Improvement Programme for England's Natura 2000 Sites (IPENS) – Planning for the Future IPENS050

Case Studies for Delivering Ammonia Measures

Culm Grasslands Special Area of Conservation (SAC)

Cerne and Sydling Downs Special Area of Conservation (SAC)

Minsmere to Walberswick Marshes and Heath Special Area of Conservation (SAC) and Minsmere-Walberswick Special Protection Area (SPA)

Norfolk Valley Fens Special Area of Conservation (SAC)

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Foreword

The **Improvement Programme for England's Natura 2000 sites (IPENS)**, supported by European Union LIFE+ funding, is a new strategic approach to managing England's Natura 2000 sites. It is enabling Natural England, the Environment Agency, and other key partners to plan what, how, where and when they will target their efforts on Natura 2000 sites and areas surrounding them.

As part of the IPENS programme, we are identifying gaps in our knowledge, and where possible, we are addressing these through a range of evidence projects. Results from these projects will feed into Theme Plans and Site Improvement Plans. This project forms one of these studies.

Atmospheric nitrogen deposition is considered a key threat to Natura 2000 sites and to the reaching of biodiversity objectives. Ammonia (NH_3) emissions from agriculture can represent a significant local source of atmospheric nitrogen for protected sites, and encouraging changes in local agricultural practices could lead to substantial reductions in N deposition at these sites. However, there is currently no delivery mechanism specifically aimed at encouraging those changes in the vicinity of Natura 2000 sites. Catchment Sensitive Farming (CSF) represents a potential delivery mechanism for the targeted identification and implementation of mitigation measures aimed at reducing atmospheric nitrogen deposition at Natura 2000 sites, in tandem with efforts for water quality.

The aim of this study was to assess the suitability of the CSF approach as a delivery mechanism for potential NH_3 abatement measures, by investigating its potential at four case study Natura 2000 sites.

The outcomes of the study will be used to inform potential schemes for delivering ammonia abatement measures, in particular the future of CSF. The results will also feed into the development of the IPENS theme action plan on atmospheric nitrogen. The key audience for this work is decision makers involved in the development of agri-environment schemes and CSF.

Natural England Project officer: Wilbert van Vliet, **Wilbert.vanVliet@naturalengland.org.uk**

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Case Studies for Delivering Ammonia Measures

T. H. Misselbrook[1], U. Dragosits[2], J. Williams[3]

[1]Rothamsted Research, North Wyke, Okehampton, Devon EX20 2SB
[2]CEH Edinburgh, Bush Estate, Penicuik, Midlothian EH26 0QB, Scotland, UK
[3]ADAS Boxworth, Battlegate Lane, Boxworth, Cambs. CB3 8NN

Executive summary

The overall objective of this project was to assess the suitability of the Catchment Sensitive Farming scheme for delivering mitigation measures aimed at reducing ammonia emissions from agricultural sources - specifically to reduce the negative effects of nitrogen (N) deposition on Natura 2000 sites. Drawing on the four case studies conducted, the project workshop and the interaction with Project IPENS 049 (Site categorisation for nitrogen measures), the following are considered to be the key messages arising from this project:

1. Catchment Sensitive Farming (CSF) does represent a potentially good route for delivery of mitigation measures targeting agricultural ammonia emissions to reduce the effects of N deposition at selected Natura 2000 sites especially where there is overlap between sensitive Natura 2000 sites and priority catchments for diffuse water pollution (DWP), because:
    a. There are integrated environmental benefits with many of the measures delivering to both DWP and air quality;
    b. Engagement is with the same ‘customers’, and CSF has a good track record of local engagement.
2. Catchment Sensitive Farming Officers (CSFOs) would require an understanding of the issues relating to ammonia emission and deposition, the main emission sources and potential mitigation measures. A Guidance Note has been drafted as part of this project for this purpose. In addition, specific training workshops delivered by the appropriate science and policy experts are also recommended. It is suggested that a revision/update of the User Guide for mitigating diffuse pollution from agriculture would also be useful.
3. CSFOs are experienced in farmer engagement with regard to mitigation measures for reducing DWP, having built up relationships and developed an understanding of the issues over a number of years. There is some concern among CSFOs that introducing another issue, that of ammonia emission/deposition, could make engagement more difficult. A focus on win-win solutions (for water and air) and on the potential farmer benefits is, therefore, very important.
4. Specific priority action plans can be prepared for selected Natura 2000 sites using the approach described in the IPENS theme plan and the IPENS 049 project. This can inform the initial selection of potential measures and farm holdings to target. Local engagement within the target area by CSFOs will provide the information on detailed local management practices for specific farms which can be used to refine the plans.
5. The greatest benefits for both air and water pollution will be realised where target areas coincide and good synergies exist between mitigation measures. Where there are potential trade-offs for a given mitigation measure between air and water pollution, compromises will have to be made, based on the relative importance of the issues for a given catchment.
6. For most catchments, manure management (storage and spreading) is likely to represent the major potential emission source for which the most practical and cost-effective mitigation measures can be implemented, for which there is good synergy between mitigating air and water pollution, and for which there can be clearly recognised farmer benefits.

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1. Introduction

There is compelling evidence of the adverse effects of nitrogen deposition in terrestrial and freshwater ecosystems (e.g. Dise et al., 2011) . In the UK it is estimated that 70% of Special Areas of Conservation (SACs) exceed or partly exceed critical loads for nitrogen and critical levels for ammonia (NH_3). UK nitrogen deposition derives from emissions of nitrogen oxides (NO_x) and NH_3, in almost equal parts but with significant local variations. Nitrogen oxides are mainly emitted by vehicles and other combustion sources while NH_3 is predominantly emitted by agriculture. Substantial reductions in NO_x have been achieved in the UK over the last decade, with further significant reductions projected to 2020. Reductions in NH_3 emissions have been less substantial, declining by c. 20% since 1980 with a further 8% reduction expected by 2020. Proposed revisions of the National Emissions Ceilings Directive (NECD) are likely to result in a more challenging emission reduction target for the UK for 2030.

Ammonia emissions from agriculture therefore represent a significant local source for many of the Natura 2000 sites, and changing local agricultural practices could lead to significant reductions in N deposition at these sites. Previous by CEH have explored the potential of targeted measures to reduce N deposition at sensitive sites, and developed a framework for a site action plan for identification of the most appropriate abatement measures. A range of potential measures to reduce emissions exists from sources including livestock housing, manure storage and the spreading of livestock manures and fertilisers (Newell-Price *et al*., 2011). However, in contrast to countries such as the Netherlands and Denmark where changing practice has largely been in response to legislation, there has to date been only limited uptake of mitigation measures in the UK where we have largely relied on voluntary uptake of codes of good practice.

Catchment Sensitive Farming (CSF) is a joint project between the Environment Agency and Natural England, funded by Defra and the Rural Development Programme for England, which works in priority catchments (where evidence suggests that pollution from farming practices impacts significantly on water quality and aquatic habitats) within England with the objective of mitigating diffuse water pollution from agriculture. The priority catchments cover over 46% of the total utilisable agricultural area in England and engagement with farmers in these areas is through Catchment Sensitive Farming Officers (CSFOs). This is a voluntary initiative and CSFOs work with local farmers in the target areas to encourage adoption of practices to mitigate diffuse water pollution. CSFOs deliver training, information and advice on best practice and also assist with uptake of the Capital Grants available for specific infrastructure investments within specified target areas of the catchment.

Catchment Sensitive Farming represents a potential delivery mechanism for the targeted identification and implementation of mitigation measures aimed at reducing N deposition at Natura 2000 sites, taking advantage of the good local knowledge and contacts of the CSFOs and using the fact that it is a national scheme with the associated benefits in terms of delivering training and consistent messages. There are also benefits and potential synergies in bringing together the advice regarding water pollution and air quality. This IPENS 050 project assessed the potential of delivering targeted NH_3 abatement measures through the CSF scheme.

The overall aim of the IPENS 050 project was to assess the suitability of CSF as a delivery mechanism and develop guidance on how the potential NH_3 abatement measures can be targeted for an individual site.

The project conducted a detailed investigation of four Natura 2000 sites as case studies to inform this guidance:

- to show how a provided list of potential measures can be translated into a package of site-suited measures for a given Natura 2000 site;
- to investigate how the measures may be best spatially targeted around a given Natura 2000 site;
- to assess the practicality and information needed for establishing an optimal targeting of the measures, using CSF as a delivery mechanism.

2. Approaches

The project was based around four case study sites, selected for their contrasting agricultural landscapes and experience of their CSFOs, for which the processes of identifying potential NH_3 emission sources impacting on the Natura 2000 sites, the potential mitigation measures and the feasibility of CSFOs delivering targeted advice to encourage adoption of best practices with regard to NH_3 emissions was assessed. The project team worked with the CSFO for each site to develop a detailed case site report and these were brought together at a workshop held in London involving the project team, the CSFOs, the project Steering group and other relevant stakeholders from Defra, Natural England and the Environment Agency at which the common messages emerging from the case studies and the advantages and disadvantages of CSF as a delivery mechanism for NH_3 mitigation measures to reduce impact at Natura 2000 sites were discussed more widely.

2.1. Case study site descriptions

The four case study areas were agreed prior to commencement of the project as:

a) Culm Grassland SAC (located in CSF target area E, Rivers Taw and Torridge)
b) Cerne and Sydling Downs SAC (located in CSF target area 20, Rivers Piddle, Frome and Fleet Lagoon)
c) Minsmere and Walberswick SAC (located in CSF target area 45, River Blythe and surrounding SSSIs)
d) Norfolk Valley Fens SAC (located in CSF target area 10, Little Ouse – Thetford Ouse)

Further descriptions of the study areas are given below, but their selection was based on providing contrast in terms of the agriculture, from grassland-based dairy, beef and sheep production in Devon, through mixed farming in Dorset and predominantly arable and intensive pig and poultry in East Anglia, giving differences in the potential NH_3 emission sources and mitigation options. A second important criteria for selection was to have an experienced CSFO in place, with a good knowledge of the local farming practices, experience of engaging with farmers regarding diffuse water pollution and who would be able to provide useful feedback regarding the potential of delivering NH_3 mitigation measures through CSF.

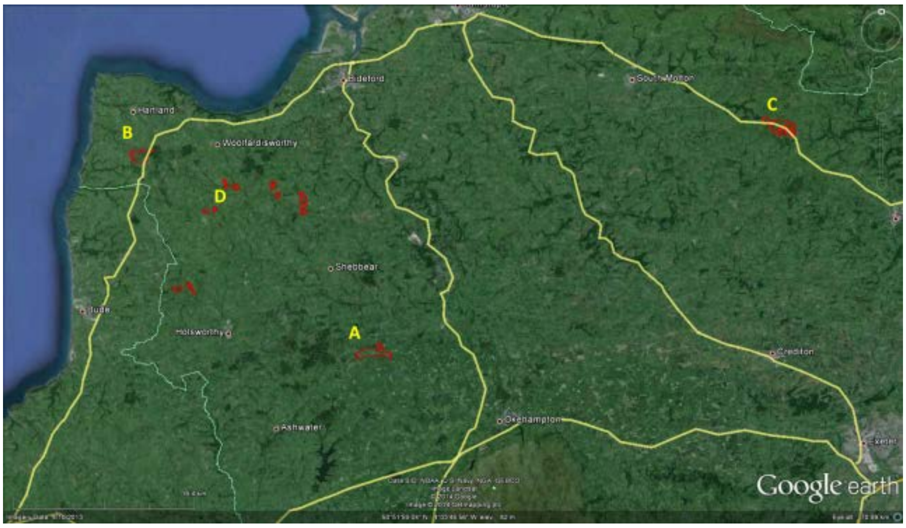

Figure 1. Location of the Culm Measures SAC. Red lines indicate SAC boundaries. Sites A to D were used in the project.

Figure 2. Typical agricultural landscape in the Taw/Torridge catchment.

The Culm Measures are acidic clay soils, poorly drained, which have given rise to a unique grassland habitat known as Culm grassland in Northwest Devon. While much of the area has been drained and improved for agricultural production, there are some remaining areas, including those designated as Natura 2000 sites (Fig. 1). The SAC comprises a number of sites, all of which lie within the catchment, but some lie outside of the specific target areas for diffuse water pollution. To assess all of the sites was beyond the resources of this project (they were assessed in IPENS 049, see Dragosits *et al*., 2014), therefore selected sites were chosen (labelled A to D in Fig. 1). Agriculture in the area is predominantly grassland based dairy, beef and sheep production (the typical landscape is shown in Fig. 2), generally made up of small to medium family farms, although a few intensive pig and poultry units also exist.

Figure 3. Location of the Cerne & Sydling Downs SAC. Bold yellow lines indicate SAC boundaries.

Figure 4. Typical agricultural landscape in the Piddle/Frome catchment

The Cerne and Sydlings Downs SAC are located in west Dorset, just north of Dorchester (Fig. 3). The site consists of a large area of semi-natural dry grassland over the west Dorset chalk. This type of calcareous grassland is almost entirely restricted to parts of Wiltshire and Dorset. Agriculture in the area is mixed, with a lot of cereal crop production but also dairy, beef and sheep production and some intensive pig production units (typical landscape shown in Fig. 4). The SAC consists of several sites, but all were considered together in this study. All lie within the catchment and within the specific target area for diffuse water pollution.

The Minsmere-Walberswick Heaths and Marshes are located on the North Sea coast between Southwold and Sizewell in Suffolk, extending over an area of coastline of approximately 11 km in length (Fig. 5). It includes a range of habitats, being made up of a complex mosaic of marshes, reed beds, shingle banks and lowland heath. Agriculture in the area is predominantly arable, outdoor pig production (Fig. 6) and a number of intensive indoor pig and poultry units. The SAC consists of several closely located sites, which were considered together, which lie entirely within the Blythe catchment and within the specific target area for diffuse water pollution.

Figure 5. Location of the Minsmere-Walberswick Heaths and Marshes. Red lines indicate SAC boundaries.

Figure 6. Outdoor pigs were a prominent feature of the Minsmere-Walberswick site.

Norfolk Valley Fens SAC comprises scattered sites (Fig. 7), primarily designated for the presence of rare spring fed alkaline fens which support a rich floral assemblage, in addition to strong populations of narrow-mouthed whorl snail and Desmoulin's whorl snail. The sites sit within a predominantly arable agricultural landscape but associated with a large number of intensive pig and poultry units. A number of the sites are located within the Little Ouse – Thetford Ouse catchment, although not all necessarily within the specific target area for diffuse water pollution, and other sites lie outside of the catchment entirely. Sub-sites A and B were selected for purposes of this study.

Figure 7. Location of the Norfolk Valley Fens. Bold yellow lines indicate SAC boundaries.

Figure 8. Typical agricultural landscape in the Little Ouse – Thetford Ouse catchment.

2.2. Identification of emission sources

An initial mapping was conducted for each site, using the boundary datasets for the designated Natura 2000 sites, identifying the sites within the context of the surrounding landscape (Figs. 1, 3, 5 and 7). Any known Industrial Emissions Directive (IED) permitted sites (large intensive pig or poultry housing) were then marked on the maps, together with details of the type and size of operation. More detailed information was then sought on the agricultural activities within a 2 – 5 km zone of the site boundaries. Aerial images (via GoogleEarth and StreetView) were interrogated to add further detail of potential emission sources, including livestock housing and manure storage facilities in particular. Initial maps detailing potential emission sources were then sent to the local CSFO for each case study site with questions aimed at confirming (or otherwise) the identified sources and providing more information on relevant management practices details of which could not be gained from aerial images, such as manure spreading methods and timings and existing adoption of any mitigation measures. Revised maps and tables were then developed detailing the emission sources most likely to be impacting on the Natura 2000 sites, taking into account the feedback from CSFOs regarding farm types, size and management practices (where known) and the prevailing wind direction.

2.3. Identification of most appropriate ammonia mitigation measures

Following identification of the most important emission sources for a given Natura 2000 site, a list of the most appropriate NH_3 abatement measures specific to that site was developed. There are a number of potential NH_3 mitigation measures, which can be grouped according to the emission source they apply to: livestock housing (e.g. air scrubbers for intensive pig or poultry housing); manure storage (e.g. covering of slurry tanks and lagoons); manure application to land (e.g. use of low emission slurry application techniques such as shallow injection); fertiliser (e.g. use of urease inhibitors with urea fertiliser); whole system (e.g. dietary changes for livestock). These abatement measures have been summarised in the IPENS theme plan on atmospheric nitrogen and Natura 2000 with more detail for most also provided in the User Guide for mitigating diffuse pollution from agriculture (Newell-Price *et al*., 2011).

The list of recommended abatement options for each site was based on the relative importance of the emission sources, the relative effectiveness of the various abatement measures and consideration of the practicalities and costs of implementation. Importantly, any potential secondary impacts of the abatement measures were also considered, such as 'pollution swapping', where implementation may give a reduction in NH_3 emissions but an increase in another pollutant pathway (increased nitrate leaching or nitrous oxide emissions), and potential farmer benefits such as improved manure nitrogen use efficiency.

There was insufficient resource within the project to conduct any detailed impact assessment modelling of implementation of the potential measures. However, the project has provided more detailed farm practice data and associated NH_3 emission factors to project IPENS 049 which will conduct a cost-benefits analysis for the Culm Grasslands and Cerne and Sydling Downs sites.

2.4. Project workshop

On completion of the four case studies, a project workshop was convened to present the results to the project Steering Group and a wider group of Defra, Natural England and Environment Agency stakeholders. The aims of the workshop were to:

- Discuss the approaches taken and the degree of success in identifying the main emission sources and potential mitigation measures.
- Discuss farmer issues – how to engage, barriers to uptake, incentives.
- Discuss CSFO issues – change in focus from water pollution, knowledge and training requirements.
- Discuss wider policy objectives of how best to meet multiple objectives and the potential of CSF for delivering NH_3 measures.

2.5 Guidance note for Catchment Sensitive Farming Officers

Based on the outcomes of the case studies and the workshop discussions, a Guidance Note was drafted for CSFOs on a targeted approach to reducing the impact of NH_3 emissions on Natura 2000 sites.

3. Results and Discussion

3.1. Identification of emission sources and potential abatement measures

The four case studies are presented in detail in Annexes 1 – 4. There was some variation as to the degree of success in identifying the major emission sources for the four sites. For the Culm Grasslands site, there was generally good agreement between potential sources identified using the aerial mapping and those known by the local CSFO, although the detail of knowledge of the CSFO varied considerably across the catchment, being greater for the specific target area for diffuse water pollution. Similarly, for the Minsmere and Walberswick Heaths, there was good general agreement that the large number of outdoor pigs bordering the SAC were likely to be the major local emission source. However, for the Cerne and Sydling Downs site, the aerial mapping proved to be fairly inaccurate, with several of the potential emission sources actually being redundant livestock buildings or misidentified, and a number of actual emission sources being missed completely. For the Norfolk Valley Fens, CSFO knowledge of farming activities around the selected sites was not as detailed, so there was no indication of the degree to which the aerial mapping had successfully identified potential sources.

Project IPENS 049 (Site categorisation for nitrogen measures) also included the Culm Grasslands as a case study site. IPENS 049 made use of detailed spatial data sets including NH_3 concentration maps from FRAME model runs and concentration based estimates of N deposition and farm holding-level details of the June Agricultural Survey (for livestock numbers). There are some differences in the detailed maps produced by both projects regarding potential influencing sources, but the general conclusions were the same, i.e. that local emissions from agricultural activities were greatest around sub-site D (Fig. 1) and predominantly related to dairy farming activities which should therefore be the focus for mitigation measures. While only based on a single comparison of case site studies, it is reassuring that the ‘cruder’, less-detailed approach used in IPENS 050 identified the same focus target area as the more detailed IPENS 049 approach. Ultimately, the accuracy of both approaches will depend on the level of local farm activity data that can be provided, and this would certainly be critical in terms of providing impact assessments or cost-benefits analyses.

There were a number of differences, but also important similarities, in the type of emission sources identified across the four case study sites. For the Culm Grasslands, dairy farming was the major source with the larger housing units and outdoor yards being identified as important sources. For Cerne and Sydling Downs, there were few specific livestock housing sites identified as major local sources, with the exception of the identified IED-permitted pig farm. At Minsmere and Walberswick Heaths, the outdoor pig production bordering the site was identified as a main local emission source. For the Norfolk Valley Fens, intensive pig and poultry housing were identified as important potential emission sources. Across all sites, manure storage and application to land close to the SAC sites was identified as important potential emission sources near the SAC. The zone of influence of these different emission sources will depend on actual management practices and local conditions including topography, soil conditions and prevailing wind direction. Additionally, the general intensity of agricultural activities within the wider region around the SAC will influence the extent to which NH_3 concentrations at the SAC are elevated. However, some generic guidance can be given as to the area around the SAC in which the different activities will be having a major local contribution: dairy housing (including outdoor yards) and intensive pig and poultry housing units within 2 km upwind or 1 km downwind; slurry storage lagoons (large surface area) within 2 km upwind or 1 km downwind; cattle, pig or poultry manure heaps and all livestock manure spreading operations within 500 m (upwind or downwind).

3.2. Selection of mitigation measures based on site characteristics

From the case studies, it was evident that the selection of mitigation measures will depend on the type of agriculture in the area and on potentially constraining features such as soil type and slope. Measures to mitigate NH_3 emissions from land application of livestock manures are among the most cost-effective (per kg of NH_3 emission abated), practical and easily-implemented of measures aimed at reducing emissions from agriculture and, although differing in detail, applicable across all sites. Housing measurements are generally the most expensive, and often not possible to retro-fit. However, specific options may arise within a given catchment and all options should therefore be considered as potential at the outset. Obviously, the strongest focus regarding uptake of options should be in the region close to the site, as described above, but adoption of options more widely within a given catchment will all contribute to reducing elevated NH_3 concentrations.

3.2.1. Predominantly grassland areas

Grassland-based agriculture dominates much of the west of England, typically featuring dairy, beef and sheep production and Case study site 1 (Culm Grasslands) is a good example of this. For land spreading measures, opportunities to rapidly incorporate manures into the soil after spreading are likely to be limited, although should be encouraged where tillage operations do occur. More emphasis should therefore be placed on low emission slurry application measures. The most effective method applicable to grassland is shallow injection, although this is not appropriate for all cases, particularly on stony soils. Shallow injection of slurry on shallow soils overlying chalk, such as in the Cerne and Sydling Downs study area would greatly increase the risk of leaching to ground water. Similarly, on heavy soils under ‘plastic’ conditions, shallow injection slots can effectively become channels, which if on a slope can cause considerable run-off of slurry, potentially to surface waters. Under such circumstances, trailing shoe application is more appropriate, although associated with a lower emission reduction.

For manure storage, the main focus is likely to be on slurry stores, predominantly associated with medium to large dairy farms. For above-ground tanks, the most effective measure is to fit a rigid tent-like cover. This has the additional benefit of excluding rainfall from the tank which in high rainfall areas can significantly reduce the volume of slurry to be applied to land and will also reduce methane emissions from the store. However, this measure is relatively expensive and not all existing tanks have the required structural integrity to enable a cover to be fitted. A less expensive, although less effective option is the use of floating covers, such as expanded clay granules. These can be used on slurry tanks and lagoons (which are otherwise very difficult to cover), but will not exclude rainfall. Where new storage facilities are required, the use of slurry storage bags, with minimal emission, should be considered as an option. Covering of solid manure heaps with plastic sheeting is an effective emission reduction measure which could be targeted to manure heaps close to the site, but only if the manure is rapidly incorporated following subsequent application to land, otherwise any emission reductions at the storage stage will be offset by greater emissions following spreading. This measure is therefore unlikely to be widely applicable in predominantly grassland agricultural areas.

Measures targeted at dairy cattle housing are among the more costly to implement and often impractical to retro-fit to existing housing. Where renovations or expansion is taking place, then opportunities should be taken to incorporate emission reducing features such as efficient manure removal systems into the new housing design. For existing housing and outdoor yard areas, steps can be taken to minimise the area of fouled concrete from which emissions will occur. Roofing over of outdoor yard areas will reduce emissions to some extent and is also a measure recommended to reduce diffuse water pollution.

3.2.2. Predominantly arable areas

In arable areas, mitigation measures will be focussed largely on manure and fertiliser application. Livestock manures (and/or digestates and other biosolids) may be imported to the area from further afield for spreading. A significant proportion of the manures (and in particular the solid manure) will be applied in conjunction with tillage operations. Opportunities should therefore be taken to encourage rapid incorporation (within 4-6 h of application) of the applied manure, by plough (most effective) or other form of cultivation, which will greatly reduce NH_3 emission; between 50 -90% of the total emission after application typically occurs within the first 24 h. Covering with plastic sheeting of solid manure heaps established in fields close to the site prior to spreading and incorporation should be encouraged, particularly for high N content manures such as from poultry (this is an existing requirement for Nitrate Vulnerable Zones to minimise leaching). For slurries applied to growing crops, the most appropriate low emission application method is band spreading by trailing hose. Large boom-width machines are available so that applications can be made from the established cropping tramlines.

Use of urea-based fertilisers is associated with greater NH_3 emissions than other commonly-used forms of fertiliser in England. Where urea use on arable cropping is prevalent close to the site, potential mitigation measures include switching from urea-based fertilisers to another form (e.g. ammonium nitrate) or use of a urea-based fertiliser product which also incorporates a urease inhibitor, greatly reducing emissions.

3.2.3. Intensive livestock housing

Larger intensive pig and poultry units are likely to have already been assessed and implemented appropriate emission reduction technology as part of complying with the Industrial Emissions Directive. However, there may be further potential for adoption of emission reduction measures on such units and on smaller (below IED-threshold) units. As noted above, housing measures are often expensive and some are only applicable for new buildings. Opportunities should be taken therefore where housing renovation or expansion occurs to encourage the adoption of specific emission reduction measures, which might include floor design for pig housing, rapid slurry removal or slurry acidification systems, manure drying systems for poultry housing and air scrubbers for pig or poultry housing. Covering of slurry tanks and lagoons, as described for cattle slurry above, or the use of slurry storage bags for new/increased storage provision, will also be appropriate measures to consider. The establishment of tree belts around intensive housing and/or slurry storage can give some emission reduction (up to c. 20%) through reducing air flow around the emission source and direct canopy recapture of emitted NH_3 and may be an appropriate measure to consider for some situations.

3.2.4. General comments regarding potential mitigation measures

Associated benefits of low NH_3 emission manure application techniques include lower odour emissions during and after application and potentially improved manure nitrogen use efficiency. Theoretically, the amount of nitrogen saved through lower NH_3 emissions would be directly available for crop uptake and therefore have an equivalent inorganic fertiliser nitrogen value. The extent to which this is realised in practice will depend on application rates and timings and prevailing soil and weather conditions. Shallow injection and trailing shoe application to grassland have the additional benefit that they do not cover the grass leaves with slurry, giving an expanded window of application timing as there can be a shorter 'lay-off' period before cattle grazing or silage harvest. The potential for pollution swapping, by increasing nitrate leaching or nitrous oxide emissions, is small if applications are made at agronomically appropriate rates and timings.

Some of the existing measures being implemented in the case study sites through CSF for reducing diffuse water pollution may also have benefits for NH_3 emissions. In particular, the covering of livestock gathering yards and covering of slurry and manure stores will result in NH_3 emission reductions. The extent to which these will benefit the Natura 2000 sites depends on the location of such activities and therefore the extent to which existing diffuse water pollution target areas overlap with the identified NH_3 emission reduction target areas. Similarly, the manure management measures being proposed to give NH_3 emission reductions will yield some benefits for diffuse water pollution, through reduced run-off, but may not be located in the appropriate target areas. However, while not always targeted, these synergies will provide benefits to reducing diffuse pollution to air and water in general.

3.3. Farmer engagement

There is a good track record of CSFO engagement with farmers regarding the issues around diffuse water pollution, although it has taken time to develop this dialogue. The NH_3 emission/deposition issue is similar in that emissions generally occur from a number of diffuse sources upwind of a site which is then being negatively influenced through subsequent deposition. It is not easy therefore to directly associate a given farm or individual source with the downwind effects. Given the timescale of subsequent effects and potential recovery, it can also be difficult to demonstrate that changes in practices on a given farm will have beneficial effect on the site being protected. However, given the similarities with the diffuse water pollution issue and the successes that CSFOs have had with farmer engagement around that, there is no reason to think that engagement on the diffuse air pollution issue will be any more difficult. One cautionary note raised by some CSFOs during the project was the danger of overloading farmers with 'yet another environmental issue' and that there would definitely be benefits in dealing with the water and air issues in an integrated way.

There have been some awareness raising activities regarding NH_3 with the agricultural industry in the past, and potential mitigation measures certainly feature in the Code of Good Agricultural Practice. There has also been strong recent engagement with the National Farmers Union regarding the revision to the National Emission Ceilings Directive and what implications that might have for UK agriculture. Large pig and poultry units will also have come across the issue through the IED permitting procedure. However, on an individual farmer basis, CSFOs are probably best to engage on an integrated environmental benefit delivery (good for water and air) and to highlight potential farmer benefits. The most positive story here, which fits well with the identified mitigation measures, is to focus on best manure management practices to improve nutrient utilisation and reduce diffuse pollution to water and air. CSFOs would continue to deliver advice as before through farmer visits, workshops, advisory notes etc., but potentially in new target areas and delivering an integrated package of advice.

Consideration should also be given to engagement with not just farmers, but other operators within the sector such as contractors and equipment suppliers. Increasingly, manure application operations are carried out by contractors, and the opportunity may therefore exist through engagement with farmer and contractor around a specific site to influence slurry spreading methods not just in the target area but more generally over the area covered by the contractor. Similarly, discussions with local equipment suppliers (slurry storage, spreading equipment, livestock housing) to raise their awareness of potential options and promote discussion and awareness more widely within the local agricultural community are likely to be beneficial.

3.4. Implications for Catchment Sensitive Farming Officers

It was evident from this project that while CSF might represent a good potential route for NH_3 measures delivery to protect Natura 2000 sites, there would be a need for increased resource for CSFOs to deliver to both water and air target areas and a greater knowledge within CSFOs regarding NH_3 emission sources and mitigation measures. Vitally important would be for CSFOs to gain a good understanding of the impacts of NH_3 emission and deposition, the main emission sources, likely distance of effects, potential mitigation measures and the factors which will influence the effectiveness of those measures; the CSFO needs to be fully 'signed up' to the message in order to be able to deliver effective advice within the catchment.

Clear guidance will need to be provided on where the specific target areas for NH_3 mitigation measures are within the catchment, based on identification of the major emission sources in relation to the Natura 2000 sites as described above. The CSFOs will then need to engage with farmers in the target area to get a better understanding of the current management practices and where the best opportunities for mitigation might exist. The CSFOs will need a clear idea of the 'package' of advice and potential grants which they can offer to farmers in the target areas.

The Guidance Note developed as part of this project (Annex 5) will provide a useful information source for CSFOs and will complement existing sources including the User Guide. In addition, specific training will be required, ideally through workshops delivered by the appropriate science and policy experts, with potentially a different focus for different regions. Additionally, linkages between IED-permitting activities and CSFOs, where relevant, would be beneficial, as CSFOs would have had little interaction with intensive pig and poultry farms to date.

3.5. Policy development

Delivery of NH_3 measures to protect Natura 2000 sites through the existing CSF scheme would seem possible as a) there will be integrated environmental benefits in addressing both diffuse water and air pollution through the same mechanism; and b) engagement is with the same 'customers' and CSFOs have a good track record for this. The following considerations that need to be taken into account in deciding on the preferred approach:

- Firstly, a small number of Natura 2000 sites are located outside of existing CSSF catchments, and would therefore see no benefit or would require the establishment of new target catchments. Approximately 80% of sensitive Natura 2000 sites with elevated NH_3 deposition are located wholly or partly within current CSF priority catchments and those outside are predominantly coastal or upland sites where the local approach is unlikely to deliver significant results, so this is a relatively minor issue.

- Secondly, within a given catchment, the target area defined for the Natura 2000 site may be different from that specified for diffuse water pollution. With a limited resource and time, clear steer would need to be given over the priorities to place on resource use for a given catchment.

- Thirdly, there would be benefits in engagement between policy development focussed on local targeting to reduce impacts on Natura 2000 sites and policy development aimed at ensuring that the UK meets the proposed future NECD NH_3 targets. Delivery through CSF might act as a pilot scheme and demonstration of how measures could be adopted more generally at the national scale.

4. Conclusions and Recommendations

Catchment Sensitive Farming represents a good potential route for delivery of spatially targeted NH_3 emission mitigation measures to reduce the effects of N deposition on Natura 2000 sites located within CSF catchments. CSF has a good track record of engagement and delivery regarding diffuse water pollution and there are strong similarities regarding engagement and delivery of NH_3 mitigation measures. Engagement through CSFOs would be with the same 'customers' and there would be clear benefits in an integrated approach addressing both diffuse water and air pollution.

The selection of appropriate mitigation measures for a given site from the list of available potential measures will be guided by the predominant type of agriculture around the site (grassland, arable, mixed, intensive livestock), identification of the major emission sources and of any particular constraints to implementation of specific measures. A site action plan should be developed using the approach described in the IPENS 049 project, which will inform the initial selection of potential measures and farm holdings to target. Local engagement within the target area by CSFOs will provide the information on detailed local management practices for specific farms which can be used to refine the plans.

In addition to the Guidance Note developed as part of this project, it is recommended that training is delivered to CSFOs, through workshops led by appropriate science and policy experts, specifically on issues relating to NH_3 emission and deposition, the main emission sources and potential mitigation measures. It is suggested that a revision/update of the User Guide for mitigating diffuse pollution from agriculture would also be useful. The greatest benefits for both air and water pollution will be realised where target areas coincide and good synergies exist between mitigation measures. Where there are potential trade-offs for a given mitigation measure between air and water pollution, compromises will have to be made, based on the relative importance of the issues for the given catchment, and for these the CSFOs should be given a clear steer on catchment priorities.

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