

## Diffuse Pollution of Water by Agriculture



Water pollution regulation is devolved in the UK. Surface, coastal and ground waters in England suffer from significant pollution problems: 78% of surface and groundwater bodies fail to meet the 'good' ecological status prescribed by the EU Water Frameworks Directive. Pollution increases water treatment costs and adversely affects wildlife. Compared to treatment, preventing water pollution at source can have a cost-benefit ratio as high as 1:65. This POSTnote describes the contribution of agriculture to water pollution, and measures that can be taken to reduce it.

### Diffuse Pollution of Water

Diffuse pollution of water (DPW) arises from numerous, small pollution sources that accumulate in surface and ground waterways. The main sources are runoff from agricultural land, urban areas, septic tanks and misconnected or leaking drains, the national road network, disused mines and industrial sites, and the direct deposition of airborne pollutants (especially nitrogen; [POSTNote 458](#)). Lakes, rivers and streams cover around 2% of the landscape, but their composition reflects the combination of every activity in the area of land that they drain (their 'catchment'). Reducing DPW requires actions at a whole-catchment level.

### Diffuse Water Pollutants and their Impacts

Pollution reduces water quality, necessitating additional treatment before it is fit for human consumption. For example, South West Water estimates that 17% of their customer's bills is for water treatment costs (costs vary between companies and areas). Pollution damages fisheries and ecosystems, as well as reducing the recreational and cultural amenity of landscapes.<sup>1,2</sup> The effects of specific

### Overview

- Water pollution raises drinking water treatment costs and harms the natural environment.
- Diffuse pollution of water (DPW) is a major contributor to water pollution; agriculture is the source of around a third of DPW.
- Reducing agricultural DPW requires actions across entire catchments.
- The complexity and geographical variability of catchments across the country means that no single set of DPW reduction measures will be universally applicable.
- Locally appropriate catchment scale management programs can mitigate DPW and provide multiple environmental and social benefits, but funding and implementing these programs at scale is challenging.
- Despite the most extensive monitoring program in the EU, water quality data in England are sparse and further effort is needed to fully understand the problem.

DPW substances are as varied as the sources they come from and include:

- toxic heavy metals and chemicals from industrial sites
- phosphates ([POSTnote 477](#)) and particulate matter ([POSTnote 458](#)) from urban areas (especially septic tanks and misconnected drains) and the road network
- fertilisers, pesticides, sediments and faecal bacteria from agriculture, the focus of this note.

The relative importance of these pollutant types varies across England.

### Agricultural Diffuse Pollutants

Agricultural pollutants are transported in water runoff from farmed land. Runoff from a single field would not present a problem, but 70% of land in England is farmed, which collectively constitutes a significant pollution source.<sup>3</sup>

Agriculture produces four distinct types of pollution:

- **Fertilisers.** Nitrogen, phosphates and potassium in either chemical (fertiliser pellets and sprays) or organic forms (manure) are routinely added to agricultural land. Rainfall can wash a proportion of fertiliser off fields into local waterways, or cause soluble nutrients to filter into

### Box 1. Major EU DPW Legislation

#### Water Framework Directive (2009)

The WFD is a piece of EU legislation that establishes a framework for the protection of the water environment. It requires water bodies to meet 'good' ecological status or potential, except where exemptions apply, such as where it is not technically feasible, or disproportionately costly (POSTNote 320). The WFD aims to move water bodies towards higher biodiversity and natural river forms. In general, the greater the complexity in natural systems, the better they are able to cope with unusual stresses (e.g. from climate change).

#### Nitrates Directive (1991)

Around 70% of nitrogen fertiliser applied globally each year is lost into the environment.<sup>4</sup> The EU introduced the Nitrates Directive to reduce the impacts of nitrogen fertilisers from agriculture through the establishment of Nitrate Vulnerable Zones, where eutrophication, and nitrate concentrations in drinking and ground water were becoming a major problem or the nitrate standard was exceeded in Member States. Nitrate Vulnerable Zones have strict limits on the timing and amount of nitrogen application.

#### Common Agricultural Policy (1962)

Recent Common Agricultural Policy (CAP) reforms<sup>5</sup> make 30% of pillar 1 payments depend upon 'greening' measures being implemented on farms.<sup>6</sup> A significant addition for water quality is the requirement for arable farms over 15 hectares to identify 5% of land as Ecological Focus Areas, which can be managed in a number of ways, all of which act to improve water quality. Defra is currently developing the New Environmental Land Management Scheme (NELMS) to detail how the £3.5bn available through pillar 2 will be spent.<sup>7</sup> Spending is likely to be more focussed, and include a water quality element in line with WFD goals

groundwater. Nutrients can fuel unusually high growth rates in microorganisms and plants, which at low levels causes a loss of biodiversity, and at high levels can cause algal blooms that can produce high concentrations of toxins and remove all the oxygen (a process known as eutrophication). This can affect untreated water quality, leading to higher treatment costs, as well as causing excessive plant growth that can clog waterways, block sluices and disrupt flood defences. In extreme cases, eutrophication can lead to the widespread death of aquatic animals and insects.

- **Pesticides.** On arable crops and to a lesser extent pasture, the application of insecticides, fungicides and herbicides is common for pest control. These can be washed into water bodies by rainwater, or may enter them directly if spraying close to water. They can also enter groundwater via soil infiltration. Pesticides are hard to remove during water treatment, and there are stringent limits on the concentration of pesticides allowed in drinking water (0.1 µg/l).
- **Sediments.** Erosion washes topsoil into water bodies, where it causes problems in channels downstream, increasing flood risk, smothering fish breeding grounds and reducing biological diversity in riverbed gravels. Soils can also carry large amounts of phosphate and agricultural chemicals that bond to clay particles. The degree of erosion varies widely depending on land use, local geology and land management practices.
- **Faecal bacteria.** Animal manure and slurry stores on farms are sources of faecal matter. The presence of faecal matter in water (identified by the presence of faecal 'indicator organisms') affects drinking water processing, shellfish safety and bathing water quality.

### Box 2. Water Classification

The WFD assesses water quality using three categories:

- **Ecological quality** is assessed via the presence or absence of various 'indicator' species, the concentration of nitrates, phosphates and specific biological toxins, and the degree of water oxygenation.
- **Chemical quality** is assessed based on the presence of various controlled priority chemical substances in the water.
- **Hydrological quality** describes the extent to which a river channel has been modified from its natural form.

These three criteria are each assigned one of five grades ('bad', 'poor', 'moderate', 'good' or 'high'), which are combined to provide an overall classification for the water body. The scores are combined on a 'one out, all out' basis, such that if a water body attains 'high' ecological and hydrological status, but 'poor' chemical status, the overall classification will be 'poor'.<sup>18</sup> The WFD classification system is more stringent than the previous Environment Agency classification, which suggested that 79% of English rivers were in 'good' condition, as opposed to 21% of rivers under the WFD. It is also a legal requirement to meet the WFD standards for Protected Areas, which include bathing waters, shellfish waters, drinking water sources, sites designated under the Habitats Directive and nutrient sensitive areas designated under the Nitrates and Urban Waste Water Treatment Directives.

#### Implementation of Water Classification

Assessing England's 6192 water bodies has proved challenging. Rivers change dramatically in response to seasonal variations and extreme weather events; a single assessment of the water quality may not always represent its actual status. Evaluating the parameters prescribed by the WFD involves first-hand inspection by experts, water sampling, and expensive chemical tests. For these reasons, water quality data are infrequent and sparse and often missing altogether from initial classifications in 2009 that were based on 'best available knowledge'. More evidence has since accumulated, which has reduced the number of surface water bodies meeting 'good' status from 26% to 25%, reflecting the collection of additional data, rather than an actual decline in water quality.

These four types of agricultural pollutants contribute 50-60% of nitrates, 20-30%<sup>8,9</sup> of phosphates and 75% of sediment in England's waterways.<sup>8,10,11</sup> They are also a source of faecal and other bacteria and pesticides.<sup>12,13</sup> DPW from agriculture and rural land use is directly attributed to 28% of failures to meet Water Framework Directive standards (WFD, see Box 1).<sup>14,15</sup>

#### Classification of Water Quality

The major legislation relating to water quality and pollution is outlined in Box 1. The WFD requires that all water bodies in the EU attain 'good' or 'high' status (Box 2) by 2015, except where exemptions apply. Today, only 25% of England's surface water bodies meet these criteria.<sup>16</sup> Across 21 EU member states, 43% of surface water bodies are currently estimated to reach at least 'good' status.<sup>17</sup> England is significantly below the EU average; the reasons for this have not been investigated.

#### How Can DPW be Reduced?

While the WFD deals with water quality, all the changes necessary to address pollution sources must take place on land in the river catchments. Catchments are complex systems, which vary widely across the country depending on geology, weather patterns and land use. This complexity makes it difficult to identify sources responsible for DPW, particularly in large catchments containing urban, industrial and agricultural activities. The level of complexity and variability in catchments limits the ability to design universal

DPW reduction measures. However, it is feasible to develop a policy framework that allows the adoption of locally appropriate management techniques. This would be on the basis of universal guiding principles that help ensure water security throughout the catchment, promote resilience to climate change and mitigate flood risks.

### Catchment Scale Management

A variety of schemes seek to tackle DPW at a catchment level, through the voluntary involvement of local stakeholders. They are funded by capital grants, higher-level stewardship payments or payments by private companies and are largely co-ordinated through local Rivers Trusts and Wildlife Trusts. Such schemes include:

- the Catchment Based Approach (CaBA, Environment Agency, Defra)
- Catchment Sensitive Farming (CSF, Natural England)
- Upstream Thinking (South West Water)
- Catchment Wise and the Sustainable Catchment Management Program (SCaMP, United Utilities)

Upstream Thinking, run by South West Water (SWW) in conjunction with the Westcountry Rivers Trust and the Devon and Cornwall Wildlife Trusts (Box 3), could provide a model for other parts of the country. It is an example of a 'Payments for Ecosystem Services' (PES) structure, where the customer (SWW) is paying the farmers for land management practices that provide a water treatment service, which is easily valued based on the cost of traditional treatment processes. These schemes can also 'offset' waste from sewage treatment works.

### Using Ecological and Hydrological Processes

Catchment scale management schemes encourage ecological processes that remove agricultural pollutants before they reach the waterways. In natural systems, complex networks of well-established plant roots and soil

#### Box 3. Upstream Thinking

Upstream Thinking began in response to severe pollution problems in some of SWW's drinking water reservoirs. Rather than investing significant resources in new treatment works, SWW turned 'up stream', to tackle the farms that were the sources of pollution in the reservoirs' catchments. Using Rivers and Wildlife Trusts as intermediaries, SWW were able to approach farms upstream of the reservoirs with business proposals. They offered capital investments to improve farm infrastructure, and provided long-term contracts to farmers to manage land to minimise water pollution. Comprehensive water quality monitoring stations at SWW's downstream abstraction sites made the effects of the scheme clearly quantifiable, and pollution incidents could be picked up rapidly and addressed.

The actions taken in this scheme were guided by a novel ecosystem service mapping approach. A series of catchment maps assigned qualitative scores to the land based on its contribution to pollution, flood and drought risks, carbon-capture, biodiversity, recreation, and economic and agricultural productivity. These maps are combined to identify the areas of land where improving management could provide the most benefits across the widest range of ecosystem services. The nature of these maps is qualitative, as they combine the relative importance of different land areas rather than trying to quantify the absolute importance, which is much less certain. Upstream thinking has been successful in reducing water pollution, is financially beneficial to the farmers, and provides a 1:65 cost-benefit ratio for SWW's investment through direct savings in treatment infrastructure and indirect benefits to society.<sup>19</sup> The SCaMP program run by United Utilities has shown similarly successful results in North-east England.

bacteria act as water filters. The roots and bacteria actively absorb nutrients and keep soil loose and aerated. This provides an environment that slows the flow of water through the soil and allows time for the break down (biodegradation) of chemicals, such as pesticides.

Modern agriculture creates artificially nutrient-rich soil to maintain high food productivity. On intensively farmed land, the soil is repeatedly compacted by the passage of heavy machinery or animals. Compacted soil is less able to absorb water, and the plants are unable to use up all the nutrients in the soil. Rain that falls on a compacted field will be relatively unimpeded on its path into the nearest waterway, carrying sediment, nutrients and pesticides with it.

A key concept in DPW reduction is 'slow water'. By slowing the flow of rainwater from the land into watercourses, more is absorbed into the soils, where nutrients can be removed and chemicals broken down. It also reduces flood risks downstream, by reducing peak river flows (POSTNote 396). A number of specific measures that can accomplish this on a catchment scale have been identified, many of which act to move land back to a more 'natural' state.<sup>12,20,21,22</sup>

### Land Management Measures

Relatively few academic studies have investigated how these management techniques affect DPW at the catchment scale.<sup>17</sup> However, on-going trials are rapidly expanding the evidence base, demonstrating the efficacy of the measures outlined below.<sup>17,18</sup> In particular, the National Demonstration Test Catchment Network (Box 4) is producing the type of data required to inform future management approaches. These measures involve changes in land management, land use, or both.

- **Riparian and buffer zone management.** Strips of uncultivated land along the bottom edge of fields and alongside streams provide a 'buffer strip' that slows the runoff of water from cultivated land. It also helps reduce sediment, nutrient and pesticide load, as long as buffer strips are not bypassed by field drains.
- **Wetlands.** Large wetlands and marshes are particularly good at retaining and slowing water, providing an efficient means of nutrient and chemical removal. Wetlands that accept a large amount of polluted water require regular maintenance to remain effective.
- **Catch and cover crops.** Temporary vegetation planted when an arable field lies unused, reducing the amount of bare soil vulnerable to erosion. These crops can also reduce nitrate leaching.

#### Box 4. Demonstration Test Catchments (DTC)

This government-funded collaboration between over 40 organisations is the most comprehensive assessment of DPW reduction measures to date.<sup>23</sup> The project has set up a comprehensive monitoring network over four 'test' catchments, which represent 80% of UK soil, rainfall and land use combinations. This framework has collected a large amount of data on DPW sources in catchment systems across multiple seasons, and has begun to directly evaluate various DPW reduction measures. The amount of data produced means that analysing and understanding all aspects of the system could take years. However, the monitoring framework put in place by the project, and the already collected data make the DTC ideal for answering specific questions about DPW reduction. These data can be used by organisations seeking to investigate the efficacy of different DPW management options in specific situations.

- **Appropriate land use.** Planting crops that are appropriate to the location and soil type helps reduce pollution inputs – e.g. maize planted on steep slopes is a significant source of sediment.
- **Slurry storage and application.** Leaking slurry stores are a significant source of nitrogen and phosphates, and uncovered stores can overflow in heavy rain. The timing of slurry application, and the application method can also significantly affect the amount of runoff from fields.
- **Appropriate drainage management.** Blocking unnecessary ditches and field drains to slow down rainwater runoff and promote ‘slow water’ can aid water absorption, and reduce sediment and nutrient loads.
- **Controlled trafficking.** Managing farm traffic to minimise soil compaction can help improve soil health and water absorption.
- **Fencing off waterways.** Preventing livestock access to streams and rivers reduces direct sediment inputs and allows the development of riparian zones alongside streams, providing a long-term pollution reduction benefit.
- **Nutrient management planning/precision farming.** The active monitoring of soil nutrient and moisture levels and crop health allows the precise application of fertilisers and pesticides to crops as they are needed. Minimising the amount of chemicals applied to crops reduces their contribution to DPW.

Farmers have been taking steps to reduce diffuse pollution for over 20 years, through regulatory requirements, participation in incentivised agri-environment schemes such as CSF and voluntary programs such as the industry-led ‘Campaign for the Farmed Environment’.

## Policy Challenges for Reducing DPW

In catchments where water companies have a direct interest in water quality (44% of England<sup>24</sup>) catchment-scale PES schemes have the potential to improve water quality significantly. Following the success of programs like Upstream Thinking and SCaMP, other water companies have been granted permission to fund similar projects from customer bills in the Ofwat 2014 price review, marking a significant shift towards catchment-scale water supply management in England.<sup>25,26,27</sup> However, PES schemes have only been shown to be effective in two parts of the country, in relatively small catchments, where benefits are rapid and easily quantifiable. Application in other parts of the country could be less straightforward. For example, where water companies operate in large catchments, and extract groundwater, where payments are relatively large because of the number of farms, and benefits may not be seen for a number of decades. The cost-benefit relationship of PES is much less clear in these circumstances, making it less attractive to water companies.

Outside the areas where water companies have an interest (56% of England<sup>21</sup>), there is no clear ‘customer’ in the PES model and catchment management is less straightforward. When dealing with agricultural DPW, government is obliged by EU legislation to adhere to the ‘polluter pays’ principle. However, this is challenging to enforce in England, as the operator causing a pollution incident can only be prosecuted after it has occurred, and farm inspections are random, and rare (approximately 1% a year inspected for ‘cross-

compliance’, plus other Environment Agency inspections). Without sufficient evidence to prove that pollution was significant and arose specifically from the suspected cause prosecution is difficult. Scotland is addressing this by phasing in ‘General Binding Rules’, where pollution risks can be prosecuted, rather than incidents, which may make agricultural DPW easier to manage.<sup>28</sup> However, without a complete overhaul of the enforcement mechanisms this approach is not applicable in England.

Priority regions that affect bathing water quality or Sites of Special Scientific Interest (SSSIs) may be able to attract funding from alternate sources to facilitate catchment scale management schemes, but these cases will be a minority. Policies to encourage catchment scale management and reduce DPW require innovation if WFD requirements are to be fulfilled and financial penalties avoided. These policies will need to facilitate wide-scale collaboration between government, water companies, NGOs and farmers in areas where PES schemes are not easily applicable. Catchment management approaches are being developed by Defra, the Environment Agency and the Rivers Trusts. However, the resources and knowledge required to apply these programs country-wide is lacking:

- Many Rivers and Wildlife Trusts that could undertake Ecosystem Service Mapping to inform and manage PES schemes are not sufficiently funded to do so.
- Much of the groundwork for catchment management relies on volunteers.
- There are major gaps in the monitoring of water quality in England (although more intensive than other EU states) that hinder the classification of water quality and the effective prioritisation of pollution reduction schemes.
- Data on the combined effect of DPW reduction measures at the catchment scale and quantitative understanding of catchment processes are still in the early stages of research.

## Endnotes

- 1 [Defra, Dec 2011, Water For Life White Paper](#)
- 2 [Environment Agency, May 2007, The unseen threat to water quality](#)
- 3 [Defra Farming Statistics](#)
- 4 [Erisman \(2008\) Nature Geoscience vol 1, pg 636-639](#)
- 5 [EC: Overview of CAP Reform 2014-2020](#)
- 6 [CAP Reform in England: Status report on Direct Payments](#)
- 7 [CAP Reform countdown timeline](#)
- 8 [Edwards and Withers \(2008\) Journal of Hydrology vol 350, pg 171-184](#)
- 9 [Policy: Improving Water Quality](#)
- 10 [Collins et al \(2009\) Marine and Freshwater Research vol 60 pg 626-637](#)
- 11 [Randall et al \(2012\) Environmental Evidence vol 1, pg 12](#)
- 12 [Kay et al \(2008\) Environmental Science Policy vol 11, pg 171-184](#)
- 13 [Carsten an der Ohe et al \(2011\) Science of the Total Environment vol 409, pg 2064-2077](#)
- 14 [Environment Agency: Challenges and Choices Consultation](#)
- 15 [Environment Agency, March 2014: Progressing towards WFD objectives – the role of agriculture](#)
- 16 [Environment Agency Data: WFD Catchment Management Information Reasons for Failure \(unpublished\)](#)
- 17 [Brussels, 14.11.2012, COM\(2012\) 670](#)
- 18 [Method statement for the classification of water bodies v3](#)
- 19 [Defra, May 2013, Developing the potential for Payments for Ecosystem Services: an Action Plan](#)
- 20 [The Value of On-Farm Interventions for Improving Water quality. What is the Evidence?](#)
- 21 [Mitigation Methods User Guide](#)
- 22 [Upstream Thinking Catchment Management Evidence Review: Water quality](#)
- 23 [Demonstration Test Catchments Project: Summary Paper](#)

---

24 POST calculated the % area of WFD cycle 2 River Waterbody catchments containing/without abstraction sites, as listed in abstraction site data provided by the EA.

25 [OFWAT: From Catchment to Customer](#)

26 [DWI PR14 guidance – Catchment Management Schemes](#)

27 [Blueprint for PR14: Environmental outcomes for the Price Review](#)

28 [SEPA General Binding Rules 10 and 11](#)