Progressing towards WFD objectives – the role of agriculture March 2014

1. INTRODUCTION

62% of the food we eat in Britain is produced by our farmers and, in England, nearly 70% of the land area is utilised for agriculture[i]. The agricultural landscape also delivers a wealth of other 'ecosystem services'.

The Water Framework Directive (WFD) aims to protect and improve the quality of the water environment. Its objectives include:

- To prevent deterioration in the status of aquatic ecosystems.
- To meet the requirements of protected areas (e.g. bathing waters, Natura 2000 sites, shellfish waters).
- To achieve 'good' status for all waters by 2015, where this is possible and worthwhile (or by 2021 or 2027 where affordability or recovery time constrains the pace of improvement).
- To reduce the pollution of groundwater and prevent or limit the entry of pollutants.
- To reduce pollution from priority and hazardous substances.

Agriculture is one of many influences on water quality and water-dependent ecosystems, and has a role to play in meeting WFD and related environmental objectives. The main agricultural pollutants are nutrients (phosphates and nitrates), pesticides and other agrochemicals, faecal bacteria, and soil (sediment). The negative impacts these can sometimes cause include eutrophication (the adverse ecological effects of excess nutrients), increased water treatment costs, and damage to tourism and fisheries.

The agricultural sector is making a contribution to achieving WFD objectives[ii,iii]. However, there remains a need for a combination of best practice national measures operational at a farm level, and more tailored measures targeted at a number of high risk farming activities in high risk and impacted areas. These need to be implemented through a variety of voluntary, incentivised and regulatory policy mechanisms to achieve the agricultural pollutant reductions required for WFD compliance. Action is also being taken by other sectors, such as the water industry, transport, angling and conservation.

In this report the focus is on water quality; we recognise agriculture also contributes to other water-related pressures such as abstraction, flow and physical modification of rivers. We also acknowledge that to achieve WFD objectives, we need to tackle the range of sectors contributing to the problem in a cost-effective and proportionate way. All information is for England only, unless stated otherwise.

This report has been co-authored by a large number of technical experts from across the Environment Agency (see Appendix 1).

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[i] DEFRA Farming statistics - https://www.gov.uk/government/publications/farming-statistics-final-land-use-livestock-populations-and-agricultural-workforce-as-at-1-june-2013-england. UAA is made up of arable and horticultural crops, uncropped arable land, common rough grazing, temporary and permanent grassland and land used for outdoor pigs. It does not include woodland and other non-agricultural land.

[ii] https://www.gov.uk/government/policies/improving-water-quality

[iii] http://www.nfuonline.com/assets/17485

2. ENVIRONMENT AGENCY INFORMATION ON AGRICULTURAL RISK

The Environment Agency's WFD Challenges and Choices consultation presented the reasons why water bodies are expected to fail their WFD good status objectives in 2015 (**Table 1**[iv]). These data on 'reasons for failure' (RFF) summarise a variety of assessment methods, including:

- **Catchment walkovers** – To date, our staff, contractors and partners have walked more than 15,000 miles of watercourse in catchments which fail to achieve good status and identified over 25,000 issues. Of the data we hold centrally, agriculture accounts for 35% of the pollution sources. 27% of the agricultural issues are related to livestock poaching and trampling. See Appendix 2 for more detail.
- **Modelling –** We use a variety of modelling approaches to estimate losses from agricultural land-use to help understand sector source contribution and to quantify the cost and effectiveness of multiple mitigation methods for multiple pollutants for the dominant farming systems across England.
- **Monitoring –** Our monitoring programme covers all surface waters, groundwaters, groundwater dependant wetlands and protected areas. For each water body we monitor a range of parameters including: biology (phytoplankton, diatoms, macrophytes, invertebrates and fish); hydromorphology; physico-chemical (including pollutants) and priority and priority-hazardous substances.

The RFF data allows us to look at the relative importance of different pressures and sectors in terms of their overall contribution to waterbodies not meeting their good status objectives. Each identified RFF has an associated level of certainty (suspected, probable or confirmed) based on a weight of evidence approach[v].

Table 1 Reasons For Failure data presented in National England Challenges and Choices[vi] consultation June 2013 summarising the main sectors responsible for pressures where the pressure is known (note that these are counts of RFF within water bodies not individual waterbodies (there can be multiple RFF in water bodies) and includes all data regardless of level of certainty assigned to each RFF (suspected, probable or confirmed)

Pressure	Agriculture and rural land management	Environment Agency	Forestry	Industry	Mining & Quarrying	Navigation	Urban & transport	Water industry	No relevant sector	Total RFFs
Abstraction and flow	91	7		27	2	0	4	211	177	519
Chemicals	49			41	400	2	78	42	51	663
BOD	35			17			58	187	1	298
Dissolved Oxygen	208	7		25	2	2	75	189	47	555
Ammonia	158			54	3	1	136	472	14	838
Fine sediment	382	3	21	17	11		33	7	10	484
Invasive species									71	71
Nitrate	52						1	24	28	105
Phosphate	1876	1	6	154	1	4	608	1754	228	4632
Physical modification	422	264	5	141	22	46	506	420	418	2244
Total RFFs	3273	282	32	476	441	55	1499	3306	1045	10409
Percentage	31.4	2.7	0.3	4.6	4.2	0.5	14.4	31.8	10.0	100

[iv] This data represents a snapshot of the current understanding of the WFD RFF data at the time of extraction from the national database (February 2013). The database does not cover protected area RFF which are recorded in separate databases. All of the failures listed in the RFF database are elements which were failing in 2009 (i.e. published in the first cycle plans). The RFF data is an ongoing live data set that gets constantly updated as investigations progress and new classification information comes on line. The information in this collation will have taken account of the 2012 classifications (ie classification data collected up to December 2011) plus all investigations up to the end of 2012.

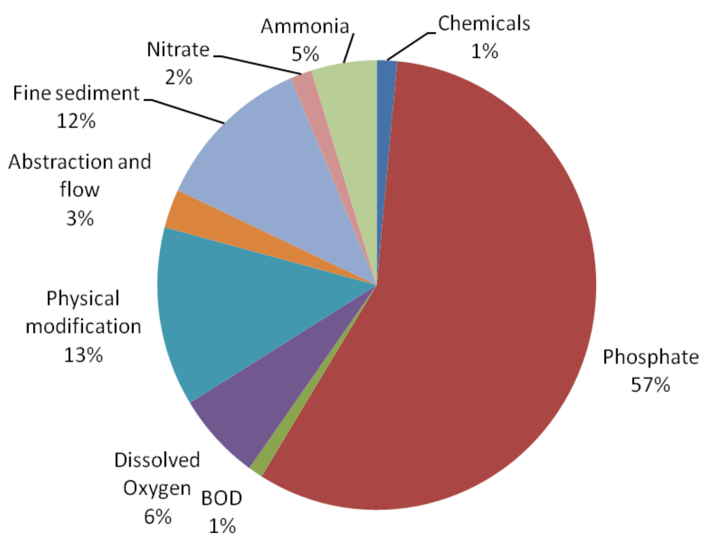
[v] The Catchment Planning System (CPS) is the system we use to store and share key River Basin Planning information. It holds the core evidence base that describes the state of the water environment, the pressures and risks acting on it, the objectives we are seeking to achieve with others and the actions we and others will do to deliver them. By June 2014, the information we maintain will be freely available to external partners and the public.

[vi] http://www.environment-agency.gov.uk/research/planning/33252.aspx

78% (4823 out of a total of 6192) of all water bodies in England currently fail WFD objectives due to one or more pressures from different sectors[vii]. Of those water bodies with recorded RFF information, 36% (1757 out of 4823) have a RFF from agriculture and rural land management i.e. there are 1757 unique water bodies with an RFF related to the agriculture and rural land management sector. **This represents 28% of the total number of water bodies in England overall** (i.e. 1757/6192 x 100). Looking at the data in a different way, there are **3273 out of a total of 10,409 RFF counts where agriculture and rural land management is recorded as the sector responsible i.e. 31% (see Table 1).** Approximately 25% of the agriculture and rural land management RFF are described as 'rural' and are not necessarily 'agricultural'. The 'rural' category includes land drainage structures, water abstraction and barriers to fish migration. Looking at the data by waterbody type[viii]: 1,618 river waterbodies and canals, 66 lakes, 51 groundwaters (of which 29 are Drinking Water Protected Areas), 18 estuaries and 4 coastal waters have a recorded RFF from the agriculture and rural land management sector.

For all waterbodies where a WFD element failure is recorded, and where the pressures is known to be from agriculture and rural land management, phosphate accounts for the greatest proportion (57%), followed by physical modification (13%) and fine sediment (12%) (**Figure 1)**. Dissolved oxygen, biochemical oxygen demand, chemicals, ammonia and nitrate account for a further 15%. The nitrate figure is lower than expected as nitrate is not an element under the WFD classification scheme, so the WFD RFF exercise rarely generates consideration of the impact that nitrate can have on ecology. A major programme of investigations has been taking place since publication of the first RBMPs in 2009 to improve the confidence in these figures as only 19% of the pressures ascribed to the agriculture and rural land management sector are assessed as being confirmed, with 46% probable, 33% suspected, and 2% have no confidence assigned. 13,137 investigations had been completed by the end of March 2013. For river water bodies, our RFF data show that mixed agricultural holdings i.e. farms that have a mix of arable and livestock, are most frequently identified as a contributing to a problem. Other significant sectors are arable (27%) and dairy/beef (26%). Pig and poultry farming, sheep farming, farm infrastructure and horticulture are identified less often.

Figure 1 WFD RFF (England) for all pressures attributed to the Agriculture and Land Management sector (note that the percentages are based on the number of counts of RFF rather than individual water bodies).



Pollution incident data is also important. We receive around 60 verified reports relating to pollution incidents every day. There were 504 serious (category 1) and significant (category 2) pollution incidents in England in 2012, of which 96 were due to the agricultural sector (Environment Agency, 2013a). See Appendix 3.

[vii] More than one RFF can be identified for a failing element (or for a pressure affecting a biological element) and a water body can be failing for more than one element, and influenced by more than one sector.

[viii] The water body is the unit used for reporting and assessing compliance with the WFD's environmental objectives.

3. WFD PROTECTED AREAS

Under the WFD, protected areas are designated as requiring special protection under Community legislation for their use (such as drinking water or fisheries), or for the protection of habitats and species directly depending on water. They are managed to achieve WFD objectives and the objectives of the existing legislation. They include:

- Recreational waters (areas protected under Bathing Water Directives 76/160/EEC and 2006/7/EC).
- Areas designated for the protection of habitats or species where maintenance or improvement of the status of water is an important factor in their protection (Natura 2000 sites under Birds Directive 79/409/EEC and Habitats Directive 92/43/EEC).
- Water bodies used for the abstraction of drinking water.
- Areas designated to protect economically significant aquatic species (areas protected under Freshwater Fish Directive 78/659/EEC; Shellfish Directive 79/923/EEC).
- Nutrient sensitive areas (areas protected under Nitrates Directive 91/676/EEC; Urban Wastewater Treatment Directive 91/271/EEC).

A protected area register and location maps are available.[ix]

3.1 Bathing waters[x]

The Bathing Water Directive (BWD) aims to protect public health and the quality of the environment from **microbial pollution** at designated bathing waters. In 2013, 342 of 415 bathing waters met the highest current standard (guideline). Only 5 failed the Directive's current mandatory minimum standard.

The most significant sources of pollution impacting on bathing water compliance are [viii]:

- Sewage from sewage treatment works or combined sewer overflows (CSOs)
- Pollution from faeces of grazing animals
- Urban run-off which contains dog and bird faeces
- Birds and animals on the beach – for example seagulls, pigeons, dogs, horses and donkeys.

The majority of bathing waters are subject to multiple sources of microbial pollution. The proportions vary from site to site, and in response to weather patterns. Identifying the source of microbial pollution can be difficult. Most livestock operations produce excreta that present a risk that Faecal Indicator Organisms (FIOs) will enter watercourses. The risk is a combination of source (manure/excreta amount, type and age, location), pathway (hydrological connectivity and proximity) and farm management. It is estimated that 0.1 to 1% (by weight) of the annual FIO burden in fresh excreta/manure from farming enters watercourses (Defra, 2012).

Outputs from a *FIO-SA* (Faecal Indicator Organism – Source Apportionment) model (Defra, 2005) indicate that the agricultural contribution to the bathing season FIO budget for three failing bathing water clusters could be *c.*30%. These catchments are characterised by flashy river regimes (i.e. those where the river level rises very quickly in response to heavy rainfall) and intensively grazed livestock, particularly dairy cows. Our own source apportionment[xi] shows that the average agricultural FIO contribution for 48 at risk bathing water sites is 35%[xii]. For 8 out of the 48 at risk bathing waters FIO pollution is predominantly (>60%) from agriculture, and could be as high as 85-90%. For 11 at risk bathing waters, there was no agricultural contribution.

[ix] http://www.environment-agency.gov.uk/research/planning/33346.aspx

[x] For further detail: Defra Agriculture and Water Quality Project. Protected Areas - Bathing Waters, the role of agriculture, Dec 2013.

[xi] Source: Environment Agency Bathing Water Actions Database 26th Feb 2013. Source apportionment information is a combination of estimates based on expert knowledge from local and regional staff of catchment-wide contributions to local beach quality, DNA analysis and limited modelling, so generally the confidence in data is "medium"

[xii] Data only available for 48 out of the 55 sites assessed in 2012 as at risk of not meeting revised BWD standard

In 2015 a revised BWD (rBWD) will come into force with a stricter compliance standard. Nevertheless, we estimate that compliance with the rBWD will improve from the 89.6% in 2013 (based on applying rBWD standards to 2013 data) to 94% in 2015 and could reach 98% in 2020. However the improvement depends on funding for planned actions.

3.2 Natura 2000 (N2K) sites

There are 234 N2K sites (521,914 ha) in England with features (species, communities and habitats) directly dependent on water. These include rivers, lakes, coastal and estuarine habitats and other wetlands. Currently 46.5 % (by area) are in favourable condition. Around 50% (by area) are classified as unfavourable but recovering and are dependent on ongoing action to sustain recovery. A further 3.5% (by area) are classified as unfavourable, with no change *or* declining condition and require action to instigate recovery in order to deliver WFD Protected Area requirements and EU 2020 biodiversity targets.

The risk posed to Natura 2000 sites depends on the nature of their designated features, but include both local and catchment-wide hazards (**see Figure 2**). There are 41 Natura 2000 Protected Areas (77 component Sites of Special Scientific Interest) covering 13278 ha for which Diffuse Water Pollution Plans are being developed chiefly to address catchment wide agricultural sources. We believe that transitional and coastal waters and groundwater dependant terrestrial ecosystems are currently underrepresented in this programme. As refreshed condition assessments for these habitats are completed in 2014, the number of sites requiring action on diffuse water pollution is likely to increase.

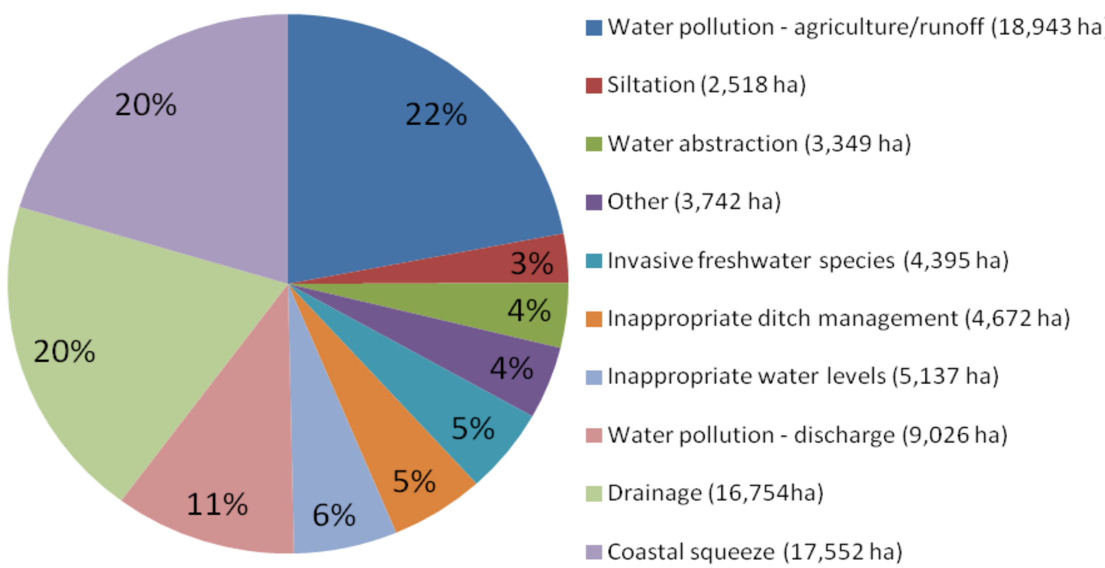


Figure 2 Relative significance of different water-related pressures on N2K sites[xiii]

Actions are underway to tackle all these pressures through a range of measures, including planning, funding, advisory and regulatory routes. Work by Natural England up to 2015 to tackle diffuse water pollution from agriculture is focused on developing detailed Site Improvement Plans to direct future action, whilst making as much progress as possible in the short term using the Catchment Sensitive Farming (CSF) scheme (95% of N2K sites requiring action lie within CSF catchments) and agri-environment schemes. 90% (54,755 ha) of all water dependent N2K sites will have agri-environment measures in place by 2015 (Natural England, 2013). It is important to recognise the role of agriculture in addressing other pressures on N2K sites, including water level management and abstraction as well as land use change to provide new coastal, wetland or riparian habitat.

[xiii] Based on area of protected site in unfavourable condition against which each pressure has been assigned (note: more than one pressure may be assigned to the same unit area)

Measures to address diffuse water pollution from agriculture are likely to take a long timescale to deliver, and must be sustained if affected sites are to recover. Success will depend on the scale and targeting of future agri-environment funding under the next Common Agricultural Policy (CAP) period and potential future regulatory mechanisms. We anticipate that partnerships under the Catchment Based Approach will also have a key role in some river SSSIs affected by diffuse pollution.

3.3 Surface Drinking Water Protected Areas (DrWPAs) and Safeguard Zones (SgZs)

Article 7 of the WFD designates all water bodies with significant (>10m^3/day) abstractions for human consumption as Drinking Water Protected Areas (DrWPAs). Member States must aim to avoid deterioration in the quality of these waters, with the intention that over time catchments become cleaner and there is a reduction in the level of purification needed to meeting Drinking Water Directive standards at the tap. Wherever extra drinking water treatment has been required, or there is a likelihood of this, a DrWPA is designated at risk. There are 560 surface water DrWPAs in England, 182 (32%) of which are currently assessed as at risk[xiv]. **Figure 3** identifies the substances causing these areas to be designated at risk: pesticides (50%); colour (28%); algae/eutrophication largely in response to elevated phosphorus levels (15%); and nitrogen species, mainly nitrate (5%). Some DrWPAs are impacted by more than one substance.

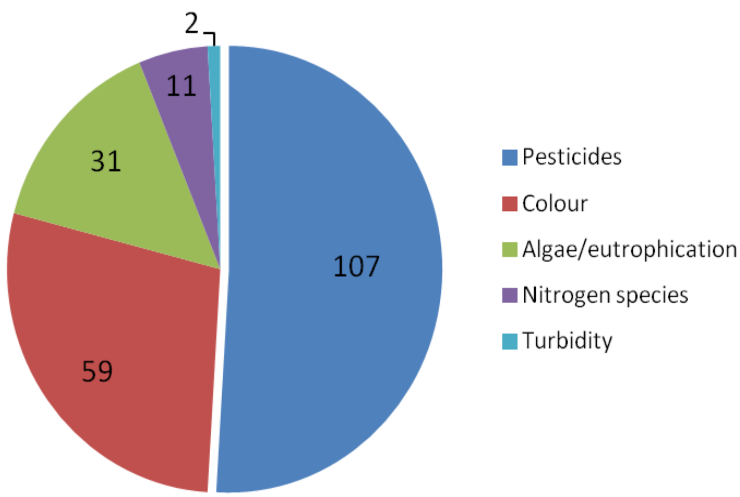


Figure 3 Substances causing surface water DrWPAs to be identified as at risk of not meeting the requirements of Article 7 (numbers are individual substances recorded not individual waterbodies)

Safeguard Zones (SgZ) are catchments draining to at risk drinking water abstractions in which actions are targeted to improve water quality and reduce the risk of extra water treatment being required. We work closely with water companies in identifying SgZs and writing associated action plans to protect them. In terms of source apportionment and the role of agricultural activity, our expert judgement, based on a review of SgZ actions plans and other available information is that:

- Over 80% of pesticide risk is from agriculture, based on analysis of: the types of pesticides identified and the sectors they are approved for; land use patterns in the areas they are identified; and exposure patterns in rivers compared to known agricultural use periods. Significant effort by Defra, regulators and industry is ongoing to address pesticides in surface water DrWPAs.
- The evidence behind an adverse colour trend suggests a range of causes. Overgrazing and resultant peat damage may be implicated in some upland catchments, but climate change and mineralisation of peat are also significant factors.
- Agriculture's contribution to nutrient loadings is discussed in more detail elsewhere– see Sections 3.4 and 3.5 (nitrogen) and Section 4.1 (phosphorus).

[xiv] Environment Agency national compliance spreadsheet for surface water DrWPAs (DrWPA_QA_Oct2013). Note: The WFD RFF database (see Section 2) does not consider Protected Area RFF

3.4 Groundwater Drinking Water Protected Areas (DrWPAs) and Safeguard Zones (SgZs)

All groundwaters (except unproductive strata) are designated DrWPAs and there are currently 210 groundwater SgZs. The biggest single water quality issue is nitrate **(Figure 4)**. National assessments show the dominance of agricultural sources to nitrate loadings (see Section 3.5) and our local source apportionment work in individual SgZs confirms this. For example, we studied three public water supply catchments in East Anglia in detail and found that agriculture was responsible for 74%, 94% and 95% of the nitrate. In many areas the highest nitrate concentrations may be due to historic rather than current farming activities. This is due to the long timescales for water to move down through the unsaturated zone and then the groundwater itself, before being sampled at the monitoring point. Published estimates show that this process can take decades e.g. up to 60 years for chalk aquifers (Wang, 2012). Recent modelling indicates that nitrate loads from agriculture to many UK aquifers may have peaked, following reductions in fertiliser inputs since c. 1990 (Wang, 2012). Our NVZ borehole monitoring data also suggests that nitrate concentrations are generally improving (very slowly) over large parts of England (large hydrological areas) although there are areas in southern England where concentrations are generally increasing (Environment Agency, 2012d). Against this generally improving picture, data from some individual boreholes/resource areas do show increased failures for nitrate in groundwater. The reasons for this are explained in Section 4.5. Data from ADAS, based on farming activities in 2010, shows that the nitrate concentrations in water that leaches from soils, contributing to aquifer recharge and river base flow, is close to or above the safe drinking water nitrate concentration in many parts of England (see Section 3.5).

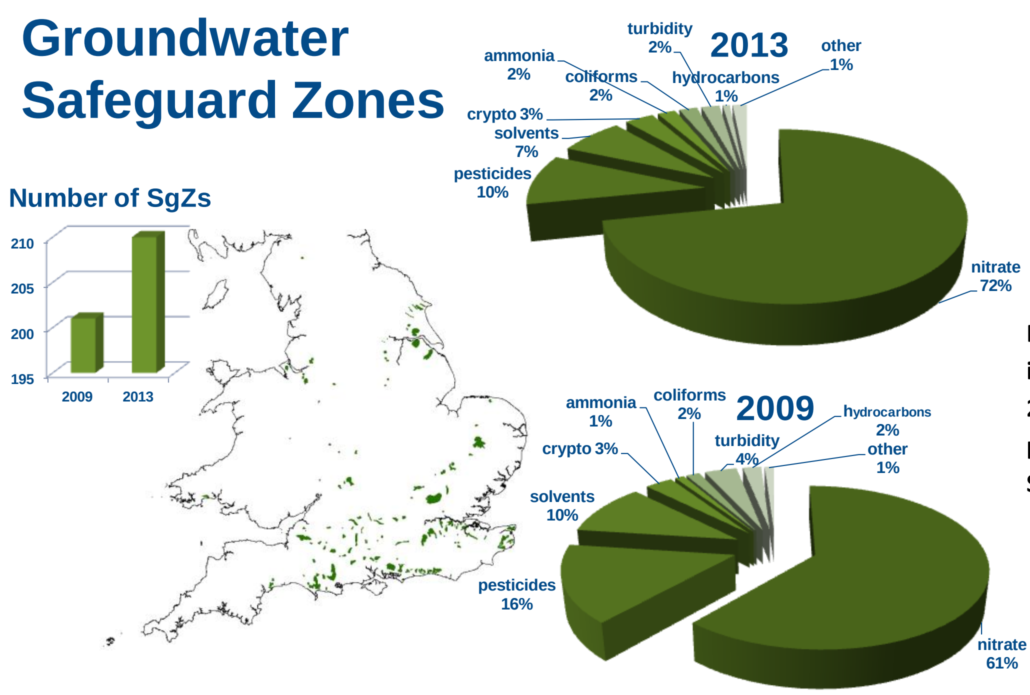


Figure 4 Substances impacting groundwater SgZs, 2009 and 2013 (as a proportion of number of SgZs)

Treatment to remove pollutants from drinking water is very expensive; a typical plant costs upwards of £4m with annual operational expenditure often in excess of several hundred thousand pounds. More sustainable and cost-effective approaches are being trialled by several water companies through catchment management schemes i.e. working with farmers to reduce pollution at source. Whilst public supplies have robust systems in place to ensure that the nitrate standard is not exceeded at consumers' taps, this is often not the case for private supplies. Of 4,300 private supply samples analysed at consumers' taps in England in 2012, 11% exceeded the limit for nitrate (Drinking Water Inspectorate, 2013). Many of these are in rural areas away from public mains supplies where we are working with the Drinking Water Inspectorate and Local Authorities to consider how to address this.

3.5 Nutrient-sensitive areas

Nutrient-sensitive areas are those designated as Nitrate Vulnerable Zones (NVZs) under the Nitrates Directive and Eutrophic Sensitive Areas under the Urban Wastewater Treatment (UWWT) Directive. While the Nitrates Directive seeks to reduce nitrate pollution though a farming action programme, the UWWTD aims to reduce nitrate and (in particular) phosphorus pollution from larger water company discharges. As Sensitive Area objectives under UWWTD do not apply to farming, these are not discussed further.

The Nitrates Directive aims to protect surface and ground waters from high or increasing concentrations of nitrates from agricultural sources, and to prevent or reduce eutrophication. NVZs and N-eutrophic waters are reviewed on a four-yearly cycle with the most recent designations reported in 2013 based on monitoring data up to 2009 (see Appendix 4 and Environment Agency 2012a, 2012b, 2012c). 57.5% (74,679 km^2) of the land area in England is currently designated as NVZ. 23% of our river and lake monitoring sites had maximum nitrate concentrations exceeding 50 mg L^{-1}, the threshold for protection of drinking water (see Appendix 4 for further information). 33 individual lakes and 13 estuarine and coastal waters are designated as N-eutrophic waters, where nitrates from agriculture contribute to the ecological problems associated with excessive algal and plant growth. There is strong evidence of eutrophic disturbance of lakes at much lower concentrations than 50 mg L^{-1} NO_3 (see Environment Agency, 2012c for a review).

Recent reviews demonstrate the rapid increase in river nitrate concentrations that followed the intensification of agriculture in the 1970s (Howden et al., 2010; Burt *et al.*, 2011). Modelling suggests that concentrations in rivers may have peaked in the period 1990-2000 in many catchments, followed by widespread but modest improvements in river water quality (Miller *et al*., 2014). These improvements probably reflect the c. 32% reduction in UK fertiliser use over the same period (Passant *et al*., 2012) and the range of voluntary and regulatory mechanisms to control nitrogen use and efficiency. However, the decline in agricultural N fertiliser use appears to have reversed since 2008, with an 8% increase between 2009 and 2010 and an increase in the proportion applied as urea (Passant et al., 2012). Present day nitrate concentrations in groundwaters are believed to be dominated by historic N losses from agricultural land (see Sections 3.4 and 4.5).

Agriculture is estimated to account for some 60% of nitrate entering surface waters in England and two-thirds of nitrate in groundwater (Environment Agency, 2013b), with significant variation between and within catchments and water bodies. The NEAP-N model (**Figure 5**) provides evidence of where the excess nitrate leaching from agricultural soils alone exceeds 50 mg L^{-1} (as an annual average concentration). Water company effluent discharges are a further source of nitrate in rivers, but given the elevated baseline loading from agriculture it is relatively unusual for agriculture to be found not to make a significant contribution. NVZ designations therefore make it possible to identify where reductions in N-losses from agriculture help to meet environmental objectives.

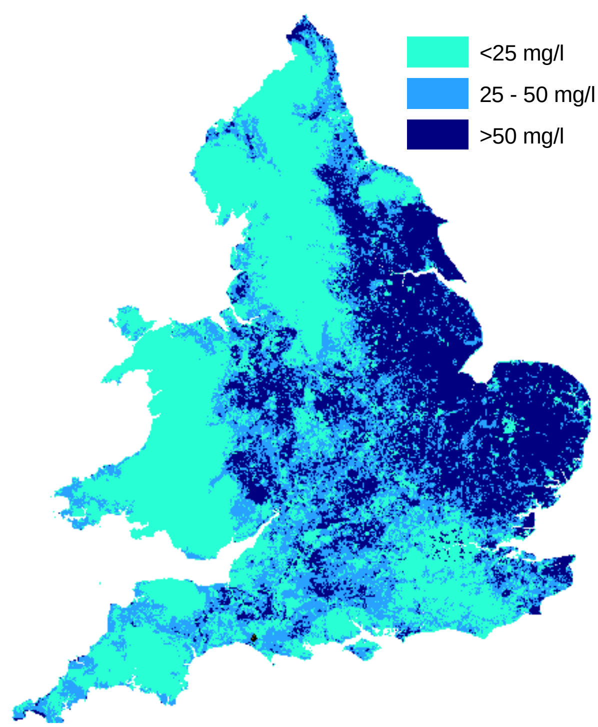


Figure 5 Nitrate leaching losses from agricultural land based on 2010 NEAP-N model (Total Dissolved N, mg l^{-1})

3.6 Shellfish waters

There are 98 shellfish waters in England designated as WFD protected areas to protect the high quality of shellfish products directly edible by humans. Compliance with the guideline microbial standard in shellfish flesh has varied between 27% and 44% over the last 10 years. Microbial pollution of shellfish waters originates from multiple point and diffuse sources including Combined Sewer Overflows (CSOs), emergency overflows, urban surface water runoff and rural losses from 'natural' (wildlife), farm livestock and human sources. Our investigations suggest agriculture contributes to 22% of the failures to achieve guideline standards (**Figure 6**)[xv].

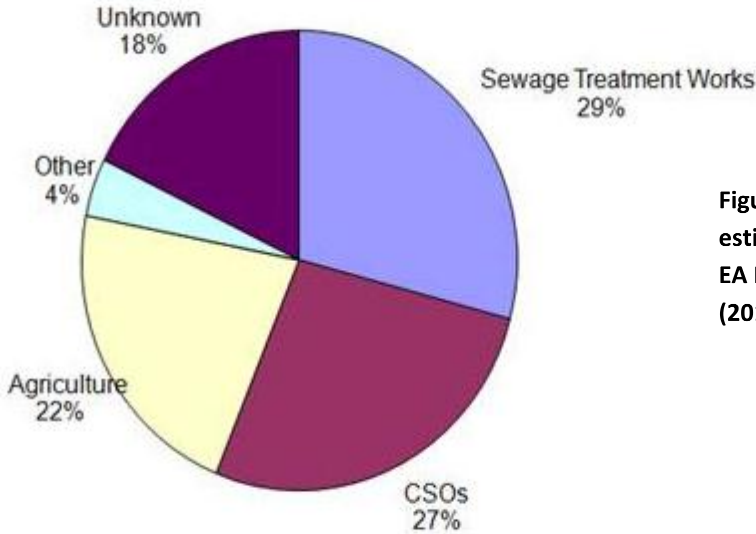


Figure 6 Source apportionment estimates for Shellfish waters based on EA Reasons for failure Shellfish waters (2010) data

While sources are well understood, the relationship between microbial pollution in water and in shellfish flesh is extremely complicated, which means measures that reduce microbial pollution in surface waters do not always translate into improved shellfish flesh quality. Action plans are in place for all failing shellfish waters and are being updated for 2nd cycle draft River Basin Management Plans (RBMPs). These involve a combination of investigations to identify or confirm pollutant sources and actions across a range of sectors to improve compliance, for example, sewerage infrastructure improvements, guidance on maintenance of septic tanks, and Catchment Sensitive Farming (CSF) is currently in place in catchments draining to 23 shellfish waters. Based on CSF phase 2 modelling, we expect this CSF work will reduce FIOs by up to 12%, which will contribute to achieving guideline status.

4. WFD GOOD STATUS

Under the WFD there is a requirement to achieve good status for all waters by 2015, or by 2021 or 2027 where affordability or recovery time constrains the pace of improvement. Good status is defined as a slight deviation from natural conditions. For some water bodies, reaching good status will not be achievable because the necessary improvements would be disproportionately costly and technically very difficult, or might create other risks such as flooding. In these cases, the aim for these water bodies is to achieve their best possible status. For surface water bodies to be at good status both ecological and chemical status must be at least good. Ecological status is determined by the condition of biological elements, for example fish, invertebrates, and macrophytes, supporting physio-chemical elements, for example levels of nutrients and dissolved oxygen, as well as specific chemical pollutants, flow, and hydromorphology. If a water body is less than good for one element, it cannot be classified as good and will be classified at the lowest ranking element (the 'one out, all out' principle). An assessment of chemical status is required where priority substances and other specific pollutants are known to

[xv] Reasons for failure Shellfish Waters (2010) data, Environment Agency

exist in significant quantities in water bodies. Good status for groundwater covers quantity and good chemical status.

24% of surface water bodies in England are at good overall status/potential or better compared to 26% when we first reported in 2009 (based on data collected to the end of December 2012) - see **Figure 7**. We are confident that the work carried out to date and planned, both by ourselves and with our partners will deliver significant improvements but it may take longer than first thought for the environment to respond.

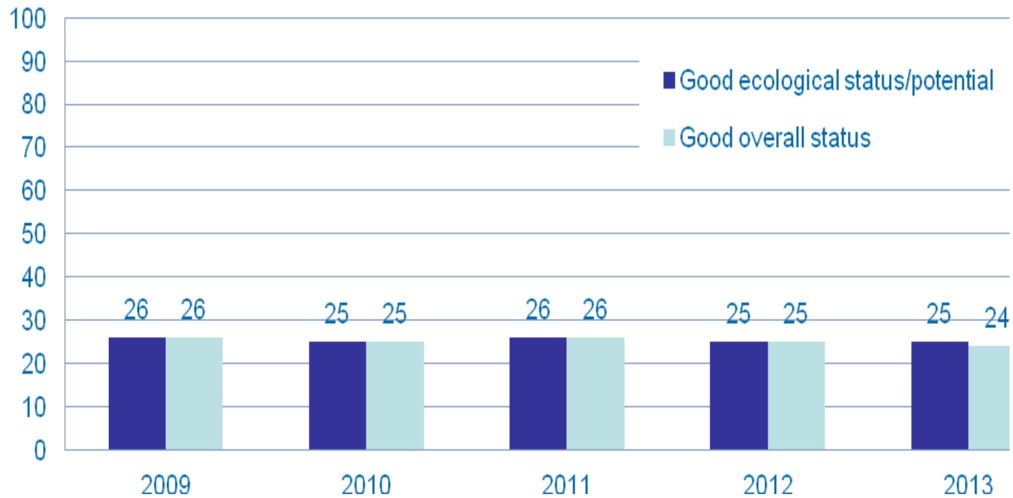


Figure 7 Percentages of surface water bodies at WFD good status in England

4.1 Rivers and lakes - phosphorus

The WFD standards for phosphorus (P) are designed to prevent freshwater eutrophication. Phosphorus is the most common cause of WFD water quality failures in rivers and lakes in England:

- 45% (1,644 out of 3666) of assessed river water bodies exceed the chemical P standards for good ecological status (2013 classification data). This equates to 19,550km or 44% of the total length of monitored river water bodies;
- 252 of 341 assessed lake water bodies were at less than good status for P, which equates to 74% (2013 classification data).

This is despite long term records (1990-2009), 2013 WFD classification data and published research (Miller et al., 2014) showing a reduction in average river P concentrations that is largely due to P removal at sewage treatment works and more recently to the decline in farm-gate nutrient budgets (see Section 5) .

The largest source of P entering rivers nationally is sewage effluent (c. 70% of the total in England) with agriculture responsible for about 25%, although national estimates vary according to different studies, and contributions will vary across catchments (White and Hammond, 2009; Murdoch,. 2014). For lakes, drainage from agricultural land is generally the largest source of P (DEFRA, 2008).

We have updated our estimates of the reductions needed to meet good status for P by 2015, 2021 or 2027 (based on the proposed, revised WFD standards[xvi] and Psychic model estimates of agricultural P loss) (Willows *et al*., 2013):

[xvi] New river phosphate standards are being finalised following consultation through UKTAG.

- Action to control agricultural sources of P will be required over a large area of England, *even in the absence* of other sources of P, if WFD good status is to be achieved in rural headwaters[xvii].

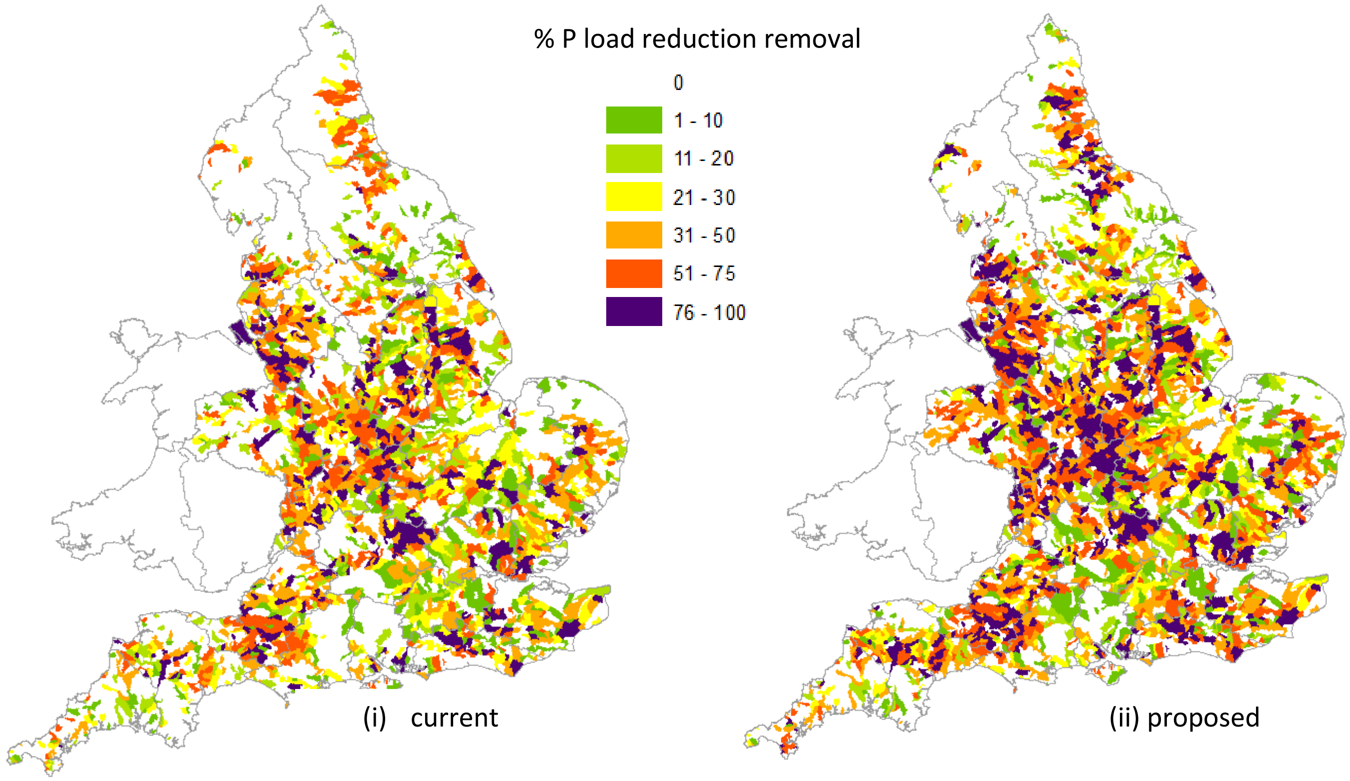


Figure 8 SAGIS-SIMCAT percentage agricultural P load reductions required for WFD compliance, current and proposed P standards

- The *minimum* reduction in agricultural P loss to meet the least stringent of the range of revised P standards for rivers is c. 28%, averaged over *the whole* of England.
- Based on a more stringent river target of 40 µg P L^{-1}, the average required reduction is 43%.
- If targeted to the 27-45% of England at the highest risk from agricultural sources then a reduction of 44-53% in agricultural P loss may be required .
- Preliminary findings of a separate EA study[18], using the SAGIS model, indicate that an agricultural load reduction of 45% is needed to meet current P standards and 56% to achieve the revised P standards (**Figure 8**). This assumes that the burden of reductions is proportionate to the contributions from water company discharges and agriculture.

These modelled predictions are similar to the conclusions from Defra policy analysis that suggested agriculture, on average, needs to reduce P loads by 48% for there to be a minimum 80% probability of meeting the WFD P standards for rivers by 2015 (Defra, 2007). The policy analysis considered agriculture's contribution in isolation. Reductions needed were predicted to be most pronounced for the livestock sectors (poultry – 40%; pigs – 43%; dairy - 41%; beef – 25%) and less for the arable sector at 13%.

The agricultural load reductions needed to meet good status for P are considerably greater than the estimated levels of reduction achieved through current measures. For CSF and ELS, P load reductions are typically around 4-8% (Environment Agency, 2011; Boatman, et al., 2008) and lower for NVZs (Johnson *et al*., 2011), although greater reductions may be achieved in individual catchments and at the farm scale.

[xvii] Rural headwaters are permanent or seasonally recurring streams/brooks and small rivers streams (Strahler order 1 and 2) that drain land that consists principally of agricultural fields.

4.2 Rivers - sediment

The loss of valuable soil from land is of concern for individual farms and for the future of productive farming across the country. Soil erosion is a natural phenomenon, but rates are hugely increased by certain farming practices, in particular, when bare soil is exposed to intense rainfall. Annual soil erosion rates in the UK vary widely, but are estimated to be in the range of 0.1-15 tonnes per hectare of farmland (Defra, 2006).

There are no in-river sediment standards for WFD, hence there are no compliance statistics. Sediment, however, can impact directly upon on river biology (invertebrates and fish) or indirectly through links to other pressures (e.g. pesticides, chemicals and nutrients). Our 2013 sediment risk assessment estimated that 44% of river water bodies (47% of total river length in England) are at risk or probably at risk of being at less than good status in 2015 due to the direct impacts of sediment from all sources. Our RFF data suggests a much lower figure with only 484 recorded WFD good status failures attributed to fine sediment (4.6% of all RFF counts where the pressure is known). This discrepancy probably reflects a combination of: under-recording of sediment-related impacts due to the lack of a specific standard; low awareness by operational staff of sediment related biological impacts; and limited sediment monitoring). Improved understanding and the widespread use of sediment-specific biological metrics should increase the number of waterbodies identified as having sediment as a pressure in the future.

Assembling accurate information on catchment sediment sources is difficult, because of the limitations and uncertainties associated with traditional measurement and monitoring procedures and the event-based nature of sediment delivery from land to water and subsequent in-river transport. Our WFD RFF data shows nearly 80% of the fine sediment WFD failures are due to the agriculture and rural land management sector (Table 1). This is similar to the national source apportionment work reported by Collins et al., (2009) which suggested that the agricultural sector dominates sediment inputs to rivers (76%) compared with eroding channel banks (15%), diffuse urban sources (6%) and point sources (3%). In combination, factors such as topography, soil type, crop types, vegetation cover, farming practice, farm tracks and rural roads, and proximity of activity to a watercourse all affect sediment generation in the landscape, and delivery to water bodies.

In 2009 we initiated the Rural Sediment Tracing (RST) Project to identify and classify sources of fine sediment inputs to streams and rivers in 11 rural catchments across England. The RST project included 2,100 km of catchment walkovers. The results show that fine sediment pollution is a significant problem in many of our most important salmon and trout catchments, and that sediment from agricultural sources is a major contributory factor. The most common type of Grade 1 (most severe) fine sediment source identified was runoff from agricultural land (**Figure 9**); see APEM (2010) for explanation of grading. Arable and livestock farming accounted for 54% of all Grade 1 sources. In general, the prevailing soil and climatic conditions mean that livestock poaching was more important in the north and west of the country, while arable runoff was more predominant in the south and east. Other common sources were roads, farm tracks and field drains, while bank re-sectioning and local excavation work caused localised sediment sources.

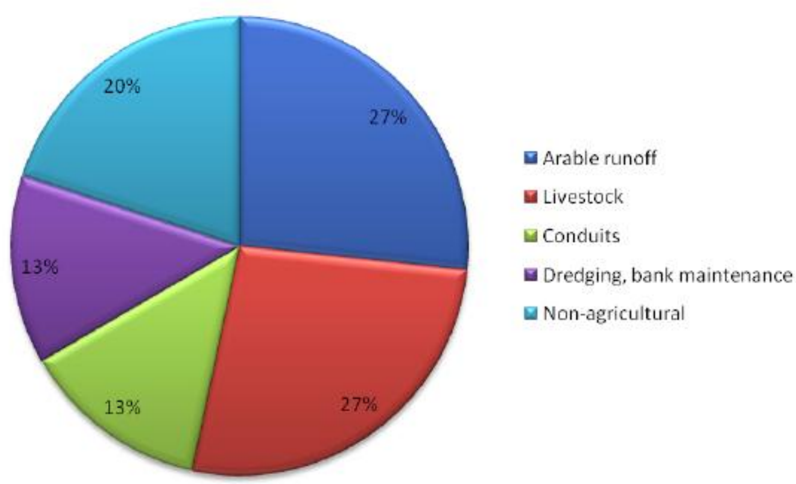


Figure 9 Source apportionment of fine sediment across 11 rural catchments (Rural Sediment Tracing Project)

4.3 Rivers and lakes – Sanitary determinands (DO, BOD and ammonia)

Over the past twenty years water quality has been steadily improving for dissolved oxygen (DO), biochemical oxygen demand (BOD)[xviii], and ammonia, all indicators of sanitary pollution (i.e. wastewater from faeces and urine). This is primarily due to significant expenditure to reduce loadings from sewage treatment works. Aquatic life needs well oxygenated waters. Excess BOD reduces DO levels, while ammonia is directly toxic to aquatic life. DO levels can also be adversely affected by excess plant growth in eutrophic waters. In the 2013 river classifications for England[xix], of the assessed water bodies, 18% were less than good for DO (equivalent to 7,458km of the total monitored river length), 14% for BOD, and 9% for ammonia. 29 of the 168 lakes assessed were less than good for DO. Together, DO, BOD and ammonia account for 16% of all WFD RFF (Table 1), and a figure of 12.3% of all RFF for the agriculture and rural land management sector.

Slurry, manure and silage contain high levels of ammonia and BOD. Poor management contributes to chronic pollution and, in severe cases, pollution incidents. The loss of inorganic fertilisers to surface waters can cause eutrophication, and associated DO problems and fish kills. The relative importance of farming sources in any water body depends on local and regional differences in urban/rural land-use. Our national incident data shows a marked decrease in pollution incidents from agricultural slurry, manure or silage storage since 1991. This is largely through: the control of pollution and legal construction standards for storage facilities[xx]; manure management planning (about 67% of farms have a plan) and agri-environment schemes.

4.4 Estuaries and Coastal Waters

There are 69 WFD coastal and 100 estuarine water bodies in England. A large number of these have been monitored for nutrients (dissolved inorganic nitrogen (DIN)) and their adverse biological impacts (eutrophication), particularly nuisance green weed ("opportunistic macroalgae") and blooms of suspended algal cells ("phytoplankton"). About 70% of the 95 annually monitored water bodies show elevated nutrients (deemed as moderate in the WFD classification) (**Table 2**). Although this can be quite variable between years, the percentage has not changed much over time. About 20% of the 80 water bodies, annually monitored for opportunistic macroalgae are classified as moderate or worse (**Table 2**). About 16% of the 80 water bodies monitored for phytoplankton are also moderate or worse (**Table 2**).

Table 2 WFD status of estuaries and coastal waters from 2009 to 2013

WFD status	2009	2010	2011	2012	2013
	Dissolved Inorganic Nitrogen (DIN)				
Good or better	27%	33%	22%	34%	28%
Moderate or worse	73%	67%	78%	66%	72%
	Opportunistic macroalgae				
Good or better	73%	77%	77%	85%	77%
Moderate or worse	27%	23%	23%	15%	23%
	Phytoplankton				
Good or better	81%	80%	85%	87%	87%
Moderate or worse	19%	20%	15%	13%	13%

[xviii] Biochemical Oxygen Demand (BOD) is an analytical method for measuring the amount of oxygen consumed during the microbial or chemical breakdown of oxygen-depleting substances in water
[xix] 2013 EA classification data
[xx] Water Resources (Control of Pollution) (Silage, Slurry and Agricultural Fuel Oil) (England) Regulations 2010 and Nitrate Pollution Prevention (England) Regulations 2008

All water bodies that exceed the WFD nitrogen standards for coastal waters have been investigated for possible causes and extent of impacts; the certainty of eutrophication in these water bodies is currently being assessed – initial results suggest that up to 20% of water bodies may be at some degree of risk of eutrophication. The majority of these are estuaries and are already designated (as affected by eutrophication) under the Nitrates Directive and/or the UWWT Directive, with control measures in place to reduce nutrient inputs from agricultural and sewage sources.

Previous work undertaken on source apportionment for nitrogen by Defra estimated that about 50 to 60% of the total N load delivered to surface waters comes from agriculture, and 25 to 30% comes from sewage and industrial effluents (ADAS and ENSIS, 2008). For those transitional and coastal water bodies modelled in our South East and South West Regions, source apportionment assessment indicates similar figures for the total N inputs from agriculture, and sewage and industrial effluents, although there is some local variation. These estimates also correlate well with estimates of total N export to the seas around the UK collated for OSPAR reporting purposes. Modelling scenarios investigated how much nutrient reduction would be required to reduce the biological impacts. These show a large difference between individual waterbodies with required reductions ranging from 10% to >50% in order to allow the biology to return to good or better status. The costs versus benefits of further control measures in order to achieve good ecological status for nitrogen, over and above the measures in place under Nitrates and UWWT Directives, are now being assessed. This is part of the work to develop potential programmes of measures for the draft 2nd cycle RBMPs.

4.5 Groundwater chemical status

Achievement of good status in groundwater involves meeting a series of conditions, assessed by tests designed for each of the quality elements defining good (chemical and quantitative) groundwater status. There are five chemical and four quantitative tests[xxi]. The general chemical assessment test considers concentrations of nitrate (single threshold value of 37.5 mg l^{-1} (as NO_3)), pesticides and other chemicals in groundwater which put the groundwater body at risk. In 2009 around 40% (122 out of 304) of groundwater bodies (GWBs) were reported as poor status, with nitrate implicated in 76 and the sole reason for failure in 63. Since 2009 our records show there has been a notable deterioration, with around 45% of GWBs now at poor status. Most additional failures are related to nitrate (a few are linked to pesticides). The unsaturated zone time lag effect will account for some of the increase, while more monitoring data and a change in the threshold used for the assessment of nitrate (from 42 to 37.5 mg l^{-1} in 2012) will account for some more[xxii]. However, a significant portion still represents genuine deterioration suggesting that although nitrate concentrations in some groundwater bodies are slowly improving (Section 3.4), high nitrate concentrations in groundwater are widespread and in some groundwater bodies concentrations are still rising. There is an absolute requirement that deterioration should be prevented under the WFD and potentially costly measures will need to be put in place to reverse these trends (see Section 5). Our evidence, and national source apportionment studies show agriculture is the largest source of nitrate reaching groundwater, making up over half of all inputs, but as much as 80% in some rural areas (see Sections 3.4 and 3.5 for further details).

[xxi] http://www.wfduk.org
[xxii] Note: Nitrates Directive threshold is 50 mg l^{-1}

5. NO DETERIORATION

As well as securing improvements in the second cycle of WFD, there is also a duty to ensure 'no deterioration' in the status of surface and ground water bodies. The Directive has two exceptions: temporary deterioration of the status as a result of circumstances of natural cause or *force majeure*; and new modifications. Preventing deterioration of status is a significant challenge in some water bodies. For deterioration to have occurred under the terms of the Directive, the impact has to be at a whole water body scale and is assessed by comparing the classification results for a water body with the 2009 baseline. This and local information will be used to identify those locations where there is sufficient confidence to justify immediate remediation action to prevent a formal failure.

To date there has not been a waterbody-by-waterbody assessment of the risk of deterioration of good ecological status. For the first time a statistical procedure was used to determine whether a deterioration in the classification results for 2013 indicates a real change in status. The results of the statistical procedures can help us prioritise those deteriorations that come out of the interim classifications that merit further attention.

For groundwater DrWPAs a no deterioration risk assessment was undertaken in 2013 to show the risk from chemicals between now and 2027 (**Figure 10**). The risk assessment took account of pressures from agriculture (land use), water industry (population), and changes in climate. The output clearly shows groundwaters in large parts of the country are at risk, or probably at risk, from chemical impacts. To date, this is the only protected area no deterioration risk assessment undertaken and published.

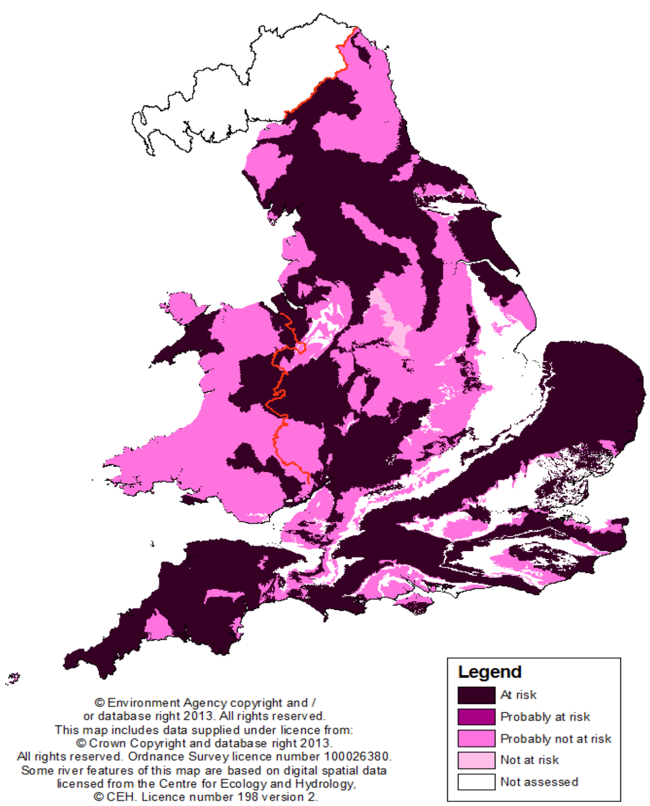


Figure 10. Groundwater chemical pressures – risk of impact in DrWPAs now to 2027, including risk of deterioration

For the agricultural sector, the decline in farm-gate nutrient budgets for harvested and grassland crops (ADAS, 2011), particularly for P, should reduce the present day loading to surface and ground waters (see Appendix 5). The historical legacy issues will continue to challenge the no deterioration objective for good status.

6. CLOSING THE GAP

A range of mitigation measures are available to tackle agricultural pollution by: (i) controlling pollutant sources; (ii) slowing pathways between sources and receptors; or (iii) protecting receptors. Measures are outlined and assessed for their impact on a range of environmental pressures in several sources, including:.

- Mitigation methods – User Guide. An Inventory of Mitigation Methods and Guide to their Effects on Diffuse Water Pollution, Greenhouse Gas Emissions and Ammonia Emissions from Agriculture (DEFRA, 2011)
- Evidence requirements to support the design of new agri-environment schemes (FERA, 2013)
- Identification of basic measures to address agriculture's impact on water (Newell Price, 2013)

However, there is uncertainty in relation to the efficacy of many measures over larger scales and longer timeframes. The Demonstration Test Catchments[xxiii], a £6.5m Defra-Environment Agency project, is helping to address this.

The extent of the challenge suggests the way forward requires a mix of: best practice national measures operational at a farm level; catchment-based planning and partnerships to identify more locally tailored measures targeted at a number of high risk farming activities in high risk and impacted areas; and a likely need for alternative objectives (both extended deadlines and less stringent objectives) in some areas, where these are justified under the exemptions in the WFD.

[xxiii] http://www.lwec.org.uk/activities/demonstration-test-catchments

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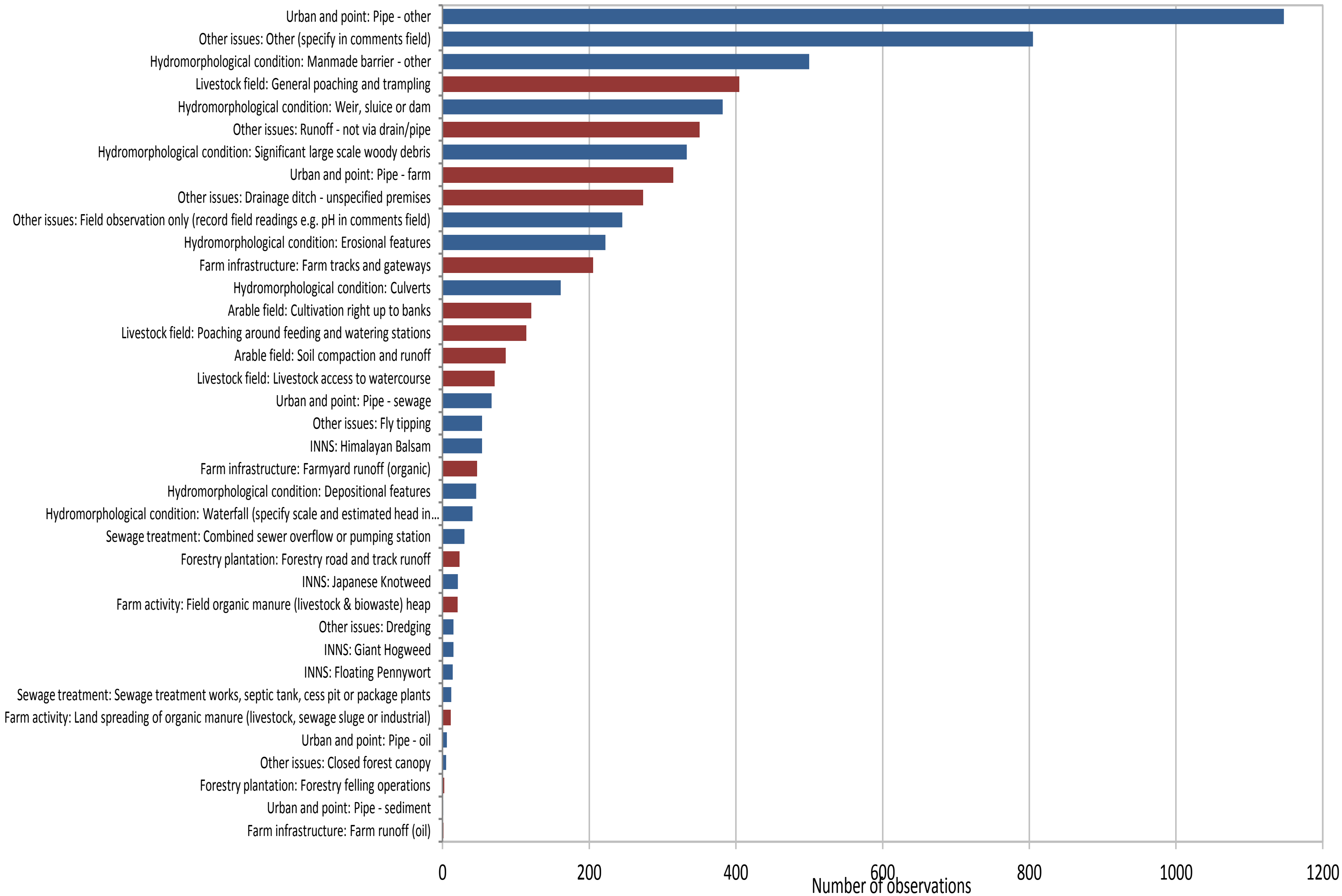
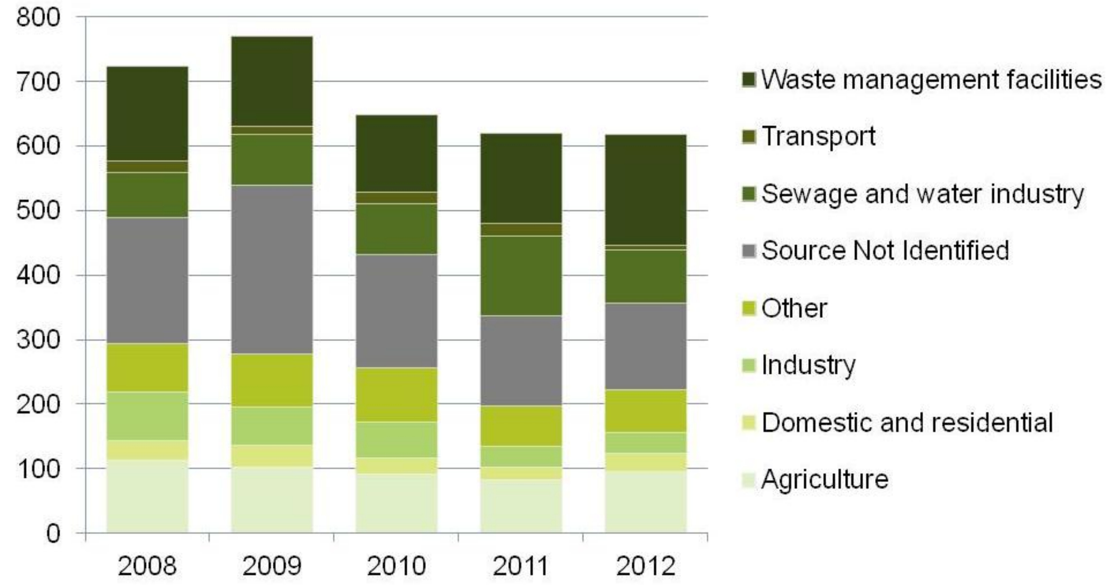
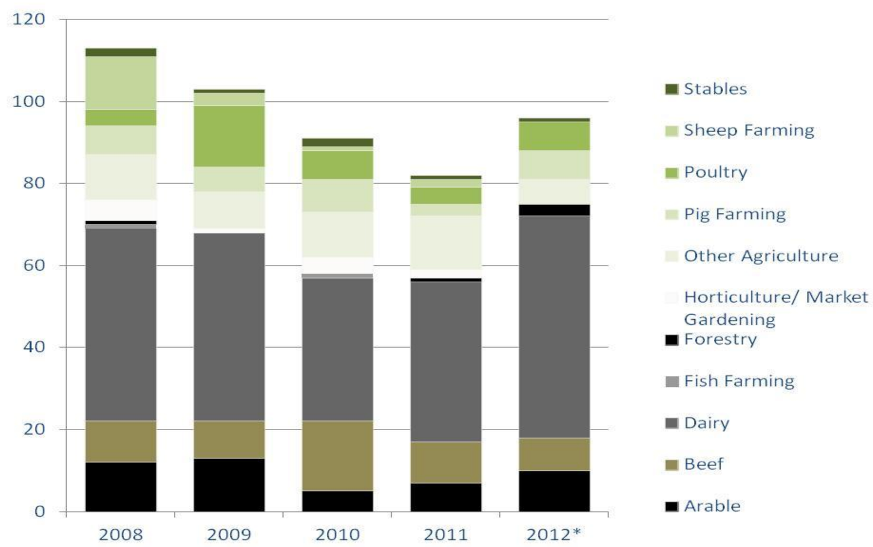
Editors: Rachael Dils, Robert Willows, Phil Smith, Simon Leaf, Jamie Letts, Vicky Beaumont-Brown

APPENDIX 2 Catchment walkover breakdown of observations by type (red = agriculture, blue = other)



APPENDIX 3 (i) Number of category 1 & 2 pollution incidents by sector 2012, and (ii) Agriculture category 1 (serious) & 2 (significant) pollution incidents by subsector



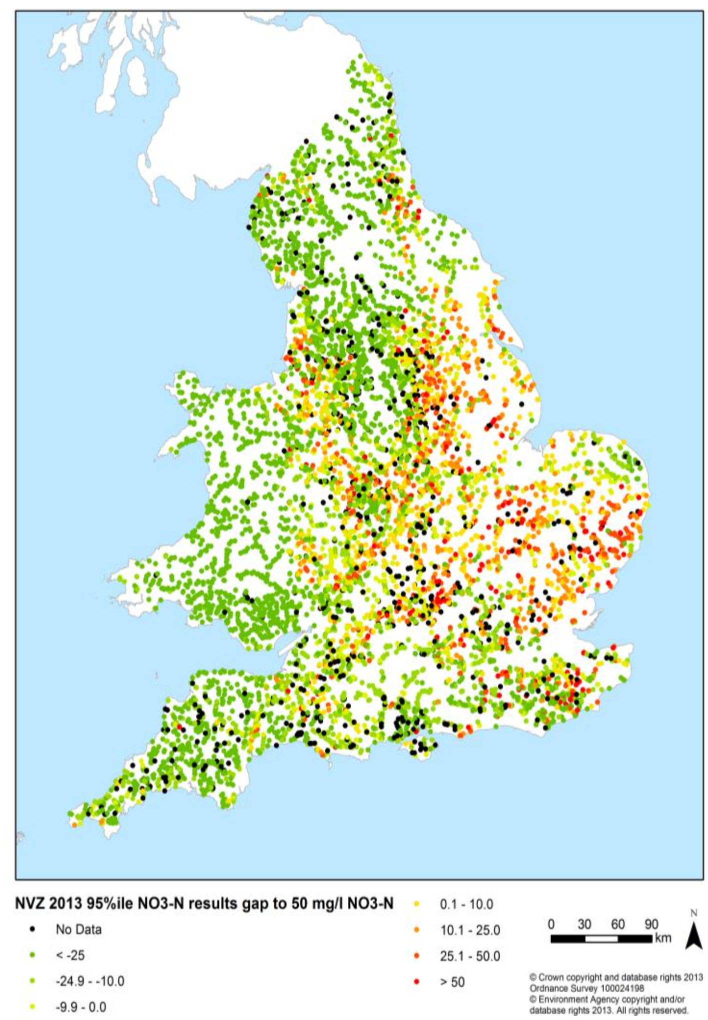


APPENDIX 4 - Further information on Nitrates Directive & NVZ designations

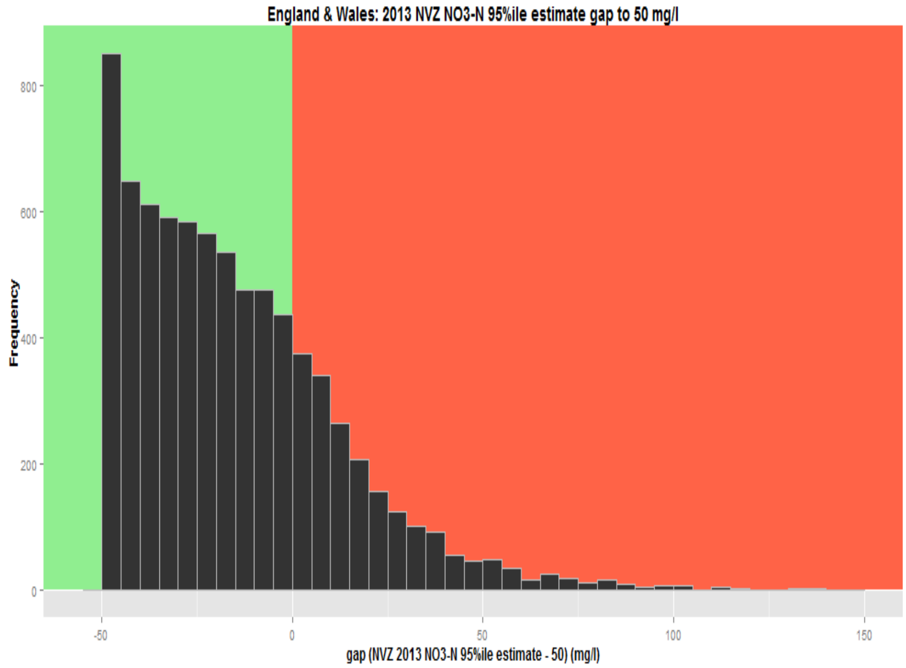
NVZs and N-eutrophic waters are reviewed on a 4-yearly cycle with the most recent designations reported in 2013, based on our water quality and other monitoring data collected up to 2009. For rivers, 20 years of data was used with an emphasis on data from 2004-2009. For groundwater longer time series were used, reflecting the slower response times of groundwater to nutrient loading. Information on land-use from the 2010 Defra farm survey was used to provide present-day estimates of excess nitrate losses based on an empirical model, NEAP-N, developed by ADAS. The NEAP-N model uses information on current N-fertiliser practice, data on crop uptake of N, soil water N concentrations and mineralisation rates based on field and farm scale measurements and 30 year rainfall statistics. The designation of eutrophic lakes drew on initial results from WFD ecological monitoring. The published method statements provide full details of the data used (EA, 2012a, 2012b, 2012c).

57.5% (74,679 km^2) of the land area in England is identified as draining waters which are polluted or could be nitrate polluted and where agriculture makes a significant contribution to that pollution. Different designations overlap one another: surface water (rivers) cover 59,410 km^2, groundwater 32,126 km^2 and eutrophic waters 6,279 km^2.

Based on the Nitrates Directive Article 10 report (Environment Agency, 2012d): 15% of groundwater monitoring sites had annual average nitrate concentrations greater than 50mg NO_3 L^{-1}. For surface waters (rivers and lakes) 8% of monitoring sites had annual average nitrate concentrations > 50 NO_3 L^{-1} but in terms of maximum concentrations the percentage is much higher at 23%. The designation of waters under the Nitrates Directive is based on water-body specific assessments. For rivers, nitrate pollution is indicated where >5% of water quality samples exceed 50mg NO_3 N L^{-1} (the drinking water standard). This occurred in c. 25% of all monitoring sites across England and Wales (based on data from 2004-2009). The vast majority of these sites (almost 2000) were located in England (see **Figure opposite**). The size of the gap – the number of $1km^2$ and their distance from the target – is indicated by the red area in the histogram below (derived from the NEAP-N model using data from the 2010 Defra farm census).



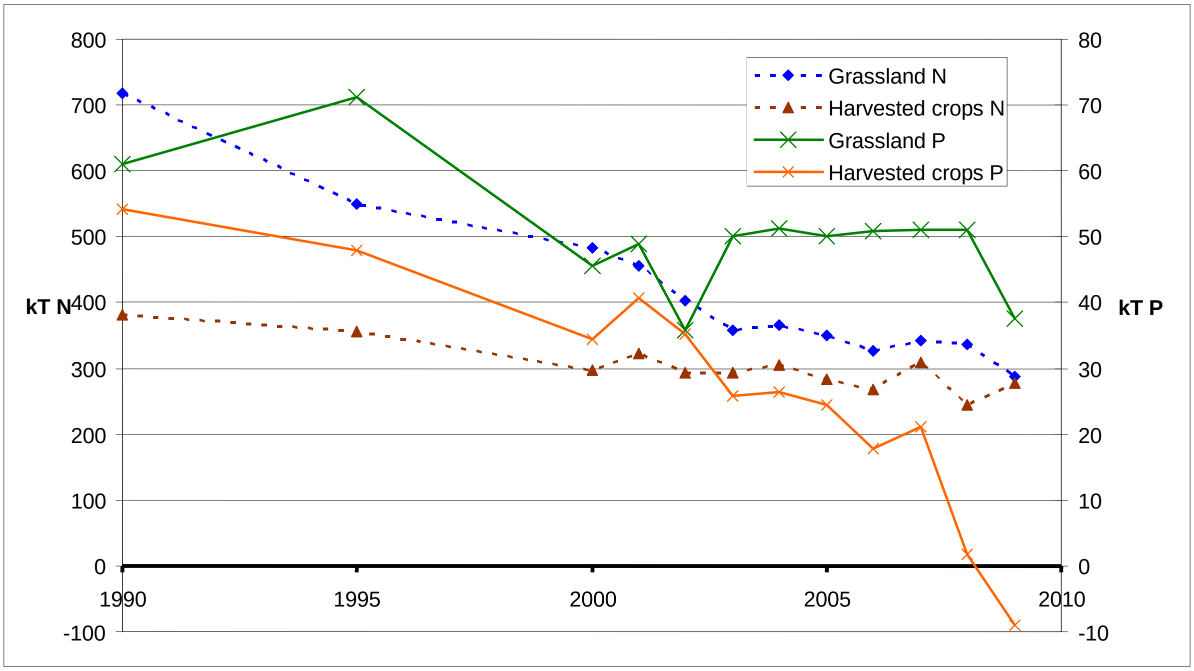
Water bodies can also be designated based on upward trends in N concentration (evidence of deterioration) and where high nitrate concentrations are predicted based on the losses of N expected from agricultural land within the catchment. In total, almost 1000 individual surface river water bodies in England were identified as having evidence of nitrate pollution with a significant contribution from agriculture.



England & Wales: 2013 NVZ NO3-N 95%ile estimate gap to 50 mg/l
Frequency
800
600
400
200
0
-50
0
50
100
150
gap (NVZ 2013 NO3-N 95%ile estimate - 50) (mg/l)

APPENDIX 5 Nutrient balances and fertiliser use

Nutrient balances can be used to assess the potential risk of environmental pollution from different farming sectors over time. Work undertaken by ADAS for the Environment Agency in 2011 (using the farm gate balance approach at a national scale) showed agricultural N and P balances for England and Wales have fallen over the past 20 years, reflecting increasing efficiency of nutrient use[24]. The farm gate balance approach calculates the difference between inputs (fertiliser, livestock feed, N fixed by legumes, other land inputs e.g. sewage sludge and industrial wastes) and outputs (crop products removed, livestock products removed, manures exported) but internal transfers within a sector (e.g. grass grazing, manure deposition) are not. The method is structured to build up national balances for arable, pigs and poultry, and grazing systems separately.



Net grassland and harvested crop sector balances (kT N, P) after inclusion of manure transfers and other inputs to land.

The main trends identified from the sector nutrient balances are:

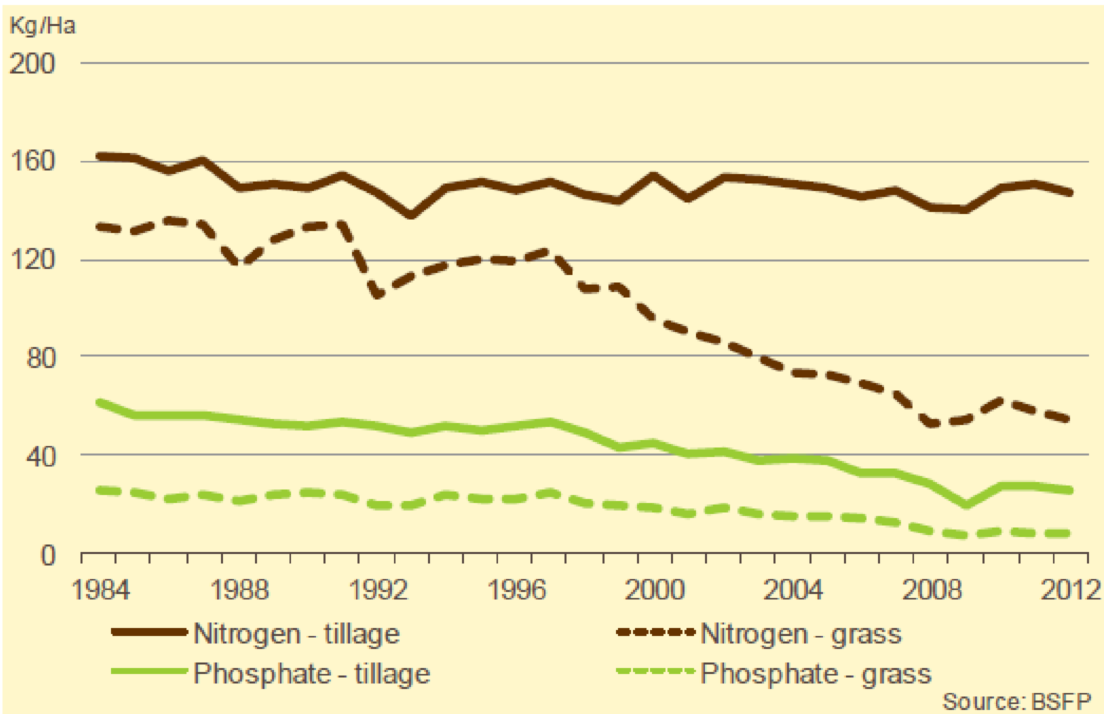
- For N, the grassland (cattle and sheep) balance has declined strongly since 2000 (ie the difference between excess inputs and outputs has declined), due to a strong reduction in N fertiliser inputs to grass with a contributory factor being the reduction in stock numbers. There has been relatively little change since 2000 in the harvested crops sector. The highest balances per ha (i.e. greatest excess of inputs versus offtake in products) are associated with peas/beans; oilseed rape; and some vegetable crops. Pig and poultry N balances have changed little, keeping in line with stock numbers.

- For P, the balance has fallen on both arable and grassland sectors, mainly due to strong reductions in P fertiliser input. The arable P balance (including manures and other inputs) is now close to zero, falling below zero for the first time in decades in 2009 but rising back to near zero in 2010. This means that P offtake in product and P inputs are almost in balance, such that soil P status on average should remain constant. There are likely to be some areas where soil P reserves are being run down. On grassland, there is still a considerable

[24] Assessment of trends in N and P balance in Agriculture, by sector, with likely causes. David Johnson, Eunice Lord, ADAS. Report to the Environment Agency 2011

positive P balance, despite very low fertiliser inputs, due to P inputs in cattle feed exceeding P outputs in products. The P balance in the pig sector has fallen slightly due to reduced numbers, and in the poultry sector has changed little. The changes were due to changes in livestock numbers rather than efficiency change.

Data from the British Survey of Fertiliser Practice (BSFP) shows overall phosphate (P_2O_5) use on tillage crops has gradually declined since 1983, with five-year means of 58 kg/ha in 1983-87, 54 kg/ha in 1988-92, 53 kg/ha in 1993-97, 46 kg/ha in 1998-02, 38 kg/ha in 2003-07 and 28 kg/ha for the period 2008-12. For grassland, the five-year means have been 25 kg/ha in 1983-87, 23 kg/ha in 1988-92, 23 kg/ha in 1993-97, 20 kg/ha in 1998-02, 16 kg/ha in 2003-07 and 9 kg/ha for the period 2008-12.



Overall application rates of nitrogen (N) and phosphate (P_2O_5) on crops (tillage) and grassland in England and Wales, Source: British Survey of Fertiliser Practice