NITRATE VULNERABLE ZONE
ACTION PROGRAMME
REGULATIONS

Assessment Of The Benefits And Costs Of Changes To The Nitrate Vulnerable Zones Action Programme In Scotland (SCL/010/05)

Report prepared for the Scottish Executive Environment and Rural Affairs Department

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PROPOSED MEASURES

Article 3 of the Nitrates Directive (91/676/EEC) requires that waters affected by pollution, and waters that could be affected by pollution, shall be identified in accordance with criteria set out at Annex I of the Directive. It also requires that all known areas of land which drain in to the waters so identified should be designated as Nitrate Vulnerable Zones (NVZs). Article 5 of the Directive states that action programme measures designed to limit inputs of nitrate from agricultural sources in NVZs shall be established and implemented within specified timescales.

As a result of the extended monitoring by SEPA, polluted surface waters have been identified in Angus and the Borders. BGS identified candidate groundwater NVZs where catchments with a high risk of nitrate contamination of groundwaters from diffuse agricultural sources are coincident with highly vulnerable aquifers. The proposals for NVZs in Moray; Aberdeenshire, Banff & Buchan; Strathmore & Fife; Lothian & Borders; and Nithsdale have been verified against water quality monitoring data from a range of sources including SEPA's extended groundwater monitoring network.

The Nitrates Directive requires the Action Programme to be reviewed periodically. A report to the Commission considered the risk of nitrogen losses (nitrates, but also other nitrogen forms) by run-off and leaching and the measures to control this in the Action Programmes for Member States. Since then, further research on a Great Britain basis has been carried out by ADAS, based on scientific evidence and specific agricultural, soil and climate conditions. This showed that there is a significant risk of run-off or leaching of nitrates in the winter months and that the risks are substantial on agricultural soils generally, not just on sandy or shallow soils.

CHANGES TO THE ACTION PROGRAMME

A number of changes are proposed to the NVZ action programmes. There are four major elements to these changes, namely;

1. *Organic manure deposition of 170 kg N/ha to apply to grassland as well as other agricultural land.*

The present permitted limit of 250 kg N/ha from organic manure applied to grassland is to be reduced to 170 kg/ha N.

2. *A proposed change to the closed period for the application of some types of organic manures*

Arable Land

The current closed period for spreading organic manures with high available N (slurries and poultry manures and liquid digested sewage sludge) applied to arable land, applies to shallow and sandy soils only. The closed periods are between 1 October and 1 November for autumn sown crops and between 1 August to 1 November in any other case.

The Contractor is asked to assess the effects of the closed period being from 1 August to 15 January and of it applying to <u>all soil types on arable land. However, the following exemptions will apply:</u>

- on other soils in arable cropping, organic manures with high available N (slurries and poultry manures and liquid digested sewage sludge) may be applied from harvest up to 30 September, provided that a crop is sown by 15 October, and

- on sandy and shallow soils in arable cropping, organic manures with high available N (slurries and poultry manures and liquid digested sewage sludge) may be applied on cereal crops between harvest and 15 September provided that the land is drilled with a cereal crop by 15 September, or with oilseed rape, catch crops and cover crops by 1 October.

Grassland
For grassland the extended closed period applies to all soil types and has a number of variants, specifically;

i) *Sandy and Shallow Soils*

Main Proposal:	1/9 to 15/1
Variant I:	1/10 to 15/1
Variant II:	1/9 to 31/1

ii) *Other Soils*

Main Proposal:	15/8 to 31/1
Variant I :	15/10 to 1/2

It is envisaged that the closed period for *inorganic fertilisers* will remain as in the current Action Programme, i.e. applying to all soil types and lasting from 15th September to 20th or 15th February for grassland, depending on the NVZ.

3. Farmers are required to complete a manure management plan
Whereas previously farmers were asked to complete a fertiliser and manure plan, a manure management plan (MMP) requires more detail. A MMP does not replace the fertiliser plan that contains an assessment of crop and grass requirement for nitrogen fertiliser in each field taking account of nitrogen supply from soil organic matter, crop residues and organic manure. A full specification for a MMP is outlined in Appendix 4. However, the main requirements are:-

- Calculation of quantities of livestock slurry and manure produced
- A detailed description of a farm's existing collection and storage systems
- A farm risk assessment map, including identification of steep slopes within the farm
- A description of the typical cropping on the farm
- A monthly land availability schedule, taking account of risks associated with spreading in each field.
- Details of the days available for spreading each month.
- Accumulated production and distribution schedule
- A contingency plan, for extreme weather conditions etc.

4. Limitation of land application of fertilisers
Farmers may be required to adhere to the NVZ Guidelines (Scottish Executive, 2003) on application of fertilisers as a maximum. This may involve a maximum N limit for each crop which the farmer must not exceed.

The following categories of farms were identified as being most likely to be affected by the introduction of the Action Programme Regulations in the NVZ designated areas.

- Cereals and General Cropping
- Mixed livestock
- Specialist pig farms
- Cropping and sheep
- Cattle and sheep
- Cropping and intensive livestock
- Specialist poultry
- Cropping and dairy
- Dairy farms

These farm types produce and use large quantities of slurry and the closed period restrictions for the application of slurry to land will impact on many of them. This may require the provision of new or additional slurry storage facilities to cover the period when land application is not permitted.

IMPACTS ON NVZ'S

The main benefits of implementing all these elements will arise from reducing the inputs of nitrate to waters in the NVZs. However, it should be emphasised that this study is restricted to secondary data collection. To quantify the costs and benefits more accurately would require a detailed investigation of individual farms following the collection of primary data.

Element 1 - Organic manure deposition of 170 kg N/ha to apply to grassland as well as other agricultural land.

The change in the limits results in the area of land on farms which exceed the limit more than doubling, and the effect is seen most strongly on dairy and cattle farms. The proportion of land on specialist farms, e.g. pigs and poultry etc., which have a surplus of excretal N remains high.

The increase in N surplus arises mainly in the dairy and cattle farms. The increase is numerically greater on cattle farms, but proportionally greater on dairy farms. It is likely that the increase on cattle farms is due largely to their dairy component. The mean N loading from livestock excreta to land plus manure application is 42 kg N per ha of agricultural land . Loadings on dairy farms are much greater, averaging 153 kg N per ha, which is close to the proposed limit of 170. Loadings are also very large on the (relatively few) pig and poultry 'specialist' farms.

About 17% and 6% of dairy and cattle farms respectively are in surplus in relation to current limits, and about 37% of dairy farms, and 12 % of cattle farms, are in surplus under the new limits. The proportion of 'special' farms in surplus is already substantial, and increases little (from 26.8 to 28.5%). Livestock manure and excretal N surplus increases by 18.7% with the new farm-level limits, from 9.8% of excretal N to 11.6%.

The total cost of additional slurry storage for pig and dairy farms across the whole area of the NVZs is therefore estimated at:

- £1,355,950 for the case of "blanket" 5-months storage requirement; and
- £1,434,825 for the case of 6-months storage requirement (considering 26 weeks storage requirement for pig and poultry farms).

If 70% of units require storage the total cost will be:

- £949,165 for the case of "blanket" 5-months storage requirement; and

- £1,004,377 for the case of 6-months storage requirement (considering a 26 weeks storage requirement for pig and poultry farms).

Some of the additional slurry storage above may be substituted with the cost of midden improvements without altering the overall cost. The remit of the current study did not allow a detailed assessment of the number or state of middens in the NVZs.

There will also be annual costs to the farmer associated with the necessary construction of new slurry storage facilities. The estimated total annual cost across the whole area of NVZs will be:
- £185,395 for the case of "blanket" 5-months storage requirement; and
- £192,494 for the case of 6-months storage requirement.

If 70% of units require storage the total annual cost of maintenance and depreciation will be:
- £129,777 for the case of "blanket" 5-months storage requirement; and
- £134,746 for the case of 6-months storage requirement.

It is also likely that a loan will be required to pay for the new slurry storage facilities. There will be annual costs relating to interest and repayment charges. The charges have been estimated assuming an interest charge of 6% and a repayment term of 3 years.

Under these circumstances the estimated annual cost to farmers over the 3-year loan repayment term across the whole area of NVZs will be:
- £165,873 for the case of "blanket" 5-months storage requirement; and
- £175,521 for the case of 6-months storage requirement.

If 70% of units require storage the total annual cost over the 3-year loan repayment term will be:
- £116,111 for the case of "blanket" 5-months storage requirement; and
- £122,865 for the case of 6-months storage requirement.

Element 2 – Extension of Closed Periods

Under average rainfall conditions, very little manure-derived nitrate will leach from applications made after the end of December and especially after mid-January. These conclusions are supported by extensive experimental data.

The data indicate that extending the closed period from late autumn to January will prevent all or most nitrate leaching associated with the manure applied in the current season.

The proportion of total N which is potentially available to the crop from these manures is 40 – 60%. After allowing for volatilisation, this falls, to about 24-50% depending on conditions. When the manure is applied in the autumn, on sandy soil, all of the available N (i.e. N convertible to nitrate) is leached. On the medium soil, about 80% of the N at risk of leaching is actually leached from an autumn application to arable land, or 64% from an application to typical grassland (assuming the grass crop takes up some of the manure N). When the manure is applied in spring, or indeed from mid January onwards, these losses are prevented. The N is available for uptake by the growing crop.

These calculations assume that the management of manure is not affected by the change in timing. It is assumed that manures applied in late winter/ early spring will be incorporated. If this is not the case, volatilisation losses may be greater, thereby reducing the N available to the crop.

The total cost of additional slurry storage for pig and dairy farms across the whole area of the NVZs due to the extension in this closed period is estimated at:

- £18,133,764 for the case of "blanket" 5-months storage requirement; and
- £21,169,645 for the case of 6-months storage requirement (considering 26 weeks storage requirement for pig and poultry farms).

If 70% of units require storage the total cost will be:

- £12,693,635 for the case of "blanket" 5-months storage requirement; and
- £14,818,752 for the case of 6-months storage requirement (considering 26 weeks storage requirement for pig and poultry farms).

As was the case with the reduced N deposition limits some of this additional slurry storage may be substituted with the cost of midden improvements, again without altering overall costs.

There will also be annual costs to the farmer associated with the necessary construction of new slurry storage facilities. The estimated total annual cost across the whole area of NVZs will be:

- £1,806,279 for the case of "blanket" 5-months storage requirement; and
- £2,079,508 for the case of 6-months storage requirement.

If 70% of units require storage the total annual cost of maintenance and depreciation will be:

- £1,264,395 for the case of "blanket" 5-months storage requirement; and
- £1,455,656 for the case of 6-months storage requirement.

It is also likely that a loan will be required to pay for the new slurry storage facilities. The charges have been estimated assuming an interest charge of 6% and a repayment term of 3 years. The estimated annual cost to farmers over the 3-year loan repayment term across the whole area of NVZs will be:

- £2,218,293 for the case of "blanket" 5-months storage requirement; and
- £2,589,671 for the case of 6-months storage requirement.

If 70% of units require storage the total annual cost over the 3-year loan repayment term will be:

- £1,552,805 for the case of "blanket" 5-months storage requirement; and
- £1,812,770 for the case of 6-months storage requirement.

Element 3 – Completion of a Manure management Plan

Completion of a manure management plan is beneficial, in that it ensures that all the issues are considered in advance. Under the Action Programme, rules are laid down for manure management. Completion of a manure management plan adds nothing in principle to these requirements, i.e. does not necessarily affect farm management practice. No additional impact on nitrate leaching is therefore calculated.

A manure management plan will however reduce the risk of breach of the regulations caused by lack of planning or foresight. It will also increase transparency – it is

easier during compliance checking to demonstrate that the requirements of the Action Programme have been taken into account.

Costs for the preparation of MMPs have been estimated for each of the main farm types on the basis of time required and hourly costs of SAC Consultancy Services and are presented in Table E1. The time requirements for MMP preparation vary across the farm types from 1 hour at a cost of £60 per hour for specialist fruit and horticulture farms to 20 hours and a cost of £1200 for specialist livestock farms.

Table E1. Estimated consultant time requirements and costs for Manure Management Plan preparation classified by farm type.

Main Farm Type	Hours	Cost (£)
Cereals & General Cropping*	2	120
Specialist Fruit, Grass & Other Horticulture	1	60
Specialist Pigs	20	1,200
Specialist Poultry	14	840
Mixed Pigs and Poultry	20	1,200
Dairy(LFA & Lowground)	20	1,200
Cattle & Sheep	11	660
Cropping & Dairy	20	1,200
Cropping, Cattle & Sheep	11	660
Cropping & Intensive Livestock	14	840
Cropping & Mixed Livestock	11	660
Mixed Livestock	11	660
Specialist Grass & Forage	6	360
Specialist Horses	4	240

* Assumes no livestock present on farm.

Across the four NVZs the upper bound cost of MMP preparation is estimated to total £5,961,060; with the following costs in each NVZ:

- Moray, Aberdeenshire, Banff and Buchan: £2,939,820;
- Fife and Strathmore: £1,490,280;
- Lothian and Borders: £924,180; and
- Nithsdale: £606,780.

Balanced against the costs of preparing a MMP, are the off-set risks of non-compliance. These relate not only to the compliance with specific NVZ measures, but also for farms in receipt of the Single Farm Payment, penalties associated with non-compliance with Good Agricultural and Environmental Condition (GEAC) standards. Failure to follow NVZ Action Programme measures constitutes non-compliance with GAEC conditions.

Failure to comply with NVZ Action Programme or with associated SEERAD notices measures are criminal offences. Penalties include a maximum fine of £5,000 upon summary conviction or an unlimited fine if convicted upon indictment.

Element 4 - Limitation of land application of fertilisers

The evidence from survey data (for example the British Survey of Fertiliser Practice) indicates that the main improvement required in compliance with crop economic fertiliser requirement, is improved adjustment of fertiliser inputs for local/ annual circumstances, including N supplied from manures; N residues from previous crops; and soil type.

Based on experimental data, improved compliance with detailed fertiliser recommendations would be economically beneficial to farmers by either reducing costs or increasing yield or quality of the crop.

Table E.2. shows the effect of a SYSTEMATIC change in N input relative to current recommendation, over a number of years, on the risk of nitrate leaching. The change in soil mineral nitrogen (i.e. nitrate plus ammonium, SMN) due to an increase or decrease in input of 20 kg/ha N was 10 or 8 kg/ha N. An increase or decrease of SMN in late autumn indicates a corresponding change in N at risk of leaching. In dry areas, not all of this would leach. The change is equivalent to a 10-20% change in nitrate leaching depending on soil type.

Table E.2. Effect of change in fertiliser inputs, relative to the economic optimum, on profit; and on autumn SMN. Date from medium-term experiment on clay soil (Ropsley).

Fertiliser input relative to optimum	Change in yield	Effect on autumn SMN
kg/ha N	t/ha grain at 85% Dry Matter	kg/ha N
-40	-0.3	-13
-20	-0.1	-8
Optimum	0	0
20	0.1	10
40	0.2	23

Summary Cost and Benefits Per NVZ

Total compliance cost-benefits from all sectors for Moray, Aberdeenshire, Banff and Buchan NVZ:

All sectors	expected costs	expected benefits
Completion of a Manure Management Plan	£ 2.630 – 2.940 m	No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.

Limitation of organic N application	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs:				
Maintenance of capital items 5% and depreciation 4% and 20%	£ 0.033 - 0.047 m	£ 0.033 - 0.048 m	Protection of environment. No costs for non-compliance with NVZ.	Protection of environment. No costs for non-compliance with NVZ.
Finance charges on capital loan	£ 0.030 - 0.042 m	£ 0.030 - 0.043 m	No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
Transportation costs	£ 0.076 - 0.076 m	£ 0.076 - 0.076 m		
One-off cost:				
New slurry storage	£ 0.242 - 0.345 m	£ 0.248 - 0.355 m		

Extension of closed periods	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs:				
Maintenance of capital items 5% and depreciation 4% and 20%	£ 0.504 - 0.720 m	£ 0.584 - 0.835 m	Protection of environment. No costs for non-compliance with NVZ.	Protection of environment. No costs for non-compliance with NVZ.
Finance charges on capital loan	£ 0.628 - 0.897 m	£ 0.737 - 1.053 m	No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
One-off cost:				
New slurry storage	£ 5.135 - 7.336 m	£ 6.027 - 8.610 m		

Limitation of land application of fertilisers	N/A	Increased Efficiencies in N usage

Total compliance cost-benefits from all sectors for Fife and Strathmore NVZ:

All sectors	expected costs	expected benefits
Completion of a Manure Management Plan	£1.344 – 1.490 m	No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments

Limitation of organic N application	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs:				
Maintenance of capital items 5% and depreciation 4% and 20%	£ 0.021 - 0.029 m	£ 0.022 - 0.031 m	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
Finance charges on capital loan	£ 0.019 - 0.027 m	£ 0.020 - 0.029 m		
Transportation costs	£ 0.087 - 0.087 m	£ 0.087 - 0.087 m		
One-off cost:				
New slurry storage	£ 0.154 - 0.220 m	£ 0.165 - 0.235 m		

Extension of closed periods	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs:				
Maintenance of capital items 5% and depreciation 4% and 20%	£ 0.329 - 0.470 m	£ 0.381 - 0.545 m	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
Finance charges on capital loan	£ 0.399 - 0.570 m	£ 0.470 - 0.671 m		
One-off cost:				
New slurry storage	£ 3.261 - 4.658 m	£ 3.838 - 5.483 m		

Limitation of land application of fertilisers	N/A	Increased Efficiencies in N usage

Total compliance cost-benefits from all sectors for Lothian & Borders NVZ:

All sectors	expected costs	expected benefits
Completion of a Manure Management Plan	£ 0.831 - £0.924 m	No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments

Limitation of organic N application	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs:				
Maintenance of capital items 5% and depreciation 4% and 20%	£ 0.005 - 0.007 m	£ 0.005 - 0.007 m	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
Finance charges on capital loan	£ 0.005 - 0.008 m	£ 0.005 - 0.008 m		
Transportation costs	£ 0.026 - 0.026 m	£ 0.026 - 0.026 m		
One-off cost:				
New slurry storage	£ 0.044 - 0.063 m	£ 0.044 - 0.063 m		

Extension of closed periods	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs:				
Maintenance of capital items 5% and depreciation 4% and 20%	£ 0.132 - 0.188 m	£ 0.150 - 0.215 m	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
Finance charges on capital loan	£ 0.162 - 0.232 m	£ 0.187 - 0.268 m		
One-off cost:				
New slurry storage	£ 1.327 - 1.896 m	£ 1.532 - 2.189 m		

Limitation of land application of fertilisers	N/A	Increased Efficiencies in N usage

Total compliance cost-benefits from all sectors for Nithsdale NVZ:

All sectors	expected costs	expected benefits
Completion of a Manure Management Plan	£ 0.536 – 0.607 m	No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments

Limitation of organic N application	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs:				
Maintenance of capital items 5% and depreciation 4% and 20%	£ 0.071 - 0.102 m	£ 0.075 - 0.106 m	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
Finance charges on capital loan	£ 0.062 - 0.089 m	£ 0.067 - 0.096 m		
Transportation costs	£ 0.149 - 0.149 m	£ 0.149 - 0.149 m		
One-off cost:				
New slurry storage	£ 0.510 - 0.728 m	£ 0.548 - 0.782 m		

Extension of closed periods	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs:				
Maintenance of capital items 5% and depreciation 4% and 20%	£ 0.299 - 0.428 m	£ 0.340 - 0.486 m	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
Finance charges on capital loan	£ 0.363 - 0.519 m	£ 0.419 - 0.598 m		
One-off cost:				
New slurry storage	£ 2.971 - 4.244 m	£ 3.421 - 4.888 m		

Limitation of land application of fertilisers	N/A	Increased Efficiencies in N usage

TOTAL COMPLIANCE COST-BENEFITS FROM ALL NVZ'S

All sectors	expected costs	expected benefits
Completion of a Manure Management Plan	£ 5.340 – 5.940 m	No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments

Limitation of organic N application	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs: Maintenance of capital items 5% and depreciation 4% and 20%	£0.13 - 0.185 m	£0.135 – 0.192 m	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
Finance charges on capital loan	£0.116 – 0.158 m	£0.122 – 0.176 m		
Transportation costs	£0.338 – 0.338 m	£0.338 – 0.338 m		
One-off cost: New slurry storage	£0.95 – 1.356 m	£1.005 – 1.435 m		

Extension of closed periods	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement	Case of "blanket" 5-months storage requirement	Case of 6-months storage requirement
Annual costs: Maintenance of capital items 5% and depreciation 4% and 20%	£1.264 – 1.806 m	£1.455 - 2.081 m	Value of N Saved £0.07M - £0.14M	Value of N Saved £0.14M - £0.25M
Finance charges on capital loan	£1.552 – 2.218 m	£1.813 - 2.59 m	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.	Protection of environment. No costs for non-compliance with NVZ. No penalties being applied to Single Farm Payment and Rural Development Regulation payments.
One-off cost: New slurry storage	£12.694 – 18.134 m	£14.82 - 21.162 m		

Limitation of land application of fertilisers	N/A	Increased Efficiencies in N usage

CHAPTER 1 INTRODUCTION

BACKGROUND

The proposal was commissioned by the Scottish Executive Environment and Rural Affairs Department in December 2005 as a result of the requirement under Article 3 of the Nitrates Directive (91/676/EEC). This requires that waters affected by pollution and waters which could be affected by pollution shall be identified in accordance with criteria set out at Annex I of the Directive, and that all known areas of land which drain into the waters so identified should be designated as Nitrate Vulnerable Zones (NVZs). Article 5 of the Directive states that action programme measures designed to limit inputs of nitrate from agricultural sources in NVZs shall be established and implemented within specified timescales.

During 2000 the Ythan NVZ was designated as a result of infraction proceedings instigated by the European Commission on the condition of the river estuary. In a separate Nitrates infraction case the UK also conceded the principle that it had wrongly implemented the Nitrates Directive by monitoring drinking waters only and undertook to extend monitoring to all surface and groundwaters. Work was immediately put into effect to extend the monitoring networks. Despite this the European Commission referred the UK infraction case to the European Court of Justice who ruled against the UK implementation on 7th December 2000. As a result of the extended monitoring by SEPA, polluted surface waters have been identified in Angus and the Borders. BGS have identified candidate groundwater NVZs where catchments with a high risk of nitrate contamination of groundwaters from diffuse agricultural sources are coincident with highly vulnerable aquifers. The proposals for NVZs in Black Isle and Moray; Aberdeenshire, Banff and Buchan; Strathmore; Fife; Lothian and Borders; and Nithsdale have been verified against water quality monitoring data from a range of sources including SEPA's extended groundwater monitoring network.

The Nitrates Directive requires the Action Programme to be reviewed periodically. A report to the Commission considered the risk of nitrogen losses (nitrates, but also other nitrogen forms) by run-off and leaching and the measures to control this in the Action Programmes for Member States. Since then, further research on a Great Britain basis has been carried out by ADAS, based on scientific evidence and specific agricultural, soil and climate conditions. This showed that there is a significant risk of run-off or leaching of nitrates in the winter months and that the risks are substantial on agricultural soils generally, not just on sandy or shallow soils.

Consequently, this research report examines the impact of proposed changes to the action programmes. Chapter 3 outlines these proposed changes in detail but generally, they can be identified as i) organic manure deposition of 170 kg N/ha to apply to grassland as well as other agricultural land, ii) an extension to the closed period for application of certain types of fertilisers to arable and grassland areas, iii) all producers to prepare a Manure Management Plan, which includes identification of steep slopes on farm land, and iv) farmers following SAC recommended guidelines for application of fertilisers as a maximum.

AIMS AND OBJECTIVES

The primary aim of the study is to identify the economic and environmental costs and benefits of proposed changes to the Nitrate Vulnerable Zones action programme in Scotland. Essentially, this is composed of two main objectives:-

1) To estimate the environmental consequences of further changes to the action programmes for each Nitrate Vulnerable Zone.

2) To estimate costs and benefits of the proposed changes to the action programmes for each farming sector within each Nitrate Vulnerable Zone.

CHAPTER 2 METHODS OF APPROACH

Study Components

The study will include the following elements:

- A review of the current composition of the agricultural sector within the proposed NVZs.

- Identification of the actions required by each of the major farm types in order to comply with the requirements of the proposed changes to the action programmes to be considered by the project.

- Identification of the associated cost implications for each of the major farm types represented within the zone.

- Estimation of the aggregate cost to the farming sector within the zone arising from compliance with the various elements of the programme regulations.

- Identification of the relative contributions of compliance with components of the regulations to reductions in nitrate leaching. These will, as far as permitted by the available data, be broken down not only by type of measure, but also by farm type.

- Livestock numbers and cropping practices within the proposed NVZs would be used to identify slurry storage requirements, etc. associated with compliance with the regulations.

- These data would provide the basis of procedures to estimate the aggregate levels of impacts of the proposed regulations, in terms of both their relative contributions to reductions in nitrate leaching and also aggregate cost implications for the farming sector within the zone.

- An assessment will be made of the implications for each NVZ associated with the new regulatory environment likely to result from Action Programme proposals.

The design of the RIA will take full account of the guidelines issued by the Scottish Executive Improving Regulation in Scotland Unit (IRIS), including a comparative analysis of the options. Costs and benefits of the action programme option measures (record keeping, construction and maintenance costs of storage facilities, changes in fertiliser use, etc.) will be identified for each farming sector in each catchment/regional area as appropriate with an assessment of their relative importance for reduction in nitrate leaching. Total costs/ benefits will be summarised for discrete catchments/regional areas and will include the cost analysis must include the costs of financing borrowing for any capital items and any depreciation and maintenance costs or charges.

Sources of information regarding nitrate leaching which will be drawn on include:

- Census data from June 2004
- Computer programmes predicting leaching of nitrate.
- Scientific papers and reports.

The computer-based decision support system MANNER was used to predict nitrate leaching following the land application of dairy and pig slurry and broiler litter at different dates, winter rainfalls and soil textures. The MANNER computer program was developed by ADAS (Chambers et al, 1999). NCYCLE, a specific N cycling computer model based on grassland, was used to predict nitrate leaching from grassland. NCYCLE was developed by staff at IGER (Scholefield et al, 1991).

CHAPTER 3 SPECIFICATION OF STUDY

This report examines the environmental implications and economic costs and benefits of the proposed changes to the NVZ action programmes. These changes are outlined in detail below.

3.1. Organic manure deposition of 170 kg N/ha to apply to grassland as well as other agricultural land.

The present farm-based permitted limit of 250 kg N/ha from organic manure applied to grassland is to be reduced to 170 kg/ha N.

3.2. A proposed change to the closed period for the application of some types of organic manures

Arable Land
The current closed period for spreading organic manures with high available N (slurries and poultry manures and liquid digested sewage sludge) applied to arable land, applies to shallow and sandy soils only. The closed periods are between 1 October and 1 November for autumn sown crops and between 1 August to 1 November in any other case.

The Contractor is asked to assess the effects of the closed period being from 1 August to 15 January and of it applying to all soil types on arable land. However, the following exemptions will apply:

- on other soils in arable cropping, organic manures with high available N (slurries and poultry manures and liquid digested sewage sludge) may be applied from harvest up to 30 September, provided that a crop is sown by 15 October, and
- on sandy and shallow soils in arable cropping, organic manures with high available N (slurries and poultry manures and liquid digested sewage sludge) may be applied on cereal crops between harvest and 15 September provided that the land is drilled with a cereal crop by 15 September, or with oilseed rape, catch crops and cover crops by 1 October.

Grassland
For grassland the extended closed period applies to all soil types and has a number of variants, specifically;

i) *Sandy and Shallow Soils*

Main Proposal:	1/9 to 15/1
Variant I:	1/10 to 15/1
Variant II:	1/9 to 31/1

ii) *Other Soils*

Main Proposal:	15/8 to 31/1
Variant I :	15/10 to 1/2

Inorganic fertilisers
It is envisaged that the closed period for inorganic fertilisers will remain as in the current Action Programme, i.e. applying to all soil types and lasting from 15th September to 20th or 15th February for grassland, depending on the NVZ.

3.3. Farmers are required to complete a manure management plan

Whereas previously farmers were asked to complete a fertiliser and manure plan, a manure management plan (MMP) requires more detail. A full specification is outlined in Appendix 4. However, the main requirements are:-

- Calculation of quantities of livestock slurry and manure produced
- A detailed description of a farm's existing collection and storage systems
- A farm risk assessment map, including identification of steep slopes within the farm
- A description of the typical cropping on the farm
- A monthly land availability schedule, taking account of risks associated with spreading in each field.
- Details of the days available for spreading each month.
- Accumulated production and distribution schedule
- A contingency plan, for extreme weather conditions etc.

3.4. Limitation of land application of fertilisers

Farmers may be required to adhere to the SAC Guidelines on application of fertilisers as a maximum. This may involve a maximum N limit for each crop which the farmer must not exceed[1].

The remainder of this report is concerned with the impacts of the above elements of the action programmes on farmers operating within the NVZ's. Consequently:-

- Chapter 4 outlines the structure and activities of farms operating within the NVZ's

- Chapter 5 specifies the main environmental impacts of these proposed changes, in terms of Nitrate leaching and possible sensitivities

- Chapter 6 examines the economic costs and benefits of these proposed changes with possible sensitivities

[1] see page 34 of the PEPFAA Code

CHAPTER 4 COMPOSITION OF THE AGRICULTURAL SECTOR WITHIN EACH GROUNDWATER CATCHMENT

The four NVZs cover much of the arable agricultural areas in east Scotland as well as the catchment area of a major aquifer around Nithsdale. The area identified was divided into four separate zones taking account of geography and climatic zones. The four zones are shown in Figure 4.1. Detailed maps for all maps are given in Appendix 6. The type of land use and distribution of farm types in the four catchments are summarised in Table 4.1 and Tables 4.2a – d.

Figure 4.1 Nitrate Vulnerable Zones within Scotland.

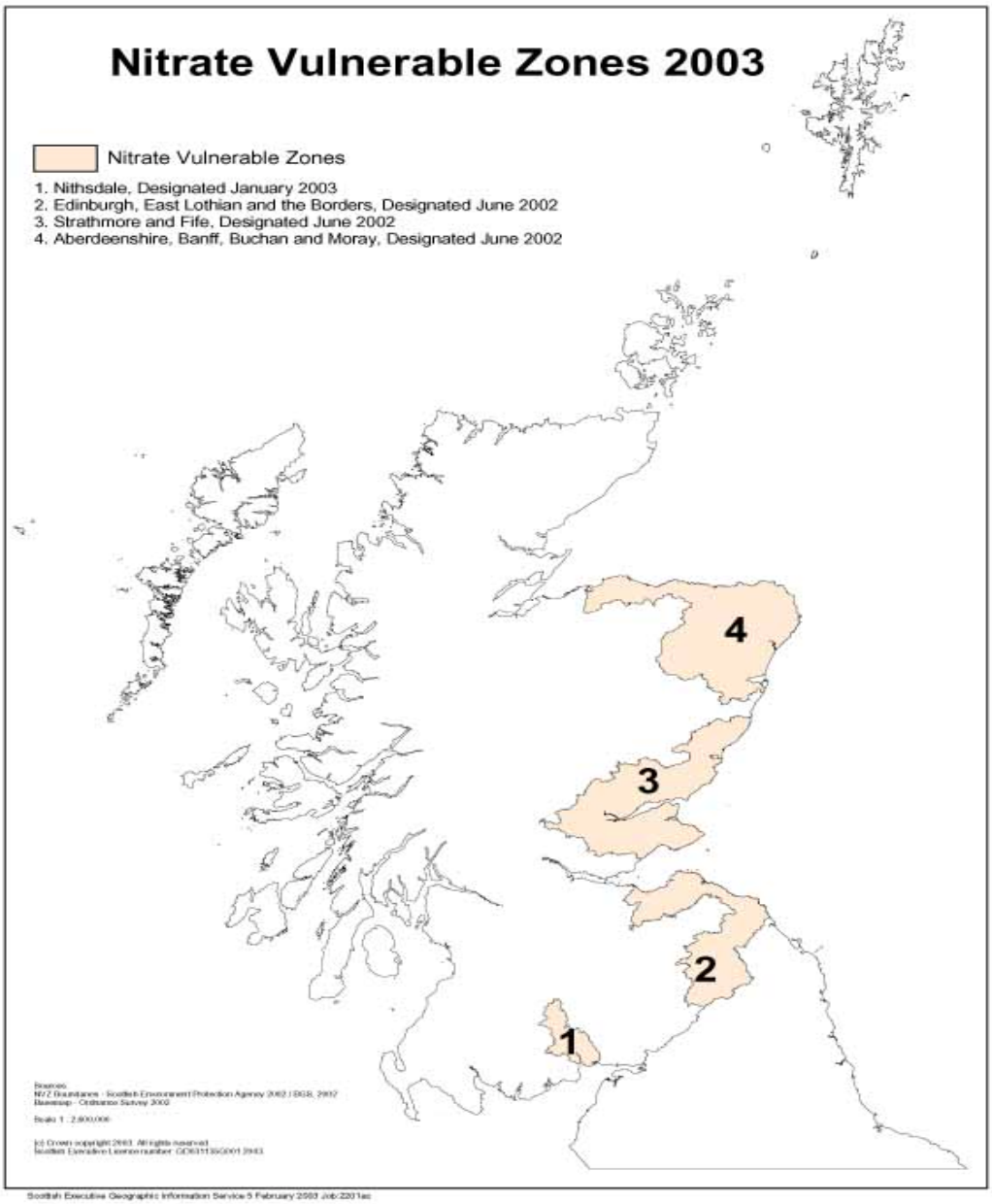


Table 4.1 Land and holding numbers in the six groundwater NVZs, classified by main farm type

	Moray, Aberdeenshire, Banff and Buchan		Fife &Strathmore		Lothian & Borders		Nithsdale	
Main Farm Type	Total Area (ha)	Holding Number	Total Area (ha)	Holding Number	Total Area (ha)	Holding Number	Total Area (ha)	Holding Number
Cereals & General Cropping	173,715	1,717	236,187	1,869	123,468	728	6,281	59
Specialist Fruit, Glass & Other Horticulture	745	103	2,177	97	363	43	46	12
Specialist Pigs	3,279	39	537	22	832	14	47	2
Specialist Poultry	1,435	160	1,365	108	289	63	219	33
Mixed Pigs and Poultry	*	*	*	*	*	*	*	*
Dairy(LFA & Lowground)	9,003	79	5,297	41	3,235	20	12,395	111
Cattle & Sheep[1]	83,588	1,362	110,815	572	130,984	508	66,663	381
Cropping & Dairy	6,466	26	6,779	33	2,905	9	946	2
Cropping, Cattle & Sheep	81,780	726	40,537	248	36,810	147	5,326	41
Cropping & Intensive Livestock	6,300	44	2,175	15	1,086	9	*	*
Cropping & Mixed Livestock	88	11	273	8	10	2	17	1
Mixed Livestock	3,279	67	1,692	21	84	11	255	4
Specialist Grass & Forage	30,761	2,161	24,655	1,061	11,378	614	9,242	350
Specialist Horses	5,214	733	4,086	414	2,262	251	1,336	106
Other[2]	6,650	351	4,727	179	1,957	85	266	22

Source: 2004 agricultural census data. . "*" Indicates data withheld when less than 5 holdings.

1 Includes specialist sheep, specialist beef, mixed cattle & sheep, cattle & sheep and lowground (cattle and sheep).

2 Includes cropping & mixed livestock, specialist set aside, specialist goats, non-classifiable holdings (fallow) and non-classifiable holdings (other).

Table 4.2a Cropping and livestock numbers for livestock enterprises in the Moray, Aberdeenshire, Banff and Buchan groundwater NVZ, classified by farm type

Main Farm Type	Crops, Fallow & Set Aside	Grass: Mowing/ Grazing	Rough Grazing	Cattle	Sheep & Lambs	Pigs	Poultry
	Hectares			Number			
Cereals & General Cropping	108,176	4,076	15,920	49,295	64,606	58,934	72,334
Specialist Fruit Glass & other Hortic crops	191	*	15	122	82	20	1,433
Specialist Pigs	2,201	*	166	671	1,578	93,359	54
Specialist Poultry	494	71	126	40	82	5	2,099,546
Mixed Pigs and Poultry	*	*	*	*	*	*	*
Dairy(LFA & Lowground)	2,877	1,462	346	19,503	4,318	*	52
Cattle & Sheep	10,180	13,878	20,867	131,440	254,818	1,040	7,085
Cropping & Dairy	4,126	372	68	7,489	363	2,950	*
Cropping, Cattle & Sheep	34,206	7,542	5,290	110,942	166,892	2,386	1,734
Cropping & Intensive Livestock	4,658	59	353	1,846	2,759	63,594	173,449
Cropping & Mixed Livestock	24	18	3	64	87	*	493
Mixed Livestock	1,334	110	142	4,435	7,888	27,687	27,696
Specialist Grass & Forage	163	1,227	8,893	*	*	*	*
Specialist Horses	114	548	540	26	1,712	33	1,817
Other	2,060	500	416	*	127	52	34

Source: 2004 agricultural census data. . "*" Indicates data withheld when less than 5 holdings.

Table 4.2b Cropping and livestock numbers for livestock enterprises in the Fife and Strathmore groundwater NVZ, classified by farm type

Main Farm Type	Crops, Fallow & Set Aside	Grass: Mowing/ Grazing	Rough Grazing	Cattle	Sheep & Lambs	Pigs	Poultry
	Hectares			Number			
Cereals & General Cropping	174,463	2,424	11,416	54,465	70,953	25,886	115,054
Specialist Fruit Glass & other Hortic crops	1,460	70	59	95	775	7	41,041
Specialist Pigs	353	*	19	83	2	29,094	4,059
Specialist Poultry	426	16	36	185	2,540	4	4,194,641
Mixed Pigs and Poultry	*	*	*	*	*	*	*
Dairy(LFA & Lowground)	1,459	936	593	12,157	8,768	*	6
Cattle & Sheep	3,807	7,011	74,019	55,478	340,193	236	2,296
Cropping & Dairy	4,327	378	83	8,602	2,699	106	25,000
Cropping, Cattle & Sheep	14,114	5,114	7,019	41,747	103,309	26	2,138
Cropping & Intensive Livestock	1,760	*	90	359	1,678	24,470	129,156
Cropping & Mixed Livestock	71	120	9	380	58	*	105
Mixed Livestock	566	231	65	3,690	1,904	22,200	130,799
Specialist Grass & Forage	111	288	12,507	*	*	*	*
Specialist Horses	37	142	1,410	18	491	5	1,127
Other	1,222	*	344	*	*	*	20

Source: June 2004 Agricultural Census

Table 4.2c Cropping and livestock numbers for livestock enterprises in the Lothian & Borders groundwater NVZ, classified by farm type

Main Farm Type	Crops, Fallow & Set Aside	Grass: Mowing/ Grazing	Rough Grazing	Cattle	Sheep & Lambs	Pigs	Poultry
	Hectares			Number			
Cereals & General Cropping	91,860	1,635	2,824	25,343	72,046	6,532	77,419
Specialist Fruit Glass & other Hortic crops	113	*	12		226	40	1,437
Specialist Pigs	357	*	83	25	3,825	22,003	15
Specialist Poultry	1	9	57	*	212	*	1,547,557
Mixed Pigs and Poultry	*	*	*	*	*	*	*
Dairy(LFA & Lowground)	1,108	483	173	5,399	7,771	*	18
Cattle & Sheep	5,335	23,104	72,058	66,427	640,804	710	3,967
Cropping & Dairy	2,009	280	85	2,688	3,823	12	*
Cropping, Cattle & Sheep	13,823	5,809	3,906	33,494	170,211	138	526
Cropping & Intensive Livestock	874	*	25	150	*	9,946	9,582
Cropping & Mixed Livestock	*	6	2	*	6	*	23
Mixed Livestock	*	*	5	1	151	43	283
Specialist Grass & Forage	43	449	3,029	*	*	*	*
Specialist Horses	20	140	178	7	287	12	1,000
Other	654	*	*	*	56	*	*

Source: June 2004 Agricultural Census

Table 4.2d Cropping and livestock numbers for livestock enterprises in the Nithsdale groundwater NVZ, classified by farm type

Main Farm Type	Crops, Fallow & Set Aside	Grass: Mowing/ Grazing	Rough Grazing	Cattle	Sheep & Lambs	Pigs	Poultry
	Hectares			Number			
Cereals & General Cropping	1,860	1,396	768	304	658	1	108
Specialist Fruit Glass & other Hortic crops	6	1	1	*	8	*	96
Specialist Pigs	29	*	*	1	*	3,864	*
Specialist Poultry	4	*	11	*	35	*	343,932
Mixed Pigs and Poultry							
Dairy(LFA & Lowground)	1,650	6,404	619	33,634	7,516	4	261
Cattle & Sheep	1,794	11,138	31,316	67,058	282,827	45	1,103
Cropping & Dairy	424	*	28	868	30	*	*
Cropping, Cattle & Sheep	1,481	1,187	558	6,240	9,123	5	152
Cropping & Intensive Livestock	*	*	*	*	*	*	*
Cropping & Mixed Livestock	*	*	*	*	*	*	*
Mixed Livestock	30	82	37	201	572	19	917
Specialist Grass & Forage	20	1,053	1,556	*	*	*	*
Specialist Horses	16	206	217	2	271	5	247
Other	155	*	*	*	*	*	*

Source: June 2004 Agricultural Census

Table 4.3 Area of arable crops and grass in the four groundwater NVZs

Crop / grass	Area of crops and grass within each NVZ (ha)			
	Moray,Aberdeenshire, Banff & Buchan	**Fife & Strathmore**	**Lothian and Borders**	**Nithsdale**
Set aside	23,218	21,666	13,533	500
Wheat	10,398	39,218	36,089	681
Winter barley	21,877	13,724	8,511	1,215
Spring barley	85,104	72,701	34,783	3,119
Vegetables for human consumption	723	7,612	1,629	5
Combine peas and beans	230	1,543	2,040	13
OSR	12,480	13,843	7,600	118
Potatoes	4,191	8,977	4,120	37
Neeps and stock feed	3,451	2,381	1,903	224
Grass (mowing and grazing)	29,865	16,730	31,916	21,468
Total crops and grass	**333,730**	**305,315**	**213,238**	**62,665**
Rough grazing	53,145	107,667	82,436	35,112

2004 Agricultural Census data for Main and Minor Holdings

Note: Soft fruit, orchard fruit and other crops with low acreage within the NVZ have not been listed separately but are included in the "total crops and grass".

CHAPTER 5 ACTION PROGRAMME IMPACTS ON NITRATE LEACHING IN THE GROUNDWATER NVZS

5.1. Organic manure deposition of 170 kg N/ha to apply to grassland as well as other agricultural land.

This report considers the impacts on the farming enterprises in Scotland of a possible modification to the regulations governing the return to land of nitrogen derived from livestock excreta in designated Nitrate Vulnerable Zones (NVZs) and in particular the impact of changing the limits on grassland from the current 250 kg ha^{-1} yr^{-1} to 170 kg ha^{-1} $yr^{-1.}$ The limit on arable land was assumed to remain at 170, as under the current NVZ Action Programme.

Agricultural census data for 2004 were acquired for the whole of Scotland (50,799 farms) anonymised at both the farm and parish levels to ensure that confidentiality undertakings could not be compromised. The 15,895 farms either wholly or partly within Scotland's four NVZs were abstracted for analysis. Sixty nine percent of farm holdings in Scotland are unaffected by any proposed change in regulations as they are outwith the NVZs. Holdings of less than 2 ha and with few livestock were excluded, bringing the number of holdings to 13,846.

The annual nitrogen loading associated with the stock type and numbers reported in the census was calculated at individual farm level and this figure was used as both 250 kg ha^{-1} yr^{-1} for grass, 170 kg ha^{-1} yr^{-1} for arable; and as 170 kg ha^{-1} yr^{-1} for all land level to derive the agricultural area requirement. This requirement was then compared to the agricultural land reported in the census at farm level to determine if there was sufficient (surplus) or insufficient (deficit) areal capacity. These data were then aggregated to parish, farm-type, NVZ and national level and presented as numbers of holdings impacted, areas of holdings impacted and changes in numbers and areas impacted.

Methodology

Exclusion of small holdings:

The CREH (2005) report, concluded that small holdings represented a substantial proportion of holdings, but only a tiny proportion of the area in exceedence of the 170 limit. We have therefore excluded small holdings from the calculation, using the CREH definition (which is rather strict):

a. Total land area of less than 2 hectares
b. Less than 25 cattle
c. Less than 25 pigs
d. Less than 25 other
e. Less than 50 sheep
f. Less than 50 poultry
g. Less than 25 miscellaneous (goats, deer or horses)

Farms which satisfied ALL criteria were excluded from the analysis. The number of holdings was reduced from 15,895 to 13,846.

Allocation of total nitrogen loads to livestock types

Values are taken from the CREH report (Tables 3.1 to 3.5.) These "…show the results of cross referencing the census livestock type with total nitrogen load information. The total nitrogen loads are always presented as a kg yr^{-1} figure and are per head of livestock. Where several similar classes of livestock have the same total

nitrogen load then the alternative livestock classes for that load are all shown in the source definition column.

Where a cross reference is speculative, such as in the case of deer in Table 3.5, then the ‘source of total nitrogen figure’ column has been marked with an asterisk. All of the speculative cross references are for livestock that are not widely farmed in Scotland and so the uncertainty in these cross references are unlikely to significantly affect the overall total nitrogen balances at a parish or NVZ level.”

Table 5.1. Percentage of arable, grass plus rough grazing land which is on farms which exceed the present limit (250 kg/ha N on all grass, 170 kg/ha N on arable).

Group	Cattle	Cereals	Dairy	General	Horticu	Mixed	Other	Special	Grand Total
Wholly Within Lothian/Borders NVZ	1.2	0.0	0.2	0.0	0.0	2.0	0.0	2.5	0.5
Partially Within Lothian/Borders NVZ	0.2	0.0	2.3	0.0	0.0	0.0	0.1	66.6	0.3
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	7.7	0.0	2.2	0.0	0.0	0.6	0.0	27.3	1.4
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	1.3	0.0	10.8	0.0	0.0	0.1	0.0	23.3	0.8
Wholly Within Nithsdale NVZ	0.1	0.0	14.7	0.0	0.0	0.0	0.0	24.6	3.1
Partially Within Nithsdale NVZ	1.0	0.0	15.7	0.0	0.0	0.0	0.0	20.7	2.5
Wholly Within Strathmore and Fife NVZ	4.4	0.0	19.3	0.2	6.8	3.0	0.0	35.1	1.2
Partially Within Strathmore and Fife NVZ	0.4	0.0	10.7	0.0	0.0	1.6	0.0	58.1	0.8
Grand Total	**1.3**	**0.0**	**10.6**	**0.1**	**3.2**	**1.0**	**0.0**	**32.6**	**1.0**

Table 5.2. Percentage of arable, grass plus rough grazing land which is on farms which exceed the proposed limit (170 kg/ha N on all agricultural land).

Group	Cattle	Cereals	Dairy	General	Horticu	Mixed	Other	Special	Grand Total
Wholly Within Lothian/Borders NVZ	1.6	0.0	0.2	0.0	0.0	2.7	0.0	2.7	0.7
Partially Within Lothian/Borders NVZ	0.5	0.0	2.3	0.0	0.0	0.0	0.1	69.9	0.6
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	13.8	0.0	20.2	0.0	0.0	1.9	0.0	31.6	3.0
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	3.9	0.0	37.0	0.0	0.0	0.8	0.1	23.3	2.4
Wholly Within Nithsdale NVZ	1.0	0.0	44.3	0.0	0.0	0.0	0.0	24.6	9.7
Partially Within Nithsdale NVZ	2.2	0.0	39.8	0.0	0.0	0.0	0.0	20.7	6.0
Wholly Within Strathmore and Fife NVZ	11.2	0.0	35.5	0.2	6.8	4.6	0.0	35.3	2.1
Partially Within Strathmore and Fife NVZ	1.1	0.0	16.6	0.0	0.0	1.6	0.0	58.1	1.1
Grand Total	**2.9**	**0.0**	**29.1**	**0.1**	**3.2**	**1.9**	**0.0**	**34.9**	**2.1**

The change in the limits results in the area of land on farms which exceed the limit more than doubling, and the effect is seen most strongly on dairy and cattle farms. The proportion of land on special farms which have a surplus of excretal N remains high.

Table 5.3. Percentage farms failing at current limit, all agricultural land (including rough grazing)

group	Cattle	Cereals	Dairy	General	Horticu	Mixed	Other	Special	Grand Total
Wholly Within Lothian/Borders NVZ	8.2	0.0	12.5	0.0	0.0	4.5	0.0	34.6	2.3
Partially Within Lothian/Borders NVZ	3.1	0.0	8.3	0.0	0.0	0.0	0.5	17.6	1.5
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	8.3	0.0	4.1	0.0	2.3	1.5	0.0	21.5	2.0
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	5.1	0.0	10.0	0.0	0.0	0.4	0.5	15.0	2.0
Wholly Within Nithsdale NVZ	2.6	0.0	23.5	0.0	0.0	0.0	0.0	25.0	4.2
Partially Within Nithsdale NVZ	3.0	0.0	24.7	0.0	0.0	0.0	0.0	12.5	4.3
Wholly Within Strathmore and Fife NVZ	8.1	0.0	22.2	0.3	4.4	4.1	0.0	39.1	2.1
Partially Within Strathmore and Fife NVZ	4.1	0.0	17.4	0.0	0.0	2.0	0.0	41.3	2.3
Grand Total	**5.7**	**0.0**	**16.8**	**0.1**	**1.7**	**1.7**	**0.1**	**26.8**	**2.2**

Table 5.4. Percentage farms failing at proposed limit (170 for all land), all agricultural land (including rough grazing)

group	Cattle	Cereals	Dairy	General	Horticu	Mixed	Other	Special	Grand Total
Wholly Within Lothian/Borders NVZ	14.6	0.0	12.5	0.0	0.0	5.7	0.3	38.5	3.5
Partially Within Lothian/Borders NVZ	6.8	0.0	8.3	0.0	0.0	0.0	0.5	23.5	2.7
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	17.0	0.0	22.4	0.0	2.3	3.1	0.1	23.4	3.8
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	10.2	0.0	36.7	0.0	0.0	2.1	0.6	15.0	4.0
Wholly Within Nithsdale NVZ	5.3	0.0	52.9	0.0	0.0	0.0	0.0	25.0	8.4
Partially Within Nithsdale NVZ	7.9	0.0	49.5	0.0	0.0	0.0	0.0	12.5	9.1
Wholly Within Strathmore and Fife NVZ	17.6	0.0	38.9	0.3	4.4	5.3	0.0	41.3	3.2
Partially Within Strathmore and Fife NVZ	7.5	0.0	26.1	0.0	0.0	2.6	0.0	41.3	3.1
Grand Total	**11.8**	**0.0**	**36.8**	**0.1**	**1.7**	**3.0**	**0.2**	**28.5**	**3.9**

The effect of the change in rules on number of farms failing is similar to the effect on land area shown in the previous two tables. However, the proportion of farms affected is substantially greater than the proportion of land area affected.

Table 5.5. N surplus under current limits (250 grass, 170 arable) , all agricultural land included. Kg N

group	Cattle	Cereals	Dairy	General	Horticu	Mixed	Other	Special	Grand Total
Wholly Within Lothian/Borders NVZ	82872	0	3851	0	0	3578	0	122650	212951
Partially Within Lothian/Borders NVZ	16924	0	3005	0	0	0	182463	357203	559595
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	243489	0	3790	0	11	21933	0	867515	1136738
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	129835	0	16875	0	0	1036	480	119781	268008
Wholly Within Nithsdale NVZ	386	0	10279	0	0	0	0	9638	20303
Partially Within Nithsdale NVZ	71594	0	94257	0	0	0	0	44070	209920
Wholly Within Strathmore and Fife NVZ	123722	0	13920	140627	5708	132095	0	435464	851537
Partially Within Strathmore and Fife NVZ	58309	0	35238	0	0	24126	0	1559323	1676995
Grand Total	727131	0	181214	140627	5719	182768	182943	3515644	4936047

Table 5.6. N surplus under proposed limits (170 grass, 170 arable) , all agricultural land included. Kg N

group	Cattle	Cereals	Dairy	General	Horticu	Mixed	Other	Special	Grand Total
Wholly Within Lothian/Borders NVZ	113212	0	4067	0	0	14960	109	123510	255858
Partially Within Lothian/Borders NVZ	38129	0	6098	0	0	0	183120	369769	597115
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	406898	0	39242	0	11	40402	46	889670	1376268
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	199173	0	45536	0	0	4206	1208	121135	371259
Wholly Within Nithsdale NVZ	1674	0	43000	0	0	0	0	10006	54680
Partially Within Nithsdale NVZ	129417	0	268826	0	0	0	0	45518	443761
Wholly Within Strathmore and Fife NVZ	185639	0	43922	142292	5868	172043	0	437379	987143
Partially Within Strathmore and Fife NVZ	98941	0	52033	0	0	45711	0	1577341	1774027
Grand Total	1173083	0	502723	142292	5879	277323	184483	3574328	5860110

These tables show the total of the surplus N on all of the individual farms, which exceed the stated farm-level limit. It therefore indicates the quantity of manure, which would have to be moved to achieve compliance (Alternatively it can be seen as an index of the number of livestock which would have to be moved to other farms or culled). The increase in N surplus arises mainly in the dairy and cattle farms. The increase is numerically greater on cattle farms, but proportionally greater on dairy farms. It is likely that the increase on cattle farms is due largely to their dairy component.

Table 5.7. Total land area within each farm type and NVZ grouping for the dataset analysed ('000 ha)

group	Cattle	Cereals	Dairy	General	Horticu	Mixed	Other	Special	Grand Total
Wholly Within Lothian/Borders NVZ	28	59	1	26	0	19	4	0	137
Partially Within Lothian/Borders NVZ	98	22	2	8	0	20	9	0	158
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	27	98	6	27	0	64	18	3	245
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	53	26	2	11	0	29	18	1	141
Wholly Within Nithsdale NVZ	4	1	2	0	0	1	1	0	9
Partially Within Nithsdale NVZ	60	4	10	1	0	5	9	0	89
Wholly Within Strathmore and Fife NVZ	14	49	2	100	1	26	8	1	201
Partially Within Strathmore and Fife NVZ	92	27	3	46	1	23	19	1	211
Grand Total	376	286	28	220	3	186	86	7	1191

Table 5.8. Total N load from livestock, kg N, for the dataset analysed.

group	Cattle	Cereals	Dairy	General	Horticu	Mixed	Other	Special	Grand Total
Wholly Within Lothian/Borders NVZ	1609332	589929	182122	471573	1692	1235042	9424	143726	4242840
Partially Within Lothian/Borders NVZ	4595368	278191	196272	174650	578	1224899	199323	424160	7093441
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	3087811	1621283	832262	706451	5973	4778955	52139	1250490	12335364
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	3580898	250530	365995	126725	1016	1885048	32539	186013	6428763
Wholly Within Nithsdale NVZ	314304	7781	307732	25	0	75061	1283	10817	717003
Partially Within Nithsdale NVZ	3908943	8545	1692373	1621	13	309062	9635	53804	5983996
Wholly Within Strathmore and Fife NVZ	1411630	417551	379798	1599160	29290	2013153	36085	488111	6374777
Partially Within Strathmore and Fife NVZ	2723190	194523	398339	840455	480	1295047	13597	1686847	7152479
Grand Total	21231476	3368332	4354893	3920662	39041	12816266	354024	4243968	50328662

Table 5.9. Mean N loading kg per ha of agricultural land

group	Cattle	Cereals	Dairy	General	Horticu	Mixed	Other	Special	Grand Total
Wholly Within Lothian/Borders NVZ	58	10	138	18	10	66	2	330	31
Partially Within Lothian/Borders NVZ	47	13	117	21	6	62	23	997	45
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	112	16	136	26	16	75	3	381	50
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	67	10	152	11	6	64	2	229	46
Wholly Within Nithsdale NVZ	88	6	168	0	0	64	2	578	82
Partially Within Nithsdale NVZ	65	2	169	2	0	62	1	239	67
Wholly Within Strathmore and Fife NVZ	98	9	157	16	23	78	5	962	32
Partially Within Strathmore and Fife NVZ	30	7	149	18	1	57	1	1727	34
Grand Total	56	12	153	18	14	69	4	635	42

Although a significant proportion of livestock farms are in N surplus, the actual N loadings averaged across farm types on each of the NVZs are all below the 170 limit. Specialist dairy farms come closest to this limit, especially in Nithsdale. However, when averaged across the whole NVZ agricultural area, all N loadings are under half of the proposed 170 limit. This indicates that there is land available for spreading of manures or for more even distribution of cattle. The limitation is cost and practicality.

The mean N loading from livestock excreta to land plus manure application is 42 kg N per ha of agricultural land . Loadings on dairy farms are much greater, averaging 153 kg N per ha, which is close to the proposed limit of 170. Loadings are also very large on the (relatively few) pig and poultry ‘specialist’ farms.

About 17% and 6% of dairy and cattle farms respectively are in surplus in relation to current limits, and about 37% of dairy farms, and 12 % of cattle farms, are in surplus under the new limits. The proportion of ‘special’ farms in surplus is already substantial, and increases little (from 26.8 to 28.5%).

Livestock manure and excretal N surplus increases by 18.7% with the new farm-level limits, from 9.8% of excretal N to 11.6%.

5.2. A proposed change to the closed period for the application of organic manures with high available N (slurries and poultry manures and liquid digested sewage sludge)

5.2.1 The proposed measures :

The proposed measures apply to all manures with high available N, and to all soils. The closed period extends from autumn to January. It is proposed that the dates of start and end of the closed periods be varied according to:

Soil type: Closed periods to start earlier on sandy and shallow soils because of the greater risk of nitrate leaching from autumn applications of manures. Closed periods to end later on other soils because of the greater risk of runoff, with possible exemptions where the risk can be shown to be small.

Cropping: Closed periods to start later on grassland; and where a crop is drilled in early autumn on sandy and shallow soils;

Note: Inorganic fertilisers

The closed period for inorganic fertilisers was already set to ensure maximum efficiency of use and minimum environmental impacts. It is envisaged that the closed period for inorganic fertilisers will remain as in the current Action Programme, i.e. applying to all soil types and lasting from 15th September to 15th or 20th February for grassland, depending on the NVZ, and 1 September to 15th or 20th February for arable land. Exceptions are made where a specific crop requirement can be shown within these closed periods.

5.2.2 Impact of timing of manure application on nitrate leaching

The effect of date of manure application on the proportion of the applied N which is leached was investigated using the MANNER program (Chambers et al., 1999), as recently modified under the Defra project KT0106. The model estimates ammonia volatilisation, modified according to the delay before incorporation; effect of incorporation on the location of manure N, delay before the manure ammonium or uric acid N is nitrified and therefore at risk of leaching; and leaching as a function of soil properties and excess rainfall between application date and end of drainage.

An annual quantity of Hydrologically Effective Rainfall of 450 mm was deemed to be typical of the NVZs in Scotland, although it will be greater in Nithsdale. This value is consistent with that used in Oglethorpe et al., 2002. Rainfall data from the UKCIPS database for the Borders NVZ area was used, and modified marginally to give exactly 450 mm of HER. The monthly distribution of rainfall and HER (drainage) which was used is shown below.

Table 5.10. Water balance data assumed in the study

Month	Rainfall mm	Actual Evapotranspiration mm	HER (drainage volume) mm
1	83.1	10.7	72.2
2	59.8	12.7	49.5
3	67.7	22.5	54.3
4	49.8	44.1	24.0
5	65.3	65.6	16.3
6	58.9	74.7	0.0
7	64.7	51.2	0.0
8	78.6	35.0	12.5
9	77.9	21.2	51.6
10	77.1	19.7	54.5
11	72.1	11.8	52.2
12	75.3	10.8	62.6
Total	**830.0**	**380.0**	**450.0**

Table 5.11. Manure N composition data

Type	Total N Kg/t or kg/m^3	% of N which is Ammonium plus Uric acid N
Dairy slurry 6% DM	3	50
Pig slurry 4% DM	4	60
Broiler litter	30	40

Table 5.12. Calculated quantity of N at risk of leaching (kg/ha) after allowance for ammonia volatilisation, assuming total N applied as manure was 170 kg/ha N.

Type	Incorporated 4h	Incorporated 14 days	Not incorporated
Dairy slurry 6% DM	74	54	54
Pig slurry 4% DM	93	76	76
Broiler litter	67	49	41

The soil types used in the simulations were sandy (sandy loam over loamy sand) and a medium loamy soil . These soil types were chosen as typical respectively of the 'sandy and shallow' class of soils within the Action Programme, and the remainder of Scottish agricultural soils. Estimates were made for soil of 1 m depth; and for shallow soils (60 cm). The values of total volumetric water content at field capacity to 100 cm (60 cm) were 224 (136) and 338 (205) mm respectively.

Model runs were carried out for dairy slurry, pig slurry and broiler litter. The differences in quantity of N leached at a given date of application are due to differences in the proportion of N in these manures which is present as ammonium or uric acid N, and therefore rapidly converted to nitrate; and also due to differences in the volatilisation losses. The pattern of leaching of the residual nitrate is similar for all the manure types.

The data are for nitrate leaching to below 1m at the end of the winter leaching period. It is assumed that in most soils, nitrate which is within 1m will be recovered by the crop during the growing season. Under average rainfall conditions, very little

manure-derived nitrate will leach from applications made to stubble ground after the end of December and especially after mid January. (Table 5.13). In grassland very little manure-derived nitrate will leach after 15 November from sandy soils and after 15 October from medium loams. The quantity at risk of leaching is reduced by volatilisation and by uptake into grass. These conclusions are supported by extensive experimental data.

The model runs were repeated for shallow soils, where roots may make poor recovery of N below about 60 cm. (Table 5.14). The majority of these soils are of medium texture – sandy soils tend to be deeper. The runs were carried out for both medium and sandy textures for completeness. It will be seen that the results for medium shallow soils are broadly similar to those for sandy soils of normal depth.

Table 5.13. Percentage of total N applied as manure, which is leached before the next growing season, for different application timings, incorporation delays, and soils. Total winter drainage (HER) 450 mm. Leaching below 100 cm.

i. Medium soils

	Delay before incorporation		
Date applied	4h	14 days	Grass, Not incorporated
A. Dairy slurry			
15-Aug	39	28	6
15-Sep	35	26	9
15-Oct	26	19	1
15-Nov	13	9	0
15-Dec	3	2	0
15-Jan	0	0	0
15-Feb	0	0	0
B. Pig slurry			
15-Aug	49	40	16
15-Sep	44	36	17
15-Oct	32	26	6
15-Nov	16	13	0
15-Dec	4	3	0
15-Jan	0	0	0
15-Feb	0	0	0
C. Broiler Litter			
15-Aug	35	26	0
15-Sep	32	23	4
15-Oct	23	17	0
15-Nov	12	9	0
15-Dec	3	2	0
15-Jan	0	0	0
15-Feb	0	0	0

ii) Sandy soils

	Delay before incorporation		
Date applied	4h	14 days	Grass, Not incorporated
A. Dairy slurry			
15-Aug	44	32	8
15-Sep	43	32	19
15-Oct	41	30	15
15-Nov	32	24	6
15-Dec	12	9	0
15-Jan	0	0	0
15-Feb	0	0	0
B. Pig slurry			
15-Aug	55	45	21
15-Sep	55	45	31
15-Oct	52	42	26
15-Nov	41	33	13
15-Dec	15	12	0
15-Jan	1	1	0
15-Feb	0	0	0
C. Broiler Litter			
15-Aug	39	29	1
15-Sep	39	29	11
15-Oct	37	27	8
15-Nov	29	21	2
15-Dec	11	8	0
15-Jan	0	0	0
15-Feb	0	0	0

Table 5.14. Percentage of total N applied as manure, which is leached before the next growing season, for different application timings, incorporation delays, on shallow soils. Total winter drainage (HER) 450 mm. Leaching below 60 cm.

i) Shallow soil, Medium soil texture

	Delay before incorporation		
Date applied	4h	14 days	Grass, Not incorporated
A. Dairy slurry			
15-Aug	44	32	8
15-Sep	44	32	20
15-Oct	43	32	17
15-Nov	40	29	9
15-Dec	22	16	0
15-Jan	2	1	0
15-Feb	0	0	0
B. Pig slurry			
15-Aug	55	45	21
15-Sep	55	45	32
15-Oct	55	45	28
15-Nov	50	41	18
15-Dec	28	23	0
15-Jan	2	2	0
15-Feb	0	0	0
C. Broiler Litter			
15-Aug	39	29	1
15-Sep	39	29	12
15-Oct	39	29	10
15-Nov	36	26	4
15-Dec	20	15	0
15-Jan	2	1	0

ii) Shallow soil, Sandy texture

	Delay before incorporation		
Date applied	4h	14 days	Grass, Not incorporated
A. Dairy slurry			
15-Aug	44	32	8
15-Sep	44	32	20
15-Oct	44	32	20
15-Nov	44	32	19
15-Dec	39	29	8
15-Jan	9	7	0
15-Feb	0	0	0
B. Pig slurry			
15-Aug	55	45	21
15-Sep	55	45	33
15-Oct	55	45	33
15-Nov	55	45	31
15-Dec	49	40	16
15-Jan	12	9	0
15-Feb	1	0	0
C. Broiler Litter			
15-Aug	39	29	1
15-Sep	39	29	12
15-Oct	39	29	12
15-Nov	39	29	11
15-Dec	35	26	3
15-Jan	8	6	0
15-Feb	0	0	0

5.2.4. Impact of a change in the closed period on nitrate leaching.

The data indicate that extending the end of the closed period from late autumn to 31 December or beyond will prevent all or most nitrate leaching associated with the manure applied in the current season, for soils where N is recovered to a depth of 100 cm. Small losses (5-10% of total applied N) may occur on sandy soils in arable cropping, following applications of manure in early January.

On soils where recovery of N is unlikely below 60 cm, under arable cropping, some nitrate leaching to below 60 cm may be expected on light sandy soils. Losses from medium soils and from grassland would be very small or zero.

For a closed period ending on 28th February, no nitrate leaching losses would be expected under these climatic conditions and soil types, from subsequent applications of manure whether to arable or grass crops.

The proportion of total N which is potentially available to the crop from these manures is 40 – 60%. After allowing for volatilisation, this falls, to about 24-50% depending on conditions. When the manure is applied in the autumn, on sandy soil, all of the available N (i.e. N convertible to nitrate) is leached. On the medium soil,

about 80% of the N at risk of leaching is actually leached from an autumn application to arable land, or 64% from an application to typical grassland (assuming the grass crop takes up some of the manure N). When the manure is applied in spring, or indeed from mid January onwards, these losses are prevented. The N is available for uptake by the growing crop.

These calculations assume that the management of manure is not affected by the change in timing. I.e. It is assumed that manures applied in late winter/ early spring will be incorporated. If this is not the case, volatilisation losses may be greater for manures applied in spring, thereby reducing the N available to the crop compared to the calculated value. Table 5.12 gives the assumed proportions of total manure N which are at risk of leaching, for different manure types and incorporation scenarios.

Recent UK surveys (Smith et al., 2000; Smith et al., 2001a & b) have been used to give estimates of the proportion of manure which is produced as slurry (rather than as straw-based solid manure i.e. farmyard manure, FYM) (Table 5.15) and the time of application of manures (Table 5.16).

Table 5.15. Form of manure production in the UK.

Manure	Proportion spread as	
type	Slurry (%)	FYM (%)
Dairy	65	35
Beef	20	80
Sheep	0	100
Pigs	45	55
Poultry	0	100
Total	37	63

Table 5.16. Timing of application of manures to agricultural land.

Manure	Proportion spread during			
type	Feb-April	May-July	Aug-Oct	Nov-Jan
Dairy	34	9	27	30
Beef	34	10	30	26
Pigs	26	12	38	24
Poultry	28	13	41	18

Table 5.15. N loadings from livestock manure, and total N loadings including grazing returns, expressed as kg N per ha agricultural land

NVZ area	Agricultural land, ha	Cattle manure	Sheep manure	Pig manure	Poultry manure	Other manure	Manure total	N load total
Wholly Within Lothian/Borders NVZ	137446	8.7	1.1	0.5	1.2	0.3	11.8	30.9
Partially Within Lothian/Borders NVZ	157961	9.8	2.1	0.5	2.2	1.4	16.0	44.9
Wholly Within Moray/Aberdeenshire/Banff & Buchan NVZ	244899	18.3	0.7	2.8	4.2	0.3	26.2	50.4
Partially Within Moray/Aberdeenshire/Banff & Buchan NVZ	140999	17.6	0.8	1.0	1.0	0.4	20.7	45.6
Wholly Within Nithsdale NVZ	8772	34.4	1.1	0.0	1.3	0.3	37.1	81.7
Partially Within Nithsdale NVZ	88846	24.5	1.8	0.1	0.5	0.2	27.1	67.4
Wholly Within Strathmore and Fife NVZ	201107	10.9	0.5	1.2	2.8	1.2	16.7	31.7
Partially Within Strathmore and Fife NVZ	211211	7.7	1.0	0.4	8.2	0.2	17.5	33.9
Grand Total	1191242	13.4	1.0	1.1	3.4	0.6	19.5	42.2

In order to estimate potential savings of nitrate leaching, and potential benefits in terms of fertiliser input reduction, we first need to know production of livestock manures (Table 5.17). It is assumed that all sheep manure and 'other ' manure is FYM.

The cattle manure was apportioned between beef and dairy by assessing the N loadings from productive dairy cows (census items 100, 102, 104, 106, 111, 115). These were 16% of the total N loadings from cattle. This fits well with the ratio between N loadings from farms classed as dairy farms and cattle farms.

The calculation of timing of manure will be illustrated for dairy slurry. The proportion of cattle manure N which is produced as slurry is 65%. The remainder is FYM, which contains rather little rapidly-available N, and is therefore not deemed to be a risk when applied to grassland in autumn, and is not subject to the closed period rules.

Of the dairy slurry produced, 27% is applied in autumn (August to October) and 30% in November to January. Assuming the manure for each quarter is evenly spread between the three months, this gives 9% of manure applied per month in autumn, of which just under two thirds is as slurry, Hence in Table 5.18, 5.9% of dairy manure is assumed to be applied as slurry during August, September and October.

Table 5.18 Estimated percentage of manure produced by each livestock type which is slurry / poultry manure and is spread in each month of autumn/winter.

Month applied:	Aug	Sept	Oct	Nov	Dec	Jan	Feb
Dairy	5.9	5.9	5.9	6.5	6.5	6.5	7.4
Beef	2.0	2.0	2.0	1.7	1.7	1.7	2.3
Sheep	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pigs	5.7	5.7	5.7	3.6	3.6	3.6	3.9
Poultry	13.7	13.7	13.7	6.0	6.0	6.0	9.3

Using these estimates, linked to the data on nitrate leaching, we can estimate the saving in N leaching as a percentage of manure total N (Table 5.19).

Table 5.19. N leaching from slurries/poultry manures for each month, as a percentage of total slurry/PM manure N applied annually to land; together with estimates of N saved under different closed period assumptions. For arable, the mean of the two scenarios for incorporation delay (4h and 14 days) was used.

a) By month

N saved, as percentage of total N from specified livestock category in all forms of manure

Normal soils (leaching to below 100 cm). Medium

		Aug	Sept	Oct	Nov	Dec	Jan	Feb
Grass	Dairy	0.4	0.5	0.1	0.0	0.0	0.0	0.0
Grass	Beef	0.1	0.2	0.0	0.0	0.0	0.0	0.0
Arable	Pigs	2.5	2.3	1.7	0.5	0.1	0.0	0.0
Arable	Poultry	4.2	3.8	2.7	0.6	0.2	0.0	0.0

Normal soils (leaching to below 100 cm). Sandy

		Aug	Sept	Oct	Nov	Dec	Jan	Feb
Grass	Dairy	0.5	1.1	0.9	0.4	0.0	0.0	0.0
Grass	Beef	0.2	0.4	0.3	0.1	0.0	0.0	0.0
Arable	Pigs	2.9	2.9	2.7	1.3	0.5	0.0	0.0
Arable	Poultry	4.6	4.6	4.4	1.5	0.6	0.0	0.0

Shallow soils (leaching to below 60 cm). Medium

		Aug	Sept	Oct	Nov	Dec	Jan	Feb
Grass	Dairy	0.5	1.2	1.0	0.6	0.0	0.0	0.0
Grass	Beef	0.2	0.4	0.3	0.2	0.0	0.0	0.0
Arable	Pigs	2.9	2.9	2.9	1.6	0.9	0.1	0.0
Arable	Poultry	4.6	4.6	4.6	1.9	1.1	0.1	0.0

Shallow soils (leaching to below 60 cm). Sandy

		Aug	Sept	Oct	Nov	Dec	Jan	Feb
Grass	Dairy	0.5	1.2	1.2	1.2	0.5	0.0	0.0
Grass	Beef	0.2	0.4	0.4	0.3	0.1	0.0	0.0
Arable	Pigs	2.9	2.9	2.9	1.8	1.6	0.4	0.0
Arable	Poultry	4.6	4.6	4.6	2.0	1.8	0.4	0.0

b) Aggregated results for different assumed periods when manures, which are currently applied within the stated periods, are instead applied in late winter or spring

N saved from leaching as percentage of total N from specified livestock category in all forms of manure

Normal soils (leaching to below 100 cm). Medium				
	Aug-Jan	**Sept-Jan**	**Oct-Jan**	**Oct-Dec**
Dairy	0.9	0.6	0.1	0.1
Beef	0.3	0.2	0.0	0.0
Pigs	7.1	4.6	2.3	2.3
Poultry	11.4	7.3	3.5	3.5
Normal soils (leaching to below 100 cm). Sandy				
	Aug-Jan	**Sept-Jan**	**Oct-Jan**	**Oct-Dec**
Dairy	2.8	2.4	1.3	1.3
Beef	0.9	0.8	0.4	0.4
Pigs	10.2	7.4	4.5	4.5
Poultry	15.7	11.1	6.4	6.4
Shallow soils (leaching to below 60 cm). Medium				
	Aug-Jan	**Sept-Jan**	**Oct-Jan**	**Oct-Dec**
Dairy	3.2	2.7	1.6	1.6
Beef	1.1	0.9	0.5	0.5
Pigs	11.2	8.3	5.5	5.4
Poultry	16.9	12.3	7.6	7.6
Shallow soils (leaching to below 60 cm). Sandy				
	Aug-Jan	**Sept-Jan**	**Oct-Jan**	**Oct-Dec**
Dairy	4.6	4.1	2.9	2.9
Beef	1.4	1.3	0.9	0.9
Pigs	12.3	9.5	6.6	6.3
Poultry	18.2	13.6	8.9	8.5

Oglethorpe et al. estimated that 40% of the total NVZ area is sandy or shallow soils. The majority of these are considered to be sandy, and for the present calculation it was assumed that 30% were sandy and 10% shallow, leaving 60% as medium soils of good depth. It was assumed that cattle manures are applied mainly to grassland, and pig and poultry manures mainly to arable land. If we apply these data to the N applied as manure from each livestock source within each NVZ, we arrive at the following estimates (Table 5.20). The estimated saving per ha of agricultural land has been multiplied by the total NVZ area as reported by Oglethorpe et al.:

Table 5.20: Calculated saving in N leaching for different closed periods (kg N per ha agricultural land; and t N).

TOTAL	All NVZ land		Proportion of area		1.00
Closed period:		Aug-Jan	Sept-Jan	Oct-Jan	Oct-Dec
Sector					
Grass	Dairy	0.040	0.031	0.014	0.014
Grass	Beef	0.066	0.051	0.022	0.022
Arable	Pigs	0.093	0.064	0.037	0.036
Arable	Poultry	0.453	0.305	0.165	0.164
	Total	**0.653**	**0.451**	**0.237**	**0.236**
Area (ha)	826,818				
Total N saved	**t N**	**540**	**373**	**196**	**195**

These estimates are broadly consistent with those of Oglethorpe et al., for N saved in relation to dairy slurry and pig slurry for closed periods on sandy and shallow soils only, but are substantially greater due to inclusion of all soils and of poultry manures.

The estimated saving from cattle slurry is rather small, partly because the majority of cattle manure is FYM, and partly because of the estimated smaller quantity of leaching from grassland due to continued N uptake especially during autumn. It should be noted that this potential for N uptake is variable depending on local conditions. Data from elsewhere in the UK are consistent with the estimates given, but there are few data specific to Scotland.

The impact of poultry manure is relatively large, because all poultry manure has high available N, and therefore results in substantial leaching from autumn applications; and because a large proportion of poultry manure is assumed (from surveys) to be applied in autumn to arable land, where the risk of greater than from grassland applications or spring applications.

Effect of the closed period on N fertiliser requirement

The NVZ Action Programme requires farmers to take due account of the N supplied by manures in calculating their chemical fertiliser applications. Therefore every kg of N saved from leaching can be used to replace fertiliser N. The potential saving in fertiliser N is equal to the cost of fertiliser times the N saved from leaching.

5.3. Farmers are required to complete a manure management plan

Completion of a manure management plan is beneficial, in that it ensures that all the issues are considered in advance. It therefore reduces the risk of applications of manure under adverse conditions. It should also ensure that the required estimation of fertiliser adjustment is carried out, although this aspect could be covered under fertiliser planning.

Under the Action Programme, rules are laid down for manure management. Completion of a manure management plan adds nothing in principle to these requirements, i.e. does not necessarily affect farm management practice. No additional impact on nitrate leaching is therefore calculated.

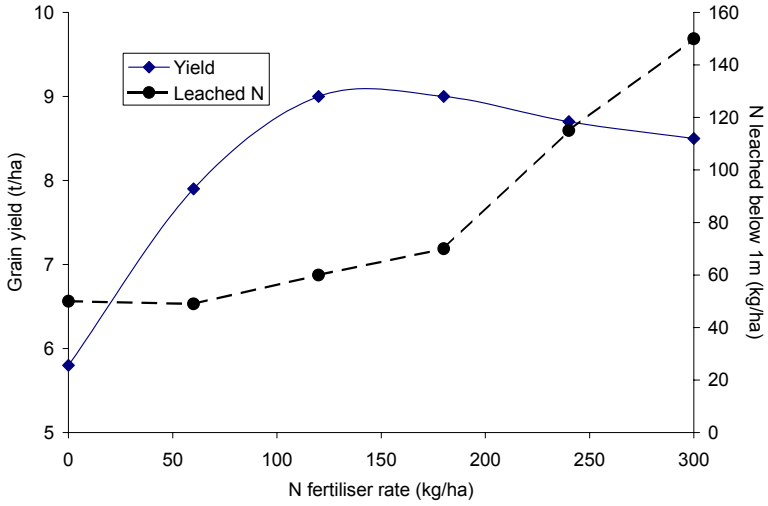
A manure management plan will however reduce the risk of breach of the regulations caused by lack of planning or foresight. It will also increase transparency – it is easier during compliance checking to demonstrate that the requirements of the Action Programme have been taken into account.

5.4. Limitation of land application of fertilisers

5.4.1. Effects of N Fertiliser Inputs on yield and N leaching: Arable

Yields increase with nitrogen fertiliser input, but the yield response shows diminishing returns as inputs increase. This is because other constraints on yield become limiting. Crop N uptake cannot accommodate all the nitrate available, and the residues after harvest increase. Nitrate leaching therefore increases with N fertiliser input – very gradually at inputs below the optimum, and more steeply at greater inputs. (Figure 5.1; Lord & Mitchell, 1999).

Figure 5.1. Example of the relationship between N fertiliser rate and subsequent N leaching for arable crops. (Sandy soil; annual rainfall ca 750 mm).



Inputs are used efficiently at small inputs, and less efficiently as the crop capacity for uptake become satisfied or is exceeded. Each additional 1 kg of fertiliser N increases residual nitrate at risk of leaching by less than 0.1 kg at low inputs, by about 0.5 kg at inputs close to the optimum, and by 0.8-1.0 kg at inputs well in

excess of the optimum. Figure 5.21 shows data for single year effects, taken from Lord & Mitchell (1999).

Data from Lord & Mitchell (1999) show that at inputs close to the optimum, any change in input results in a corresponding change in residual N which is about 50%. In other words, miscalculating the optimum by 20 kg/ha N results in a change in residual N of around 10 kg/ha N. (Note that, following data presented in Lord & Mitchell (1999), the residual N calculation assumes that, for each 1 kg N in grain, approximately 0.9 kg is taken up into straw, roots and root exudates, and is therefore not available for leaching.)

Effects of unpredictable variation in crop N requirements

Crop N requirements vary from year to year and site to site. Some of this variation is not predictable in advance. Therefore even when farmers comply with recommendations, they may apply more or less than the economic optimum for that particular site and year.

The effect of an over or under-application of fertiliser was tested using fertiliser response curves fitted to individual experimental data from hundreds of UK fertiliser response experiments on cereals in the UK. The data are collated in the NITRIC database (Gillian Goodlass, personal communication)., The N response curve fitted is that generally accepted within the UK, the linear-exponential (LpE). :

Y = A + B x R^N + C x N

The curve relating N inputs to N content of grain was a Normal Type curve with Depletion

N%=D+C*exp(-A*(N-B)**2).

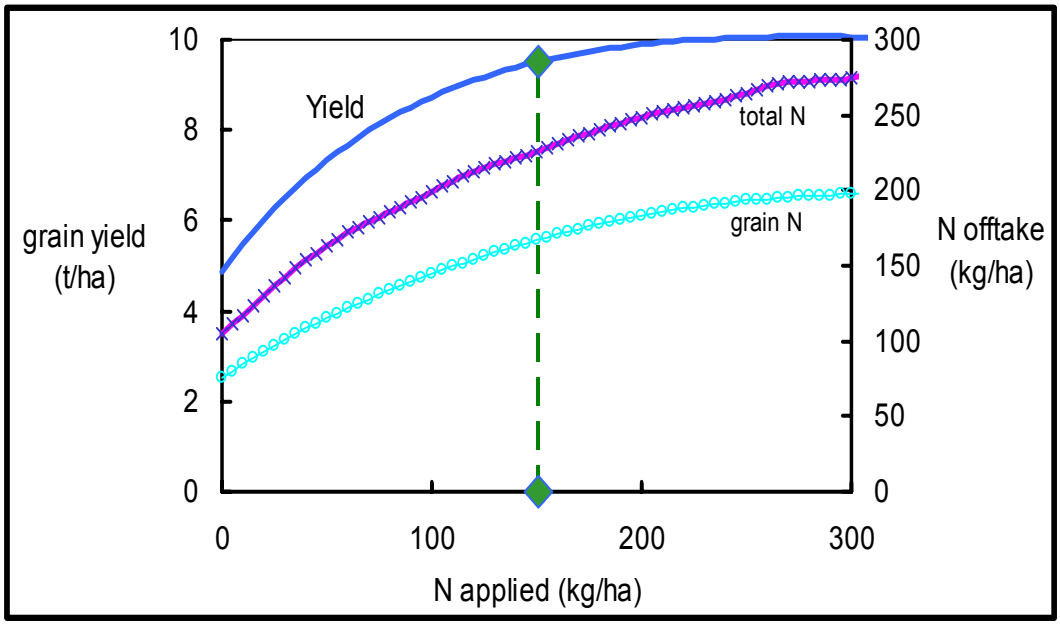


Figure 5.2. N response curve, and associated N offtake into grain and total above-ground dry matter, for winter wheat on medium to heavy soils, taken from the NITRIC database.

The effect on nitrate leaching risk of this unavoidable variation in the accuracy with which farmers can predict the crop economic optimum, is indicated in Table 5.21, taken from summarised N response data from hundreds of cereal experiments in the UK, collated within the NITRIC database (Gillian Goodlass, personal communication). These data are for single-year experiments. The change in residual fertiliser N (or N at risk of leaching) is slightly steeper above the optimum than below because the capacity for uptake of the additional N diminishes at high N inputs. The net effect is that, if inputs are on average about 20 kg/ha N too high OR too low (and the mean input is equal to the mean optimum), the net effect is a slight increase in leaching relative to that with perfect precision. This increase is estimated as 1 kg/ha N per year. Part of the environmental benefit of a reduction in N fertiliser inputs is due to reduction in the number of sites where the crop has been inadvertently over-fertilised.

Table 5.21. Effect of variation in N fertiliser input, relative to the optimum for the year, on N offtake, total N uptake by the plant, and (fertiliser – uptake) balance.

Fertiliser input relative to optimum	Change in yield	Effect on profit	Effect on grain N offtake	Effect on total N uptake	Effect on fertilizer - N balance
kg/ha N	t/ha grain at 85% Dry Matter	£/ha	kg/ha N		
-40	-0.3	-7	-12	-23	-17
-20	-0.1	-2	-6	-11	-9
Optimum	0	0	0	0	0
20	0.1	-1	5	9	11
40	0.1	-5	8	15	25

If a change in mean N input results from the NVZ Action Programme, this change could have cumulative effects. This possibility was investigated over a number of years at Ropsley in England, on a clay loam soil. Table 5.21 shows the effect of a SYSTEMATIC change in N input relative to current recommendation, over a number of years, on the risk of nitrate leaching. The results are not markedly different from those averaged across many single-year sites. The change in SMN due to an increase or decrease in input of 20 kg/ha N was 10 or 8 kg/ha N. In dry areas, not all of this would leach. The change is equivalent to a 10-20% change in nitrate leaching depending on soil type.

Table 5.21. Effect of change in fertiliser inputs, relative to the economic optimum, on profit; and on autumn SMN. Date from medium-term experiment on clay soil (Ropsley), single site.

Fertiliser input relative to optimum	Change in yield	Effect on autumn SMN
kg/ha N	t/ha grain at 85% Dry Matter	kg/ha N
-40	-0.3	-13
-20	-0.1	-8
Optimum	0	0
20	0.1	10
40	0.2	23

5.4.2. Effects of N Fertiliser Inputs on yield and N leaching: Arable

Similar behaviour is seen in grassland systems. The range of N inputs is very wide in grassland compared to arable crops, and the effects of any variation in crop N requirement vary depending on the level of input.

The effects if variation in N supply relative to crop demand, on residual N at risk of leaching, are much greater at high N inputs than at low inputs. At low inputs the grass can take up 'surplus' N into dry matter. Additional grass will be producedAt higher inputs, some of the surplus N may not be taken up, and the situation is similar to that for arable crops.

The NCYCLE model of fate of N in grassland (del Prado et al., 2004; Brown et al., 2003) indicates that at low inputs in a grazed system (100 kg/ha N as fertiliser) an increase of 1 kg/ha N in inputs causes an increase of 0.2 kg/ha N in the N at risk of leaching; at moderately high inputs (200 kg/ha N), an increase of 1 kg/ha N in inputs causes additional leaching of about 0.4 kg/ha N. Gradients are more shallow on cut fields (0.1 and 0.15 respectively).

In general in grassland systems, leaching will be minimised by ensuring inputs are broadly tuned to stocking density; and that proper allowance is made for manure inputs and for weather (grass growth capacity).

5.4.3. Current practice: fertiliser inputs

Evidence from the most recent (2002) Survey of Fertiliser Practice indicates that average N fertiliser input to arable crops is close to or smaller than the recommendation (taken from Defra's Reference Book 209, which is closely similar to Scottish recommendations). However, there is substantial variation. Over-fertilisation relative to recommendations was linked primarily to situations where manure had been applied in arable rotations. About 15-20% of arable land receives manure in any one year.

Most grassland systems are fertilised at well below the crop-determined 'economic' optimum, because in practice other farm-specific factors determine the optimum herd size, and grass growth required per ha of land.

The evidence indicates that the main improvement required in compliance with crop economic fertiliser requirement, is improved adjustment of fertiliser inputs for local/ annual circumstances, including N supplied from manures; N residues from previous crops; and soil type.

Based on experimental data, improved compliance with detailed fertiliser recommendations would be economically beneficial to farmers by either reducing costs or increasing yield or quality of the crop.

CHAPTER 6 ACTION PROGRAMME IMPACTS ON AGRICULTURAL ENTERPRISES

KEY FARM TYPES

The following categories of farms were identified as being most likely to be affected by the introduction of the Action Programme Regulations in the proposed groundwater NVZs, as defined in SEERAD Main Farm Type Classification (Appendix 2).

- Cereals and general cropping
- Mixed livestock
- Specialist pig farms
- Cropping and sheep
- Cattle and sheep
- Cropping and intensive livestock
- Specialist poultry
- Cropping and dairy
- Dairy farms

Further detailed analysis of each of these SEERAD Main Farm Types was therefore undertaken. The analysis was carried out at the aggregate level for the catchment, using 2004 agricultural census data for farms within the NVZ.

The results of this aggregate, catchment-level analysis of the impacts by farm type are presented in this chapter. However, care must be taken in interpreting these figures, as aggregate analysis may mask issues, which exist at the level of individual farm units. In particular, even where aggregate figures indicate the existence of adequate land for slurry spreading, some individual farm units may not possess adequate land for this purpose, necessitating the establishment of spreading agreements with other holdings in the area, or the export of slurry to land outside the NVZ.

In addition, variations in farming practices between individual farmers may further limit the land available for slurry spreading resulting in an effective area below that indicated by the aggregated calculations outlined below. For example, some dairy farmers avoid applying slurry to grazing grass due to their belief that this has contributed to problems with cow fertility. Other dairy farmers avoid the application of slurry to silage grass as the variable release of nitrogen from slurry may influence the fermentation of the silage.

6.1. Organic manure deposition of 170 kg N/ha to apply to grassland as well as other agricultural land

The total N produced in livestock manures was found to be in excess of farm-based limits (post-adoption of action programme changes) on specialist pig farms in all the NVZ areas, on mixed livestock farms in Moray, Aberdeenshire, Banff and Buchan NVZ and Fife and Strathmore NVZ, on specialist poultry farms in Fife and Strathmore NVZ and Lothians and Borders NVZ and on dairy farms in the Nithsdale NVZ.

We assume that the excess of slurry due to limitation of application of organic N post-change has to be stored for the proposed closed period (the case of "blanket" 5-months storage requirement and the case of 6-months storage requirement for all farm types except pig and poultry, for which there is a requirement of 26 week

storage capacity) before transporting it to other farms within the same NVZ. The storage requirement before transportation is related to the assumption that farmers would be exporting slurry to farms within NVZ areas and therefore the extended closed period applies to all farms.

Overall, the excess N produced that incurs extra storage facilities is equivalent to approximately 28,530 m^3 of undiluted slurry for the first case and approximately 32,611 m^3 of undiluted slurry for the second case. We compute the storage-related costs (annual and one-off costs) to farmers for each case assuming full storage capacity at present and implicitly the need for new storage facilities. We assume that the farmers have had storage capacity to fully comply with the current limitation of application of organic N and current closed periods[2] and therefore they would need to build new storage capacity to accommodate the slurry/manure in excess due to limitation of application of organic N post-change and accumulated in the proposed closed periods.

The volume of additional slurry storage to be erected on farm will depend on the existing slurry storage capacity and land capability. The total one-off costs involved in providing storage were estimated based on data from the SAC Farm Buildings Cost Guide (SAC, 2005a). Maintenance costs of 5% per annum, depreciation of 4% per annum on a linear basis for storage tanks and reception pits and depreciation of 20% per annum on a linear basis for slurry pumps (PTO mounted for pit agitation and tanker filling and agitation/aeration unit) were also derived using the same source of information.

We calculated the storage cost per mixed farm based on the costs of storage tank (£232 x m^3 $capacity^{0.667}$), slurry pump - PTO mounted for pit agitation and tanker filling and agitation/aeration unit (average cost of £3,300 and respectively £2,250), reception pit (£1,650) and consultancy fees and authorisation payments[3]. The total cost of additional slurry storage for pig and dairy farms across the whole area of the NVZs is therefore estimated at £1,355,950 for the case of "blanket" 5-months storage requirement and at £1,434,825 for the case of 6-months storage requirement (considering 26 weeks storage requirement for pig and poultry farms). If 70% of units require storage the total cost will be £949,165 for the case of "blanket" 5-months storage requirement and £1,004,377 for the case of 6-months storage requirement (considering 26 weeks storage requirement for pig and poultry farms). Some of the additional slurry storage above may be substituted with the cost of midden improvements without altering the overall cost. The remit of the current study did not allow a detailed assessment of the number or state of middens in the NVZs.

There will also be annual costs to the farmer associated with the necessary operation of new slurry storage facilities. Annual maintenance charges have been assumed at 5% of the capital cost. Depreciation has also been calculated at 4% per annum, on a linear basis, plus 20% depreciation per annum for slurry pumps. Therefore the estimated total annual cost across the whole area of NVZs will be £185,395 for the case of "blanket" 5-months storage requirement and £192,494 for the case of 6-months storage requirement. If 70% of units require storage the total annual cost of

[2] In practice, there might be farms without storage capacity to comply with the current (relatively short) closed periods, farms that apply alternative temporary management strategies. Nevertheless, as we do not have survey data for such farms and, moreover as they should have storage facilities to comply with current NVZ regulations, we make the assumption that all farms have storage facilities to comply with the current closed periods.

[3] Source: The Farm Building Cost Guide 2005/2006 and The Farm Management Handbook 2005/2006

maintenance and depreciation will be £129,777 for the case of "blanket" 5-months storage requirement and £134,746 for the case of 6-months storage requirement.

It is also likely that a loan will be required to pay for the new slurry storage facilities. There will be annual costs relating to interest and repayment charges. The charges have been estimated assuming an interest charge of 6% and a repayment term of 3 years. Under these circumstances the estimated annual cost to farmers over the 3-year loan repayment term across the whole area of NVZs will be £165,873 for the case of "blanket" 5-months storage requirement and £175,521 for the case of 6-months storage requirement. If 70% of units require storage the total annual cost over the 3-year loan repayment term will be £116,111 for the case of "blanket" 5-months storage requirement and £122,865 for the case of 6-months storage requirement.

The above cost implications of impact on additional slurry storage are problematic in the absence of comprehensive individual farm-level data, and consequently all estimates must be treated with caution. However, wherever possible an attempt has been made to give an indication of the potential scale of the associated costs. To quantify these effects more accurately, a detailed investigation of farm-level impacts based on the collection of primary data is required. However, a detailed empirical investigation and data collection exercise of this nature are outside the scope of the present study.

The total cost of transporting the excess slurry from these farms to neighbouring farms post-change would be about £338,774 per annum. Due to time constraints the report does not take into consideration issues such as transport biosecurity (direct costs, e.g., cleaning and disinfection costs, which include facility charges, operative time and chemicals; indirect costs of downtime, extra drivers etc.) and waste licensing.

6.2. A proposed change to the closing period for the application of some types of organic manures

The duration of closed periods is proposed to be extended and applicable to all soil types. Specifically, for arable land the closed period applies to all soil types and extends from the 1st of August to either the 15th January or the 31st of January. Some exemptions apply: on other soils with livestock manures (between harvest and 30/9 (sown by 15/10); on sandy and shallow soils with livestock manures with high available nitrogen (between harvest and 15/9) and with land drilled with OSR, catch crops and cover crops (between harvest and 15/9). For grassland the extended closed period applies to all soil types and has a number of variants, specifically: on sandy and shallow soils (main proposal: 1/9 to 15/1 with variant I: 1/10 to 15/1 and variant II: 1/9 to 31/1); on other soils (main proposal: 15/8 to 31/1 with variant I: 15/10 to 1/2).

We consider two options, namely the case of "blanket" 5-months storage requirement and the case of 6-months storage requirement for all farm types except pig and poultry, for which there is a requirement of 26 week storage capacity. We compute the storage-related costs (annual and one-off costs) to farmers for each of these cases assuming full storage capacity at present and implicitly the need for new storage facilities. We assume that the farmers have had storage capacity to fully comply with the current closed periods and therefore they would need to build new storage capacity to accommodate the slurry/manure accumulated in the *additional* months of the proposed closed periods.

The volume of additional slurry storage to be erected on farm will depend on the existing slurry storage capacity and land capability. The total one-off costs involved in providing storage were estimated based on data from the SAC Farm Buildings Cost Guide (SAC, 2005a). Maintenance costs of 5% per annum, depreciation of 4% per annum on a linear basis for storage tanks and reception pits and depreciation of 20% per annum on a linear basis for slurry pumps (PTO mounted for pit agitation and tanker filling and agitation/aeration unit) were also derived using the same source of information.

Data extracted from the SEERAD Census Data (June 2004) indicates that there are a total of 120 farms with dairy herds and 78 farms with pig breeding herds in the groundwater NVZs summing up to significant potential for slurry production. In addition there will be farms where pigs are either bought and finished, or are contract reared. Dairy and pig breeding farms occur in all NVZ regions, but the largest relative proportion of dairy producers is in the Nithsdale region, whereas Moray, Aberdeenshire, Banff and Buchan contains the largest relative proportion of pig breeding herds.

We calculated the storage cost per mixed farm based on the costs of storage tank (£232 x m^3 capacity$^{0.667}$), slurry pump - PTO mounted for pit agitation and tanker filling and agitation/aeration unit (average cost of £3,300 and respectively £2,250), reception pit (average cost of £1,650) and consultancy fees and authorisation payments. The total cost of additional slurry storage for pig and dairy farms across the whole area of the NVZs is therefore estimated at £18,133,764 for the case of "blanket" 5-months storage requirement and at £21,169,645 for the case of 6-months storage requirement (considering 26 weeks storage requirement for pig and poultry farms). If 70% of units require storage the total cost will be £12,693,635 for the case of "blanket" 5-months storage requirement and £14,818,752 for the case of 6-months storage requirement (considering 26 weeks storage requirement for pig and poultry farms). Some of the additional slurry storage above may be substituted with the cost of midden improvements without altering the overall cost. The remit of the current study did not allow a detailed assessment of the number or state of middens in the NVZs.

There will also be annual costs to the farmer associated with the necessary operation of new slurry storage facilities. Annual maintenance charges have been assumed at 5% of the capital cost. Depreciation has also been calculated at 4% per annum, on a linear basis, plus 20% depreciation per annum for slurry pumps. Therefore the estimated total annual cost across the whole area of NVZs will be £1,806,279 for the case of "blanket" 5-months storage requirement and £2,079,508 for the case of 6-months storage requirement. If 70% of units require storage the total annual cost of maintenance and depreciation will be £1,264,395 for the case of "blanket" 5-months storage requirement and £1,455,656 for the case of 6-months storage requirement.

It is also likely that a loan will be required to pay for the new slurry storage facilities. There will be annual costs relating to interest and repayment charges. The charges have been estimated assuming an interest charge of 6% and a repayment term of 3 years. Under these circumstances the estimated annual cost to farmers over the 3-year loan repayment term across the whole area of NVZs will be £2,218,293 for the case of "blanket" 5-months storage requirement and £2,589,671 for the case of 6-months storage requirement. If 70% of units require storage the total annual cost over the 3-year loan repayment term will be £1,552,805 for the case of "blanket" 5-months storage requirement and £1,812,770 for the case of 6-months storage requirement.

The above cost implications of impact on additional slurry storage are problematic in the absence of comprehensive individual farm-level data, and consequently all estimates must be treated with caution. However, wherever possible an attempt has been made to give an indication of the potential scale of the associated costs. To quantify these effects more accurately, a detailed investigation of farm-level impacts based on the collection of primary data is required. However, a detailed empirical investigation and data collection exercise of this nature are outside the scope of the present study.

In terms of benefits there is a very real benefit for extra strorage of N saved. Table 5.20 in the previous chapter found that, depending on assumptions over the closed period tN saved ranged from 326 tn to 591. Table 6.1 illustrates the possible cost savings from these figures, given a range of prices for N, which has fluctuated from between £0.23 to £0.43 in recent years.

Table 6.1. Estimated Benefits from Storage of N

Closed period:		Sept-Jan	Oct-Jan	Oct-Dec
Total N saved	Kg N	**591,000**	**330,000**	**326,000**
£ 0.23	Kg N	£135,930	£75,900	£74,980
£0.30	Kg N	£177,300	£99,000	£97,800
£0.43	Kg N	£254,130	£141,900	£140,180

6.3. Farmers are required to complete a manure management plan

Farmers within NVZs will be required to complete a Manure Management Plan (MMP). This differs from the current Fertiliser and Manure Plan in that the requirements are more detailed, for instance requiring the production of a risk assessment map and the calculation of N storage requirements. The requirements of the MMP are set out in Appendix 4.

Costs for the preparation of MMPs have been estimated for each of the main farm types on the basis of time required and hourly costs of SAC Consultancy Services and are presented in Table 6.2. The time requirements for MMP preparation vary across the farm types from 1 hour at a cost of £60 for specialist fruit and horticulture farms to 20 hours and a cost of £1200 for specialist livestock farms. **However, it should be emphasised that this is mostly a one-time cost as a risk-assessment map can be used for a number of years operation of the MMP.**

The estimated cost for cereals and general cropping farms assumes that there are no livestock present. As the farm census data presented in Appendix 5 shows there are livestock present on many cereal and general cropping farms, in which case the costs of MMP preparation will be similar to those for either cropping and mixed livestock or cropping and intensive livestock farms. We would expect therefore that the time requirements for MMP preparation for such farms would be 8 hours or 11 hours for cereal and general cropping farms where the livestock can be considered mixed or intensive respectively. These estimates assume a reduction of 3 hours in MMP preparation when compared to cropping and either mixed or intensive livestock.

Tables 6.3a to 6.3d present these costs for each NVZ broken down by farm type. The initial costs are for larger farms of each type, however variations exist in the average size of different farm types across each NVZ. For example the average size of a cropping and dairy farm in Nithsdale is 473 ha compared to 205 ha in Fife and Strathmore. It would be expected that time required for MMP preparation for smaller farms would be up to 15% lower to reflect the reduced area covered for aspects such as risk assessment maps. For non-livestock farms where the MMP is less complex, there would remain a minimal cost requirement. To reflect the differences in cost due to farm size Tables 6.3a to 6.3d also include variation in time required of 15% less, rounded up to the nearest full hour.

Across the four NVZs the upper bound cost of MMP preparation is estimated to total £5,961,060; with the following costs in each NVZ:

- Moray, Aberdeenshire, Banff and Buchan - £2,939,820;
- Fife and Strathmore - £1,490,280;
- Lothian and Borders - £924,180; and
- Nithsdale - £606,780.

The estimated total cost across the four NVZs on the basis of a 15% reduction in preparation time is £5,339,820 thus giving a range of £621,240 when accounting for different farm sizes. We have not adjusted the figures for cereals and general cropping farms to account for the presence of livestock, as we have assumed that the upper bound cost figures will adequately cover the total costs of MMP preparation within each NVZ.

In addition to the direct costs of MMP preparation to farmers there will potentially be one-off costs associated with modifying spreading equipment, for example from high trajectory to low trajectory operation. These will either fall directly on the farmer or indirectly through contractors passing on such costs. The typical cost of such modification is estimated at £300 to £400 per spreader. The use of contractors will also require monitoring by farmers to ensure that NVZ Action Programme measures are complied with.

Balanced against the costs of preparing a MMP, are the off-set risks of non-compliance. These relate not only to the compliance with specific NVZ measures, but also for farms in receipt of the Single Farm Payment, penalties associated with non-compliance with Statutory Management Requirements (4) of cross compliance. Failure to follow NVZ Action Programme measures constitutes non-compliance with these conditions.

Failure to comply with NVZ Action Programme or with associated SEERAD notices measures are criminal offences. Penalties include a maximum fine of £5,000 upon summary conviction or an unlimited fine if convicted upon indictment.

The Statutory Management Requirements (4) of cross compliance (Scottish Executive, 2005) states that negligent failure to comply will result in direct payments being reduced by 3%, this may be reduced to 1% or increased to 5% depending in the seriousness of the non-compliance. Where non-compliance was intentional the reduction in payments is 20%, where this can be reduced to 15% or increased to 100%. Intentional non-compliance may also result in exclusion from the scheme payments.

Table 6.2. Estimated consultant time requirements and costs for Manure Management Plan preparation classified by farm type.

Main Farm Type	Hours	Cost (£)
Cereals & General Cropping*	2	120
Specialist Fruit, Grass & Other Horticulture	1	60
Specialist Pigs	20	1,200
Specialist Poultry	14	840
Mixed Pigs and Poultry	20	1,200
Dairy(LFA & Lowground)	20	1,200
Cattle & Sheep	11	660
Cropping & Dairy	20	1,200
Cropping, Cattle & Sheep	11	660
Cropping & Intensive Livestock	14	840
Cropping & Mixed Livestock	11	660
Mixed Livestock	11	660
Specialist Grass & Forage	6	360
Specialist Horses	4	240

* Assumes no livestock present on farm.

Table 6.3a Costs of Manure Management Plan by farm type for Moray, Aberdeenshire, Banff and Buchan NVZ.

Main Farm Type	Total area (ha)	Number of holdings	MMP hours	Cost (£60/hour)	Total hours	Total cost (£)	Cost Sensitivity (-15%)			
							Time (hours)	Cost (£)	Total hours	Total (£)
Cereals & General Cropping	173,715	1,717	2	120	3434	206040	2	120	3434	206040
Specialist Fruit, Grass & Other Horticulture	745	103	1	60	103	6180	1	60	103	6180
Specialist Pigs	3,279	39	20	1,200	780	46800	17	1020	663	39780
Specialist Poultry	1,435	160	14	840	2240	134400	12	720	1920	115200
Mixed Pigs and Poultry	0	0	20	1,200	0	0	17	1020	0	0
Dairy(LFA & Lowground)	9,003	79	20	1,200	1580	94800	17	1020	1343	80580
Cattle & Sheep	83,588	1,362	11	660	14982	898920	10	600	13620	817200
Cropping & Dairy	6,466	26	20	1,200	520	31200	17	1020	442	26520
Cropping, Cattle & Sheep	81,780	726	11	660	7986	479160	10	600	7260	435600
Cropping & Intensive Livestock	6,300	44	14	840	616	36960	12	720	528	31680
Cropping & Mixed Livestock	88	11	11	660	121	7260	10	600	110	6600
Mixed Livestock	3,279	67	11	660	737	44220	10	600	670	40200
Specialist Grass & Forage	30,761	2,161	6	360	12966	777960	5	300	10805	648300
Specialist Horses	5,214	733	4	240	2932	175920	4	240	2932	175920
Total	**405653**	**7228**			**48997**	**2939820**			**43830**	**2629800**

Table 6.3b Costs of Manure Management Plan by farm type for Fife & Strathmore NVZ

Main Farm Type	Total area (ha)	Number of holdings	MMP hours	Cost (£60/hour)	Total hours	Total cost (£)	Cost Sensitivity (-15%)			
							Time (hours)	Cost (£)	Total hours	Total (£)
Cereals & General Cropping	236,187	1,869	2	120	3738	224280	2	120	3738	224280
Specialist Fruit, Grass & Other Horticulture	2,177	97	1	60	97	5820	1	60	97	5820
Specialist Pigs	537	22	20	1,200	440	26400	17	1020	374	22440
Specialist Poultry	1,365	108	14	840	1512	90720	12	720	1296	77760
Mixed Pigs and Poultry	0	0	20	1,200	0	0	17	1020	0	0
Dairy(LFA & Lowground)	5,297	41	20	1,200	820	49200	17	1020	697	41820
Cattle & Sheep	110,815	572	11	660	6292	377520	10	600	5720	343200
Cropping & Dairy	6,779	33	20	1,200	660	39600	17	1020	561	33660
Cropping, Cattle & Sheep	40,537	248	11	660	2728	163680	10	600	2480	148800
Cropping & Intensive Livestock	2,175	15	14	840	210	12600	12	720	180	10800
Cropping & Mixed Livestock	273	8	11	660	88	5280	10	600	80	4800
Mixed Livestock	1,692	21	11	660	231	13860	10	600	210	12600
Specialist Grass & Forage	24,655	1,061	6	360	6366	381960	5	300	5305	318300
Specialist Horses	4,086	414	4	240	1656	99360	4	240	1656	99360
Total	**436575**	**4509**			**24838**	**1490280**			**22394**	**1343640**

Table 6.3c Costs of Manure Management Plan by farm type for Lothian & Borders NVZ

Main Farm Type	Total area (ha)	Number of holdings	MMP hours	Cost (£60/hour)	Total hours	Total cost (£)	Cost Sensitivity (-15%)			
							Time (hours)	Cost (£)	Total hours	Total (£)
Cereals & General Cropping	123,468	728	2	120	1456	87360	2	120	1456	87360
Specialist Fruit, Grass & Other Horticulture	363	43	1	60	43	2580	1	60	43	2580
Specialist Pigs	832	14	20	1,200	280	16800	17	1020	238	14280
Specialist Poultry	289	63	14	840	882	52920	12	720	756	45360
Mixed Pigs and Poultry	0	0	20	1,200	0	0	17	1020	0	0
Dairy(LFA & Lowground)	3,235	20	20	1,200	400	24000	17	1020	340	20400
Cattle & Sheep	130,984	508	11	660	5588	335280	10	600	5080	304800
Cropping & Dairy	2,905	9	20	1,200	180	10800	17	1020	153	9180
Cropping, Cattle & Sheep	36,810	147	11	660	1617	97020	10	600	1470	88200
Cropping & Intensive Livestock	1,086	9	14	840	126	7560	12	720	108	6480
Cropping & Mixed Livestock	10	2	11	660	22	1320	10	600	20	1200
Mixed Livestock	84	11	11	660	121	7260	10	600	110	6600
Specialist Grass & Forage	11,378	614	6	360	3684	221040	5	300	3070	184200
Specialist Horses	2,262	251	4	240	1004	60240	4	240	1004	60240
Total	**313706**	**2419**			**15403**	**924180**			**13848**	**830880**

Table 6.3d Costs of Manure Management Plan by farm type for Nithsdale NVZ

Main Farm Type	Total area (ha)	Number of holdings	MMP hours	Cost (£60/hour)	Total hours	Total cost (£)	Cost Sensitivity (-15%)			
							Time (hours)	Cost (£)	Total hours	Total (£)
Cereals & General Cropping	6,281	59	2	120	118	7080	2	120	118	7080
Specialist Fruit, Grass & Other Horticulture	46	12	1	60	12	720	1	60	12	720
Specialist Pigs	47	2	20	1,200	40	2400	17	1020	34	2040
Specialist Poultry	219	33	14	840	462	27720	12	720	396	23760
Mixed Pigs and Poultry	0	0	20	1,200	0	0	17	1020	0	0
Dairy(LFA & Lowground)	12,395	111	20	1,200	2220	133200	17	1020	1887	113220
Cattle & Sheep	66,663	381	11	660	4191	251460	10	600	3810	228600
Cropping & Dairy	946	2	20	1,200	40	2400	17	1020	34	2040
Cropping, Cattle & Sheep	5,326	41	11	660	451	27060	10	600	410	24600
Cropping & Intensive Livestock	0	0	14	840	0	0	12	720	0	0
Cropping & Mixed Livestock	17	1	11	660	11	660	10	600	10	600
Mixed Livestock	255	4	11	660	44	2640	10	600	40	2400
Specialist Grass & Forage	9,242	350	6	360	2100	126000	5	300	1750	105000
Specialist Horses	1,336	106	4	240	424	25440	4	240	424	25440
Total	**102773**	**1102**			**10113**	**606780**			**8925**	**535500**

6.4. Limitation of land application of fertilisers

Reductions in fertiliser are most effective for those crops receiving inputs above the 'economic' optimum. The cost of reduction is also smallest at high inputs (and there may indeed be a financial benefit, in preventing uneconomic over-fertilisation of crops).

The economic optimum clearly depends on the ratio between fertiliser cost and crop value.

- Decrease in produce price or increase in fertiliser price = economic optimum decreases
- Increase in produce price or decrease in fertiliser price = economic optimum increases

Recent economic changes are driving fertiliser inputs downward. The effect is clearly documented for grassland systems (from 114kg N per ha in 1995, the centre of the period for designation of NVZs, to 105 kg N per ha in Scotland in 2002). In arable systems, it appears that the effect has not yet been fully felt.

Based on experimental data, improved compliance with detailed fertiliser recommendations would be economically beneficial to farmers by either reducing costs or increasing yield or quality of the crop.

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