Nitrates Directive Consultation Document Environmental Impact of the 2009-13 Nitrates Action Programme & of potential further measures.

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Environmental Impact of the 2009-13 Nitrates Action Programme & of potential further measures

CONTENTS

1 INTRODUCTION

1.1 Background

Under the EC Nitrates Directive (91/676), the AP measures and NVZ areas must be reviewed at least every four years and revised if they are not effective at reducing nitrate pollution or do not otherwise meet Directive requirements.

This paper provides an evaluation of the current AP (2009-2013) and potential impacts on nitrate losses of key potential revisions to the AP for 2013-2016. The revisions are divided into 'proposed revisions' and 'potential future revisions'. The proposed revisions have been assessed, where possible, using modelling approaches and data developed under the Nit18 and Closed Period projects. The potential future revisions have been assessed using expert knowledge based on published literature. This report is part of the evidence base under pinning the 'Consultation on the Implementation of the Nitrates Directive in England'. The questions posed in the consultation are reproduced in Annex 1 of this report along with reference to the sections of this report that provide relevant evidence.

The possible future NVZ AP measures which are being assessed in detail are:

- Extend the closed period for spreading slurries or poultry manures by 1 or 2 months into the spring.
- The use of cover crops on land which would otherwise have no established crop during autumn/early winter.
- Increasing the coefficients for manure N efficiency used in the farm-level Nmax nitrogen application limit calculations.
- Changes to the management requirements for solid manure field heaps.

Further potential approaches which may be considered in the longer term include:

- A move towards P based targets and monitoring with full nutrient planning.
- Alignment of the SSAFO and NVZ regulations on slurry storage capacity.
- Encouraging the use of low protein animal feeding (LNF) to reduce the nitrogen content of manures.

Impacts of the proposed AP measures on other pollutants are also assessed. The application of organic manures contributes not only to the loss of nitrate from agricultural land, but also to the loss of phosphorus and other pollutants to water, and ammonia to air. The application of manufactured nitrogen fertilisers contributes to the loss of both nitrate to water and ammonia to air. The assessment draws on research and modelling within Defra's NIT18 project (Monitoring the effectiveness of NVZ Action Programme measures: continuation and development of existing effectiveness evaluation strategy), as well as on recent impact assessments for possible modifications to the NVZ AP, including projects WT0932 (extension of the closed periods; manure use efficiency) and WT1006 (management of field manure heaps).

This paper complements the report 'The evidence base for assessing the impacts of the NVZ Action Programme on water quality across England and Wales' (which gives more detail on the data and methodology used) and 'Economics report for NVZ Action Programme impact assessment'.

1.2 How to use this document

This document is designed to present key messages on the **impact of the previous and current action programmes** within Nitrate Vulnerable Zones. The document is written as a series of single sentence ***headlines***, with a paragraph below which gives more detail. If, after reading the paragraph, the reader needs more information more detail is provided via the references.

2 IMPACTS OF THE CURRENT (2009-12) ACTION PROGRAMME

This section gives estimates of the impact of the current NVZ AP (2009-2013), compared to no Action Programme. Some of the measures within the current NVZ AP were already included in the previous AP (2002-2008), and we have drawn on evidence of impacts from this earlier period where appropriate. Later sections of this document discuss the potential impact of proposed revisions to the AP, and of other potential measures which may be considered in the longer term.

Further details can be found in the full Evidence report (Defra 2011b), and in the references.

2.1 Nitrate loss prior to the NVZ AP

Prior to the NVZ AP (i.e. based on agricultural practices in the year 2000), average annual nitrate loss within the current NVZ area was estimated as 31 kg N per ha of managed agricultural land (Defra 2008a)

NVZ coverage	Nitrate loss to water (kg/ha N)	Phosphorus loss to water (kg/ha P)	Ammonia loss to air (kg/ha N)
Current (2008-12)	31	0.47	20

The NVZ area is largely in Eastern England, and has lower rainfall and a greater proportion of arable farming than England as a whole. For example 67% of the agricultural land within NVZs is arable, compared with about 56% for England as a whole. Both low rainfall and arable farming are associated with relatively high nitrate concentrations in water. More information on the background to agriculture and water quality in NVZs in England may be found in the accompanying evidence paper (Defra 2011b).

2.2 Evidence for changes in management practices under the NVZ AP

The overall impact of a measure within NVZs depends on the local effectiveness of the measure at field scale; and how widely the measure is implemented. The evidence on the extent of changing practices due to the NVZ AP is summarised here.

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Farmers are compliant with NVZ regulations. During the most recent reporting period (2004-7), the Environment Agency's compliance monitoring reported that more than 99% of the 12 000 farmers visited within NVZs were compliant with regulations on manure storage, manure spreading controls, and Closed Periods for manure application, while 97% were compliant in terms of fertiliser application quantity. The most difficult aspect for many farmers

was record keeping, but even here compliance was 95% of farms. Full compliance was reported for 90% of farms. (Defra 2008a). More recent figures (pers com, Environment Agency) would tell a similar story. There is however evidence that many farmers do not as yet have sufficient slurry or manure storage to comply with the 2009-2013 NVZ AP, which will become mandatory in January 2012.

Fertiliser inputs to tillage have fallen within NVZs, especially following manure applications. While average fertiliser inputs were already close to crop requirement, over-fertilisation did occur in some cases. The main reason for over fertilisation was due to insufficient allowance for N supplied by manures (Goodlass and Shepherd, 2004; Defra (2008a). There has been a greater reduction in nitrogen fertiliser inputs to arable crops inside NVZs than outside, consistent with a more detailed consideration of crop N requirement and nitrogen supply from sources other than fertiliser N. There is clear evidence of improved allowance for the N supplied by manures. This trend is reinforced by the increasing cost of fertiliser relative to the price received for crops which has caused fertiliser inputs to decrease independently of NVZ AP measures.

Fertiliser inputs to grass have fallen both inside and outside NVZs. This reduction in N inputs to grassland is part of a long-term trend, which predates NVZ implementation (Defra 2007a), and appears to be driven largely by economics, However, measures within the NVZ AP, and the revision of grassland fertiliser recommendations, will have played a part in encouraging and enabling farmers to maximise the efficiency of nutrient use.

Compliance with some measures within the NVZ AP was already high before designation. Several measures within the NVZ AP reinforced good practice which was already widely adopted. For example, applications of manufactured nitrogen fertiliser in autumn had already fallen to low levels in England before introduction of the NVZ AP (Defra 2002). The additional impact of NVZ measures for which prior compliance was already high, will of course be limited. In such cases the NVZ AP underpins good practice.

2.3 Record keeping

Record keeping is required both to encourage improved management, and to facilitate compliance monitoring. No specific pollution reduction was attributed to record keeping, the impacts for each individual measure are dealt with under that measure.

2.4 Fertiliser quantity: The crop N requirement limit

Nmax and manure N efficiency coefficients

Planning nitrogen use (Leaflet 6)
Before any nitrogen is applied, you must plan the spreading of nitrogen from organic manures and manufactured nitrogen fertilisers to each crop in each field. The plan must show that you have:
• assessed the soil nitrogen supply (SNS);
• assessed the nitrogen requirement of the crop taking into account the SNS;
• assessed the crop available nitrogen supplied from planned applications of organic manures for the crop; and
• calculated the amount of manufactured nitrogen fertiliser that is needed taking into account the contribution of crop available nitrogen from organic manures and the nitrogen requirement of the crop.
Record keeping: *for each crop in each field, you must keep records of your plan including the crop type and date sown, SNS, crop nitrogen requirement, and details of each planned application of organic manure and manufactured nitrogen fertiliser.*

The crop N requirement limit – Nmax (Leaflet 7)
For each of the main crop types, you must make sure that the farm average application rate of crop available nitrogen from livestock manure plus manufactured nitrogen fertiliser does not exceed the maximum application rate (Nmax) for the crop type. You must use the values for the percentage of the livestock manure total N content that is available for crop uptake which are specified in Leaflet 3.
Record keeping: *you must be able to demonstrate compliance with the Nmax limit if required. For each crop in each field, you must keep a record of the amount of nitrogen actually spread including details of each application of organic manure and manufactured nitrogen fertiliser.*

In general, fertiliser applications to crops were already close to the recommended quantities
The British Survey of Fertiliser Practice (BSFP, e.g. Defra 2002; Defra 2007a) shows that average fertiliser N applications to most crops were consistent with the recommendations (RB209, Defra 2011a) and the PLANET software (Gibbons *et al.* 2005), and were less than the Nmax values within the NVZ AP. The Nmax values have been set as the maximum for a range of conditions, and therefore would be expected to be greater than the average recommendation.

The main cause of non-compliance was in relation to adjusting for other sources of N, notably manures. Over-application relative to recommendation was most commonly due to not making full allowance for other sources of nitrogen, in particular livestock manures (Goodlass and Shepherd 2004; Goodlass and Welch 2006).

Manure is an important source of N to crops, and the NVZ measures aim to increase its efficiency of use. Manures can supply 0-150 kg/ha N to the crop in the year they are applied. Manures are applied on about 20% of arable crops and 35% of grassland crops in any one year (Defra 2007a). The 'Manure N efficiency' values within the NVZ AP assign N utilisation by manure type, these values are mandatory and enable farmers to check that they have adjusted for this source. RB209 (Defra 2011a) and PLANET (Gibbons, *et al* 2005) provide detailed field-level calculations.

Limiting the application of manufactured nitrogen fertiliser to the crop requirement, including adjustments for manure N supply, is expected to reduced nitrate leaching by 3-7%. (Lord *et al* 2007). More efficient use of, and allowance for, the nitrate from manures reduces the requirement for manufactured fertiliser, and the loss of nitrate to the environment. The maximum impact is in catchments with high densities of livestock, especially where combined with arable cropping. These are also the catchments which tend to have particularly high losses prior to implementation of the NVZ AP. This estimate assumes compliance with the Fertiliser Manual RB209, as well as with overall farm-scale limits (Nmax limits, Manure N efficiency standards) which are used to assess compliance.

2.5 Closed Periods for Manufactured Fertiliser Nitrogen

2009-12 NVZ AP: Closed spreading periods for manufactured fertiliser
You must not apply manufactured nitrogen fertilisers to land during the following periods (inclusive dates):

Grassland	Tillage land
15 Sep – 15 Jan	1 Sep – 15 Jan

Applications during the closed period will be permitted:
- to specified crops; or
- if written advice is obtained from a FACTS qualified adviser.

Little N fertiliser was applied to autumn crops prior to the NVZ AP, with the exception of crops such as oilseed rape which can show an economic response. Autumn and winter N applications (August to January) have declined since the mid-1980s. By 2002 only about 8% of winter wheat and 16% of winter barley in Britain received autumn N (Defra, 2002). This decline represents recognition that autumn N was not cost effective. The application rate would be low but statistics are not available. This use of N has been prohibited by all NVZ APs since 2002, and the national average usage has declined further since 2002. The NVZ AP does permit autumn N applications to crops such as winter oilseed rape, where there can be an economic response.

Autumn-applied N fertiliser is inefficiently used. Fertiliser applied in autumn is inefficiently used, and much of it is normally leached over winter (Davies and Sylvester-Bradley 1995). Prevention of unnecessary use of autumn N is therefore a very effective measure at the local level, but the area of land where it will result in a change in management is relatively small because use of autumn fertiliser N was already at a low level in England prior to the NVZ AP.

The regulations on timing of application of manufactured N fertiliser have reduced nitrate leaching in NVZs by 0.5 to 1%.

This measure has a very small impact on ammonia loss, and no impact on P loss
Ammonia loss to the atmosphere, ammonium loss to water, and nitrous oxide emissions will all be slightly reduced due to a reduction in fertiliser inputs. P and other pollutants are not affected.

2.6 Organic manure timing (Closed Periods) and slurry storage:

You must not apply organic manures with a high readily available nitrogen content (e.g. slurry, poultry manure and liquid digested sludge) to land during the following periods (inclusive dates):

Grassland		Tillage land	
Sandy or shallow soils	All other soils	Sandy or shallow soils	All other soils
1 Sep – 31 Dec	15 Oct – 15 Jan	1 Aug – 31 Dec*	1 Oct – 15 Jan

*On tillage land with sandy or shallow soils, application is permitted between 1 August and 15 September inclusive, provided a crop is sown on or before 15 September.
Registered organic producers may apply organic manures during the closed periods subject to certain conditions.
From the end of the closed period until the last day in February, the maximum amount you can apply to land at any one time is 50 m3/ha of slurry and 8 tonnes/ha of poultry manure.
There must be at least three weeks between each individual application

Slurry storage enables farmers to make better decisions about timing of slurry spreading. The slurry storage requirement is set to be longer than the Closed Period for spreading, in order to provide insurance against adverse weather conditions or other problems which could prevent spreading immediately the permitted period starts. The impact of improved slurry storage on water quality is included within the calculation of the effects of the Closed Period for slurries and poultry manures.

Risk of nitrate loss due to manure applications is greatest for autumn applications, particularly under arable cropping and on sandy and shallow soils. Manures release nitrate, and over winter this may be lost by leaching before it can be taken up by a crop. This risk is greater on sandy and shallow soils, and also greater under arable cropping because of the low N uptake in autumn. The closed period reduces this risk considerably.

On drained soils, the risks of ammonium-N, phosphorus and microbial pathogen contamination of drainage and surface waters are greatest for winter applications. The risk is highest when slurry applications are made to soils with a soil moisture deficit of less than 20 mm and enough rainfall occurs in the 10-20 days after application to initiate drainflow. In contrast autumn applications (and those from late spring onwards), are low risk.

On sandy or shallow soils the Closed Period can reduce nitrate loss due to manure applications by about 30-50 kg/ha where slurries or poultry manures were previously applied in autumn. Manures applied from January onwards contribute little to overwinter leaching – any nitrate generated will move down the soil profile but is unlikely to be moved beyond rooting depth before the spring.

On sandy or shallow soils, the Closed Period will reduce nitrate leaching by an average of c.5-8%. This value takes account of the proportion of the land area which received slurry or poultry manure in autumn prior to the NVZ AP. The reduction will be greatest in arable areas where large quantities of slurry or poultry manure were previously applied in autumn.

On other soils, the Closed Period will have much less effect on nitrate leaching. Applications are permitted up to the end of September, so that considerable manure applications can continue to take place. On these soils, the risk of nitrate leaching from autumn applications is less severe than for the sandy and shallow soils; while conversely the

risk of direct pollution of watercourses with P, faecal indicator organisms (FIO) and ammonium, as a result of surface runoff and drain flow following winter applications, is more severe, particularly on the heaviest clay soils in surface water catchments (Hodgkinson et al., 2002, Kay *et al.,* 2010, and recent data from Defra project WQ0118) The Closed Period is designed to reduce winter applications on these soils.

The current Closed Periods are expected to reduce nitrate leaching by 0.5 to 1.5% within the NVZ area. The relatively small effect is due to the fact that the most effective Closed Period in terms of nitrate leaching reduction is that for sandy and shallow soils, and these constitute less than 10% of the agricultural land in England and Wales. The Closed Periods on other soils allow substantial inputs in autumn, and are therefore less effective in reducing nitrate loss. The estimate also takes account of the small increase in nitrate at risk of leaching due to the reduction in ammonia emissions, arising from the requirement that slurries and poultry manures be incorporated within 24 hours.

The current Closed Periods are expected to reduce overall phosphorus loss to water by 0.5 to 2%. This reduction is due to a reduction in livestock manure applications during winter, on heavy soils, when the risk of surface runoff and drain flow is greatest. However, this benefit could be partially outweighed by an increase in applications in early spring, risking increased P losses at the time of greatest ecological sensitivity. Losses to water of other manure-related pollutants such as ammonium and faecal indicator organisms will be similarly affected.

The current Closed Periods are expected to reduce ammonia emissions to air by 1.5 to 2%. This reduction is mainly due to the requirement that slurries and poultry manures be incorporated within 24 hours, which has a particularly large impact on ammonia loss from poultry manures.

2.7 Livestock Manure N Farm Limit of 170 kg N per ha of agricultural land

You must not exceed a loading of 170 kg/ha of total N produced by livestock in each calendar year averaged over the area of your holding or land. Britain has been granted a derogation to allow dairy farmers with more than 80% grassland to operate at a higher limit.

NOTE: Reassessment of the impact of this measure is hampered by inadequate statistics: as a consequence of the change to recording cattle numbers via the cattle tracing system, these data are no longer fully 'linked' to farm areas, and the stocking density calculations are unreliable until the full census for 2010 data are released. The assessment is therefore based on 2003 data.

Nutrient loss per head of grazing livestock increases at high stocking density. At high stocking densities, the system tends to become less efficient. Two farms, one stocked at high and one at low density will tend to be slightly more polluting than if they were both stocked at the average, moderate density (Jarvis *et al.* 1996). This measure is intended to discourage very high stocking densities. Where stock are entirely kept indoors, the limit becomes a limit on the land area available for manure spreading.

Current trends are towards intensification / polarisation of the dairy industry. (Defra 2010b) Average herd size on dairy farms is increasing, farms are becoming more specialist,

and stocking densities (cows per ha of land on the farm) are increasing. Total milk output has changed relatively little.

Application of the 170 kg/ha limit will affect about 12% of the NVZ grassland area in England, representing c.42% of dairy cows in NVZs (based on 2006 statistics i.e. just prior to the current NVZ AP) These farmers will have to either apply for a derogation, or take other steps to comply with the limit.

Pig and poultry farms, beef farms and sheep farms are little affected by this rule, Pig and poultry farms have been subject to a spreading limit for some years, e.g. under IPPC legislation (Defra 2010a) and the majority of manure from these farms has long been exported to other farms. The additional effect of the NVZ AP 170 limit is considered to be small. Beef and sheep farms rarely have sufficiently high stocking densities for the measure to affect them.

Mainly grassland farms can apply for a derogation to increase the limit from 170 to 250 kg N/ha (Defra 2008b)

The conditions for a derogation are:

- At least 80% of the agricultural land on the farm must be grass.

Farmers must:

- Prepare a nitrogen and phosphate application plan for each field.
- Plant a crop with a high nitrogen demand immediately after ploughing grassland.
- NOT plough up temporary grassland on sandy soils between 1 July and 31 December.
- NOT plough up an area of grass before 16 January if you have spread livestock manure to that area between the following dates:
  – Sandy soils 1 Sept to 31 Dec
  – All other soils 15 Oct to 15 Jan
- NOT include leguminous or other atmospheric nitrogen-fixing plants in the crop rotation (except grass with less than 50% clover or legumes under-sown with grass).
- Keep a record of your calculation showing compliance with the livestock manure N farm limits plus other records outlined in this leaflet.
- Submit some of these records to the Environment Agency for inspection by 30 April in the calendar year following the derogated year.

The option for a derogation may eventually be phased out.

Between 400-450 dairy farms have so far applied for a derogation, which is a small proportion of affected farms. Compliance with the 170N limit may be achieved in a number of ways, including acquiring control over more land with low or zero stock numbers, or exporting manure to less intensively stocked farms. The option to reduce stock numbers is usually economically less attractive than these other approaches. Farmers may also apply for a derogation in preference to reducing stock numbers. Areas where destocking may be the only practicable response because alternatives are less available were identified as those where dairying is most concentrated, in the **North West, West Midlands** and **South West** regions. It was estimated (Marks and Ryan 2005) that 10-15% of all dairy cows, up to one third of those on farms exceeding the 170 limit, would be in locations where other options are impracticable. These farmers were expected to apply for derogations, and the number of applications is broadly consistent with this estimate.

Application of the 170N limit will reduce nitrate leaching by <0.1% (if there were no derogations). One reason for this modest impact is that, as indicated above, compliance with

the limit can be achieved by approaches which do not involve reduction in stock numbers on the holding. Another reason is that the total number of dairy cows in England is unlikely to change due to this measure, since it is determined by market forces and availability of suitable land. The industry is currently very fluid. If some farmers decide to reduce stock numbers, it is likely that others will increase. The net benefit will reflect the greater N efficiency of moderately stocked systems compared to intensively stocked, but the difference will be small. On farms where a derogation is in force, the impact on nitrate would of course be smaller.

Application of the 170N limit will have very little impact on P and ammonia loss. Since the total number of dairy cows is unlikely to be affected, this measure will have little impact on loss of ammonia to air, or P, FIO etc to waters.

2.8 Organic manure N field limit - 250 kg/ha total N

Repeated applications of large quantities of manure increase pollution risk by excessively increasing the N and P status of the soil (Smith *et al.,* 2002). Other measures within the NVZ AP limit quantities of manure via limits to total manure N at farm level; and via the requirement that crop-available N should not exceed crop requirement. However some manures, e.g. stored straw-based manures, have low crop-available N in the year of application. The limit on manure total N applications is designed to avoid excessive applications of such manures.

This measure will reduce nitrate losses by <1%. Under the crop N requirement limits, applications of manure may already be limited. The main impact of this rule will be on applications of FYM or other manures with low crop-available N, which could otherwise still be applied at very high rates without providing excessive N to the crop. The organic N in these manures is released slowly, and large inputs could lead to build up of soil N supply, causing increased leaching. Although potentially important locally, the national effect will be small because advisory experience indicates that such situations are not common.

This measure will have a small beneficial effect on P losses. The total quantity of livestock manures applied will not be changed. However the risk of build up of very high soil P levels, as sometimes occurs close to livestock holdings, will be reduced. Sites with very high P levels tend to lose a disproportionately large quantity of soluble P. No effect on ammonium or other manure-related pollutants is foreseen.

2.9 Other measures

Several measures within the NVZ AP are aimed at reducing the risk of pollution from surface-applied manures direct to streams. These measures include restrictions on manure applications close to streams, on steep slopes and during conditions where surface runoff is likely.

These measures will reduce the risk of pollution incidents, and of loss of P, FIOs and ammonium to water. Estimating the exact impact of these measures is difficult, but the number of pollution incidents associated with manures fell between 2003 and 2007. More recent figures (2005 to 2010) show that the number of category 1 and 2 pollution incidents have remained roughly constant while incidents related to the water industry continue to fall.

These measures will have less impact on nitrate leaching. Most nitrate derived from manures reaches waters by leaching (through the whole soil profile) rather than by surface runoff (Lord 1992; Smith et al., 2001). Therefore measures which limit surface runoff have

little effect on nitrate loss. In contrast, pollutants such as phosphorus, bacteria, ammonium and organic contaminants, derived from manures, reach streams mainly via surface runoff or drain flow, and it is these pollutants which will be most affected by such measures.

2.10 Summary of impacts: Nitrate, Phosphorus and ammonium

The modelled changes due to the measures within the 2009-13 NVZ AP (relative to no NVZ AP) are summarised below (Defra, 2008a). Negative values signify a reduction in nitrate pollution

Measure	Nitrate	Phosphorus	Ammonia
Compliance with the crop N requirement limit (Nmax)	-3 to -7%	0	small
Closed period for manufactured fertiliser	-0.5 to -1%	0	very small
Closed period for high available N manure applications, and must be incorporated within 24h	-0.5 to -1.5%	-0.5 to -2%	- 1.5 to -2%
Livetsock Manure N Farm Limit of 170kg N/ha, with derogation	0 to -0.1%	0 to -0.1%	0 to -0.1%
Other NVZ AP measures	Very small	Very small	Very small

3 POTENTIAL IMPACTS OF ADDITIONAL MEASURES PROPOSED FROM 2013

The assessment of impacts reported in this section are reported as percentage decrease or increase in nitrate leaching from the 2009-2013 AP.

3.1 Extending the Closed Period for slurries and poultry manures

You must not apply organic manures with a high readily available nitrogen content (e.g. slurry, poultry manure and liquid digested sludge) to land during the following periods (inclusive dates):

Option 1: Closed periods remain unchanged.

Grassland		Tillage land	
Sandy or shallow soils	All other soils	Sandy or shallow soils	All other soils
1 Sep – 31 Jan	15 Oct – 15 Jan	1 Aug (15 Sep) – 31 Jan	1 Oct – 15 Jan

Option 2: Extend by 2 weeks for soils other than sandy or shallow.

Grassland		Tillage land	
Sandy or shallow soils	All other soils	Sandy or shallow soils	All other soils
1 Sep – 31 Jan (No change)	15 Oct – 31 Jan	1 Aug (15 Sep) – 31 Jan (No change)	1 Oct – 31 Jan

Option 3: Extend by 1 month for soils other than sandy or shallow

Grassland		Tillage land	
Sandy or shallow soils	All other soils	Sandy or shallow soils	All other soils
1 Sep – 31 Jan (No change)	15 Oct – 15 Feb	1 Aug (15 Sep) – 31 Jan (No change)	1 Oct – 15 Feb

*On tillage land with sandy or shallow soils, application is permitted between 1 August and 15 September inclusive, provided a crop is sown on or before 15 September.
Registered organic producers may apply organic manures during the closed periods subject to certain conditions. From the end of the closed period until the last day in February, the maximum amount you can apply to land at any one time is 50 m3/ha of slurry and 8 tonnes/ha of poultry manure.
There must be at least three weeks between each individual application

There is pressure from the EC to extend the Closed Period to cover a greater proportion of the winter period during which risk of surface runoff is greatest. The objective is to minimise the risk of direct pollution of surface waters with manure-derived pollutants (such as P, FIOs and ammonium).

Risk of nitrate pollution is greatest for manure applications made in autumn. This is because the N will not be efficiently taken up before winter leaching begins. Applications from mid winter onwards are less risky because the manure-derived nitrate will usually still be within rooting depth by the end of winter. Most nitrate is transported by leaching through the soil profile, as rainfall displaces soil water, and this process takes several months of drainage. (On clay soils, some nitrate losses may occur even after late winter or spring applications, carried by rapid flow to drains, which bypasses the soil matrix)

Risk of pollution by phosphorus, ammonium, faecal organisms and manure solids is greatest for manures top dressed in winter or early spring, especially on clay soils. These pollutants move via surface runoff or, on clay soils, by rapid flow to drains during heavy rain. Such flow is most likely when soils are wet e.g. in winter. Incorporation of manure into the soil reduces the risk of pollution via these pathways. Risks are therefore smaller for autumn applications especially where these are incorporated promptly.

Risk of pollution by ammonia volatilisation to air is greater when manures are left on the surface, and in warmer weather.

The 'Closed Period' will result in a change of manure timing, and must be designed to minimise any adverse effects of such change. A very prolonged Closed Period could increase manure applications in summer, which would increase the risk of ammonia emissions. It could limit the opportunities for spreading to the extent that farmers are forced to spread when conditions are less than ideal, thereby increasing pollution risk, or could result in manure spreading becoming concentrated during a very short period in spring, with resultant risk of a surge of pollution into water bodies if rain follows.

An extension of the Closed Period in winter by 1 month is expected to reduce nitrate leaching by a further 0.2 to 0.4% of baseline loss, beyond the benefit of the current Closed Period. It is expected to reduce phosphorus loss by a further 0.3 to 1% of baseline due to reductions in winter applications to heavy soils. However it is likely to increase ammonia emissions by 0.3-0.5% of baseline, due to increase slurry and poultry manure applications in summer.

3.2 Increasing the livestock manure N efficiency standard values used in Nmax calculations

You must use the livestock manure N efficiency standard values given in the table below in Nmax calculations.

Grassland		Tillage land	
Manure type	Current NVZ AP from Jan 2009 to end of 2011	Current NVZ AP from January 2012	Proposed values in next NVZ AP
Cattle slurry	20	35	40
Pig slurry	25	45	50
Poultry manures	20	30	30
FYM	10	10	10

The proposed increase in the manure N efficiency coefficients would have little effect on fertiliser use or nitrate losses. The Nmax and Manure Efficiency coefficients are used for checking nitrogen inputs against the crop N requirement limits (Nmax) for the whole area of the crop on the farm. This approach allows some flexibility for nitrogen inputs at the individual field level. The crop-specific Nmax values, being maximum values to represent a multitude of situations, are necessarily often greater than the average recommendation, providing further flexibility. Even after the proposed increase in the manure N efficiency coefficients, most farmers would still be able to use the economic recommendation while remaining within the Nmax limits. The increase in coefficients reinforces good practice, and provides encouragement towards more efficient use of manure N.

3.3 Changes to the restrictions on solid manure field heaps

The Action Programme does not require any amendments with respect to the temporary storage of solid manures in field heaps.

Field heaps of manures can be a source of both ammonia emissions and seepage of pollutants to waters. Current NVZ AP restrictions require that they be sited away from watercourses and field drains. Pollution incidents have arisen from such heaps when badly sited, especially on impermeable soils.

Experimental data suggest that losses from such heaps are in fact usually modest. The main factor affecting loss to water is location of the heap. If heaps are well sited, as required under the NVZ AP, the total national impact on water quality is small.

The cost of preventing or collecting all seepage would be very great compared to the benefit.

3.4 Cover crops

Establish green cover by 15 September on sandy and shallow soils within Groundwater NVZs which would otherwise have no crop present from 1 September to 15 January. Cover crop to be destroyed no earlier than 15 December. The type of crop used to provide cover is not significant for reducing nutrient losses. Acceptable cover crops would include:

- Natural greening up of stubbles (cover crop).
- Scratch and broadcast of tailcorn (cover crop).
- Stubble turnips (catch crops, used as fodder).

Assessment of the impact of cover crop on nitrate, phosphorus and sediment losses has been undertaken by modelling using the ADAS Pollutant Transfer model (APT). A description of the model and a more detailed assessment of the impacts are presented in the full Evidence report. (Defra 2011b)

Establishment of cover crops only on "sandy soils" as defined within the NVZ AP would have an impact of <1%. This is because these soils occupy only 5-10% of the NVZ area. Establishment of cover crops on all land with spring cropping would reduce nitrate leaching from agricultural land within NVZs by 4 - 7%.

Cover crops reduce nitrate loss by 40% on average where used (Lord, 1999; Shepherd, 1999). They are particularly effective where the soil nitrate supply in autumn is high, for example where manures are used. Catch crops such as stubble turnips, if sown early and unfertilised, have the same effect.

Cover crops as defined above could be grown on 15-20% of land in NVZs. Suitable rotations with spring crops are more common on medium to light soils. Rotations based on autumn-sown crops, typical of heavy soils, offer no opportunities for cover crops.

The implementation of cover cropping is compatible with stubble management for overwintering birds. There has been concern that establishment of cover crops could reduce the area of stubbles available to overwintering birds. However, there is an emerging consensus on the overall benefits which different 'designs' of cover crops could bring to both diffuse pollution and over wintering birds (Chris Bailey, RSPB, pers. comm.) Cover and catch crops can be established very effectively in stubbles (e.g. stubble turnips) and avoidance of ploughing increases both their effectiveness for nitrate reduction and their value to birds. There is a need for a full examination of the ecosystem services which uncropped land can provide over winter, and of the role of different types of green cover within these.

Cover cropping is not compatible with some farming situations. Cover crops need to be sown by early September if they are to be effective, and are therefore not suitable following most maize and beet crops, and some potato crops. On heavier soils, farmers seeking to establish spring crops may prefer to plough in autumn, to allow seedbeds to weather. This practice may make establishment of autumn cover impractical. However these heavier soils typically have a smaller proportion of spring cropping.

Cover cropping may be most appropriate in targeted situations such as drinking water aquifers, where nitrate reduction is of particular importance and the farming system is suitable. The soils over groundwaters tend to be lighter and easier to cultivate which makes them, more suited to spring crops. Cover crops would therefore be most successful here (as has been demonstrated within Nitrate Sensitive Areas). Reducing nitrate in groundwaters used for drinking water affects the costs of providing water compliance with quality targets. Here, 30-40% of fields may be suitable for cover cropping so N reductions could be 10-15%. This measure will be particularly effective in catchments with high soil N i.e. where manures regularly used.

Cover crops would reduce sediment and P loss, and loss of other manure-derived pollutants to surface waters within NVZs due to the protective effect of crop cover against surface runoff and erosion. The range of impacts is estimated to be very small if cover crops are restricted to sandy soils, chiefly because of the small area involved. If cover crops were required on all soils the overall reduction in losses to water is estimated as 0 – 1% for P and 0 – 2% for sediment.

3.5 Align storage requirements under the SSAFO (Silage, Slurry and Agricultural Fuel Oil Regulations) to the NVZ regulations

Align the methods for calculating storage volumes required under the SSAFO regulations with the method used in the current NVZ regulations. This change will not mean any change within NVZs.

The SSAFO regulations apply to new slurry stores, and use a different calculation than under the NVZ regulations. Aligning the calculation method for the size of a slurry store so that the SSAFO regulations require the same volume of storage as required in NVZs simplifies regulation. It also ensures that farmers who re-build their slurry stores will not have to make further storage provision should they subsequently be included within a new NVZ.

The SSAFO regulations can result in a smaller storage requirement than the NVZ regulations – although this depends on farm circumstances and rainfall. The estimated typical difference is 0.5 months storage on dairy farms, and 1.5 months on pig farms.

This measure would tend to increase storage provision outside of NVZs, and improve the potential for control of direct manure pollutant losses from winter applications. This impact will actually be more effective outside than inside NVZs because the areas outside the NVZs tend to be wetter with ecologically more sensitive rivers.

SSAFO regulations only apply to farmers who are renewing their storage provision. They are not tied to regulations on manure application timing. Any impact of this measure on water quality is therefore uncertain, and would take many years to take effect.

4 POTENTIAL IMPACTS OF OTHER POSSIBLE MEASURES NOT INTENDED FOR IMMEDIATE IMPLEMENTATION

4.1 Move towards P based targets and monitoring and full nutrient planning

Possible measure formulation: Farm P balance shall not exceed 5 kg/ha P2O5 annually per ha of arable crop, and 25 kg/ha P2O5 per ha of managed grassland.

Currently more P is applied to land than is removed in crops or produce, causing a build-up in soil P levels. The total P surplus across England in 2004 was 72 kT P (about 9 kg P per ha of agricultural land) (Lord et al., 2010; Clothier, 2011). This was a little smaller than the P input as fertiliser (90 kT P, 11 kg/ha) and roughly equal to the P input as livestock feed. On arable systems where manure is not used, P inputs are generally in balance with off take (this is the principle used in fertiliser recommendations). However where manure is used, and in grassland systems, P inputs as feed may already be enough to balance most or all P removed in product – fertiliser is therefore largely surplus to requirement.

There is substantial scope for reduction of P, fertiliser inputs by more effective deployment of P from manure, especially on grassland farms. The 2004 data indicate substantial scope for fertiliser reduction by more efficient use of the P in manures. P inputs have been falling, due partly to the cost of fertiliser, and by 2008 were already 30% below

their 2004 value for England (Defra 2009). Continued improvement will require more accurate adjustment for P supplied, and in many cases, more even distribution of manure to allow full use to be made of the P it contains.

Typical P surplus is greater in grassland (especially dairy) than arable systems
Within arable systems, the P surplus is often close to zero but there is probably further scope for improvement on farms using manures especially poultry manure, which has a very high P content. (Lord *et al.,* 2010; Goodlass *et al*., 2006 and data from Defra project ES0124 Farm Nutrient Auditing). The surplus is greater on livestock farms than arable, and the import of P in feed especially on dairy farms is often greater than the output as product. As a result the balance could not be reduced to zero without change to diets.

	Inputs	Off take	Balance
Feed	43		
Fertiliser	27		
Product		-24	
Balance			46

Table 4.1. Main inputs and outputs of P (kg/ha P2O5) from surveyed commercial dairy farms, c.2002 (Source: Defra project ES0124).

Northern Ireland has gone part way down this route by setting both N and P targets, we need to learn from their experience about what worked and any unintended consequences.
To minimise costs, any measure would need to allow some headroom for fertiliser inputs to land not suitable for manure spreading.

The use of full nutrient planning is credited with enabling the Danish AP to be the most effective in Europe. The process of developing and maintaining these plans has been found to increase farmer awareness of the value of their nutrient resource as well as improving their understanding of the consequences of poor nutrient management. This measure would carry significant costs for the industry.

We already have the tools required to make more efficient use of P (PLANET, Gibbons *et al.* 2005) and with the current high fertiliser prices a P based target would be more acceptable and would provide a cap on P inputs which could protect against future price reductions.

The impacts of a P target and full nutrient planning in the short term are likely to be a reduction in the losses of soluble P. Over a considerable period of time losses of particulate P will also be reduced as soil P levels drop. There will be no impact on N, ammonia or ammonium.

4.2 Encouraging the use of low protein animal feeding (LNF) to reduce the nutrient content of manures.

Where productivity is not compromised, reducing dietary N intake increases the efficiency of feed N utilisation. Considerable variation exists for N utilisation by livestock with much of the variation attributable to feed selection, livestock management, increased productivity, age of livestock, or health status. There is therefore considerable scope for increasing N utilisation – and thereby reducing N excretion – from the adoption of currently available technology.

The environmental benefits of low N diets have been widely reported, and they have been adopted across many livestock sectors in the UK and EU. In the absence of any comprehensive data on feed use data in the UK, however, the extent to which they are being used here – and the scope for any further reductions in N excretion - is unknown (Lord *et al*., 2010).

5 IMPACTS OF THE CURRENT NVZ AP (2009-2013) ON WATER QUALITY AT CATCHMENT SCALE

The current measures are estimated to reduce nitrate leaching from agricultural land within NVZs by 1-8%, with potential to perhaps double this (at most) by further measures. But these headline figures hide great variation between catchments. The factors affecting impacts are discussed below.

5.1 Effect of local agricultural activity

The impact of the NVZ AP is dependent on location. At the scale of an individual field the impacts of the NVZ AP can be large. However, when the impacts are averaged to NVZ or national scale they will be smaller, because the measure is applicable to only a small area of land in any given year. For example, less than 20% of arable land receives manure in any one year as a result losses associated with changes to the closed period will be smaller when presented as an average over the NVZ area compared to the field scale.

The NVZ AP will have had significant impact in losses from agricultural land in some groundwater NVZs, notably where there are large livestock numbers and arable cropping, on sandy or shallow soils. These areas are those where leaching is currently elevated due to high livestock numbers and intensive arable cropping; and where leaching risk is also high. Cover crops can be highly effective in GW catchments.

5.2 Effect of soil type

Nitrate concentrations tend to be greatest in leachate from light soils. These light soils (including sandy and shallow soils) are more common in groundwater than surface water NVZs.

The impacts of the current closed period for organic manures vary according to soil type. Autumn applications (which carry the greatest risk of nitrate leaching) are more restricted on sandy or shallow soils than on other soils. Other, heavier soils, are more common in surface water catchments.

5.3 Effect of climate

Nitrate concentrations are greater in drier areas. In wetter climates, nitrate concentrations tend to be lower (although the total quantity of nitrate leached tends to be greater). Furthermore, wetter areas in England tend to have a greater proportion of grass land, and as rainfall increases further, stocking densities on the grass decrease. These factors combine to create a general trend for greatest nitrate concentrations in the driest areas of the country, which is broadly reflected in the location of NVZs.

Average nitrate concentrations under arable cropping usually exceed 50 mg/l
Nitrate losses under arable cropping are on average greater than under grass. In addition most arable cropping (other than fodder crops) is in areas where rainfall is low to moderate. Achieving compliance with the 50 mg/l threshold at catchment-scale generally depends on the presence of non-agricultural land or extensive grassland.

5.4 Effect of catchment type (Surface water dominated or Groundwater dominated)

Many surface water catchments are fed by impermeable (clay) soils. This means that it takes only hours or at most days for water to move from the field to the stream. Water quality is highly responsive to weather and to agricultural management practices. Nitrate concentrations in such streams are very variable. In order to avoid breaching the 50 mg/l threshold, average nitrate concentrations would typically need to be below 30-35 mg/l. (Defra 2011)

Groundwaters in England – especially those used as water supplies – are usually deep and have long residence times. It can take decades or more for the impact of agricultural changes to be fully apparent in the water abstracted at boreholes. The concentrations of nitrate tend to be relatively constant compared with surface waters, because of the mixing which takes place during the years in which the water moves to the abstraction point. (Defra 2011b)

6 CONCLUDING REMARKS

At the national scale the impact of the current NVZ AP is modest, and is focussed on farms with livestock and/or manures. The inclusion of cover crops into the NVZ AP in the future could significantly increase the national impact of the NVZ AP, and would increase the impact of the NVZ AP within arable areas, provided the measure was widely applied.

Impacts are spatially variable, and within individual catchments may be substantially greater than the national mean.

Assessment of a range of other measures, and experience with previous schemes, suggests that there are limits to the reduction in nitrate leaching which can be achieved using management change alone (Lord *et al*., 2008). There are many areas of the country where nitrate concentrations will remain above 50 mg/l unless there is substantial land use change and/or reduction in livestock numbers. Nitrate losses from manures in the year of application are estimated to account for 3-4% of the total nitrate load, and this sets a limit to improvements attainable via the Closed Period approach.

A number of measures have been identified which reduce the risk of other pollutants (P, FIOs, ammonium, sediment) reaching waters. Some of these relate to manure management, and the current NVZ AP Closed Period takes account of these risks. The NVZ AP also includes other measures aimed at reduction of these pollutants, while some relevant measures are implemented (both within and outside NVZs) via other schemes.

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Annex 1: Questions from the 'Consultation on Implementation of the Nitrates Directive in England' and the supporting evidence that can be found in this document.

Question 3: Do you agree that crop available nitrogen from all types of organic manures should count towards the Nmax limits?

- Section 3.2. Increasing the livestock manure N efficiency standard values.

Question 8: Which of the 3 closed spreading period options do you prefer?

- Section 2.6. 2009 to 2013 closed period.
- Section 2.10. Summary of pollutant losses under the 2009 to 2013 Action program.
- Section 3.1. Extended closed period.
- Section 5.1. The impact of scale on predicted losses
- Section 5.2. The impact of soil type on predicted losses.

Question 13: Do you agree that the Action Programme does not require any amendments with respect to the storage of solid livestock manures?

- Section 3.3

Question 16: Do you think cover crops should be included in the Action Programme?

- Section 3.4