The Total External Environmental Costs and Benefits of Agriculture in the UK

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Contents

1) Purpose

Economic activity in the agriculture sector includes outputs that have negative and positive effects on the welfare of people and organisations in society. These effects are not taken into account by the organisations causing them, as they receive no compensation (or sanction) for their production. These outputs are said to be "external" to the production decisions in the sector.

This paper uses available techniques and information to estimate the external environmental costs and benefits of agriculture in the UK. The purpose of the paper is to inform the development of policies and plans for improving the environmental and economic performance of agriculture. This includes measures for implementing the Water Framework Directive (WFD) such as Catchment Sensitive Farming (CSF), Eutrophication Action Plans (ECAPs), abstraction controls and the Agency's Restoring Sustainable Abstraction (RSA) programme. It also forms input into the reporting of environmental and resource costs under Article 5 of the WFD.

2) Context: Uses and Limitations

The estimated value of environmental costs and benefits in this paper provides contextual information to highlight the scale and significance of the environmental problems and benefits of agriculture, and to identify their major causes. It highlights the need for careful and serious consideration of policy initiatives intended to address the environmental problems and to encourage greater production of the benefits.

Any measures to reduce these environmental problems could entail significant costs, which must be carefully taken into account before deciding on any action to take. Therefore the estimates in this paper (on their own) **cannot and should not** determine which specific interventions may be needed since this judgement will require careful appraisal of the feasibility and scope for reducing the environmental impacts as well as the costs of doing so.

Consequently, the analysis in this paper is only an input to the start of the assessment and reinforces the need for the careful options appraisal that will subsequently be needed. This paper is based on a pre-WFD approach to the assessment of the impacts of environmental pressures, so should only be seen as a marker. It records what is currently known (on the basis of current estimates and techniques), prior to the detailed assessments which are to be undertaken as part of the implementation of the Directive.[1]

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[1] In this vein, the Environment Agency, Defra, Scottish Executive, Welsh Assembly Government, Department of Trade and Industry, SEPA, English Nature, UKWIR, RSPB, NFU, CLA, British Ports Association and the UK Major Ports Group are carrying out a major collaborative research programme to prepare the economic analyses and appraisal techniques to aid implementation of the WFD. In particular, this includes a study to develop sound methodologies to assess the costs and effectiveness of options for tackling the major causes of the environmental problems highlighted in this paper.

3) Organisation of this report

The remainder of this paper consists of the following sections:
- A list of the data sources.
- A summary, which presents the headline figures for the external costs and benefits of agriculture.
- An introduction to the methods for valuing external costs and benefits
- The main section provides more detail on the source of the estimates for air, soil and water damage impacts and the external benefits. It gives a brief justification for the source used.
- Annex A which provides rationales for the proposed possible reductions in the damage costs in the short and long run.

4) Information sources

The costs and benefits estimates in this note are derived from the following sources:

- *Agriculture and Natural Resources: Benefits, Costs and Potential Solutions* Environment Agency 2002 (from now on referred to as the EA 2002 report).
- *Framework for Environment Accounts for Agriculture* Eftec (Economics for the Environment Consultancy) in association with Institute for European Environmental Policy (IEEP) July 2004 (from now on referred to as Eftec 2004 Report).
- The economic analysis to assess water environmental damage costs to support the environment programme in the Periodic Review of the Water Industry 2004 (From now on in this report the analysis will be referred to as the PR04). The source is *The Environment Damage Costs of Current Water Quality and Flows and the Contribution of PR04 in Reducing them.* Environment Agency 2004.

This note attempts to extract the preferred estimates from the above. There is no new analysis and some of the conditions and assumptions in the above reports may no longer hold. In addition, it should be noted that for some of the impacts there is a great deal of uncertainty and more research is needed.

The estimates in the EA 2002 Report are in 2000 prices and the estimates in PR04 and Eftec 2004 Report are in 2003 prices respectively. All data that follow in this note are in 2004-05 prices unless otherwise stated.

5) Summary

5.1) The Total External Environmental Damage Costs from Agriculture

In the EA 2002 Report the total external environmental damage costs from agriculture in the UK was estimated at £1365m per year. The total reported here ranges from £1149m to £3050m per year. The difference is accounted for by the much larger estimates for water and air. See table 1 for a summary and table 3 for a more detailed breakdown of the valuation of the different damage categories. The valuations are based on a review of available studies of people's preferences and valuations for the impacts in question.

The new analysis improves on the EA 2002 Report figures by:

- Providing estimates of the values held for certain damage categories, which have not previously been quantified, including:
    - -valuations held by people for impacts on ecosystems and natural habitats, including non use values
    - -impacts on recreational and amenity caused by inland water pollution
    - -impacts on groundwater of poor water quality
- Providing damage cost values based on more up to date physical air emission figures and more up to date unit damage cost figures. (Unit damage cost figures give a measure, in monetary terms, of the damage caused by one unit of pollution.)
- Providing more recent water industry treatment costs

Table 1: Summary of UK agricultural external costs by category - £million per year in 2004 prices

Environmental pollution or impact category	Agricultural cost £m per year		Max possible short run (5 years) achievable reduction*		Max possible long run (20 years) achievable reduction*	
	Low	High	Low	High	Low	High
Soil	120	219	86	160	90	164
Water	445	872	82	188	238	543
Air	583	1959	58	196	146	490
Total	**1149**	**3050**	**226**	**544**	**475**	**1197**

Due to rounding, some figures may not sum correctly.
*Assumes the same possible % reductions as in EA 2002 Report and applies them to the appropriate figures from the Eftec 2004 Report and PR04.

The above figures for water impacts are underestimates of the UK totals as they are for England and Wales only.

Aggregation Issues

There are important crossovers between the three categories presented in table 1 where some factors cannot be disaggregated into the three main categories presented.

Some of the off site costs of soil erosion are incorporated in the values of damages to water, insofar as soil erosion impacts upon water quality. The estimates for soil (£120-219 pa) quoted here include off site costs, carbon loss from soil cultivation and contribution to flooding.

The water category contains the cost to the Agency in restocking rivers for fish (Soil particles in rivers will contribute to fish deaths.) and the increased water treatment cost from removing soil particles. For this reason to estimate for the soil category is likely to be an underestimate (though the combined total of the three categories is not affected).

Other Factors

The external costs in table 1 are considered to be conservative because no estimates are included for:

- Loss of life, health impacts and environmental damages from flooding
- Total Government expenditure as a result of soil erosion
- Marine eutrophication costs
- Health and biodiversity impacts from pesticides
- Impact for fishery and recreation of low flows in rivers and lakes
- Impacts of abstraction on the quantity of groundwater
- Impacts of water pollution (other than eutrophication) on lakes
- The non-use impacts associated with poor quality groundwater.

Estimated Achievable Reductions in the External Environmental Damage Costs

In table 1 the estimated maximum short run (5 years) and long run (20 years) achievable reductions in the estimates are calculated using the percentage potential reductions for each damage category from the EA 2002 Report. Annex A gives the rationale for the percentage applied. The percentage reductions are those that it is estimated could be achieved if farmers implemented best management practices such as soil and nutrient management planning.

These percentage reductions have been applied to the relevant damage costs from the Eftec 2004 Report and the PR04 analysis where they have been used. The reductions for each damage cost category were calculated and then totalled for soil, water, air and overall. There is a range for both the short run and long run because the percentage reductions are applied to a damage cost range. See box 1 for an illustrative example of the calculations for methane.

Box 1: Calculation of the short run (SR) and long run (LR) achievable reductions in damage costs from methane

From table 3 the damage cost ranges from £187m to £745m per year (Eftec 2004 Report). SR reduction of 10% and LR reduction of 25% (EA 2002 Report)

> Given that knowledge is uncertain in this area, it is conservatively suggested that an achievement of a 10% reduction in air emissions could be reached in the short term (Environment Agency's Rural Land Use Group (RLUG) members meeting 25/10/01). It is likely that a higher reduction could be achieved in the long term, though further research and development would be needed. A 25% long term reduction is assumed here.

- EA Report 2002

The low SR reduction is 10% of the low damage cost estimate (£187m) giving £19m. The high SR reduction is 10% of the high damage cost estimate (£745m) giving £75m. This means that it is estimated that in the short run (5 years) the maximum possible reduction in the total annual damage cost caused by agricultural methane emissions is between £19m and £75m.

The low LR reduction is 25% of the low damage cost estimate (£187m) giving £47m. The high LR reduction is 25% of the high damage cost estimate (£745m) giving £186m. It is estimated that in the long run (20 years) the maximum possible reduction in the total annual damage cost caused by agricultural methane emissions is between £47m to £186m.

5.2) The Total External Environmental Benefits of Agriculture

Table 2: The annual environmental benefits of agriculture in 2004-05 prices

Environmental benefit category	**Source**	**£m per year in 2004 prices**
Value of landscape amenity services by the current provision of landscapes	Eftec 2004	498
Value of habitat protection services provided by current land use within the agriculture sector	Eftec 2004	229
Value of species protection services provided by current land use within the agriculture sector	Eftec 2004	313
Carbon sink service	Hartridge and Pearce[2]	415
Total		**1455**

Costs were converted to 2004 prices using the GDP Deflator
Source Eftec 2004 report

For the environmental benefits of agriculture we have used figures from the Eftec 2004 Report as opposed to the EA 2002 Report as the Eftec 2004 report uses valuation estimates derived from a greater number of source studies.

[2] The source of the above figure for the CO2 sink service provided by agriculture is Hartridge and Pearce 2001. Sink is estimated to be 12.1m tonnes of carbon per year with a unit damage cost of £29.8 per tonne in 1998 prices gives a total of £415m per year (2004 prices). This is not a net figure since the emissions of CO2 are presented earlier (emissions of CO2 from fossil fuel combustion etc of £111m and CO2 emissions from soil cultivation of £82m per year). The total 12.1 m tonnes of C includes: forest biomass and litter (2.1m tonnes); non forest biomass (0.3m tonnes); forest soils (0.1m tonnes); set a-side soils (0.4m tonnes); undrained peatlands (0.7m tonnes); CO2 and N fertilisation (2m tonnes); crops for consumption (6m tonnes); livestock (0.5m tonnes)

Section 7 has further details on the external environmental benefits of agriculture.

5.3) Conclusion

Tables 1 and 2 show that there are significant external environmental costs and benefits associated with agriculture, which merit special attention both to reduce the environmental damage costs in Table 1 and enhance the environmental benefits in Table 2. Table 1 shows that resource and environmental pollution problems in terms of improved water quality are ranked most highly in terms of potential achievable reductions in the short and long run. In general, soil management practices cost significantly less than other practices, with measures to reduce air emissions being the most costly (partly because of the high capital spending required, as noted in the EA 2002 Report). This suggests the need to target attention on soil and water problems and, in particular, that agri-environment schemes need to be targeted on improved soil and water management.

Table 3: Estimates of the Environmental Damage costs of Agriculture £m per year (in 2004-05 prices)

Medium	**Impact**	**Agri cont to total %**	**Source***	**Scope**	**Agri damage cost £m per year**			**SR Red (%)****	**LR Red (%)****	**SR Red+**		**LR Red+**	
					Low	Central	High			Low	High	Low	High
Soil	Flooding (property and council damage)	Upto 14%	Eftec	UK	29		128	75	75	22	96	22	96
Soil	Soil cultivation (CO2 loss)	95%	EA Rep	UK	82		82	75	75	62	62	62	62
Air	Emission: Nitrous oxide	50%	Eftec	UK	250	500	999	10	25	25	100	62	250
Air	Emissions: non methane volatile organic compounds	8%	Eftec	UK	6		6	10	25	1	1	2	2
Air	Emission (CO2 excluding soil cultivation)	2%	EA Rep	UK	111		111	10	25	11	11	28	28
Air	Emission : methane	40%	Eftec	UK	187	373	745	10	25	19	75	47	186
Soil	Soil erosion (accidents, stream channels)	95%	EA Rep	UK	9		9	25	75	2	2	7	7
Air	Emission: ammonia	90%	Eftec	UK	24	50	75	10	25	2	8	6	19
Air	Emission: sulphur dioxide	1%	Eftec	UK	1	2	3	10	25	0	0	0	1
Air	Emission nitrogen oxide	2%	Eftec	UK	4	10	17	10	25	0	2	1	4
Water	Nutrients in lakes	45%	PR04	E&W	20		33	25	75	5	8	15	25
Water	Informal recreation from poor water quality	30-50%	PR04	E&W	10		23	25	75	2	6	7	18
Water	Fishing affected by poor water quality	20-50%	PR04	E&W	14		36	45	75	6	16	11	27
Water	Bathing water quality affected by water pollution	35-65%	PR04	E&W	23		42	25	75	6	11	17	32
Water	Amenity loss (incl. CSOs) (reflected in impacts on local property prices of poor water quality and low flows)	10%	PR04	E&W	5		5	25	75	1	1	4	4
Water	Impacts on groundwater of poor water quality	40-70%	PR04	E&W	50		88	25	75	13	22	38	66
Water	Surface water treatment costs by water companies	60-70	PR04	E&W	127		148						
Water	Ecosystems, natural habitats impacts – rivers etc affected by poor water quality and low flows	25-35%	PR04	E&W	183		456	25	75	46	114	137	342
Water	Ecosystems, natural habitats impacts – wetlands affected by poor water quality and low flows	25-35%	PR04	E&W	13		41	25	75	3	10	10	31
Water	Marine eutrophication (nitrogen)	20%	EA Rep	UK	n.a.	n.a.	n.a.	25	75	n.a.	n.a.	n.a.	n.a.
Water	Health and biodiversity effects from pesticides	89%	EA Rep	UK	n.a.	n.a.	n.a.	50	50	n.a.	n.a.	n.a.	n.a.
Soil	Health, life and biodiversity effects from flooding	14%	EA Rep	UK	n.a.	n.a.	n.a.			n.a.	n.a.	n.a.	n.a.
	Total				**1149**		**3050**			**226**	**544**	**475**	**1197**

Costs were converted to 2004 prices using the GDP Deflator see annex B

Due to rounding, some figures may not add correctly.

SR:short run LR:long run n.a. not available

*Source of the % contribution of agriculture to the total problem and the damage cost estimate for agriculture:

** Assumes the same possible % reductions as in EA 2002 Report and applies them to the figures from the Eftec 2004 Report and PR04. See annex A for details of how the % red were derived.

+The SR and LR reductions are often ranges because the damage value is often a range. See Box 1 for an example.

6) External environmental damage costs of agriculture

This section provides more detail on the techniques used to derive the external environmental costs of agriculture.

6.1) External costs from poor water quality and low flows

The water external environmental costs used are taken from the economic analysis for the Environment Programme in the Periodic Review of the Water Industry (PR04). The economic analysis involved estimating the total damage cost of current water quality and low flows across 8 damage categories:

- Eutrophication in lakes
- Informal recreation from poor water quality and low flows
- Fishing affected by poor water quality and low flows
- Amenity, economic development and combined sewer overflows
- Bathing water quality affected by water pollution
- Impacts of groundwater of poor water quality,
- Ecosystems and natural habitat impacts – wetlands affected by poor water quality and low flows
- Ecosystems and natural habitat impacts – rivers affected by poor water quality and abstraction.

The PR04 data concern damage to water bodies from all possible sources. This paper is only concerned with damage resulting from the agriculture sector, so the total amounts have been adjusted (following expert opinion) to reflect the proportion of damage likely to have been cause by agricultural sources.

The data do not include:

- Impacts of water pollution (other than eutrophication) on lakes;
- Impacts for fishing and recreation of low flow problems in rivers and lakes (caused by abstraction) and
- Impacts of abstraction on the quantity of groundwater.
- Health and biodiversity impacts from pesticides
- Non use impacts of poor groundwater quality

The figures in PR04 are for England and Wales and are therefore likely to be an underestimate of the UK value.

There are certain water impacts that are not included as specific damage cost categories because they are included elsewhere. These include:

- Nitrates, which is included in the water treatment costs in the groundwater impacts. See Box 1.
- Faecal Pathogens. Faecal pathogens are included partly in the impacts on bathing water of poor water quality and in the water treatment costs (in groundwater impacts), which includes the cost of treating *cryptosproridium*.
- Organic waste. To avoid the risk of double counting it is assumed that the affect of organic waste is already included in the damage categories covering the impacts of poor water quality.

The total for the external water costs from agriculture also includes a proportion of the total costs for water companies to treat raw water for supply to customers.

6.1.1) Nutrients and Eutrophication in lakes

There are a wide range of impacts arising as a result of nutrients and eutrophication.

Based on the study by Pretty et al (2001)[3], the total damage costs of eutrophication was estimated as being between £58 – 94 million annually. These damage cost estimates do not include health costs to humans, livestock and pets; nor impacts in saline waters. We made the following adjustments to Pretty's estimates. We excluded impacts on drinking water treatment costs to remove nitrogen on the grounds that these are covered in the groundwater category. Also we did not include Pretty's estimates of revenue losses for commercial aquaculture, fisheries, and shellfisheries to avoid the risk of double counting with the impacts on fishing and fisheries of poor water quality. We also excluded monetary impacts on lost tourism revenues, since these regional changes may just be a displacement from another area or type of tourism rather than a welfare loss as such.

While eutrophication affects both standing water (lakes and reservoirs) and rivers, the estimates of damage calculated in Pretty et al apply mostly to standing fresh waters (assumed at 80% of total damage value). Thus we consider that any risk of double counting in the impacts on recreation is

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[3] JN Pretty, CF Mason, DB Newell and RE Hine (2001) *A preliminary Assessment of the Environmental Damage Costs of the Eutrophication of Fresh Waters in England and Wales*, report prepared for Environment Agency. This latest report by Pretty for the Agency has correctly focused on estimating and valuing the environmental damage costs and benefits. It does not include any estimates of control costs as a measure of benefits. It might be worthwhile updating the findings of this study.

effectively minimised by the fact that the eutrophication costs apply mainly to lakes and reservoirs, whereas the other costs apply mainly to rivers and canals. In aggregating for total damage costs we have included only the damage cost estimate for lakes to reduce the risk of double counting. This is estimated at between £45-73 million per year (£2004/5).

Contribution from Agriculture

Eutrophication is caused from increased nutrient discharges to water bodies. Phosphorous (P) is the main pollutant associated with the water industry, which causes eutrophication. The widespread use of agricultural chemicals and the spreading of manure is a major contributor. Current evidence suggests that agricultural sources of pollution account for about 70% of nitrogen; 50% of phosphorus and the majority of silt pollution in UK waters[4]. The Agency estimates that agriculture's contribution is approximately 45% (£20m - £33m pa) with other diffuse and point sources of pollution contributing 5% (£2 - £4m).

6.1.2) Informal Recreation from Poor Water Quality

The total willingness to pay (WTP) to improve all rivers to RE2 in terms of informal recreation was estimated. RE2 was taken as equivalent to good water quality. The RE (River Ecosystem) standards range from 1 to 5 with RE1 very good water quality and RE5 the worst quality. It is a system devised by the Agency and is based on chemical parameters that are conducive to healthy fish populations. While nearly 30,000 rivers are at RE1 or RE2, about 13,000 are at lower quality grades.[5]

Estimates of the numbers of visitors/users of rivers and their WTP for informal recreation were taken from the Foundation for Water Research (FWR) manual.[6]

The estimates were applied to the data on water quality in rivers in England and Wales to derive the total potential benefit from upgrading all rivers (in England and Wales) to RE2 and to RE3. It does not include potential benefits of upgrading river quality above RE2 (ie to RE1) – and hence may underestimate the damage costs of current river quality.

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[4] Defra (2004), Developing Measures to Promote Catchment-Sensitive Farming: A joint Defra-HM Treasury Consultation

[5] Source: Environment Agency 2003, based on 2002 river quality, River Ecosystem (RE) Face Values (All Determinands) 2002

[6] Foundation for Water Research (1996): Assessing the Benefits of Surface Water Quality Improvements (FWR Manual), December 1996.

However, extrapolating benefit valuations for recreation for marginal improvements to achieving good quality in all rivers may overestimate the benefits. There may be limits to the extent to which such increasing recreation opportunities could, in fact, arise at all rivers and to how much people are willing to pay for them. On balance, therefore, we consider that Table 4 presents reasonable estimates. The values estimated capture leisure visits but exclude angling and boating, which are included in the eutrophication category.

Table 4: Informal recreational benefits from improving river quality in England and Wales

	Improve all rivers to RE2	Improve all rivers to RE3
Length of river below RE3	6351 km	6351 km
Length of river at RE3	6886 km	0
Total length of river	13237 km	6351 km
Trips/Km/year	7500	7500
£/person/trip for rivers changing from RE4 and below	£0.84 (1)	£0.701(1)
£/person/trip for rivers changing from RE3	£0.138(1)	0
Benefits from river improvement from RE4 and below ((£m 2004/5 prices) to RE2	£40m pa (6351kmx7500x0.84)	£33.37m pa
Estimated benefits from river improvement from RE3 to RE2 (£m 2004/5 prices)	£7m pa (6886kmx7500x0.138)	-
Total (£m pa 2004/5 prices)	£47.12m pa	£33.37m pa

Source: Adapted from Table 11.100 WRC & Oxera (1998) (WRC/WFD). See also Annex A Section 3.1.
Notes: (1) Prices converted from 1995/6 prices to 2004/5 using GDP deflator.
River lengths calculated from Table C2 above

The total annual benefits for informal recreation of improving river quality in all rivers to RE2 and RE3 are estimated to be about £47million and £33million respectively, and provide an indication of the damage costs of current river quality.

Contribution from Agriculture

The pollutants contributing most to the deterioration of current river quality are ammonia, phosphorous and BOD. The Agency estimates that about 20% of ammonia failure is due to the agricultural sector, with the balance accounted for by water companies. It is estimated that agriculture contributes between 30-50% and so the share of the damage costs of current water quality in terms of informal recreation is estimated to be £10m-£23m. Other diffuse and point sources contribute 10% which is £3-£5m per annum.

6.1.3) Impacts on Fishing and Fisheries

We used the study by Spurgeon et al 2001, which derived values for the WTP to maintain current angling opportunities at coarse and game fisheries at £2.86-£3.67 per person per trip. Multiplying the total annual trip numbers affected by the potential improvements in water quality by these values gives approximately £71m pa for the potential angling benefits for improving river quality. We have used conservatively this estimate in our estimation of the environmental damage costs from current water discharges and abstractions.

Contribution from Agriculture

The Agency estimates that the water industry contributes between 40 and 70% of these impacts on fishing, partly due to the impact downstream of sewage treatment works. It is estimated that agriculture contributes 20 to 50% (14-£36m pa) and other diffuse and point sources contribute 10% (£7m pa). This includes the impact of diffuse urban run off.

6.1.4) Impacts on Amenity and economic wellbeing

The quality of the water environment is associated with regeneration and sustainable economic activities such as tourism. There are costs and benefits from general environmental quality and these can be captured through looking at the enhanced riparian property values associated with the improved water environment. Poor environmental quality conversely leads to lower property values.

We have been able to estimate the total value of benefits in terms of amenity improvements expected from PR04 at about £14.6 million per year.[7] These benefits arise from investments made by the water companies, and at present they are thought to reduce the water companies amenity impacts by about 50% - slightly greater than the reductions in other environmental damages. The water industry is estimated to contribute 50-70% of amenity environmental damages. The total damage costs can therefore be estimated on a *pro rata* basis, at around £49 million per year. The damage is mainly visual loss predominantly in urban areas. Other diffuse and point sources are likely to figure quite highly and certainly more than agriculture, with problems such as fly tipping and surface oil. There may be some algal blooms caused by agriculture. The Agency estimates that agriculture contributes 10% (£5m pa) and other sources contribute 20-40% (£10m-20m).

6.1.5) Bathing Water Quality affected by Water Pollution

The damage costs were estimated as a combination of WTP to reduce the risks of stomach illness, plus the direct economic costs of output foregone as a result of gastrointestinal illness associated with bathing. The WTP to reduce risk were derived from Eftec (2002).

The Eftec 2002 damage cost for all beaches is £2.53/household per year (2002 prices); updated to 2004/5 prices this becomes £2.70 per household per year, or £65.4 million per year. In addition, the indirect costs attributable to illness and loss of earnings as a consequence of intestinal disease have been estimated at £50.7m pa (at 2004/5 prices). The estimates do not include any estimates of foregone output associated with illness.
A value of illness associated with the illness of poor quality bathing waters in England and Wales at £65 million per year was used.

<u>Contribution from Agriculture</u>

Contamination derives from water company discharges, agriculture, urban run off and birds. While the causes will be location specific, the Agency estimates that overall the contribution of the water companies lies between 30-60%[8], or between £20.5 – £39 million. The contribution from agriculture is estimated to be 35% to 65% (£23-42m) and from other sources it is 5% (£3m pa).

6.1.6) Impacts of poor groundwater quality

Much more empirical research is needed on the value of groundwater resources and the value of the impact of water pollution and abstraction on groundwater, especially since studies in other European countries have demonstrated the high importance of impacts on groundwater.[9] At the time of writing the Environment Agency is undertaking research on the value of groundwater[10] but it is too early to report the findings here.

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[8] This estimate is consistent with the Agency's estimate for the water companies' contribution to poor water quality (see Section 2.2).
[9] Chegrani, P (2005) Evaluer Les Benefices Envrironnementaux sur les Masses d'Eau. Ministere De l'ecologie et du developpement durable. D4e Unit. Series D'etudes 05 – E08.
[10] *Assessing the Value of Groundwater* Eftec

Box 2 (prices are in 2002 prices) below reports a study for Defra[11] which found that water companies' expenditures on water treatment from all sources include about £303m pa on removing nitrates and pesticides and reducing risks associated with *cryptosporidium* along with a number of other parameters. Around a third of drinking water is abstracted from groundwater sources, and so it is assumed that the costs are divided pro rata (£100m)[12]. There are also the treatment costs for private abstractions from groundwater. We assume here that the total private treatment costs £25m pa[13].

We use these figures to provide an estimate of the value of the impact of water pollution on groundwater at £125 million per year. This is likely to be an underestimate as:

- it may not adequately take account of the cost of finding and establishing new groundwater sources when existing ones are lost to pollution;
- it does not take account of the added operational costs caused by the reduced flexibility for managing supply abstractions, and
- it doesn't include estimates for the non use values attached to groundwater.

The value of the impact of poor water quality on groundwater is likely to rise significantly in the future as the scarcity of groundwater sources increase. Pollution of groundwater may mean that it can no longer be used as a source of water for drinking or other uses. If it is not possible to treat then the abstractor will need to find an alternative source. The cost of this includes the cost of the new infrastructure etc needed to access the new source etc. This increasing scarcity of groundwater is highlighted by a study for UKWIR by the British Geological Survey [14](BGS 2004).

As noted above we conservatively estimate the impact of poor water quality on groundwater at £125m per year. We estimate that agriculture is responsible for 40-70% of the impacts of water pollution on groundwater (£51-89m pa in 2004 prices). It should be stressed that there is a lot of uncertainty

[11] Assessing current levels of cost recovery and incentive pricing, ERM, Stone & Webster for DEFRA May 2004
[12] Discussions with Tim Besien (Environment Agency)
[13] Discussion with Tim Besien (Environment Agency) and Nigel Crane (Environment Agency Groundwater Policy Advisor)
[14] British Geological Survey (2004) Implications of Changing Groundwater Quality for Water resources and the UK Water Industry: Phase 3 – Financial Impact. Report for UKWIR, the Environment Agency and the British Geological Survey. It reports that about 2800 ml/d of supplied water is currently affected by groundwater pollution. This represents 54% of the total amount of water supplied from groundwater. They estimate that the quantity of water supplies affected by water pollution could double by 2029, which would raise costly issues in terms of seeking alternative supplies and increasing costs of treating polluted water. They estimate that future capital costs to manage the impact of groundwater pollution are likely to be of the order of £200m for successive AMP periods (ie about £40m pa). There would be increasing operating expenditures possibly reaching £150m pa by AMP8 (ie by 2029).

regarding the estimates of the impacts of poor groundwater quality. As noted above important impacts have not been included such as estimates for the non use values attached to groundwater. Much more research is needed in this area.

Box 2 External water treatment costs in England and Wales in 2002 Prices

Water companies' expenditures on water treatment include about £303m pa on removing nitrates and pesticides and reducing risks associated with *cryptosporidium* along with a number of other parameters. About £211m of these costs are attributable to external sources such as agriculture. These represent external financial costs incurred by the water companies to treat pollutants from other sectors (most notably agriculture) and other diffuse sources of pollutants, which do not pay for these costs.

Estimated annual costs in 2002-03 of external impacts on raw water quality (£m pa 2002-03 prices)

	Annual Costs borne by water Company customers	%contributions due to agriculture	Total annual remediation attributable to agriculture
Capital Costs			
Nitrates	14.4	80%	11.5
Pesticides	78.3	89%	69.7
Other parameters	108.6	50%	54.3
Cryptosporidium	23.3	90%	21.0
Sub Total	224.6		156.5
Operating Costs			
Deteriorating raw water quality	70.4	67%	47.4
Cryptosporidium	8.3	90%	7.5
Sub Total	78.7		54.9
Total	303.4	70%	211.4

Source:
ERM, Stone & Webster. Assessing current levels of cost-recovery and incentive pricing, DEFRA, May 2004
Pretty, J.N. et al (2000). An assessment of the total external costs of UK agriculture. Agricultural Systems, 65, pp 113-136.

The annual water treatment costs excluding the cost of treating pesticides is £155m[15]. This is an underestimate because the operating costs of treating

[15] This was calculated by subtracting the capital costs of pesticide treatment (£69.7m per year) and the total operating cost of treating deteriorating raw water quality (£70.4m per year) from the total water treatment costs (£303.4m per year)

deteriorating raw water quality (£70.4m per year) have been removed. This will involve treating nutrients as well as pesticides. It has not been possible to allocate these operating costs between pesticides and nutrients.

6.1.7) Surface Water Treatment Costs.

Part of the total cost faced by water companies to treat raw water prior to supplying to water customers is an external cost of agriculture. As noted in Box 2 above around £300m pa is spent on removing nitrates, pesticides etc. A proportion of this cost needs to be included in any assessment of the external costs of agriculture. It was assumed above that a third of this cost is for the treatment of groundwater. Around £200m pa is therefore spent treating surface water. Pretty et al (2000) quote estimates of the percentage of nitrate, pesticide etc emissions to sources of drinking water attributable to agriculture (these are the percentages quoted in Box 2 above) with an overall allocation of 70%.

Ofwat asked water companies to comment on the Pretty et al (2000) percentages [16]. Some of the companies thought the pesticide figure is too high. One company quoted a figure of 50%. The rationale is that the amount of pesticides in water bodies from non agricultural sources is more than proportional to their share of pesticides consumption because pesticides from these sources can find a more direct way into water bodies. This casts doubt on the Pretty figures and so it is conservatively assumed here that 60-70% of the overall costs of raw water treatment can be attributed to agriculture. The surface water treatment costs attributable to agriculture therefore range from £127m to £148m pa (2004 prices).

6.1.8) Impacts of water pollution and low flows on river ecosystems and natural habitats

<u>Poor Water Quality</u>

We used the Willis and Garrod (1994) value of £0.00217 (2004/5 prices) per household per km per year, for a change from medium (RE3) to good quality (RE2/1) to value the damages (as benefits foregone). For a change from below RE3 (poor) to RE3 (medium) the figure is £0.0065 (2004/5 prices) per household per km per year.

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[16] Ofwat provided EA with this information, which is part of the background information for what is still a draft report on the "Impact of Agricultural Pollution on Water Companies costs" Ofwat.

Based on the lengths of river of poor, medium and good quality before the impact of PR04, the value of benefits foregone can be calculated, as shown in table 5.

The estimates in table 5 relate only to current water quality. They do not include the potential benefits of improving those rivers that are currently below RE3 to RE2/1. It only estimates the benefit of upgrading these rivers to RE3 – and hence may underestimate the damage costs of current river quality (the benefits foregone of upgrading these rivers from RE3 to RE2/1 is £290m pa (6351 km x £0.00217 x 21.07m). On the other hand, extrapolating benefit valuations for achieving good quality in all rivers may overestimate the benefits since there may be limits to the extent to which such benefits could in fact arise at all rivers and in how much people would be willing to pay for them. Jacobs (2002) have identified and analysed the challenges for the valuation of such non-use benefits and sets out a long term strategy for the Environment Agency to improve gradually their valuation so as to aid decisions on measures. On balance, we consider that table 5 are the best estimates that are currently available.

Table 5 Calculating damage costs of current water quality for ecosystems and natural habitats (2004/5 prices)

Length of river below RE3	6351 km
Length of river at RE3	6886 km
Total length of river	13237 km
£/household/km changing from below RE3 to RE3	£0.0065
£/household/km changing from RE3 to RE2/1	£0.00217
Cost of poor ecosystem and natural habitat conservation in poor rivers (below RE3)	£870 million
Cost of poor ecosystem and natural habitat conservation in moderate rivers (below RE3)	£315 million
Total ‘non-use’ value of poor environmental quality	£1,185 million

Source: Willis and Garrod
Note: 21.07m households

<u>Low flows</u>

There are estimates in the literature for the benefit accruing from reducing the risks of low flows in all rivers in England and Wales. Using ERM & Willis (1993) it is possible to calculate an overall figure. The CVM survey in this study asked respondents for the willingness to pay for low-flow alleviation on all 40 rivers identified as low-flow rivers nationally.[17] The total willingness to pay can be calculated as about £115 million per year (2004/5 prices), almost all of which relates to non-use impacts on natural habitats. A more recent study[18] (in 2002) valued the low flow alleviation benefits at the river Mimram in the context of a programme of measures to tackle all low flow rivers in the Thames region. This gave similar valuations to Willis' earlier study.

Therefore we estimate that the total impacts on natural habitats and ecosystems of current river quality and low flows amount to about £1300m pa (1185+115). The above estimates are based on the values given by Willis and Garrod's national studies. The values from a study by Georgiou et al (2000b)[19] are 56% lower. Therefore we have divided the above upper bound estimates by 56% to give a lower bound estimate of £730m pa. The range for poor water quality is £665m to £1185m and the range for low flows is £64m to £115m per year.

Contribution from Agriculture

Water companies have been identified as being the significant source in 24 (or 15%) out of the 164 sites, for which there is evidence of a problem of damage to a key natural habitat site. There are possible links with water company abstraction and discharges in a further 89 cases (or about 54%). Thus water companies have been identified as a source of the damage in nearly 70% of these sites. Water company abstractions are estimated to account for 76% of the abstractions causing environmentally unacceptable low flow problems at rivers in England and Wales. We have therefore assumed that water companies contribute about 60-70% (£439m-913m pa) of the ecosystem and natural habitats impacts for wetlands and rivers affected by poor water quality and low flows. The other major contributor is agriculture with an estimated share of 25-35% (£183-456m). Other sources therefore contribute 5% (£37-65m).

6.1.9) Impacts of water pollution and low flows on wetlands ecosystems and natural habitats

We have estimated the benefits of PR04 in reducing damage caused by abstraction and water pollution for ecosystems and natural habitats at

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[17] At the time of that study (1993) a total of 40 rivers had been identified by the Agency as having low flow problems. Now, in 2000, some 500 sites have been identified for reduced abstraction related to low flows – it is not clear how these 500 sites relate to the 40 rivers

[18] Jacobs (2002) River Mimram Low Flow Alleviation Public Preferences Study: Final Report. Report to the Environment Agency.

[19] Georgiou, S., Bateman, I., Cole, M., and Hadley, D., 2000b. 'Contingent Ranking and Valuation of River Water Quality Improvements: Testing Scope Sensitivity, Ordering and Distance Decay Effects'. CSERGE Working Paper GEC 2000-18.

wetlands as being about £19.5 – 41m pa. Assuming PR04 reduces the water industry's damage by 60% (in line with the reductions in the water industry's impacts on natural habitats and ecosystems at rivers) and using the estimate that the water industry is responsible for about 60% of such impacts on ecosystems and natural habitats, then the current total damage to ecosystems and natural habitats at wetlands is estimated to be about £51 – 112m pa.

Contribution from Agriculture

Water companies have been identified as being the significant source in 24 (or 15%) out of the 164 sites for which there is evidence of a problem of damage to a key natural habitat site. There are possible links with water company abstraction and discharges in a further 89 cases (or about 54%). Thus, water companies have been identified as a source of damage in nearly 70% of sites. Water company abstractions are estimated to account for 76% of the abstractions causing environmentally unacceptable low flow problems at rivers in England and Wales. We have therefore assumed that water companies contribute about 60-70% (£31-79m pa) of the ecosystem and natural habitats impacts for wetlands and rivers affected by poor water quality and low flows. The other major contributor is agriculture with an estimated share of 25-35% (£13-41m). Other sources therefore contribute 5% (£3-6m).

6.2) Air pollution damage costs

Table 6 below gives the environmental costs from agriculture's emissions of air pollutants. Some emitted gases have impacts at the local level such as ammonia's contribution to acidification and enrichment while others have global impacts for example carbon dioxide, methane and nitrous oxide.

Global Impacts

The greenhouse gases emitted by the agriculture sector include: carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). CO_2 is emitted by the cultivation of soil and by the combustion of fossil fuels to power tractors and other vehicles. Agriculture is the main source of methane and nitrous oxide in the UK. Methane is formed during the decomposition of organic matter and nitrous oxide is formed from nitrogen fertiliser and from the treatment and disposal of animal wastes.

Local and regional impacts

Along with the 3 greenhouse gases mentioned above, ammonia is the main gas (in volume terms) released by agriculture. Most of the ammonia released in the UK is from agriculture. It is released from nitrogen rich products from

mainly cattle and pigs. It is also released from the use of inorganic fertiliser. It causes acidification and enrichment.
The combustion of fossil fuels also releases regional impact pollutants such as sulphur dioxide (SO2) and nitrogen oxides (NOx) and local impact pollutants. SO2 and NOx produce acid rain, which erodes buildings, damages ecosystems, reduces crop yields and impacts on human health. The local pollutants can exacerbate respiratory illness. The estimates used here for the impact of regional and local pollutants focus only on the mortality risk.
The damage cost figures for local and regional air pollution excludes[20]:

- impacts on ecosystems
- additional health effects
- damage to cultural heritage
- impacts on visibility
- altruistic values associated with health impacts.

One of the advantages of the Eftec 2004 report over the EA 2002 report is that it uses more up to date Netcen figures for the quantity of emissions (2001 as opposed to 1997).

[20] *Framework for Environment Accounts for Agriculture* Eftec (Economics for the Environment Consultancy) in association with Institute for European Environmental Policy (IEEP) July 2004.

Table 6 Damage costs of air emissions from agriculture

Air Pollutant	**Unit damage cost. (£/tonne)** 2004 prices	**Quantity of emissions (ktonnes per year)**	**Total damage cost (£m per year 2004 prices)**	**Source**
Carbon*			111	EA2002
Methane	£204 - £816	914	186 - 745	Eftec 2004
Nitrogen Oxide	£194 - 915	18.7	4-17	Eftec 2004
Sulphur Dioxide	£759 - £2341	1.5	1-3	Eftec 2004
Nitrous Oxide	£2849 - 11397	88	250 - 999	Eftec 2004
NMVOC	£1394	4.2	6	Eftec 2004
Ammonia	£89	272	24 - 75	Eftec 2004
Total			583-1959	

*This figure does not include the carbon dioxide loss from soil cultivation. This is included under the soil category.

The total damage cost figure is calculated by multiplying the unit damage cost by the quantity of emissions per year.

For carbon the figures used here are from the EA 2002. The Eftec 2004 Report does not provide separate details of the emissions of carbon dioxide and the quantity of carbon sequestration.

We have not included a figure for airborne particulates because of a risk of double counting with ammonia.

6.3) Impacts of poor soil structure/soil erosion/soil cultivation

Soil erosion, declining organic matter and runoff problems related to poor soil structure are growing problems in UK agriculture. Enhanced runoff and soil erosion have been influenced by factors that affect soil structure and the ability of soils to absorb rainfall, including:

- the conversion of marginal lands
- increased intensification

- removal of hedgerows/field boundaries
- overgrazing practices
- untimely vehicle use
- soil cultivation practices that cause slumping and capping of the soil[21]

There are many costs resulting from poor soil structure and soil erosion including:

- On site costs: falling productivity, increase in fertiliser use etc
- Increase in drinking water treatment costs,
- eutrophication, (much of the phosphorous and pesticide losses from farm land to surface water are bound to soil particles)
- council expenditure (for example the cost on local government of dredging stream channels removing soil from roads),
- damage to others property
- damage to salmon spawning grounds and
- damage to aquatic habitats and ecological change.
- Increased risk of flooding.
- Carbon loss.
- Contributing to flooding

Poor soil structure and soil erosion is a bigger issue than the figures in the reports suggest. Some of the off site costs would already be incorporated in the values of damages to water, insofar as soil erosion impacts upon water quality. There are effects such as increased treatment costs to remove soil particles, which are sometimes included under water damage costs or carbon emissions from soil, which are sometimes included under air emissions. Often it is difficult to disentangle these cost estimates to get a better idea of the damage costs of poor soil structure and soil erosion.

<u>EA2002 Report</u>

The EA 2002 Report includes the following damage costs for poor soil structure and soil erosion:

- On farm cost (wind and water erosion) £9m (source Evans 1996)
- Off site cost mainly including dredging stream channels £9.17m with £8.68m attributed to agriculture (95%). (Source Evans 1996)
- Carbon loss £82m from Pretty et al 2000 (from cultivation of soil)
- Poor soil structure contributing to flooding £128m

The EA 2002 Report does not include the following under soil damage costs:

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[21] *Agriculture and Natural Resources: Benefits, costs and potential solutions* Environment Agency 2002

- The cost to the Agency in restocking rivers for fish. Soil particles in rivers will contribute to fish deaths. This cost is included in the water pollution cost.
- The increased water treatment cost from removing soil particles. This is included in the cost of eutrophication (which is in the figure for Phosphorous £21.17m). It was not possible to remove soil particle removal from phosphate removal drinking water costs

None of the reports have data that would allow the welfare losses and gains from improvements or degradations to soil as a natural asset to be assessed.

This note does not include the on site costs since these costs are not external to agriculture. It was decided to continue to use the EA 2002 Report figures for the off site damage costs and the loss of carbon. Both studies (EA2002 and Eftec 2004) quote the same figure for the off site damage costs. The carbon loss from soils is included.
In the EA 2002 Report the annual cost of flooding is £0.9b (source HR Wallingford). The cost includes damages to:

- the capital values of built property,
- the capital values of agricultural land,
- the value of land and property within zones subject to coastal erosion,
- foregone agricultural production and
- increased travel cost due to road traffic disruption

It did not include:

- values for costs such as loss of life, health and stress implications,
- road and bridge damage and
- rail traffic disruption.

From the Agency's flood event data 25% of all flood events in the 80s and 90s were hillslope events. On the basis that 57% of hillslope events were caused by soil erosion and deposition then 14% of all flood events and event costs are conservatively assumed to be attributed to soil erosion from agriculture. Therefore the cost of flooding caused by agriculture is £127.8m

<u>Eftec2004 report</u>

The Eftec 2004 Report has more up to date figures for the annual cost of flooding. They use market data for the UK provided by the Foresight Report (Evans et al 2004) giving the total cost of flooding at £1.14b. They copy the approach of the EA 2002 Report and assume 14% contribution from agriculture giving £156m. The report does however find a general absence or uncertainty of the impacts of land management practices and recommends further research in this area.

<u>Approach taken here</u>

Off site costs	£8.68m pa (EA2002 report)
Carbon loss from soil cultivation	£82m pa (EA2002 report)
Contribution to flooding	From £29m to £128m pa (Evan (1996) and EA 2002)
Total	£**120m to 219m** per year (in 2004 prices)

The approach taken here is to assess separately the damage cost of CO2 emissions and the benefit of agriculture as a carbon sink.

There is some evidence that farming practices influence the frequency of small scale, local 'muddy floods' (O'Connell et al 2004). The annual cost of these floods is difficult to assess, with estimates ranging from £24-51 million for the UK (Evans 1996) up to £115 million for England and Wales alone (EA2002 report 2000 prices). Research is ongoing into the link between land management and more infrequent larger catchment scale flooding which causes major economic damages. These estimates have been updated to 2004 prices to give a range of £29m to £128m. They therefore do not take account of changes in circumstances, knowledge, evidence etc since the original figures were derived. The estimates should therefore be treated with caution - it should be noted that there is a great deal of uncertainty in this area and more research is needed.

7) External Environmental Benefits of Agriculture

The source of the environmental benefits of agriculture in EA 2002 report is Hartridge and David Pearce 2001[22]. It was decided to use figures from the Eftec 2004 report here. See table 7 below. The Eftec 2004 Report cites a IERM and SAC (2001) study which uses benefits transfer[23] based on the majority of the existing literature on UK landscapes and habitats. In contrast Hartridge and Pearce 2001 cite fewer studies to derive their estimates.

[22] "Is UK Agriculture Sustainable? Environmentally Adjusted Economic Accounts for UK Agriculture" November 2001 Olivia Hartridge and David Pearce CSERGE Economics and University College London.

[23] Technique where valuation estimates are taken from an original study and applied to a new context, sometimes with adjustments to take account of the characteristics of the new situations)

The exception is the figure for agriculture as a carbon sink. This is taken from Hartridge and Pearce 2001. It was decided to keep the carbon sink figure because the Eftec 2004 study does not explicitly report this sink benefit of agriculture. It presents the damage cost of net carbon emissions. Hartridge and Pearce 2001 use a unit damage cost of £29.8 per tonne in 1998 prices for carbon.

Table 7 : Environmental Benefits of agriculture £m per year 2004 prices

Benefit category	**2004**
Value of landscape amenity services by the current provision of landscape	498
Value of habitat protection services	229
Value of species protection	313
Agriculture a sink of carbon dioxide*	415
Total	1455

Costs were converted to 2004 prices using the GDP Deflator
Source: Eftec 2004 report

Table 7 gives the environmental benefits provided by agriculture's good management of the land. Only the central figures are provided. There is a large variation in economic value estimates. Further research is needed to provide a clearer indication of agriculture's role in the provision of the non-market goods and services provided by the countryside. The figures reflect the benefits derived from all the land managed by agriculture (74% of all land).

The countryside provides many non-market goods and services through the provision of landscapes, habitats and species. Agriculture contributes to this provision. When assessing the contribution of the sector it is necessary to compare what the farmed environment provides with what would occur in its absence or what would occur if the agricultural land were managed in a different way. In many cases if land is left it will turn through natural succession to scrub and then woodland, which itself provides environmental benefit.

Of course agricultural activities can both improve and erode habitats and species. Biodiversity loss can result from inappropriate farm management practices. The figures quoted above are net of the negative impacts on landscape/habitats/species.

Most of the UK is covered in semi natural habitats created from historical agricultural practices. These semi natural habitats often have a higher biodiversity value than the type of habitat that would result if management were removed (scrub followed by woodland- although this is likely to be more valuable than intensively managed farmland). Agriculture is very important in the creation and maintenance of these semi natural habitats. To keep them requires continuation of agricultural activity. Examples of semi natural habitats include grassland, wetlands, moorland, wood pasture, salt marches etc.

The activities of agriculture, which can result in external benefits include:
- the maintenance of landscape features such as hedges, dry stone walls, field margins, banks etc;
- the contribution to the aesthetics of the UK landscape through crop cover and permanent grassland;
- maintenance of historic archaeological sites.
- The maintenance of semi natural habitats such as neutral grassland, bog, dwarf shrub heath, acid grassland, fen, Marsh, swamp, farm woodland etc

Some farmers derive significant non-farm income from farm based tourism, which may relate to some of the landscape amenity benefits above. The source of the environmental benefits of agriculture is the Eftec 2004 report except for the estimate for the carbon sink.

*Agriculture as a sink of carbon dioxide

The source of the above figure for the CO_2 sink service provided by agriculture is Hartridge and Pearce 2001. Sink is estimated to be 12.1m tonnes of carbon per year with a unit damage cost of £29.8 per tonne in 1998 prices gives a total of £415m per year (2004 prices). This is not a net figure since the emissions of CO_2 are presented earlier (emissions of CO_2 from fossil fuel combustion etc of £111m and CO_2 emissions from soil cultivation of £82m per year).

The total 12.1 m tonnes of C includes: forest biomass and litter (2.1m tonnes); non forest biomass (0.3m tonnes); forest soils (0.1m tonnes); set a-side soils (0.4m tonnes); undrained peatlands (0.7m tonnes); CO_2 and N fertilisation (2m tonnes); crops for consumption (6m tonnes); livestock (0.5m tonnes)

Annex A: Possible Reductions in the short run (SR) and long run (LR).

The EA 2002 Report sets out the possible short run (5 years) and long run (20 years) reductions in each of the damage costs. Consulting with Agency experts and using certain assumptions, percentage reductions for each damage category were derived. Details are given below.

The values in the EA 2002 Report are in 2000 prices. These have been converted and all values quoted below are in 2004-05 prices unless otherwise stated.

Environmental damage costs from poor water quality and low flows

In the EA 2002 Report it is estimated that the technical potential reduction in damage costs are 25% and 75% for the short run and long run respectively for most of the water damage categories. 25% and 75% have been applied to the new damage estimates from the PR04 analysis for the SR and LR reductions respectively.

Freshwater Eutrophication

To reduce the amount of phosphate rich water and soil entering watercourses, farmers need to implement nutrient management and soil protection strategies.
It is estimated that implementing all technically feasible management practices may reduce phosphate losses by 25% in the short run and by 75% in the long run (Rachael Dils, Environment Agency, e-mail communication 20/08/01 and RLUG members meeting 25/10/01)

Nitrogen

The key issue identified by the Agency is reducing nitrate below 50 mg/l in water supplies to comply with drinking water standards. Nitrate concentrations are not stable, their cycles consist of peaks and troughs (in response to climatic changes). A targeted programme could concentrate on the peaks during the winter period where nitrate exceeds water quality standards. It is estimated that best practice may result in overall nitrogen level reductions of 25% in the short run and a 75% reduction in the long run. However targeting management practices towards peaks and troughs may result in meeting water quality standards 100% of the time (RLUG members meeting 25/10/01).

Pesticides and sheep dip

The EA 2002 Report conservatively only considers the potential reductions in point source contamination. It has been suggested that at least half of pesticide pollution incidents originate from accidental spillage and poor handling facilities. Implementation of good handling practices may reduce pesticides issues by up to 50% in the short and long run.

<u>Organic wastes</u>

Actions to reduce organic waste pollution will not be 100% effective. Little research has been done to find out whether land disposal following good management practice of organic waste has any implications for the organic matter or nutrients recorded in receiving waters on a stream or catchment scale (Chartered Institution of Water and Environment Management 2000). It is assumed that best practice will follow phosphorus and nitrate results, with a reduction of 25% of organic wastes in the short run and a 75% reduction in the long run.

<u>Faecal pathogens (soil and water)</u>

To reduce faecal pathogen pollution, actions similar to soil erosion, nitrate and phosphate are needed. Soil and nutrient management planning is needed.

Actions to reduce faecal pathogen issue will not be 100% effective. It is likely that reductions will be similar to organic waste potential, with a 25% reduction of faecal pathogens in the short run ad 75% in the long run.

<u>Fishery damage/river water quality (soil and water)</u>

Actions to reduce fishery damage will not be 100% effective. An average of potential reductions that could be achieved results in a 45% reduction in the short run and 75% in the long run.

<u>Low flows</u>

The Environment Agency (2000b) suggests that a 10% reduction in water use can be achieved each year via efficient spray delivery. Given available technology and knowledge, it is possible that around 90% of agriculture’s contribution to low flow problems could be reduced in the short term, with 100% achievable in the long term.

Environmental damage costs from soil erosion

Actions to improve organic matter and reduce soil erosion will not be 100% effective. Given the available evidence, RLUG members suggest that a 75% reduction in problems with soils can be achieved in the short run.

The EA report uses the effectiveness of options in improving soil issues as a proxy; namely a 75% reduction in flooding problems of key contributing sectors such as arable can be achieved in the short and long run.

Environmental damage costs from atmospheric emissions

Some agricultural responses that would reduce atmospheric emissions include changing feed diets, improving energy efficiency, changing housing systems and implementing certain technology and managing landspreading.

Given that knowledge is uncertain in this area, it is conservatively suggested that an achievement of a 10% reduction in emissions could be reached in the short term (RLUG members meeting 25/10/01). It is likely that a higher reduction could be achieved in the long term, though further research and development would be needed. A 25% long-term reduction is assumed here.

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