixed Costs :			
Regular Labour			4584
Unpaid Labour			5569
Power Costs			
- Fuel & Electricity			1675
- Repairs & Insurance			3021
- Depreciation			5430
Occupiers Repairs			1701
Rent and Rates			7379
Miscellaneous			3220
TOTAL FIXED COSTS before interest			32577
MANAGEMENT & INVESTMENT INCOME			670
MANAGEMENT & INVESTMENT INCOME PER HA			8.1

LEAM CATCHMENT- NO PESTICIDE RESTRICTIONS
FARM MODEL

	1997 no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	5.7		
Permanent Pasture	27.4		
Rough Grazing	0.0		
Maize	0.4		
Fodder Crops	0.0		
DIVIDED BETWEEN STOCK ENTERPRISES (ha):			
Dairy	0	839.7	0
Dairy Replacements	0	371.1	0
Autumn Calving Single Sucklers	7	278.6	1950
Beef heifer Replacements	1	257.7	258
Fattening Suckled Calves	6	95.1	571
2.5 year Beef	8	249.1	1992
2 year Beef	5	226.9	1134
Sheep	124	30.7	3801
CROPPING			
Wheat	21.7	588.7	12776
Winter Barley	2.2	503.5	1108
Spring Barley	0.0	458.7	0
Oats	0.0	527.9	0
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.8	1622.3	1298
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	6.4	543.9	3481
Harvest Peas	0.6	518.6	311
W. Oilseed Rape	8.3	574.7	4770
S. Oilseed Rape	0.0	520.3	0
Linseed	0.3	493.3	148
	0.0		
Other crops inc Triticale	0.0		
Fallow	0.0		0
Set-Aside Scheme (net of spray costs)	7.0	238.8	1671
TOTAL CROPPING	47.3		
Woodland/Other Land	2.2		
TOTAL FARM AREA	83.0		
TOTAL FARM GROSS MARGIN			35269
Fixed Costs :			
Regular Labour			4433
Unpaid Labour			5569
Power Costs			
- Fuel & Electricity			1641
- Repairs & Insurance			2980
- Depreciation			5430
Occupiers Repairs			1701
Rent and Rates			7379
Miscellaneous			3220
TOTAL FIXED COSTS before interest			32352
MANAGEMENT & INVESTMENT INCOME			2917
MANAGEMENT & INVESTMENT INCOME PER HA			35.1

LEAM CATCHMENT- TOTAL PESTICIDE BAN
FARM MODEL

	1997 no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	5.6		
Permanent Pasture	27.4		
Rough Grazing	0.0		
Maize	0.6		
Fodder Crops	0.0		
DIVIDED BETWEEN STOCK ENTERPRISES (ha):			
Dairy	0	839.5	0
Dairy Replacements	0	370.9	0
Autumn Calving Single Sucklers	7	278.5	1950
Beef heifer Replacements	1	257.6	258
Fattening Suckled Calves	6	95.0	570
2.5 year Beef	8	248.9	1991
2 year Beef	5	226.7	1134
Sheep	124	30.6	3799
CROPPING			
Wheat	15.4	459.2	7072
Winter Barley	6.0	416.2	2497
Spring Barley	1.1	463.6	510
Oats	3.6	470.2	1693
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.0	1135.4	0
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	4.0	433.5	1734
Harvest Peas	0.0	374.4	0
W. Oilseed Rape	10.0	561.9	5619
S. Oilseed Rape	0.0	519.1	0
Linseed	0.0	444.0	0
	0.0		
Other crops inc Triticale	0.0		
Fallow	0.0		0
Set-Aside Scheme (net of spray costs)	7.0	238.8	1671
TOTAL CROPPING	47.1		
Woodland/Other Land	2.2		
TOTAL FARM AREA	82.9		
TOTAL FARM GROSS MARGIN			30497
Fixed Costs :			
Regular Labour			3873
Unpaid Labour			5563
Power Costs			
- Fuel & Electricity			1598
- Repairs & Insurance			2928
- Depreciation			7293
Occupiers Repairs			1698
Rent and Rates			7370
Miscellaneous			3216
TOTAL FIXED COSTS before interest			33538
MANAGEMENT & INVESTMENT INCOME			-3040
MANAGEMENT & INVESTMENT INCOME PER HA			-36.7

LEAM CATCHMENT - RESTRICTED PESTICIDE USAGE
FARM MODEL

	1997 no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	5.7		
Permanent Pasture	27.4		
Rough Grazing	0.0		
Maize	0.5		
Fodder Crops	0.0		
DIVIDED BETWEEN STOCK ENTERPRISES (ha):			
Dairy	0	838.8	0
Dairy Replacements	0	369.9	0
Autumn Calving Single Sucklers	7	277.8	1944
Beef heifer Replacements	1	256.8	257
Fattening Suckled Calves	6	94.5	567
2.5 year Beef	8	247.9	1983
2 year Beef	5	226.0	1130
Sheep	124	30.5	3787
CROPPING			
Wheat	21.7	582.6	12654
Winter Barley	2.2	501.3	1089
Spring Barley	0.0	456.5	0
Oats	0.0	526.6	0
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.8	1622.3	1258
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	6.4	535.7	3407
Harvest Peas	0.6	518.6	331
W. Oilseed Rape	8.3	574.7	4756
S. Oilseed Rape	0.0	520.3	0
Linseed	0.2	493.3	82
	0.0		
Other crops inc Triticale	0.0		
Fallow	0.0		0
Set-Aside Scheme (net of spray costs)	6.9	238.8	1657
TOTAL CROPPING	47.0		
Woodland/Other Land	2.2		
TOTAL FARM AREA	82.9		
TOTAL FARM GROSS MARGIN			34902
Fixed Costs :			
Regular Labour			4401
Unpaid Labour			5559
Power Costs			
- Fuel & Electricity			1637
- Repairs & Insurance			2975
- Depreciation			5420
Occupiers Repairs			1697
Rent and Rates			7366
Miscellaneous			3214
TOTAL FIXED COSTS before interest			32269
MANAGEMENT & INVESTMENT INCOME			2633
MANAGEMENT & INVESTMENT INCOME PER HA			31.8

LEAM CATCHMENT- PROTECTION ZONE
FARM MODEL

	1997 no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	5.7		
Permanent Pasture	27.8		
Rough Grazing	0.0		
Maize	0.4		
Fodder Crops	0.0		
DIVIDED BETWEEN STOCK ENTERPRISES (ha):			
Dairy	0	839.7	0
Dairy Replacements	0	371.1	0
Autumn Calving Single Sucklers	7	278.6	1950
Beef heifer Replacements	1	257.7	258
Fattening Suckled Calves	6	95.1	571
2.5 year Beef	8	249.1	1992
2 year Beef	5	226.9	1134
Sheep	124	30.7	3801
Additional Costs for Persistent Weed Control			0.0
CROPPING			
Wheat	21.6	588.7	12717
Winter Barley	2.2	503.5	1108
Spring Barley	0.0	458.7	0
Oats	0.0	527.9	0
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.8	1622.3	1298
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	6.3	543.9	3426
Harvest Peas	0.6	518.6	311
W. Oilseed Rape	8.2	574.7	4713
S. Oilseed Rape	0.0	520.3	0
Linseed	0.3	493.3	148
	0.0		
Other crops inc Triticale	0.0		
Fallow	0.0		0
Set-Aside Scheme (net of spray costs)	6.9	238.8	1648
TOTAL CROPPING	46.9		
Woodland/Other Land	2.2		
TOTAL FARM AREA	83.0		
TOTAL FARM GROSS MARGIN			35075
Fixed Costs :			
Regular Labour			4430
Unpaid Labour			5569
Power Costs			
- Fuel & Electricity			1638
- Repairs & Insurance			2977
- Depreciation			5430
Occupiers Repairs			1701
Rent and Rates			7379
Miscellaneous			3220
TOTAL FIXED COSTS before interest			32343
MANAGEMENT & INVESTMENT INCOME			2732
MANAGEMENT & INVESTMENT INCOME PER HA			32.9

COLNE CATCHMENT - NO PESTICIDE RESTRICTIONS
FARM MODEL 1992

	no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	8.3		
Permanent Pasture	19.2		
Rough Grazing	3.6		
Maize	0.4		
Fodder Crops	0.1		
DIVIDED BETWEEN STOCK ENTERPRISES (no.):			
Dairy	0	865.0	0
Dairy Replacements	0	310.4	0
Autumn Calving Single Sucklers	14	226.2	3167
Beef heifer Replacements	3	180.9	543
Fattening Suckled Calves	13	68.5	891
2.5 year Beef	4	181.5	726
2 year Beef	0	214.7	0
Sheep	56	26.3	1470
CROPPING			
Wheat	29.6	673.2	19927
Winter Barley	12.7	548.6	6967
Spring Barley	4.2	432.7	1817
Oats	1.6	513.2	821
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.0	1622.3	0
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	2.0	566.4	1127
Harvest Peas	0.0	477.8	0
W. Oilseed Rape	7.2	555.0	3996
S. Oilseed Rape	0.0	524.9	0
Linseed	2.8	582.1	1630
Other crops inc Triticale	0.0		
Fallow	0.4		0
Set-Aside Schemes	0.5	180.0	90
TOTAL CROPPING	61.0		
Woodland/Other Land	3.0		
TOTAL FARM AREA	95.6		
TOTAL FARM GROSS MARGIN			43172
Fixed Costs :			
Regular Labour			7287
Unpaid Labour			3422
Power Costs			
- Fuel & Electricity			2207
- Repairs & Insurance			3986
- Depreciation			7178
Occupiers Repairs			1611
Rent and Rates			7915
Miscellaneous			3072
TOTAL FIXED COSTS before interest			36678
MANAGEMENT & INVESTMENT INCOME			6494
MANAGEMENT & INVESTMENT INCOME PER HA			67.9

COLNE CATCHMENT - NO PESTICIDE RESTRICTIONS

FARM MODEL	1997 no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	8.4		
Permanent Pasture	19.2		
Rough Grazing	3.6		
Maize	0.4		
Fodder Crops	0.0		
DIVIDED BETWEEN STOCK ENTERPRISES (ha):			
Dairy	0	932.8	0
Dairy Replacements	0	386.5	0
Autumn Calving Single Sucklers	14	289.7	4055
Beef heifer Replacements	3	270.4	811
Fattening Suckled Calves	13	103.4	1344
2.5 year Beef	4	264.5	1058
2 year Beef	0	237.9	0
Sheep	56	29.1	1628
CROPPING			
Wheat	22.1	648.3	14329
Winter Barley	10.2	570.6	5820
Spring Barley	0.0	500.1	0
Oats	0.0	550.9	0
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.0	1622.3	0
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	4.1	561.8	2304
Harvest Peas	2.0	507.6	1015
W. Oilseed Rape	12.2	627.7	7658
S. Oilseed Rape	0.0	588.2	0
Linseed	1.2	528.0	634
	0.0		
Other crops inc Triticale	0.0		
Fallow	0.0		0
Set-Aside Scheme (net of spray costs)	9.2	238.8	2197
TOTAL CROPPING	61.0		
Woodland/Other Land	3.0		
TOTAL FARM AREA	95.6		
TOTAL FARM GROSS MARGIN			42852
Fixed Costs :			
Regular Labour			7053
Unpaid Labour			3422
Power Costs			
- Fuel & Electricity			2153
- Repairs & Insurance			3922
- Depreciation			7178
Occupiers Repairs			1611
Rent and Rates			7916
Miscellaneous			3072
TOTAL FIXED COSTS before interest			36328
MANAGEMENT & INVESTMENT INCOME			6524
MANAGEMENT & INVESTMENT INCOME PER HA			68.2

COLNE CATCHMENT - TOTAL PESTICIDE BAN
FARM MODEL

	1997 no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	8.4		
Permanent Pasture	19.2		
Rough Grazing	3.6		
Maize	0.6		
Fodder Crops	0.0		
DIVIDED BETWEEN STOCK ENTERPRISES (ha):			
Dairy	0	932.3	0
Dairy Replacements	0	385.7	0
Autumn Calving Single Sucklers	14	289.1	4047
Beef heifer Replacements	3	269.7	809
Fattening Suckled Calves	13	102.9	1338
2.5 year Beef	4	263.7	1055
2 year Beef	0	237.3	0
Sheep	56	29.0	1623
CROPPING			
Wheat	18.0	490.8	8834
Winter Barley	7.7	446.9	3441
Spring Barley	5.2	484.6	2520
Oats	2.6	500.0	1300
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.0	1135.4	0
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	5.2	433.5	2254
Harvest Peas	0.0	374.4	0
W. Oilseed Rape	13.0	561.9	7305
S. Oilseed Rape	0.0	519.1	0
Linseed	0.0	444.0	0
	0.0		
Other crops inc Triticale	0.0		
Fallow	0.0		0
Set-Aside Scheme (net of spray costs)	9.1	238.8	2173
TOTAL CROPPING	60.8		
Woodland/Other Land	3.0		
TOTAL FARM AREA	95.6		
TOTAL FARM GROSS MARGIN			36700
Fixed Costs :			
Regular Labour			7140
Unpaid Labour			3422
Power Costs			
- Fuel & Electricity			2140
- Repairs & Insurance			3907
- Depreciation			9048
Occupiers Repairs			1611
Rent and Rates			7916
Miscellaneous			3072
TOTAL FIXED COSTS before interest			38257
MANAGEMENT & INVESTMENT INCOME			-1557
MANAGEMENT & INVESTMENT INCOME PER HA			-16.3

COLNE CATCHMENT - RESTRICTED PESTICIDE USAGE
FARM MODEL

	1997 no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	8.4		
Permanent Pasture	19.2		
Rough Grazing	3.6		
Maize	0.5		
Fodder Crops	0.0		
DIVIDED BETWEEN STOCK ENTERPRISES (ha):			
Dairy	0	932.1	0
Dairy Replacements	0	385.4	0
Autumn Calving Single Sucklers	14	288.9	4044
Beef heifer Replacements	3	269.5	809
Fattening Suckled Calves	13	102.8	1336
2.5 year Beef	4	263.4	1054
2 year Beef	0	237.1	0
Sheep	56	29.0	1622
CROPPING			
Wheat	22.0	648.3	14254
Winter Barley	10.2	569.2	5785
Spring Barley	0.0	500.1	0
Oats	0.0	550.9	0
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.0	1622.3	0
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	4.1	553.5	2247
Harvest Peas	1.9	507.6	977
W. Oilseed Rape	12.2	627.7	7645
S. Oilseed Rape	0.0	588.2	0
Linseed	1.2	528.0	646
	0.0		
Other crops inc Triticale	0.0		
Fallow	0.0		0
Set-Aside Scheme (net of spray costs)	9.1	238.8	2170
TOTAL CROPPING	60.6		
Woodland/Other Land	3.0		
TOTAL FARM AREA	95.3		
TOTAL FARM GROSS MARGIN			42591
Fixed Costs :			
Regular Labour			7022
Unpaid Labour			3414
Power Costs			
- Fuel & Electricity			2147
- Repairs & Insurance			3911
- Depreciation			7160
Occupiers Repairs			1606
Rent and Rates			7895
Miscellaneous			3064
TOTAL FIXED COSTS before interest			36218
MANAGEMENT & INVESTMENT INCOME			6372
MANAGEMENT & INVESTMENT INCOME PER HA			66.8

COLNE CATCHMENT - PROTECTION ZONES
FARM MODEL

	1997 no./ha	GM per head/ha	Total Gross Margin £
FORAGE			
Leys	8.4		
Permanent Pasture	19.2		
Rough Grazing	3.6		
Maize	0.5		
Fodder Crops	0.0		
DIVIDED BETWEEN STOCK ENTERPRISES (ha):			
Dairy	0	932.1	0
Dairy Replacements	0	385.5	0
Autumn Calving Single Sucklers	14	288.9	4045
Beef heifer Replacements	3	269.6	809
Fattening Suckled Calves	13	102.8	1337
2.5 year Beef	4	263.5	1054
2 year Beef	0	237.2	0
Sheep	56	29.0	1623
CROPPING			
Wheat	22.1	634.1	14015
Winter Barley	10.2	563.4	5746
Spring Barley	0.0	500.1	0
Oats	0.0	550.9	0
Mixed Corn/Rye/Triticale	0.0		
Potatoes	0.0	1622.3	0
Sugar Beet	0.0		
Hops	0.0		
Hort Crops	0.0		
Field Beans	4.1	553.4	2269
Harvest Peas	1.9	504.8	959
W. Oilseed Rape	12.2	627.7	7658
S. Oilseed Rape	0.0	588.2	0
Linseed	1.2	528.0	634
	0.0		
Other crops inc Triticale	0.0		
Fallow	0.0		0
Set-Aside Scheme (net of spray costs)	9.2	238.8	2197
TOTAL CROPPING	60.9		
Woodland/Other Land	3.0		
TOTAL FARM AREA	95.6		
TOTAL FARM GROSS MARGIN			42345
Fixed Costs :			
Regular Labour			7036
Unpaid Labour			3422
Power Costs			
- Fuel & Electricity			2150
- Repairs & Insurance			3919
- Depreciation			7178
Occupiers Repairs			1611
Rent and Rates			7916
Miscellaneous			3072
TOTAL FIXED COSTS before interest			36305
MANAGEMENT & INVESTMENT INCOME			6041
MANAGEMENT & INVESTMENT INCOME PER HA			63.2

ANNEX 2

HISTORICAL AND FUTURE PESTICIDE USE AND THE EFFECT ON NON-AGRICULTURAL USERS OF RESTRICTING PESTICIDE USE

1. INTRODUCTION

This annex describes the method used to derive non-agricultural pesticide use in the Leam and Colne catchment areas.

Areas on which non-agricultural pesticides are applied are assumed to remain constant.

The impact of the various scenarios has been evaluated on the Leam catchment only, there being no predicted case of non-agricultural pesticides exceeding the MAC in the Colne catchment.

2. SURVEY APPROACH

The boundaries of the two catchments were used to de-lineate the study area and a copy of the appropriate map with questionnaire and covering letter was sent through to named individuals or positions of all organisations identified as significant users (see Appendix 1). These included local government authorities, public utilities, transport (rail and road) and golf clubs.

Response rate to the questionnaire was poor and it was found necessary to back up the request for information either through a personal visit or telephone calls. One respondent stated that the need for obtaining detailed information on pesticide use was evaluated and rejected on the grounds of time and effort.

Local authorities are 'multi users' of pesticides covering such departments as amenities, highways and environmental health. Where possible contact was restricted to one individual with the responsibility of providing the relevant information to avoid double-counting. On occasions it was necessary to obtain information from departments separately either because the nominated person had not been successful in so doing or no one person was nominated as representative.

Due to the study areas not coinciding with the operational areas of the users, the respondents were requested to estimate the likely allocation of pesticide usage to the study areas. On occasions where this was not possible the consultants obtained measurements for areas within the catchment and applied the appropriate pesticide application rates.

A number of users were unable to provide information due to 'administrative problems' and the request for further pesticide data collection (two recent surveys were being carried out by Thames Water and the National Rivers Authority) was greeted with some dismay. The co-operation of Thames Water was helpful in securing appropriate information from a number of respondents.

3. HISTORICAL AND FUTURE PESTICIDE APPLICATIONS

3.1 Introduction

The recent ban in the non-agricultural use of atrazine and simazine with effect from 31st August 1993, the continued prominence of Severn Trent's 'Spraysafe' campaign in the Leam catchment (and elsewhere) and the fact that most local authorities are now committed to an environmental charter, have all served to focus users in the public sector on the need to reduce the impact of pesticides on the environment. The majority of respondents confirmed that they were regularly reviewing their policy on pesticide use in order to maintain the balance between cost effectiveness and environmental impact.

Accurate and detailed information on pesticide usage greater than one year old was difficult to obtain for the following reasons:

- the majority of pesticide applications are carried out by contractors who are normally given an approved list of pesticides from which they select pesticides of their own choice - the client not requiring details of the active ingredients and rates at which they are applied;
- the client's main concern is that the performance and cost levels stipulated in the contract have been fulfilled using pesticides on the approved list;
- the rate of application and mixes used in applications is generally viewed by contractors as part of their 'competitive edge' in what is a fiercely competitive industry and they are normally unwilling to divulge the full application details;
- the role of detailed record keeping of spray operations is generally viewed by the client as being the responsibility of the contractor, which combined with the requirement for greater efficiency in local government and other organisations limited the resources available to provide the necessary data;
- with the introduction of competitive tendering there has also been an increase in the number of contractors carrying out contracts over comparatively short time periods. In one particular instance, information was unobtainable on the previous year's application since the contractor involved had lost the contract and was not prepared to provide the necessary information.

Notwithstanding the lack of availability and accuracy of the data, a methodology to evaluate trends in pesticide usage has been developed and is detailed below.

For both the Leam and Colne catchments comparison of the estimated figures on pesticide usage obtained during the field survey was made with the findings of a report commissioned by the Department of the Environment 'The Use of Herbicides in Non-Agricultural Situations in England and Wales' completed by Produce Studies Limited in January 1991. The Produce Studies Report was prepared on the basis of water company operating areas, Severn Trent for the Leam and Thames Water for the Colne. The Produce Studies calculation of active ingredients for the Water Company areas were apportioned according to this study's gross catchment areas and comparison then made between the Produce Studies figures and those obtained during this study. It was then possible to obtain an indication as to the changes in pesticide use over the two year period to the time of collection of data for this study (November 1992 to June 1993). Further analysis is included in Appendix 2.

Where it was not possible to obtain full details of pesticide use by individual respondents estimates of pesticide application were made either through the use of unit measurements and active ingredient application rates or through the use of a model - this method being adopted for the calculation of pesticide use by golf courses in the Colne catchment.

3.2 Historical pesticide applications - the Leam catchment

A summary table of active ingredient levels calculated from the Produce Studies 1991 report and the figures gained during this study is shown in Appendix 2. Changes in pesticide usage in the Leam Catchment indicate:

- the virtual disappearance in the use of atrazine and simazine with the exception of a small quantity 'being used up' by a contractor on behalf of a utility;
- a 70% increase in the use of dichlobenil (Casoron G), a residual herbicide recorded by amenity and utility users;
- a substantial increase, albeit from a small base, in the use of maleic hydrazide, a plant growth regulator used on roadside vegetation in this instance;
- an increase of over 100% in the use of glyphosate which was also the most popular pesticide being used by the majority of users and which was calculated as the highest quantity of active ingredient applied in the catchment area;
- a decrease of 50% in the use of mecoprop, the majority being applied by one amenity user;
- pesticides used in the maintenance of 'fine turf' areas have shown a significant increase, areas such as golf and bowling greens requiring regular application of fungicides, lumbricides and herbicides to maintain the quality of turf.

3.3 Future use of pesticides in the leam Catchment without restriction

Respondents to the survey indicated that the future use of pesticides would continue to be decided on the basis of cost and efficiency. The 'weather window' can be a particular problem with the use of glyphosate and a number of users were considering contractors' proposals to increase the use of residuals such as imazapyr and diuron. However a number of users indicated that they were now more careful in their selection of residual chemicals due to the potential environmental impact of their use.

It was quite clear in discussions with the respondents that the main reason for the abrupt increase in glyphosate and diuron has been the banning of atrazine and simazine. It is expected that usage of these chemicals will soon stabilise. Subject to legislative and policy restrictions, none of the respondents expected to make any major changes in their approved range of chemicals. Any changes that would be made would be driven by revisions in budgets - expectations being downwards - although it was not possible to quantify any likely changes.

In estimating the future use of pesticides it has been assumed that mecoprop and diuron are the only pesticides likely to be restricted and that existing usage of other pesticides is unlikely to change significantly over the time period.

3.4 Total ban throughout the Leam catchment

Under this scenario, no pesticides were assumed to be used by the non-agricultural sector. The financial impact is discussed in Annex 4.

3.5 Protection zone in the Leam catchment

Protection zones in this surface water catchment are assumed to be:

Type of Surface	Protection Zone
Roads and hard surfaces	Complete Ban*
Railways	50 m either side of each traversed water course
Soft surface**	9.6 m either side of the water course

* Although the dilution is not known it is considered likely that all drains serving hard surfaces will lead directly into water courses serving the Leam catchment.

** Grass verges, sports pitches, flower beds, etc.

The width of the protection zones have been calculated on the basis of the area required to contain isoproturon (which was not recorded as being used by the non-agricultural sector) within the MAC.

The main impact will be on the cost of weed control on roads, rail and hard surfaces since there would be an effective ban on the use of diuron - a residual herbicide of choice for some users.

Diuron is used by British Rail for weed control on tracks running through the catchment. The use of the contractors' 'spray train' allows accurate spraying of pre-determined lengths. It is understood that in selected areas (outside this catchment), sensitive zones close to water courses have been agreed between Severn Trent and British Rail where a restricted range of chemicals are used. The results of this work are not yet known but the logistics of changing the spray regime for short distances of track have been feasible to implement.

Soft surfaces which fall within 9.6 metres of water courses serving the Leam within the catchment and on which pesticides are used constitute a small area. The area has been calculated by applying the apportionment between urban and agricultural area in the catchment (approximately 14% of the gross land area is for use other than agriculture) to the protection zone allocation of 245 ha. 14% of the protection zone area is approximately 43 ha, and it is assumed that out of this 43 ha, 7 ha would be taken up by hard surfaces including roads and railways with 8 ha being allocated to soft surfaces for which there is a 9.6 m protection zone. The balance of 28 ha would be taken up by private residential/industrial areas and golf courses.

3.6 Restrictions on the quality and timing of pesticides in the Leam catchment

Restrictions on the quantities and timing are considered for mecoprop and diuron.

For the most effective control of problem weeds recommendations are given by the manufacturers on timing of applications. In the case of mecoprop (which in this instance is used in a mix with 2,4-D) optimum results are obtained when weeds are in active growth normally between April and September.

For diuron, a residual herbicide acting through the plant roots, optimum results are obtained from later Winter to early Spring. Applications to frozen ground is not recommended since moisture is required to carry the chemical through the rooting zone of weed.

Theoretically, there is scope to vary the timing, however in practice, the preferred timing of application by users is when the application of pesticides are likely to have the optimum effect. This is normally in Spring when the soil is damp and weeds are showing active growth. In performance-related contracts the contractor wishes to fulfil the agreed performance levels as cheaply as possible and ensuring as complete a 'kill' as possible. To practically spray outside the optimal period would incur extra cost, increase the volume of pesticides applied overall and not achieve the necessary level of 'kill'. The opportunity to vary the timing of the two chemicals is not therefore considered to be a viable option.

As with pesticides sold into the agro-chemical sector, manufacturers are required to provide clear recommendations on application rates for each pesticide on each container. It is also the responsibility of the person carrying out the application to ensure that he has *"read and understood the safety precautions, particularly the instructions on the product* *label*". (Page 41, Part 9 of the Code of Practice for the use of Approved Pesticides in Amenity and Industrial Areas).

Some pesticide application contracts now state the concentration of active ingredient and application rates and include a statement that all work on the contract shall be carried out strictly in accordance with the Control of Pesticides Regulations 1986 with regard to the supply, storage and use of pesticides. On such contracts, whilst there may be opportunity for spot (rather than blanket) spraying, there is little scope to reduce the concentration of active ingredient applied per hectare. Also, applications of pesticides below manufacturer's recommended rates can reduce the effectiveness of the chemical thereby risking the need for the contractor to re-visit the site and incur extra costs. However, it is likely that where volumes of active ingredient are not stated in the contract, contractors do adjust the rates to suit the particular situation. It has not been possible to confirm this. The most realistic option is therefore to restrict the area to which chemicals are applied in the catchment.

3.7 More acceptable pesticides in the Leam catchment

Diuron and mecoprop are the only pesticides currently used in the non-agricultural sector which are likely to exceed the MAC. Due to the small size of the market compared to agriculture, the research and development budget for the development of specifically non-agricultural pesticides is comparatively small. The majority of new chemicals are 'spin offs' from the agricultural sector. As with agriculture, the 'environmental friendliness' of pesticides is becoming a key selling point as Monsanto have so successfully demonstrated with the introduction of glyphosate to the non-agricultural sector.

Further discussion on this issue is very similar to that relating to agriculture and is discussed in Annex 1, Section 5.7, and will not be dwelt upon here.

3.8 Non-chemical methods in the Leam catchment

Respondents to the survey indicated that various methods of non-chemical methods of pest control are used in the catchment. These range from the use of a 'Weed Ripper' which is occasionally used to sweep road edges and kerbs, the planting of roses with improved disease resistance (thereby minimising the use of fungicides) and improved mulching of herbaceous borders to reduce the need for herbicides. The design of roads, pathways and street furniture to reduce the likelihood of weed establishment can contribute to reducing the use of pesticides although this was not possible to realistically quantify. A new system of chemical-free vegetation control has recently been introduced to the UK from New Zealand where it is well established in local authority use. It trades under the name Waipuna Systems Limited and reportedly controls vegetative growth through the application of superheated water applied at specific pressure and volume. No costs are available for the systems at the time of writing. 'Weed burners' have met with some success on the continent but, as for the use of superheated water, there has been little up-take in the UK to-date.

The use of mechanical and manual methods of weed removal are possible alternatives to the use of herbicides in some situations. These have been used in calculating the costs under the Total Ban scenario.

3.9 Historical pesticide applications in the Colne catchment

The same methodology as used for the Leam Catchment has been applied to the Colne catchment. Table 2 in Appendix 2 compares the level of active ingredients recorded in this survey and those calculated from the Produce Studies survey of 1991. Analysis of the data collected during the study and that available from the Produce Studies report indicate:

- the complete disappearance in the use of atrazine and simazine;
- substantially greater use of pesticides overall - three times the quantity of active ingredients over that recorded in the Leam catchment in an urban area of approximately double the size;
- mecoprop was calculated to be the active ingredient of greatest volume predominantly due to golf course use;
- four times the glyphosate use over that recorded in the 1991 Product Studies Survey for a range of users, the major ones being roads and railways;
- a considerable use of thiophanate-methyl which is sold as a fungicide for use on fine turf areas and in this catchment predominantly used by the golf sector.

3.10 Scenarios in the Colne catchment

Since none of the pesticide concentrations in borehole water of the Colne catchment requiring reduction - atrazine, simazine, isoproturon and chlortoluron - were found to be used or are likely to be used in the non-agricultural sector, no development of the scenarios has been carried out.

4. APPENDICES

Appendix 1	Survey of non-agricultural pesticide use
Appendix 2	Analysis of Produce Studies data

APPENDIX 1

SURVEY OF NON-AGRICULTURAL PESTICIDE USE

Table A2.1 Contacts made during the survey of non-agricultural users of pesticides

Contact Name	Position	Organisation
LEAM CATCHMENT		
M J Stockwin	Director	Adams Cundell Engineers Ltd
Mr J Allbutt		John Allbutt Associates
Mr N Astley	-	Astley Landscapes
Mr S Jarrett	-	Audit Commission
Mr R Trow-Smith	Communications Manager	B.A.A
-	The Secretary	B.A.S.I.S
Mr T Bott	Transmission Engineering Manager	British Gas (West Midlands)
Mr A Barclay	Facilities Manager	British Gas (West Midlands)
Mr R Raybold	Gas Supply Manager	British Gas (West Midlands)
Mr M Clarke	Permanent Way Contracts	British Rail Technical Services Manager
Mr T Hopkins	Intercity Civil Engineer	British Rail
Mr J Bright	Permanent Way Maintenance Assistance	British Rail
Ms J Baker	Building Services Officer	British Telecom (West Midlands)
Mr A Grimmett	Engineering Supervisor	British Waterways
Mr R Turner	Managing Director	Complete Weed Control Ltd
Mr D O Pryse	-	Complete Weed Control Ltd
Mr A P Lord	Sales Manager	Danline International Ltd
Mr D Walsh	Principal Environmental Health Officer	Daventry District Council
Mr R Cure	Horticultural Manager	Department of Transport
P J Adkins	District Operations Manager	East Midlands Electricity
Mr S Hennell	Safety Adviser	East Midlands Electricity
Mr R A Lane	-	Environmental Husbandry
Mr D Ives	Supervisor Operations & Maintenance Department	East Midlands Electricity
Mr J Tilley	Agency Manager	Forest Enterprise
Mr N O'Connor	Principal Inspector	Health & Safety Executive
Mr L Shaw	Golf Course Manager	Hellidon Lakes Hotel & Country Club
Mr A Marlow	Contracts Manager	Languard Ltd
Mr D Compton	Head Green Keeper	Leamington & County Golf Club
Mr A Jones	Pesticides Safety Division	MAFF
Mr F Biddlestone	Civil Engineering Department	Midlands Electricity plc
Mr C W Cother	Civil Engineering Department	Midlands Electricity plc
Mr J Cox	Marketing Manager	Monsanto plc

Table A2.1 continued/2

Contact Name	Position	Organisation
Mrs Smith	-	National Association of Agricultural Contractors
Mr A Witte	Secretary	National Association of Public Golf Courses
M Gordon	Area Surveyor	Northampton Planning & Transportation
Mr M Lowden	Daventry Area Surveyor	Northamptonshire County Council
Mr R Anderson	Client Services	Northamptonshire County Council
Mr K Parrott	Deputy Motorway & Trunk Roads Manager	Northamptonshire County Council
Mr McCleod	Secretary	Northamptonshire Union of Golf Clubs
Mr J Batty	Pollution Control Officer	NRA
Mr M Dunkley	Grounds Maintenance Manager	Nuneaton & Bedworth Council
Mr C C H Fry	Environmental Health Manager	Nuneaton & Bedworth Council
Mr J Bradbury	-	Oakfords Contracting Limited
Ms H Cranmer	-	OFWAT
Ms Joan Elliot	Bursar	Princethorpe College
B W Jayes	Department of Technical Services	Rugby Borough Council
Mr D Cox	-	Rugby Borough Council
Mr R Honeybunn	-	Rugby Borough Council
Mr I Stuart	-	Rugby Borough Council
Mr J Lawton	Chief Executive	Rugby Borough Council
Mr B Jones	Client officer	Rugby Borough Council
Mrs K Stone	Chief Environmental Health Officer	Rugby District Council
Mr Smith	Groundsman	Rugby School
Mr E Ewington	Acting Water Supply Manager	Severn Trent Water Ltd
Ms B Ryan	-	Severn Trent Water Ltd
Mr G Forrest-Hay	Quality Planning	Severn Trent Water Ltd
Mr C J King-Turner	Quality and Environmental Planning	Severn Trent Water
Mr M Porter	-	Severn Trent Plc
Dr R Breach	Water Quality Manager	Severn Trent Water
Mr T Harris	Golf Course Manager	Staverton Park Golf Club Ltd
P J Ogden	Amenity Services Manager	Stratford upon Avon District Council

Table A2.1 continued/3

Contact Name	Position	Organisation
Mr T Barrett	Principal Environmental Health Officer	Stratford upon Avon District Council
Mr A Shreeve	Housing Department	Stratford Services
Mr J Kirk	Chief Environmental Health Officer	Warwick District Council
Mr S Lawrence	Architectural Services Technician	Warwick District Council
Mr J McGowan	Contracts Manager Amenities Department	Warwick District Council
Mr B Bywater	Assistant Engineer	Warwick District Council
Mr T H Cripps	Senior Contracts Manager	Warwick Services
Mr R Holmes	Sports & Grounds Client Service Manager	Warwickshire County Council Education Department
Mr M Hancocks	Planning & Transportation Department	Warwickshire County Council
Mr T Holmes	Information Management & Research	Warwickshire County Council
Mr F B Evans	Divisional Engineer	Warwickshire County Council
Mr C Whittaker	Highways Manager	Warwickshire County Council
Mr Urry	-	Warwickshire Union of Golf Clubs
Mr R C Davis	Divisional Surveyor	Warwickshire County Council
Mr A Chapman	Green Keeper	Whitefields Hotel & Golf Complex Ltd
Mr M Bullock	-	3 Counties Spraying Company
COLNE CATCHMENT		
Mr A Morton	Green Keeper	Abbey View Golf Course
Mr A Low	Green Keeper	Aldenham Golf Course
Mr A Low	Head Green Keeper	Aldenham Golf Course
Mr I Robinson	Head of Facilities	Barnet Healthcare
-	Head Green Keeper	Batchwood Hall Golf Course
Mr M J Morrison	Standards Production Officer	British Gas
Mr G Mansfield	Operational Support Engineer	British Gas Eastern
Mr J G Gill	Engineering Service Manager	British Gas Eastern
Mrs J Quigley	Environmental Policy Manager	British Telecom Plc
Mr R Ingram	Estate Services	Building Research Establishment
Mr P Harrington	Green Keeper	Bushey Hall Golf Course
Mr S Augustine	Estates Officer	Cell Barns Hospital
Mr S Robertson	Green Keeper	Chorleywood Golf Course

Table A2.1 continued/4

Contact Name	Position	Organisation
Mr Lazenby	-	Dacorum & St Albans Community NHS Trust
Mr P Ankrah	Quality Assurance Technologist	Do-It-All Ltd
Mr C J Drake	Plant Manager	Eastern Electricity
Mr S Jones	Civil Trades Foreman	Eastern Electricity
Mr P Windwood	Environment Business Analyst	Eastern Electricity
Mr C Taylor	-	Forest Enterprise
Mr R F Medhurst	Manager	GU Projects (Three Valleys Water)
Mr R Simons	Estates Officer	Harperbury Hospital
Mr T Hill	Green Keeper	Haste Hill Golf Course
Mr B Cooper	Motorway & Trunk Road Division	Hertfordshire County Council
Mr S Arias	Countryside Information & Development Manager	Hertfordshire County Council
Mrs D Cunion	Waste Regulation	Hertfordshire County Council
Mr B Cowan	Manager, Commercial Services	Hertfordshire County Council
Mr A Howling	Divisional Highway Manager	Hertfordshire County Council
Mr C Connor	-	Hertfordshire County Council, Motorway & Trunk Division
Mr R C Crooks	Chief Environmental Health Officer	Hertsmere Borough Council
Mr Deards	-	Highground
Mr C High	Estates Officer	Leavesden Hospital
Mr G Reed	Green Keeper	Little Hay Golf Complex
Mr N Robinson	-	London Underground
Mr R Powell	Environment & Legislation Manager	London Underground Ltd
Mr Edward	Green Keeper	Moor Park Golf Course
Mr I Robinson	Estates Officer	Napsbury Hospital
Mr P Barlett	Sales Admin Manager	Nomix Chipman
Mr C Slater	Green Keeper	Northwood Golf Course
S Killen	Senior Scientist	NRA
Mr A Ferguson	-	NRA
Mr S Killeen	Senior Scientist	NRA Thames Region
Mr J Edwards	Green Keeper	Rickmansworth Golf Course
Mr G Morris	-	Schering Agriculture Ltd
Mr N Patterson	Estates Officer	Shenley Hospital
Mr R Bangs	Estates Officer	South West Hertfordshire Health Authority

Table A2.1 continued/5

Contact Name	Position	Organisation
Mr J Warburton	Estates Officer	St Albans City Hospital
Mr R Ridley	Director of Environmental Services	St Albans City & District Council
Mr K Holyoake	Quality Control Supervison	St Albans District Council
Ms D Chaplin	-	St Albans District Council
Ms D Pinkstone	Senior Scientist	Thames Water
Dr S White	Principal Scientist	Thames Water Utilities Ltd
Mr M Davis	National Projects Officer	The Pesticides Trust
Mr P Avis	Client Services Manager	Three Rivers District Council
A Gough	Scientific Officer	Watford Council
Mr G Bernard	-	3 Rivers District Council

Our Ref: JCA/2404

7 April 1993

Mr R Ridley
Director of Environmental Services
St. Albans City & District Council
PO Box 2
Civic Centre
St. Peters Street
St. Albans
HERTFORDSHIRE AL1 3JE

Dear Mr Ridley

Department of the Environment: Economic Study of Restrictions in the Use of Pesticides to Improve Water Quality

Thank you for your time on the telephone. As promised I write to give you some more details about the work we are carrying out on behalf of the Department of the Environment.

The study is to evaluate the economic effects of restrictions in the use of pesticides in order to improve water quality. Part of the study requires us to obtain an indication of the likely costs incurred by users of pesticides if alternative forms of restrictions are introduced. The "Three Rivers" catchment area has been selected as one of the pilot areas on which a theoretical study is being carried out; a map is enclosed with the survey area hatched on it. As you will see a part of the Council's operational area comes within the area. The terms of the study include an evaluation of the costs to pesticide users should pesticides in the designated area:

a. be banned throughout the area;
b. require the use of alternative pesticides or non-chemical methods with lower potential for leaching into the water sources.

As a first step we need to identify the normal timing of application and quantity of pesticides used by the Council. We also need to know the actions that the Council would need to take and the strategy adopted if either of the options outlined above were implemented. It is likely that there would be a consequent effect on costs such as the number of people employed, purchases of different types of machinery, alternative techniques of control required etc. I am sure that there are also likely to be a number of other aspects which you feel would impact on the Council's costs and which should be included to complete as realistic assessment and cost benefit analysis as possible.

We also need to know the Council's:

- existing policy on pesticide use;
- changes in pesticide use and policy that have occurred over the past five years; and
- future policy and likely pesticide use over the next five years given your present knowledge of the Council's future needs, pesticide availability and likely legislation.

As we discussed there have been a number of surveys recently carried out on pesticide usage within the area including those by Thames Water and the National Rivers Authority. Each is similar although different in the scope of the information required. It would be much appreciated if I could prevail on

p.t.o......

your patience to complete the enclosed questionnaire.

Thank you for your help in providing the necessary information. For your information I also enclose some details about Gould Consultants. I look forward to hearing from you.

Yours sincerely

JOHN C ARNOLD
enc

Economic Study of Restrictions
in the Use of Pesticides
to Improve Water Quality

A Study carried out on behalf of the
Department of the Environment

Questionnaire

John Arnold,
Gould Consultants,
Birmingham Road,
Saltisford,
WARWICK CV34 4TT

Tel: 0926 496121
Fax: 0926 401882

PLEASE FILL IN THE DETAILS BELOW
BEFORE COMPLETING THE QUESTIONNAIRE:

Name:..

Position:..

Council:..

Telephone Number:................................. **Date:**................................

Questionnaire Number:............

1. Please complete the table below for the Council's existing pesticide usage:

DEPARTMENT/ LOCATION OF USE	PESTICIDES USED		REASONS FOR USE	NORMAL APPLICATION RATE OF ACTIVE INGREDIENT Litres (l) or kilogrammes (kg) per hectare (ha) or acre (ac) * - please delete as necessary below	APPROX- IMATE AREA OF APPLIC- ATION (ha or ac)	NORMAL MONTH(S) OF APPLIC- ATION/ USE	NO. OF APPLIC- ATIONS /YEAR	APPROX. VOLUME OF PESTICIDE USED PER ANNUM Litres (l) or kilo- grammes (kg) * - please delete as necessary below	APPROXIMATE EXPENDITURE /ANNUM (£)	COMMENTS
	BRAND NAME(S)	ACTIVE INGREDIENT								
				l* or kg*/ha* or ac*						
				l* or kg*/ha* or ac*				l* or kg*	£	
				l* or kg*/ha* or ac*				l* or kg*	£	
				l* or kg*/ha* or ac*				l* or kg*	£	
				l* or kg*/ha* or ac*				l* or kg*	£	
				l* or kg*/ha* or ac*				l* or kg*	£	
				l* or kg*/ha* or ac*				l* or kg*	£	
				l* or kg*/ha* or ac*				l* or kg*	£	

2. What is the Council's 1993 budget for expenditure on pesticides? How much has this changed in real term over the past five years and by how much is it likely to change over the next five years?

3. What extra costs would be incurred if pesticides were banned? If there would be a saving please indicate.

Activity	Description of extra work/resources required <u>or</u> savings made	ESTIMATED EXTRA COSTS/ANNUM (£)		
		Labour	Machinery	Other (Please give details)

4. Do you use contractors for any of your pesticide applications? Yes/No
If yes, which applications?

5. Where would you normally obtain advice on the availability, use and legislation of pesticides?

6. What improvements would you like to see in the provision of information and advice on the availability and use of pesticides?

7. What principle changes in the Council's pesticide use have there been over the past five years?

8. What changes in pesticide use does the Council expect to make over the next five years given the present knowledge of the Council's future needs, pesticide availability and likely legislation.

9. What 'policy' does the Council have on pesticide use and what brands of pesticide are recommended for use? How often is the 'policy' and brand listing reviewed and by whom?

THANK YOU FOR THE TIME YOU HAVE
SPENT COMPLETING THIS QUESTIONNAIRE

APPENDIX 2

ANALYSIS OF PRODUCE STUDIES DATA

TABLE 1 - ACTIVE INGREDIENT COMPARISON - GOULD/PRODUCE STUDIES. LEAM CATCHMENT

ACTIVE INGREDIENT	Calculated from PS figures (kg)	Calculated from GOULD figures (kg)	Difference between GOULD & PS figures (kg)	% difference
2,4-D	98.1	96.5	-1.6	-2%
Amitrole	71.1	2.4	-68.7	-97%
Asulam	3.4		-3.4	Not noted by Gould
Atrazine	282.6	1.5	-281.1	-99%
Bromacil	5.1	0.1	-5.0	-98%
Carbaryl		26.3	26.3	Not noted by PS
Dalapon-sodium	3.4		-3.4	Not noted by Gould
Dicamba	5.1	11.8	6.7	132%
Dichlobenil	28.8	48.9	20.1	70%
Dichlorophen		1.7	1.7	Not noted by PS
Diuron	123.5	73.7	-49.8	-40%
Gamma-HCH		3.4	3.4	Not noted by PS
Glyphosate	59.2	119.6	60.4	102%
Imazapyr	18.6	0.2	-18.4	-99%
Ioxynil		17.3	17.3	Not noted by PS
Iprodione		45.0	45.0	Not noted by PS
Maleic Hydrazide	6.8	84.0	77.2	1141%
MCPA	60.9	33.8	-27.1	-45%
Mecoprop	103.2	51.5	-51.7	-50%
Paclobutrazol	1.7		-1.7	Not noted by Gould
Paraquat dichloride	8.5	5.7	-2.8	-33%
Picloram	5.1		-5.1	Not noted by Gould
Simazine	177.7		-177.7	Not noted by Gould
Sodium Chlorate	113.4		-113.4	Not noted by Gould
Thiabendazole		35.6	35.6	Not noted by PS
Thiophanate-methyl		38.0	38.0	Not noted by PS
Triclopyr	22.0	73.0	51.0	232%
TOTAL QUANTITY	1,198	770	-428	-36%
TOTAL COUNT	20	21		

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TABLE 2 - ACTIVE INGREDIENT COMPARISON - GOULD/PRODUCE STUDIES. COLNE CATCHMENT

ACTIVE INGREDIENT	Calculated from PS figures (kg)	Calculated from GOULD figures (kg)	Difference between GOULD & PS figures (kg)	% difference
2,4-D	200.5	189.0	-11.4	-6%
Amitrole	101.9	46.4	-55.5	-54%
Asulam	1.7	20.0	18.3	1077%
Atrazine	424.7	0.0	-424.7	Not recorded by Gould
Bromacil	25.5	1.8	-23.7	-93%
Carbaryl		50.0	50.0	Not recorded by PS
Carbendazim		8.7	8.7	Not recorded by PS
Dalapon-sodium	13.6		-13.6	Not recorded by Gould
Dicamba	13.6	22.3	8.7	64%
Dichlobenil	61.2	26.0	-35.2	-58%
Dichlorophen		20.4	20.4	Not recorded by PS
Diuron	292.2	214.6	-77.6	-27%
Fosamine-ammonium		24.0	24.0	Not recorded by PS
Gamma-HCH		6.8	6.8	Not recorded by PS
Glufosinate-ammonium		2.4	2.4	Not recorded by PS
Glyphosate	90.0	371.8	281.7	313%
Imazapyr	27.2	2.8	-24.4	-90%
Ioxynil	3.4		-3.4	Not recorded by Gould
Iprodione		184.5	184.5	Not recorded by PS
Maleic Hydrazide	17.0		-17.0	Not recorded by Gould
MCPA	83.2	6.3	-76.9	-92%
Mecoprop	164.8	605.4	440.6	267%
Mefluidide	1.7			Not recorded by Gould
Paclobutrazol	3.4		-3.4	Not recorded by Gould
Paraquat dichloride	11.9	7.0	-4.9	-41%
Picloram	10.2	34.5	24.3	238%
Propyzamide		20.0	20.0	Not recorded by PS
Simazine	302.4		-302.4	Not recorded by Gould
Sodium Chlorate	27.2		-27.2	Not recorded by Gould
Terbutryn		0.1	0.1	Not recorded by PS
Thiabendazole		54.0	54.0	Not recorded by PS
Thiophanate-methyl		360.0	360.0	Not recorded by PS
Triclopyr	32.3	166.7	134.4	416%
Vinclozolin		10.0	10.0	Not recorded by PS
TOTAL QUANTITY	1,909	2,455	546	29%
TOTAL COUNT	22	27		

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SEVERN TRENT REGION						
Area Served (sq.km)	21,600					
Population	8,300,000					
Study Area (sq.km)	365.47	1.69%				
A	B		C	D	E	F
ACTIVE INGREDIENT	FOR WHOLE SEVERN TRENT AREA (tonnes)		Calculated from PS figures (kg) (B x .0169)	Calculated from GOULD figures (kg) (Survey results)	Difference between GOULD & PS figures (kg) (C - D)	% difference
2,4-D	5.8	8%	98.1	96.5	(1.6)	-2%
Amitrole	4.2	6%	71.1	2.4	(68.7)	-97%
Asulam	0.2	0%	3.4		(3.4)	Not noted by Gould
Atrazine	16.7	24%	282.6	1.5	(281.1)	-99%
Bromacil	0.3	0%	5.1	0.1	(5.0)	-98%
Carbaryl				26.3	26.3	Not noted by PS
Dalapon-sodium	0.2	0%	3.4		(3.4)	Not noted by Gould
Dicamba	0.3	0%	5.1	11.8	6.7	132%
Dichlobenil	1.7	2%	28.8	48.9	20.1	70%
Dichlorophen				1.7	1.7	Not noted by PS
Diuron	7.3	10%	123.5	68.9	(54.6)	-44%
Gamma-HCH				3.4	3.4	Not noted by PS
Glyphosate	3.5	5%	59.2	97.6	38.4	65%
Imazapyr	1.1	2%	18.6	0.2	(18.4)	-99%
Ioxynil				17.3	17.3	Not noted by PS
Iprodione				45	45.0	Not noted by PS
Maleic Hydrazide	0.4	1%	6.8	84	77.2	1141%
MCPA	3.6	5%	60.9	10.7	(50.2)	-82%
Mecoprop	6.1	9%	103.2	51.5	(51.7)	-50%
Paclobutrazol	0.1	0%	1.7		(1.7)	Not noted by Gould
Paraquat dichloride	0.5	1%	8.5	5.7	(2.8)	-33%
Picloram	0.3	0%	5.1		(5.1)	Not noted by Gould
Simazine	10.5	15%	177.7		(177.7)	Not noted by Gould
Sodium Chlorate	6.7	9%	113.4		(113.4)	Not noted by Gould
Thiabendazole				35.6	35.6	Not noted by PS
Thiophanate-methyl				38	38.0	Not noted by PS
Triclopyr	1.3	2%	22.0	73	51.0	232%
TOTAL QUANTITY	70.8		1,197.9	720.1	(477.8)	-40%
TOTAL COUNT	20		20	21		

METHODOLOGY:

Column B are the figures recorded by Produce Studies for the Severn Trent Region.
The study area is approximately 1.69% of total Severn Trent Region.
0.0169 has been used as the multiplier on column B to give column C.
Column E is then the difference between C & D.

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METHOD USED TO CALCULATE ACTIVE INGREDIENTS FROM PRODUCE STUDIES DATA. COLNE CATCHMENT.

THAMES REGION						
Area Served (sq.km)	13,750					
Population	11,700,000					
Study Area (sq.km)	233.59	1.70%				
A	B		C	D	E	F
ACTIVE INGREDIENT	FOR WHOLE THAMES AREA (tonnes)		Calculated from PS figures (kg)	Calculated from GOULD figures (kg)	Difference between GOULD & PS figures (kg)	% difference
2,4-D	11.8	10%	200.5	189.0	-11.4	-6%
Amitrole	6	5%	101.9	46.4	-55.5	-54%
Asulam	0.1	0%	1.7	20.0	18.3	1077%
Atrazine	25	22%	424.7	0.0	-424.7	Not recorded by Gould
Bromacil	1.5	1%	25.5	1.8	-23.7	-93%
Carbaryl				50.0	50.0	Not recorded by PS
Carbendazim				8.7	8.7	Not recorded by PS
Dalapon-sodium	0.8	1%	13.6		-13.6	Not recorded by Gould
Dicamba	0.8	1%	13.6	22.3	8.7	64%
Dichlobenil	3.6	3%	61.2	26.0	-35.2	-58%
Dichlorophen				20.4	20.4	Not recorded by PS
Diuron	17.2	15%	292.2	214.6	-77.6	-27%
Fosamine-ammonium				24.0	24.0	Not recorded by PS
Gamma-HCH				6.8	6.8	Not recorded by PS
Glufosinate-ammonium				2.4	2.4	Not recorded by PS
Glyphosate	5.3	5%	90.0	371.8	281.7	313%
Imazapyr	1.6	1%	27.2	2.8	-24.4	-90%
Ioxynil	0.2	0%	3.4		-3.4	Not recorded by Gould
Iprodione				184.5	184.5	Not recorded by PS
Maleic Hydrazide	1	1%	17.0		-17.0	Not recorded by Gould
MCPA	4.9	4%	83.2	6.3	-76.9	-92%
Mecoprop	9.7	9%	164.8	605.4	440.6	267%
Mefluidide	0.1	0%	1.7			Not recorded by Gould
Paclobutrazol	0.2	0%	3.4		-3.4	Not recorded by Gould
Paraquat dichloride	0.7	1%	11.9	7.0	-4.9	-41%
Picloram	0.6	1%	10.2	34.5	24.3	238%
Propyzamide				20.0	20.0	Not recorded by PS
Simazine	17.8	16%	302.4		-302.4	Not recorded by Gould
Sodium Chlorate	1.6	1%	27.2		-27.2	Not recorded by Gould
Terbutryn				0.1	0.1	Not recorded by PS
Thiabendazole				54.0	54.0	Not recorded by PS
Thiophanate-methyl				360.0	360.0	Not recorded by PS
Triclopyr	1.9	2%	32.3	166.7	134.4	416%
Vinclozolin				10.0	10.0	Not recorded by PS
TOTAL QUANTITY	112.4 tonnes		1909.5	2,455	546	29%
TOTAL COUNT			22	27		

METHODOLOGY:

Column B are the figures recorded by Produce Studies for the Thames Region.
The study area is approximately 1.70% of total Thames Region.
0.017 has been used as the multiplier on column B to give column C.
Column E is then the difference between C & D.

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ANNEX 3

WATER TREATMENT COST TABLES

1. TABLES FOR WATER TREATMENT COSTS

The cost estimates for each of the processes (ozone and/or GAC) have been made assuming that plant life is 20 years (both mechanical and civil).

Cost estimates are presented on the following five pages for the following process options:

- Ozone
- GAC alone (15 minutes contact time)
- Ozone/GAC (15 minutes contact time) combination
- GAC alone (5 minutes contact time)
- GAC alone (10 minutes contact time)

The total capital costs and the annual operating costs are presented. The Present Values of these costs are calculated, from these figures, in Appendix 8 of Annex 4.

OZONE COST ESTIMATES

PLANT		RIVER LEAM
Plant size		24 Ml/d
Number of ozone generators		2 (1 as duty standby)
Ozone dose		3 mg l^{-1}
Contact time		10 minutes
Ozone generator capacity (installed)		2 x 3 kg/h
Actual quantity of ozone generated		26.3 tonnes/y
Contact tank volume		1 x 166.7 m^3
CAPITAL COSTS in £,000s		
Generators	:	544.5
Building	:	25.3
Contractors	:	79.6
Repumping	:	0.0
Indirect	:	61.7
Civil	:	256.5
Mechanical	:	454.6
TOTAL	:	711.1
RUNNING COSTS in £,000s/y		
Power(@ 5.0 p/kWh)	:	32.9
Cooling water(@10.0 p/m^3)	:	5.3
Repumping	:	0.0
Maintenance	:	22.7
TOTAL	:	60.9

GAC COST PREDICTIONS

SITE:
Source - RIVER LEAM
which is surface water

PROCESS PARAMETERS:

Plant throughput	:	24. Ml/day
Filters:		
Number in-line	:	10
Pressure	:	3.99 m diameter
	:	2.00 m bed depth
EBCT	:	15.00 mins
Regeneration period	:	62.0 weeks
Regeneration System	:	off-site
GAC Transfer System	:	mechanical

SUMMARY OF CAPITAL COSTS:

		COST (£,000s)
Backwash pump cost	:	58.97
Backwash water tanks cost	:	62.59
Spent GAC storage tank cost	:	0.34
GAC transfer plant cost	:	57.33
Pressure filter construction cost	:	588.84
Feed pump pump-house cost	:	45.70
Initial GAC cost(@ 1500. £/tonne)	:	159.37
Indirect costs	:	98.00
Total civil engineering capital costs	:	452.99
Total mechanical engineering capital costs	:	648.15
TOTAL	:	1101.13

SUMMARY OF RUNNING COSTS:

		COST (£,000s/annum)
Feed pump power cost(@ 5.0 p/kWh)	:	6.24
Backwash water and pump cost	:	9.25
Off-site regeneration cost(@ 750. £/tonne)	:	66.98
Loss of GAC on regeneration	:	6.70
Maintenance costs	:	32.41
Labour costs	:	5.08
TOTAL	:	126.65

GAC COST PREDICTIONS WHEN PRECEDED BY OZONE

SITE:
Source - RIVER LEAM
which is surface water

PROCESS PARAMETERS:

Plant throughput	:	24. Ml/day
Filters:		
Number in-line	:	10
Pressure	:	3.99 m diameter
	:	2.00 m bed depth
EBCT	:	15.00 mins
Regeneration period	:	156.0 weeks
Regeneration System	:	off-site
GAC Transfer System	:	mechanical

SUMMARY OF CAPITAL COSTS:

		COST (£,000s)
Backwash pump cost	:	58.97
Backwash water tanks cost	:	62.59
Spent GAC storage tank cost	:	30.34
GAC transfer plant cost	:	57.33
Pressure filter construction cost	:	588.84
Feed pump pump-house cost	:	45.70
Initial GAC cost(@ 1500. £/tonne)	:	159.37
Indirect costs	:	98.00
Total civil engineering capital costs	:	452.99
Total mechanical engineering capital costs	:	648.15
TOTAL	:	1101.13

SUMMARY OF RUNNING COSTS:

		COST (£,000s/annum)
Feed pump power cost(@ 5.0 p/kWh)	:	6.24
Backwash water and pump cost	:	9.25
Off-site regeneration cost(@ 750. £/tonne)	:	26.62
Loss of GAC on regeneration	:	2.66
Maintenance costs	:	32.41
Labour costs	:	4.33
TOTAL	:	81.51

GAC COST PREDICTIONS (5 MINUTES CONTACT TIME)

SITE:
Source - COLNE VALLEY
which is groundwater

PROCESS PARAMETERS:

Plant throughput	:	114. Ml/day
Filters:		
Number in-line	:	15
Pressure	:	4.10 m diameter
	:	2.00 m bed depth
EBCT	:	5.00 mins
Regeneration period	:	260.0 weeks
Regeneration System	:	off-site
GAC Transfer System	:	mechanical

SUMMARY OF CAPITAL COSTS:

		COST (£,000s)
Spent GAC storage tank cost	:	30.95
GAC transfer plant cost	:	58.10
Pressure filter construction cost	:	903.80
Initial GAC cost(@ 1500. £/tonne)	:	252.34
Indirect costs	:	114.33
Total civil engineering capital costs	:	408.56
Total mechanical engineering capital costs	:	950.96
TOTAL	:	1359.52

SUMMARY OF RUNNING COSTS:

		COST (£,000s/annum)
Feed pump power cost(@ 5.0 p/kWh)	:	40.63
Off-site regeneration cost(@ 750. £/tonne)	:	25.29
Loss of GAC on regeneration	:	2.53
Maintenance costs	:	47.55
Labour costs	:	4.28
TOTAL	:	120.27

GAC COST PREDICTIONS (10 MINUTES CONTACT TIME)

SITE:
Source - COLNE VALLEY
which is groundwater

PROCESS PARAMETERS:

Plant throughput	:	114. Ml/day
Filters:		
Number in-line	:	30
Pressure	:	4.10 m diameter
	:	2.00 m bed depth
EBCT	:	10.00 mins
Regeneration period	:	260.0 weeks
Regeneration System	:	off-site
GAC Transfer System	:	mechanical

SUMMARY OF CAPITAL COSTS:

		COST (£,000s)
Spent GAC storage tank cost	:	30.95
GAC transfer plant cost	:	58.10
Pressure filter construction cost	:	1807.59
Initial GAC cost(@ 1500. £/tonne)	:	504.69
Indirect costs	:	219.44
Total civil engineering capital costs	:	766.01
Total mechanical engineering capital costs	:	1854.75
TOTAL	:	2620.77

SUMMARY OF RUNNING COSTS:

		COST (£,000s/annum)
Feed pump power cost(@ 5.0 p/kWh)	:	32.25
Off-site regeneration cost(@ 750. £/tonne)	:	50.58
Loss of GAC on regeneration	:	5.06
Maintenance costs	:	92.74
Labour costs	:	4.73
TOTAL	:	185.35

ANNEX 4

FINANCIAL AND UK ECONOMIC ANALYSES

1. INTRODUCTION

Two main analyses have been undertaken to appraise the effects on agriculture and non-agricultural organisations from imposing restrictions on the use of pesticides compared with the water treatment costs saved. The two analyses are as follows:

- Financial Analysis - to demonstrate the effects from the point of view of agents in the market place (i.e. farmers, the National Rivers Authority, the Water Companies, etc).
- United Kingdom Economic Analysis - using factors applied to agricultural commodity market prices and support payments, to indicate the effect from the point of view of the United Kingdom. The appropriate factors were obtained from the Ministry of Agriculture, Fisheries and Food (MAFF).

Two study areas were examined, the Leam which is a surface water catchment and the Colne which is a groundwater catchment. The terms of reference called for six alternative scenarios to be examined in each catchment, these were as follows:

- no restrictions;
- a total ban throughout the catchment;
- restrictions on quantities and timing;
- protection zones;
- more acceptable pesticides;
- non-chemical methods.

In practice, four scenarios were examined because the practical scope for implementing the two last-named scenarios was very limited (see Section 4.2 of main text).

Restrictions on the timing of pesticide applications are not considered to be a practical option because there is normally only a narrow 'window' through which the chemicals are effective against the target weeds, diseases or pests. The rate of development of weed growth and the build up of pests and diseases is largely dictated by climatic conditions which vary from year to year. In the two catchments, the existing pesticide usage would suggest that the key weed problems are blackgrass, wildoats and cleavers, and the scope to reduce rates for these weeds is particularly limited. Restrictions on the quantities of pesticides applied therefore means limiting the area to which they can be applied.

The land areas involved in the two catchments, for each scenario considered in detail, are given in Table A4.1 below. Under the Protection Zone option, the land area has been calculated as that required to contain the most problematical key pesticide within the Maximum Admissible Concentration (MAC). This is considered to be the only practical option even though the zone would overprotect for other key pesticides.

Table A4.1 The land area involved under each restriction scenario considered

Catchment	Leam			Colne		
Restriction Scenario	Land Area Affected ha			Land Area Affected ha		
	Agric	N/Agric	Total	Agric	N/Agric	Total
No Restriction/ Total Ban/ Restricted Use	30379	6168	36547	7776	11546	19322
Protection Zones	212	43	255	7000	10400	17400

2. METHOD

The method used in the financial and UK analyses are basically the same, the main difference being the variation in the value of agricultural Gross Margins.

2.1 Agricultural cash flows

The total annual catchment area Gross Margin for the No Restriction and each of the restricted cases was derived by multiplying the projected annual crop areas and numbers of livestock units for each case by their respective Gross Margins per annum.

Regular farm labour costs were derived by using 1992 as the base year and noting the annual change in tractor hours required (see Annex 1) to grow the crops and grass in the two catchment areas. A unit cost per hour was applied to the base cost to reflect the increased or reduced labour requirement.

Machinery repair and fuel costs were also based on the standard tractor hours required to grow the crops and unit costs per hour applied.

Maintenance and miscellaneous costs were based on Cambridge and Reading University costs per hectare and applied to the total agricultural return area in each catchment.

Restrictions on pesticide usage would result in a decrease in farm profitability (see Annex 1) and this may lead to a reduction in both land values and rents. The potential long term fall in rental charges is difficult to determine and is outside the scope of this study. Consequently, it has been assumed that the cost per hectare for the No Restriction case and each of the restriction options within each catchment area will be the same. The incremental cost is therefore zero when comparing the various restriction cases with the No Restriction scenario and rent has therefore been omitted from the cash flows.

The introduction of a total ban will require farmers to invest in a comb weeder to control weeds and pre-cleaning equipment to clean harvested crops. This investment would be partially offset by the sale of their sprayers. The net capital costs have been multiplied by the estimated number of farmers in each catchment with arable crops to arrive at the total incremental investment per annum.

No additional farm equipment, other than that described above, will be required as a result of the changes under the No Restriction and other restriction cases. Consequently, only existing machinery will need to be replaced under the farmers' normal replacement policy. This will be the same for all cases and as a result the incremental cost will be zero. These costs have therefore been omitted from the agricultural cash flow.

The annual regular labour, machinery repairs and fuel, maintenance and miscellaneous costs, have been deducted from the annual total Gross Margins for the catchment area in order to arrive at the annual agricultural cash flow.

The agricultural cash flows, which exclude rent, normal machinery replacement costs and interest charges, have been discounted at eight per cent (which is the appropriate Treasury

Real Discount Rate) over a ten year project life (i.e. 1992 to 2002). The restriction scenarios are assumed to have been introduced in the Autumn of 1992, this year has therefore been taken as Year 0.

The No Restriction case represents the 'future without project' scenario and this has therefore been used as the basis to compare the 'future with project' cases represented by each of the restricted pesticide options. The Present Value (PV) of the former has been deducted from the PV of the alternative restriction cases in order to arrive at the agricultural disbenefits for the various restriction options.

2.2 Non-agricultural areas

2.2.1 No pesticide restrictions

In the first scenario, in which future usage is assumed to be unrestricted, the present levels of pesticide expenditure were estimated for key non-agricultural users in both the Leam and Colne catchment areas. These estimates then provided the benchmark against which the costs and disbenefits of alternative scenarios could be assessed.

Under the No Restrictions scenario, 1993 retail prices for the various pesticides were applied to the estimated volumes currently being applied by non-agricultural users. The main users of pesticides in non-agricultural areas included:

- District Councils (roads, parks/amenity land);
- County Councils (motorways, dual carriageways, trunk roads) on behalf of the Department of Transport;
- British Rail;
- British Telecom;
- British Gas;
- Electricity Supply Companies;
- Water companies; and
- Golf courses.

It should, however, be noted that estimates of the volumes of pesticides applied by private urban users, i.e. residential, industrial and commercial users, were not readily available. Consequently, it was not possible to estimate this type of expenditure. This omission should not detract from the conclusions drawn from the analysis of non-agricultural pesticide usage, as it is very unlikely that there would be any significant change in pesticide usage under either the Restricted Use or Protection Zone scenarios. In addition, the imposition of a total ban on all pesticides within given residential areas would, in practice, be extremely expensive and difficult to enforce.

2.2.2 Total ban on pesticides

Under the Total Ban scenario, the anticipated changes in the methods of weed, disease and pest control that would be required if no pesticides were available were determined for each of the main users. The additional labour and machinery required for alternative practices were then estimated and costed. Mechanical and/or hand methods of weed control generally substituted for pesticides, but for some users further substantial costs are also likely to accrue, e.g. increase in the frequency of re-ballasting rail track (British Rail) and establishing enclosures on motorways (Department of Transport). The postulated changes in practices, as well as the expected increase in expenditure on labour and machinery (or contract charges) were based on discussions with a wide range of non-agricultural users.

The savings in pesticide expenditure, together with the labour/machinery costs (or contract charges) of applying the pesticides, were then deducted from the expenditure on the alternative methods in order to determine the annual incremental costs associated with the enforcement of a total ban on pesticide usage in non-agricultural areas. The Present Value of the incremental costs was calculated over a ten year period at the Treasury Discount Rate of eight percent.

2.2.3 Restricted usage

In order to comply with EC standards on pesticides in water sources, it was established by WRc that only two pesticides (namely Diuron and Mecoprop) currently being applied by non-agricultural users would need to be restricted. This restriction would also only be necessary in the Leam catchment, as the levels of pesticide usage in non-agricultural areas of the Colne catchment are not predicted to cause exceedances of the EC limit for drinking water.

In the Leam catchment suitable substitute pesticides (for Diuron and Mecoprop) were introduced under the Restricted Usage scenario, and the anticipated increase in pesticide expenditure for each non-agricultural user, as well as the overall catchment, was then determined. Finally, the Present Value of the incremental expenditure was calculated over a ten-year period.

2.2.4 Protection zones

It is proposed that a 9.6 metre wide protection zone would be required to avoid any contamination of the watercourse in the Leam catchment by Diuron and Mecoprop. This amounts to about 43 hectares of the non-agricultural land. Restricted pesticides were then assumed to be banned in the protection zones, and so users need to alter their pesticide application practices accordingly. For Local Authority parks/amenity areas and public utility land, the protection zone was considered adequate. However, for roads and railways, where drainage permits a far greater degree of pesticide transmission to watercourses, further restrictions were considered necessary. The incremental costs of applying alternative pesticides for each non-agricultural user under the Protection Zone scenario was then determined. Finally, the Present Value of the incremental costs over a ten year period was calculated.

2.3 Policing costs

The costs of policing both the agricultural and non-agricultural users of pesticides, to ensure that they comply with the restrictions imposed, were determined for the various alternative scenarios, i.e. Total Ban, Restricted Usage and Protection Zone. Since there would be no exceedances of the MAC by **non-agricultural** users in the Colne catchment, no expenditure on policing these organisations should be necessary. The assumptions used in the derivation of these costs are discussed below. Policing costs can be broadly divided into:

- field inspection;
- soil analysis;
- water sampling; and
- water analysis.

2.3.1 Leam catchment

Total Ban on Pesticides

- Field Inspection

  It is estimated that 4 Pollution Inspectors would be required to monitor the agricultural areas of the Leam catchment. Random visits would be made to farms at three times of the year and each Pollution Inspector would be actively engaged on this work for a period of three months per annum. The marginal cost of employing a Pollution Inspector is estimated at £1,583 per month taking into account salary, pension, employers' NI, life and health insurance costs, but excluding overheads and travelling/subsistence expenses.

  In the non-agricultural areas, a Pollution Consultant would need to be employed to check records and contracts of Local Authorities, British Rail, Public Utility Companies, golf courses etc. A Pollution Consultant would be required for 15 days per annum. A fee rate of £450 per day, excluding travelling expenses, has been assumed.

  Travelling expenses have been determined on the assumption that staff would be based in Solihull and travel daily to the catchment area. It is estimated that the total mileage covered by the Pollution Inspectors during the course of a year would be about 20 400 (i.e. 5,100 miles per Inspector), at a cost of £0.42 per mile. The Pollution Consultant is estimated to travel 1,500 miles at the same rate.

- Soil Analysis

No soil sampling and analysis has been assumed under the total ban scenario.

- Water Sampling

Ideally, water sampling should be undertaken at three locations in the catchment (i.e. at the intake, and the two confluences upstream) on a weekly basis. This work is estimated to require 0.5 mandays per week (26 mandays per annum) at a marginal cost of £50 per manday. Travelling expenses have been calculated on the basis of 100 miles per round trip (i.e. 5200 miles per annum) at a cost of £0.42 per mile.

The NRA are currently sampling at one or two locations on a monthly basis, so the staff and travelling cost associated with this activity were deducted from the proposed water sampling schedule in order to determine the incremental water sampling costs.

In practice a more logical and cost effective approach would be to sample at the intake once per month and, if there is a pollution problem, additional samples could be taken further upstream in order to identify the location of the pollution source. This is likely to reduce the 'ideal' water sampling costs by 50 percent, and consequently this has been assumed in the estimation of the net increase in water sampling expenditure.

- Water Analysis

Under the 'ideal' water sampling schedule 312 samples would be taken each year, compared with 18 currently being taken by the NRA. Therefore, an additional 294 samples would need to be analysed for three suites of pesticides at a total estimated cost of £300 per sample.

In practice, the total annual expenditure on water analyses would be reduced by 50 percent if the more cost effective approach to water sampling was adopted, and this assumption has been built into the cost estimates.

Restricted Usage

- Field Inspection

Under the Restricted Usage Scenario, 4 Pollution Inspectors would be required for a period of six months each to closely monitor farms within the Leam catchment, as well as to collect soil samples for analysis. In the non-agricultural areas a Pollution Consultant would be employed for a period of 15 days. Soil samples in the non-agricultural areas would be collected by a Field Assistant, who would be required for five days at a rate of £50 per day.

Pollution Inspectors are estimated to travel approximately 25 500 miles per annum (6375 miles per Inspector). The Pollution Consultant and Field Assistant would travel 1500 miles and 500 miles respectively.

- Soil Analysis

The soils on the 338 farms in the Leam catchment would be sampled once every five years, i.e. 67.6 farms per annum. An average of 12 samples would be collected from each farm, with an allowance of five percent for return visits. The total number of samples collected for analysis would therefore be 852 per annum. The costs of soil analysis is estimated at £300 per sample (i.e. three suites of pesticides at £100 per suite).

In the non-agricultural areas an average of 13 soil samples would be collected from golf courses each year. A further 26 samples would be collected from other non-agricultural areas (based on the ratio of agricultural land to non-agricultural land multiplied by 15 percent to allow for residential areas, roads and other 'hard' areas).

- Water Sampling and Analysis

The incremental water sampling and analysis costs would be the same as under the Total Ban scenario.

Protection Zone

- Field Inspection

Under the Protection Zone scenario it is estimated that four Pollution Inspectors would be required for a period of 2.25 months per annum to monitor the protection zone within the agricultural areas of the Leam catchment. In the non-agricultural areas a Pollution Consultant would be engaged for 15 days.

Pollution Inspectors would travel approximately 15 300 miles per annum (i.e. 3825 miles per Inspector), while Pollution Consultants would travel about 1500 miles per annum.

- Soil Analysis

No soil sampling or analysis has been assumed under the Protection Zone scenario.

- Water Sampling and Analysis

The incremental water sampling and analysis costs would be the same as under the Total Ban scenario.

A summary of the policing costs for the Leam catchment under the various scenarios is given in Table A4.2 and detailed in Appendix 1.

Table A4.2 Summary of Policing Costs - Leam catchment

	Annual Policing Costs (£)		
	Total Ban	Restricted Usage	Protection Zone
Field Inspection	34 948	56 550	28 056
Soil Analysis	-	267 090	-
Water Sampling	1 415	1 415	1 415
Water Analysis	44 100	44 100	44 100
Total Annual Costs	80 463	369 155	73 571
Present Value @ 8% (£'000)[1]	540	2 477	494
Present Value @ 5% (£'000)[2]	621	2 851	568

1 Calculated over a 10 year period at the Treasury Discount Rate of eight percent.
2 Calculated over a 10 year period at Treasury Discount Rate of five percent

2.3.2 Colne catchment

Total Ban on pesticides

- Field Inspection

It is estimated that two Pollution Inspectors will be required to monitor the agricultural areas of the Colne catchment. Each Inspector would undertake this work over a period of three months per annum. In the non-agricultural areas, a Pollution Consultant would be engaged for a period of 20 days.

Pollution Inspectors (based in Ware) are likely to travel approximately 5440 miles per annum (i.e. 2720 miles per Inspector). The Pollution Consultant would travel about 1500 miles per annum.

- Soil Analysis

  No soil sampling and analysis has been assumed under the total ban scenario.

- Water Sampling and Analysis

  It has been assumed that, as traces of pesticides in the ground water could be up to five years old, water sampling and analysis would not be undertaken in the Colne catchment, and so monitoring would need to be focused on field inspection.

Restricted usage

- Field Inspection

  Two Pollution Inspectors would be required, for a period of six months per annum each, to monitor the farms within the Colne catchment, as well as to collect soil samples. In the non-agricultural areas a Pollution Consultant would be required for 20 mandays and a Field Assistant for 10 days.

  Travelling costs have been based on 3400 miles per annum for each Pollution Inspector, 1500 miles per annum for the Pollution Consultant and 750 miles for the Field Assistant.

- Soil Analysis

  The soils on the 67 farms in the Colne catchment would be sampled once every three years and an average of 15.5 samples would be collected from each farm, with a five percent allowance for return visits. The total number of samples collected for analysis would, therefore, be 363 per annum, and soil analysis is estimated to cost £300 per sample.

  In non-agricultural areas an average of 42 soil samples would be collected from golf courses each year. A further 81 samples would be collected from other non-agricultural areas.

Protection zone

The assumptions used for the Protection Zone scenario are the same as for the Restricted Usage scenario, except that the area is reduced by ten percent (i.e. the protection zone covers 90 percent of the overall catchment). This change affects the mileage travelled by Pollution Inspectors (i.e. reduced to 3060 miles per inspector) and the total number of soil samples collected for analysis per annum (i.e. 327 for farms, 38 for golf courses and 73 for other non-agricultural areas).

A summary of the policing costs for the Colne catchment under the various scenarios is given in Table A4.3 and detailed in Appendix 2.

Table A4.3 Summary of Policing Costs - Colne catchment

	Annual Policing Costs (£) Total Ban	Restricted usage	Protection zone
Field Inspection	21 415	21 856	21 570
Soil Analysis	-	109 043	98 138
Water Sampling	-	-	-
Water Analysis	-	-	-
Total Annual Costs	21 415	130 899	119 709
Present Value @ 8% (£'000)[1]	144	878	803
Present Value @ 5% (£'000)[2]	165	1011	924

1 Calculated over a 10 year period at the Treasury Discount Rate of eight percent.
2 Calculated over a 10 year period at Treasury Discount Rate of five percent

2.4 Water treatment costs

A similar procedure has been adopted for engineering costs. In each catchment, it has been assumed that the plant would be constructed in Year 0. The annual capital and O&M (operating and maintenance) costs are presented in Annex 3. The economic life of civil works and mechanical electrical equipment has been taken to be 20 years. Terminal values have been calculated assuming straight line depreciation.

Three water treatment options were costed for the Leam catchment (GAC, ozonation and ozonation followed by GAC). Two options were costed for the Colne catchment, both GAC treatments, one with five minutes, the other with 10 minutes contact time. The two options considered to be the most technically feasible were:

- Leam - ozonation followed by GAC (15 minutes retention time);
- Colne - GAC with a 10 minute retention time.

3. FINANCIAL ANALYSIS

3.1 Introduction

The financial analysis has been undertaken using early to mid 1993 prices which are assumed to remain constant in real terms. For agricultural commodities, the February 2nd UK green rate was taken (£0.951031:1 ECU) to convert prices from ECU to £ Sterling. This was a higher exchange rate than that prevailing in May 1993 (£0.95911:1 ECU) when most of the Gross Margins were constructed, but was used in anticipation of a further strengthening of the pound against other EC currencies. Since May 1993 other changes have taken place, for instance the pound has firmed to a greater extent than envisaged and the EC has modified the level of area payments. In view of the continuing evolution of the agricultural support system, these, and other more minor changes, have not been taken into account. However, they would not affect the results of the financial analysis because any changes equally affect both the No Restriction case and the restriction scenarios. The incremental effect is therefore zero.

The Present Values (PVs) of the financial costs and benefits over ten years are calculated using both an eight and a five percent Treasury Discount Rate.

3.2 Agriculture

The cropping projections for the No Restriction case and each of the restriction options are presented in Annex 1, together with the financial Gross Margins for crops.

The unit costs for labour, machinery repairs and fuel maintenance and miscellaneous costs are discussed in Annex 1 and are briefly summarised in Table A4.4.

Table A4.4 Summary of Agricultural Unit Costs

		Leam £	Colne £
Regular labour (per hour)		5.52	5.52
Machinery -	repairs (per standard tractor hour)	1.75	1.75
	fuel (per standard tractor hour)	1.46	1.46
Occupiers' repairs (per hectare)		20.50	16.90
Miscellaneous costs (per hectare)		38.80	32.10

Annual changes in regular labour costs were derived by calculating the incremental change in cropping and stocking from the 1992 base year and applying the standard labour and tractor hours to the marginal change. The above unit costs were then applied.

The financial agricultural cash flows for the No Restriction case and the alternative restriction scenarios in each catchment were estimated and the Present Values (PV) are summarised in Table A4.5 and detailed in Appendix 3.

Table A4.5 Financial analysis - summary of the Present Values of the agricultural cash flows for the alternative pesticide restriction scenarios

Restriction Scenario	Leam Catchment £'000		Colne Catchment £'000	
	@8%	@5%	@8%	@5%
No Restrictions	67 454	76 565	17 030	19 303
Total Ban	52 306	59 498	12 818	14 530
Restricted Usage	66 829	75 849	16 955	19 218
Protection Zone(s)	67 072	76 123	16 700	18 921

The PV of the agricultural disbenefits for each restriction option is presented in Table A4.6. Although the agricultural area in the Colne is significantly smaller than that in the Leam, the similarity of disbenefits under the Protection Zone option is explained by the fact that, in the Colne, the zone will occupy 90 per cent of the area whereas in the Leam, it is less than one per cent of the agricultural area.

Table A4.6 Financial analysis - summary of the Present Value of agricultural disbenefits from the alternative pesticide restriction scenarios

Restriction Scenario	Leam catchment £'000		Colne catchment £'000	
	@8%	@5%	@8%	@5%
Total Ban	15 148	17 067	4212	4773
Restricted Usage	625	716	75	85
Protection Zone(s)	382	442	330	382

3.3 Non-agricultural areas

In the financial analysis of the costs and disbenefits to non-agricultural users, the following assumptions were made with respect to the alternative scenarios under review.

3.3.1 No restrictions

The volumes of pesticides presently being applied by non-agricultural users were determined on the basis of information provided by the main users. In 1993 retail prices for the range of pesticides applied were then obtained from manufacturers and distributors and applied to these volumes. The volumes of pesticides applied by user, together with the pesticide prices and total expenditure, are given in Appendix 4.

The estimated costs of annual pesticide applications by non-agricultural users within the Leam and Colne catchments under the No Restriction scenario are summarised in Table A4.7. Golf courses are the main users of pesticides, accounting for 53 and 49 percent of expenditure in the Leam and Colne catchments respectively. Other important users are Local Authorities (mainly for parks/amenity land) and British Rail.

Table A4.7 Present annual expenditure on pesticides by non-agricultural users in the Leam and Colne catchment areas

Non-Agricultural User	Annual Pesticide Expenditure (£) Leam	Colne
District Councils	13 404	15 908
Motorway/Trunk Roads	1 367	6 189
British Rail	6 965	11 633
British Telecom	-	586
British Gas	68	479
Electricity Companies	17	395
Water Companies	744	54
Golf Courses	26 684	48 314
Colleges/Schools etc	1 344	7 255
Total - £	50 593	90 843
Present Value @ 8% (£'000)[1]	339	610
Present Value @ 5% (£'000)[2]	391	701

1 Calculated over a 10 year period at the Treasury Discount Rate of eight percent.
2 Calculated over a 10 year period at Treasury Discount Rate of five percent

3.3.2 Total ban on pesticides

The impact of a total ban on pesticide usage will affect non-agricultural users in a variety of ways. The assessment of the changes in weed, disease and pest control practices required to comply with a total ban has therefore been undertaken on an individual user basis.

- Department of Transport Roads

  The Department of Transport is responsible for maintaining motorways, dual carriageways and trunk roads passing through the Leam and Colne catchment areas. It is estimated that 31 km and 56 km of such roads would be affected by a total ban in the Leam and Colne catchments respectively and unit mowing and clearance costs for verges are estimated at £48 per km for each verge. Furthermore, it was estimated by respondents that £400 per km is required to establish enclosures to enable clearance to be undertaken with safety. Other areas that require additional mowing and clearance include central reservation areas and entry/exit junctions. For all areas, an additional two passes per annum would be required under a total pesticide ban.

  The contract costs of spraying (including pesticide expenditure), estimated at £88/km for verges and £96/km for other areas, were then deducted from these additional clearance costs. The detailed calculations are presented in Appendix 5.

  No assessment has been made of the impact on road users from lane closures due to the additional clearance, but these indirect disbenefits could be substantial.

- Local Authority Roads

  Under a total ban on pesticides Local Authorities would need to control weeds on kerbed roads and paved areas by additional brushing and clearance. It is estimated that 160 km and 480 km of kerb roads and pavements in the Leam and Colne catchments respectively would be affected, and unit brushing and clearance costs have been taken to be £400/km. It is anticipated that these areas would be cleared twice per annum. A further allowance of 10 percent has been made for sundry paved areas.

  The contract spraying costs (including pesticides) are estimated at £40 per km for kerb roads and pavements and an additional allowance of 15 percent has been made for other paved areas. Two spray applications per annum has also been assumed. The detailed calculations are presented in Appendix 5.

  It has been assumed that on minor roads and other non-kerbed roads, pesticides are not currently being applied and no changes in weed control practices are, therefore, envisaged under the Total Ban scenario.

- British Railways

It was confirmed by managers responsible for track maintenance that, without the use of pesticides, the frequency of re-ballasting the rail track would need to increase from once every 15 years to once every seven years. The costs of re-ballasting are estimated at £55 000 per km of single track and the length of track affected is calculated at 62 km in the Leam catchment and 104 km in the Colne catchment. (All lines are assumed to be double track.)

In addition, there would be an increase in the costs of manually and/or mechanically controlling weed growth in the areas adjoining the track, e.g. cuttings, embankments etc. The cost of maintaining these areas is estimated at £750 per km for each side of the track.

The cost of spraying the track with pesticides is estimated at £105.50 per km, while the cost of applying pesticides to the adjoining areas is calculated at £250 per km.

The impact on rail users to changes in the scheduling of the network due to an increase in the frequency of re-ballasting has not been evaluated, but is likely to be very significant.

- Public Utilities and Local Authority Parks/Amenity Areas

For land owned by public utilities and parks/amenity areas maintained by Local Authorities, the estimated costs of weed control by non-pesticide methods were based on a multiplier of the assumed overall spray costs (including labour and machinery). For areas where manual control was the only alternative, respondents estimated that a multiplier of nine times the overall spraying costs was appropriate, e.g. land owned by British Telecom, British Gas and Electricity Supply Companies. Where both mechanical and manual methods are substituted for pesticides, e.g. water companies, a multiplier of four was suggested.

For Local Authority maintained parks, the multipliers varied from three to five times the cost of spraying, depending on the type of weed control required.

In calculating spraying costs, it has been assumed that the expenditure on pesticides would account for 15 percent of the overall spraying costs with the remaining 85 percent being accounted for by labour and machinery.

- Golf Courses

In the evaluation of the incremental costs associated with implementation of a total ban on pesticide usage on golf courses, the impact on a typical golf course was first determined and then applied to the six courses in the Leam catchment and ten courses in the Colne catchment.

It is estimated that expenditure on controlling weeds on the greens would double if pesticides were not available, due predominantly to an increase in labour costs.

This would, however, not be sufficient to maintain the greens to the high standards required and so the turf would need to be replaced once every five years. The cost of green turf replacement is estimated at £1200 per green (i.e. £21 600 on an 18 hole golf course).

Furthermore, there would be a loss of revenue due to the closure of greens which is expected to be in the order of five percent of the annual gross revenue of £380 000 (i.e. £19 000 per annum).

On fairways and other areas there is likely to be a marginal rise in labour costs to eradicate certain problem weeds, as well as a small increase in machinery usage for extra mowing and strimming. In total, this is estimated to be in the order of £3000 per annum per course.

Pesticide expenditure on a typical 18 hole golf course in the catchment areas amounts to approximately £4000 per annum. This expenditure is estimated to account for a third of the overall spraying costs, so the savings in pesticide application is expected to be around £12 000 per annum.

The imposition of a total ban on pesticide usage within the Leam and Colne catchments would result in a very substantial increase in the costs of weed, disease and pest control for non-agricultural users. The annual expenditure required for weed control, if users are solely reliant on manual and/or mechanical methods, is estimated to be in the order of £1.3 and £2.3 million in the Leam and Colne catchments respectively. This represents an incremental annual cost of £0.8 and £1.6 million vis á vis the current pesticide spraying regimes. Tables A4.8 and A4.9 summarise the levels of additional expenditure for each non-agricultural user under the Total Ban scenario, and the corresponding incremental costs in comparison with present weed control practices. It can be seen from the Tables that all users would face very considerable, possibly even prohibitive, increases in weed control expenditure to maintain existing levels of control.

Table A4.8 Estimated incremental annual expenditure for non-agricultural users in the Leam catchment under the total ban scenario

Non-Agricultural User	Labour/ Machinery Costs incurred £	Less: Costs Saved Pesticides £	Application Costs £	Annual Incremental Costs £	Present Value @ 8% £'000	Present Value @ 5% £'000
District Councils	396 157	13 404	62 631	320 122	2 149	2 472
Motorways/Trunk Roads	83 328	1 367	7 682	74 279	498	574
British Rail	533 643*	6 965	242 409*	284 269	1 908	2 195
British Telecom	-	-	-	-	-	-
British Gas	4 080	68	385	3 627	24	28
Electricity Companies	1 020	17	96	907	6	7
Water Companies	19 840	744	4 216	14 880	100	115
Golf Courses	193 920†	26 684	45 316	121 920	818	941
Colleges/Schools etc.	26 880	1 344	7 616	17 920	120	138
Total - £	1 258 868	50 593	370 351	837 924		
Present Value @ 8% (£'000)[1]	8 447	339	2 485		5623	
Present Value @ 5% (£'000)[2]	9 721	391	2 860			6 470

* Includes re-ballasting of track
† Includes loss of revenue
1 Calculated over a 10 year period at the Treasury Discount Rate of eight percent.
2 Calculated over a 10 year period at Treasury Discount Rate of five percent

Table A4.9 Estimated incremental annual expenditure for non-agricultural users in the Colne catchment under the total ban scenario

Non-Agricultural User	Labour/ Machinery Costs Incurred £	Less: Costs Saved Pesticides £	Application Costs £	Annual Incremental Costs £	Present Value @ 8% £'000	Present Value @ 5% £'000
District Councils	739 937	15 908	122 937	601 092	4 034	4 642
Motorways/Trunk Roads	150 528	6 189	9043	135 296	908	1 045
British Rail	895 143*	11 663	395 670*	487 810	3 273	3 767
British Telecom	35 160	586	3 321	31 253	210	241
British Gas	28 740	479	2 714	25 547	171	197
Electricity Companies	23 700	395	2 238	21 067	141	163
Water Companies	1 440	54	306	1 080	7	8
Golf Courses	323 200†	48 314	71 686	203 200	1 363	1 569
Colleges/Schools etc.	145 100	7 255	41 112	96 733	649	747
Total - £	2342 948	90 843	649 027	1 603 078		
Present Value @ 8% (£'000)[1]	15 721	610	4 355		10 756	
Present Value @ 5% (£'000)[2]	18 092	701	5 012			12 379

* Includes re-ballasting of track
† Includes loss of revenue
1 Calculated over a 10 year period at the Treasury Discount Rate of eight percent.
2 Calculated over a 10 year period at Treasury Discount Rate of five percent

The present value of the incremental annual expenditure is estimated at £5.6 million and £10.8 million in the Leam and Colne catchment areas respectively.

3.3.3 Restricted use

Under the Restricted Use scenario it has been assumed that there would be a ban on the application of Diuron and Mecoprop for non-agricultural users within the Leam catchment area and that alternative pesticides would be used. Diuron is currently being used by Local Authorities (on roads and hard surfaces), British Rail and British Gas; while Mecoprop is applied in Local Authority parks and sports areas.

It has been assumed that Borocil K (Bromacil + Diuron) would be substituted by Casoron G (Dichlobenil), Diuron 80 WP (Diuron) by Arsenal 50 (Imazapyr), and Supertox 30 (2,4-D + Mecoprop) by Estermone (2,4-D + Dicamba) in approximately equal quantities.

The volumes of pesticides applied by each non-agricultural user in the Leam catchment under the Restricted Use scenario, together with the pesticide prices and total expenditure, are given in Appendix 6. The Colne catchment would not be affected because none of the pesticides used are predicted to exceed the MAC.

3.3.4 Protection zone

The protection zone for the Leam catchment is expected to cover 43 ha of non-agricultural land, of which 28 ha is estimated to be comprised of private residential/ industrial areas and golf courses, 8 ha of parks/amenity and public utility land and 7 ha of motorways, roads and railways.

Within the protection zone the use of Diuron and Mecoprop would be banned and substituted by alternative pesticides. On amenity/public utility land there would therefore be a very marginal change in pesticide usage, i.e. affecting less than two percent of the overall area.

However, for motorways/roads it has been assumed that more restrictive measures should be imposed on users to ensure that there is no possibility of Diuron flowing into watercourses. Consequently, it has been assumed that the use of Diuron would be banned for road use within the Leam catchment.

Similarly, greater restrictions would also need to be imposed on British Rail and it has been assumed that a 50 metre protection zone along a railway line either side of a watercourse crossing would need to be established. However, there would still be a marginal change in pesticide usage affecting only two percent of the railway area within the Leam catchment.

From 1993 there would be no application of Diuron or Mecoprop by non-agricultural users and consequently no change in pesticide usage within these areas.

The volumes of pesticides applied by each non-agricultural user under the Protection Zone scenario, together with the pesticide prices and total expenditure, are given in Appendix 7.

Table A4.10 summarises the levels of pesticide expenditure by non-agricultural users under both the Restricted Usage and Protection Zone scenarios, together with the incremental costs vis á vis current pesticide usage. It is apparent from the Table that there is likely to be only a small overall increase in pesticide expenditure, i.e. £1660, under the restricted usage scenario, although certain users, e.g. Local Authorities, British Rail, would incur most of this additional expense.

Under the Protection Zone scenario the overall incremental pesticide expenditure is even smaller, at a negligible £160 per annum.

The Present Value of the incremental annual expenditure over a ten year period for the restricted use and protection zone in the Leam catchment is estimated to be £12 200 and £1185 respectively.

Table A4.10 Estimated annual expenditure on pesticides by non-agricultural users in the Leam catchment under restricted usage and protection zone scenarios

Non-Agricultural User	Estimated Annual Pesticide Expenditure (£)		Incremental Annual Pesticide Expenditure (£)	
	Restricted Use	Protection Zone	Restricted Use	Protection Zone
District Councils	14 216	13 420	812	15
Motorway/Trunk Road	1 498	1 499	131	131
British Rail	7 638	6 979	673	14
British Telecom	-	-	-	-
British Gas	110	69	42	1
Electricity Companies	17	17	-	-
Water Companies	744	744	-	-
Golf Courses	26 684	26 684	-	-
Colleges/Schools etc.	1 344	1 344	-	-
Total - £	52 252	50 756	1658	161
Present Value @ 8% (£'000)[1]	351	341	11	1
Present Value @ 5% (£'000)[2]	403	392	13	1

1 Calculated over a 10 year period at the Treasury Discount Rate of eight percent.
2 Calculated over a 10 year period at Treasury Discount Rate of five percent
Note: No additional expenditure would be incurred on labour and machinery compared with the present situation.

3.4 Water treatment costs

The water treatment cost streams and Present Values are presented in Appendix 8 and a summary of the latter is given in Table A4.11.

Table A4.11 Present Value of Water Treatment Costs - £'000

Catchment		Leam £'000 @8%	Leam £'000 @5%	Colne £'000 @8%	Colne £'000 @5%
GAC - retention time	- 5 mins	-	-	1904	1931
	- 10 mins	-	-	3359	3362
	- 15 mins	1738	1789	-	-
Ozonation		982	993	-	-
Ozonation/GAC (retention 15 mins)		2417	2434	-	-

The initial capital costs of the two favoured forms of treatment were estimated to be £1.8 million and £2.6 million for the Leam and Colne catchments respectively.

4. UNITED KINGDOM ECONOMIC ANALYSIS

4.1 Agricultural Cash Flow

In view of the recent changes in the agricultural support system, telephone discussions were held with MAFF officers to determine whether new factors had been calculated to take into account the switch from price to area support. No factors had been specifically calculated and the consultants were advised to use the appropriate factors set out in a recent MAFF publication entitled 'Flood and Coastal Defence - Project Appraisal Guidance Notes'.

These guidance notes give three approaches depending on the flooding scenarios to be evaluated. The three alternatives are as follows:

Scenario I annual probability of inundation and hence loss of agricultural production

Scenario II intermittent probability of inundation

Scenario III increased incidence of flooding under the 'without project' resulting in reduced yields

For Scenario I it is recommended that a factor is applied to land values. Scenario III appeared to be the most appropriate but discussions with MAFF indicated that Scenario II should be taken as the base case for estimating the effect of restricting pesticide usage from the point of view of the United Kingdom. The factors that have been applied are as follows, but the economic basis on which they have been calculated is unknown:

- the Gross Output (sales value and area payments) of cereals, oilseeds, peas and beans reduced by 35 per cent;
- the Gross Output of beef enterprises reduced by 35 per cent; and
- the Gross Output of sheep enterprises reduced by 25 per cent.

The United Kingdom economic Gross Margins and agricultural cash flows for the two catchment areas were estimated and the results are summarised in Table A4.12 and detailed in Appendix 9. The incremental agricultural disbenefits are presented in Table A4.13.

Table A4.12 UK economic analysis - summary of the Present Values of the agricultural cash flows for the alternative pesticide restriction scenarios

Restriction Scenario	Leam Catchment £'000 @8%	Leam Catchment £'000 @5%	Colne Catchment £'000 @8%	Colne Catchment £'000 @5%
No Restrictions	25 806	29 433	7 022	7 987
Total Ban	17 953	20 785	4 800	5 506
Restricted Usage	25 220	28 764	6 957	7 913
Protection Zone(s)	25 597	29 191	6 701	7 615

Table A4.13 UK economic analysis - summary of the Present Value of agricultural disbenefits from alternative pesticide restriction scenarios

Restriction Scenario	Leam Catchment £'000 @8%	Leam Catchment £'000 @5%	Colne Catchment £'000 @8%	Colne Catchment £'000 @5%
Total Ban	7853	8648	2222	2481
Restricted Usage	586	669	65	74
Protection Zone(s)	209	242	321	372

4.2 Non-agricultural, policing and engineering costs

No change has been made to the financial costs as it has been assumed that components within each of these represents a true cost to the UK economy. These therefore remain as summarised in the previous chapter.

4.3 Results

The results of the main financial and UK Economic analyses are presented in Tables A4.14 and A4.15.

Table A4.14 Leam catchment - summary of financial and UK economic costs, in Present Value terms, associated with each restriction scenario - £million (discounted at eight percent)

(1) Financial costs - £M

Restriction scenario	Pesticide user Agric	Pesticide user Non-agric	Water treatment	Policing	Total costs
No restrictions	-	-	2.4	-	2.4
Total Ban	15.1	5.6	-	0.5	21.2
Restricted usage	0.6	-	-	2.5	3.1
Protected zone(s)	0.4	-	-	0.5	0.9

(2) UK economic costs - £M

Restriction scenario	Pesticide user Agric	Pesticide user Non-agric	Water treatment	Policing	Total costs
No restrictions	-	-	2.4	-	2.4
Total Ban	7.9	5.6	-	0.5	14.0
Restricted usage	0.6	-	-	2.5	3.1
Protected zone(s)	0.2	-	-	0.5	0.7

Table A4.15 Colne catchment - summary of financial and UK economic costs, in Present Value terms, associated with each restriction scenario - £million (discounted at eight percent)

(1) Financial costs - £M

Restriction scenario	Pesticide user		Water treatment	Policing	Total costs
	Agric	Non-agric			
No restrictions	-	-	3.4	-	3.4
Total Ban	4.2	10.8	-	0.1	15.1
Restricted usage	0.1	-	-	0.9	1.0
Protected zone(s)	0.3	-	-	0.8	1.1

(2) UK economic costs - £M

Restriction scenario	Pesticide user		Water treatment	Policing	Total costs
	Agric	Non-agric			
No restrictions	-	-	3.4	-	3.4
Total Ban	2.2	10.8	-	0.1	13.1
Restricted usage	0.1	-	-	0.9	1.0
Protected zone(s)	0.3	-	-	0.8	1.1

In the Leam catchment overall costs, in financial and UK economic terms, of the Total Ban and the Restricted Usage scenarios exceed the estimated cost of installing and operating a water treatment plant. In the Restricted Use scenario, about eighty per cent of costs are likely to be represented by policing costs. The introduction of a protection zone adjacent to watercourses represents the least cost option in both financial and UK economic terms and under this scenario the financial costs are likely to be almost equally borne by the agricultural and water industries.

In the Colne catchment, the higher costs of treating water means that only under the Total Ban scenario does the cost to agricultural and non-agricultural pesticide users exceed those incurred by the water industry. Under the Restricted Usage and Protection Zone scenarios the total costs are about one third of that required to install and operate a water treatment plant and, again, in each case most of the expenditure would be incurred in policing costs.

4.4 Sensitivity analysis

A sensitivity analysis was undertaken in which the cash flows have been discounted at five percent, the current cost of capital to the Water Service Companies. The results of this analysis are presented in Tables A4.16 and A4.17. The lower discount rate causes the cost of a Total Ban, Restricted Usage and Protection Zone(s) to rise by between 10 and 18 percent but has little impact on the cost of treating water. The ranking of the alternative scenarios is unaffected by the use of this discount rate.

Table A4.16 Sensitivity analysis - Leam catchment - summary of financial and UK economic costs, in Present Value terms, associated with each restriction scenario - £million (discounted at five percent)

(1) Financial costs - £M

Restriction scenario	Pesticide user Agric	Pesticide user Non-agric	Water treatment	Policing	Total costs
No restrictions	-	-	2.4	-	2.4
Total Ban	17.1	6.5	-	0.6	24.2
Restricted usage	0.7	-	-	2.9	3.6
Protected zone(s)	0.4	-	-	0.6	1.0

(2) UK economic costs - £M

Restriction scenario	Pesticide user Agric	Pesticide user Non-agric	Water treatment	Policing	Total costs
No restrictions	-	-	2.4	-	2.4
Total Ban	8.6	6.5	-	0.6	15.7
Restricted usage	0.7	-	-	2.9	3.6
Protected zone(s)	0.2	-	-	0.6	0.8

Table A4.17 Sensitivity analysis - Colne catchment - summary of financial and UK economic costs, in Present Value terms, associated with each restriction scenario - £million (discounted at five percent)

(1) Financial costs - £M

Restriction scenario	Pesticide user Agric	Pesticide user Non-agric	Water treatment	Policing	Total costs
No restrictions	-	-	3.4	-	3.4
Total Ban	4.8	12.4	-	0.2	17.4
Restricted usage	0.1	-	-	1.0	1.1
Protected zone(s)	0.4	-	-	0.9	1.3

(2) UK economic costs - £M

Restriction scenario	Pesticide user Agric	Pesticide user Non-agric	Water treatment	Policing	Total costs
No restrictions	-	-	3.4	-	3.4
Total Ban	2.4	12.4	-	0.2	15.0
Restricted usage	0.1	-	-	1.0	1.1
Protected zone(s)	0.4	-	-	0.9	1.3

5. APPENDICES

APPENDIX 1

LEAM CATCHMENT - POLICING COSTS

POLICING COSTS - LEAM CATCHMENT

Total Ban Scenario

a) FIELD INSPECTION

1) Staff Costs	No. Staff	Months/ person	Total Months	Cost/ Month (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	4	3	12	1583	19000
- Field Assistants	0		0	1000	0
ii) Non-Agricultural Areas					
- Pollution Consultants	1	0.75	0.75	9000	6750
- Field Assistants	0	0	0	1000	0
		sub-total			25750

2) Travelling Costs	No. Staff	Mileage/ person	Total Mileage	Cost/ Mile (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	4	5100	20400	0.42	8568
- Field Assistants	0	0	0	0.42	0
ii) Non-Agricultural Areas					
- Pollution Consultants	1	1500	1500	0.42	630
- Field Assistants	0	0	0	0.42	0
		sub-total			9198
Field Inspection Costs					34948

b) SOIL ANALYSIS	No.Farms/ Annum	No.Samples /Farm	Total Samples	Cost/ Sample (£)	Annual Cost (£)
i) Agricultural Areas	0	0	0	300	0
ii) Non-Agricultural Areas					
- Golf Courses	0	0	0	300	0
- Other Non-Agric. Areas			0	300	0
Soil Analysis Costs					0

POLICING COSTS - LEAM CATCHMENT

Total Ban Scenario

c) WATER SAMPLING	No.Visits /Annum	No.Mandays /Visit	Total Mandays	Cost/ Manday (£)	Annual Cost (£)
i)Staff Costs					
Future Sampling With Project	52	0.5	26	50	1300
Future Sampling Without Project	12	0.25	3	50	150

	No.Visits /Annum	Mileage /Visit	Total Mileage	Cost/ Mile	Annual Cost
ii) Travelling Costs					
Future Sampling With Project	52	100	5200	0.42	2184
Future Sampling Without Project	12	100	1200	0.42	504
Incremental Water Sampling Costs					2830
less 50%					1415
Incremental Water Sampling Costs (in practice)					1415

d) WATER ANALYSIS	No. Locations	No.Samples /Location	Total Samples	Cost/ Sample (£)	Annual Cost (£)
Future Analysis With Project	3	104	312	300	93600
Future Analysis Without Project	1.5	12	18	300	5400
Incremental Water Analysis Costs					88200
less 50%					44100
Incremental Water Analysis Costs (in practice)					44100
POLICING COSTS PER ANNUM					80463

POLICING COSTS - LEAM CATCHMENT

Restricted Use Scenario

a) FIELD INSPECTION

1) Staff Costs	No. Staff	Months/ person	Total Months	Cost/ Month (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	4	6	24	1583	38000
- Field Assistants	0	0	0	1000	0
ii) Non-Agricultural Areas					
- Pollution Consultants	1	0.75	0.75	9000	6750
- Field Assistants	1	0.25	0.25	1000	250
		sub-total			45000

2) Travelling Costs	No. Staff	Mileage/ person	Total Mileage	Cost/ Mile (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	4	6375	25500	0.42	10710
- Field Assistants	0	0	0	0.42	0
ii) Non-Agricultural Areas					
- Pollution Consultants	1	1500	1500	0.42	630
- Field Assistants	1	500	500	0.42	210
		sub-total			11550
Field Inspection Costs					56550

b) SOIL ANALYSIS	No.Farms/ Annum	No.Samples /Farm	Total Samples	Cost/ Sample (£)	Annual Cost (£)
i) Agricultural Areas	67.6	12.6	852	300	255528
ii) Non-Agricultural Areas					
- Golf Courses	1.2	10.5	13	300	3780
- Other Non-Agric. Areas			26	300	7782
Soil Analysis Costs					267090

POLICING COSTS - LEAM CATCHMENT

Restricted Use Scenario

c) WATER SAMPLING

i) Staff Costs	No.Visits /Annum	No.Mandays /Visit	Total Mandays	Cost/ Manday (£)	Annual Cost (£)
Future Sampling With Project	52	0.5	26	50	1300
Future Sampling Without Project	12	0.25	3	50	150

ii) Travelling Costs	No.Visits /Annum	Mileage /Visit	Total Mileage	Cost/ Mile	Annual Cost
Future Sampling With Project	52	100	5200	0.42	2184
Future Sampling Without Project	12	100	1200	0.42	504

Incremental Water Sampling Costs	2830
less 50%	1415
Incremental Water Sampling Costs (in practice)	1415

d) WATER ANALYSIS

	No. Locations	No.Samples /Location	Total Samples	Cost/ Sample (£)	Annual Cost (£)
Future Analysis With Project	3	104	312	300	93600
Future Analysis Without Project	1.5	12	18	300	5400

Incremental Water Analysis Costs	88200
less 50%	44100
Incremental Water Analysis Costs (in practice)	44100
POLICING COSTS PER ANNUM	369155

POLICING COSTS - LEAM CATCHMENT

Protection Zone Scenario

a) FIELD INSPECTION

1) Staff Costs	No. Staff	Months/ person	Total Months	Cost/ Month (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	4	2.25	9	1583	14250
- Field Assistants	0	0	0	1000	0
ii) Non-Agricultural Areas					
- Pollution Consultants	1	0.75	0.75	9000	6750
- Field Assistants	0	0.25	0	1000	0
		sub-total			21000

2) Travelling Costs	No. Staff	Mileage/ person	Total Mileage	Cost/ Mile (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	4	3825	15300	0.42	6426
- Field Assistants	0	0	0	0.42	0
ii) Non-Agricultural Areas					
- Pollution Consultants	1	1500	1500	0.42	630
- Field Assistants	0	500	0	0.42	0
		sub-total			7056

Field Inspection Costs 28056

b) SOIL ANALYSIS	No.Farms/ Annum	No.Samples /Farm	Total Samples	Cost/ Sample (£)	Annual Cost (£)
i) Agricultural Areas	0	0	0	300	0
ii) Non-Agricultural Areas					
- Golf Courses	0	0	0	300	0
- Other Non-Agric. Areas			0.0	300	0

Soil Analysis Costs 0

POLICING COSTS - LEAM CATCHMENT

Protection Zone Scenario

c) WATER SAMPLING	No.Visits /Annum	No.Mandays /Visit	Total Mandays	Cost/ Manday (£)	Annual Cost (£)
i)Staff Costs					
Future Sampling With Project	52	0.5	26	50	1300
Future Sampling Without Project	12	0.25	3	50	150

ii) Travelling Costs	No.Visits /Annum	Mileage /Visit	Total Mileage	Cost/ Mile	Annual Cost
Future Sampling With Project	52	100	5200	0.42	2184
Future Sampling Without Project	12	100	1200	0.42	504
Incremental Water Sampling Costs					2830
less 50%					1415
Incremental Water Sampling Costs (in practice)					1415

d) WATER ANALYSIS	No. Locations	No.Samples /Location	Total Samples	Cost/ Sample (£)	Annual Cost (£)
Future Analysis With Project	3	104	312	300	93600
Future Analysis Without Project	1.5	12	18	300	5400
Incremental Water Analysis Costs					88200
less 50%					44100
Incremental Water Analysis Costs (in practice)					44100
POLICING COSTS PER ANNUM					73571

APPENDIX 2

COLNE CATCHMENT - POLICING COSTS

POLICING COSTS - COLNE CATCHMENT

Total Ban Scenario

a) FIELD INSPECTION

1) Staff Costs	No. Staff	Months/ person	Total Months	Cost/ Month (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	2	3	6	1583	9500
- Field Assistants	0	0	0	1000	0
ii) Non-Agricultural Areas					
- Pollution Consultants	1	1	1	9000	9000
- Field Assistants	0	0	0	1000	0
		sub-total			18500

2) Travelling Costs	No. Staff	Mileage/ person	Total Mileage	Cost/ Mile (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	2	2720	5440	0.42	2284.8
- Field Assistants	0	0	0	0.42	0
ii) Non-Agricultural Areas					
- Pollution Consultants	1	1500	1500	0.42	630
- Field Assistants	0	0	0	0.42	0
		sub-total			2915
Field Inspection Costs					21415

b) SOIL ANALYSIS	No.Farms/ Annum	No.Samples /Farm	Total Samples	Cost/ Sample (£)	Annual Cost (£)
i) Agricultural Areas	0	0.0	0	300	0
ii) Non-Agricultural Areas					
- Golf Courses	0	0.0	0	300	0
- Other Non-Agric. Areas			0	300	0
Soil Analysis Costs					0
POLICING COSTS PER ANNUM					21415

POLICING COSTS - COLNE CATCHMENT

Restricted Use Scenario

a) FIELD INSPECTION

1) Staff Costs	No. Staff	Months/ person	Total Months	Cost/ Month (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	2	6	12	1583	19000
- Field Assistants	0	0	0	1000	0
ii) Non-Agricultural Areas					
- Pollution Consultants	0	1	0	9000	0
- Field Assistants	0	0.5	0	1000	0
		sub-total			19000

2) Travelling Costs	No. Staff	Mileage/ person	Total Mileage	Cost/ Mile (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	2	3400	6800	0.42	2856
- Field Assistants	0	0	0	0.42	0
ii) Non-Agricultural Areas					
- Pollution Consultants	0	1500	0	0.42	0
- Field Assistants	0	750	0	0.42	0
		sub-total			2856
Field Inspection Costs					21856

b) SOIL ANALYSIS	No.Farms/ Annum	No.Samples /Farm	Total Samples	Cost/ Sample (£)	Annual Cost (£)
i) Agricultural Areas	22.3	16.3	363	300	109043
ii) Non-Agricultural Areas					
- Golf Courses	0.0	10.5	0	300	0
- Other Non-Agric. Areas			0	300	0
Soil Analysis Costs					109043

POLICING COSTS PER ANNUM 130899

POLICING COSTS - COLNE CATCHMENT

Protection Zone Scenario

a) FIELD INSPECTION

1) Staff Costs	No. Staff	Months/ person	Total Months	Cost/ Month (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	2	6	12	1583	19000
- Field Assistants	0	0	0	1000	0
ii) Non-Agricultural Areas					
- Pollution Consultants	0	1	0	9000	0
- Field Assistants	0	0.5	0	1000	0
		sub-total			19000

2) Travelling Costs	No. Staff	Mileage/ person	Total Mileage	Cost/ Mile (£)	Annual Cost (£)
i) Agricultural Areas					
- Pollution Inspectors	2	3060	6120	0.42	2570
- Field Assistants	0	0	0	0.42	0
ii) Non-Agricultural Areas					
- Pollution Consultants	0	1500	0	0.42	0
- Field Assistants	0	750	0	0.42	0
		sub-total			2570
	Field Inspection Costs				21570

b) SOIL ANALYSIS	No.Farms/ Annum	No.Samples /Farm	Total Samples	Cost/ Sample (£)	Annual Cost (£)
i) Agricultural Areas	20.1	16.3	327	300	98138
ii) Non-Agricultural Areas					
- Golf Courses	0.0	10.5	0	300	0
- Other Non-Agric. Areas			0	300	0
	Soil Analysis Costs				98138
POLICING COSTS PER ANNUM					119709

APPENDIX 3

FINANCIAL AGRICULTURAL CASH FLOWS

LEAM CATCHMENT - PROJECTED FINANCIAL AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
NO PESTICIDE RESTRICTIONS
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	2251	2370	2401	2427	2427	2427	2427	2427	2427	2427	2427
Beef Cows	509	649	650	655	655	655	655	655	655	655	655
Dairy heifers	192	226	233	240	240	240	240	240	240	240	240
Beef heifers	90	102	119	135	135	135	135	135	135	135	135
Beef 2yrs+	457	701	686	674	674	674	674	674	674	674	674
Fattening Suckled Calves (2 yrs)	140	218	216	216	216	216	216	216	216	216	216
Beef 2yrs	354	437	414	393	393	393	393	393	393	393	393
Sheep	1178	1230	1267	1301	1301	1301	1301	1301	1301	1301	1301
Sub-Total Livestock	5171	5934	5988	6042	6042	6042	6042	6042	6042	6042	6042
Arable Crop Gross Margins :											
Wheat	4656	3906	4046	4238	4280	4322	4322	4322	4322	4322	4322
Winter Barley	1145	1029	891	745	558	370	370	370	370	370	370
Spring Barley	106	102	42	30	15	0	0	0	0	0	0
Oats	56	52	38	25	13	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	253	253	253	253	253	253	253	253	253	253	253
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	106	106	105	104	103	102	102	102	102	102	102
Field Beans	560	633	768	904	1037	1169	1169	1169	1169	1169	1169
Harvest Peas	69	80	88	97	104	112	112	112	112	112	112
W. Oilseed Rape	941	706	932	1162	1385	1608	1608	1608	1608	1608	1608
S. Oilseed Rape	0	123	93	62	31	0	0	0	0	0	0
Linseed	352	378	294	210	127	43	43	43	43	43	43
Other crops inc Triticale	6	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	110	535	562	562	562	561	561	561	561	561	561
Sub-Total Crops	8359	7903	8112	8392	8466	8540	8540	8540	8540	8540	8540
TOTAL GROSS MARGIN	13530	13837	14100	14435	14508	14582	14582	14582	14582	14582	14582
RECURRENT FIXED COSTS											
Regular Labour	1880	1857	1848	1842	1836	1829	1829	1829	1829	1829	1829
Machinery-Repairs/Fuel etc.	1839	1818	1816	1815	1814	1814	1814	1814	1814	1814	1814
Occupiers Repairs	641	641	641	641	641	641	641	641	641	641	641
Miscellaneous Costs	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229
Sub-Total Recurrent Costs	5589	5545	5535	5528	5520	5513	5513	5513	5513	5513	5513
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	7941	8292	8565	8907	8988	9069	9069	9069	9069	9069	9069
PRESENT VALUE @ 8% discount factor	67454										
PRESENT VALUE @ 5% discount factor	76565										

LEAM CATCHMENT - PROJECTED FINANCIAL AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
TOTAL PESTICIDE BAN
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	2251	2372	2402	2428	2428	2428	2428	2428	2428	2428	2428
Beef Cows	509	650	651	655	655	655	655	655	655	655	655
Dairy heifers	192	227	234	240	240	240	240	240	240	240	240
Beef heifers	90	102	120	135	135	135	135	135	135	135	135
Beef 2yrs+	457	703	687	675	675	675	675	675	675	675	675
Fattening Suckled Calves (2 yrs)	140	218	217	217	217	217	217	217	217	217	217
Beef 2yrs	354	438	415	393	393	393	393	393	393	393	393
Sheep	1178	1233	1269	1302	1302	1302	1302	1302	1302	1302	1302
Sub-Total Livestock	5171	5943	5994	6046	6046	6046	6046	6046	6046	6046	6046
Arable Crop Gross Margins :											
Winter Wheat	4656	2814	2777	2786	2586	2387	2387	2387	2387	2387	2387
Spring Wheat	0	0	0	0	0	0	0	0	0	0	0
Winter Barley	1145	777	830	886	865	844	844	844	844	844	844
Spring Barley	106	101	121	143	157	170	170	170	170	170	170
Winter Oats	56	28	46	64	82	99	99	99	99	99	99
Spring Oats	0	0	0	0	0	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	253	85	64	42	21	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	106	60	59	58	58	57	57	57	57	57	57
Field Beans	560	509	528	548	567	587	587	587	587	587	587
Harvest Peas	69	59	44	29	15	0	0	0	0	0	0
W. Oilseed Rape	941	701	1001	1300	1600	1900	1900	1900	1900	1900	1900
S. Oilseed Rape	0	124	93	62	31	0	0	0	0	0	0
Linseed	352	340	255	170	85	0	0	0	0	0	0
Other crops inc Triticale	6	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	110	568	599	601	603	604	604	604	604	604	604
Sub-Total Crops	8359	6165	6417	6689	6669	6648	6648	6648	6648	6648	6648
TOTAL GROSS MARGIN	13530	12108	12411	12735	12715	12694	12694	12694	12694	12694	12694
RECURRENT FIXED COSTS											
Regular Labour	1880	1931	1863	1798	1733	1669	1669	1669	1669	1669	1669
Machinery-Repairs/Fuel etc.	1839	1937	1927	1919	1912	1904	1904	1904	1904	1904	1904
Occupiers Repairs	641	641	641	641	641	641	641	641	641	641	641
Miscellaneous Costs	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229
Sub-Total Recurrent Costs	5589	5739	5661	5588	5515	5443	5443	5443	5443	5443	5443
CAPITAL COSTS											
Incremental Machinery Purchases		3160									
ANNUAL CASH FLOW	7941	3209	6750	7147	7199	7252	7252	7252	7252	7252	7252
PRESENT VALUE @ 8% discount factor	52306										
PRESENT VALUE @ 5% discount factor	59498										

LEAM CATCHMENT - PROJECTED FINANCIAL AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
RESTRICTED PESTICIDE USE
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	2251	2369	2400	2426	2426	2426	2426	2426	2426	2426	2426
Beef Cows	509	648	649	653	653	653	653	653	653	653	653
Dairy heifers	192	226	233	240	240	240	240	240	240	240	240
Beef heifers	90	102	119	135	135	135	135	135	135	135	135
Beef 2yrs+	457	700	684	672	672	672	672	672	672	672	672
Fattening Suckled Calves (2 yrs)	140	217	215	215	215	215	215	215	215	215	215
Beef 2yrs	354	437	413	392	392	392	392	392	392	392	392
Sheep	1178	1228	1265	1298	1298	1298	1298	1298	1298	1298	1298
Sub-Total Livestock	5171	5927	5979	6031	6031	6031	6031	6031	6031	6031	6031
Arable Crop Gross Margins :											
Wheat	4656	3812	3977	4194	4236	4277	4277	4277	4277	4277	4277
Winter Barley	1145	1020	885	742	555	368	368	368	368	368	368
Spring Barley	106	95	34	18	2	0	0	0	0	0	0
Oats	56	53	39	26	13	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	253	253	253	253	253	253	253	253	253	253	253
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	106	106	105	104	103	102	102	102	102	102	102
Field Beans	560	628	759	890	1021	1152	1152	1152	1152	1152	1152
Harvest Peas	69	80	88	97	104	112	112	112	112	112	112
W. Oilseed Rape	941	706	932	1162	1385	1608	1608	1608	1608	1608	1608
S. Oilseed Rape	0	123	93	62	31	0	0	0	0	0	0
Linseed	352	378	294	211	127	28	28	28	28	28	28
Other crops inc Triticale	6	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	110	534	561	561	560	560	560	560	560	560	560
Sub-Total Crops	8359	7789	8020	8320	8390	8459	8459	8459	8459	8459	8459
TOTAL GROSS MARGIN	13530	13716	13999	14351	14421	14490	14490	14490	14490	14490	14490
RECURRENT FIXED COSTS											
Regular Labour	1880	1855	1846	1840	1833	1827	1827	1827	1827	1827	1827
Machinery-Repairs/Fuel etc.	1839	1818	1816	1815	1814	1813	1813	1813	1813	1813	1813
Occupiers Repairs	641	641	641	641	641	641	641	641	641	641	641
Miscellaneous Costs	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229
Sub-Total Recurrent Costs	5589	5543	5532	5525	5517	5511	5511	5511	5511	5511	5511
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	7941	8172	8467	8826	8904	8979	8979	8979	8979	8979	8979
PRESENT VALUE @ 8% discount factor	66829										
PRESENT VALUE @ 5% discount factor	75849										

LEAM CATCHMENT - PROJECTED FINANCIAL AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
PROTECTION ZONE
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	2251	2370	2401	2427	2427	2427	2427	2427	2427	2427	2427
Beef Cows	509	649	650	655	655	655	655	655	655	655	655
Dairy heifers	192	226	233	240	240	240	240	240	240	240	240
Beef heifers	90	102	119	135	135	135	135	135	135	135	135
Beef 2yrs+	457	701	686	674	674	674	674	674	674	674	674
Fattening Suckled Calves (2 yrs)	140	218	216	216	216	216	216	216	216	216	216
Beef 2yrs	354	437	414	393	393	393	393	393	393	393	393
Sheep	1178	1230	1267	1301	1301	1301	1301	1301	1301	1301	1301
Sub-Total Livestock	5171	5934	5988	6042	6042	6042	6042	6042	6042	6042	6042
Arable Crop Gross Margins :											
Wheat	4656	3879	4017	4207	4250	4291	4291	4291	4291	4291	4291
Winter Barley	1145	1022	885	740	553	367	367	367	367	367	367
Spring Barley	106	101	42	29	14	0	0	0	0	0	0
Oats	56	51	38	25	13	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	253	253	253	253	253	253	253	253	253	253	253
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	106	103	103	103	102	102	102	102	102	102	102
Field Beans	560	629	762	897	1030	1161	1161	1161	1161	1161	1161
Harvest Peas	69	80	88	96	103	111	111	111	111	111	111
W. Oilseed Rape	941	701	926	1154	1375	1596	1596	1596	1596	1596	1596
S. Oilseed Rape	0	122	92	61	31	0	0	0	0	0	0
Linseed	352	375	292	209	126	42	42	42	42	42	42
Other crops inc Triticale	6	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	110	531	558	558	557	557	557	557	557	557	557
Sub-Total Crops	8359	7847	8056	8333	8407	8481	8481	8481	8481	8481	8481
TOTAL GROSS MARGIN	13530	13781	14044	14375	14449	14523	14523	14523	14523	14523	14523
RECURRENT FIXED COSTS											
Regular Labour	1880	1855	1847	1840	1834	1828	1831	1831	1831	1831	1831
Machinery-Repairs/Fuel etc.	1839	1816	1814	1813	1813	1812	1813	1813	1813	1813	1813
Occupiers Repairs	641	641	641	641	641	641	641	641	641	641	641
Miscellaneous Costs	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229
Sub-Total Recurrent Costs	5589	5542	5531	5524	5517	5510	5515	5515	5515	5515	5515
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	7941	8239	8512	8851	8932	9013	9008	9008	9008	9008	9008
PRESENT VALUE @ 8% discount factor	67072										
PRESENT VALUE @ 5% discount factor	76123										

COLNE CATCHMENT - PROJECTED FINANCIAL AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
NO PESTICIDE RESTRICTIONS
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	845	890	902	911	911	911	911	911	911	911	911
Beef Cows	206	262	263	264	264	264	264	264	264	264	264
Dairy heifers	40	46	48	49	49	49	49	49	49	49	49
Beef heifers	32	36	43	48	48	48	48	48	48	48	48
Beef 2yrs+	47	71	69	68	68	68	68	68	68	68	68
Fattening Suckled Calves (2 yrs)	59	89	89	89	89	89	89	89	89	89	89
Beef 2yrs	0	0	0	0	0	0	0	0	0	0	0
Sheep	98	102	105	109	109	109	109	109	109	109	109
Sub-Total Livestock	1326	1497	1518	1539	1539	1539	1539	1539	1539	1539	1539
Arable Crop Gross Margins :											
Wheat	1336	1086	1053	1032	994	955	955	955	955	955	955
Winter Barley	467	407	407	411	400	389	389	389	389	389	389
Spring Barley	123	66	40	28	14	0	0	0	0	0	0
Oats	15	14	11	7	4	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	59	59	61	64	67	70	70	70	70	70	70
Field Beans	71	77	96	115	134	153	153	153	153	153	153
Harvest Peas	0	0	17	35	52	69	69	69	69	69	69
W. Oilseed Rape	266	214	289	364	438	512	512	512	512	512	512
S. Oilseed Rape	0	45	34	23	11	0	0	0	0	0	0
Linseed	110	119	101	82	62	43	43	43	43	43	43
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	6	138	146	146	146	146	146	146	146	146	146
Sub-Total Crops	2454	2225	2255	2307	2322	2336	2336	2336	2336	2336	2336
TOTAL GROSS MARGIN	3780	3722	3773	3846	3861	3876	3876	3876	3876	3876	3876
RECURRENT FIXED COSTS											
Regular Labour	683	675	673	671	669	668	668	668	668	668	668
Machinery-Repairs/Fuel etc.	542	535	535	534	534	534	534	534	534	534	534
Occupiers Repairs	142	142	142	142	142	142	142	142	142	142	142
Miscellaneous Costs	271	271	271	271	271	271	271	271	271	271	271
Sub-Total Recurrent Costs	1638	1623	1621	1619	1617	1615	1615	1615	1615	1615	1615
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	2142	2099	2153	2227	2244	2261	2261	2261	2261	2261	2261
PRESENT VALUE @ 8% discount factor	17030										
PRESENT VALUE @ 5% discount factor	19303										

COLNE CATCHMENT - PROJECTED FINANCIAL AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
TOTAL PESTICIDE BAN
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	845	890	902	911	911	911	911	911	911	911	911
Beef Cows	206	262	263	264	264	264	264	264	264	264	264
Dairy heifers	40	47	48	49	49	49	49	49	49	49	49
Beef heifers	32	37	43	48	48	48	48	48	48	48	48
Beef 2yrs+	47	71	69	68	68	68	68	68	68	68	68
Fattening Suckled Calves (2 yrs)	59	90	89	89	89	89	89	89	89	89	89
Beef 2yrs	0	0	0	0	0	0	0	0	0	0	0
Sheep	98	102	106	109	109	109	109	109	109	109	109
Sub-Total Livestock	1326	1498	1519	1539	1539	1539	1539	1539	1539	1539	1539
Arable Crop Gross Margins :											
Winter Wheat	1336	746	719	706	648	589	589	589	589	589	589
Spring Wheat	0	0	0	0	0	0	0	0	0	0	0
Winter Barley	467	292	289	285	259	232	232	232	232	232	232
Spring Barley	123	62	89	119	143	168	168	168	168	168	168
Winter Oats	15	8	10	12	13	15	15	15	15	15	15
Spring Oats	0	0	0	0	0	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	59	33	34	36	38	39	39	39	39	39	39
Field Beans	71	60	83	105	128	150	150	150	150	150	150
Harvest Peas	0	0	0	0	0	0	0	0	0	0	0
W. Oilseed Rape	266	194	267	340	413	486	486	486	486	486	486
S. Oilseed Rape	0	40	30	20	10	0	0	0	0	0	0
Linseed	110	101	76	50	25	0	0	0	0	0	0
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	6	147	155	155	155	155	155	155	155	155	155
Sub-Total Crops	2453	1683	1752	1829	1831	1833	1833	1833	1833	1833	1833
TOTAL GROSS MARGIN	3780	3181	3271	3368	3370	3373	3373	3373	3373	3373	3373
RECURRENT FIXED COSTS											
Regular Labour	683	691	688	686	684	682	682	682	682	682	682
Machinery-Repairs/Fuel etc.	542	558	557	557	557	556	556	556	556	556	556
Occupiers Repairs	142	142	142	142	142	142	142	142	142	142	142
Miscellaneous Costs	271	271	271	271	271	271	271	271	271	271	271
Sub-Total Recurrent Costs	1639	1662	1658	1656	1654	1652	1652	1652	1652	1652	1652
CAPITAL COSTS											
Incremental Machinery Purchases		626									
ANNUAL CASH FLOW	2141	892	1613	1712	1716	1721	1721	1721	1721	1721	1721
PRESENT VALUE @ 8% discount factor	12818										
PRESENT VALUE @ 5% discount factor	14530										

COLNE CATCHMENT - PROJECTED FINANCIAL AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
RESTRICTED PESTICIDE USE
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	845	890	901	911	911	911	911	911	911	911	911
Beef Cows	206	262	262	264	264	264	264	264	264	264	264
Dairy heifers	40	46	48	49	49	49	49	49	49	49	49
Beef heifers	32	36	42	48	48	48	48	48	48	48	48
Beef 2yrs+	47	71	69	68	68	68	68	68	68	68	68
Fattening Suckled Calves (2 yrs)	59	89	89	89	89	89	89	89	89	89	89
Beef 2yrs	0	0	0	0	0	0	0	0	0	0	0
Sheep	98	102	105	108	108	108	108	108	108	108	108
Sub-Total Livestock	1326	1495	1517	1537	1537	1537	1537	1537	1537	1537	1537
Arable Crop Gross Margins :											
Wheat	1336	1080	1049	1030	991	953	953	953	953	953	953
Winter Barley	467	403	404	410	399	388	388	388	388	388	388
Spring Barley	123	66	40	28	14	0	0	0	0	0	0
Oats	15	14	11	7	4	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	59	59	61	64	67	70	70	70	70	70	70
Field Beans	71	75	94	114	132	151	151	151	151	151	151
Harvest Peas	0	0	14	30	48	66	66	66	66	66	66
W. Oilseed Rape	266	214	289	364	438	512	512	512	512	512	512
S. Oilseed Rape	0	45	34	23	11	0	0	0	0	0	0
Linseed	110	119	101	82	62	43	43	43	43	43	43
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	6	138	146	146	146	146	146	146	146	146	146
Sub-Total Crops	2454	2213	2244	2297	2312	2327	2327	2327	2327	2327	2327
TOTAL GROSS MARGIN	3780	3708	3760	3834	3849	3864	3864	3864	3864	3864	3864
RECURRENT FIXED COSTS											
Regular Labour	683	674	672	670	669	667	667	667	667	667	667
Machinery-Repairs/Fuel etc.	542	535	534	534	534	534	534	534	534	534	534
Occupiers Repairs	142	142	142	142	142	142	142	142	142	142	142
Miscellaneous Costs	271	271	271	271	271	271	271	271	271	271	271
Sub-Total Recurrent Costs	1638	1623	1620	1618	1616	1614	1614	1614	1614	1614	1614
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	2142	2086	2140	2216	2233	2250	2250	2250	2250	2250	2250
PRESENT VALUE @ 8% discount factor	16955										
PRESENT VALUE @ 5% discount factor	19218										

COLNE CATCHMENT - PROJECTED FINANCIAL AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
PROTECTION ZONES
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	845	890	901	911	911	911	911	911	911	911	911
Beef Cows	206	262	262	264	264	264	264	264	264	264	264
Dairy heifers	40	46	48	49	49	49	49	49	49	49	49
Beef heifers	32	36	42	48	48	48	48	48	48	48	48
Beef 2yrs+	47	71	69	68	68	68	68	68	68	68	68
Fattening Suckled Calves (2 yrs)	59	89	89	89	89	89	89	89	89	89	89
Beef 2yrs	0	0	0	0	0	0	0	0	0	0	0
Sheep	98	102	105	108	108	108	108	108	108	108	108
Sub-Total Livestock	1326	1495	1517	1537	1537	1537	1537	1537	1537	1537	1537
Arable Crop Gross Margins :											
Wheat	1336	1062	1031	1012	974	936	936	936	936	936	936
Winter Barley	467	399	401	406	395	384	384	384	384	384	384
Spring Barley	123	66	40	28	14	0	0	0	0	0	0
Oats	15	14	11	7	4	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	59	59	61	64	67	70	70	70	70	70	70
Field Beans	71	75	94	114	132	151	151	151	151	151	151
Harvest Peas	0	0	14	31	48	66	66	66	66	66	66
W. Oilseed Rape	266	214	289	364	438	512	512	512	512	512	512
S. Oilseed Rape	0	45	34	23	11	0	0	0	0	0	0
Linseed	110	119	101	82	62	43	43	43	43	43	43
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	6	138	146	146	146	146	146	146	146	146	146
Sub-Total Crops	2454	2190	2221	2276	2292	2307	2307	2307	2307	2307	2307
TOTAL GROSS MARGIN	3780	3686	3738	3814	3829	3845	3845	3845	3845	3845	3845
RECURRENT FIXED COSTS											
Regular Labour	683	677	678	679	681	682	682	682	682	682	682
Machinery-Repairs/Fuel etc.	542	537	538	539	541	543	543	543	543	543	543
Occupiers Repairs	142	142	142	142	142	142	142	142	142	142	142
Miscellaneous Costs	271	271	271	271	271	271	271	271	271	271	271
Sub-Total Recurrent Costs	1638	1627	1629	1632	1635	1638	1638	1638	1638	1638	1638
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	2142	2059	2109	2182	2194	2207	2207	2207	2207	2207	2207
PRESENT VALUE @ 8% discount factor	16700										
PRESENT VALUE @ 5% discount factor	18921										

APPENDIX 4

VOLUME OF PESTICIDES USED BY NON-AGRICULTURAL USERS

VALUE OF PESTICIDES APPLIED BY NON-AGRICULTURAL USERS - LEAM CATCHMENT

BRAND NAME	TOTAL VOLUME L/KG	PRICE L/KG	TOTAL VALUE (£)
Arsenal 50	4	£20.50	£82
BH MCPA 75	45	£1.44	£65
Borocil K	12	£1.10	£13
Burtolin	375	£5.75	£2,156
Carbaryl 45	30	£14.44	£433
Casoron G	725	£4.60	£3,336
Castaway Plus	56	£17.55	£983
Dextrone X	29	£6.50	£187
Diuron 80 WP	92	£11.15	£1,022
Dormone	6	£1.50	£9
Estermone	215	£7.38	£1,587
Garlon 4	152	£30.00	£4,560
Mildothane Turf Liquid	20	£13.00	£260
MSS 2,4-D Amine	1	£1.50	£1
MSS Aminotriazole 80 WP	3	£3.30	£10
MSS Atrazine 50 FL	3	£2.50	£8
Regulox K	59	£5.20	£304
Roundup	63	£10.80	£682
Roundup GC	30	£12.40	£372
Roundup Pro	151	£14.70	£2,220
Rovral Green	180	£21.72	£3,910
Spasor	55	£13.55	£738
Stirrup	84	£13.80	£1,159
Sulphate of Iron	61	£0.22	£13
Super Mosstox	5	£8.45	£42
Super Verdone	360	£51.60	£18,576
Supertox 30	271	£4.60	£1,247
Tecto	79	£56.60	£4,471
Turfex	100	£15.80	£1,580
Twister	15	£37.80	£567
		TOTAL:	£50,593

QUANTITY OF PESTICIDES USED BY NON-AGRICULTURAL USERS - LEAM CATCHMENT

BRAND NAME	CHEMICAL NAME	PRICE /LT or KG	MARKETING COMPANY	CONCENTRATION	DISTRICT COUNCILS				COUNTY ROADS	OTHER COUNTY SERVICES	BRITISH RAIL	UTILITIES				GOLF COURSES	TOTAL	KG or LTR
					WARWICK	STRATFORD	RUGBY	DAVENTRY				TELECOM	GAS	ELEC-TRICITY	WATER			
Arsenal 50	Imazapyr	20.50	Nomix-Chipman	50 g/l											4		4	lt
BH MCPA 75	MCPA	1.44	RP Environmental	750 g/l			31		14								45	lt
Borocil K	Bromacil + Diuron	1.10	RP Environ./Du Pont	0.88:0.88% w/w									12				12	kg
Burtolin	Maleic Hydrazide	5.75	RP Environmental	185 g/l	375												375	lt
Carbaryl 45	Carbaryl	14.44	Vitax & Others	450g/l	30												30	lt
Casoron G	Dichlobenil	4.60	Nomix-Chipman & ICI	6.75% w/w	500	15	1			197			12				725	kg
Castaway Plus	Gamma-HCH + thiophanate-methyl	17.55	RP Environmental	60:500 g/l												56	56	lt
Dextrone X	Paraquat	6.50	Nomix-Chipman & ICI	200 g/l	25					4							29	lt
Diuron 80 WP	Diuron	11.15	RP Environmental	80% w/w			6		14		72						92	kg
Dormone	2,4-D	1.50	RP Environmental	465 g/l					6								6	lt
Estermone	2,4-D + Dicamba	7.38	Vitax	200 g/l & 35 g/l	50											165	215	lt
Garlon 4	Triclopyr	30.00	Nomi-Chipman	480 g/l							152						152	lt
Mildothane Turf Liquid	Thiophanate-methyl	13.00	RP Environmental	500 g/l												20	20	lt
MSS 2,4-D Amine	2,4-D	1.50	Mirfield	500 g/l										1			1	lt
MSS Aminotriazole 80 WP	Amitrole	3.30	Mirfield	80% w/w					3								3	kg
MSS Atrazine 50 FL	Atrazine	2.50	Mirfield	500 g/l										3			3	lt
Regulox K	Maleic Hydrazide	5.20	RP Environmental	250 g/l					59								59	lt
Roundup	Glyphosate	10.80	Monsanto	360 g/l			19	10	23					1		10	63	lt
Roundup GC	Glyphosate	12.40	Monsanto	360 g/l	30												30	lt
Roundup Pro	Glyphosate	14.70	Monsanto	360 g/l					42		109						151	lt
Rovral Green	Iprodione	21.72	RP Environmental	250 g/l	100											80	180	lt
Spasor	Glyphosate	13.55	RP Environmental	360 g/l	50	5											55	lt
Stirrup	Glyphosate	13.80	Nomix-Chipman	144 g/l		5	1			30					48		84	lt
Sulphate of Iron	n/a	0.22	Vitax	n/a												61	61	lt
Super Mosstox	Dichlorophen	8.45	RP Environmental	340 g/l	5												5	lt
Super Verdone	2,4-D + dicamba + ioxynil	51.60	ICI Professional	72:12:48 g/l												360	360	lt
Supertox 30	2,4-D + mecoprop	4.60	RP Environ.	90:190 g/l	270	1											271	lt
Tecto	Thiabendazole	56.60	Vitax	450 g/l	50											29	79	lt
Turfex	n/a	15.80	Fisons	n/a												100	100	lt
Twister	Carbaryl	37.80	RP Environ.	85% w/w												15	15	kg

VALUE OF PESTICIDES USED BY NON-AGRICULTURAL USERS - LEAM CATCHMENT

BRAND NAME	CHEMICAL NAME	PRICE /LT or KG	MARKETING COMPANY	CONCENTRATION	DISTRICT COUNCILS				COUNTY ROADS	OTHER COUNTY SERVICES	BRITISH RAIL	UTILITIES				GOLF COURSES	TOTAL
					WARWICK	STRATFORD	RUGBY	DAVENTRY				TELECOM	GAS	ELEC-TRICITY	WATER		
Arsenal 50	Imazapyr	£20.50	Nomix-Chipman	50 g/l											£82		£82
BH MCPA 75	MCPA	£1.44	RP Environmental	750 g/l			£45		£21								£65
Borocil K	Bromacil + Diuron	£1.10	RP Environ./Du Pont	0.88:0.88% w/w									£13				£13
Burtolin	Maleic Hydrazide	£5.75	RP Environmental	185 g/l	£2,156												£2,156
Carbaryl 45	Carbaryl	£14.44	Vitax & Others	450g/l	£433												£433
Casoron G	Dichlobenil	£4.60	Nomix-Chipman & ICI	6.75% w/w	£2,300	£69	£6			£906			£55				£3,336
Castaway Plus	Gamma-HCH + thiophanate-methyl	£17.55	RP Environmental	60:500 g/l												£983	£983
Dextrone X	Paraquat	£6.50	Nomix-Chipman & ICI	200 g/l	£163					£24							£187
Diuron 80 WP	Diuron	£11.15	RP Environmental	80% w/w			£63		£156		£803						£1,022
Dormone	2,4-D	£1.50	RP Environmental	465 g/l					£9								£9
Estermone	2,4-D + Dicamba	£7.38	Vitax	200 g/l & 35 g/l	£369											£1,218	£1,587
Garlon 4	Triclopyr	£30.00	Nomi-Chipman	480 g/l							£4,560						£4,560
Mildothane Turf Liquid	Thiophanate-methyl	£13.00	RP Environmental	500 g/l												£260	£260
MSS 2,4-D Amine	2,4-D	£1.50	Mirfield	500 g/l										£1			£1
MSS Aminotriazole 80 WP	Amitrole	£3.30	Mirfield	80% w/w					£10								£10
MSS Atrazine 50 FL	Atrazine	£2.50	Mirfield	500 g/l										£8			£8
Regulox K	Maleic Hydrazide	£5.20	RP Environmental	250 g/l					£304								£304
Roundup	Glyphosate	£10.80	Monsanto	360 g/l			£207	£108	£251					£8		£108	£682
Roundup GC	Glyphosate	£12.40	Monsanto	360 g/l	£372												£372
Roundup Pro	Glyphosate	£14.70	Monsanto	360 g/l					£617		£1,602						£2,220
Rovral Green	Iprodione	£21.72	RP Environmental	250 g/l	£2,172											£1,738	£3,910
Spasor	Glyphosate	£13.55	RP Environmental	360 g/l	£678	£61											£738
Stirrup	Glyphosate	£13.80	Nomix-Chipman	144 g/l		£69	£14			£414					£662		£1,159
Sulphate of Iron	n/a	£0.22	Vitax	n/a												£13	£13
Super Mosstox	Dichlorophen	£8.45	RP Environmental	340 g/l	£42												£42
Super Verdone	2,4-D + dicamba + ioxynil	£51.60	ICI Professional	72:12:48 g/l												£18,576	£18,576
Supertox 30	2,4-D + mecoprop	£4.60	RP Environ.	90:190 g/l	£1,242	£5											£1,247
Tecto	Thiabendazole	£56.60	Vitax	450 g/l	£2,830											£1,641	£4,471
Turfex	n/a	£15.80	Fisons	n/a												£1,580	£1,580
Twister	Carbaryl	£37.80	RP Environ.	85% w/w												£567	£567
				TOTAL:	£12,757	£204	£335	£108	£1,368	£1,344	£6,965		£68	£17	£744	£26,684	£50,593

CURRENT EXPENDITURE ON PESTICIDES BY NON-AGRICULTURAL USERS - COLNE CATCHMENT.

BRAND NAME	TOTAL VOLUME L/Kg	PRICE /LT or KG	TOTAL VALUE (£)
Arsenal 50	55	£20.50	£1,128
Asulox	50	£12.00	£600
Atladox HL	346	£12.00	£4,152
Borocil K	200	£1.10	£220
Broadshot	50	£13.49	£675
Carbaryl 45	111	£14.44	£1,603
Casoron G	385	£4.60	£1,771
Clarosan 1 FG	14	£3.57	£50
Clovotox	2,007	£4.46	£8,950
Dash	20	£8.00	£160
Diuron 80 WP	266	£11.15	£2,967
Estermone	480	£7.38	£3,542
Fettel	10	£17.50	£175
Garlon 4	339	£30.00	£10,170
Gramoxone 100	35	£5.13	£180
Kerb	50	£28.40	£1,420
Krenite	50	£18.50	£925
Mascot Contact Turf Fungicide	20	£40.45	£809
Mascot Systemic Turf Fungicide	17	£27.60	£478
Mildothane Turf Liquid	720	£13.00	£9,360
MSS Aminotriazole 80 WP	58	£3.30	£191
Roundup	183	£10.80	£1,981
Roundup Pro	825	£14.70	£12,132
Rovral Green	738	£21.72	£16,029
Spasor	24	£13.55	£325
Super Mosstox	60	£8.45	£507
Tecto	120	£56.60	£6,792
Tordon 22K	50	£24.00	£1,200
Tribute/Docklene	25	£5.15	£129
Twister	59	£37.80	£2,223
		TOTAL:	£90,843

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VOLUME OF PESTICIDES CURRENTLY APPLIED BY NON-AGRICULTURAL USERS - COLNE CATCHMENT.

BRAND NAME	CHEMICAL NAME	PRICE	MARKETING COMPANY	CONCENTRATION	DISTRICT COUNCILS				COUNTY ROADS	OTHER COUNTY SERVICES	BRITISH RAIL	UTILITIES				GOLF COURSES	TOTAL VOLUME CHEMICAL	KG or LTR
					HERTSMERE	ST.ALBANS	3 RIVERS	WATFORD				TELECOM	GAS	ELEC-TRICITY	WATER			
Arsenal 50	Imazapyr	£20.50	Nomix Chipman	50 g/l				55									55	lt
Asulox	Asulam	£12.00	RP Environ	400 g/l						50							50	lt
Atladox HL	2,4 D + picloram	£12.00	Nomix Chipman	240:65 g/l					346								346	lt
Borocil K	Bromacil + Diuron	£1 10	RP Environ./Du Pont	0.88:0.88% w/w										200			200	kg
Broadshot	2,4-D + dicamba + triclopyr	£13.49	Shell	200:85:65 g/l						50							50	lt
Carbaryl 45	Carbaryl	£14.44	Vitax & Others	450g/l												111	111	lt
Casoron G	Dichlobenil	£4.60	Nomix Chipman & ICI	6.75% w/w	10	150		100		50		75					385	kg
Clarosan 1 FG	Terbutryn	£3.57	Ciba-Geigy	1% w/w	4							10					14	kg
Clovotox	Mecoprop	£4.46	RP Environmental	300g/l		27										1980	2007	lt
Dash	Glufosinate-ammonium	£8.00	Nomix-Chipman	120g/l				20									20	lt
Diuron 80 WP	Diuron	£11.15	RP Environmental	80% w/w	120						120		26				266	kg
Estermone	2,4-D + Dicamba	£7.38	Vitax	200 g/l & 35 g/l												480	480	lt
Fettel	Dicamba + mecoprop + triclopyr	£17.50	Farm Protection	78:130:72 g/l										10			10	lt
Garlon 4	Triclopyr	£30.00	Nomi-Chipman	480 g/l				20	14	50	255						339	lt
Gramoxone 100	Paraquat	£5.13	ICI	200g/l								35					35	lt
Kerb	Propyzamide	£28.40	PBI/Rohm & Haas	400 g/l						50							50	lt
Kreoite	Fosamine-ammonium	£18.50	Du Pont	480 g/l						50							50	lt
Mascot Contact Turf Fungicide	Vinclozolin	£40.45	Rigby Taylor	500 g/l		20											20	lt
Mascot Systemic Turf Fungicide	Carbendazim (MBC)	£27.60	Rigby Taylor	500 g/l		13		4									17	lt
Mildothane Turf Liquid	Thiophanate-methyl	£13.00	RP Environmental	500 g/l												720	720	lt
MSS Aminotriazole 80 WP	Amitrole	£3.30	Mirfield	80% w/w	8					50							58	kg
Roundup	Glyphosate	£10.80	Monsanto	360 g/l	6		20	85		50			17		5		183	lt
Roundup Pro	Glyphosate	£14.70	Monsanto	360 g/l		533			110		182						825	lt
Rovral Green	Iprodione	£21.72	RP Environmental	250 g/l				18								720	738	lt
Spasor	Glyphosate	£13.55	RP Environmental	360 g/l												24	24	lt
Super Mosstox	Dichlorophen	£8.45	RP Environemtal	340 g/l		60											60	lt
Tecto	Thiabendazole	£56.60	Vitax	450 g/l												120	120	lt
Tordon 22K	Picloram	£24.00	Nomix-Chipman	240 g/l						50							50	lt
Tribute/Docklene	Dicamba + MCPA + mecoprop	£5.15	Nomix-Chipman	18:252:84 g/l				20				5					25	lt
Twister	Carbaryl	£37.80	RP Environ.	85% w/w												59	59	kg

CURRENT EXPENDITURE ON PESTICIDES BY NON-AGRICULTURAL USERS - COLNE CATCHMENT.

BRAND NAME	CHEMICAL NAME	PRICE £ per L/Kg	MARKETING COMPANY	CONCENTRATION	DISTRICT COUNCILS HERTSMERE	DISTRICT COUNCILS ST.ALBANS	DISTRICT COUNCILS 3 RIVERS	DISTRICT COUNCILS WATFORD	COUNTY ROADS	OTHER COUNTY SERVICES	BRITISH RAIL	UTILITIES TELECOM	UTILITIES GAS	UTILITIES ELEC-TRICITY	UTILITIES WATER	GOLF COURSES	TOTAL VALUE OF CHEMICALS
Arsenal 50	Imazapyr	£20.50	Nomix-Chipman	50 g/l				£1,128									£1,12
Asulox	Asulam	£12.00	RP Environ	400 g/l						£600							£60
Atladox HL	2,4-D + picloram	£12.00	Nomix Chipman	240:65 g/l					£4,152								£4,15
Borocil K	Bromacil + Diuron	£1.10	RP Environ./Du Pont	0.88:0.88% w/w										£220			£22
Broadshot	2,4-D + dicamba + triclopyr	£13.49	Shell	200:85:65 g/l						£675							£67
Carbaryl 45	Carbaryl	£14.44	Vitax & Others	450g/l												£1,603	£1,60
Casoron G	Dichlobenil	£4.60	Nomix-Chipman & ICI	6.75% w/w	£46	£690		£460		£230		£345					£1,77
Clarosan 1 FG	Terbutryn	£3.57	Ciba-Geigy	1% w/w	£14							£36					£5
Clovotox	Mecoprop	£4.46	RP Environmental	300g/l		£119										£8,831	£8,95
Dash	Glufosinate ammonium	£8.00	Nomix Chipman	120g/l				£160									£16
Diuron 80 WP	Diuron	£11.15	RP Environmental	80% w/w	£1,338						£1,338		£291				£2,96
Estermone	2,4-D + Dicamba	£7.38	Vitax	200 g/l & 35 g/l												£3,542	£3,54
Fettel	Dicamba + mecoprop + triclopyr	£17.50	Ferm Protection	78:130:72 g/l										£175			£17
Garlon 4	Triclopyr	£30.00	Nomix Chipman	480 g/l				£600	£420	£1,500	£7,650						£10,17
Gramoxone 100	Paraquat	£5.13	ICI	200g/l								£180					£18
Kerb	Propyzamide	£28.40	PBI/Rohm & Haas	400 g/l						£1,420							£1,42
Krenite	Fosamine-ammonium	£18.50	Du Pont	480 g/l						£925							£92
Mascot Contact Turf Fungicide	Vinclozolin	£40.45	Rigby Taylor	500 g/l		£809											£80
Mascot Systemic Turf Fungicide	Carbendazim (MBC)	£27.60	Rigby Taylor	500 g/l		£368		£110									£47
Mildothane Turf Liquid	Thiophanate-methyl	£13.00	RP Environmental	500 g/l												£9,360	£9,36
MSS Aminotriazole 80 WP	Amitrole	£3.30	Mirfield	80% w/w	£26					£165							£19
Roundup	Glyphosate	£10.80	Monsanto	360 g/l	£65		£216	£918		£540			£188		£54		£1,98
Roundup Pro	Glyphosate	£14.70	Monsanto	360 g/l		£7,840			£1,617		£2,675						£12,13
Rovral Green	Iprodione	£21.72	RP Environmental	250 g/l				£391								£15,638	£16,02
Spasor	Glyphosate	£13.55	RP Environmental	360 g/l												£325	£32
Super Mosstox	Dichlorophen	£8.45	RP Environmental	340 g/l		£507											£50
Tecto	Thiabendazole	£56.60	Vitax	450 g/l												£6,792	£6,79
Tordon 22K	Picloram	£24.00	Nomix-Chipman	240 g/l						£1,200							£1,20
Tribute/Docklene	Dicamba + MCPA + mecoprop	£5.15	Nomix-Chipman	18:252:84 g/l				£103				£26					£12
Twister	Carbaryl	£37.80	RP Environ.	85% w/w												£2,223	£2,22
				TOTAL:	£1,489	£10,333	£216	£3,870	£6,189	£7,255	£11,663	£586	£479	£395	£54	£48,314	£90,84

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MODEL OF PESTICIDE USAGE BY GOLF COURSES IN THE COLNE CATCHMENT

BRAND OF PESTICIDE	LOCATION OF APPLICATION	AREA OF APPLICATION	MONTHS OF USE	APPLICATIONS/ YEAR	APPROXIMATE APPLICATION RATE	TOTAL VOLUME/ WEIGHT	PRICE /l or kg	EXPENDITURE /ANNUM
WEED CONTROL								
Clovotox	Fairways	18 ha	April - September	1	11 l/ha	198 l	£4.46 /l	£883
Spasor	Bunkers & pathways	0.5 ha	April - September	1	5 l/ha	2.4 l	£13.55 /l	£33
Estermone	Greens, fairways & tees	16 ha	April - September	1	3 l/ha	48 l	£7.38 /l	£354
							SUB TOTAL:	*£1,270*
DISEASE CONTROL								
Mildothane	Greens	1.8 ha	March - September	2	20 l/ha	72 l	£13.00 /l	£936
Rovral Green	Greens	1.8 ha	January - December	2	20 l/ha	72 l	£21.72 /l	£1,564
Tecto	Greens	1.8 ha	October - April	1	6.7 l/ha	12 l	£56.60 /l	£679
							SUB TOTAL:	*£3,179*
WORM CONTROL								
Carbaryl 45	Greens, fairways & tees	1.8 ha	September - June	1	6.2 l/ha	11 l	£14.44 /l	£160
Twister	Greens, fairways & tees	1.8 ha	September - June	1	3.3 kg/ha	6 kg	£37.80 /kg	£223
							SUB TOTAL:	*£383*
							TOTAL;	£4,832

APPENDIX 5

DETAILED CALCULATIONS OF NON-AGRICULTURAL INCREMENTAL COSTS - TOTAL BAN

Non-Agricultural Areas

Total Pesticide Ban - Detailed Calculations

Department of Transport Motorways and Trunk Roads

Leam Catchment

	£/annum
Additional Mowing and Maintenance Costs	
- Verges 62km x 2* x £48/km	5,952
- Other Areas 31km x 2* x £48/km	2,976
Closure Cost	
- Verges 62km x 2* x £400/km	49,600
- Other Areas 31km x 2* x £400/km	24,800
	83,328
Spraying Costs saved	
- Verges 62km x £88/km	5,456
- Other Areas 31km x £96/km	2,976
	8,432
Incremental Costs/Annum	74,896

Colne Catchment

	£/annum
Additional Mowing and Maintenance Costs	
- Verges 112km x 2* x £48/km	10,752
- Other Areas 56km x 2* x £48/km	5,376
Closure Costs	
- Verges 112km x 2* x £400/km	89,600
- Other Areas 56km x 2* x £400/km	44,800
	150,528
Spraying Costs Saved	
- Verges 112km x £88/km	9,856
- Other Areas 56km x £96/km	5,376
	15,232
Incremental Costs/Annum	135,296

* Operations likely to be required twice/year

Local Authority Roads

Leam Catchment

	£/annum
Additional Brushing and Clearance Costs	
- Kerb Roads/Pavements 160km x 2* x £400[1/]	128,000
- Sundry Areas (@ 10%)	12,800
	140,800
Spraying Costs Saved	
- Kerb Roads/Pavements 160km x 2* x £40	12,800
- Sundry Areas (@ 15%)	1,920
	14,720
Incremental Costs/Annum	126,080

Colne Catchment

	£/annum
Additional Brushing and Clearance Costs	
- Kerb Roads/Pavements 480km x 2* x £400[1/]	384,000
- Sundry Areas (@ 10%)	38,400
	422,400
Spraying Costs Saved	
- Kerb Roads/Pavements 480km x 2* x £40	38,400
- Sundry Areas (@15%)	5,760
	44,160
Incremental Costs/Annum	378,240

* Operation likely to be required twice/year

[1/] Cost/km for hiring contractor using 'Danline Weedripper'

British Rail

Leam Catchment

	£/annum
Future Re-ballasting of Track	
62km @ £55,000/km every 7 years	487,143
Weed Control in adjoining areas	
62km @ £750/km	46,500
	533,643
Present Re-ballasting of Track	
62km @ £55,000/km every 15 years	227,333
Spraying Costs saved	
- Track 62km x £105.50	6,541
- Adjoining Areas 62km x £250/km	15,500
	249,374
Incremental Costs/Annum	284,269

Colne Catchment

Future Re-ballasting of Track	
104km @ £55,000/km every 7 years	817,143
Weed Control in Adjoining Areas	
104km @ £750/km	78,000
	895,143
Present Re-ballasting of Track	
104km @ £55,000/km every 15 years	381,333
Weed Control in Adjoining Areas	
104km @ £250/km	26,000
	407,333
Incremental Costs/Annum	487,810

Local Authorities and Public Utilities (Costs/Annum)

	Leam	Colne
British Telecom		
Present Spraying Costs (£)	-	3,907
Future Weed Control Costs (£)	-	35,160
Incremental Costs/Annum (£)	-	31,253
British Gas		
Present Spraying Costs (£)	453	3,193
Future Weed Control Costs (£)	4,080	28,740
Incremental Costs/Annum (£)	3,627	25,547
Electricity Companies		
Present Spraying Costs (£)	113	2,633
Future Weed Control Costs (£)	1,020	23,700
Incremental Costs/Annum (£)	907	21,067
Water Companies		
Present Spraying Costs (£)	4,960	360
Future Weed Control Costs (£)	19,840	1,440
Incremental Costs/Annum (£)	14,880	1,080
Local Authority Park/Amenity Land		
Present Spraying Costs (£)	61,315	94,685
Future Weed Control Costs (£)	255,357	317,537
Incremental Costs/Annum (£)	194,042	222,852
Colleges/Schools etc		
Present Spraying Costs (£)	8,960	48,367
Future Weed Control Costs (£)	26,880	145,100
Incremental Costs/Annum (£)	17,920	96,733

Golf Courses

Typical Golf Course

	£/annum
Greens	
- Weed Control with no pesticides	6,000
- Turf Replacement £1,200/green x 18 greens every 5 years	4,320
- Loss of Revenue (5% of £380,000)	19,000
Fairways and other areas	3,000
	32,320
Spraying Costs Saved	12,000
Incremental Costs/Annum	20,320

Leam (6 courses)

Annual Costs without pesticides	193,920
Spraying Costs saved	72,000
Incremental Costs/Annum	121,920

Colne (10 courses)

Annual Costs without pesticides	323,200
Spraying Costs saved	120,000
Incremental Costs/Annum	203,200

APPENDIX 6

VOLUMES OF NON-AGRICULTURAL PESTICIDES, PRICES AND TOTAL EXPENDITURE - RESTRICTED USE SCENARIO

VALUE OF PESTICIDES APPLIED BY NON-AGRICULTURAL USERS UNDER RESTRICTED USAGE SCENARIO - LEAM CATCHMENT

BRAND NAME	TOTAL VOLUME L/KG	PRICE /L or KG	TOTAL VALUE
Arsenal 50	96	£20.50	£1,968
BH MCPA 75	45	£1.44	£65
Borocil K	0	£1.10	£0
Burtolin	375	£5.75	£2,156
Carbaryl 45	30	£14.44	£433
Casoron G	737	£4.60	£3,391
Castaway Plus	56	£17.55	£983
Dextrone X	29	£6.50	£187
Diuron 80 WP	0	£11.15	£0
Dormone .	6	£1.50	£9
Estermone	486	£7.38	£3,587
Garlon 4	152	£30.00	£4,560
Mildothane Turf Liquid	20	£13.00	£260
MSS 2,4-D Amine	1	£1.50	£1
MSS Aminotriazole 80 WP	3	£3.30	£10
MSS Atrazine 50 FL	3	£2.50	£8
Regulox K	59	£5.20	£304
Roundup	63	£10.80	£682
Roundup GC	30	£12.40	£372
Roundup Pro	151	£14.70	£2,220
Rovral Green	180	£21.72	£3,910
Spasor	55	£13.55	£738
Stirrup	84	£13.80	£1,159
Sulphate of Iron	61	£0.22	£13
Super Mosstox	5	£8.45	£42
Super Verdone	360	£51.60	£18,576
Supertox 30	0	£4.60	£0
Tecto	79	£56.60	£4,471
Turfex	100	£15.80	£1,580
Twister	15	£37.80	£567
		TOTAL:	£52,252

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QUANTITY OF PESTICIDES USED BY NON-AGRICULTURAL USERS UNDER THE RESTRICTED USAGE SCENARIO - LEAM CATCHMENT

BRAND NAME	CHEMICAL NAME	PRICE /LT or KG	MARKETING COMPANY	CONCENTRATION	WARWICK				COUNTY ROADS	OTHER COUNTY SERVICES	BRITISH RAIL	UTILITIES				GOLF COURSES	TOTAL	KG or LTR
					WARWICK	STRATFORD	RUGBY	DAVENTRY				TELECOM	GAS	ELEC-TRICITY	WATER			
Arsenal 50	Imazapyr	£20.50	Nomix-Chipman	50 g/l			6		14		72				4		96	lt
BH MCPA 75	MCPA	£1.44	RP Environmental	750 g/l			31		14								45	lt
Borocil K	Bromacil + Diuron	£1.10	RP Environ./Du Pont	0.88:0.88% w/w														kg
Burtolin	Maleic Hydrazide	£5.75	RP Environmental	185 g/l	375												375	lt
Carbaryl 45	Carbaryl	£14.44	Vitax & Others	450g/l	30												30	lt
Casoron G	Dichlobenil	£4.60	Nomix-Chipman & ICI	6.75% w/w	500	15	1			197			24				737	kg
Castaway Plus	Gamma-HCH + thiophanate-methyl	£17.55	RP Environmental	60:500 g/l												56	56	lt
Dextrone X	Paraquat	£6.50	Nomix-Chipman & ICI	200 g/l	25					4							29	lt
Diuron 80 WP	Diuron	£11.15	RP Environmental	80% w/w														kg
Dormone	2,4-D	£1.50	RP Environmental	465 g/l					6								6	lt
Estermone	2,4-D + Dicamba	£7.38	Vitax	200 g/l & 35 g/l	320	1										165	486	lt
Garlon 4	Triclopyr	£30.00	Nomi-Chipman	480 g/l							152						152	lt
Mildothane Turf Liquid	Thiophanate-methyl	£13.00	RP Environmental	500 g/l												20	20	lt
MSS 2,4-D Amine	2,4-D	£1.50	Mirfield	500 g/l										1			1	lt
MSS Aminotriazole 80 WP	Amitrole	£3.30	Mirfield	80% w/w					3								3	kg
MSS Atrazine 50 FL	Atrazine	£2.50	Mirfield	500 g/l										3			3	lt
Regulox K	Maleic Hydrazide	£5.20	RP Environmental	250 g/l					59								59	lt
Roundup	Glyphosate	£10.80	Monsanto	360 g/l			19	10	23					1		10	63	lt
Roundup GC	Glyphosate	£12.40	Monsanto	360 g/l	30												30	lt
Roundup Pro	Glyphosate	£14.70	Monsanto	360 g/l					42		109						151	lt
Rovral Green	Iprodione	£21.72	RP Environmental	250 g/l	100											80	180	lt
Spasor	Glyphosate	£13.55	RP Environmental	360 g/l	50	5											55	lt
Stirrup	Glyphosate	£13.80	Nomix-Chipman	144 g/l		5	1			30					48		84	lt
Sulphate of Iron		£0.22	Vitax	n/a												61	61	lt
Super Mosstox	Dichlorophen	£8.45	RP Environemtal	340 g/l	5												5	lt
Super Verdone	2,4-D + dicamba + ioxynil	£51.60	ICI Professional	72:12:48 g/l												360	360	lt
Supertox 30	2,4-D + mecoprop	£4.60	RP Environ.	90:190 g/l														lt
Tecto	Thiabendazole	£56.60	Vitax	450 g/l	50											29	79	lt
Turfex		£15.80	Fisons	n/a												100	100	lt
Twister	Carbaryl	£37.80	RP Environ.	85% w/w												15	15	kg

VALUE OF PESTICIDES USED BY NON-AGRICULTURAL USERS UNDER THE RESTRICTED USAGE SCENARIO - LEAM CATCHMENT

BRAND NAME	CHEMICAL NAME	PRICE /LT or KG	MARKETING COMPANY	CONCENTRATION	DISTRICT COUNCILS				COUNTY ROADS	OTHER COUNTY SERVICES	BRITISH RAIL	UTILITIES				GOLF COURSES	TOTAL
					WARWICK	STRATFORD	RUGBY	DAVENTRY				TELECOM	GAS	ELEC-TRICITY	WATER		
Arsenal 50	Imazapyr	£20.50	Nomix-Chipman	50 g/l			£123		£287		£1,476				£82		£1,968
BH MCPA 75	MCPA	£1.44	RP Environmental	750 g/l			£45		£21								£65
Borocil K	Bromacil + Diuron	£1.10	RP Environ./Du Pont	0.88:0.88% w/w													
Burtolin	Maleic Hydrazide	£5.75	RP Environmental	185 g/l	£2,156												£2,156
Carbaryl 45	Carbaryl	£14.44	Vitax & Others	450g/l	£433												£433
Casoron G	Dichlobenil	£4.60	Nomix-Chipman & ICI	6.75% w/w	£2,300	£69	£6			£906			£110				£3,391
Castaway Plus	Gamma-HCH + thiophanate-methyl	£17.55	RP Environmental	60:500 g/l												£983	£983
Dextrone X	Paraquat	£6.50	Nomix-Chipman & ICI	200 g/l	£163					£24							£187
Diuron 80 WP	Diuron	£11.15	RP Environmental	80% w/w													
Dormone	2,4-D	£1.50	RP Environmental	465 g/l					£9								£9
Estermone	2,4-D + Dicamba	£7.38	Vitax	200 g/l & 35 g/l	£2,362	£7										£1,218	£3,587
Garlon 4	Triclopyr	£30.00	Nomi-Chipman	480 g/l							£4,560						£4,560
Mildothane Turf Liquid	Thiophanate-methyl	£13.00	RP Environmental	500 g/l												£260	£260
MSS 2,4-D Amine	2,4-D	£1.50	Mirfield	500 g/l										£1			£1
MSS Aminotriazole 80 WP	Amitrole	£3.30	Mirfield	80% w/w					£10								£10
MSS Atrazine 50 FL	Atrazine	£2.50	Mirfield	500 g/l										£8			£8
Regulox K	Maleic Hydrazide	£5.20	RP Environmental	250 g/l					£304								£304
Roundup	Glyphosate	£10.80	Monsanto	360 g/l			£207	£108	£251					£8		£108	£682
Roundup GC	Glyphosate	£12.40	Monsanto	360 g/l	£372												£372
Roundup Pro	Glyphosate	£14.70	Monsanto	360 g/l					£617		£1,602						£2,220
Rovral Green	Iprodione	£21.72	RP Environmental	250 g/l	£2,172											£1,738	£3,910
Spasor	Glyphosate	£13.55	RP Environmental	360 g/l	£678	£61											£738
Stirrup	Glyphosate	£13.80	Nomix-Chipman	144 g/l		£69	£14			£414					£662		£1,159
Sulphate of Iron	n/a	£0.22	Vitax	n/a												£13	£13
Super Mosstox	Dichlorophen	£8.45	RP Environemtal	340 g/l	£42												£42
Super Verdone	2,4-D + dicamba + ioxynil	£51.60	ICI Professional	72:12:48 g/l												£18,576	£18,576
Supertox 30	2,4-D + mecoprop	£4.60	RP Environ.	90:190 g/l													
Tecto	Thiabendazole	£56.60	Vitax	450 g/l	£2,830											£1,641	£4,471
Turfex	n/a	£15.80	Fisons	n/a												£1,580	£1,580
Twister	Carbaryl	£37.80	RP Environ.	85% w/w												£567	£567
				TOTAL:	£13,507	£206	£395	£108	£1,499	£1,344	£7,638		£110	£17	£744	£26,684	£52,252

APPENDIX 7

VOLUMES OF NON-AGRICULTURAL PESTICIDES, PRICES AND TOTAL EXPENDITURE - PROTECTION ZONE

VALUE OF PESTICIDES APPLIED BY NON-AGRICULTURAL USERS UNDER PROTECTION ZONE SCENARIO - LEAM CATCHMENT

BRAND NAME	TOTAL VOLUME L/KG	PRICE L/KG	TOTAL VALUE (£)
Arsenal 50	20	£20.50	£401
BH MCPA 75	45	£1.44	£65
Borocil K	12	£1.10	£13
Burtolin	375	£5.75	£2,156
Carbaryl 45	30	£14.44	£433
Casoron G	725	£4.60	£3,337
Castaway Plus	56	£17.55	£983
Dextrone X	29	£6.50	£187
Diuron 80 WP	76	£11.15	£848
Dormone	6	£1.50	£9
Estermone	220	£7.38	£1,627
Garlon 4	152	£30.00	£4,560
Mildothane Turf Liquid	20	£13.00	£260
MSS 2,4-D Amine	1	£1.50	£1
MSS Aminotriazole 80 WP	3	£3.30	£10
MSS Atrazine 50 FL	3	£2.50	£8
Regulox K	59	£5.20	£304
Roundup	63	£10.80	£682
Roundup GC	30	£12.40	£372
Roundup Pro	151	£14.70	£2,220
Rovral Green	180	£21.72	£3,910
Spasor	55	£13.55	£738
Stirrup	84	£13.80	£1,159
Sulphate of Iron	61	£0.22	£13
Super Mosstox	5	£8.45	£42
Super Verdone	360	£51.60	£18,576
Supertox 30	266	£4.60	£1,222
Tecto	79	£56.60	£4,471
Turfex	100	£15.80	£1,580
Twister	15	£37.80	£567
		TOTAL:	£50,754

QUANTITY OF PESTICIDES APPLIED BY NON-AGRICULTURAL USERS UNDER THE PROTECTION ZONE SCENARIO - LEAM CATCHMENT.

BRAND NAME	CHEMICAL NAME	MARKETING COMPANY	CONCENTRATION	DISTRICT COUNCILS				COUNTY ROADS	OTHER COUNTY SERVICES	BRITISH RAIL	UTILITIES				GOLF COURSES	TOTAL	KG or LTR
				WARWICK	STRATFORD	RUGBY	DAVENTRY				TELECOM	GAS	ELEC-TRICITY	WATER			
Arsenal 50	Imazapyr	Nomix-Chipman	50 g/l			0.11		14		1				4		20	lt
BH MCPA 75	MCPA	RP Environmental	750 g/l			31		14								45	lt
Borocil K	Bromacil + Diuron	RP Environ/Du Pont	0.88:0.88% w/w									12				12	kg
Burtolin	Maleic Hydrazide	RP Environmental	185 g/l	375												375	lt
Carbaryl 45	Carbaryl	Vitax & Others	450g/l	30												30	lt
Casoron G	Dichlobenil	Nomix-Chipman & ICI	6.75% w/w	500	15	1			197			12				725	kg
Castaway Plus	Gamma-HCH + thiophanate methyl	RP Environmental	60:500 g/l												56	56	lt
Dextrone X	Paraquat	Nomix-Chipman & ICI	200 g/l	25					4							29	lt
Diuron 80 WP	Diuron	RP Environmental	80% w/w			6				71						76	kg
Dormone	2,4-D	RP Environmental	465 g/l					6								6	lt
Estermone	2,4-D + Dicamba	Vitax	200 g/l & 35 g/l	55	0										165	220	lt
Garlon 4	Triclopyr	Nomi-Chipman	480 g/l							152						152	lt
Mildothane Turf Liquid	Thiophanate-methyl	RP Environmental	500 g/l												20	20	lt
MSS 2,4-D Amine	2,4-D	Mirfield	500 g/l										1			1	lt
MSS Aminotriazole 80 WP	Amitrole	Mirfield	80% w/w					3								3	kg
MSS Atrazine 50 FL	Atrazine	Mirfield	500 g/l										3			3	lt
Regulox K	Maleic Hydrazide	RP Environmental	250 g/l					59								59	lt
Roundup	Glyphosate	Monsanto	360 g/l			19	10	23					1		10	63	lt
Roundup GC	Glyphosate	Monsanto	360 g/l	30												30	lt
Roundup Pro	Glyphosate	Monsanto	360 g/l					42		109						151	lt
Rovral Green	Iprodione	RP Environmental	250 g/l	100											80	180	lt
Spasor	Glyphosate	RP Environmental	360 g/l	50	5											55	lt
Stirrup	Glyphosate	Nomix-Chipman	144 g/l		5	1			30					48		84	lt
Sulphate of Iron		Vitax													61	61	lt
Super Mosstox	Dichlorophen	RP Environemtal	340 g/l	5												5	lt
Super Verdone	2,4-D + dicamba + ioxynil	ICI Professional	72:12:48 g/l												360	360	lt
Supertox 30	2,4-D + mecoprop	RP Environ.	90:190 g/l	265	1											266	lt
Tecto	Thiabendazole	Vitax	450 g/l	50											29	79	lt
Turfex		Fisons													100	100	lt
Twister	Carbaryl	RP Environ.	85% w/w												15	15	kg

VALUE OF PESTICIDES APPLIED BY NON-AGRICULTURAL USERS UNDER THE PROTECTION ZONE SCENARIO - LEAM CATCHMENT.

BRAND NAME	CHEMICAL NAME	MARKETING COMPANY	CONCENTRATION	DISTRICT COUNCILS				COUNTY ROADS	OTHER COUNTY SERVICES	BRITISH RAIL	UTILITIES				GOLF COURSES	TOTAL
				WARWICK	STRATFORD	RUGBY	DAVENTRY				TELECOM	GAS	ELEC-TRICITY	WATER		
Arsenal 50	Imazapyr	Nomix Chipman	50 g/l			£2		£287		£30				£82		£401
BH MCPA 75	MCPA	RP Environmental	750 g/l			£45		£21								£65
Borocil K	Bromacil + Diuron	RP Environ./Du Pont	0.88:0.88% w/w									£13				£13
Burtolin	Maleic Hydrazide	RP Environmental	185 g/l	£2,156												£2,156
Carbaryl 45	Carbaryl	Vitax & Others	450g/l	£433												£433
Casoron G	Dichlobenil	Nomix Chipman & ICI	6.75% w/w	£2,300	£69	£6			£906			£56				£3,337
Castaway Plus	Gamma-HCH + thiophanate-methyl	RP Environmental	60:500 g/l												£983	£983
Dextrone X	Paraquat	Nomix Chipman & ICI	200 g/l	£163					£24							£187
Diuron 80 WP	Diuron	RP Environmental	80% w/w			£62				£787						£848
Dormone	2,4-D	RP Environmental	465 g/l					£9								£9
Estermone	2,4-D + Dicamba	Vitax	200 g/l & 35 g/l	£409	£0										£1,218	£1,627
Garlon 4	Triclopyr	Nomi Chipman	480 g/l							£4,560						£4,560
Mildothane Turf Liquid	Thiophanate-methyl	RP Environmental	500 g/l												£260	£260
MSS 2,4-D Amine	2,4-D	Mirfield	500 g/l										£1			£1
MSS Aminotriazole 80 WP	Amitrole	Mirfield	80% w/w					£10								£10
MSS Atrazine 50 FL	Atrazine	Mirfield	500 g/l										£8			£8
Regulox K	Maleic Hydrazide	RP Environmental	250 g/l					£304								£304
Roundup	Glyphosate	Monsanto	360 g/l			£207	£108	£251					£8		£108	£682
Roundup GC	Glyphosate	Monsanto	360 g/l	£372												£372
Roundup Pro	Glyphosate	Monsanto	360 g/l					£617		£1,602						£2,220
Rovral Green	Iprodione	RP Environmental	250 g/l	£2,172											£1,738	£3,910
Spasor	Glyphosate	RP Environmental	360 g/l	£678	£61											£738
Stirrup	Glyphosate	Nomix-Chipman	144 g/l		£69	£14			£414					£662		£1,159
Sulphate of Iron		Vitax													£13	£13
Super Mosstox	Dichlorophen	RP Environmental	340 g/l	£42												£42
Super Verdone	2,4-D + dicamba + ioxynil	ICI Professional	72:12:48 g/l												£18,576	£18,576
Supertox 30	2,4-D + mecoprop	RP Environ.	90:190 g/l	£1,217	£5											£1,222
Tecto	Thiabendazole	Vitax	450 g/l	£2,830											£1,641	£4,471
Turfex		Fisons													£1,580	£1,580
Twister	Carbaryl	RP Environ.	85% w/w												£567	£567
			TOTAL	£12,772	£204	£336	£108	£1,499	£1,344	£6,979		£69	£17	£744	£26,684	£50,754

APPENDIX 8

WATER TREATMENT COSTS AND PRESENT VALUES

WATER TREATMENT COSTS

LEAM CATCHMENT - GAC - £'000

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	TV
Capital Costs												
Civil Engineering Costs	452.99											203.85
Mechanical and Electrical Costs	648.15											291.67
Total Capital Costs	1101.14											495.51
Annual Operating Costs		126.65	126.65	126.65	126.65	126.65	126.65	126.65	126.65	126.65	126.65	
Total Costs	1101.14	126.65	126.65	126.65	126.65	126.65	126.65	126.65	126.65	126.65	126.65	-495.51
Present Value @ 8% discount factor	1738.45											
Present Value @ 5% discount factor	1789.38											

WATER TREATMENT COSTS

LEAM CATCHMENT - OZONE - £'000

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	TV
Capital Costs												
Civil Engineering Costs	256.50											115.43
Mechanical and Electrical Costs	454.60											204.57
Total Capital Costs	711.10											320.00
Annual Operating Costs		60.80	60.80	60.80	60.80	60.80	60.80	60.80	60.80	60.80	60.80	
Total Costs	711.10	60.80	60.80	60.80	60.80	60.80	60.80	60.80	60.80	60.80	60.80	-320.00
Present Value @ 8% discount factor	981.83											
Present Value @ 5% discount factor	993.49											

WATER TREATMENT COSTS

LEAM CATCHMENT - OZONE/GAC - £'000

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	TV
Capital Costs												
Civil Engineering Costs	709.49											319.27
Mechanical and Electrical Costs	1102.75											496.24
Total Capital Costs	1812.24											815.51
Annual Operating Costs		142.31	142.31	142.31	142.31	142.31	142.31	142.31	142.31	142.31	142.31	
Total Costs	1812.24	142.31	142.31	142.31	142.31	142.31	142.31	142.31	142.31	142.31	142.31	-815.51
Present Value @ 8% discount factor	2417.39											
Present Value @ 5% discount factor	2434.31											

WATER TREATMENT COSTS

COLNE CATCHMENT - GAC - 5 MINUTE BED CONTACT TIME - £'000

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	TV
Capital Costs												
Civil Engineering Costs	408.56											183.85
Mechanical and Electrical Costs	950.96											427.93
Total Capital Costs	1359.52											611.78
Annual Operating Costs		120.27	120.27	120.27	120.27	120.27	120.27	120.27	120.27	120.27	120.27	
Total Costs	1359.52	120.27	120.27	120.27	120.27	120.27	120.27	120.27	120.27	120.27	120.27	-611.78
Present Value @ 8% discount factor	1904.16											
Present Value @ 5% discount factor	1930.52											

WATER TREATMENT COSTS

COLNE CATCHMENT - GAC - 10 MINUTE BED CONTACT TIME - £'000

Year	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	TV
Capital Costs												
Civil Engineering Costs	766.01											344.70
Mechanical and Electrical Costs	1854.75											834.64
Total Capital Costs	2620.76											1179.34
Annual Operating Costs		185.35	185.35	185.35	185.35	185.35	185.35	185.35	185.35	185.35	185.35	
Total Costs	2620.76	185.35	185.35	185.35	185.35	185.35	185.35	185.35	185.35	185.35	185.35	-1179.34
Present Value @ 8% discount factor	3358.67											
Present Value @ 5% discount factor	3362.45											

APPENDIX 9

UK ECONOMIC AGRICULTURAL CASH FLOWS

LEAM CATCHMENT - PROJECTED UK ECONOMIC AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
NO PESTICIDE RESTRICTIONS
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	2251	2370	2401	2427	2427	2427	2427	2427	2427	2427	2427
Beef Cows	218	309	313	319	319	319	319	319	319	319	319
Dairy heifers	192	226	233	240	240	240	240	240	240	240	240
Beef heifers	36	44	56	67	67	67	67	67	67	67	67
Beef 2yrs+	105	260	259	259	259	259	259	259	259	259	259
Fattening Suckled Calves (2 yrs)	11	60	63	66	66	66	66	66	66	66	66
Beef 2yrs	101	153	145	138	138	138	138	138	138	138	138
Sheep	648	677	714	748	748	748	748	748	748	748	748
Sub-Total Livestock	3563	4099	4184	4264	4264	4264	4264	4264	4264	4264	4264
Arable Crop Gross Margins :											
Wheat	2337	1961	2063	2200	2222	2243	2243	2243	2243	2243	2243
Winter Barley	567	513	451	384	287	190	190	190	190	190	190
Spring Barley	53	52	22	16	8	0	0	0	0	0	0
Oats	56	52	38	25	13	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	253	253	253	253	253	253	253	253	253	253	253
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	106	106	105	104	103	102	102	102	102	102	102
Field Beans	305	347	422	499	572	645	645	645	645	645	645
Harvest Peas	35	41	45	50	54	58	58	58	58	58	58
W. Oilseed Rape	440	346	461	579	690	801	801	801	801	801	801
S. Oilseed Rape	0	66	50	33	17	0	0	0	0	0	0
Linseed	185	193	150	108	65	22	22	22	22	22	22
Other crops inc Triticale	6	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	110	535	562	562	562	561	561	561	561	561	561
Sub-Total Crops	4452	4465	4624	4813	4844	4876	4876	4876	4876	4876	4876
TOTAL GROSS MARGIN	8015	8564	8808	9077	9108	9140	9140	9140	9140	9140	9140
RECURRENT FIXED COSTS											
Regular Labour	1880	1857	1848	1842	1836	1829	1829	1829	1829	1829	1829
Machinery-Repairs/Fuel etc.	1839	1818	1816	1815	1814	1814	1814	1814	1814	1814	1814
Occupiers Repairs	641	641	641	641	641	641	641	641	641	641	641
Miscellaneous Costs	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229
Sub-Total Recurrent Costs	5589	5545	5535	5528	5520	5513	5513	5513	5513	5513	5513
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	2426	3019	3273	3549	3588	3627	3627	3627	3627	3627	3627
PRESENT VALUE @ 8% discount factor	25806										
PRESENT VALUE @ 5% discount factor	29433										

LEAM CATCHMENT - PROJECTED UK ECONOMIC AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
TOTAL PESTICIDE BAN
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	2251	2372	2402	2428	2428	2428	2428	2428	2428	2428	2428
Beef Cows	218	310	314	320	320	320	320	320	320	320	320
Dairy heifers	192	227	234	240	240	240	240	240	240	240	240
Beef heifers	36	44	56	67	67	67	67	67	67	67	67
Beef 2yrs+	105	262	260	259	259	259	259	259	259	259	259
Fattening Suckled Calves (2 yrs)	11	61	63	66	66	66	66	66	66	66	66
Beef 2yrs	101	154	145	138	138	138	138	138	138	138	138
Sheep	648	680	716	749	749	749	749	749	749	749	749
Sub-Total Livestock	3563	4108	4190	4268	4268	4268	4268	4268	4268	4268	4268
Arable Crop Gross Margins :											
Winter Wheat	2337	1552	1550	1573	1460	1348	1348	1348	1348	1348	1348
Spring Wheat	0	0	0	0	0	0	0	0	0	0	0
Winter Barley	567	429	465	503	491	479	479	479	479	479	479
Spring Barley	53	58	70	84	92	100	100	100	100	100	100
Winter Oats	56	28	46	64	82	99	99	99	99	99	99
Spring Oats	0	0	0	0	0	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	253	85	64	42	21	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	106	60	59	58	58	57	57	57	57	57	57
Field Beans	305	291	302	313	324	335	335	335	335	335	335
Harvest Peas	35	31	23	15	8	0	0	0	0	0	0
W. Oilseed Rape	440	403	575	748	920	1093	1093	1093	1093	1093	1093
S. Oilseed Rape	0	73	55	37	18	0	0	0	0	0	0
Linseed	185	196	147	98	49	0	0	0	0	0	0
Other crops inc Triticale	6	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	110	568	599	601	603	604	604	604	604	604	604
Sub-Total Crops	4452	3774	3956	4136	4125	4115	4115	4115	4115	4115	4115
TOTAL GROSS MARGIN	8015	7882	8146	8403	8393	8382	8382	8382	8382	8382	8382
RECURRENT FIXED COSTS											
Regular Labour	1880	1931	1863	1798	1733	1669	1669	1669	1669	1669	1669
Machinery-Repairs/Fuel etc.	1839	1937	1927	1919	1912	1904	1904	1904	1904	1904	1904
Occupiers Repairs	641	641	641	641	641	641	641	641	641	641	641
Miscellaneous Costs	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229
Sub-Total Recurrent Costs	5589	5739	5661	5588	5515	5443	5443	5443	5443	5443	5443
CAPITAL COSTS											
Incremental Machinery Purchases		3160									
ANNUAL CASH FLOW	2426	-1017	2485	2815	2877	2940	2940	2940	2940	2940	2940
PRESENT VALUE @ 8% discount factor	17953										
PRESENT VALUE @ 5% discount factor	20785										

LEAM CATCHMENT - PROJECTED UK ECONOMIC AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
RESTRICTED PESTICIDE USE
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	2251	2369	2400	2426	2426	2426	2426	2426	2426	2426	2426
Beef Cows	218	308	312	318	318	318	318	318	318	318	318
Dairy heifers	192	226	233	240	240	240	240	240	240	240	240
Beef heifers	36	44	56	67	67	67	67	67	67	67	67
Beef 2yrs+	105	259	257	257	257	257	257	257	257	257	257
Fattening Suckled Calves (2 yrs)	11	59	62	65	65	65	65	65	65	65	65
Beef 2yrs	101	152	144	137	137	137	137	137	137	137	137
Sheep	648	675	712	745	745	745	745	745	745	745	745
Sub-Total Livestock	3563	4092	4175	4253	4253	4253	4253	4253	4253	4253	4253
Arable Crop Gross Margins :											
Wheat	2337	1867	1994	2156	2177	2199	2199	2199	2199	2199	2199
Winter Barley	567	504	445	381	285	189	189	189	189	189	189
Spring Barley	53	48	18	10	1	0	0	0	0	0	0
Oats	56	53	39	26	13	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	253	253	253	253	253	253	253	253	253	253	253
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	106	106	105	104	103	102	102	102	102	102	102
Field Beans	305	342	413	485	556	628	628	628	628	628	628
Harvest Peas	35	41	45	50	54	58	58	58	58	58	58
W. Oilseed Rape	440	346	461	579	690	801	801	801	801	801	801
S. Oilseed Rape	0	66	50	33	17	0	0	0	0	0	0
Linseed	185	193	150	108	65	14	14	14	14	14	14
Other crops inc Triticale	6	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	110	534	561	561	560	560	560	560	560	560	560
Sub-Total Crops	4452	4354	4535	4745	4774	4803	4803	4803	4803	4803	4803
TOTAL GROSS MARGIN	8015	8446	8710	8998	9027	9056	9056	9056	9056	9056	9056
RECURRENT FIXED COSTS											
Regular Labour	1880	1855	1846	1840	1833	1827	1827	1827	1827	1827	1827
Machinery-Repairs/Fuel etc.	1839	1818	1816	1815	1814	1813	1813	1813	1813	1813	1813
Occupiers Repairs	641	641	641	641	641	641	641	641	641	641	641
Miscellaneous Costs	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229
Sub-Total Recurrent Costs	5589	5543	5532	5525	5517	5511	5511	5511	5511	5511	5511
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	2426	2902	3178	3473	3510	3545	3545	3545	3545	3545	3545
PRESENT VALUE @ 8% discount factor	25220										
PRESENT VALUE @ 5% discount factor	28764										

LEAM CATCHMENT - PROJECTED UK ECONOMIC AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
PROTECTION ZONE
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	2251	2370	2401	2427	2427	2427	2427	2427	2427	2427	2427
Beef Cows	218	309	313	319	319	319	319	319	319	319	319
Dairy heifers	192	226	233	240	240	240	240	240	240	240	240
Beef heifers	36	44	56	67	67	67	67	67	67	67	67
Beef 2yrs+	105	260	259	259	259	259	259	259	259	259	259
Fattening Suckled Calves (2 yrs)	11	60	63	66	66	66	66	66	66	66	66
Beef 2yrs	101	153	145	138	138	138	138	138	138	138	138
Sheep	648	677	714	748	748	748	748	748	748	748	748
Sub-Total Livestock	3563	4099	4184	4264	4264	4264	4264	4264	4264	4264	4264
Arable Crop Gross Margins :											
Wheat	2337	1947	2048	2184	2206	2227	2227	2227	2227	2227	2227
Winter Barley	567	510	448	381	285	189	189	189	189	189	189
Spring Barley	53	52	22	16	8	0	0	0	0	0	0
Oats	56	51	38	25	13	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	253	253	253	253	253	253	253	253	253	253	253
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	106	103	103	103	102	102	102	102	102	102	102
Field Beans	305	344	419	495	568	641	641	641	641	641	641
Harvest Peas	35	41	45	49	53	57	57	57	57	57	57
W. Oilseed Rape	440	344	458	575	686	796	796	796	796	796	796
S. Oilseed Rape	0	66	50	33	17	0	0	0	0	0	0
Linseed	185	192	149	107	64	22	22	22	22	22	22
Other crops inc Triticale	6	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	110	531	558	558	557	557	557	557	557	557	557
Sub-Total Crops	4452	4434	4592	4780	4811	4844	4844	4844	4844	4844	4844
TOTAL GROSS MARGIN	8015	8533	8776	9043	9075	9108	9108	9108	9108	9108	9108
RECURRENT FIXED COSTS											
Regular Labour	1880	1855	1847	1840	1834	1828	1831	1831	1831	1831	1831
Machinery-Repairs/Fuel etc.	1839	1816	1814	1813	1813	1812	1813	1813	1813	1813	1813
Occupiers Repairs	641	641	641	641	641	641	641	641	641	641	641
Miscellaneous Costs	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229	1229
Sub-Total Recurrent Costs	5589	5542	5531	5524	5517	5510	5515	5515	5515	5515	5515
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	2426	2991	3244	3519	3558	3598	3593	3593	3593	3593	3593
PRESENT VALUE @ 8% discount factor	25597										
PRESENT VALUE @ 5% discount factor	29191										

COLNE CATCHMENT - PROJECTED UK ECONOMIC AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
NO PESTICIDE RESTRICTIONS
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	845	890	902	911	911	911	911	911	911	911	911
Beef Cows	91	127	129	131	131	131	131	131	131	131	131
Dairy heifers	40	46	48	49	49	49	49	49	49	49	49
Beef heifers	13	16	20	24	24	24	24	24	24	24	24
Beef 2yrs+	12	27	27	27	27	27	27	27	27	27	27
Fattening Suckled Calves (2 yrs)	7	27	28	29	29	29	29	29	29	29	29
Beef 2yrs	0	0	0	0	0	0	0	0	0	0	0
Sheep	53	55	59	62	62	62	62	62	62	62	62
Sub-Total Livestock	1061	1189	1212	1234	1234	1234	1234	1234	1234	1234	1234
Arable Crop Gross Margins :											
Wheat	717	576	560	551	530	510	510	510	510	510	510
Winter Barley	246	214	217	221	215	209	209	209	209	209	209
Spring Barley	64	35	21	15	8	0	0	0	0	0	0
Oats	15	14	11	7	4	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	59	59	61	64	67	70	70	70	70	70	70
Field Beans	39	42	53	64	74	85	85	85	85	85	85
Harvest Peas	0	0	9	18	27	35	35	35	35	35	35
W. Oilseed Rape	131	110	149	189	227	265	265	265	265	265	265
S. Oilseed Rape	0	25	19	13	6	0	0	0	0	0	0
Linseed	59	63	53	43	33	23	23	23	23	23	23
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	6	138	146	146	146	146	146	146	146	146	146
Sub-Total Crops	1337	1276	1298	1331	1337	1343	1343	1343	1343	1343	1343
TOTAL GROSS MARGIN	2398	2464	2510	2565	2571	2577	2577	2577	2577	2577	2577
RECURRENT FIXED COSTS											
Regular Labour	683	675	673	671	669	668	668	668	668	668	668
Machinery-Repairs/Fuel etc.	542	535	535	534	534	534	534	534	534	534	534
Occupiers Repairs	142	142	142	142	142	142	142	142	142	142	142
Miscellaneous Costs	271	271	271	271	271	271	271	271	271	271	271
Sub-Total Recurrent Costs	1638	1623	1621	1619	1617	1615	1615	1615	1615	1615	1615
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	760	841	890	947	954	962	962	962	962	962	962
PRESENT VALUE @ 8% discount factor	7022										
PRESENT VALUE @ 5% discount factor	7987										

COLNE CATCHMENT - PROJECTED UK ECONOMIC AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
TOTAL PESTICIDE BAN
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	845	890	902	911	911	911	911	911	911	911	911
Beef Cows	91	127	129	131	131	131	131	131	131	131	131
Dairy heifers	40	47	48	49	49	49	49	49	49	49	49
Beef heifers	13	16	20	24	24	24	24	24	24	24	24
Beef 2yrs+	12	27	27	27	27	27	27	27	27	27	27
Fattening Suckled Calves (2 yrs)	7	27	28	29	29	29	29	29	29	29	29
Beef 2yrs	0	0	0	0	0	0	0	0	0	0	0
Sheep	53	55	59	62	62	62	62	62	62	62	62
Sub-Total Livestock	1061	1190	1213	1234	1234	1234	1234	1234	1234	1234	1234
Arable Crop Gross Margins :											
Winter Wheat	717	418	406	403	369	336	336	336	336	336	336
Spring Wheat	0	0	0	0	0	0	0	0	0	0	0
Winter Barley	246	164	164	164	148	133	133	133	133	133	133
Spring Barley	64	36	52	70	84	99	99	99	99	99	99
Winter Oats	15	8	10	12	13	15	15	15	15	15	15
Spring Oats	0	0	0	0	0	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	59	33	34	36	38	39	39	39	39	39	39
Field Beans	39	34	47	60	73	86	86	86	86	86	86
Harvest Peas	0	0	0	0	0	0	0	0	0	0	0
W. Oilseed Rape	131	111	154	196	238	280	280	280	280	280	280
S. Oilseed Rape	0	24	18	12	6	0	0	0	0	0	0
Linseed	59	58	44	29	15	0	0	0	0	0	0
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes	6	147	155	155	155	155	155	155	155	155	155
Sub-Total Crops	1337	1033	1084	1135	1138	1141	1141	1141	1141	1141	1141
TOTAL GROSS MARGIN	2398	2223	2297	2370	2373	2375	2375	2375	2375	2375	2375
RECURRENT FIXED COSTS											
Regular Labour	683	691	688	686	684	682	682	682	682	682	682
Machinery-Repairs/Fuel etc.	542	558	557	557	557	556	556	556	556	556	556
Occupiers Repairs	142	142	142	142	142	142	142	142	142	142	142
Miscellaneous Costs	271	271	271	271	271	271	271	271	271	271	271
Sub-Total Recurrent Costs	1639	1662	1658	1656	1654	1652	1652	1652	1652	1652	1652
CAPITAL COSTS											
Incremental Machinery Purchases		626									
ANNUAL CASH FLOW	759	-66	638	713	719	724	724	724	724	724	724
PRESENT VALUE @ 8% discount factor	4800										
PRESENT VALUE @ 5% discount factor	5506										

COLNE CATCHMENT - PROJECTED UK ECONOMIC AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
RESTRICTED PESTICIDE USE
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	845	890	901	911	911	911	911	911	911	911	911
Beef Cows	91	126	128	131	131	131	131	131	131	131	131
Dairy heifers	40	46	48	49	49	49	49	49	49	49	49
Beef heifers	13	16	20	24	24	24	24	24	24	24	24
Beef 2yrs+	12	27	27	27	27	27	27	27	27	27	27
Fattening Suckled Calves (2 yrs)	7	26	27	29	29	29	29	29	29	29	29
Beef 2yrs	0	0	0	0	0	0	0	0	0	0	0
Sheep	53	55	58	61	61	61	61	61	61	61	61
Sub-Total Livestock	1061	1187	1210	1232	1232	1232	1232	1232	1232	1232	1232
Arable Crop Gross Margins :											
Wheat	717	570	556	548	528	507	507	507	507	507	507
Winter Barley	246	210	214	220	214	208	208	208	208	208	208
Spring Barley	64	35	21	15	8	0	0	0	0	0	0
Oats	15	14	11	7	4	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	59	59	61	64	67	70	70	70	70	70	70
Field Beans	39	41	51	62	72	82	82	82	82	82	82
Harvest Peas	0	0	7	16	25	34	34	34	34	34	34
W. Oilseed Rape	131	110	149	189	227	265	265	265	265	265	265
S. Oilseed Rape	0	25	19	13	6	0	0	0	0	0	0
Linseed	59	63	53	43	33	23	23	23	23	23	23
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	6	138	146	146	146	146	146	146	146	146	146
Sub-Total Crops	1337	1264	1288	1323	1329	1335	1335	1335	1335	1335	1335
TOTAL GROSS MARGIN	2398	2450	2499	2556	2561	2567	2567	2567	2567	2567	2567
RECURRENT FIXED COSTS											
Regular Labour	683	674	672	670	669	667	667	667	667	667	667
Machinery-Repairs/Fuel etc.	542	535	534	534	534	534	534	534	534	534	534
Occupiers Repairs	142	142	142	142	142	142	142	142	142	142	142
Miscellaneous Costs	271	271	271	271	271	271	271	271	271	271	271
Sub-Total Recurrent Costs	1638	1623	1620	1618	1616	1614	1614	1614	1614	1614	1614
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	760	828	879	938	945	953	953	953	953	953	953
PRESENT VALUE @ 8% discount factor	6957										
PRESENT VALUE @ 5% discount factor	7913										

COLNE CATCHMENT - PROJECTED UK ECONOMIC AGRICULTURAL GROSS MARGINS, RECURRENT AND CAPITAL COSTS
PROTECTION ZONE
£'000

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Livestock Gross Margins :											
Dairy Cows	845	890	901	911	911	911	911	911	911	911	911
Beef Cows	91	126	128	131	131	131	131	131	131	131	131
Dairy heifers	40	46	48	49	49	49	49	49	49	49	49
Beef heifers	13	16	20	24	24	24	24	24	24	24	24
Beef 2yrs+	12	27	27	27	27	27	27	27	27	27	27
Fattening Suckled Calves (2 yrs)	7	26	27	29	29	29	29	29	29	29	29
Beef 2yrs	0	0	0	0	0	0	0	0	0	0	0
Sheep	53	55	58	61	61	61	61	61	61	61	61
Sub-Total Livestock	1061	1187	1210	1232	1232	1232	1232	1232	1232	1232	1232
Arable Crop Gross Margins :											
Wheat	717	551	537	531	511	491	491	491	491	491	491
Winter Barley	246	207	210	216	211	205	205	205	205	205	205
Spring Barley	64	35	21	15	8	0	0	0	0	0	0
Oats	15	14	11	7	4	0	0	0	0	0	0
Mixed Corn/Rye/Triticale	0	0	0	0	0	0	0	0	0	0	0
Potatoes	0	0	0	0	0	0	0	0	0	0	0
Sugar Beet	0	0	0	0	0	0	0	0	0	0	0
Hops	0	0	0	0	0	0	0	0	0	0	0
Hort Crops	59	59	61	64	67	70	70	70	70	70	70
Field Beans	39	40	51	62	72	83	83	83	83	83	83
Harvest Peas	0	0	7	16	25	33	33	33	33	33	33
W. Oilseed Rape	131	110	149	189	227	265	265	265	265	265	265
S. Oilseed Rape	0	25	19	13	6	0	0	0	0	0	0
Linseed	59	63	53	43	33	23	23	23	23	23	23
Other crops inc Triticale	0	0	0	0	0	0	0	0	0	0	0
Fallow	0	0	0	0	0	0	0	0	0	0	0
Set-Aside Schemes (net of spray costs)	6	138	146	146	146	146	146	146	146	146	146
Sub-Total Crops	1337	1241	1266	1302	1309	1315	1315	1315	1315	1315	1315
TOTAL GROSS MARGIN	2398	2428	2477	2535	2541	2547	2547	2547	2547	2547	2547
RECURRENT FIXED COSTS											
Regular Labour	683	677	678	679	681	682	682	682	682	682	682
Machinery-Repairs/Fuel etc.	542	537	538	539	541	543	543	543	543	543	543
Occupiers Repairs	142	142	142	142	142	142	142	142	142	142	142
Miscellaneous Costs	271	271	271	271	271	271	271	271	271	271	271
Sub-Total Recurrent Costs	1638	1627	1629	1632	1635	1638	1638	1638	1638	1638	1638
CAPITAL COSTS											
Incremental Machinery Purchases											
ANNUAL CASH FLOW	760	801	848	903	906	910	910	910	910	910	910
PRESENT VALUE @ 8% discount factor	6701										
PRESENT VALUE @ 5% discount factor	7615										

ANNEX 5

ECONOMIC INSTRUMENTS TO RESTRICT PESTICIDE USAGE

1. INTRODUCTION

In this section, the potential use of levies and marketable permits to control the use of pesticides is discussed. As such the use of economic instruments to achieve environmental objectives within the agricultural and non-agricultural sectors represents a variation and extension to Scenario 4, Restrictions on Quantities and Timing of Application of Pesticides.

The objectives of this analysis are to assess the feasibility and applicability of economic instruments, specifically levies and marketable permits, in controlling the use of pesticides and to provide recommendations on how they should be applied. These objectives will be achieved by briefly describing the concepts, reviewing experiences from other countries and identifying the appropriate approach for controlling the use of pesticides.

2. ECONOMIC INSTRUMENTS

Economic instruments have been defined as 'instruments that affect costs and benefits of alternative actions open to economic agents [consumers and producers], with the effect of influencing behaviour in a way that is favourable to the environment' (OECD 1989).

The need for government intervention in the market stems from the fact that environmental goods have been typically regarded as 'free' public goods. The absence of property rights for environmental resources means that the full costs of consuming these resources are not borne by the users. Consequently external costs (externalities) of production may arise which leads to the social cost of production exceeding the private cost of production. For example, a farmer may apply an urea-based herbicide (urons) to his land which eventually leaches into nearby surface water. Downstream a water utility may abstract from the surface water with the purpose of providing potable water. In order to meet its legal obligations and duties the water utility would have to provide treatment in order to remove the herbicide. The costs to the farmer (i.e. the private cost) will comprise the costs associated with purchasing and applying the herbicide, whilst the social costs will include the costs of extra treatment incurred by the water utility.

Economic instruments therefore seek to 'internalise' these externalities within the decision-making process, thereby ensuring an appropriate pricing of environmental resources which will promote the efficient use and allocation of these goods. Hence economic instruments are seen as an important means of implementing the 'Polluter Pays Principle.'

The purpose of this analysis is to consider marketable permits and levies within the context of the use of pesticides, but recognises that other instruments (e.g. subsidies) exist and a combination of measures might also be appropriate.

3. MARKETABLE PERMITS

Pearce and Turner (1990) provide a detailed economic analysis of marketable or tradeable permits, whilst Tietenberg (1985) describes how they have been applied in the US to control emissions to the air. For the purposes of this discussion a brief review of the approach will suffice.

The application of marketable permits involves the setting of environmental quotas, allowances or ceilings, typically based on emission levels, which can then be traded within a regulated market. The 'Bubble Concept' illustrates how a marketable permit system operates. It involves visualising several different pollution sources being contained within a 'bubble'. A total emission load is set for the bubble as a whole to ensure that the environmental quality standards are achieved and emissions from any individual source are allowed to rise as long as there is a corresponding reduction from other sources within the bubble. An emitter wishing to increase emission levels must therefore obtain emission reduction credits from the other emitters. Once the overall level of emissions has been set by the regulatory authority the price is determined by the market. Agents with low costs of abatement will sell their permits, whilst those with high abatement costs will buy permits. This ensures that compliance with a given environmental quality standard is achieved efficiently compared to the application of uniform emission standards within a typical command and control regulatory framework.

The principal requirements for an effective marketable permit system are:

- a large number of traders must exist in order to ensure a competitive market;
- all contributors to the bubble must be identifiable;
- a bubble can be defined;
- transaction costs associated with the trading of the permits must be kept low; and
- regulation of the market to ensure rules and procedures are adhered to is essential.

Marketable permits have been applied in the United States since the introduction of the 1977 Clean Air Act. Results to date show air quality has improved with some exceptions and significant cost savings have been realised. Examples showing the application of marketable permits to the control of pesticides have not been found in a brief review carried out for this contract.

4. LEVIES

Two types of levies exist which may be used as economic instruments, emission charges and product charges, and these are briefly described in this section. Emission charges are based on the discharge of pollutants into an environmental compartment based on the quantity and effect of the pollutant. Product charges are levied on goods or substances which are harmful to the environment when they are used in production processes, consumed or disposed of. Baumol and Oates (1988) provide the best reference for further reading on environmental charges.

The emission and product charges are fixed by the regulatory authorities and market forces determine the level of emissions and consumption, respectively. Neo-Classical economics states that the correct level of the charge or levy should equal the marginal net cost (i.e. the difference between the marginal social and private cost) generated by the level of activity. It is in most cases, however, very difficult to measure the marginal social cost as in many cases the natural resource is unpriced. Thus the charge rate which will ensure the optimal allocation of resources is extremely difficult to determine. Whilst this problem is recognised, the charges do provide an incentive to change behaviour, raise revenue, encourage the development of cleaner processes and improved pollution control equipment. In contrast to the application of uniform emission standards, levies allow compliance costs to be minimised.

In contrast to marketable permits, product charges have been applied to pesticides within Europe, though the reasons for the charges may not be specifically to act as an incentive to reduce the use of pesticides. Charges have been introduced to raise revenue and recover administration and monitoring costs. A recent survey (OECD, 1993) of eco-taxes within the OECD is summarised below.

Denmark introduced a tax on pesticides to fund a research programme investigating pesticides as part of an Action Plan to reduce the total consumption of pesticides by at least 25% in 1990 and an additional 25% by 1997. The retail sale of pesticides (i.e. for small quantities) is subject to 20% tax. The aim for reduced pesticide application is interpreted as an equivalent percentage reduction in the amount of active ingredients used as well as the number of treatments applied (the number of treatments being measured as the number of times the whole agricultural area can be treated with the purchased amount of pesticides assuming the labelled dosages are applied).

Norway introduced fertiliser and pesticide levies in 1988. The pesticide tax is charged at 13% of the purchase price and was estimated to raise NKr 22 million (£1.96 million) in 1992.

Sweden has implemented a pesticides charge of SKr 8 per Kg of active substances. The fertiliser and pesticide charges raise over SKr 200 million (£19.28 million).

The Netherlands laid down a policy objective in the Multi-Year Crop Protection Plan to reduce the consumption of pesticides in 1990 by at least 50% by 2000, calculated by the weight of active components applied. A primary policy objective is for groundwater quality to satisfy drinking water standards. The levy imposed on pesticides is used to finance the action programmes in each of the sectors affected.

Sections 3 and 4 have provided the background and framework for a more detailed discussion on the application of these economic instruments to the control of pesticides.

5. POSSIBLE APPROACHES AND APPLICATION

Objectives

The precise objective of a policy to control the use of pesticides needs to be clearly defined as this will have significant implications on the effectiveness of the selected economic instrument. Possible objectives may be to:

- reduce the total inputs of pesticides; or
- reduce inputs by a given percentage; or
- control individual pesticides in order to ensure that the concentration of individual pesticides do not exceed the drinking water standard for the specified pesticides.

Product charges and marketable permits could achieve all three objectives, but specific problems are likely to be encountered for each potential application. To reduce the use of pesticides by a given amount will require detailed information on the responsiveness of demand with respect to changes in price levels. In the absence of this information product charges could be introduced at a low level with increases in the charge rate phased in over a period of time (Baumol and Oates 1971). The principal problem associated with the third objective is that unless all pesticides are covered the consumers will shift their demand to substitute goods which might be equally polluting. Additional incentives could be provided to encourage users to purchase less environmentally damaging pesticides. In contrast to fertilizers, pesticides have a threshold level of application below which the input of pesticides becomes ineffective. There is thus a danger that, in order to achieve the required environmental quality standard for ground or surface water, the input has to be reduced to a level at which it is ineffective as a pesticide.

Approaches

OECD (1991a) distinguished three distinct approaches to the use of economic instruments; output/impact related, input-source related and process-technology related. The use of pesticides produces non-point-source pollution which is difficult to monitor and suggests that an input or source-related approach would provide the most appropriate framework for assessing the application of levies and marketable permits.

Marketable Permits

Marketable permits for pesticide inputs could be applied within the framework of the 'Bubble' concept for a clearly defined area (i.e. groundwater catchment area). Instead of defining the bubbles in terms of, for example, SO_2 emission loads, the bubbles would be defined in terms of usage. The precise form of the permits would need to be carefully considered. The permits could be defined either in terms of separate pesticides (e.g. a potential user would receive permits for atrazine, chlorotoluron and diuron etc.) or for types of pesticides (e.g. permits for herbicides, fungicides, insecticides and growth regulators) or in its simplest form in terms of a basket of pesticides. However a basket approach would be unlikely to work as the policy would need to target specific pesticides and allow alternatives to be used.

A permit system for each type of pesticide would require either a complex single market or numerous markets for each of the pesticides within the system.

The geographical area would define the size of the bubble and the extent of the market could be based on river catchments or sub-catchments which would create many bubbles throughout the country. As such each bubble would constitute separate independent markets and trade between markets would not be permitted. It would be necessary to ensure that each bubble contains a sufficient number of potential traders to create a competitive market.

The creation of the pesticide bubbles, which would take into account soil type, available dilution and infiltration rate, would allow the targeting of the policy to protect the environment to reflect the diversity on regional and local characteristics. Environmentally sensitive areas, such as water protection zones, could be created within which the input bubbles could be more stringently defined than elsewhere in the country.

The permits for pesticides could either be allocated initially through the market or assigned ('grandfathering') to the farmers and non-agricultural users on the basis of existing farming characteristics (e.g. farm size, intensity and type of crop farming) and existing levels of non-agricultural use. Permits would be allocated on an annual basis. Once trading had commenced within the market the possibility exists for other agents, such as water utilities, to enter the market and purchase pesticide permits which they may never use. This action would be justified if, for example, it was cheaper to buy the permits rather than installing treatment to remove pesticide residues from the source.

OECD (1991a) have reviewed the potential use of marketable permits to control the use of pesticides and concluded that the potential benefits that may accrue are outweighed by the practical difficulties associated with its implementation. The major practical difficulty stems from the monitoring and policing costs likely to arise from the implementation of the policy. The system would almost be impossible to police effectively. The practical difficulties arise not only from the variety of pesticide types and methods of application, but also from the seasonal fluctuations associated with pest control, as well as anticipated high transaction and administration costs.

Product levies

The following assessment of levies focuses on product charges as opposed to emission charges, due to the emphasis of an input-source related approach and difficulties associated with monitoring non-point source pollution which characterises the use of pesticides. It is recognised that product levies can function as a substitute for emission charges where these are not appropriate.

Fertiliser levies have been applied in several West European countries and empirical studies have suggested that the price elasticity of demand for fertilizers is low (i.e. there is a low response in the change in quantity demanded in relation to changes in the price for fertilizers), suggesting that the benefits in terms of crop yield increase resulting from increased fertiliser use far outweighs the increased cost of fertilizers unless the taxes are very high. However a fertiliser charge was introduced in Austria at a low level in 1986 and was found to have a significant effect on fertiliser use. Despite this the overall implication is that in order to have a significant impact on the levels of consumption the product tax would have to be very high. To date the main purpose of the introduction of these taxes has been to raise revenue rather than influence levels of consumption. At this point it is worth emphasising that in the past the UK agricultural market has not been a free market and has been subject to Government intervention (e.g. EC price support). Government agricultural policy seeks to achieve multiple objectives including safeguarding farmers' incomes, promoting agricultural exports and encouraging self-sufficiency which has lead to distortions in the price mechanism for agricultural goods. If the protection of the environment is to be another policy objective, then economic instruments will have to take account of the existing allocational inefficiencies in the market caused by current policies.

Pesticide levies could be based on either the amount of active ingredients or on the number of treatments. However as discussed in Section 4 the main practical difficulty associated with product charges is the calculation of the appropriate charge rates in order to achieve what economists define as the optimal level of pollution. Baumol and Oates (1971) argued that taxes should be selected in order to achieve specific acceptability standards, rather than attempting to base the taxes on the unknown value of marginal net damages. While this may not achieve the optimal allocation of resources and level of pollution, it does achieve compliance with the standards at the least cost. This last point does highlight the complementary role of standards and economic instruments and the fact that they should not be regarded as substitutes.

The Institute for Public Policy Research (1990) concludes that excise type product charges could be applied to fertilisers and pesticides. The single stage tax would act as an incentive on both firms and individuals.

6. COMPARISON OF MARKETABLE PERMITS AND PRODUCT CHARGES

A comparison of marketable permits and product charges within the context of the use of pesticides is shown in Table A5.1. The Table is based upon the five criteria included in the Annex to the OECD's Recommendations of the Council on the Use of Economic Instruments in Environmental Policy (OECD 1991b).

Marketable permits rate highly only in terms of economic efficiency by promoting cost savings in meeting compliance requirements. Product charges rate highly for each of the five criteria and would appear to be the appropriate economic instrument to be used for controlling the use of pesticides, though it should be stressed that economic instruments should be regarded as complementary to other policy instruments such as regulation and the use of standards.

Table A5.1 Comparison of Marketable Permits and Product Charges for the control of pesticides against OECD criteria for choice of economic instrument

No	Criteria	Interpretation	Marketable Permits	Product Charges
1.	Environmental effectiveness	Environmental effectiveness is determined by ability of polluters to respond to policy. Economic instrument must provide permanent incentive to pollution abatement, technical innovation and product substitution.	Difficult to apply to pesticides due to variety of pesticides and modes of application.	Provides permanent incentive to reduce pollution and encourages dynamic efficiency.
2.	Economic efficiency	Optimal allocation of resources, but in operational sense, implies that economic cost of complying with standards is minimised.	Differences in marginal compliance costs between target groups provides opportunity to achieve cost savings in meeting compliance requirements.	Agricultural prices distorted and low elasticity of demand, levies would have to be set at high levels.
3.	Equity	Distributive consequences vary according to types of policy instruments applied.	Dependent on how initial permits are allocated.	Purpose of revenue raised would be important.
4.	Administrative feasibility and cost	Ease and cost of enforcing system and nature of existing legal and institutional arrangements.	Difficult to monitor and high transaction costs. Likely to be expensive.	Relatively easy to implement. Point of sale charge or charge for producers and importers
5.	Acceptability	Need to inform and consult target groups. Success requires certainty and stability over time.	New concept, would have to be carefully explained.	Familiar concept, but would need to consult and inform target groups.

7. RECOMMENDED BASIC GUIDELINES FOR PRODUCT LEVIES

The successful introduction of product charges for the control of the use of pesticides requires:

- clear framework and objectives;
- well defined field of operation;
- simple mode of operation;
- acceptability.

Clear framework and objectives

The relationship between the economic instrument and direct regulation needs to be clearly defined, e.g. with certain products bans would be desirable. The complementary nature of the two approaches would need to be emphasised. More specifically the precise objectives of the charge should also be stated, e.g. to reduce the consumption of pesticides by a given percentage within a period of time. This will help to define the precise nature of the product charge, i.e. revenue raising or providing incentives to change patterns of consumption.

Well defined field of operation

The scope of the environmental tax needs to be well defined (including the scope of pesticide types and application methods etc.) and has to be formulated taking account of the features of the target groups. Clearly defined fields of operation would also allow users to identify environmentally friendly alternatives and switch consumption to these substitute goods.

Simple mode of operation

The introduction of product charges on pesticides could be implemented in the form of excise duties, comprising single stage, non-deductible taxes. Excise duties are already levied on a number of goods in the UK including alcohol and tobacco, hence the institutional mechanisms for raising excise duties already exist although the introduction of new charges would give rise to additional administrative costs. It would be necessary to subject pesticides from abroad to Import Duties in order to avoid distortions to trade. Product charges in both instances would be set at fixed rates, which could be amended in future years as the effect on demand became known so that policy objectives could be achieved.

Acceptability

It would be necessary for all users of pesticides to be consulted about the proposed introduction of taxes. The successful implementation and acceptance of pesticide charges would depend greatly on clearly defined objectives and fields of operation, simplicity of operation and overall equity. Consultation and effective communication between the regulator and users would be prerequisites for ensuring the acceptability of the introduction of product charges for pesticides. Where the charges are large it may be appropriate for the charges to be introduced gradually over a period of time so that the users may respond to the possible imposition of additional financial burdens.

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