National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Agricultural practice and water quality on farms reg

Agricultural practice and water quality on farms registered for derogation

Results for 2011 in the derogation monitoring network

National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Agricultural practice and water quality on farms registered for derogation

Results for 2011 in the derogation monitoring network

National Institute for Public Health and the Environment,
RIVM report 680717035/2013

Colophon

A.E.J. Hooijboer, RIVM
A. van den Ham, LEI
L.J.M. Boumans, RIVM
C.H.G. Daatselaar, LEI
G.J. Doornewaard, LEI
E. Buis, RIVM

Contact person:
Arno Hooijboer
Centre for Environmental Monitoring
arno.hooijboer@rivm.nl

This study was commissioned by the Ministry of Economic Affairs as part of Project No. 680717, Minerals Policy Monitoring Programme (LMM).

Abstract

Agricultural practice and water quality on farms registered for derogation
Results for 2011 in the derogation monitoring network

The EU Nitrates Directive obligates member states to limit the use of livestock manure to a maximum of 170 kg of nitrogen per hectare per year. Dutch farms cultivating at least 70 percent of their total area as grassland are allowed to deviate from this requirement under certain conditions, and apply up to 250 kg of nitrogen per hectare (this partial exemption is referred to as 'derogation'). The Netherlands is obligated to monitor agricultural practices and water quality at 300 farms to which derogation has been granted, and to submit an annual report on the results to the EU. The outcome of this study is that the average groundwater nitrate concentration on these farms has decreased during the 2007-2012 period. This report was prepared by the National Institute for Public Health and the Environment together with the Agricultural Economics Research Institute of Wageningen University & Research Centre, and commissioned by the Dutch Ministry of Economic Affairs.

Agricultural practices
The report also shows that, on average, derogation farms in 2011 used a few kilogrammes less nitrogen in livestock manure than the prescribed maximum of 250 kg per hectare. The quantity of nitrogen that can potentially leach into the groundwater in the form of nitrate is partly determined by the nitrogen soil surplus. This surplus is defined as the difference between nitrogen input (e.g. in the form of fertilisers) and nitrogen output (e.g. via milk). On average, the nitrogen soil surplus decreased significantly throughout the Netherlands between 2006 and 2011.

Groundwater quality
In 2011, the average groundwater nitrate concentration on derogation farms in the Sand Region amounted to 41 milligrammes per litre (mg/l) and was therefore below the nitrate standard of 50 mg/l. On average, farms in the Clay and Peat Regions have even lower nitrate concentrations (14 and 7 mg/l, respectively). With an average groundwater nitrate concentration of 55 mg/l, only derogation farms in the Loess Region exceed the standard. The difference between the regions is mainly caused by a higher percentage of soils prone to nitrogen leaching in the Sand and Loess Regions. On these soils less denitrification occurs, and more nitrate can therefore leach into the groundwater.

Keywords:
derogation decision, agricultural practices, manure, Nitrates Directive, water quality

Rapport in het kort

Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie
Resultaten meetjaar 2011 in het derogatiemeetnet

De Europese Nitraatrichtlijn verplicht lidstaten om het gebruik van dierlijke mest te beperken tot 170 kg stikstof per hectare. Landbouwbedrijven in Nederland met ten minste 70% grasland mogen onder bepaalde voorwaarden van deze norm afwijken en 250 kg per hectare gebruiken (derogatie). Nederland is verplicht om op 300 bedrijven die derogatie gebruiken, de bedrijfsvoering en waterkwaliteit te meten en deze resultaten jaarlijks aan de EU te rapporteren. Uit de rapportage over 2011 die het RIVM met het LEI in opdracht van het ministerie van Economische Zaken heeft opgesteld, volgt dat de nitraatconcentratie in het grondwater op deze bedrijven tussen 2007 en 2012 gemiddeld is gedaald.

Bedrijfsvoering
Uit de rapportage blijkt ook dat het stikstofgebruik uit dierlijke mest op de derogatiebedrijven in 2011 gemiddeld enkele kilogrammen lager was dan 250 kg stikstof per hectare. De hoeveelheid stikstof die mogelijk als nitraat kan uitspoelen naar het grondwater, wordt mede bepaald door het stikstofbodemoverschot. Dit is het verschil tussen de aanvoer van stikstof (zoals meststoffen) en de afvoer ervan (waaronder via melk). Het stikstofbodemoverschot is gemiddeld over heel Nederland significant gedaald tussen 2006 en 2011.

Grondwaterkwaliteit
In 2011 ligt de nitraatconcentratie in het grondwater in de Zandregio met gemiddeld 41 milligram per liter (mg/l) onder de nitraatnorm van 50 mg/l. Bedrijven in de Kleiregio en de Veenregio hebben gemiddeld een lagere nitraatconcentratie (14 en 7 mg/l). Alleen de derogatiebedrijven in de Lössregio zitten gemiddeld met 55 mg/l boven de norm. Het verschil tussen de regio's wordt vooral veroorzaakt door een hoger percentage uitspoelingsgevoelige gronden in de Zand- en Lössregio; dit zijn gronden waar nitraat minder in de bodem wordt afgebroken en daardoor kan uitspoelen naar het grondwater.

Trefwoorden:
derogatiebeschikking, landbouwpraktijk, mest, Nitraatrichtlijn, waterkwaliteit

Preface

This report was commissioned by the Dutch Ministry of Economic Affairs, and prepared by the National Institute for Public Health and the Environment (RIVM) in collaboration with the Agricultural Economics Research Institute (LEI) of Wageningen University & Research Centre. LEI is responsible for the information about agricultural practices, while RIVM is responsible for the water quality data. RIVM also served as the official secretary for this project.

This report provides an overview of agricultural practices in 2011 on all farms registered for derogation in the derogation monitoring network. The agricultural practice data includes data on fertiliser use and actual nutrient surpluses. Information is also provided about the results of water quality monitoring conducted in 2011 and 2012 at farms in the derogation monitoring network.

The monitoring network covers 300 farms. The farms in the derogation monitoring network were either already participating in the Minerals Policy Monitoring Programme (LMM), or were recruited and sampled during sampling campaigns. This is the first year in which new regional boundaries were defined, resulting in changes to the number of farms in each region.

The authors would like thank Mr E. Mulleneers of the Ministry of Economic Affairs, Mr K. Locher of the Ministry of Infrastructure and the Environment, the members of the LMM Feedback Group, and Mr G.L. Velthof and Mr J.J. Schröder of the Committee of Experts on the Fertilisers Act (CDM) for their comments. Finally, we would like to thank our colleagues at LEI (particularly P.W. Blokland, M.W. Hoogeveen, T.C. van Leeuwen, J.W. Reijs and H.B. van der Veen) and at RIVM who, each in their own way, have contributed to the realisation of this report.

Arno Hooijboer, Aart van den Ham, Leo Boumans, Co Daatselaar, Gerben Doornewaard and Eke Buis

27 June 2013

Contents

Summary

Background
The EU Nitrates Directive obligates member states to limit the use of nitrogen in livestock manure to a maximum of 170 kg of nitrogen per hectare per year. A member state can request the European Commission for exemption from this obligation, provided certain conditions are met (this exemption is referred to as 'derogation' throughout this report). In December 2005, the European Commission issued the Netherlands with a definitive derogation decision for the 2006-2009 period; in February 2010 this decision was extended until December 2013. Under this decision, farms cultivating at least 70 percent of their total area as grassland may, under specific conditions, apply up to 250 kg of nitrogen per hectare in the form of manure from grazing livestock. The conditions attached to this exemption arrangement include an obligation for the Dutch government to set up a monitoring network for exempted farms in accordance with the requirements stipulated in the derogation decision, and to submit annual reports to the European Commission.

The derogation monitoring network
In 2006 a network was set up to monitor the development of agricultural practices and water quality following introduction of the derogation scheme. This so-called 'derogation monitoring network' comprises 300 farms that have registered for derogation. Of these 300 farms, 290 participated in the derogation scheme in 2011 (see Table S1). The derogation monitoring network was set up by expanding the Minerals Policy Monitoring Programme (*Landelijk Meetnet effecten Mestbeleid*, LMM) of RIVM and LEI. A stratified random sampling method was used to select 300 farms, distributed as evenly as possible according to soil type (sand, loess, clay and peat), farm type (dairy farms and other grassland farms) and economic size. Designing the monitoring network in this way fulfils the requirement, as stipulated in the derogation decision, that the network must be representative of all soil types (clay, peat, sand and loess soils), crop rotations and fertilisation practices, and must have a particular focus on the Sand Region.

New regional boundaries
Compared to the previous report (Buis *et al.*, 2012), there have been some changes to the regions that are reported on. The old classification was based on the municipal boundaries, whereas the new classification is based on postcode districts. The new system is more in line with the actual soil types found in the different regions and the boundaries are more consistent because they are no longer subject to changes in municipal boundaries. The new regional boundaries have resulted in changes to the average water quality and soil surpluses in each region (refer to Appendix 8). These changes are minor, however. The regional boundaries have been adjusted with retroactive effect for all years surveyed, resulting in a recalculation of historical data sets.

Characteristics of farmland and farms in the derogation monitoring network
The stratification for data year 2011 is based on the old regional boundaries (refer to Table S1). As a result, the number of farms in each region in 2011 differs from the original set-up.

In 2011, the total area of agricultural land in the derogation monitoring network amounted to 2 percent of the surface area used by all exempted farms that fulfilled the criteria for inclusion in the monitoring network (the sample population).

Table S1 Characteristics of farms included in the derogation monitoring network in 2011, per region

Characteristics	*Region*				
	Sand	*Loess*	*Clay*	*Peat*	*All*
Number of farms included in monitoring network	160	20	60	60	300
Number of exempted farms fully processed in FADN	149	19	68	54	290
- Of which specialised dairy farms	129	17	61	49	256
- Of which other grassland farms	20	2	7	5	34
Descriptive characteristics					
Average acreage of cultivated land (hectares)	49	46	58	59	53
Average percentage of grassland	81	72	85	92	83
Average milk production (in kg of FPCM[1] per hectare of fodder crop)	16,500	15,500	15,900	14,700	15,900

[1] FPCM = Fat and Protein Corrected Milk, a standard used to compare milk with different fat and protein contents (1 kg of milk with 4.00 percent fat content and 3.32 percent protein content = 1 kg of FPCM). The reported milk production averages only concern dairy farms (N = 256).

With an average size of 53 hectares (refer to Table S1), the average acreage of farms in the derogation monitoring network exceeds that of the average farm in the sample population (44 hectares). Dairy farms in the network also produced more milk per hectare, especially in the Clay and Peat Regions. At 83 percent (see Table S1), the percentage of farmland used as grassland is equal to the average for the sample population.

Use of fertilisers

In 2011, the farms in the derogation monitoring network used on average 246 kg of nitrogen from livestock manure per hectare of cultivated land (Table S2). This is a few kilogrammes less than the nitrogen application standard for livestock manure (250 kg per hectare). An average of 175 kg of nitrogen per hectare was used on arable land, whereas on grassland an average of 259 kg of nitrogen from livestock manure was applied. The total use of nitrogen (in the form of inorganic fertilisers and plant-available nitrogen from livestock manure) remained below the total nitrogen application standard (260 kg per hectare on average). The average phosphate use was equal to the phosphate application standard for farms in the derogation monitoring network (90 kg per hectare), taking account of the phosphate status of the soil.

Table S2 Average use of fertilisers on farms in the derogation monitoring network in 2011, per region

Characteristics		*Region*				
		Sand	*Loess*	*Clay*	*Peat*	*All*
Nitrogen from livestock manure	Farm level	247	250	241	247	246
(Kilogrammes of nitrogen per hectare)	Arable land[2]	184	168	153	176	175
	Grassland	264	262	251	256	259
Total plant-available nitrogen[1]	Farm level	234	235	268	247	244
(Kilogrammes of nitrogen per hectare)	Arable land[2]	123	128	125	118	123
	Grassland	264	274	292	260	270
Total phosphates[1]	Farm level	90	94	87	89	90
(kg P_2O_5/ha)	Arable land[2]	77	69	75	81	77
	Grassland	94	95	88	91	92

[1] From livestock manure and other organic and inorganic fertilisers. The quantity of plant-available nitrogen from livestock manure and other organic fertilisers was calculated based on the statutory availability coefficients for 2011.
[2] Most arable land on grassland farms (90 percent on average) is used for the cultivation of silage maize.

Crop yields and nutrient surpluses at farm level

On average, yields of 190 kg of nitrogen per hectare and 70 kg of phosphate per hectare were estimated for silage maize, and yields of 274 kg of nitrogen per hectare and 87 kg of phosphate per hectare were calculated for grassland (Table S3). The average nitrogen surplus on the soil surface balance in 2011 was calculated at 175 kg per hectare. The nitrogen surplus decreases in the following order: Peat > Clay > Sand > Loess (Table S3). The high surplus in the Peat Region was caused by an average of 75 kg of net nitrogen mineralisation per hectare being included in the calculation, whereas in the other regions the net nitrogen mineralisation was probably negligible. The nitrogen surplus on the soil surface balance in the Clay Region is higher than in the Loess Region, due to greater use of inorganic fertilisers (Table S2). The phosphate surplus on the soil surface balance amounted to 12 kg of P_2O_5 per hectare on average. The phosphate surplus in the Sand and Loess Regions is slightly higher than in the Clay and Peat Regions.

Table S3 Average estimated silage maize yields and calculated grassland yields on all farms that fulfilled the selection criteria for application of the calculation method[1], and nutrient surpluses on the soil surface balance on farms in the derogation monitoring network in 2011, per region

Characteristics	*Region*				
	Sand	*Loess*	*Clay*	*Peat*	*All*
Estimated silage maize yields[2]					
Kilogrammes of dry matter per hectare	16,500	16,700	15,800	15,000	16,200
Kilogrammes of nitrogen per hectare	194	196	187	177	190
Kilogrammes of P_2O_5 per hectare	70	71	70	66	70
Calculated grassland yield[2]					
Kilogrammes of dry matter per hectare	9,900	9,700	9,900	10,000	9,800
Kilogrammes of nitrogen per hectare	273	287	272	289	274
Kilogrammes of P_2O_5 per hectare	89	90	89	85	87
Nutrient surpluses per hectare of cultivated land					
Nitrogen surplus on the soil surface balance (kg of nitrogen per hectare)	163	148	166	229	175
Phosphate surplus in the soil surplus balance (kg of P_2O_5 per hectare)	14	15	7	12	12

[1] Aarts *et al.*, 2008

[2] The silage maize and grassland yields are based on 165 and 219 farms, respectively. The other farms did not meet the selection criteria.

Analysis of agricultural practices during the 2006-2011 period

The increase in milk production per farm, per hectare and per cow, combined with virtually no growth in the total surface area of cultivated land indicates a gradual increase in scale and intensification, resulting in higher milk production per hectare and per cow. The proportion of grassland has remained virtually stable, while the proportion of farms with grazing dairy cows is slowly declining. This decrease is greater for farms where cows are grazing in September and October than for farms where cows are grazing throughout the entire May-October grazing period. The proportion of farms with grazing animals and pigs and poultry is decreasing (Table S4).

Table S4 Development of average size, farm type and milk production levels on farms participating in the derogation monitoring network

Characteristics	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Total area of cultivated land (hectares)	51	53	+	+
Proportion of grassland (%)	83	83	≈	≈
Proportion of farms with pigs and poultry (%)	11	8	-	-
Kilogrammes of FPCM[1] per farm (x 1,000)	776	869	+	+
Kilogrammes of FPCM[1] per dairy cow (x 1,000)	8.5	8.6	+	+
Kilogrammes of FPCM[1] per hectare of fodder crop (x 1,000)	15	16	+	+
Percentage of dairy farms where dairy cows are grazing in May-October period	85	78	-	-
Percentage of dairy farms where dairy cows are grazing in September-October period	83	71	-	-

[1] FPCM = Fat and Protein Corrected Milk, a standard used to compare milk with different fat and protein contents (1 kg of milk with 4.00 percent fat content and 3.32 percent protein content = 1 kg of FPCM).

Difference: direction and significance of difference between 2011 and average for previous years. ≈ : insignificant difference ($p > 0.05$), +/- : significant difference ($p < 0.05$). Trend: direction and significance of trend in 2006-2011 period. ≈ : insignificant trend ($p > 0.05$), +/- : significant trend ($p < 0.05$).

The application of nitrogen from livestock manure does not exceed the standard of 250 kg per hectare. There is a significant increase in the use of plant-available nitrogen in livestock manure (Table S5). This increase is caused mainly by the increased availability coefficient of nitrogen in livestock manure in 2008 (see Appendix 5, Table A5.3). The difference between the total nitrogen application standard and the actual use of plant-available nitrogen decreased from an average of over 40 kg per hectare (2006-2010 period) to an average of approx. 16 kg per hectare (2011) (Table S5). This can be partly attributed to an increase in the statutory availability coefficient and a reduction of the nitrogen application standard.

The difference between actual phosphate use per hectare and the phosphate application standard per hectare decreased from an average of approx. 7 kg per hectare (2006-2010 period) to 0 kg per hectare (2011), mainly as a result of the stricter regulations for use which were introduced in 2010. These regulations also take into account the phosphate status of the soil. The use of phosphates as well as the phosphate application standard decreased significantly between 2006 and 2010 (Table S5). This went hand in hand with a decline in the use of phosphate-containing inorganic fertilisers.

Table S5 Development of average use of nitrogen in livestock manure, total use of plant-available nitrogen and phosphate, and nitrogen and phosphate surpluses on the soil surface balance on farms participating in the derogation monitoring network

Characteristics	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Use of nitrogen in livestock manure per hectare, excluding availability coefficient	241	246	≈	≈
Total use of plant-available nitrogen per hectare, including availability coefficient	232	244	+	+
Total nitrogen application standard per hectare for farms	273	260	-	-
Average nitrogen surplus on soil surface balance, per hectare	184	175	-	-
Phosphate use per hectare	93	90	-	-
Phosphate application standard for farms, per hectare	100	90	-	-
Average phosphate surplus on soil surface balance, per hectare	17	12	-	-

Difference: direction and significance of difference between 2011 and average for previous years. ≈ : insignificant difference ($p > 0.05$), +/- : significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2011 period. ≈ : insignificant trend ($p > 0.05$), +/- : significant trend ($p < 0.05$).

On average, the nitrogen surpluses on the soil surface balance decreased significantly on all farms during the 2006-2011 period. The decrease is significant in the Sand Region, but not in the other regions. The phosphate soil surplus also showed a significant decrease between 2006 and 2011 (Table S5). In 2011, farms in the 25 percent quartile realised a phosphate surplus of less than 0 kg per hectare (0 kg/ha = balance).

The estimated silage maize yield and the calculated grassland yield showed a significant upward trend in terms of the quantity of dry matter during the 2006-2011 period. The yield measured in kilogrammes of nitrogen is showing a rising trend for silage maize. There is no significant increase or decrease in the yield measured in kilogrammes of phosphate.

Water quality in measurement year 2011

The water quality measured in 2011 partly reflects agricultural practices in 2010 and in previous years. At 41 mg/l, the average nitrate concentration in the Sand Region is below the nitrate standard of 50 mg/l (Table S6). At 55 mg/l, the average nitrate concentration on farms in the Loess Region exceeds the standard. Nitrate concentrations in the Clay Region (14 mg/l) and the Peat Region (7 mg/l) are lower, due to a higher proportion of soils that are prone to leaching in these regions. In the Sand Region, nitrate concentrations were below the standard at 66 percent of farms (Table S6). In the Loess Region, nitrate concentrations were below the standard at 58 percent of farms. The percentage of farms with below-standard nitrate concentrations was 95 percent in the Clay Region and 98 percent in the Peat Region.

Table S6 Quality of water leaching from the root zone in 2011; average nitrate, nitrogen and phosphorus concentrations in mg/l, and percentage of farms with an average nitrate concentration higher than 50 mg/l

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	140	19	58	50
Nitrate (NO_3) (mg/l)	41	55	14	7
Percentage of farms with nitrate concentration higher than 50 mg/l	34	42	5	2
Nitrogen (N) (mg/l)	12.4	13.4	5.2	9.5
Phosphorus (P) (mg/l)	0.10	N/A[1]	0.28	0.38

[1] The phosphorus measurements conducted in the Loess Region were rejected (refer to section 3.2.1).

The nitrate and nitrogen concentrations measured in ditch water were lower than the concentrations measured in water leaching from the root zone (Table S7). In the Sand and Clay Region, the phosphorus concentrations in ditch water were comparable to the concentrations in water leaching from the root zone. In the Peat Region, the phosphorus concentrations in ditch water were lower than those in water leaching from the root zone.

Table S7 Quality of ditch water in the winter of 2010-2011; average nitrate, nitrogen and phosphorus concentrations in mg/l, and percentage of farms with an average nitrate concentration higher than 50 mg/l

Characteristic	*Region*		
	Sand	*Clay*	*Peat*
Number of farms	35	57	49
Nitrate (NO_3) (mg/l)	23	6	4
Percentage of farms with nitrate concentration higher than 50 mg/l	11	0	0
Nitrogen (N) (mg/l)	7.4	3.4	4.6
Phosphorus (P) (mg/l)	0.09	0.26	0.16

Water quality in measurement year 2012 (preliminary results)

The preliminary water quality results in 2012 partly reflect agricultural practices in 2011 (the sixth year of operation of the derogation scheme) and previous years (Tables S8 and S9). Consequently, these figures can be directly linked to the agricultural practice data that are stated in this report as well. The final water quality results for 2012 will be included in the report for 2014 (these are not expected to deviate significantly from the preliminary results). In all regions, the nitrate concentrations in water leaching from the root zone were lower than the concentrations measured in 2011.

Table S8 Quality of water leaching from the root zone in 2012; average nitrate, nitrogen and phosphorus concentrations in mg/l and percentage of farms with an average nitrate concentration higher than 50 mg/l

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	152	*	62	51
Nitrate (NO_3) (mg/l)	36	*	11	4
Percentage of farms with nitrate concentration higher than 50 mg/l	26	*	0	0
Nitrogen (N) (mg/l)	12	*	4.7	8.0
Phosphorus (P) (mg/l)	0.11	*	0.32	0.42

* Results from the Loess Region were not yet available at the time of preparation of the present report; sampling was conducted in the period between September 2012 and February 2013.

Table S9 Quality of ditch water in the winter of 2011/2012; average nitrate, nitrogen and phosphorus concentrations in mg/l and percentage of farms with an average nitrate concentration higher than 50 mg/l

Characteristic	*Region*		
	Sand	*Clay*	*Peat*
Number of farms	36	61	50
Nitrate (NO_3) (mg/l)	20	5	3
Percentage of farms with nitrate concentration higher than 50 mg/l	8	0	0
Nitrogen (N) (mg/l)	6.7	3.2	4.0
Phosphorus (P) (mg/l)	0.10	0.25	0.16

Analysis of water quality results in 2007-2012 period

In 2012, the concentrations measured in water leaching from the root zone in the Sand, Clay and Peat Regions were significantly lower than the average levels measured in previous years (Figure S1). Concentrations in these regions decreased significantly between 2007 and 2012. Nitrate concentrations in 2010 were higher than in previous and subsequent years (refer to Appendix 5, Table A5.9). Following a period of declining levels up to 2010, nitrate concentrations in the Loess Region increased again in 2011.

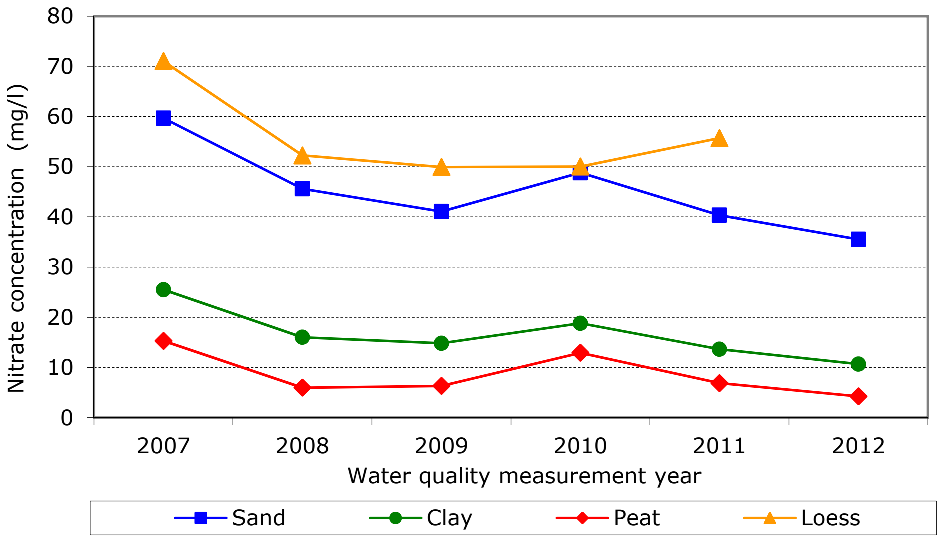

Figure S1 Development of nitrate concentrations in water leaching from the root zone, per region during successive measurement years

The downward trend in nitrate concentrations in water leaching from the root zone and the peak in 2010 can also be observed in ditch water measurements (Figure S2). In all regions, the ditch water nitrate concentrations in 2012 deviated significantly from the average of the preceding years. A significant decrease in nitrate concentrations was observed in the Sand, Clay and Peat Regions.

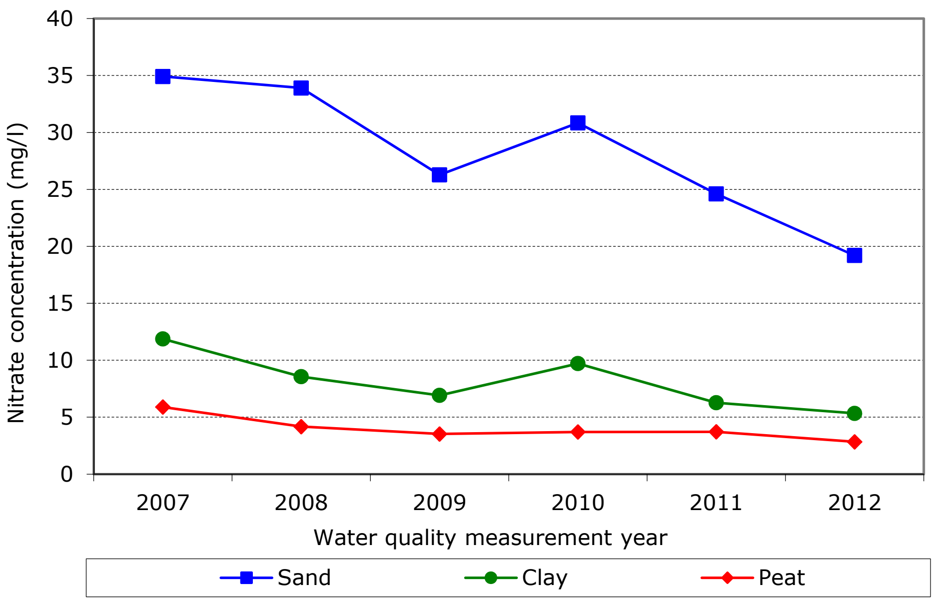

Figure S2 Development of ditch water nitrate concentrations per region in successive measurement years

In the Clay, Sand and Peat Regions, the phosphorus concentrations in water leaching from the root zone fluctuated over the years, and showed a decrease in the following order: Peat > Clay > Sand (Table A5.9). The phosphorus concentrations in water leaching from the root zone in 2012 did not deviate significantly from the average of the preceding years. A significant downward trend may be observed in the Clay Region, while a significant upward trend may be observed in the Sand Region.

Phosphorus concentrations in ditch water show a decrease in the following order: Clay > Peat > Sand. The phosphorus concentrations in ditch water did not deviate significantly from the concentrations in preceding years. Concentrations in ditch water in the Peat and Clay Regions showed a significant downward trend.

The final concentration data will be provided in the progress report for 2014. In that report it will also become apparent if these trends have continued.

Effects of agricultural practices on water quality

Nitrogen
Nitrate concentrations in water leaching from the root zone showed a decrease in all regions except the Loess Region in the period 2007-2012 (Figure S1). Calculated nitrogen surpluses in the Sand Region showed a significant decrease between 2006 and 2011. Although nitrate concentrations declined significantly in the Clay and Peat Regions, soil surpluses did not decrease significantly in these regions during the same period (Figure S3).

In addition to the nitrogen surplus, there are other factors which play a role and which may have a diluting or concentrating effect on nitrate concentrations. These may include weather conditions, sample adjustments, after-effects of nitrogen surpluses in previous years, and reduced grazing. Dairy farms appear to be growing in scale and intensifying their operations. More and more entrepreneurs are opting to keep their dairy cows in stables full-time, resulting in reduced grazing (Table S4). This development may partly explain the significant decrease in nitrate concentrations in the Sand Region.

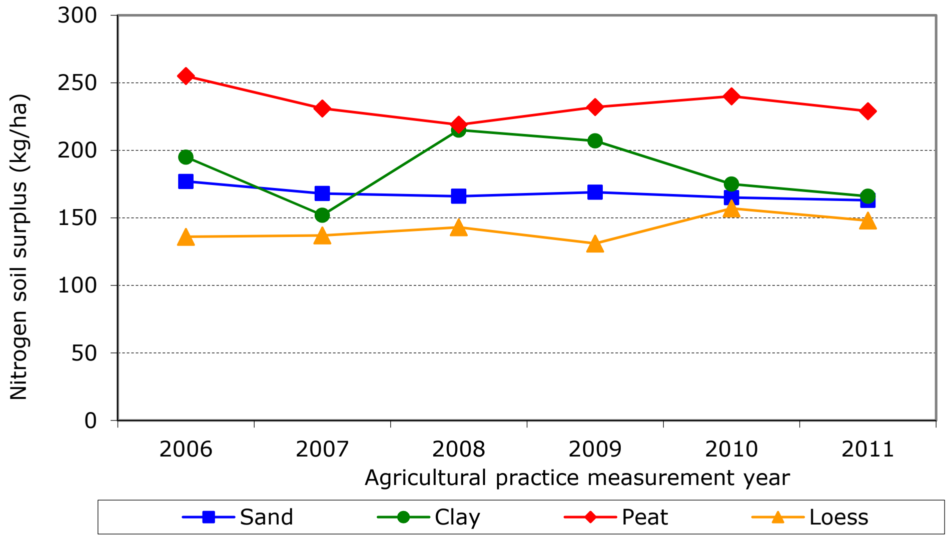

Figure S3 Development of nitrogen surpluses per region in successive measurement years (agricultural practice year x influences subsequent measurement year x+1)

Phosphate
The phosphate surplus on the soil surface balance decreased during the measurement period from 26 kg per hectare in 2006 to 12 kg per hectare in 2011, with a peak in 2008. This decrease was caused mainly by reduced use of inorganic fertilisers. The effect of this decrease was not reflected in water quality levels, probably because phosphate bonds strongly to the soil. Phosphorus concentrations in water leaching from the root zone and in ditch water are therefore mainly affected by hydrological conditions and the degree of surface runoff.

1 Introduction

1.1 Background

The EU Nitrates Directive obligates member states to limit the use of nitrogen in livestock manure to a maximum of 170 kg of nitrogen per hectare per year (EU, 1991). A member state can request the European Commission for exemption from this obligation under certain conditions (this exemption is referred to as 'derogation' throughout this report). In December 2005, the European Commission issued the Netherlands with a definitive derogation decision for the 2006-2009 period (EU, 2005). Under this decision, grassland farms cultivating at least 70 percent of their total area as grassland are allowed to apply on their total area up to 250 kg of nitrogen per hectare in the form of livestock manure originating from grazing livestock. In February 2010, the derogation decision was extended until the end of December 2013 (EU, 2010). The Dutch government is obligated to collect various data about the effects of the derogation scheme, and to report these annually to the European Commission.

One of the obligations under the derogation decision (refer to Appendix 1) concerns the establishment of 'a monitoring network for the sampling of shallow groundwater, soil moisture, drainage water and ditches' on farms granted an individual exemption (Article 8 of the decision, paragraph 2). The network must 'provide data on the nitrate and phosphorus concentrations in the water leaving the root zone and ending up in the groundwater and surface water system' (Article 8, paragraph 4). The monitoring network must cover at least 300 farms and must be 'representative of all types of soil (clay, peat, sand and sandy loess), fertilisation practices and crop rotations' (Article 8, paragraph 2). Within the monitoring network, the monitoring of water quality on farms on sandy soils should be reinforced (Article 8, paragraph 5). The composition of the monitoring network shall not be modified during the period of applicability of the derogation decision (2006-2013) (Article 8, paragraph 2). During negotiations with the European Commission, it was agreed that the design of this monitoring network would tie in with the existing national network for monitoring the effectiveness of minerals policy, the Minerals Policy Monitoring Programme (LMM). Water quality and agricultural practices at farms selected for this purpose have been monitored under this programme since 1992 (Fraters and Boumans, 2005). Additionally it was agreed that all LMM participants who satisfy the relevant conditions would be regarded as participants in the monitoring network for derogation purposes. Accordingly, the derogation monitoring network has been incorporated into the LMM programme. For LMM monitoring purposes, the top metre of phreatic groundwater, the soil moisture and/or the drainage water are sampled, as this procedure is regarded as sampling the water leaving the root zone (Appendix 4). The ditch water is sampled as well, in order to gain an impression of the quality of the surface water on farms.

Besides the obligation to monitor, participants must also report on the development of water quality levels over time. The reports must be based on 'the monitoring of water leaching from the root zone, surface water quality and groundwater quality, as well as on model-based calculations' (Article 10, paragraph 1). Furthermore, an annual report must be submitted 'for the different soil types and crops regarding the fertilisation and the yield on grassland farms on which derogation is permitted', to provide the European

Commission with insight into management practices at these farms and the level of optimisation achieved (Article 10, paragraph 4). This report is intended to meet the aforementioned reporting requirements.

1.2 Previous reports

The first report (Fraters *et al.*, 2007b) was limited to a description of the derogation monitoring network, the progress made in 2006 in terms of setting up this network, and the design and content of the reports for the years 2008 to 2010 inclusive. A general description of the measurement and calculation methods to be used and the models to be applied was also included.

In 2008, the second report was published, containing the first data collected by means of the derogation monitoring network (Fraters *et al.*, 2008). The first year of derogation was 2006. The figures on agricultural practices concern practices covered by the derogation scheme. The water quality data for 2006 relate to agricultural practices in 2005, and therefore do not yet relate to practices covered by the derogation scheme.

The third progress report was published in 2009; it contains the data for 2007 (Zwart *et al.*, 2009). In addition, the results for 2006 and 2007 were subjected to a brief comparison, on the understanding that water quality data for 2006 relate to agricultural practice in 2005. Insufficient measurement data were available to be able to draw conclusions about trends for the third progress report.

The fourth progress report was published in 2010; it contains agricultural practice data and water quality data for 2008, as well as preliminary water quality data for 2009 (Zwart *et al.*, 2010). In addition, the results for 2007, 2008 and 2009 were subjected to a brief comparison, on the understanding that the relevant data set was insufficient to draw solid conclusions about trends. For the first time, a limited analysis was conducted of the relationship between farm results and the associated water quality levels.

The fifth progress report was published in 2011; it contains agricultural practice data and water quality data for 2009 as well as preliminary water quality data for 2010 (Zwart *et al.*, 2011). Additionally, the results for previous years were incorporated, including a comparison of the average agricultural practice data for the 2006-2008 period and the data for measurement year 2009. The water quality data for the 2007-2009 period and the measurement year 2010 were compared. Furthermore, a limited analysis was performed of the relationship between farm results and the associated water quality levels.

The sixth progress report was published in 2012. This report contained agricultural practice data and water quality data for 2010, as well as preliminary water quality data for 2011 (Buis *et al.*, 2012). It also included the agriculture practice data for the period starting in 2006, and water quality data for the period starting in 2007. The sixth progress report also contained a qualitative analysis of the relationship between agriculture practices and water quality.

The boundaries of the soil type regions were adjusted in September 2011, resulting in changes to the boundaries of the Sand, Clay and Peat Region. The boundaries of the Loess Region remained virtually unchanged. The advantages of the new boundaries and their impact on water quality and surpluses on the soil surface balance are explained in Appendix 8.

The new regional boundaries have resulted in slight changes to the average water quality in each region. The regional boundaries have been adjusted with retroactive effect for all years surveyed, resulting in a recalculation of historical data sets. Consequently, the water quality data for previous years as included in this report will deviate slightly from the data included in previous reports.

Recent modifications to the Farm Accountancy Data Network (FADN) calculation model of the Agricultural Economics Research Institute (LEI) have led to changes in the results, particularly with respect to nitrogen surpluses on the soil surface balance. The net effect of all these adjustments is a decrease in the nitrogen soil surplus of 7 kg per hectare, and an increase in the phosphate surplus of 4 kg per hectare (38 percent). Refer to Appendix 9 for further information about this matter.

1.3 Contents of this report

This is the seventh annual report setting out the results of the derogation monitoring network. It contains data on fertilisation, crop yields, nutrient surpluses and water quality. The nutrient surpluses are a major determinant for the quantities of nutrients that could potentially leach out.

The results contained in this report are based on the data registered in the LEI Farm Accountancy Data Network (FADN). The actual situation on the farms is registered in FADN based on the report submitted by the farmer. These data need not necessarily correspond to the data used during enforcement checks. For instance, the area used may differ from the area recorded in the land registration system of the National Service for the Implementation of Regulations (*Dienst Regelingen*, DR) of the Ministry of Economic Affairs, since land which is counted as part of the farm for administrative purposes but which is not actually used for fertilisation, is not registered in FADN. In addition, there may be differences in the numbers of animals and the figures for the input and output of products and other stocks. The DR results are reported in Appendix 7, including a comparison with fertiliser use data compiled using the derogation monitoring network.

By linking fertilisation rates (established on the basis of FADN data) to acreage actually in use, the best possible insight is provided into the relationship between agricultural practices and water quality. However, these data cannot be used to assess compliance with legislation, since data recorded by the DR are required for this purpose.

The data analysis includes both annual average nitrate concentrations measured per region and the results of limited model calculations (refer to Appendix 6). These calculations quantify the effect of confounding factors on the measured nitrate concentrations. Nitrate concentrations in water leaching from the root zone are affected not only by fertilisation, but also by variations in the precipitation surplus (Boumans *et al.*, 1997). A statistical model has been developed to analyse the effect of variations in the precipitation surplus on nitrate concentrations in the top groundwater layer (Boumans *et al.*, 1997; Boumans *et al.*, 2001). This model corrects the sample to account for changes in the composition of the group of participating farms (Fraters *et al.*, 2004).

Participants sometimes have to be replaced in the course of the programme, or changes occur in the acreage of the participating farms. As a result, the ratio of soil types and/or drainage classes on farms participating in the derogation monitoring network can change in the course of the programme. The soil type (sand, loess, clay, peat) and the drainage class (poor, moderate, well-drained) affect the relationship between the nitrogen surplus and the measured nitrate concentration. A change in the measured nitrate concentration could therefore be caused by a change in the composition of the group of participating farms, or by changes in acreage within this group.

Chapter 2 contains a brief description of the design and implementation of the derogation monitoring network. It also details the agricultural characteristics of the participating farms and provides a description of how the water quality is sampled. In addition, an explanation of the models and analyses is given. Chapter 3 presents and discusses the measurement results of the agricultural practice and water quality monitoring conducted in 2011 (Figure 1.1). The water quality data for 2011 are related to the agricultural practice data for 2010 and the preceding years. This chapter also contains the provisional water quality monitoring results for 2012, which are related to the agricultural practice data for 2011 and the preceding years. The data resulting from the loess sampling exercise carried out between the autumn of 2012 and the spring of 2013 have not been included in this report. Chapter 4 describes developments related to agricltural practices and water quality, including a discussion of trend-based changes since the start of derogation, and a statistical analysis of the extent to which agricultural practice year 2011 differed from preceding years. Furthermore, a cautious assessment is provided concerning the effects of agricultural practice on water quality.

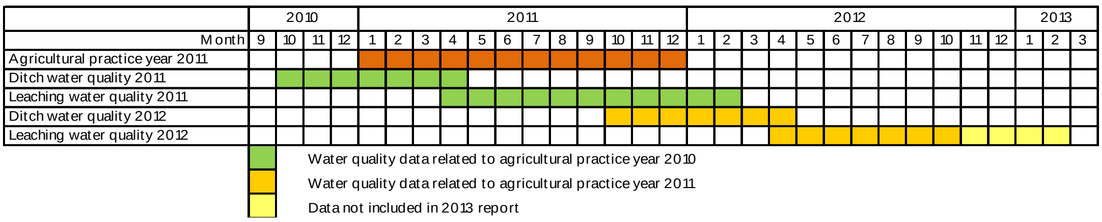

Figure 1.1 Overview of data collection periods for the presented monitoring results concerning agricultural practices and water quality

The relevant articles of the derogation decision granted to the Netherlands by the European Commission are listed in Appendix 1 (EU, 2005). Appendix 2 provides further details about the design of the derogation monitoring network. Appendix 3 provides a detailed justification of the registration of agricultural practice data, the calculation of fertilisation data and nitrogen and phosphate surpluses, and the application of confidence intervals. The water quality measurement method is explained in Appendix 4. Appendix 5 includes a number of tables containing agricultural practice and water quality data. The methodology applied for precipitation corrections and calculations of corrected nitrate concentrations is explained in Appendix 6. Appendix 7 compares fertiliser use according to DR data and according to the data collected using the derogation monitoring network. Appendix 8 explains the effects of the new regional borders on the current situation and trends relating to water quality and surpluses on the soil surface balance. Appendix 9 explains how the new FADN calculation model affects the agricultural practice results.

2 Design of the derogation monitoring network

2.1 Introduction

The design of the derogation monitoring network must satisfy the requirements of the European Commission, as stipulated in the derogation decision of December 2005 and the extension of the derogation in 2010 (refer to Appendix 1). Previous reports provided extensive details about the composition of the sample and the choices this entailed (Fraters and Boumans, 2005; Fraters *et al.*, 2007b).

The set-up of the derogation monitoring network and the reporting of results are based on the division of the Netherlands into regions as used in the action programmes for the Nitrate Directive (EU, 1991). Four regions are distinguished: the Sand Region, the Loess Region, the Clay Region and the Peat Region. The acreage of agricultural land in the Sand Region accounts for about 47 percent of the approx. 1.85 million hectares of agricultural land in the Netherlands (Statistics Netherlands Agricultural Census, data processed by LEI, 2011). The acreage of agricultural land in the Loess Region accounts for approx. 1.5 percent, in the Clay Region for approx. 41 percent, and in the Peat Region for approx. 10.5 percent of all agricultural land.

Water quality samples for measurement year 2011 were taken during the winter of 2010/2011 in the Low Netherlands, and during the summer and winter of 2011/2012 in the High Netherlands (see also section 2.4.1). The 'Low Netherlands' comprises the Clay and Peat Regions, as well as those parts of the Sand Region that are drained by means of ditches, possibly in combination with drainage pipes or surface drainage. The 'High Netherlands' comprises the other parts of the Sand Region, and the Loess Region. In measurement year 2012, samples for determining water quality were taken during the winter of 2011/2012 and the summer of 2012. Samples at farms in the Loess Region were taken during the winter of 2012/2013. The resulting loess soil data have not been incorporated into this report. The plan calls for annual water sampling at 300 farms in the derogation monitoring network. When farms are excluded, new farms are often not registered in time for sampling to take place. Farms that submitted an application but did not participate in the derogation scheme have not been included in this report, so as to avoid confounding the data on the effects of participation in the scheme. Recent changes to regional boundaries also affected the number of farms. If farms are reassigned to another region, no suitable samples may be available and the sampling period may no longer correspond to the region (e.g. if farms are reassigned from the Clay Region to the Sand Region, or from sampling in winter to sampling in summer). Such farms are excluded from the process (also see Appendix 8). Consequently, the number of farms included in the report deviates from the initial number of 300.

The water quality levels measured in 2011 partly reflect agricultural practices in 2010 and the preceding years. The extent to which agricultural practices in a preceding year affect the water quality measurements depends on various factors, including (fluctuations in the) precipitation surplus during that year, as well as local hydrological conditions. In the High Netherlands, it is assumed that agricultural practices affect water quality at least one year later. In the Low Netherlands, the impact of agricultural practices on water quality is quicker to materialise. This difference in hydrological conditions also explains the different sampling methods and periods employed in the Low and the High Netherlands.

As previously stated, all agricultural practice data relevant to the derogation scheme were registered for the 300 farms selected for derogation, according to the FADN system (Poppe, 2004). Appendix 3 provides a description of the monitoring of the agricultural characteristics and the calculation methods for fertiliser use and nutrient surpluses. Water sampling on the farms was carried out in accordance with the standard LMM procedures (Fraters *et al.*, 2004). This sampling method is explained in Appendix 4.

2.2 Sampling method

2.2.1 Number of farms in 2011

In 2011 the LMM adopted a new division into regions with retroactive effect, i.e. including for previous years (see Appendix 8). As a result, a number of farms were assigned to other regions. There were no changes in the Loess Region. However, the stratification for information year 2011 was still based on the old regional boundaries (refer to Table 2.1). As a result, the number of farms in each region under the new system deviates from the original set-up.

Although the derogation monitoring network is a permanent network, some farms will inevitably ‘drop out’ over the course of time because they are no longer participating in the LMM programme for various reasons. Even if a farm is fully registered in FADN, it is sometimes impossible to fully describe the nutrient flows. This may be attributable to the presence on the farm of animals owned by other parties, so that data on the input and output of feedstuffs, animals and manure is by definition incomplete. In addition, other administrative errors may have been made when registering inputs and/or outputs.

Agricultural practices were successfully established at 298 of the 300 planned farms. Of these 298 farms, 290 actually participated in the derogation scheme. Ten farms that participated in the derogation monitoring network in 2010 have since dropped out. These farms have therefore been replaced.

Table 2.1 Planned and realised number of dairy and other grassland farms per region in 2011 (agricultural practices)

Farm type	*Planned/realised*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Dairy farms	Planned[1]	140	17	52	52	261
	- Of which engaged in agricultural practices[2]	131	17	63	49	260
	- Of which participating in the derogation scheme	129	17	61	49	256
	- Of which submitted complete nutrient flow data	129	17	60	49	255
Other grassland farms	Planned[1]	20	3	8	8	39
	- Of which engaged in agricultural practices	23	2	8	5	38
	- Of which participating in the derogation scheme	20	2	7	5	34
	- Of which submitted complete nutrient flow data	13	2	4	4	23
Total	Planned[1]	160	20	60	60	300
	- Of which engaged in agricultural practices[2]	154	19	71	54	298
	- Of which participating in the derogation scheme	149	19	68	54	290
	- Of which submitted complete nutrient flow data	142	19	64	53	278

[1] As determined based on old regional boundaries.
[2] As determined based on new regional boundaries.

The various sections of this report detail agricultural practices at the following numbers of farms:

- The description of general farm characteristics (section 2.3) concerns all farms that could be fully processed in FADN in 2011, and that participated in the derogation scheme (290 farms).
- The description of agricultural practices in 2010 (section 3.1) concerns all farms for which a full picture of nutrient flows could be obtained from FADN data (278 farms).
- The comparison of agricultural practices in the 2006-2010 period (section 4.2) concerns all farms that participated in the derogation monitoring network in the respective years. This number varies from year to year. In 2006 this concerned 285 farms, in 2007 281 farms, in 2008 283 farms, in 2009 276 farms and in 2010 280 farms.

Of the 298 farms where agricultural practices were established, 275 farms were subjected to water quality testing (Table 2.2). It was not possible to use the water sampling results of twelve farms that had been reassigned to another region. Samples at these farms were previously taken in summer, and the farms were then reassigned to a region where samples are taken only in winter (i.e. the Clay and Peat Regions). Furthermore, eight farms did not participate in the derogation scheme. The sampling period has since been adjusted to reflect the new regional boundaries. These farms will be included in the report for 2014.

Table 2.2 Planned and realised number of dairy and other grassland farms per region in 2011 (water quality)

Farm type	*Planned/realised*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Dairy farms	Planned[1]	140	17	52	52	261
	Realised[2]	132	17	62	49	260
	Reported	129	17	51	46	243
Other grassland farms	Planned[1]	20	3	8	8	39
	Realised[2]	21	2	8	4	35
	Reported	19	2	7	4	32
Total	Planned	160	20	60	60	300
	Realised	153	19	70	53	295
	New regional boundaries					-12
	Not participating in derogation scheme					-8
	Reported	148	19	58	50	275

[1] As determined based on old regional boundaries.
[2] As determined based on new regional boundaries.

The report details the water quality on the following numbers of farms:
- The description of the water quality results for measurement year 2011 (section 3.2) concerns all farms where water quality sampling was performed in 2011, that qualified for participation in the derogation scheme in 2011, and that were suitable for reporting after introduction of the new regional boundaries (275 farms).
- The description of the water quality results for measurement year 2012 (section 3.2) concerns all farms participating in the derogation monitoring network in 2011 (excluding farms in the Loess Region), where water quality sampling was performed in measurement year 2012, and that were suitable for reporting after introduction of the new regional boundaries (266 farms).
- The description of water quality levels during the 2007-2012 period (section 4.3) concerns all farms that participated in the derogation monitoring network in the agricultural practice year preceding the measurement year, that qualified for participation in the derogation scheme in that previous year, and that were suitable for reporting after introduction of the new regional boundaries This number varies from year to year. For 2007, data are available of 279 farms, for 2008 of 280 farms, for 2009 of 281 farms, for 2010 of 280 farms, for 2011 of 281 farms, and for 2012 of 258 farms (excluding the Loess Region).

2.2.2 *Representativeness of the sample*

In 2011, 290 farms in the planned sample registered for derogation. These farms had a combined total acreage of 15,342 hectares, accounting for 2.0 percent of the total agricultural area on grassland farms in the Netherlands (Table 2.3). The sample represents 83.1 percent of the farms and 92.8 percent of the acreage of all farms that registered for derogation in 2011 and satisfied the LMM selection criteria (refer to Appendix 2). Farms outside the sample population that did register for derogation are mainly other grassland farms with a size of less than 25,000 Standard Output (SO) units.

The report for 2012 (Buis *et al.*, 2012) uses so-called Dutch Size Units (*Nederlandse Grootte-Eenheid*, NGE) to quantify the size of farms. This report uses Standard Output (SO) units to replace Dutch Size Units. This change in units means that more small farms fall outside the scope of the LMM sample. As a result, the percentage of total acreage is lower compared to the report for 2012.

The Loess Region is relatively small and therefore does not have many farms in the sample populations that also participate in the derogation scheme. Consequently, a relatively large proportion of farms (17.9 percent) is included in the monitoring network. Furthermore, it is noteworthy that in all regions the proportion of sampled total acreage is greater at dairy farms than at other grassland farms. During the selection and recruitment process, the required number of farms to be sampled for each farm type is derived from the share in the total acreage of cultivated land, whereas the other grassland farms included were on average smaller than the dairy farms in terms of their acreage of cultivated land.

Table 2.3 Area of cultivated land (in hectares) in the derogation monitoring network compared to the total area of cultivated land at farms participating in the derogation scheme in 2011 in the sample population, according to the 2011 Agricultural Census

		Sample population[1]	*Derogation monitoring network*	
Region	*Farm type*	*Area (hectares)*	*Area (hectares)*	*Percentage of total sample population acreage*
Sand	Dairy farms	327,000	6,744	2.1%
	Other grassland farms	49,717	590	1.2%
	Total	376,717	7,334	1.9%
Loess	Dairy farms	4267	821	19.2%
	Other grassland farms	617	55	9.0%
	Total	4885	876	17.9%
Clay	Dairy farms	227,820	3,833	1.7%
	Other grassland farms	26,634	137	0.5%
	Total	254,455	3,970	1.6%
Peat	Dairy farms	132,294	2,970	2.3%
	Other grassland farms	13,329	192	1.4%
	Total	145,623	3,162	2.2%
All regions	Dairy farms	691,382	14,368	2.1%
	Other grassland farms	90,298	974	1.1%
	Total	781,680	15,342	2.0%

[1] Estimate based on the 2011 Agricultural Census performed by Statistics Netherlands, data processed by LEI. Refer to Appendix 2 for further information on how the sample population was defined.

2.3 Description of farms in the sample

The 290 farms which registered for derogation in 2011 have an average of 53 hectares of cultivated land, of which 83 percent is comprised of grassland. The average livestock density is 2.29 Phosphate Livestock Units (LSUs) per hectare (Table 2.4). Farm data derived from the 2011 Agricultural Census have been included for purposes of comparison, in so far as these farms are included in the sample population (Appendix 2).

An analysis of the agricultural characteristics of the sample population and a comparison with farm data from the Agricultural Census (Table 2.4) reveals the following differences:

- The average acreage of cultivated land at the sampled farms is 20 percent greater than that of the farms in the sample population. This applies to all regions.
- The proportion of grassland on the sampled farms (83 percent) corresponds to the average for the sample population.
- At the sampled farms 92 percent of the arable land is used for the cultivation of silage maize, compared to 91 percent in the sample population.
- The livestock density of grazing livestock on the sampled farms is 6 percent higher than the average for the sample population.
- The proportion of sampled farms with grazing animals as well as stable animals is virtually identical to the corresponding proportion in the sample population.
- The acreage of natural habitat (averaging 1.1 hectares per farm) is not included in the calculation of the environmental impact per hectare of cultivated land (i.e. calculation of fertiliser use, surpluses, etc.).
- Dairy cattle and young livestock constitute almost 95 percent of grazing livestock at the sampled farms. The ‘Other grazing livestock’ category comprises beef cattle, sheep, goats, horses and ponies.

Table 2.4 Overview of a number of general characteristics in 2011 of farms participating in the derogation monitoring network (DMN), compared to average values for the Agricultural Census (AC) sample population

Farm characteristic[2]	*Population*	*Sand*	*Loess*	*Clay*	*Peat*	*All soil types*
Number of farms in DMN	DMN	149	19	68	54	290
Grassland area (hectares)	DMN	39	32	48	53	43
	AC	32	30	43	42	37
Area used to cultivate silage maize (hectares)	DMN	9.5	11.0	8.8	5.7	8.7
	AC	7.7	8.1	5.3	3.8	6.3
Other arable land (hectares)	DMN	0.8	2.6	1.4	0.1	0.9
	AC	0.8	2.4	1.5	1.0	1.1
Total area of cultivated land (hectares)	DMN	49	46	58	59	53
	AC	40	40	50	47	44
Percentage of grassland	DMN	81	72	85	92	83
	AC	79	74	86	90	83
Natural habitat (hectares)	DMN	0.6	2.5	1.7	1.5	1.1
	AC	0.3	1.0	0.5	0.8	0.4
Grazing livestock density (Phosphate Livestock Units per hectare)[1]	DMN	2.33	2.33	2.29	2.15	2.29
	AC	2.28	2.21	2.04	1.97	2.16
Percentage of farms with stable animals	DMN	9	11	3	13	8
	AC	12	3	5	6	9
Specification of livestock density on farms in derogation monitoring network (Phosphate Livestock Units per hectare)[1]						
Dairy cattle (including young livestock)	DMN	2.22	2.11	2.12	2.03	2.15
Other grazing livestock	DMN	0.11	0.22	0.16	0.12	0.13
Stable animals (total)	DMN	0.80	0.07	0.06	0.24	0.48
All animals (total)	DMN	3.14	2.39	2.35	2.39	2.76

Source: FADN and Statistics Netherlands Agricultural Census 2011, data processed by LEI.
[1] Phosphate Livestock Unit (LSU) is a standard used to compare numbers of animals based on their standard phosphate production (the standard phosphate production of one dairy cow is equivalent to one Phosphate Livestock Unit).
[2] Surface areas are expressed in hectares of cultivated land; natural habitats have not been included.

From the above comparison between the population of sampled farms and the Agricultural Census data, we can conclude that the population of sampled farms is representative of the Agricultural Census sample population, despite some minor differences.

The dairy farms participating in the derogation monitoring network produce an average of 869,000 kg of Fat and Protein Corrected Milk (FPCM) per farm, and an average of 15,900 kg of FPCM per hectare. The average annual milk production per cow is 8,580 kg of FPCM (Table 2.5). As the Agricultural Census does not provide appropriate data for comparison, Table 2.5 uses the weighted average of the national FADN sample. In all regions, the dairy farms participating in the derogation monitoring network have a larger acreage and produce more milk per farm than the weighted national average. Such a comparison cannot be made for the Loess Region, due to an insufficient number of FADN-registered farms.

Table 2.5 Average milk production and grazing on dairy farms participating in the derogation monitoring network (DMN) in 2011, compared to the weighted average for dairy farms in the national sample (FADN)

Farm characteristic	*Population*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms in DMN	DMN	129	17	61	48	255
FPCM production per farm (kg)	DMN	828,800	715,200	984,800	881,700	868,500
	FADN	683,800		807,900	680,000	713,800
FPCM production per hectare of fodder crop (kg)	DMN	16,500	15,500	15,900	14,700	15,900
	FADN	16,100		14,700	13,300	15,300
FPCM production per dairy cow (kg)	DMN	8,690	8,430	8,580	8,340	8,580
	FADN	8,780		8,490	8,250	8,620
Percentage of farms with grazing from May to October	DMN	80	82	72	79	78
	FADN	78		80	85	79
Percentage of farms with grazing from May to June	DMN	76	82	72	77	76
	FADN	74		78	83	76
Percentage of farms with grazing from July to August	DMN	80	82	70	79	78
	FADN	78		78	85	79
Percentage of farms with grazing from September to October	DMN	74	82	66	69	71
	FADN	71		70	80	72

[1] FPCM = Fat and Protein Corrected Milk, a standard used to compare milk with different fat and protein contents (1 kg of milk with 4.00 percent fat content and 3.32 percent protein content = 1 kg of FPCM).

An analysis of the differences between farms participating in the derogation monitoring network and FADN farms reveals the following:

- The average milk production of a dairy farm participating in the derogation monitoring network is 22 percent higher than the national FADN average. The difference is greatest in the Peat Region (approx. 30 percent).
- The average milk production per hectare and per dairy cow at dairy farms participating in the derogation monitoring network is virtually the same as the national FADN average. Here, too, the difference is greatest in the Peat Region at approx. 10 percent (Table 2.5).

2.4 Monitoring of water quality

2.4.1 Sampling at farms

In measurement year 2011, water quality samples were taken at 287 of the 290 farms participating in the derogation monitoring network that had applied for derogation and actually participated in the scheme in agricultural practice year 2011. The difference of three farms is caused by the fact that these farms were new in 2011, and were sampled for the first time in measurement year 2012. Following the changes to the regional boundaries, the data of 275 farms could be used for reporting purposes (Table 2.6 and Figure 2.1). In 2012, 278 farms participating in the derogation scheme were sampled in the Sand, Clay and Peat Regions. Groundwater, drain water and/or soil moisture were sampled. On participating farms in the Low Netherlands, ditch water was also sampled. Data of 266 of the sampled farms have been used in this report (Table 2.6). The average sampling frequency is also stated in Table 2.6. The agricultural practice results for 2011 are linked to the water quality results in the subsequent period (measurement year 2012).

The water quality samples associated with the agricultural practice data for 2010 were taken during the period between October 2010 and February 2012 (Figure 2.1). The water quality samples associated with the agricultural practice data for 2011 were taken during the period between October 2011 and February 2013. The water quality results for the Loess Region are based on samples taken between October 2012 and February 2013. The relevant data is not yet available for this report, as the required quality controls have not yet been completed. The water quality data included in this report for measurement year 2012 are preliminary. Definitive figures will be reported in 2014, at which time the 2012/2013 data for the Loess Region will also be completed and finalised. A detailed description of the sampling method used in each region is provided in Appendix 4.

Table 2.6 Number of sampled farms[1] per sub-programme and per region in 2011 and 2012, and sampling frequency of leaching water (LW) and ditch water (DW). The target sampling frequency is stated in parentheses.

Year	*Sand*		*Loess*	*Clay*	*Peat*
	All farms	*Of which drained*			
2011	140	35	19	58	50
LW sampling frequency	1.0 (1)	- (-)	1.0 (1)	2.9 (2-4[2])	1.0 (1)
DW sampling frequency	- (-)	3.9 (4)	- (-)	3.9 (4)	4.0 (4)
2012	152	36	-*	62	51
LW sampling frequency	1.0 (1)	- (-)	-*	3.0 (2-4[2])	1.0 (1)
DW sampling frequency	- (-)	4.0 (4)	-*	4.0 (4)	4.3 (4)

[1] The difference between the total number of farms reported in the text and listed in this table is caused by eight farms in the Sand Region. Due to the new regional boundaries, no summer sample data are available for these farms. As a result, only ditch water measurement data could be reported and no data concerning water leaching from the root zone.
[2] In the Clay Region, groundwater is sampled up to two times and drainage water up to four times, depending on the type of farm. The average total number of samples will therefore always be between two and four, depending on the proportion of farms with groundwater sampling and those with drainage water sampling.
* In the Loess Region, samples were taken at twenty farms participating in the derogation scheme during the period from October 2012 to February 2013. The sample results were not yet available when this report was compiled.

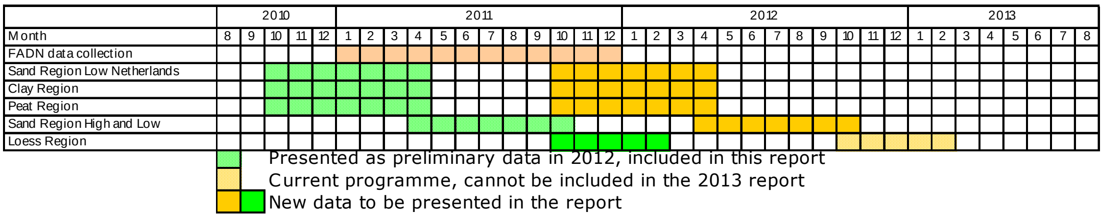

Figure 2.1 Water quality sampling periods in 2011 (green) and 2012 (yellow) per region and per programme

The map in Figure 2.2 shows the distribution of the sampled farms across the regions. In addition, a distinction is made between dairy farms and other grassland farms. The map divides the Sand Region into three subcategories: North, Central and South. A relatively large number of farms are located in the region with loess soil. The reason for this is that at least fifteen farms must be sampled in order to draw properly substantiated conclusions (Fraters and Boumans, 2005).

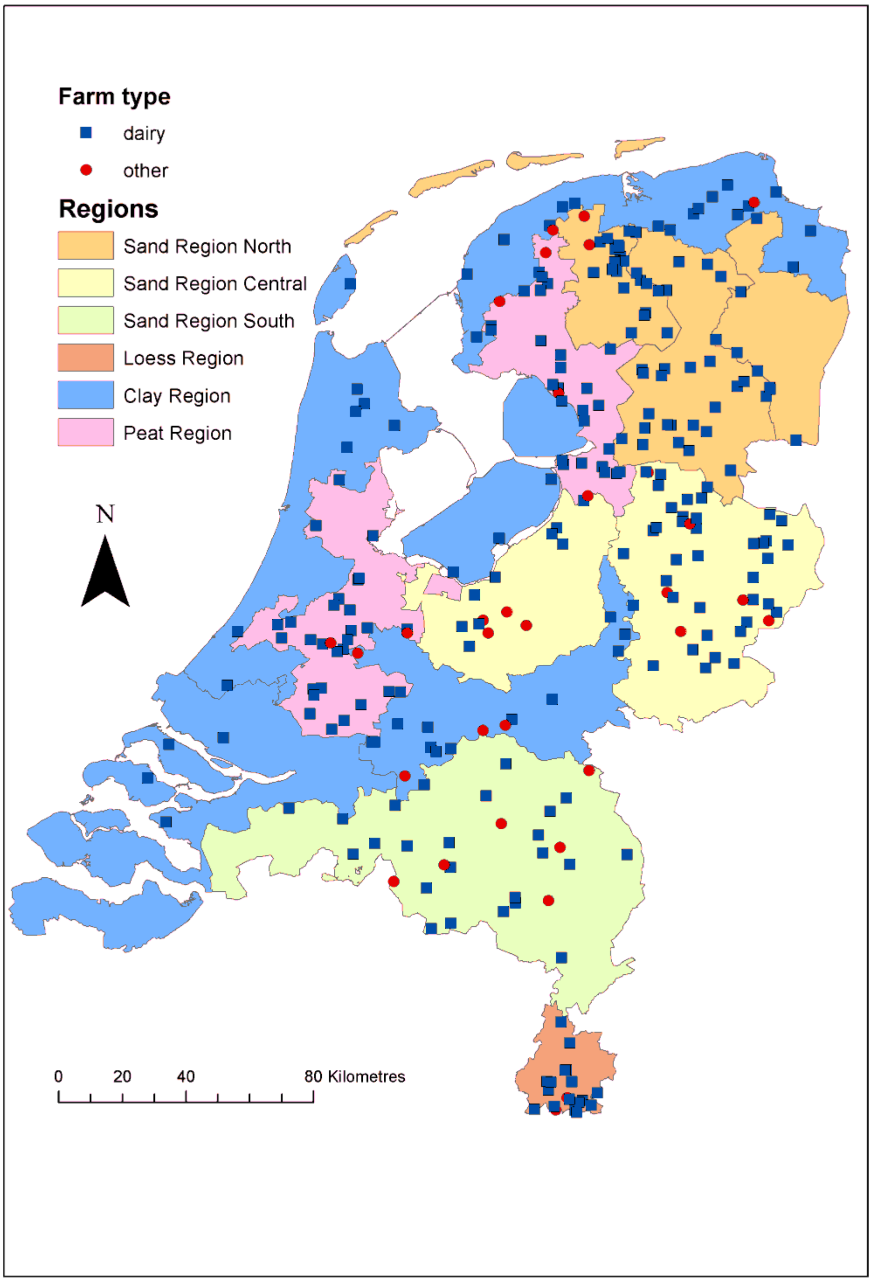

Figure 2.2 Location of the 275 grassland farms with reported data in 2011 where water samples were taken for derogation monitoring purposes

Within a particular region, other soil types occur in addition to the main soil type for which the region is named (Table 2.7 and Table 2.8). The Loess Region mainly consists of soils with good natural drainage, whereas the Peat Region mainly consists of soils with poor natural drainage. Well-drained soils in the Sand Region are under-represented in the derogation monitoring network. Traditionally, the best soils (with favourable drainage conditions and nutrient status) were used for arable farming, while poorer (i.e. wetter) soils were used for dairy farming. In addition, the driest soils in the Sand Region are often not used for agricultural purposes. Wetter sandy soils are therefore overrepresented in the derogation monitoring network. The differences in soil type and drainage class in the derogation monitoring network between 2011 and 2012 are minimal.

Table 2.7 Relative distribution (in percentages) of soil types and drainage classes in the different regions, for farms participating in the derogation scheme where samples were taken in 2011

	Soil type				*Drainage class*[1]		
Region	*Sand*	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	88	0	4	8	39	52	9
Loess	2	76	22	0	1	3	96
Clay	5	0	91	4	44	52	4
Peat	11	0	29	60	95	5	0

[1] The drainage class is linked to the water table class (*Grondwatertrap*, Gt). The 'Poor natural drainage' class encompasses water table class Gt I through Gt IV, the 'Moderate drainage' class encompasses water table class Gt V, Gt V* and Gt VI, and the 'Good drainage' class encompasses water table class Gt VII and Gt VIII.

Table 2.8 Relative distribution (in percentages) of soil types and drainage classes in the different regions, for farms participating in the derogation scheme where samples were taken in 2012

	Soil type				*Drainage class*[1]		
Region	*Sand*	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	87	0	4	9	41	51	9
Loess	*	*	*	*	*	*	*
Clay	6	0	90	4	45	51	4
Peat	11	0	29	60	95	5	0

[1] The drainage class is linked to the water table class (*Grondwatertrap*, Gt). The 'Poor natural drainage' class encompasses water table class Gt I through Gt IV, the 'Moderate drainage' class encompasses water table class Gt V, Gt V* and Gt VI, and the 'Good drainage' class encompasses water table class Gt VII and Gt VIII.
* Results from the Loess Region were not yet available at the time of preparation of the present report.

2.4.2 *Chemical analyses and calculations*

The chemical composition of the water samples was analysed at RIVM's accredited analytical laboratory (until May 2012), and at the accredited laboratory of TNO, the Netherlands Organisation for Applied Scientific Research (from June 2012). RIVM's laboratory and activities were transferred to TNO, which continued to use the former RIVM equipment. The equipment was calibrated following the relocation. Table 2.9 provides an overview of the methods used for the different analysed components. Refer to Wattel-Koekkoek *et al.* (2008) for further information.

Table 2.9 Components analysed, analytical methods and detection thresholds

Component	*Analytical method*[1]	*Detection threshold*
Nitrate (NO_3)	IC	0.31 mg/l
Ammonium (NH_4)	CFA	0.064 mg/l
Total nitrogen (N)	CFA	0.2 mg/l
Total phosphorus (P)	Q-ICP-MS	0.064 mg/l

[1] Q-ICP-MS: Quadruple Inductively Coupled Plasma Mass Spectrometry; IC: Ion Chromatography; CFA: Continuous Flow Analysis.

The annual average concentrations of each component were calculated for each farm. For the purpose of this calculation, observed concentrations below the detection threshold were assigned a value of 0. This makes it possible to calculate farm-specific average concentrations below the detection threshold. If the results presented in this report include values below the detection threshold, this will be indicated by the abbreviation <DT.

3 Results for 2011

3.1 Agricultural characteristics

3.1.1 Nitrogen use in livestock manure

In 2011, the average use of nitrogen in livestock manure on farms participating in the derogation scheme (including manure excreted during grazing) was a few kilogrammes below the livestock manure application standard of 250 kg per hectare (Table 3.1). Manure production at most farms was calculated based on generally applicable standards (i.e. standard quantities and contents). However, dairy farmers can also opt to deviate from these standards and calculate their farm-specific manure production using a guidance document published for this purpose (Ministry of Agriculture, Nature & Food Quality, 2009). These farm-specific calculation method was adopted for dairy farms that indicated use of the guidance document, provided all the necessary data were available (N = 82). On all other farms (N = 196), standards were used to calculate the volume of manure produced. A more detailed explanation of the farm-specific and standard-based calculation methods for manure production is provided in Appendix 3.

Table 3.1 Average nitrogen use in livestock manure (in kg of nitrogen per hectare) in 2011 on farms participating in the derogation monitoring network (regional averages)

Description	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms	142	19	64	53	278
Produced on farm[1]	287	260	263	267	276
+ inputs	14	10	10	5	11
+ changes in stocks[2]	-7	-1	-6	-3	-5
- outputs	47	20	25	22	36
Total	247	250	241	247	246
Use on arable land[3]	184	168	153	176	175
Use on grassland[3]	264	262	251	256	259

[1] Calculated on the basis of standard quantities, with the exception of dairy farms that indicated they were using the guidance document on farm-specific excretion by dairy cattle (see Appendix 3).
[2] A negative change in stocks is a stock increase and corresponds to output.
[3] The average use data and the application standards for grassland and arable land are based on 254 farms and 190 farms, respectively, instead of on 278 farms. This is because on 24 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 64 farms had no arable land.

The main salient points concerning the use of nitrogen in livestock manure may be summarised as follows (Table 3.1):

- The average use of nitrogen in livestock manure at farms participating in the derogation monitoring network amounted 0 to 246 kg per hectare, 4 kg below the application standard for livestock manure. In the Loess Region, the average use of nitrogen in livestock manure was exactly equal to the application standard.
- In all regions, less nitrogen in livestock manure was applied on arable land (mainly for cultivation of silage maize) than on grassland.

On average, the use of livestock manure in 2011 (including rounding-off differences) exceeded the 2010 levels by 4 kg of nitrogen per hectare (see Appendix 5, Table A5.2). The causes include:

- A 3 kg increase in use due to differences in stock changes (stock increase of 8 kg of nitrogen in 2010, as opposed to a stock increase of 5 kg of nitrogen in 2011)
- A decrease in manure production of 4 kg of nitrogen
- An increase in manure inputs of 3 kg of nitrogen
- A decrease in manure outputs of 3 kg of nitrogen

The farms in the monitoring network both import and export livestock manure. As the average production exceeded the permitted use, the average manure outputs exceeded the inputs (including stock changes). This applies to all regions (Table 3.1).

Table 3.2 Percentage of farms participating in the derogation monitoring network with livestock manure inputs and/or outputs in 2011 (regional averages)

Description	*Sand*	*Loess*	*Clay*	*Peat*	*All*
No inputs or outputs	17	21	33	28	23
Only outputs	45	37	41	49	44
Only inputs	25	21	20	21	23
Both inputs and outputs	13	21	6	2	10

Almost 25 percent of all farms in the monitoring network did not import or export livestock manure (Table 3.2). Nearly half of all farms only exported livestock manure and did not import it. Nearly 25 percent of all farms only imported livestock manure and did not export it. These farmers were probably of the opinion that importing nutrients in livestock manure offered economic benefits as compared to using inorganic fertilisers. This may also apply to the farmers who both imported and exported livestock manure (10 percent).

3.1.2 Fertiliser use compared to application standards (nitrogen and phosphate)

The quantity of plant-available nitrogen in livestock manure has been calculated by multiplying the used quantity of nitrogen in livestock manure (produced on the farm or imported) by the statutory availability coefficients applicable to the specific situation (see Appendix 3). To allow for comparisons of fertiliser use, Table 3.3 and 3.4 also specify the average application standards per hectare for arable land (mainly maize acreage) and grassland. The application standards at farm level have been derived from the separate application standards for grassland and arable land. These application standards are based on the acreage of cultivated crops and the soil type classifications as registered in FADN, as well as the statutory application standards defined for 2011 (National Service for the Implementation of Regulations, 2006; National Service for the Implementation of Regulations, 2011).

The following may be noted concerning the use of nitrogen on farms in the derogation monitoring network in 2011 (Table 3.3):

- In all regions except the Loess Region, the calculated total use of plant-available nitrogen at farm level was lower than the nitrogen application

standard. This also applied to grassland and arable land when considered separately, except for grassland in the Loess Region.
- In the Clay Region, the calculated total use of plant-available nitrogen at farm level was higher than in other regions because more inorganic fertilisers are used on these soils. The nitrogen application standards are often less stringent for clay soils (i.e. greater quantities are permitted).
- In the Sand and Loess Regions, the calculated total use of plant-available nitrogen was lower than in other regions, due to lower use of inorganic fertilisers.
- In all regions, less nitrogen fertilisers were used on arable land (mainly for the cultivation of silage maize) than on grassland.

Table 3.3 Average use of nitrogen in fertilisers (expressed in kg of plant-available nitrogen per hectare)[1] on farms participating in the derogation monitoring network in 2011 (regional averages)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms		142	19	64	53	278
Average statutory availability coefficient for livestock manure (%)		49	49	50	49	49
Fertiliser use	Livestock manure	121	122	122	122	121
	Other organic fertilisers	1	0	0	0	0
	Inorganic fertilisers	112	113	146	125	123
	Total average fertiliser use	234	235	268	247	244
	Nitrogen application standard	242	234	296	275	260
Use of plant-available nitrogen on arable land[2]		123	128	125	119	123
Application standard for arable land[2]		150	149	174	163	157
Use of plant-available nitrogen on grassland[2]		264	274	292	260	270
Application standard for grassland[2]		265	261	317	286	282

[1] Calculated on the basis of the applicable statutory availability coefficients (see Appendix 3).
[2] The average use data and the application standards for grassland and arable land are based on 254 farms and 190 farms, respectively, instead of on 278 farms. This is because on 24 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 64 farms had no arable land.

The following may be noted concerning the use of phosphate on farms participating in the derogation monitoring network in 2011 (Table 3.4):
- The average phosphate use corresponded to the phosphate application standard of 90 kg per hectare applicable to these farms. Average phosphate use in the Sand Region exceeded the application standard by 1 kg per hectare, whereas the standard was exceeded by 6 kg in the Loess Region.
- An analysis of phosphate use on different types of agricultural land revealed the following:
  - The average phosphate use on grassland was approx. 2 kg per hectare below the application standard for grassland. The average use of phosphate in the Clay, Peat and Loess Regions was 6 kg, 4 kg and 1 kg per hectare below the grassland application standard, respectively. Average phosphate use in the Sand Region exceeded the grassland application standard by 1 kg per hectare.
  - Average phosphate use on arable land exceeded the application standard for arable land by 4 kg per hectare. This was due to

fertilisation practices in the Peat and Sand Regions, where average usage exceeded the application standard for arable land by 7 kg and 5 kg per hectare, respectively. Average phosphate use in the Loess Region was 2 kg per hectare below the application standard, whereas the usage level in the Clay Region corresponded to the application standard.

This means that dairy farmers are choosing to apply fertilisers on grassland and arable land (mainly maize acreage) according to a distribution pattern that deviates from the prevailing application standards.

- On average nearly 97 percent of phosphate was applied in the form of livestock manure.

Regarding the use of phosphate on grassland and arable land in relation to the application standards, it should be noted that its use on arable land is reported by the dairy farmer. Grassland usage levels are calculated by deducting the usage level on arable land from the total usage level.

Table 3.4 Average use of phosphate in fertilisers (in kg of P_2O_5 per hectare) in 2011 on farms participating in the derogation monitoring network (regional averages)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms		142	19	64	53	278
Fertiliser use	Livestock manure	87	91	84	85	86
	Other organic fertilisers	1	0	1	0	0
	Inorganic fertilisers	3	4	3	3	3
	Total average fertiliser use	90	94	87	89	90
	Phosphate application standard	89	88	91	92	90
Use of phosphate on arable land[1]		77	69	75	81	77
Application standard for arable land[1]		72	71	75	74	73
Use of phosphate on grassland[1]		94	95	88	90	92
Application standard for grassland[1]		93	96	94	94	94

[1] The average use data and the application standards for grassland and arable land are based on 254 farms and 190 farms, respectively, instead of on 278 farms. This is because on 24 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 64 farms had no arable land.

3.1.3 *Crop yields*

In 2011, the average silage maize crop yield on farms participating in the derogation monitoring network amounted to 16,200 kg of dry matter per hectare, and 9,800 kg of dry matter per hectare for grassland (Table 3.5). These yields were estimated for silage maize and calculated for grassland, for those farms in the derogation monitoring network that met the criteria for application of the crop yield calculation method. This calculation method is based on the work of Aarts *et al.* (2008). The method developed by Aarts *et al.* involves estimating the silage maize yield by determining the quantities of ensilaged silage maize. The grass yield is calculated as the difference between the energy requirement of livestock on the one hand, and the energy uptake from farm-grown silage maize (and roughage other than grass) and purchased feedstuffs on the other hand. Further information about this method is provided in Appendix 3.

The main points with regard to the crop yields may be summarised as follows (Table 3.5):

- The estimated average dry matter yield for silage maize was 16,200 kg per hectare, resulting in an estimated average yield of 190 kg of nitrogen and 31 kg of phosphorus (70 kg of P_2O_5). Yields in the Sand and Loess Regions slightly exceeded the national average, while yields in the Clay and Peat Regions were below the national average.
- The calculated grassland dry-matter yield amounted to 60 percent of the estimated silage maize yield. However, both the nitrogen and phosphorus yields per hectare were higher due to higher nitrogen and phosphorus contents in grass. The calculated grassland dry-matter yields were highest in the Peat Region.

Table 3.5 Average crop yields (in kg of dry matter, nitrogen, phosphorus and P_2O_5 per hectare) for silage maize (estimated) and grassland (calculated) in 2011, on farms participating in the derogation monitoring network that meet the criteria for application of the calculation method (Aarts et al., 2008) (regional averages)

Description	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Silage maize yields					
Number of farms	97	11	37	22	167
Kilogrammes of dry matter per hectare	16,500	16,700	15,800	15,000	16,200
Kilogrammes of nitrogen per hectare	194	196	187	177	190
Kilogrammes of phosphorus per hectare	31	31	31	29	31
Kilogrammes of P_2O_5 per hectare	70	71	70	66	70
Grassland yields					
Number of farms	114	11	53	43	221
Kilogrammes of dry matter per hectare	9,900	9,700	9,900	10,000	9,800
Kilogrammes of nitrogen per hectare	273	287	272	289	274
Kilogrammes of phosphorus per hectare	39	39	39	37	38
Kilogrammes of P_2O_5 per hectare	89	90	89	85	87

3.1.4 Nutrient surpluses

The nitrogen surplus on the soil surface balance for farms in the derogation monitoring network amounted to an average of 175 kg per hectare in 2011 (Table 3.6). Nitrogen surpluses in the Loess, Sand and Clay Regions were lower than average, at 148 kg, 163 kg and 165 kg per hectare, respectively. The average surplus in the Peat Region amounted to approx. 230 kg per hectare and exceeded the average. The average phosphate surplus on the soil surface balance was 12 kg per hectare (Table 3.7). Phosphate surpluses in the Sand and Loess Regions were higher than average, and amounted to approx. 15 kg per hectare. Phosphate surpluses in the Clay Region were lower than average, and amounted to approx. 7 kg per hectare. The surplus on the soil surface balance was calculated using the calculation method described in Appendix 3.

Table 3.6 Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) at farms in the derogation monitoring network in 2011 (average values and 25th and 75th percentile values per region)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms		142	19	64	53	278
Farm inputs	Inorganic fertilisers	112	113	146	125	123
	Livestock manure and other organic fertilisers	18	11	11	8	14
	Feedstuffs	228	157	159	163	195
	Animals	4	1	1	2	3
	Other	2	3	2	2	2
	Total	364	286	318	300	336
Farm outputs	Milk and other animal products	82	70	77	79	80
	Animals	31	14	10	14	22
	Livestock manure	55	22	32	27	42
	Other	21	27	21	19	21
	Total	189	133	141	139	165
Average nitrogen surplus per farm		174	153	178	161	171
+ Deposition, mineralisation and organic nitrogen fixation		43	42	40	125[1]	58
- Gaseous emissions[2]		55	46	53	57	54
Average nitrogen surplus on soil surface balance		163	148	166	229	175
Nitrogen surplus on soil surface balance, 25th percentile		117	139	138	132	128
Nitrogen surplus on soil surface balance, 75th percentile		209	203	222	275	219

[1] Based on the assumption that on peat soil an additional 75 kg of nitrogen mineralises from organic matter.
[2] Gaseous emissions from stabling and storage, during application and grazing.

The variation in nitrogen surpluses on the soil surface balance was considerable. The 25 percent of farms with the lowest surpluses realised a surplus of less than 128 kg of nitrogen per hectare, whereas the surplus exceeded 219 kg of nitrogen per hectare at the 25 percent of farms with the highest surpluses (Table 3.6). This could be explained by the fact that farmers with a low nitrogen surplus on their soil surface balance are able to effectively integrate environmental aims into their farm management practices (Van den Ham *et al.*, 2010). Farms with a low surplus may also have relatively high crop yields, whereas farms with a high surplus may have soils producing relatively low yields.

For the 25 percent of farms with the lowest phosphate surpluses, the surplus was below 0 kg per hectare (0 kg per hectare constitutes balance), whereas for the 25 percent of farms with the highest surpluses, the surplus exceed 27 kg per hectare (Table 3.7). Probably for this difference the same explanation holds as in the case of nitrogen.

Table 3.7 Phosphate surpluses on the soil surface balance (in kg of P_2O_5 per hectare) at farms in the derogation monitoring network in 2011 (average values and 25th and 75th percentile values per region)

Description	*Item*	*Sand*	*Loess*	*Clay*	*Peat*	*All*
Number of farms		142	19	64	53	278
Farm inputs	Inorganic fertilisers	3	4	3	3	3
	Organic fertilisers	8	7	5	4	6
	Feedstuffs	82	59	57	62	71
	Animals	2	1	1	1	2
	Other	0	1	1	1	0
	Total	95	71	66	71	82
Farm outputs	Milk and other animal products	33	28	31	30	32
	Animals	17	9	8	9	13
	Organic fertilisers	24	10	13	14	19
	Other	7	8	7	6	7
	Total	81	56	59	59	70
Average phosphate surplus on soil surface balance		14	15	7	12	12
Phosphate surplus on soil surface balance, 25th percentile		-2	5	-1	1	0
Phosphate surplus on soil surface balance, 75th percentile		28	19	28	27	27

3.2 Water quality

3.2.1 Water leaching from the root zone, measured in 2011 (NO_3, N and P)

The nutrient concentrations measured in water leaching from the root zone in 2011 have been related to the agricultural practices on the relevant farms in 2010 and preceding years. The water quality results reported in this section are therefore related to the fifth year and the previous years in which derogation was applied, and not to the agricultural practice data for 2011 presented in the previous section. The agricultural practice data for previous years are presented in Chapter 4.

The average nitrate concentrations in most regions were lower than the limit of 50 mg NO_3 per litre stated in the Nitrates Directive (Table 3.8). Only in the Loess Region were the average nitrate concentrations slightly higher than 50 mg NO_3 per litre. Although nitrate concentrations in the Peat Region were lower than in the Clay Region, the nitrogen concentrations were higher. This is caused by higher ammonium concentrations in the groundwater. In 2011, the average ammonium concentration in the Peat Region was 4.9 mg of nitrogen per litre. In the Clay and Loess Regions, the average ammonium nitrogen concentration was less than 1 mg per litre. In the Sand Region, the average concentration was 1 mg of nitrogen per litre. The higher ammonium concentrations are probably due to nutrient-rich peat layers (Van Beek *et al.*, 2004) in which nitrogen is released in the form of ammonium due to the decomposition of organic matter (Butterbach-Bahl and Gundersen, 2011).

Groundwater that is or has been in contact with nutrient-rich peat layers often has similarly high phosphorus concentrations (Van Beek *et al.*, 2004). These nutrient-rich peat layers may also partly cause the higher average phosphorus concentrations measured in the Peat and Clay Regions compared with the Sand Region. In addition, phosphate ions are easily adsorbed by iron and aluminium (hydr)oxides and clay minerals, particularly under acidic circumstances such as those occurring in the Sand Region. Phosphate also readily precipitates in the form of poorly soluble aluminium, iron and calcium phosphates.

Phosphorus concentrations in the Loess Region in 2011 could not be included in this report. During the measurement period, phosphorus concentrations in this region suddenly increased to unexpectedly high levels (for loess soils), resulting in an average annual concentration of 0.45 mg P/l. In other years, the average phosphorus concentration remained below the detection threshold. As this could indicate possible contamination of the samples, all phosphorus measurements for the Loess Region have been rejected.

Table 3.8 Nutrient concentrations (in mg/l) in water leaching from the root zone in 2011 on farms in the derogation monitoring network (average concentrations per region and number of observations below the phosphorus detection threshold)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	140	19	58	50
Nitrate (NO_3)	41	55	14	7
Nitrogen (N)	12.4	13.2	5.3	9.4
Phosphorus[1] (P)	0.11 (58)	*[2]	0.27 (17)	0.37 (8)

[1] The percentage of farms with average concentrations below the detection threshold is stated in parentheses.

[2] All phosphorus measurements conducted in the Loess Region were rejected (refer to section 3.2.1).

In the Sand Region, 66 percent of farms had nitrate concentrations below the nitrate application standard of 50 mg NO_3/l. In the Loess Region, 58 percent of farms had below-standard nitrate concentrations (Table 3.9). In the Clay and Peat Regions, the proportion of farms with concentrations below 50 mg/l was 95 percent and 98 percent, respectively. The lower percentage of farms in the Sand and Loess Regions with nitrate concentrations below 50 mg/l compared to the Clay and Peat Regions is mainly due to a higher percentage of soils prone to leaching. These are soils where less denitrification occurs, partly due to lower groundwater levels and/or limited availability of organic material and pyrite (Biesheuvel, 2002; Fraters *et al.*, 2007a; Boumans and Fraters, 2011).

Table 3.9 Frequency distribution in 2011 of farm-specific average nitrate concentrations (in mg of NO_3/l) in water leaching from the root zone on farms in the derogation monitoring network per region, expressed as percentages per class

Concentration class (mg of NO_3 /l)	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	140	19	58	50
<15	21	0	72	86
15-25	15	5	14	6
25-40	21	37	7	6
40-50	9	16	2	0
>50	34	42	5	2

Fifty percent of all farms in the Sand Region had a nitrogen concentration of 11 mg N/l or lower (Table 3.10). This also applied to the Loess Region. Fifty percent of all farms in the Peat Region had a nitrogen concentration of 9.2 mg N/l or lower. The median value was 4.1 mg N/l for the Clay Region.

Table 3.10 Nitrogen concentrations in 2011 (in mg N/l) in water leaching from the root zone on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms	140	19	58	50
First quartile (25th percentile)	7.7	8.5	3.1	6.3
Median (50th percentile)	11	11	4.1	9.2
Third quartile (75th percentile)	16	16	6.0	11

Phosphorus concentrations on 75 percent of farms in the Sand Region were equal to or less than 0.09 mg P/l (Table 3.11). Phosphorus concentrations on 50 percent of farms in the Clay Region were equal to or less than 0.24 mg P/l. The median value for farms in the Peat Region was 0.25 mg P/l.

Table 3.11 Phosphorus concentrations[1] in 2011 (in mg P/l) in water leaching from the root zone on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess[2]*	*Clay*	*Peat*
Number of farms	140	*	58	50
First quartile (25th percentile)	<DT	*	<DT	0.10
Median (50th percentile)	<DT	*	0.24	0.25
Third quartile (75th percentile)	0.09	*	0.35	0.60

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT.

[2] The phosphorus measurements conducted in the Loess Region were rejected (refer to section 3.2.1).

3.2.2 *Ditch water quality measurements in 2010-2011 (nitrogen and phosphorus)*

The ditch water quality data for the winter of 2010-2011 reported in this section reflect agricultural practices in 2010 and the preceding years, and are related to the fifth year of the derogation scheme, not to the agricultural practice data presented in section 3.1. The results for the Sand, Peat and Clay Regions were presented as provisional data in 2012 (Buis *et al.*, 2012). The Loess Region has no farms with ditches participating in the derogation monitoring network, and results for this region have therefore not been included in the tables below.

The ditch water nitrate concentrations on farms participating in the derogation monitoring network clearly differ from region to region. Average nitrate concentrations are highest in the Sand Region at 23 mg/l, and lowest in the Peat Region at 4 mg/l (Table 3.12). Nitrogen concentrations, too, are highest in the Sand Region (7.4 mg N/l). Similar to the results for water leaching from the root zone, the average nitrogen concentration in the Peat Region (4.6 mg N/l) is higher than in the Clay Region (3.4 mg N/l). Phosphorus concentrations in ditch water are highest in the Clay Region, and lowest in the Sand Region.

Table 3.12 Average ditch water nutrient concentrations (mg/l) per region in the winter of 2010-2011 on farms in the derogation monitoring network

Characteristic	*Region*			
	Sand	*Loess**	*Clay*	*Peat*
Number of farms[1]	35	0	57	49
Nitrate (NO_3)	23	*	6	4
Nitrogen (N)	7.4	*	3.4	4.6
Phosphorus (P)	0.09	*	0.26	0.16

* There are no farms with ditches in the Loess Region.
[1] There is one farm without ditches in both the Clay Region and the Peat Region.

Of the 35 farms in the Sand Region, 31 (89 percent) had ditch water nitrate concentrations equal to or below 50 mg/l (Table 3.13). None of the farms in the Clay and Peat Regions had ditch water nitrate concentrations of more than 50 mg/l. Half of the farms in the Sand Region had ditch water nitrogen concentrations equal to or less than 6.0 mg N per litre (Table 3.14).
Fifty percent of all farms in the Clay and Peat Regions had ditch water nitrogen concentrations equal to or lower than 2.9 mg and 4.4 mg N/l, respectively.

Table 3.13 Frequency distribution of average ditch water nitrate concentrations (in mg NO_3/l) per farm, on farms in the derogation monitoring network in the winter of 2010-2011, expressed as percentages per class per region

Concentration class	*Region*			
(mg NO_3 /l)	*Sand*	*Loess*	*Clay*	*Peat*
Number of farms[1]	35	0	57	49
<15	49	*	91	98
15-25	20	*	7	0
25-40	11	*	2	0
40-50	6	*	0	2
>50	11	*	0	0

* There are no farms with ditches in the Loess Region.
[1] There is one farm without ditches in both the Clay Region and the Peat Region.

Table 3.14 Ditch water nitrogen concentrations (in mg N/l) on farms in the derogation monitoring network in the winter of 2010-2011 (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess**	*Clay*	*Peat*
Number of farms	35	0	57	49
First quartile (25th percentile)	4.0	*	2.3	3.4
Median (50th percentile)	6.0	*	2.9	4.4
Third quartile (75th percentile)	9.2	*	4.1	5.5

* There are no farms with ditches in the Loess Region.

Fifty percent of farms in the Sand Region had ditch water phosphorus concentrations below the detection threshold of 0.062 mg P/l (Table 3.15). Fifty percent of farms in the Peat Region had phosphorus concentrations equal to or lower than 0.08 mg P/l. The highest concentrations were found in the Clay Region, where 50 percent of farms had a phosphorus concentration equal to or below 0.15 mg P/l.

Table 3.15 Ditch water phosphorus concentrations[1] (in mg/l P) in the winter of 2010-2011 on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Region*			
	Sand	*Loess*	*Clay*	*Peat*
Number of farms[2]	35	*	57	49
First quartile (25th percentile)	<DT	*	<DT	<DT
Median (50th percentile)	<DT	*	0.15	0.08
Third quartile (75th percentile)	0.12	*	0.46	0.19

* There are no farms with ditches in the Loess Region.
[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT.

Comparison with provisional figures for 2011 as reported in 2012
The figures presented in this section deviate from the provisional figures reported in 2012 (Buis *et al.*, 2012). These differences are mainly due to the new regional boundaries that have since been introduced. The impact of these new boundaries on the water quality results is explained in Appendix 8.

3.2.3 *Provisional figures for measurement year 2012 (nitrogen and phosphorus)*

Only provisional results are available for the sixth water quality measurement year (2012). No results for the Loess Region were available when this report was being prepared. 'Provisional' means that the results are reasonably certain, although various cross-checks have not yet been performed. This could mean that some concentration data might change by the time the final results for 2014 are reported.

In the Sand Region, the average nitrate concentration in water leaching from the root zone was 36 mg/l (Table 3.16). Nitrate concentrations at 74 percent of farms were below 50 mg/l. This is a higher percentage than in 2011 (Table 3.9). In 2012, the average nitrate concentration in water leaching from the root zone in the Clay Region was 11 mg/l. All participating farms in the Clay Region had nitrate concentrations below 50 mg/l (Table 3.16). The average nitrate concentration on farms in the Peat Region was 4 mg/l. In this region, all farms also had nitrate concentrations below 50 mg/l.

In 2012 the average ditch water nitrate concentration in the Clay and Peat Regions amounted to 5 mg/l and 3 mg/l, respectively. These levels are well below 50 mg/l (Table 3.16). At 20 mg/l, the average ditch water nitrate concentration in the Sand Region exceeded the average concentration in the Clay and Peat Regions, but had decreased compared to 2011.

Table 3.16 Frequency distribution of average nitrate concentrations (in mg/l NO_3) in water leaching from the root zone and in ditch water per region in 2012, expressed in percentages per concentration class and average nitrate concentrations for all farms

Concentration class (mg NO_3/l)	*Water type*						
	Water leaching from root zone				*Ditch water*		
	Sand	*Loess*	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	152	0	62	51	36	61	50
Average concentration for all farms	36	*	11	4	20	5	3
<15	31	*	73	88	56	92	98
15-25	12	*	11	10	8	8	0
25-40	16	*	11	2	25	0	2
40-50	14	*	5	0	3	0	0
>50	26	*	0	0	8	0	0

* Results from the Loess Region were not yet available at the time of preparation of the present report.

Nitrogen concentrations in water leaching from the root zone are higher in the Sand Region than in the Clay and Peat Regions (Table 3.17). It is also noteworthy that nitrogen concentrations in the Peat Region are higher than in the Clay Region, due to higher ammonium concentrations in the Peat Region. The ditch water nitrogen concentrations present a similar picture to concentrations in water leaching from the root zone, but with lower concentration levels.

Table 3.17 Nitrogen concentrations (in mg/l N) in water leaching from the root zone and in ditch water in 2012 on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Water type*						
	Water leaching from root zone				*Ditch water*		
	Sand	*Loess**	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	152	0	62	51	36	61	50
Average	11.7	*	4.7	8.0	6.7	3.2	4.0
First quartile (25th percentile)	6.9	*	2.5	5.7	3.7	1.9	3.0
Median (50th percentile)	10.2	*	3.8	7.0	5.6	2.5	3.7
Third quartile (75th percentile)	14.6	*	6.0	10.8	9.1	3.9	5.0

* Results from the Loess Region were not yet available at the time of preparation of the present report.

Unlike the nitrogen concentrations, the phosphorus concentrations in water leaching from the root zone were higher in the Peat Region than in the Clay and Sand Regions (Table 3.18). The ditch water phosphorus concentrations are highest in the Clay Region. In all regions, phosphorus concentrations in ditch water are lower than in water leaching from the root zone.

Table 3.18 Phosphorus concentrations[1] (in mg/l P) in water leaching from the root zone and in ditch water in 2012 on farms in the derogation monitoring network (25th percentile, median and 75th percentile values per region)

Characteristic	*Water type*						
	Water leaching from root zone				*Ditch water*		
	Sand	*Loess*	*Clay*	*Peat*	*Sand*	*Clay*	*Peat*
Number of farms	152	*	62	51	36	61	50
Average	0.11	*	0.32	0.42	0.10	0.25	0.16
First quartile (25th percentile)	<DT	*	0.09	0.12	<DT	<DT	<DT
Median (50th percentile)	<DT	*	0.22	0.27	<DT	0.14	0.11
Third quartile (75th percentile)	0.10	*	0.36	0.43	0.16	0.46	0.18

* There are no farms with ditches in the Loess Region.

[1] Average values below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT.

4 Results after six years of operation of derogation scheme

4.1 Introduction

This chapter first describes the trends in agricultural practices at farms participating in the derogation monitoring network, followed by a description of trends in water quality. Trends since the start of the derogation scheme are identified, and a statistical analysis is provided of the extent to which agricultural practice year 2011 differed from preceding years. Finally, a link is established between developments in agricultural practices and water quality. This concerns results set out in this report as well as previous derogation monitoring reports (Fraters *et al.*, 2008; Zwart *et al.*, 2009; Zwart *et al.*, 2010; Zwart *et al.*, 2011; Buis *et al.*, 2012). Data from six measurement years are available for agricultural practices as well as water quality.

4.1.1 Selection of farms for comparison of results

In order to compare the results of successive years, previous reports used only those farms that participated in the derogation monitoring network and actually made use of the exemption in the measurement year concerned as well as in the preceding years. Because a number of farms dropped out every year and new farms were not used for trend analysis purposes, the number of farms that had participated every year diminished in successive years. Groups of sufficient size are required to safeguard the quality of the results in the long run. It was therefore decided to use a different method for the selection of farms, starting with the previous report (Buis *et al.*, 2012). Each measurement year, all farms are included that participated in the derogation monitoring network during that year and actually made use of the exemption. This method ensures a larger group of farms for the calculation of annual averages. In addition, the number of farms per year remains constant in successive reports so that changes to the results of preceding years can be avoided from now on. The corrected nitrate concentrations (section 4.3.2) form an exception, because the statistical method applied here means that nitrate concentrations in previous years might be slightly affected by the concentrations measured in the most recent measurement year.

4.1.2 Differences with previously reported results

Due to the new regional boundaries and changes to the LMM calculation model taking effect in this report, data for previous years presented in this chapter may deviate from data presented in the report of Buis *et al.* (2012). The effects of the new regional boundaries on water quality and nitrogen surplus data are explained in Appendix 8. The consequences of the revised LMM calculation model are explained in Appendix 9. The average nitrate concentration in water leaching from the root zone in the Sand Region is approx. 3 mg/l higher than in preceding years (also see Appendix 8). The average nitrate concentration in the Clay Region is slightly lower (approx. 6 mg/l) than in previous years. The new regional boundaries hardly affect the results for the Peat Region, and have no impact at all on the Loess Region. These changes have arisen because the proportion of farms with a different soil type has decreased within each region. On average, farms in the Sand Region have a higher acreage of sandy soil, while farms in the Clay Region have a higher acreage of clay soil.

The new regional boundaries also affect the soil surplus data (see Appendix 8). The average nitrogen surplus in the Peat Region has increased by approx. 5 kg of nitrogen per hectare. This is due to an increase in the surface area covered by peat soils, resulting in a greater supply of nitrogen through mineralisation. By way of contrast, the area of peatland has decreased in the Clay Region. As a result, the nitrogen surplus on the soil surface balance also decreased by approx. 5 kg of nitrogen per hectare. The new regional boundaries have virtually no effect on the soil surpluses in the Sand Region.

This report also uses a new FADN model to calculate the soil surpluses. All the changes described in Appendix 9 affect the calculated surpluses, sometimes in opposite directions. The net effect is that the average nitrogen surplus on the soil surface balance has decreased by 7 kg per hectare, while the phosphate surplus has increased by 4 kg per hectare.

4.1.3 Statistical method used to determine deviations and trends

Data for six consecutive years were available for the preparation of this report. Agricultural practice data are available for the years prior to 2011 (2006, 2007, 2008, 2009 and 2010). Water quality data are available for the years prior to 2012 (2007, 2008, 2009, 2010 and 2011).

Determining deviations in the measurement year under consideration
The comparison aims to establish if there is a significant difference between the measurement year and the average for the preceding years. The significance was determined using the Restricted Maximum Likelihood (REML) procedure. The REML method is suitable for unbalanced data sets and therefore takes account of farms which 'drop out' and are replaced. The agricultural practice data were processed using the REML method available as part of the 'linear mixed effects models procedure' (MIXED method) in IBM SPSS Statistics (version 20). The water quality data were processed using the REML method of GenStat (14th edition; VSN International Ltd.).

The calculations were based on unweighted annual farm averages, i.e. the data were not corrected for farm acreage, size, etc. All available annual farm averages were divided into two groups, with Group 1 comprising all the averages for the measurement year concerned, and Group 2 comprising all averages for the preceding years. The difference between Group 1 and Group 2 was then estimated as a so-called 'fixed effect', taking into account the fact that some data do not concern the same farms ('random effect'). A discussion of fixed and random effects may be found in standard statistical manuals on variance analysis, e.g. Kleinbaum *et al.* (1997) and Payne (2000). Welham *et al.* (2004) explain how to produce estimations with such models.

If the results for the most recent measurement year (agricultural practice year 2011, water quality measurement year 2012) deviate significantly from the average of the preceding years ($p < 0.05$), the direction of the deviation is indicated by a plus or minus sign. If there is no significant difference ($p > 0.05$), this is indicated by the 'approximately equal' sign (≈). These symbols may be found in the 'Difference' column in the overview tables (e.g. Table 4.1).

Determination of trends
The data were also analysed to identify any trends during the measurement period. The REML method with annual groups was used for this purpose as well. Only significant trends ($p < 0.05$) will be considered in this report.

4.2 Developments in agricultural practices

4.2.1 Explanation of numbers of farms

Table 4.1 lists the characteristics of all dairy and other grassland farms that participated in the derogation monitoring network during the 2006-2011 period and actually made use of the exemption (290 to 295 farms per year). The nutrient flow data for some of these farms (varying from 24 to 39 farms per year) were incomplete. Table 4.2 to Table 4.4 and Table 4.6 to Table 4.8 are based on results from a smaller number of farms than listed in Table 4.1. The relevant numbers are stated in the tables. The calculated crop yields (Table 4.5) are based on data from an even smaller number of farms. Not all farms have arable land. In addition, the yields on some farms cannot be calculated reliably, as these farms did not meet the crop yield calculation criteria.

Tables 4.1 to 4.8 contain the average values for the 2006-2010 period, the results for 2011, the deviations between the 2011 results and the average values for the 2006-2010 period, and the trends identified for the 2006-2011 period. The results for the 2006-2010 period and the results for 2011 can also be found in Appendix 5 (Table A5.1 to A5.8).

4.2.2 Classification of farms

The changes occurring in general farm characteristics over the course of time (e.g. acreage of cultivated land and percentage of grassland) are generally limited (Table 4.1). Milk production expressed in kg of FPCM per farm and per hectare has increased. This can be explained by increases in the milk quota due to purchases, leases and extensions initiated by European Union policy (0.5 percent in 2007, 2.5 percent in 2008, 1 percent in 2009, 1 percent in 2010 and 1 percent in 2011). The increase in milk production in 2011 was not accompanied by a comparable increase in the area of cultivated land per farm. As a result, the average milk production per hectare (expressed in FCPM) increased. Milk production per cow was higher in 2011 than the average for the 2006-2010 period. The proportion of farms with pigs and poultry decreased in 2011. The proportion of farms where dairy cows were grazing (78 percent) was significantly lower in 2011 than the average for the 2006-2010 period. In the 2006-2010 period, a significant declining trend may be observed in the percentage of farms with grazing dairy cows. This decrease is more pronounced for the September-October period than for the entire May-October period.

Table 4.1 Some general characteristics of farms participating in the derogation monitoring network (DMN): average values for the 2006-2010 period, results for 2011, differences between 2011 results and the average values for the 2006-2010 period, and trends identified for the 2006-2011 period (also see Appendix 5, Table A5.1)

Farm characteristic	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Number of dairy farms		256		
Number of other grassland farms		34		
Total area of cultivated land (hectares)	51	53	+	+
Proportion of grassland (%)	83	83	≈	≈
Proportion of farms with pigs and poultry (%)	11	8	-	-
Total livestock density (Phosphate Livestock Units per hectare)[1]	2.9	2.8	≈	-
Kilogrammes of FPCM per farm (x 1,000)	776	869	+	+
Kilogrammes of FPCM per dairy cow (x 1,000)	8.5	8.6	+	+
FPCM production per hectare of fodder crop (x 1,000 kg)	15	16	+	+
Percentage of dairy farms where dairy cows are grazing in May-October period	85	78	-	-
Percentage of dairy farms where dairy cows are grazing in May-June period	82	76	-	-
Percentage of dairy farms where dairy cows are grazing in July-August period	85	78	-	-
Percentage of dairy farms where dairy cows are grazing in September-October period	83	71	-	-

[1] Phosphate Livestock Unit (LSU) is a standard used to compare numbers of animals based on their standard phosphate production.
One adult dairy cow produces 41 kg of phosphate on average, which is equivalent to 1 LSU. One young animal 1-2 years of age produces 18 kg of phosphate (0.44 Phosphate LSU); one young animal 0-1 years of age produces 9 kg of phosphate (0.22 Phosphate LSU).
Difference: direction and significance of difference between 2011 and average for previous years.
≈ : insignificant difference ($p > 0.05$), +/- : significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2011 period.
≈ : insignificant trend ($p > 0.05$), +/- : significant trend ($p < 0.05$).

A significant upward trend may be observed in milk production (FCPM) per farm, per hectare and per cow during the 2006-2011 period. This also applies to the area of cultivated land per farm. A significant decrease is apparent in the proportion of farms with pigs and poultry, and the average livestock density expressed in Phosphate Livestock Units per hectare. The trend in dairy farming indicates a slow but steady increase in scale and intensification of milk production per hectare. In addition, more and more farmers are opting to keep their dairy cows in stables full-time.

4.2.3 *Use of livestock manure*

In 2011 the quantity of nitrogen in livestock manure increased by a few kg per hectare compared to the average for the 2006-2010 period. No significant trend could be identified for the entire 2006-2011 period (Table 4.2). In 2011, the use of nitrogen in livestock manure on grassland was not significantly higher than the average for the 2006-2010 period. No significant trend could be identified for the entire 2006-2011 period with respect to the application of nitrogen on grassland. Usage levels are decreasing on arable land, however. No significant trend could be identified in movements in stocks, although stocks have been increasing year-on-year since 2006 (see Appendix 5, Table A5.2).

Table 4.2 Application of nitrogen in livestock manure (in kg of nitrogen per hectare) at farms participating in the derogation monitoring network (DMN): average values for the 2006-2010 period, results for 2011, differences between 2011 results and the average values for the 2006-2010 period, and trends identified for the 2006-2011 period (also see Appendix 5, Table A5.2)

Description	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Number of farms	275	278		
Use of nitrogen in livestock manure				
Produced on farm	268	276	≈	+
+ Inputs	9	11	+	≈
+ Changes in stocks[1]	-6	-5	≈	≈
- Outputs	31	36	≈	+
Total use	241	246	≈	≈
Use on grassland	256	259	≈	≈
Use on arable land	175	175	≈	-

[1] A negative change in stocks is a stock increase and corresponds to output of manure.
Difference: direction and significance of difference between 2011 and average for previous years.
≈ : insignificant difference ($p > 0.05$), +/- : significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2011 period.
≈ : insignificant trend ($p > 0.05$), +/- : significant trend ($p < 0.05$).

4.2.4 *Use of fertilisers compared to application standards*

The total use of plant-available nitrogen is still below the total application standard, but the difference is decreasing (Table 4.3). Whereas the difference between actual usage and the total application standard for plant-available nitrogen was almost 70 kg per hectare in 2006, this difference had been reduced to 16 kg per hectare by 2011 (see Appendix 5, Table A5.3). This is partly due to higher statutory availability coefficients for grazing livestock manure, and partly due to more stringent nitrogen application standards (Table 4.3).
The use of inorganic nitrogen-containing fertilisers was fairly stable during the 2006-2011 period. The total quantity of plant-available nitrogen in 2011 was slightly higher than the average for the five preceding years. An upward trend may be observed in the total use of nitrogen, mainly due to an increase in the statutory availability coefficient for livestock manure.

Table 4.3 Nitrogen usage (in kg of plant-available nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2010 period, results for 2011, differences between 2011 results and the average values for the 2006-2010 period, and trends identified for the 2006-2011 period (also see Appendix 5, Table A5.3)

Description	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Number of farms	275	278		
Livestock manure excluding availability coefficient	241	246	+	≈
Availability coefficient	45	49	+	+
Livestock manure including availability coefficient	108	121	+	+
+ Other organic fertilisers	0	0	≈	≈
+ Organic fertilisers	125	123	≈	≈
Total use	232	244	+	+
Nitrogen application standard applicable to farm	273	260	-	-
Use on grassland	259	270	+	+
Nitrogen application standard for grassland	298	282	-	-
Use on arable land	118	123	+	+
Nitrogen application standard for arable land	155	157	+	≈

Difference: direction and significance of difference between 2011 and average for previous years.
≈ : insignificant difference ($p > 0.05$), +/- : significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2011 period.
≈ : insignificant trend ($p > 0.05$), +/- : significant trend ($p < 0.05$).

During the 2006-2011 period, the use of phosphate fertilisers on farms participating in the derogation monitoring network decreased by approx. 9 percent, while the phosphate application standard decreased by nearly 17 percent (Appendix 5, Table A5.4). This resulted in a reduction of the difference between actual phosphate use and the phosphate application standard from approximately 10 kg/ha in 2006/2007 to 1 kg/ha in 2011. A declining trend may be observed in the use of phosphate in both livestock manure and inorganic fertilisers, and on grassland as well as arable land (Table 4.4).

Table 4.4 Phosphate usage (in kg P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2010 period, results for 2011, differences between 2011 results and the average values for the 2006-2010 period, and trends identified for the 2006-2011 period (also see Appendix 5, Table A5.4)

Description	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Number of farms	275	278		
Livestock manure	87	86	≈	≈
+ Other organic fertilisers	0	0	≈	≈
+ Inorganic fertilisers	6	3	-	-
Total use	93	90	-	-
Phosphate application standard per farm	100	90	-	-
Use on grassland	96	92	-	-
Phosphate application standard for grassland	102	94	-	-
Use on arable land	82	77	-	-
Phosphate application standard for arable land	87	73	-	-

Difference: direction and significance of difference between 2011 and average for previous years.
≈ : insignificant difference ($p > 0.05$), +/- : significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2011 period.
≈ : insignificant trend ($p > 0.05$), +/- : significant trend ($p < 0.05$).

Between 2006 and 2011, the phosphate application standards were reduced from an average of 108 kg per hectare to an average of 90 kg per hectare. This means that the difference between actual usage and the level prescribed by the standard was eliminated. Reduction of the application standards also resulted in a reduction in the use of inorganic phosphate-containing fertilisers.

4.2.5 Crop yields

The average dry-matter yields for grass and silage maize show a slight increase in the 2006-2011 period. This trend can be described as significant. Yields measured in kilogrammes of nitrogen do not show a clear trend for grassland, while silage maize yields display an upward trend (Table 4.5). No trends could be identified with respect to yields measured in kilogrammes of phosphate. These differences may result in changes in the nitrogen and phosphate contents of crops.

Table 4.5 Calculated crop yields (in kg of dry matter, nitrogen, phosphorus and P_2O_5 per hectare) for grassland and estimated silage maize yields on farms participating in the derogation monitoring network that fulfil the criteria for application of the grassland yield calculation method (Aarts et al., 2008): average values for the 2006-2010 period, results for 2011, differences between 2011 results and the average values for the 2006-2010 period, and trends identified for the 2006-2011 period (also see Appendix 5, Table A5.5)

Description	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Estimated silage maize yield				
Number of farms	155	167		
Tonnes of dry matter per hectare	15.6	16.2	+	+
Kilogrammes of nitrogen per hectare	184	190	+	+
Kilogrammes of phosphorus per hectare	30	31	≈	≈
Kilogrammes of P_2O_5 per hectare	68	70	≈	≈
Calculated grassland yield				
Number of farms	207	221		
Tonnes of dry matter per hectare	9.2	9.8	+	+
Kilogrammes of nitrogen per hectare	263	274	+	≈
Kilogrammes of phosphorus per hectare	36	38	+	≈
Kilogrammes of P_2O_5 per hectare	83	87	+	≈

Difference: direction and significance of difference between 2011 and average for previous years.
≈ : insignificant difference ($p > 0.05$), +/- : significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2011 period.
≈ : insignificant trend ($p > 0.05$), +/- : significant trend ($p < 0.05$).

4.2.6 *Nutrient surpluses on the soil surface balance*

The nitrogen surpluses on the soil surface balance have fluctuated slightly over the years (see Appendix 5, Table A5.6). The average nitrogen surplus on the soil surface balance in 2011 was significantly lower than the average for the 2006-2010 period. The average nitrogen surplus on the soil surface balance showed a significant declining trend in the 2006-2011 period (Table 4.6). The surpluses in the Sand Region also show a significant declining trend. The surpluses in regions with other soil types are decreasing (with the exception of the Loess Region), but this trend cannot be considered significant (Table 4.7). The upward trend in the supply of nitrogen is not caused by inputs of inorganic fertilisers (also see Table 4.3), but by other items such as feedstuffs.

Table 4.6 Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) at farms participating in the derogation monitoring network (DMN): average values for the 2006-2010 period, results for 2011, differences between 2011 results and the average values for the 2006-2010 period, and trends identified for the 2006-2011 period (also see Appendix 5, Table A5.6)

Description	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Number of farms	275	278		
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	335	336	≈	≈
Outputs of milk, animals, feedstuffs, manure and other products	153	165	≈	+
Deposition, mineralisation and nitrogen fixation	56	58	≈	-
Gaseous emissions from stabling and storage, during grazing and application	55	54	≈	≈
Average surplus on soil surface balance	184	175	-	-
Surplus on soil surface balance (25th percentile)[1]	128	128		
Surplus on soil surface balance (75th percentile)[2]	228	219		

[1] Upper limit of the 25 percent of farms with the lowest surplus on the soil surface balance.
[2] Lower limit of the 25 percent of farms with the highest surplus on the soil surface balance.
Difference: direction and significance of difference between 2011 and average for previous years.
≈ : insignificant difference (p > 0.05), +/- : significant difference (p < 0.05).
Trend: direction and significance of trend in 2006-2011 period.
≈ : insignificant trend (p > 0.05), +/- : significant trend (p < 0.05).

Table 4.7 Nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN): average values for the 2006-2010 period, results for 2011, differences between 2011 results and the average values for the 2006-2010 period, and trends identified for the 2006-2011 period (also see Appendix 5, Table A5.7)

Region	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Sand Region (N = 137-144)	169	163	≈	-
Loess Region (N = 15-20)	141	148	≈	≈
Clay Region (N = 63-69)	189	166	-	≈
Peat Region (N = 46-53)	235	229	≈	≈
All farms (N = 269-278)	184	175	-	-

Difference: direction and significance of difference between 2011 and average for previous years.
≈ : insignificant difference (p > 0.05), +/- : significant difference (p < 0.05).
Trend: direction and significance of trend in 2006-2011 period.
≈ : insignificant trend (p > 0.05), +/- : significant trend (p < 0.05).

Table 4.8 shows that the average phosphate surplus on the soil surface balance in 2011 was significantly lower than the average for the 2006-2010 period. It also shows a declining trend during the 2006-2011 period, caused by a reduced supply of inorganic fertilisers and significantly higher outputs.

Table 4.8 Phosphate surpluses on the soil surface balance (in kg P_2O_5 per hectare) at farms participating in the derogation monitoring network (DMN): average values for the 2006-2010 period, results for 2011, differences between 2011 results and the average values for the 2006-2010 period, and trends identified for the 2006-2011 period (also see Appendix 5, Table A5.8)

Description	*Average 2006-2010*	*2011*	*Difference*	*Trend*
Number of farms	275	278		
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	84	82	≈	≈
Outputs of milk, animals, feedstuffs, manure and other products	67	70	≈	+
Average surplus on soil surface balance	17	12	-	-
Surplus on soil surface balance (25th percentile)[1]	4	0		
Surplus on soil surface balance (75th percentile)[2]	30	27		

[1] Upper limit of the 25 percent of farms with the lowest surplus on the soil surface balance.
[2] Lower limit of the 25 percent of farms with the highest surplus on the soil surface balance.
Difference: direction and significance of difference between 2011 and average for previous years.
≈ : insignificant difference ($p > 0.05$), +/- : significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2006-2011 period.
≈ : insignificant trend ($p > 0.05$), +/- : significant trend ($p < 0.05$).

4.2.7 Summary

A comparison of the results for the years 2006 up to and including 2011 reveals a significant increase in milk production per farm, per hectare and per cow. The proportion of dairy farms with pigs and poultry displays a declining trend in the 2006-2011 period. The same applies to the proportion of dairy farms where dairy cows are grazing. This decrease is more pronounced for the autumn period than for the entire grazing period.

The production of livestock manure increased significantly. During the 2006-2011 period, there was a slight but statistically significant upward trend in the use of plant-available nitrogen in livestock manure, mainly due to the higher statutory availability coefficient for grazing. In 2011, the use of livestock manure did not exceed the application standard of 250 kg of nitrogen per hectare.

The calculated use of plant-available nitrogen in livestock manure displayed a statistically significant upward trend during the period from 2006 to 2011. The total use of plant-available nitrogen was approx. 16 kg per hectare below the total application standard in 2011. Due to the more stringent application standard and the higher statutory availability coefficient for nitrogen in livestock manure, this difference has diminished over the years. The average use of plant-available nitrogen in the 2006-2010 period was 41 kg per hectare below the total application standard.

In 2011, the use of inorganic nitrogen-containing fertilisers did not differ significantly from the average for the five preceding years. The use of inorganic fertilisers did not display a significant trend during the 2006-2011 period.

Although the average nitrogen surplus on the soil surface balance of all farms fluctuated slightly over the years, a significant downward trend is apparent.

In 2011 the use of phosphate in fertilisers was significantly lower than the average for the 2006-2010 period, mainly due to a decrease in the use of inorganic fertilisers. For these and other reasons, the phosphate surplus in 2011 was significantly lower than the average for the 2006-2010 period. In 2011 the farms in the first quartile (25th percentile) realised an average phosphate surplus of less than 0 kg per hectare (0 kg/ha = balance). A significant downward trend may be observed in phosphate usage during the 2006-2011 period. This also applies to the phosphate surplus. From 2006-2007 to 2011, the difference between the phosphate application standard and actual phosphate use decreased from approx. 7 kg to 0 kg per hectare. The phosphate application standard for 2011 was significantly lower than the average for the 2006-2010 period. The estimated silage maize yield and the calculated grassland yield (expressed in kilogrammes of dry matter per hectare) showed a significant rising trend during the 2006-2011 period. The estimated silage maize yield, measured in kilogrammes of nitrogen, also showed an upward trend. No significant trend was identified in the calculated grassland yield expressed in kilogrammes of nitrogen. This also applies to the phosphate yields for maize and grass.

4.3 Development of water quality

This section outlines the development of water quality during the derogation years 2006 to 2011. Water quality is determined by approximation in the year following the agricultural practice year, in this case the 2007-2012 period. Zwart *et al.*(2009) provide a comparison between water quality in 2006 (not yet related to the derogation scheme) and 2007 (related to 2006, the first year in which the derogation scheme was operational).

The water quality results during the 2007-2012 period were determined for all farms that participated in the derogation monitoring network and that actually made use of the exemption during the agricultural practice year preceding the relevant measurement year. This means that the numbers of farms reported on in Chapter 4 differ from the numbers in Chapter 3. For 2012, only preliminary results are reported. Data for 2012 are not yet available for the Loess Region.

4.3.1 Development of average concentrations during 2007-2012 period

Nitrate and nitrogen

Average nitrate concentrations in water leaching from the root zone on farms participating in the derogation scheme in the Sand Region decreased between 2007 and 2012 (Figure 4.1). The effect of previous years with below-average precipitation was apparent in the 2010 results for the top metre of groundwater, which revealed a higher nitrate concentration than in previous and subsequent years. Nitrate concentrations in the Peat and Clay Regions displayed a similar pattern to the Sand Region, whereas nitrate levels in the Loess Region increased in 2011.

The average nitrate concentrations are highest in the Loess Region and decrease in the following order: Loess > Sand > Clay > Peat. In the Clay and Peat Regions, the average concentrations were below 50 mg of nitrate per litre in all years (Figure 4.1). In the Sand Region, this has been the case since 2008. In 2009 and 2010, the average nitrate concentration in the Loess Region corresponded to the standard of 50 mg/l. The higher nitrate concentrations in the Loess and Sand Regions are caused mainly by a higher percentage of soils prone to leaching. These are soils where less denitrification occurs, partly due to lower groundwater levels (Fraters *et al.*, 2007, Boumans and Fraters, 2011).

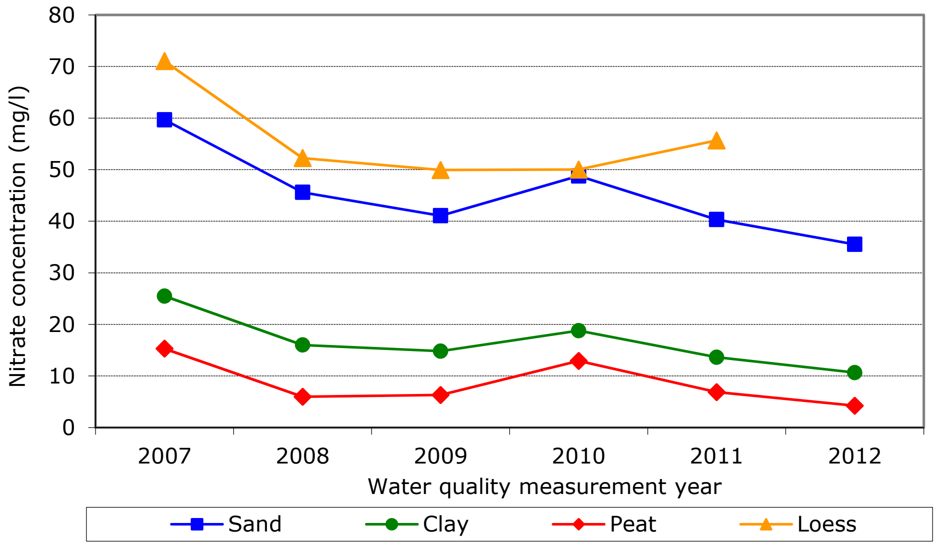

Figure 4.1 Average nitrate concentrations in water leaching from the root zone on farms participating in the derogation scheme in the four regions during the 2007-2012 period

In 2012, both nitrate and nitrogen concentrations in water leaching from the root zone in the Clay, Peat and Sand Regions were significantly lower than the average concentrations in previous years (Table 4.9). Only in the Loess Region did the nitrate and nitrogen concentrations in 2011 not deviate significantly from the average for the 2007-2010 period.

The nitrate and nitrogen concentrations in the Clay, Peat and Sand Regions decreased significantly in the 2007-2012 period. Application of the REML method revealed a declining trend in nitrate and nitrogen concentrations in the Loess Region, although nitrate concentrations did increase in 2011.

Table 4.9 Average nutrient concentrations (in mg/l) in water leaching from the root zone and ditch water: average values for the 2007-2011 period, differences between 2012 results and the average values for the 2007-2011 period, and trends identified for the 2007-2012 period

	Average 2007-2011	2012	Difference	Trend
	Water leaching from root zone in Clay Region			
Nitrate	18	11	-	-
Phosphorus	0.32	0.33	≈	-
Nitrogen	6.0	4.7	-	-
	Ditch water in Clay Region			
Nitrate	8.7	5.3	-	-
Phosphorus	0.31	0.25	≈	-
Nitrogen	3.9	3.2	-	-
	Water leaching from root zone in Sand Region			
Nitrate	47	36	-	-
Phosphorus	0.08	0.10	≈	+
Nitrogen	14	11	-	-
	Ditch water in Sand Region			
Nitrate	30	19	-	-
Phosphorus	0.13	0.11	≈	≈
Nitrogen	8.9	6.6	-	-
	Water leaching from root zone in Peat Region			
Nitrate	9.5	4.2	-	-
Phosphorus	0.41	0.42	≈	≈
Nitrogen	9.8	8.0	-	-
	Ditch water in Peat Region			
Nitrate	4.2	2.8	-	-
Phosphorus	0.16	0.16	≈	-
Nitrogen	4.2	4.0	≈	+
	Water leaching from root zone in Loess Region[1]			
	Average 2007-2010	2011	Difference	Trend
Nitrate	56	56	≈	-
Phosphorus	<DT[2]	N/A[3]	*	*
Nitrogen	14	13	-	-

Difference: direction and significance of difference between 2011 and average for previous years.
≈ : insignificant difference ($p > 0.05$), +/- : significant difference ($p < 0.05$).
Trend: direction and significance of trend in 2007-2011 period.
≈ : insignificant trend ($p > 0.05$), +/- : significant trend ($p < 0.05$).
[1] The difference was determined based on a comparison of the 2011 data with the data for the 2007-2010 period. The data for 2011 are not yet available.
[2] Average phosphorus concentrations below the detection threshold of 0.062 mg/l are indicated by the abbreviation <DT.
[3] The phosphorus measurements conducted in the Loess Region were rejected (refer to section 3.2.1).

The ditch water nitrate concentrations on farms participating in the derogation scheme present a picture similar to the concentrations in water leaching from the root zone (Figure 4.2), but with lower concentrations. Ditch water nitrate concentrations in the Sand Region decreased from 35 mg/l to below 20 mg/l, with a peak in 2010. Average ditch water nitrate concentration in the Clay

Region declined from 12 mg/l to 5 mg/l, again with a peak in 2010. Ditch water nitrate concentrations in the Peat Region decreased from approx. 6 mg/l to approx. 3 mg/l. In all regions and all measurement years, the average nitrate concentrations in ditch water remained below 50 mg/l. In all regions, the ditch water nitrate and nitrogen concentrations in 2012 deviated significantly from the average concentrations of the preceding years (Table 4.9). The nitrogen concentration in the Peat Region provided the only exception. All regions showed a significant decrease in ditch water nitrate concentrations during the period from 2007 to 2012. This also applies to nitrogen concentrations in the Clay and Sand Regions.

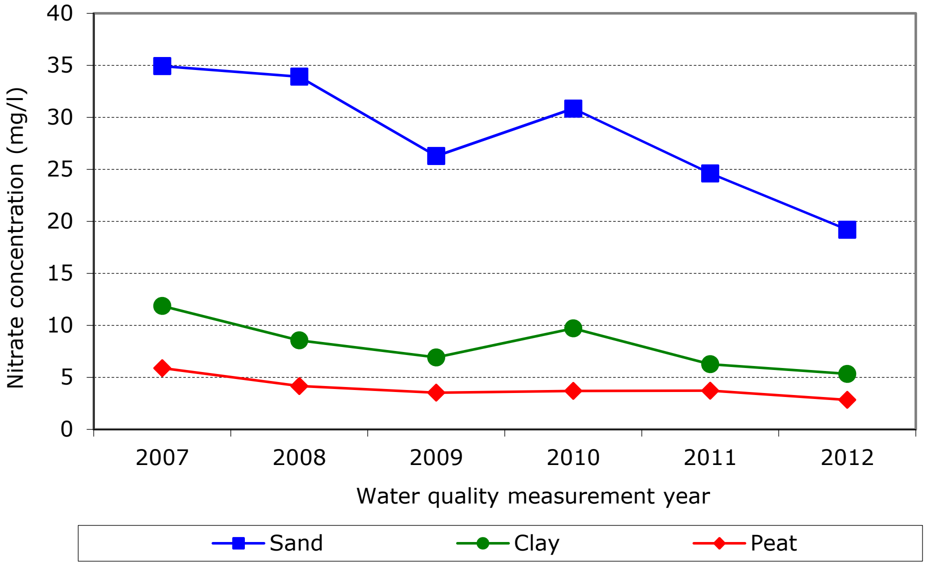

Figure 4.2 Average ditch water nitrate concentration on farms participating in the derogation monitoring network in three regions in the 2007-2012 period

Phosphorus
Phosphorus concentrations in water leaching from the root zone in the Clay, Sand and Peat Regions have fluctuated over the years (Table 4.9 and Appendix 5, Table A5.9). In all years, the average concentration in the Loess Region was below the detection threshold. It was not possible to measure phosphor concentrations in 2011. The concentrations were highest in the Peat Region, followed by the Clay Region and the Sand Region. There was no significant difference between the results for measurement year 2012 and the average of the preceding years. Phosphor concentrations in water leaching from the root zone display a significant downward trend in the Clay Region. A significant upward trend may be observed in the Sand Region.

The ditch water phosphorus concentrations in the Clay, Sand and Peat Regions have also fluctuated over the years (Table 4.9). The ditch water phosphorus concentrations decrease in the following order: Clay > Peat > Sand. There was no significant difference between the results for measurement year 2012 and the average of the preceding years. Concentrations in ditch water show a significant decreasing trend in the Clay and Peat Regions.

4.3.2 *Influence of environmental factors and sample composition on nitrate concentrations*

Nitrate concentrations in water leaching from the root zone are not only influenced by agricultural practices, but also by environmental factors. Particularly precipitation and temperature affect crop yields and consequently the output of nitrogen, soil surpluses and nitrogen leaching. Even if a long-term balance is achieved between the annual supply and breakdown of organic matter, mineralisation and immobilisation will not be exactly balanced in each year. As a result, there will be variations in soil surpluses and nitrogen leaching. Furthermore, the final nitrogen concentration is affected by the precipitation surplus and changes in groundwater levels (Boumans *et al.*, 2005; Fraters *et al.*, 2005; Zwart *et al.*, 2009; Zwart *et al.*, 2010; Zwart *et al.*, 2011). Changes in the composition of the farm sample can also have an effect, because soil types and groundwater levels vary between farms (Boumans *et al.*, 1989).

A statistical method has been developed for the Sand Region in order to correct the measured nitrate concentrations for the influence of weather conditions, groundwater levels and changes in the composition of the sample (Boumans and Fraters, 2011). This method uses relative evaporation as a measure for the impact of annual fluctuations in the precipitation surplus (Table 4.10). Nitrate concentrations will rise as evaporation increases and groundwater levels decrease, provided other factors do not change. A further explanation of the statistical method is provided in Appendix 6.

The average corrected nitrate concentrations in the Sand Region dropped significantly from approx. 58 mg/l in 2007 to approx. 40 mg/l in 2012, a reduction of 18 mg/l (Table 4.10 and Figure 4.3). Although this decrease is significant, the results must be interpreted with caution. The method used is not comprehensive and does not take all the relevant processes into consideration. However, we can conclude that fluctuations in concentration levels would decrease if we take into account weather conditions, changes in groundwater levels, and the effects of changes in the sample composition.

In recent years both measured and corrected nitrate concentrations have been below the 50 mg/l standard and have displayed a significant downward trend. Therefore, it can be concluded that weather conditions, groundwater levels or sample composition are not the reason for concentrations below 50 mg/l.

Table 4.10 Average nitrate concentrations (in mg/l) in water leaching from the root zone in the Sand Region, measured and corrected for weather conditions, including average relative evaporation and groundwater levels

Year	*Number of farms*	*Relative evaporation*	*Groundwater level*[1]	*Measured nitrate concentration*	*Corrected nitrate concentration*
2007	141	1.3	137	60	58
2008	141	0.9	146	46	53
2009	142	1.0	161	41	45
2010	143	1.4	147	49	42
2011	142	1.3	149	40	36
2012	147	1.1	144	36	40

[1] Average groundwater level in centimetres below surface level.

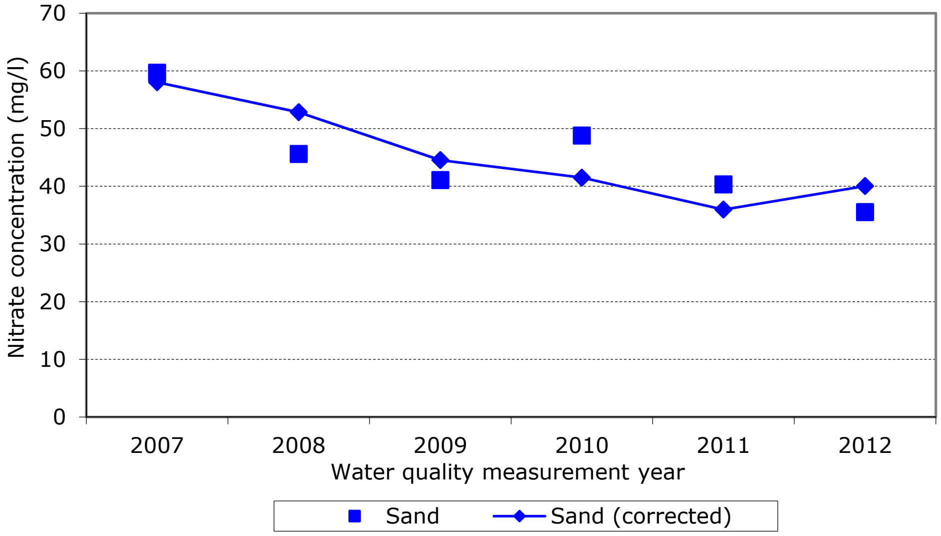

Figure 4.3 Development of uncorrected and corrected nitrate concentrations in water leaching from the root zone in the Sand Region in successive measurement years

With respect to nitrate concentrations in water leaching from the root zone in the Clay Region, no clear link has been found with the precipitation surplus or the groundwater level using the correction method originally developed for the Sand Region. This is due partly to the low nitrate concentrations, resulting in a less clear picture of relationships. In addition, groundwater level data are not available for all farms, so that no corrected concentration data can be provided. Nitrate concentrations in the Peat Region were still lower, making it even more difficult to establish clear relationships. The sample for the Loess Region was too small to perform such a correction.

4.4 Effects of agricultural practices on water quality

This section offers a qualitative analysis of trends in water quality on farms participating in the derogation scheme, in relation to developments in agricultural practices.

Nitrate
Water quality as measured in 2007 was influenced by agricultural practices in 2006 and previous years, water quality as measured in 2008 was influenced by agricultural practices in 2007, and so on. Figure 4.4 shows the trend lines for nitrate concentrations in water leaching from the root zone, and nitrogen surpluses attributable to agricultural practices.

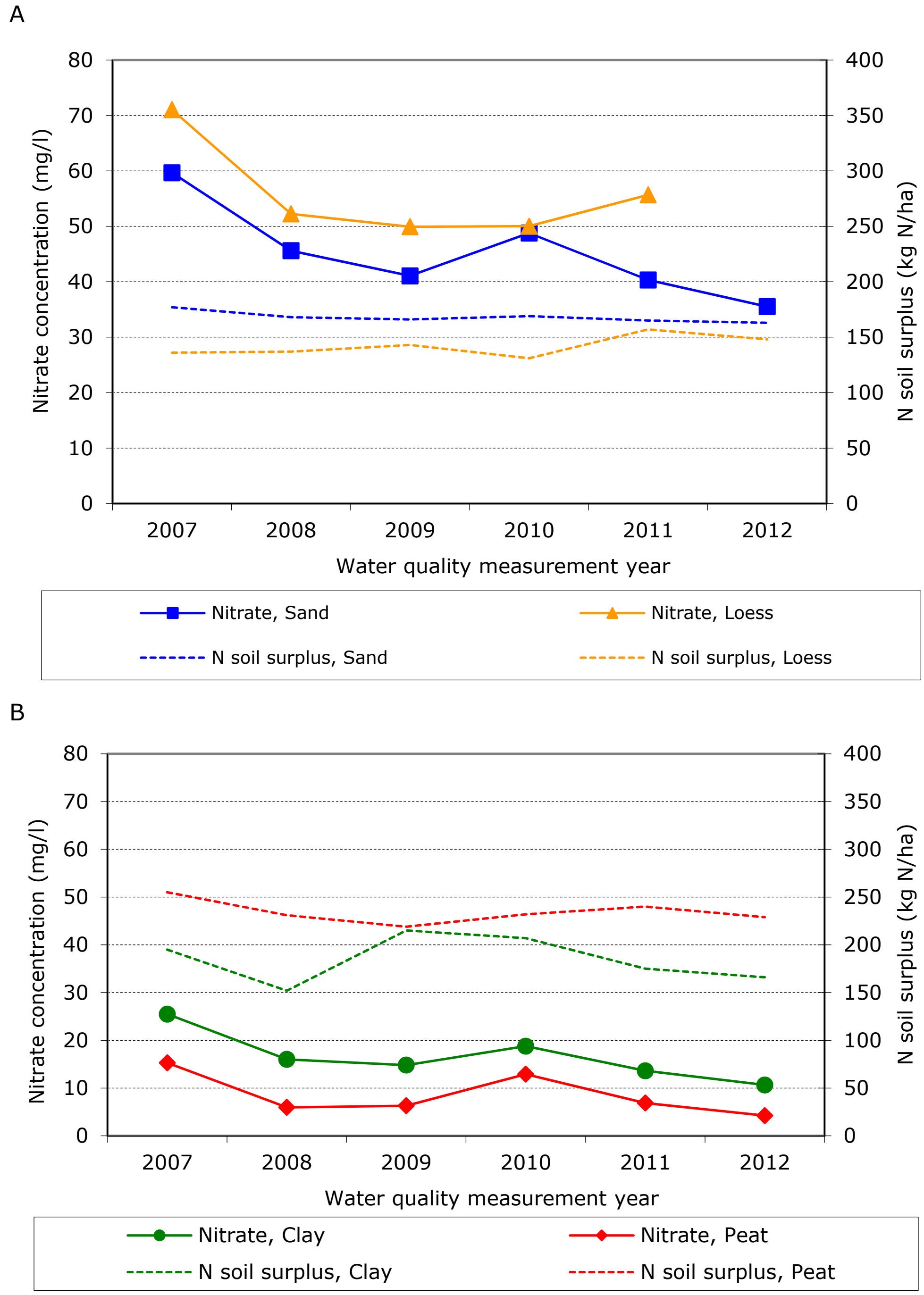

Figure 4.4 Development of average nitrate concentrations in water leaching from the root zone in the Sand and Loess Regions (A) and Clay and Peat Regions (B) in successive measurement years, including nitrogen surpluses attributable to agricultural practices in previous years

Nitrate concentrations in water leaching from the root zone in the Sand Region decreased during the 2007-2012 period. Nitrogen soil surpluses in the Sand Region have also fallen significantly, while the soil surplus in the Loess Region is increasing. The nitrogen surpluses in the Peat and Clay Regions fluctuate, but no significant decrease has occurred. In 2010, an increase was observed in the nitrate concentrations in water leaching from the root zone in the Sand Region. As 2010 was a very dry year, the measured nitrate concentrations in water leaching from the root zone increased from 2009 to 2010, followed by a decrease during the 2010-2012 period. Nitrate concentrations are sensitive to weather influences (Boumans and Fraters, 2011). After correction for weather conditions and other factors, nitrate concentrations in the Sand Region decreased during the measurement period from approx. 58 mg/l to approx. 40 mg/l.

The trend in dairy farming indicates a steady increase in scale and intensification of milk production per hectare and per cow. In addition, more and more farmers are opting to keep their dairy cows in stables full-time, resulting in a decreasing proportion of farms with grazing dairy cows Table 4.1 and section 4.2.1). This trend in grazing may partly explain the decreasing nitrate concentrations in the Sand Region (Boumans and Fraters, 2011). The percentage of dairy farms where dairy cows are kept in stables during the September-October period has shown a notable increase, from 13 percent in 2006 to 19 percent in 2011. The risk of nitrate leaching is particularly high in autumn due to the higher precipitation surplus and lower nitrogen absorption by crops. Another possible explanation for lower nitrate concentrations in the Sand Region is the greater decrease in maize fertilisation compared to grassland fertilisation. Arable land is more susceptible to nitrate leaching than grassland.

Phosphate
The phosphate surplus on the soil surface balance showed a declining trend. The effect of this decrease was not reflected in water quality levels, where the concentrations fluctuated. This lack of correlation may be explained by the fact that phosphate bonds strongly to the soil, so that any changes in the phosphate surplus have less effect on phosphorus concentrations. It is also possible that phosphorus concentrations in water leaching from the root zone and in ditch water have increased as a result of high groundwater levels and/or more surface runoff.

References

- Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2008). Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmais op melkveebedrijven. Wageningen, Plant Research International, Report No. 208.
- Baumann, R.A., A.E.J. Hooijboer, A. Vrijhoef, B. Fraters, M. Kotte, C.H.G. Daatselaar, C.S.M. Oltshoorn and J.N. Bosma (2012). Landbouwpraktijk en waterkwaliteit in Nederland, periode 1992-2010. Bilthoven, RIVM Report No. 680716007.
- Biesheuvel, A. (2002). Over het voorkomen en de afbraak van pyriet in de Nederlandse ondergrond. Deventer, Witteveen+Bos, Report No. SECI/KRUB/rap.003.
- Boumans L.J.M., C.M. Meinardi and G.J.W. Krajenbrink (1989). Nitraatgehalten en kwaliteit van het grondwater onder grasland in de zandgebieden. Bilthoven, RIVM Report No. 728472013.
- Boumans, L.J.M., G. van Drecht, B. Fraters, T. de Haan and D.W. de Hoop (1997). Effect van neerslag op nitraat in het bovenste grondwater onder landbouwbedrijven in de zandgebieden; gevolgen voor de inrichting van het Monitoringnetwerk effecten mestbeleid op Landbouwbedrijven (MOL). Bilthoven, RIVM Report No. 714831002.
- Boumans, L.J.M., B. Fraters and G. van Drecht (2001). Nitrate in the upper groundwater of 'De Marke' and other farms. NJAS - Wageningen Journal of Life Sciences 49 (2-3): 163-177.
- Boumans L.J.M., B. Fraters and G. van Drecht (2005). Nitrate leaching in agriculture to upper groundwater in the sandy regions of the Netherlands during the 1992-1995 period. Environ. Monit. Assess. 102, 225-241.
- Boumans, L.J.M. and B. Fraters (2011). Nitraatconcentraties in het bovenste grondwater van de zandregio en de invloed van het mestbeleid. Visualisatie afname in de periode 1992 tot 2009. Bilthoven, RIVM Report No. 680717020.
- Buis, E., A. van den Ham, L.J.M. Boumans, C.H.G. Daatselaar, G.J. Doornewaard (2012). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2010 in het derogatiemeetnet. Bilthoven, RIVM Report No. 68071028.
- Butterbach-Bahl, K. and P. Gundersen (2011). Nitrogen processes in terrestrial ecosystems. The European Nitrogen Assessment. M.A. Sutton, C.M. Howard, J.W. Erisman, G. Billen, A. Bleeker, P. Grennfelt, H. van Grinsven en B. Grizzetti (eds). Cambridge, Cambridge University Press.
- EU (1991). Council Directive 91/676/EEC of 12 December 1991 concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Communities, No. L 375/1-8.
- EU (2005). Commission decision of 8 December 2005 granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, No. L 324/89-93 (10 December 2005).
- EU (2010). Commission decision of 5 February 2010 amending Decision 2005/880/EC granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (2010/65/EU), Official Journal of the European Union, No. L 35/18 (6 February 2010).

- Field, A. (2005). Discovering statistics using SPSS. London, SAGE Publications Ltd.
- Fraters, B., P.H. Hotsma, V.T. Langenberg, T.C. Van Leeuwen, A.P.A. Mol, C.S.M. Olsthoorn C.G.J. Schotten and W.J. Willems (2004). Agricultural practice and water quality in the Netherlands in the 1992-2002 period. Background information for the third EU Nitrate Directive Member States report. Bilthoven, RIVM Report No. 500003002.
- Fraters, B. and L.J.M. Boumans (2005). De opzet van het Landelijk Meetnet effecten Mestbeleid voor 2004 en daarna. Uitbreiding van LMM voor onderbouwing van Nederlands beleid en door Europese monitorverplichtingen. Bilthoven, RIVM Report No. 680100001.
- Fraters D., L.J.M. Boumans, T.C. van Leeuwen and W.D. de Hoop (2005). Results of 10 years of monitoring nitrogen in the sandy region in The Netherlands. Water Science & Technology, 5 (3-4), 239-247.
- Fraters, B., L.J.M. Boumans, T.C. Van Leeuwen and J.W. Reijs (2007a). De uitspoeling van het stikstofoverschot naar grond- en oppervlaktewater op landbouwbedrijven. Bilthoven, RIVM Report No. 680716002.
- Fraters, B., T.C. Van Leeuwen, J.W. Reijs, L.J.M. Boumans, H.F.M. Aarts, C.H.G. Daatselaar, G.J. Doornewaard, D.W. de Hoop, J.J. Schröder, G.L. Velthof and M.H. Zwart (2007b). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Beschrijving van de meetnetopzet voor de periode 2006-2009 en de inhoud van de rapportages vanaf 2008. Bilthoven, RIVM Report No. 680717001.
- Fraters, B., J.W. Reijs, T.C. van Leeuwen and L.J.M. Boumans (2008). Landelijk Meetnet Effecten Mestbeleid. Resultaten van de monitoring van waterkwaliteit en bemesting in meetjaar 2006 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717004.
- Kleinbaum, D.G., L.L. Kupper and K.E. Muller (1997). Applied regression analysis and other multivariable methods. Boston, International Thomson Publishing Services.
- Ministry of Agriculture, Nature & Food Quality (2009). Handreiking bedrijfsspecifieke excretie melkvee, versie voor 2009. The Hague, Ministry of Agriculture, Nature & Food Quality, www.minlnv.nl (19 January 2008).
- National Service for the Implementation of Regulations (*Dienst Regelingen*, DR) (2006). Brochure Mestbeleid 2006: het stelsel van gebruiksnormen. Brochure dated 14 March 2007. Assen, National Service for the Implementation of Regulations, Ministry of Agriculture, Nature & Food Quality.
- National Service for the Implementation of Regulations (2011). www.hetlnvloket.nl, search term 'Tables 2010-2013'. Assen, National Service for the Implementation of Regulations, Ministry of Agriculture, Nature & Food Quality.
- Payne, R.W. (2000). The guide to GenStat. Part 2: Statistics. (Chapter 5, REML analysis of mixed models). Rothamsted, Lawes Agricultural Trust (Rothamsted Experimental Station).
- Poppe, K.J. (2004). Het Bedrijven-Informatienet van A tot Z. The Hague, Agricultural Economics Research Institute, Report No. 1.03.06.
- Van Beek, C.L., G.A.P.H. van den Eertwegh, F.H. van Schaik, G.L. Velthof and O. Oenema (2004). The contribution of agriculture to N and P loading of surface water in grassland on peat soil. Nutrient Cycling in Agroecosystems 70: 85-95.
- Van den Ham, A., N.W.T.H. van den Berkmortel, J.W. Reijs, G.J. Doornewaard, K. Hoogendam and C.H.G. Daatselaar (2010).

Mineralenmanagement en economie op melkveebedrijven. Gegevens uit de praktijk. The Hague, Agricultural Economics Research Institute of Wageningen University & Research Centre, Brochure No. 09-066.
- Van den Ham, A., G.J. Doornewaard and C.H.G. Daatselaar (2011). Uitvoering van de Meststoffenwet. Evaluatie Meststoffenwet 2012: deelrapport ex post. The Hague, Agricultural Economics Research Institute of Wageningen University & Research Centre, Report No. 2011-073.
- Van Vliet, M.E., A. de Klijne, B. Fraters, S. Lukacs, A. de Goffau, L.J.M. Boumans, M.H. Zwart, J.W. Reijs, T.C. van Leeuwen, A. van den Ham, D.W. de Hoop, H.C.J. Vrolijk, M.A. Dolman, G.J. Doornewaard, K. Locher, M. van Rietschoten and K. Kovar (2010). Evaluatie van het Landelijk Meetnet effecten Mestbeleid. Bijlagenrapport. Bilthoven, RIVM Report No. 680717013.
- Verloop, J., J. Oenema and L.B.J. Šebek (eds) (2007). Mineralen goed geregeld. Verslag Themadag Melkveehouderij 2006. Lelystad, Animal Sciences Group, Report No. 40-PRI 153.
- Wattel-Koekkoek, E.J.W., J.W. Reijs, T.C. van Leeuwen, B. Fraters, H.M. Swen, L.J.M. Boumans and G.J. Doornewaard (2008). Landelijk Meetnet effecten Mestbeleid. LMM-jaarrapport 2003. Bilthoven, RIVM Report No. 680717003.
- Welham, S., B. Cullis, B. Gogel, A. Gilmour and R. Thompson (2004). Prediction in linear mixed models. Australian and New Zealand Journal of Statistics 46(3): 325-347.
- Zwart, M.H., G.J. Doornewaard, L.J.M. Boumans, T.C. van Leeuwen, B. Fraters and J.W. Reijs (2009). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2007 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717008.
- Zwart, M.H., C.H.G. Daatselaar, L.J.M. Boumans and G.J. Doornewaard (2010). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2008 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717014.
- Zwart, M.H., C.H.G. Daatselaar, L.J.M. Boumans and G.J. Doornewaard (2011). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2009 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717022.

Websites
- Agricultural Census data on Statistics Netherlands website: http://statline.cbs.nl
- Koeien & Kansen website: http://www.koeienenkansen.nl

Appendix 1 Text of relevant articles of derogation decision

This appendix contains the literal texts of the articles concerning monitoring and reporting in the derogation decision issued by the European Commission (EU, 2005). These are complemented with the texts of the relevant articles in the Commission Decision (EU, 2010) of 5 February 2010, granting an extension of the derogation decision until 31 December 2013. The present report concerns the years under the first decision, complemented with the first year under the new derogation decision.

A1.1 Relevant articles of the derogation decision (EU, 2005)

Article 8 Monitoring

1. Maps showing the percentage of grassland farms, percentage of livestock and percentage of farmland covered by individual derogation in each municipality, shall be drawn by the competent authority and shall be updated every year. Those maps shall be submitted to the Commission annually and for the first time in the second quarter of 2006.
2. A monitoring network for sampling of soil water, streams and shallow groundwater shall be established and maintained as derogation monitoring sites. The monitoring network, corresponding to at least 300 farms benefiting from individual derogations, shall be representative of each soil type (clay, peat, sandy and sandy loessial soils), fertilisation practices and crop rotation. The composition of the monitoring network shall not be modified during the period of applicability of this Decision.
3. Survey and continuous nutrient analysis shall provide data on local land use, crop rotations and agricultural practices on farms benefiting from individual derogations. Those data can be used for model-based calculations of the magnitude of nitrate leaching and phosphorus losses from fields where up to 250 kg nitrogen per hectare per year in manure from grazing livestock is applied.
4. Shallow groundwater, soil water, drainage water and streams in farms belonging to the monitoring network shall provide data on nitrate and phosphorus concentration in water leaving the root zone and entering the groundwater and surface water system.
5. A reinforced water monitoring shall address agricultural catchments in sandy soils.

Article 9 Controls

1. The competent national authority shall carry out administrative controls in respect of all farms benefiting from an individual derogation for the assessment of compliance with the maximum amount of 250 kg nitrogen per hectare per year from grazing livestock manure, with total nitrogen and phosphate application standards and conditions on land use.
2. A programme of inspections shall be established based on risk analysis, results of controls of the previous years and results of general random controls of legislation implementing Directive 91/676/EEC. Specific inspections shall address at least 5 % of farms benefiting from an individual derogation with regard to land use, livestock number and

manure production. Field inspections shall be carried out in at least 3 % of farms in respect to the conditions set out in Article 5 and 6.

Article 10 Reporting

1. The competent authority shall submit the results of the monitoring, every year, to the Commission, with a concise report on evaluation practice (controls at farm level, including information on non compliant farms based on results of administrative and field inspections) and water quality evolution (based on root zone leaching monitoring, surface/groundwater quality and model-based calculations).
   The first report shall be transmitted by March 2007, and subsequently every year by March in 2008, 2009 and 2010.
2. In addition to the data referred to in paragraph 1 the report shall include the following:
   a. data related to fertilisation in all farms which benefit from an individual derogation;
   b. trends in livestock numbers for each livestock category in the Netherlands and in derogation farms;
   c. trends in national manure production as far as nitrogen and phosphate in manure are concerned;
   d. a summary of the results of controls related to excretion coefficients for pig and poultry manure at country level.
3. The results thus obtained will be taken into consideration by the Commission with regard to an eventual new request for derogation by the Dutch authorities.
4. In order to provide elements regarding management in grassland farms, for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the competent authority and submitted to the Commission.

A1.2 Additional provision in the extension of the derogation decision (EU, 2010)

Article 10, paragraph 1, second subparagraph shall be replaced by the following: 'The report shall be transmitted to the Commission annually in the second quarter of the year following the year of activity.'

References

- EU (2005). Commission decision of 8 December 2005 granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, No. L 324/89-93 (10 December 2005).
- EU (2010). Commission decision of 5 February 2010 amending Decision 2005/880/EC granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources (2010/65/EU), Official Journal of the European Union, No. L 35/18 (6 February 2010).

Appendix 2 Selection and recruitment of participants in the derogation monitoring network

A2.1 Introduction

This appendix explains the selection and recruitment of the 300 dairy and other grassland farms participating in the derogation monitoring network. As stated in the main text, the derogation monitoring network has been incorporated into the Minerals Policy Monitoring Programme (LMM). The selection and recruitment of farms for the derogation monitoring network is comparable to that of participants in other parts of the LMM programme. Based on the most recent Agricultural Census data (2005) at the time, a sample population was defined for each of the four regions. These sample populations were then subdivided into groups of farms ('strata') belonging to the same groundwater body and of the same farm type and economic size. Based on this distribution, the required number of sampled farms was derived for each stratum, taking into account the proportion of the total surface area of cultivated land in a given stratum (the greater the proportion of cultivated land in a stratum, the greater the number of farms to be included in the sample), as well as a minimum representation for each groundwater body.

Recruitment was initially targeted at farms participating in the Farm Accountancy Data Network (FADN; report year 2006). All suitable FADN farms were approached that had registered for derogation in 2006. After the FADN farms had been recruited, it was determined which strata needed additional farms. Additional farms were selected from a database maintained by the National Service for the Implementation of Regulations, a department of the Ministry of Agriculture, Nature & Food Quality. This database includes all farms that had registered for derogation in 2006. Fifteen of the additional participants thus selected also participate in the 'Koeien & Kansen' research project (see www.koeienenkansen.nl).

Replacements for farms that dropped out during the 2006-2011 period were preferably selected from farms that already participated in the LMM programme and the FADN network. The advantage of this approach is that water quality samples for previous years are also available for farms newly admitted to the derogation monitoring network.

A2.2 Definition of the sample populations

As with the LMM programme, the sample excludes a small number of farms that had registered for derogation and were included in the Agricultural Census database. The first group of farms excluded from participation in the derogation monitoring network are very small farms with an economic size of less than 25,000 Standard Output (SO) units. Farms using organic production methods were also excluded as, by definition, these organic farms may not use more than 170 kg of nitrogen in livestock manure per hectare (irrespective of the percentage of grassland or the type of fertiliser). Also, a minimum farm size of 10 hectares of cultivated land was adopted to ensure representativeness with respect to surface area. Finally, only farms where grassland makes up at least 60 percent of the total area of cultivated land were taken into consideration for derogation monitoring purposes.

The consequences of these selection criteria are illustrated in Tables A2.1 and A2.2. Table A2.1 (farms) and Table A2.2 (acreages) specify how the sample population has been derived from 2011 Agricultural Census data and a database maintained by the National Service for the Implementation of Regulations. This database contains over 21,900 so-called 'BRS numbers' of farms which registered for derogation for 2011. BRS numbers are the registration numbers of farms registered with the National Service for the Implementation of Regulations. As 578 BRS numbers did not appear in the 2011 Agricultural Census, it was decided not to include absolute numbers of farms and hectares in the tables. Instead, the numbers of excluded farms and hectares of cultivated land are expressed as a percentage of the more than 21,000 farms for which data were available in the 2011 Agricultural Census.

Table A2.1 Distribution of farm types represented in the sample population of the derogation monitoring network in 2011

	Distribution of farms		
	Dairy farms	*Other grassland farms*	*Total*
All farms registered for derogation in 2011	71.3%	28.7%	100.0%
Farms smaller than 25,000 SO units	0.1%	12.0%	12.1%
Organic farms	0.3%	0.2%	0.4%
Farms smaller than 10 hectares	0.7%	1.2%	19%
Farms where grassland makes up less than 60 percent of cultivated land	1.7%	0.7%	2.5%
Sample population	68.5%	14.6%	83.1%

Source: Statistics Netherlands Agricultural Census 2011, data processed by LEI.

Table A2.2 Distribution of acreage of cultivated land represented in the sample population of the derogation monitoring network in 2011

	Distribution of acreage of cultivated land		
	Dairy farms	*Other grassland farms*	*Total*
All farms registered for derogation in 2011	85.5%	14.5%	100.0%
Farms smaller than 25,000 SO units	0.0%	2.4%	2.4%
Organic farms	0.3%	0.1%	0.4%
Farms smaller than 10 hectares	0.1%	0.2%	0.4%
Farms of types not included in LMM programme	2.9%	1.0%	3.9%
Sample population	82.1%	10.7%	92.8%

Source: Statistics Netherlands Agricultural Census 2011, data processed by LEI

Tables A2.1 and A2.2 reveal that specialised dairy farms account for 68.5 percent of all farms that registered for the 2011 derogation scheme, and account for 82 percent of the acreage of cultivated land. Almost all dairy farms also fulfilled the selection criteria used to define the sample population for the derogation monitoring network. The excluded farms are mainly other grassland farms with a small economic size (as expressed in SO units) and a small area of cultivated land. Under the adopted selection criteria, nearly 17 percent of all farms registered for derogation are excluded from the sample population. However, these farms account for just 7.2 percent of the total acreage for which farmers have requested derogation.

A2.3 Notes on individual stratification variables

The derogation decision calls for a monitoring network that is representative of all soil types, fertilisation practices and crop rotations (see Article 8 of the derogation decision). The stratification was therefore based on region, as well as farm type, economic size (size class) and groundwater body. These stratification variables are explained below.

A2.4 Classification according to farm type

Since 2011, the LMM Programme has used Standard Output (SO) units as a measure of the economic size of farms. This unit replaces the previously used Dutch Size Unit (*Nederlandse Grootte-Eenheid*, NGE) (Van der Veen *et al.*, 2012). The Standard Output of a crop, animal product or other agricultural product is its average monetary value based on the prices received by the agricultural entrepreneur, expressed in euros per hectare or animal. A regional SO coefficient has been defined for each product as the average value during a specific reference period (five years). The Netherlands has been defined as a single region for this purpose. The total Standard Output of a farm (i.e. the sum of all SOs per hectare of cultivated crops and per animal) is a measure of its total economic size, expressed in euros.
A farm is characterised as 'specialised' when a particular agricultural activity (e.g. dairy farming, arable farming or pig farming) accounts for a major proportion (generally at least two-thirds) of its total economic size. Eight main farm types can be distinguished. Five of these types concern one single activity, while three types concern a combination of activities. The five single-activity farm types are: arable farming, horticulture, permanent crops (fruit growing and tree nurseries), grazing livestock, and pigs and poultry (intensive livestock farming). The three combined-activity farm types are: crop combinations, livestock combinations, and crop and livestock combinations. Each main farm type is further divided into multiple subtypes. For instance, the subcategory of specialised dairy farms is part of the overall category of grazing livestock farms.

Within the group of farms that registered for derogation, dairy farms form a large and homogeneous group, which uses almost 85 percent of the total acreage of cultivated land, as apparent from Table A2.2. Fifteen percent of the acreage is situated on farms of a different type. These farms were also included in the monitoring network in order to obtain a sample with maximum representativeness for the different crop rotations and fertilisation practices. Non-dairy farms account for approx. 29 percent of all farms (Table A2.1). These farms can be of various types, but are described in this report as 'Other grassland farms', as most of the cultivated land consists of grassland.

A2.5 Classification according to economic size

Farms are not only classified by type but also according to economic size, with three size classes being distinguished. This prevents over-representation of farms of below-average or above-average economic size.
Economic size is also expressed in SO units.

A2.6 Classification according to groundwater body per region

The Water Framework Directive distinguishes a total of twenty groundwater bodies in the Netherlands (Verhagen *et al.*, 2006). The derogation monitoring network has been designed with a view to achieving optimal distribution and representation in each region, in order to cover the most important groundwater bodies measured in terms of the area of cultivated land. Each farm was assigned to a groundwater body on the basis of the municipality where the farm receives post. In municipalities with multiple groundwater bodies, all farms were assigned to the largest groundwater body.

In the Sand Region, five groundwater bodies were distinguished as sub-regions: Eems, Maas, Rhine Central, Rhine North and Rhine East. Other farms belonging to other groundwater bodies within a region were attributed to a sixth sub-region termed 'Other'. The Loess Region only contains the 'Cretaceous' groundwater body, and was therefore not subjected to further subdivision. The Peat Region was divided into four sub-regions, namely the groundwater bodies Rhine North, Rhine East, Rhine West and 'Other'. The Clay Region was subdivided into five sub-regions. The entire marine clay area in the south-west of the Netherlands was classified as a separate sub-region, as it includes multiple groundwater bodies without one body being clearly dominant. A further three groundwater bodies were distinguished as separate sub-regions: Eems, Rhine North and Rhine West (in so far as the latter is located outside the marine clay area in the south-west of the Netherlands). The fifth sub-region includes farms in other, unallocated municipalities.

As of 2012, selection and recruitment of new farms for the derogation monitoring network will no longer be based on stratification according to groundwater body, although it will still be based on classification according to region.

References

- Veen, H.B. van der, I. Bezlepkina, P. de Hek, R. van der Meer and H.C.J. Vrolijk (2012). Sample of Dutch FADN 2009-2010: design principles and quality of the sample of agricultural and horticultural holdings. The Hague, Agricultural Economics Research Institute of Wageningen University & Research Centre, Report No. 2012-061.
- Verhagen, F.Th., A. Krikken and H.P. Broers (2006). Draaiboek monitoring grondwater voor de Kaderrichtlijn Water. Den Bosch, Royal Haskoning, Report No. 9S1139/R00001/900642/DenB.

Websites
- Agricultural Census data on Statistics Netherlands website: http://statline.cbs.nl.
- Koeien & Kansen website: http://www.koeienenkansen.nl.

Appendix 3 Monitoring of agricultural characteristics

This appendix explains how the agricultural practice data in the FADN network maintained by the Agricultural Economics Research Institute (LEI) were monitored, and how these data were used to calculate fertiliser usage (section A3.2), grass and silage maize yields (section A3.3), and nutrient surpluses (section A3.4).

A3.1 Introduction

LEI is responsible for monitoring the agricultural practice data registered in the FADN network. It does so on the basis of a stratified sample of approx. 1500 agricultural and horticultural enterprises, maintaining a set of detailed financial, economic and environmental data. The FADN represents nearly 95 percent of all agricultural production in the Netherlands (Poppe, 2004; FADN, 2013). Approx. 45 full-time LEI employees are charged with collecting and registering farm data in FADN. They process all the invoices of the participating farms. They also produce inventories of initial and final stocks and gather additional data on crop rotations, grazing systems, and the composition of the livestock population. LEI sends participants a so-called participant’s report containing mainly annual totals (e.g. a profit-and-loss account and balance sheet). When data are processed to produce information for participants or researchers, the results are of course checked for inconsistencies. This is made possible by the fact that the system also records physical flows in addition to financial flows.

Most FADN data are converted into annual totals, which are then corrected for stock changes. For example, the annual consumption of feed concentrate is derived from the sum of all purchases made during the period between two balance sheet dates, minus all sales, plus initial stocks, minus final stocks. Fertiliser usage is registered for each crop, and the data allow for calculations of usage per year and per growing season. The growing season extends from the harvesting of the previous crop to the harvesting of the current crop.

Fertiliser usage, yields and nutrient surpluses are expressed per unit of surface area. The total acreage of cultivated land is used for this purpose, i.e. the land actually fertilised and used for crop cultivation at the farm. This acreage does not include rented land, natural habitats, ditches, built-up land, paved surfaces, and grassland not used for the production of fodder (e.g. yards, camping sites).

A3.2 Calculation of fertiliser usage

The derogation decision (EU, 2005) stipulates that the report should include details of fertiliser usage and crop yields (Article 10, paragraph 4). This Article states (see Appendix 1): “In order to provide elements regarding management in grassland farms, for which a derogation applies, and the achieved level of optimisation of management, a report on fertilisation and yield shall be prepared annually for the different soil types and crops by the competent authority and submitted to the Commission.”

Nutrient usage data are presented by region (Clay, Peat, Sand and Loess Regions). Fertiliser use at farm level is reported, and a distinction is made between the use of fertilisers on arable land and on grassland.

A3.2.1 Calculation of fertiliser use

On-farm use of livestock manure
In order to calculate the use of nutrients in livestock manure, on-farm production of manure is calculated first. In the case of nitrogen, this concerns net production after deducting gaseous emissions resulting from stabling and storage. Manure production by grazing livestock is calculated by multiplying the average number of animals present by the applicable statutory excretion standards (National Service for the Implementation of Regulations, 2013, Tables 4 and 6). This method does not apply to farms that use the guidance document issued for this purpose (see the section headed 'Farm-specific use of livestock manure' below). Manure production by animals in stables is calculated by taking the feedstuff and animal inputs and deducting the outputs of animals and animal products, according to the method described by Groenestein *et al.* (2008). The calculations make use of the standard quantities provided in Tables 7, 8 and 9 (National Service for the Implementation of Regulations, 2013).

In addition, the quantities are recorded for all fertiliser inputs and outputs and all fertiliser stocks (inorganic fertilisers, livestock manure and other organic fertilisers). The nitrogen and phosphate quantities in inorganic fertilisers and other organic fertilisers are derived from the annual overviews of suppliers. If no specific supply details are known, the quantities are multiplied with factors derived from a standard composition (Nutrient Management Institute, 2013).

In principle, the nitrogen and phosphate quantities in inputs and outputs of organic fertilisers are determined by means of sampling. If sampling has not been performed, standard contents for each type of fertiliser are used (National Service for the Implementation of Regulations, 2013, Table 5). If no sampling results are available, the standard contents for outputs of on-farm manure (National Service for the Implementation of Regulations, 2013, Table 5) are corrected to account for farm-specific manure production. For instance, if application of the farm-specific excretion (BEX) method produces an excretion of 90 percent of the standard excretion quantity, outputs of on-farm manure are estimated at 90 percent of the quantity calculated using the standard contents in the aforementioned Table 5 (National Service for the Implementation of Regulations, 2013). This method is applied to both nitrogen and phosphate contents. The standard quantities stated in Table 5 are used if the BEX method is not applied. Initial and closing stocks are always calculated based on standard quantities (National Service for the Implementation of Regulations, 2013, Table 5).

The total quantity of fertiliser used at farm level is then calculated using the following formula:

> Quantity of fertiliser used on farm = Production + Opening stock level – Closing stock level + Input – Output

Farm-specific use of livestock manure
As of agricultural practice year 2007, the calculation method for manure production has been modified for farms that make use of the guidance document on farm-specific excretion by dairy cattle (Ministry of Agriculture, Nature & Food Quality, 2010). Manure production on these farms is not calculated on the basis of standard quantities but separately for each farm, provided the following criteria are fulfilled:

- The farm is a specialised dairy farm according to the Standard Output classification
- The dairy herd accounts for at least 67 percent of the total quantity of phosphate LSUs for grazing livestock
- No pigs or poultry are present on the farm
- At least 80 percent of the acreage is devoted to the cultivation of fodder crops
- The farm itself has reported that it uses the BEX method

As of 1 January 2009, the guidance document on farm-specific excretion by dairy cattle is used to calculate the farm-specific excretion of the dairy herd (Ministry of Agriculture, Nature & Food Quality, 2010). The calculation method used deviates from the guidance document in two respects (Ministry of Agriculture, Nature & Food Quality, 2010):

- The uptake from silage maize expressed in fodder units (*Voeder Eenheden Melk*, VEM) is derived directly from the silage maize yields reported by the farmer, corrected for stocks (the same method used in Aarts *et al.*, 2008). In the guidance document, the uptake is calculated using a correction method.
- The allocation of fodder units to fresh and conserved grass is calculated based on the net number of grazing hours reported by the farmer, whereas the guidance document (Ministry of Agriculture, Nature & Food Quality, 2010) and Aarts *et al.* (2008) defines three classes based on reported grazing hours.

Use of fertilisers on arable land and grassland

The quantities of fertilisers used on arable land are registered directly in the Farm Accountancy Data Network (FADN). The type of fertiliser, quantity applied, and time of application are all documented.

The quantities of nitrogen and phosphate applied on arable land are calculated by multiplying the quantity of manure (in tonnes or cubic metres) by:

- the contents derived from sampling results (if available); or
- the applicable standard contents (National Service for the Implementation of Regulations, 2013, Table 5), corrected for farm-specific production (see above) if manure production is calculated separately for each farm (see below); or
- the applicable uncorrected standard contents (National Service for the Implementation of Regulations, 2013, Table 5).

The quantity of fertiliser applied on grassland is calculated as the closing entry: Fertiliser use on grassland = Fertiliser use at farm level -/- Fertiliser use on arable land. In the case of farms where grassland accounts for less than 25 percent[1] of the total cultivated area, the fertiliser use on grassland is calculated based on allocations, and the fertiliser use on arable land is calculated as the closing entry. The quantity of fertiliser used on grassland comprises spread fertilisers and manure excreted directly by grazing animals on grassland (grassland manure). The quantity of nutrients in grassland manure is calculated for each animal category by multiplying the percentage of a year that the animals spend grazing by the standard of excretion.

[1] Not relevant for this report, as farms must be comprised of at least 70 percent grassland to qualify for participation in the derogation scheme.

Use of plant-available nitrogen
The total nitrogen use is expressed in kilogrammes of plant-available nitrogen. The quantity of plant-available nitrogen is calculated by multiplying the total quantity of nitrogen in organic fertilisers by the availability coefficients as stated in Table 3 (National Service for the Implementation of Regulations, 2013).

The availability coefficient is lower (45 percent instead of 60 percent since 2008) for all grazing livestock manure produced and applied on the farm if dairy cows are grazing on the farm. A lower availability coefficient is also used if arable land on clay and peat soils is fertilised in autumn. In all other cases, the availability coefficient depends solely on the type of fertiliser or manure.

Phosphate use
Phosphate use is expressed in kilogrammes of phosphate. All fertilisers (inorganic fertilisers, livestock manure and other organic fertilisers) are included in the calculation.

Application standards
The average application standards for grassland and arable land are calculated by multiplying the crop areas registered in FADN by the application standards stated in Tables 1 and 2 (National Service for the Implementation of Regulations, 2013). Phosphate differentiation is applicable since 2010 (depending on the phosphate status of the soil). Soil test results are registered in FADN in order to determine the phosphate status of the soil. If the phosphate status is unknown, a high phosphate status is assumed by default.

A3.2.2 Confidence intervals
On LMM farms, fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers must fall within the LMM confidence intervals. This applies to the separate quantities of nitrogen and phosphate, as well as the total quantities of fertilisers applied (inorganic fertilisers, livestock manure and other organic fertilisers). Table A3.1 shows the confidence intervals for non-organic dairy farms.

Table A3.1 Confidence intervals for applied quantities of inorganic fertilisers, livestock manure and other organic fertilisers on non-organic dairy farms, and total quantities of fertilisers applied (inorganic fertilisers, livestock manure plus other organic fertilisers), expressed in kilogrammes of nitrogen and phosphate per hectare[2]

Nutrient and type	*Lower or upper limit*	*Kg per hectare*
Nitrogen		
Inorganic fertilisers	Lower limit	<0
Inorganic fertilisers	Upper limit	>400
Livestock manure	Lower limit	<100
Livestock manure	Lower limit	<0
Livestock manure	Upper limit	>500
Other organic fertilisers	Lower limit	<0
Other organic fertilisers	Upper limit	>400
Total fertilisers	Lower limit	<50
Total fertilisers	Upper limit	>700
Phosphate		
Inorganic fertilisers	Lower limit	<0
Inorganic fertilisers	Upper limit	>160
Livestock manure	Lower limit	<0
Livestock manure	Upper limit	>250
Other organic fertilisers	Lower limit	<0
Other organic fertilisers	Upper limit	>200
Total fertiliser use	Lower limit	<25
Total fertiliser use	Upper limit	>350

A3.3 Calculation of grass and silage maize yields

A3.3.1 Calculation procedure

The procedure for calculating grass and silage maize yields in FADN is largely identical to the procedure described in Aarts *et al.* (2005, 2008). The procedure starts by determining the energy requirement of the dairy herd based on milk production and growth achieved. All transactions and stock changes of feed products are registered in FADN. These data are used to determine the proportion of the energy requirement covered by purchased feedstuffs. The energy uptake from farm-produced silage maize and other fodder crops (other than grass) is then determined based on measurements and data on silage supplies, insofar as these are available. The silage maize yield is determined by adding conservation losses to the ensilaged quantity of silage maize. If no reliable silage supply measurements can be obtained, the farmer and/or a consultant is asked to provide an estimate of the yields of farm-produced silage maize and other fodder crops.

It is then assumed that the remaining energy requirement is met by grass produced on the farm. The number of grazing days registered in FADN is used to derive a ratio between energy uptake from fresh grass and uptake from conserved grass. This procedure can be used to determine the quantity of energy (expressed in fodder units) obtained by the animals from farm-produced

[2] This table only states the confidence intervals for fertiliser use at farm level on non-organic dairy farms. Other confidence intervals are applicable to other types of farms. Confidence intervals are also applicable to other quantities and indicators.

feed. The nitrogen (N) and phosphate (P) uptake are then calculated by multiplying the uptake in fodder units (VEMs) by the N:VEM and P:VEM ratios. Finally, the N, P, kVEM and dry matter yields for grassland are calculated by adding to the uptake the average quantity of N, P, kVEMs and dry matter lost during feed production and conservation.

A3.3.2 Selection criteria

This calculation procedure cannot be applied to all farms. On mixed farms it is often difficult to clearly separate the product flows between different production units. Following Aarts *et al.* (2008), the method is therefore only used on farms that satisfy the following criteria:

- The farm is a specialised dairy farm according to the Standard Output classification
- The dairy herd accounts for at least 67 percent of the total quantity of phosphate LSUs for grazing livestock
- No pigs or poultry are present on the farm
- At least 80 percent of the acreage is used for the cultivation of fodder crops
- The so-called 'countryside premium' (fee for land on which the farmer has accepted restrictions to protect nature) does not exceed 100 euros per hectare of grassland

The following selection criteria for application of the method were not adopted from Aarts *et al.* (2008):

- At least 15 hectares used for cultivation of fodder crops
- At least 30 dairy cows
- Annual milk production of at least 4,500 kg of Fat and Protein Corrected Milk (FPCM) per cow
- Non-organic production method

These criteria were not considered because they were used in Aarts *et al.* (2008) to make statements about the population of 'typical' dairy farms. Details of the population data have already been registered in the permanent monitoring network (comprising 300 farms), and therefore these criteria can be ignored. In line with Aarts *et al.* (2008), the following additional confidence intervals for yields were applied with respect to the outcomes:

- Silage maize yield of 5,000 to 22,000 kg of dry matter per hectare
- Grassland yield of 4,000 to 20,000 kg of dry matter per hectare

If the yield falls outside this range, it is assumed that this must have been caused by a bookkeeping error. In that case, the farms concerned are also excluded from the report.

A3.3.3 Deviations from Aarts et al. (2008)

In a few cases, we deviated from the procedure described in Aarts *et al.* (2005, 2008) because more detailed information was available, or because the procedure could not be properly incorporated into FADN. This concerns the following data:

1. Composition of silage grass and silage maize pits
2. Supplement for grazing based on actual number of grazing days
3. Ratio of conserved grass to fresh grass, based on the actual number of grazing days
4. Conservation and feed production losses

Re 1
Aarts *et al.* (2008) base the composition of silage grass and silage maize pits on provincial averages supplied by the Netherlands Laboratory for Soil and Crop Research (BLGG). A slightly different method is used in FADN. Since 2006, the composition of silage grass and silage maize pits per farm is also registered in FADN. The FADN calculation procedure uses these farm-specific composition data if at least 80 percent of all silage pits have been fully sampled. The average pit composition for each soil type is used if less than 80 percent of pits have been sampled and/or if data are missing (i.e. dry matter yields, VEM uptake, nitrogen or phosphate content). Data on average silage grass and silage maize pit composition are obtained annually from BLGG.

Re 2
A so-called 'mobility factor' is taken into account when calculating the energy requirement. This factor depends on the number of grazing days, among other things. Aarts *et al.* (2008) distinguish three grazing categories: no grazing (0 grazing days), fewer than 138 days, and more than 138 days. The numbers of grazing days have been registered in FADN since 2004 and it was decided to use these data for the calculation, in accordance with Appendix 2 to the guidance document (Ministry of Agriculture, Nature & Food Quality, 2010).

Re 3
Deviating from Aarts *et al.* (2008), the ratio of energy uptake from fresh grass vs. uptake from silage grass was calculated based on the number of grazing days and/or 'zero grazing' days registered in FADN. The percentage of fresh grass varies between 0 and 35 percent for zero grazing, between 0 and 40 percent for unlimited grazing, and between 0 and 20 percent for limited grazing. This calculation, too, is performed in accordance with the method described in Appendix 2 to the guidance document (Ministry of Agriculture, Nature & Food Quality, 2009).

Re 4
The information in Appendix III in Aarts *et al.* (2008) is not complete with respect to the percentages adopted for conservation losses. To avoid any misunderstandings, all percentages used in FADN to calculate conservation and feed production losses are stated in Table A3.2.

Table A3.2 Percentages used for calculation of conservation and feed production losses

	Conservation losses				*Feed production losses*
Category	*Dry matter*	*VEM*	*N*	*P*	*Dry matter, VEM, N and P*
Wet by-products	4	6	1.5	0	2
Additional roughage consumed	10	9.5	2	0	5
Feed concentrate	0	0	0	0	2
Milk products	0	0	0	0	2
Silage maize	4	4	1	0	5
Silage grass	10	15	3	0	5
Meadow grass	0	0	0	0	0
Minerals	0	0	0	0	2

A3.4 Calculation of nutrient surpluses

In addition to fertiliser use and crop yields, the report also includes nitrogen and phosphate surpluses on the soil surface balance (in kg of nitrogen and P_2O_5 per hectare). These surpluses are calculated by applying a method derived from the method used and described by Schröder *et al.* (2004, 2007). This means that, alongside the input quantities of nitrogen and phosphate in organic and inorganic fertilisers and the output quantities in crops, allowance is also made for other sources of input such as net mineralisation of organic substances in the soil, nitrogen fixation due to leguminous plants, and atmospheric deposition.

When calculating nutrient surpluses on the soil surface balance, a state of equilibrium is assumed. It is assumed that, in the long term, the input of organic nitrogen in the form of crop residues and organic manure is equal to the annual decomposition. An exception to this rule is made for peat soils and reclaimed peat subsoils (*dalgronden*). With these types of soil, an input due to mineralisation is taken into account: 160 kg of nitrogen per hectare for grassland on peat soils, and 20 kg of nitrogen per hectare for grassland or other crops on peat soils and reclaimed peat subsoils. It is known that net mineralisation occurs in these soils as a result of groundwater level management, which is necessary in order to use the land for cultivation. Schröder *et al.* (2004, 2007) calculate the surplus on the soil surface balance by using the release of nutrients to the soil as a starting point. In this study, a method was employed that uses farm data to calculate the surplus on the soil surface balance.

The calculation method used to determine the nitrogen surplus is summarised in Table A3.3. The surplus on the farm gate balance is first calculated by determining the total input and output of nutrients as registered in the farm records. Stock changes are taken into account when calculating this surplus.

The calculated nitrogen surplus on the farm gate balance is then corrected to account for input and output items on the soil surface balance. The phosphate surplus on the soil surface balance is equal to the surplus on the farm gate balance. A more detailed explanation of the calculation methods can be found in Table A3.3 below.

Table A3.3 Calculation methods used to determine the nitrogen surplus on the soil surface balance (kg of nitrogen per hectare per year)

Description of items		*Calculation method*	
		Quantity	*Contents*
Farm inputs	Inorganic fertilisers	Balance of all inputs, outputs and stock changes of inorganic fertilisers	Data obtained from suppliers' annual overviews. If these are not available, standards are used (Nutrient Management Institute, 2013).
	Livestock manure and other organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net consumption (input)	Sampling results or standard quantities (National Service for the Implementation of Regulations, 2013, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section A3.2).
	Feedstuffs	Balance of all inputs and stock decreases of all feed products (feed concentrate, roughage, etc.)	Data obtained from suppliers' annual overviews. If these are not available, standards are used (Centraal Veevoederbureau, 2012). Standards for compound feed in 2006-2009 based on Statistics Netherlands data (2010, 2011). As of 2010, all compound feed data are calculated for each separate farm. Standards for silage grass and silage maize are based on annual averages for different soil type regions (data supplied by Netherlands Laboratory for Soil and Crop Research).
	Animals	Only imported animals	Standard quantities based on Ministry of Agriculture, Nature & Food Quality (2010) and National Service for the Implementation of Regulations (2013, Table 7)
	Plant products (sowing seeds, young plants and propagating material)	Only imported plant products	Standard quantities based on Van Dijk, 2003
	Other	Balance of all inputs, outputs and stock changes of all other products in the case of net consumption (input)	Standards based on Internet search queries
Farm	Animal products	Balance of all inputs,	Standard quantities based on

outputs	(milk, wool, eggs)	outputs and stock changes of all milk and other animal products	Ministry of Agriculture, Nature & Food Quality (2010) and National Service for the Implementation of Regulations (2013, Tables 7 and 8)
	Animals	Balance of outputs and stock changes of animals and meat	Standard quantities based on Ministry of Agriculture, Nature & Food Quality (2010) and National Service for the Implementation of Regulations (2013, Tables 7 and 8)
	Livestock manure and other organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net production (output)	Sampling results or standard quantities (National Service for the Implementation of Regulations, 2013, Table 5). If farm-specific manure production is known, the output of on-farm manure is corrected accordingly (see section A3.2).
	Crops and other plant products	Balance of outputs and stock changes of plant products (crops not intended for roughage), stock increases and sales of roughage	Standard quantities based on Van Dijk (2003) and Centraal Veevoederbureau (2012)
	Other	Balance of all inputs, outputs and stock changes of all other products in the case of net production (output)	Standards based on Internet search queries
Nitrogen surplus on farm gate balance		Farm input -/- Farm output	
Input on soil surface balance	+ Mineralisation	For grassland on peat soil: 160 kg of nitrogen per hectare per year. Other crops on peat soils and reclaimed peat subsoils (irrespective of crop): 20 kg of nitrogen per hectare per year. All other soil types: 0 kg. In the case of FADN farms, the surface areas are registered according to the four soil types used by the National Service for the Implementation of Regulations (sand, clay, peat and loess soils). Mineralisation in reclaimed peat subsoils was estimated based on overall soil classifications on each farm (based on postcode), in accordance with De Vries and Denneboom (1992).	
	+ Atmospheric deposition	Atmospheric deposition is determined annually for each province. The basic data are obtained from National Institute for Public Health and the Environment, 2013.	
	+ Nitrogen fixation by	Clover on grassland (Kringloopwijzer, 2013): the quantity of nitrogen fixation depends on the proportion of clover and the	

	leguminous plants	grassland yield, and is expressed per kg of dry matter: 0 to 1 percent clover: 0 kg; 1 to 5 percent clover: 0.03 kg; 5 to 15 percent clover: 0.1 kg; more than 15 percent clover: 0.2 kg. Other crops (Schröder, 2006): - Lucerne: 160 kg per hectare - Peas, broad beans, kidney beans and French beans: 40 kg per hectare - Other leguminous plants: 80 kg per hectare
Output on soil surface balance	- Volatilisation resulting from stabling, storage and grazing	The calculation method is based on Velthof *et al.* (2009). Calculations are based on the Total Ammonia Nitrogen (TAN) percentage. For farms that use a farm-specific calculation method for manure production, emissions resulting from grazing, stabling and storage are calculated as follows: - Ammonia emissions from stabling and storage: the stable code under the Ammonia and Livestock Farming Regulations (*Regeling Ammoniak en Veehouderij*, RAV) is used as a starting point. The total nitrogen emissions are calculated as a percentage of the emitted ammonia nitrogen (based on the RAV emission factor). - Ammonia emissions from grazing are calculated as a percentage (3.5 percent) of the total quantity of ammonia nitrogen excreted on grassland. For farms where excretions are calculated based on standard quantities, the emissions from grazing, stabling and storage are calculated as follows: - The gross standard-based excretion is calculated by adding the standard-based emission factor to the net standard-based excretion (Oenema *et al.*, 2000). This factor depends on the type of animal (11.3 percent for dairy cows). - The emissions resulting from grazing are then calculated by multiplying the nitrogen excreted in grassland manure (net standard-based excretion * grassland fraction) by 3.5 percent and then multiplied by the fraction of the total quantity of ammonia nitrogen in manure. - The emissions resulting from stabling and storage are calculated as the gross standard-based excretion minus the net standard-based excretion.

- Volatilisation resulting from application	Ammonia emission factors for application of livestock manure and inorganic fertilisers are based on Velthof *et al.* (2009). Other gaseous nitrogen emissions during application are not taken into consideration. Emissions resulting from application are calculated as a percentage of the applied ammonia nitrogen based on the emission factors as reported in Appendix 14 in Velthof *et al.* (2009). If no information on the application method is available (this has not been the case in the LMM framework since 2010), a standard for each soil type is applied. This standard is derived using the MAMBO method (De Koeijer *et al.*, 2012).
Nitrogen surplus on the soil surface balance	Nitrogen soil surplus on farm + input on soil surface balance – output on soil surface balance

References

- Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2005). Nutriëntengebruik en opbrengsten van productiegrasland in Nederland. Wageningen, Plant Research International, Report No. 102.
- Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2008). Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmais op melkveebedrijven. Wageningen, Plant Research International, Report No. 208.
- Centraal Veevoederbureau (2012). Tabellenboek Veevoeding. Lelystad, Centraal Veevoederbureau.
- De Vries, F. and J. Denneboom (1992). De bodemkaart van Nederland digitaal. Wageningen, Alterra, Rapport SC-DLO Technisch Document I.
- De Koeijer, T.J., G. Kruseman, P.W. Blokland, M.W. Hoogeveen and H.H. Luesink (2012). Mambo: visie en strategisch plan 2012-2015. Wettelijke Onderzoekstaken Natuur & Milieu. Werkdocument 308. Agricultural Economics Research Institute, Wageningen University & Research Centre.
- EU (2005). Commission decision of 8 December 2005 granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, No. L 324/89-93 (10 December 2005).
- Farm Accountancy Data Network (FADN) (2013). http://www.wageningenur.nl/nl/Expertises-Dienstverlening/Onderzoeksinstituten/lei/Sector-in-cijfers/Binternet-3.htm (16 April 2013).
- Groenestein, C.M., C. van Bruggen, P. Hoeksma, A.W. Jongbloed and G.L. Velthof (2008). Nadere beschouwing van stalbalansen en gasvormige verliezen uit de intensieve veehouderij. Wettelijke Onderzoekstaken Natuur & Milieu. Rapport 60. Wageningen University & Research Centre.
- Kringloopwijzer (2013). http://www.verantwoordeveehouderij.nl/index.asp?pzprojecten/projectkaart.asp?IDProject=503 (16 April 2013).

- Ministry of Agriculture, Nature & Food Quality (2010). Guidance document on farm-specific excretion by dairy cattle, version effective as of 2010. The Hague, Ministry of Agriculture, Nature & Food Quality, www.minlnv.nl (16 April 2013).
- National Institute for Public Health and the Environment (2013). Grootschalige concentratie- en depositiekaarten. http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl0189-Vermestende-depositie.html?i=3-17 (16 April 2013).
- National Service for the Implementation of Regulations (*Dienst Regelingen*, DR) (2013). Tabellen mestbeleid 2010-2013. http://www.drloket.nl/onderwerpen/mest/dossiers/dossier/publicaties-mest/tabellen-2010-2013. Assen, National Service for the Implementation of Regulations, Ministry of Agriculture, Nature & Food Quality (16 April 2013).
- Nutrient Management Institute (2013). Fertiliser database. http://www.nmi-agro.nl/sites/nmi/nl/nmi.nsf/dx/databank-meststoffen.htm. Nutrient Management Institute (16 April 2013).
- Oenema, O., G.L. Velthof, N. Verdoes, P.W.G. Groot Koerkamp, G.J. Monteny, A. Bannink, H.G. van der Meer and K.W. van der Hoek (2000). Forfaitaire waarden voor gasvormige stikstofverliezen uit stallen en mestopslagen. Wageningen, Alterra, Report No. 107.
- Poppe, K.J. (2004). Het Bedrijven-Informatienet van A tot Z. The Hague, Agricultural Economics Research Institute, Wageningen University & Research Centre, Report No. 1.03.06.
- Schröder, J.J., H.F.M. Aarts, M.J.C. de Bode, W. van Dijk, J.C. van Middelkoop, M.H.A. de Haan, R.L.M. Schils, G.L. Velthof and W.J. Willems (2004). Gebruiksnormen bij verschillende landbouwkundige en milieukundige uitgangspunten. Wageningen, Plant Research International B.V., Report No. 79.
- Schröder, J.J. (2006). Berekeningswijze N-bodemoverschot t.b.v. ABC en BIN2, respectievelijk WOD2. Werkgroep Onderbouwing Gebruiksnormen, Memorandum of 26 March 2006.
- Schröder, J.J., H.F.M. Aarts, J.C. van Middelkoop, R.L.M. Schils, G.L. Velthof, B. Fraters and W.J. Willems (2007). Permissible manure and fertilizer use in dairy farming systems on sandy soils in The Netherlands to comply with the Nitrates Directive target. European Journal of Agronomy 27(1): 102-114.
- Statistics Netherlands (2010). Gestandaardiseerde berekeningsmethode voor dierlijke mest en mineralen. Standaardcijfers 1990-2008. The Hague, Statistics Netherlands.
- Statistics Netherlands (2011). Dierlijke mest en mineralen 2009. http://www.cbs.nl/NR/rdonlyres/DAC00920-82AC-4E9F-8C01-122F5721D627/0/20110c72pub.pdf.
- Van Dijk, W. (2003). Adviesbasis voor de bemesting van akkerbouw- en vollegrondsgroentegewassen. Lelystad, Praktijkonderzoek Plant en Omgeving, Report No. 307.
- Velthof, G.L., C. van Bruggen, C.M. Groenestein, B.J. de Haan, M.W. Hoogeveen and J.F.M. Huijsmans (2009). Methodiek voor berekening van ammoniakemissie uit de landbouw in Nederland. WOT Report No. 70. WOT Natuur & Milieu, Wageningen.

Appendix 4 Sampling of water on farms in 2011

A4.1 Introduction

The derogation decision (EU 2005, see Appendix 1) states that a report must be produced on the development of water quality, and that this report must be based, among other things, on regular monitoring of water leaching from the root zone and surface and groundwater quality (Article 10, paragraph 1). The monitoring of the quality of the 'shallow groundwater layers, soil moisture, drainage water and watercourses on farms that are part of the monitoring network' must provide data about the nitrate and phosphorus concentrations in water leaving the root zone and ending up in the groundwater and surface water system (Article 8, paragraph 4).

A4.1.1 Water sampling

In the Netherlands, the groundwater level is often located just below the root zone. The average groundwater level in the Sand Region is approximately 1.5 metres below surface level. The average water table in the Clay and Peat Regions is less deep. The average groundwater level is more than five metres below surface level only in the Loess Region and on the push moraines in the Sand Region. In most situations, therefore, water leaching from the root zone or leaching into groundwater can be measured by sampling the top metre of the phreatic groundwater. In situations where the water table is more than five metres below surface level and the soil retains sufficient moisture (in the Loess Region), the soil moisture below the root zone is sampled. There is little agricultural activity on the push moraines in the Sand Region where the water table is far below the surface. Where these agricultural activities do occur, the soil moisture below the root zone is sampled if possible.

The surface water is loaded with nitrogen and phosphorus via run-off and groundwater. In the latter case, the travel times are usually longer. In the High Netherlands, only water leaching from the root zone is monitored by sampling the top metre of groundwater or by sampling soil moisture below the root zone. In areas drained by means of ditches in the Low Netherlands (possibly in combination with tile drainage), the travel times are shorter. Here, the loading of surface water is analysed by sampling ditch water, the top metre of groundwater, and/or water from tile drainage (drain water).

A4.1.2 Number of measurements per farm

On each farm, groundwater, soil moisture and drain water were sampled at sixteen locations, while ditch water was sampled at up to eight locations. The number of measurement locations was based on the results of previous research carried out in the Sand Region (Fraters *et al.*, 1998; Boumans *et al.*, 1997), in the Clay Region (Meinardi and Van den Eertwegh, 1995, 1997; Rozemeijer *et al.*, 2006) and in the Peat Region (Van den Eertwegh and Van Beek, 2004; Van Beek *et al.*, 2004; Fraters *et al.*, 2002).

A4.1.3 Measurement period and measurement frequency

In the Low Netherlands, samples are taken in winter. In this region of the country, shallow groundwater flows in winter transport a significant portion of the precipitation surplus to the surface water. In the dry season and especially in low-lying peat and clay polders, water from outside the polder can be let in to maintain water levels in ditches as well as groundwater levels. Samples can be taken in summer as well as winter on sand and loess soils in the High Netherlands. As the available sampling capacity must be utilised throughout the year, sampling in the Sand Region is carried out in summer and sampling in the Loess Region in autumn. The measurement period (see Figure A4.1) has been chosen in such a manner that the measurements are properly representative of water leaching from the root zone, and thus reflect as accurately as possible the agricultural practices of the previous year. Due to weather conditions, sampling campaigns may need to be extended or started at a later time.

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan
Soil moisture in Loess Region												■	■	■	■	
Total groundwater in Sand Region							■	■	■	■	■	■				
Groundwater in Sand Region in Low Netherlands		■	■	■	■	■	■									
Groundwater in Clay Region[1]	■	■	■		■	■										
Groundwater in Peat Region[1]		■	■	■	■	■										
Drain water and ditch water in all regions	■	■	■	■	■	■	■									

[1] The precise start date of sampling depends on the quantity of precipitation, as sufficient precipitation must have fallen before leaching into groundwater occurs. Under the current regulations, sampling never starts later than 1 December.

Figure A4.1 Overview of standard sampling periods for determining water quality in each region

In the High Netherlands groundwater and soil moisture are sampled once a year on each farm. The annual precipitation surplus in the Netherlands amounts to approx. 300 mm. This quantity of water spreads throughout the soil with a porosity of 0.3 (typical for sandy soils) over a soil layer of approx. 1 metre (saturated soil). Therefore, the quality of the top metre of groundwater is representative of the water leaching from the root zone every year, and the loading of the groundwater. Other types of soil (clay, peat, loess) generally have a greater porosity. In other words, a sample from the top metre will contain, on average, water from more than just the previous year. A measuring frequency of once every year is therefore sufficient. Previous research has shown that variations in nitrate concentrations within one year and between years can be eliminated when dilution effects and groundwater level variations are taken into account (Fraters *et al.*, 1997).

From the start of the first sampling period in the Low Netherlands following granting of derogation (1 October 2006), the sampling frequency for drain water and ditch water was increased from two to three rounds per winter period (the LMM sampling frequency until then) to approximately four rounds per winter (intended LMM sampling frequency). This increase in sampling frequency allows for improved distribution during the leaching season. The feasibility of four sampling rounds depends on the weather conditions. It may be impossible to sample drains during periods of frost or insufficient precipitation. The intended LMM sampling frequency was based on research carried out in the early 1990s (Meinardi and Van den Eertwegh, 1995, 1997; Van den Eertwegh, 2002). A review of the LMM programme in the clay areas during the 1996-2002 period produced the conclusion that there was no reason to change the existing relationship between the number of sampling rounds per farm and per year (actual sampling frequency) and the number of drains sampled per farm and per sampling round (Rozemeijer *et al.*, 2006). The sampling frequency was increased in response to the European Commission’s request for a higher sampling frequency. A frequency of four times a year corresponds to the proposed sampling frequency for operational monitoring of vulnerable phreatic groundwater with a relatively fast and shallow run-off (EU, 2006).

In addition to the compulsory components of nitrate content, total nitrogen content and total phosphorus content, other water quality characteristics were also determined as part of the chemical analysis of water samples. This was done to explain the results of the measurements of the compulsory components. These additional components include ammonium nitrogen, orthophosphate and a number of general characteristics such as conductivity, pH value, and dissolved organic carbon concentration. The results of these additional measurements have not been included in this report.

The sections below describe the sampling procedure for each region in greater detail. The activities were performed in accordance with the applicable work instructions. The text below refers to the applicable work instructions by stating the relevant document number (e.g. BW-W-021). An overview of the work instructions concerned is provided at the end of this appendix.

As far as sampling in the Low Netherlands is concerned, a period of frost from late November 2010 to late December 2010 meant that not all drain water and ditch water samples could be taken according to schedule. The schedule was modified slightly to prevent an extension to May 2011.

A4.2 Sand and Loess Regions

A4.2.1 Standard sampling procedure

Groundwater sampling on farms participating in the derogation scheme in the Sand Region was carried out from March 2011 to October 2011 (see Figure A4.2). In the Loess Region, samples were taken from September 2011 to December 2011 (Figure A4.2) Each farm was sampled once during these periods.

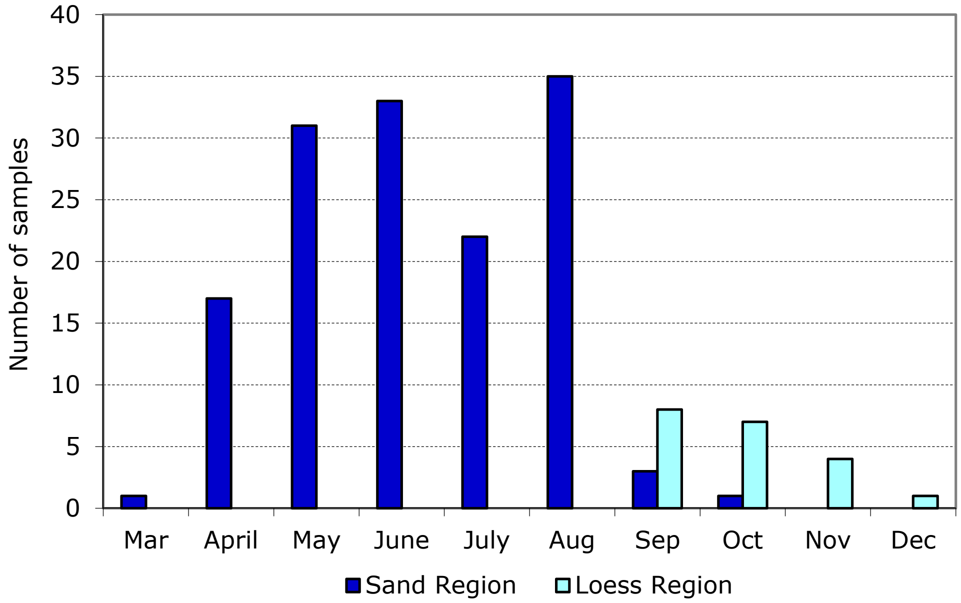

Figure A4.2 Number of groundwater and soil moisture samples in the Sand and Loess Regions per month during the period from March 2011 to December 2011

The samples were taken in accordance with the standard sampling method. On each farm, samples were taken from bore holes drilled at sixteen locations. The number of locations per plot depends on the size of the plot and the number of plots on each farm. The locations in the plot were selected at random. The locations were selected and positioned in accordance with the applicable protocol (BW-W-021). The top metre of groundwater was sampled using the open bore hole method (BW-W-015). The groundwater levels and nitrate concentrations were determined in situ at each location (Nitrachek method, BW-W-001). The water samples were filtered and stored in a cool dark place prior to transport to the laboratory (BW-W-008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously effected on-site by means of sulphuric acid or nitric acid (BW-W-009). Soil moisture samples were taken by collecting drill cores at depths ranging from 150 to 300 cm using an Edelman drill. The samples were then transported to the laboratory, untreated and packed in tightly sealed containers (BW-W-014). In the laboratory the samples were centrifuged to collect the soil moisture. In the laboratory two compound samples were prepared (each consisting of eight separate samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content.

A4.2.2 Additional sampling in low-lying areas
On farms in the Sand Region, additional ditch water samples were taken during the period from October 2010 to April 2011 (see Figure A4.3), in accordance with the standard method. On each farm, up to two types of ditches were distinguished: farm ditches and local ditches. Farm ditches transport water originating on the farm itself. Local ditches carry water from elsewhere, so that the water leaving the farm is a mixture.

If farm ditches were present, samples were taken downstream (i.e. where the water leaves the farm or ditch) in up to four of these ditches. Furthermore, samples were taken downstream in up to four local ditches to gain an impression of the local ditch water quality. If there were no farm ditches, then samples were taken both upstream and downstream in four local ditches. This provided an impression of the local water quality and the impact of the farm's activities on water quality. Three types of samples may therefore be distinguished: farm ditch, local ditch (upstream), and local ditch (downstream). The locations for ditch water sampling were selected in accordance with the relevant protocol (BW-W-021). The selection was aimed at obtaining an impression of the impact of the farm's activities on ditch water quality, and excluding as far as possible any effects external to the farm.

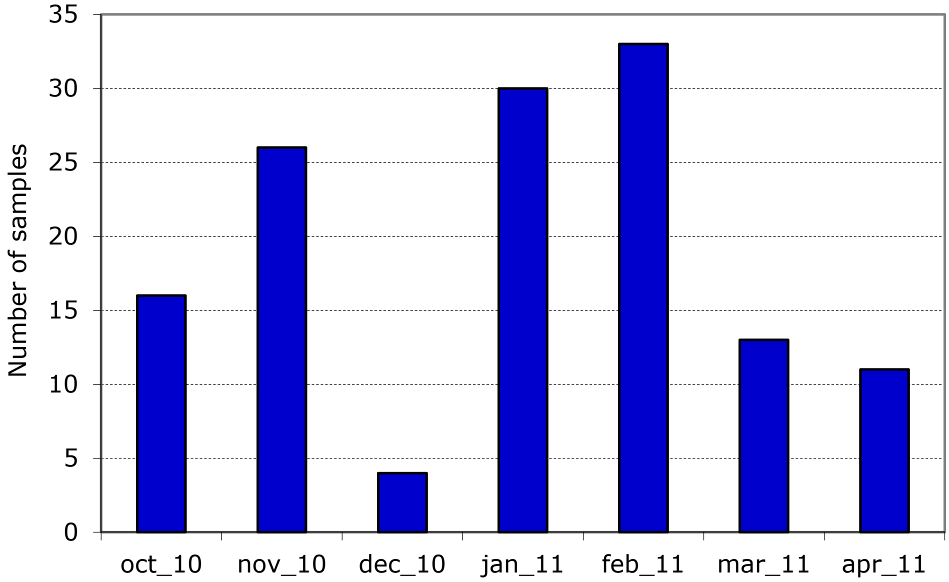

Figure A4.3 Number of ditch water samples in the Sand Region per month during the period from October 2010 to April 2011

Three to four ditch water samples were taken on these farms in the winter of 2010-2011.

The ditch water samples were taken using a measuring beaker attached to a stick or 'fishing rod' (BW-W-011). Water samples were stored in a cool, dark place prior to transport to the laboratory (BW-W-008). In the laboratory the ditch water samples were filtered the next day, and two compound samples were prepared (one for each ditch type). The separate ditch water samples were analysed for nitrate content, and the compound samples were also analysed for total nitrogen and total phosphorus content.

A4.3 Clay Region

In the Clay Region, a distinction is made between farms where the soil is drained using drainage pipes and farms where this is not the case. A farm is considered to lack drainage if less than 25 percent of its acreage is drained using drainage pipes, or if less than 13 drains can be sampled. Different sampling strategies are employed on farms with drainage and farms without drainage.

A4.3.1 Farms with drainage

On farms with drainage, drain water and ditch water were sampled during the period from October 2010 to April 2011 (see Figure A4.4). On each farm, 16 drainage pipes were selected for sampling. The number of drainage pipes to be sampled on each plot depended on the size of the plot. Within one plot, the drains were selected in accordance with the relevant protocol (BW-W-021). On each farm, two ditch types were distinguished. For each ditch type, up to four sampling locations were selected (see section A4.2). The selection was performed in accordance with the aforementioned protocol, and was aimed at obtaining an impression of the impact of the farm's activities on ditch water quality and excluding as far as possible any effects external to the farm.

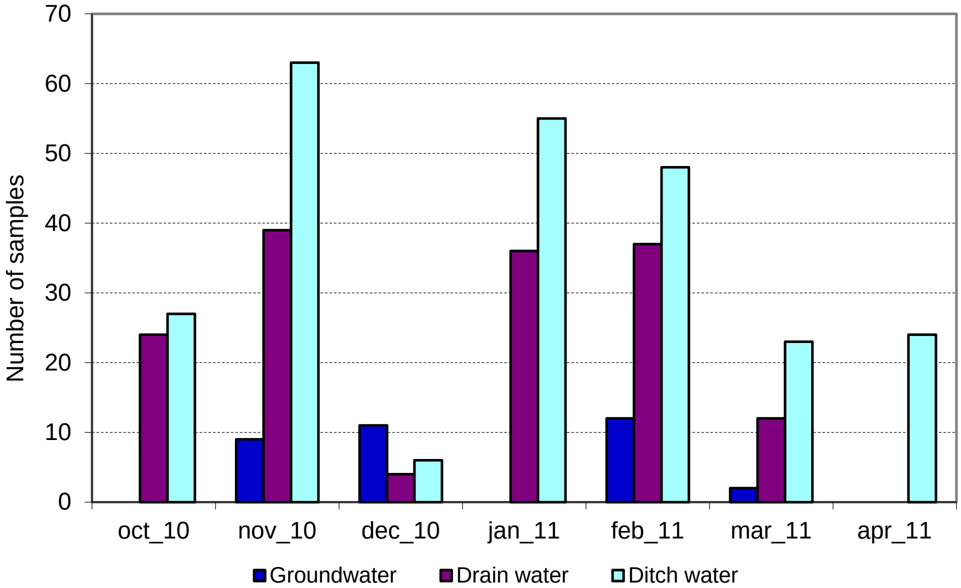

Figure A4.4 Number of groundwater, drain water and ditch water samples in the Clay Region per month during the period from October 2010 to April 2011

During the winter of 2010/2011, drain water and ditch water were sampled between one and four times as described in the previous section. The samples were taken throughout the winter, with a period of at least three weeks elapsing between two samples.

Water samples were stored in a cool, dark place prior to transport to the laboratory (BW-W-008). In the laboratory one compound sample was prepared from the drain water samples on the next day, and two compound samples were prepared from the ditch water samples (one for each ditch type). The separate drain water and ditch water samples were analysed for nitrate content, and the compound samples were also analysed for total nitrogen content and total phosphorus content.

A4.3.2 Farms without drainage

On farms without drainage, samples were taken of the top metre of groundwater and ditch water during the period from October 2010 to April 2011 (BW-W-021) (see Figure A4.4). On these farms, the groundwater was sampled one or two times, while the ditch water was sampled one to four times.

The groundwater was sampled in a manner comparable to the method used in the Sand Region, with the exception that the groundwater was sampled twice in the Clay Region. However, the closed bore hole method (BW-W-015) was occasionally used instead of the open bore hole method. The nitrate concentration was determined in situ at each of the 16 locations (Nitrachek method, BW-W-001). The water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (BW-W-008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously effected in situ by means of sulphuric acid or nitric acid (BW-W-009). In the laboratory, two compound samples were prepared (each consisting of eight individual samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content.

The ditch water samples were taken in a manner similar to the method deployed on farms with drainage, i.e. two ditch types were defined, with up to four sampling locations per ditch type. However, samples were taken using a filter lance (BW-W-011) and water samples were immediately filtered in situ and analysed for nitrate content (Nitrachek method, BW-W-001). The individual samples were not only filtered, but also conserved (BW-W-009) and stored in a cool, dark place prior to transport to the laboratory (BW-W-008). In the laboratory one compound sample was prepared for each ditch type. The compound samples were analysed for nitrate content, total nitrogen content, and total phosphorus content.

A4.4 Peat Region
In the Peat Region, the top metre of groundwater was sampled once on all farms during the period from November 2010 to April 2011 (see Figure A4.5). Three to four ditch water samples were taken on these farms in the period from November 2010 to April 2011.

The groundwater was sampled in a manner similar to the method employed in the Sand and Clay Regions. However, the reservoir tube method (BW-W-015) was regularly used instead of the open or closed bore hole method. The nitrate concentration was determined in situ at each of the 16 locations (Nitrachek method, BW-W-001). The water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (BW-W-008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously effected in situ by means of sulphuric acid or nitric acid (BW-W-009). In the laboratory two compound samples were prepared (each consisting of eight individual samples) and analysed for nitrate content, total nitrogen content, and total phosphorus content.

The ditch water samples were taken together with the groundwater samples according to a method similar to that used on farms without drainage in the Clay Region. The samples were taken using a filter lance (BW-W-011). Samples were taken at four locations for each of the two ditch types. Water samples were immediately analysed in situ for nitrate content (Nitrachek method, BW-W-001). The individual water samples were filtered and stored in a cool, dark place prior to transport to the laboratory (BW-W-008). Acidification has been deployed as a method of conservation since 1 November 2010, using sample bottles which have been previously acidified in the laboratory or by the manufacturer. Acidification was previously effected in situ by means of sulphuric acid or nitric acid (BW-W-009). In the laboratory two compound samples were prepared from these ditch water samples (one for each ditch type). The compound samples were analysed for nitrate content, total nitrogen content, and total phosphorus content.

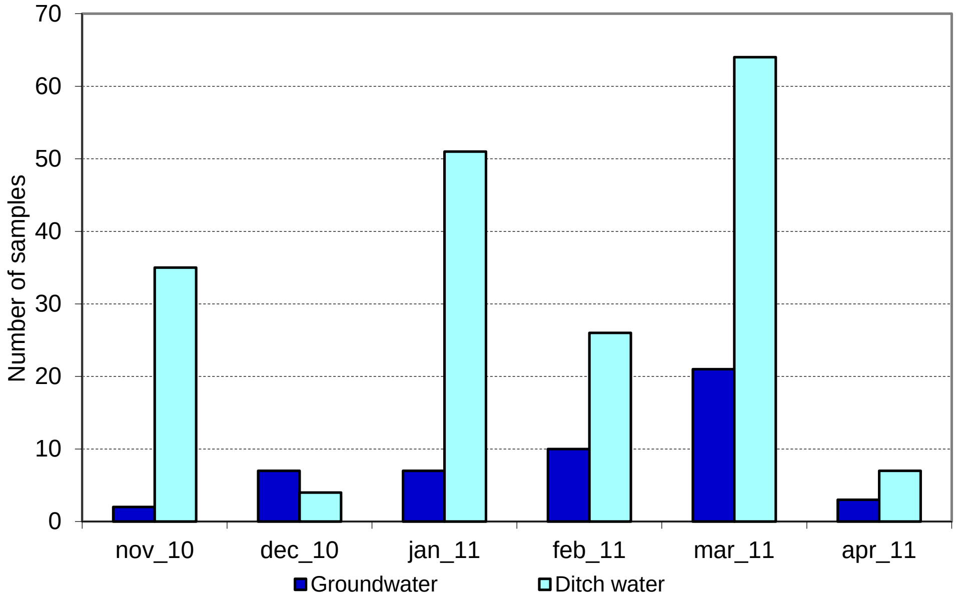

Figure A4.5 Number of groundwater and ditch water samples in the Peat Region per month during the period from November 2010 to April 2011

The additional ditch water samples were taken at the same locations as the samples that were taken together with the groundwater samples. However, a different sampling method was used, namely the method used on farms with drainage in the Clay Region. Samples were taken using a 'fishing rod' and measuring beaker. No analyses were performed in situ and the samples were stored in a cool, dark place prior to transport to the laboratory (BW-W-011), but not filtered or conserved. On the next day, one compound sample for each ditch type was prepared in the laboratory and analysed for nitrate content, total nitrogen content, and total phosphorus content. Up to four separate samples were combined to prepare a compound sample for each ditch type.

The following RIVM work instructions were used:

BW-W-001	Measuring nitrate concentrations in aqueous solutions using a Nitracheck reflectometer (type 404)
BW-W-008	Temporary storage and transportation of samples
BW-W-009	Method for conserving water samples by adding acid
BW-W-011	Sampling ditch water or surface water using a modified sampling lance and peristaltic pump
BW-W-014	Soil sampling using an Edelman drill for soil moisture analysis purposes
BW-W-015	Groundwater sampling using a sampling lance and peristaltic pump on sand, clay or peat soils
BW-W-021	Determining the sampling locations

References

- Boumans, L.J.M., G. van Drecht, B. Fraters, T. de Haan and D.W. de Hoop (1997). Effect van neerslag op nitraat in het bovenste grondwater onder landbouwbedrijven in de zandgebieden; gevolgen voor de inrichting van het Monitoringnetwerk effecten mestbeleid op Landbouwbedrijven (MOL). Bilthoven, RIVM Report No. 714831002.
- EU (2005). Commission decision of 8 December 2005 granting a derogation requested by the Netherlands pursuant to Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources. Official Journal of the European Union, No. L 324/89-93 (10 December 2005).
- EU (2006). Monitoring Guidance for Groundwater. Final draft. Drafting group GW1 Groundwater Monitoring, Common Implementation Strategy of the WFD.
- Fraters, B., H.A. Vissenberg, L.J.M. Boumans, T. de Haan and D.W. de Hoop (1997). Resultaten Meetprogramma Kwaliteit Bovenste Grondwater Landbouwbedrijven in het zandgebied (MKBGL-zand) 1992-1995. Bilthoven, RIVM Report No. 714801014.
- Fraters, D., L.J.M. Boumans, G. van Drecht, T. de Haan and W.D. de Hoop (1998). Nitrogen monitoring in groundwater in the sandy regions of the Netherlands. Environmental Pollution 102 (SUPPL. 1): 479-485.
- Fraters, B., L.J.M. Boumans, T.C. van Leeuwen and D.W. de Hoop (2002). Monitoring nitrogen and phosphorus in shallow groundwater and ditch water on farms in the peat regions of the Netherlands. Proceedings of the 6th International Conference on Diffuse Pollution. Amsterdam, the Netherlands, 30 September - 4 October 2002: 575-576.
- Meinardi, C.R. and G.A.P.H. van den Eertwegh (1995). Onderzoek aan drainwater in de kleigebieden van Nederland. Deel 1: Resultaten van het veldonderzoek. Bilthoven, RIVM Report No. 714901007.
- Meinardi, C.R. and G.A.P.H. van den Eertwegh (1997). Onderzoek aan drainwater in de kleigebieden van Nederland. Deel 2: Interpretatie van de gegevens. Bilthoven, RIVM Report No. 714801013.
- Rozemeijer, J., L.J.M. Boumans and B. Fraters (2006). Drainwaterkwaliteit in de kleigebieden in de periode 1996-2001. Evaluatie van een meetprogramma voor de inrichting van een monitoringnetwerk. Bilthoven, RIVM Report No. 680100004.
- Van Beek, C.L., G.A.P.H. van den Eertwegh, F.H. van Schaik, G.L. Velthof and O. Oenema (2004). The contribution of agriculture to N and P loading of surface water in grassland on peat soil. Nutrient Cycling in Agroecosystems 70: 85-95.
- Van den Eertwegh, G.A.P.H. (2002). Water and nutrient budgets at field and regional scale. Travel times of drainage water and nutrient loads to surface water. Wageningen, Wageningen University. PhD thesis.
- Van den Eertwegh, G.A.P.H. and C.L. van Beek (2004). Veen, Water en Vee; Water en nutriëntenhuishouding in een veenweidepolder. Eindrapport Veenweideproject fase 1 (Vlietpolder). Leiden, Rijnland District Water Control Board.

Appendix 5 Tables

Table A5.1 Some general characteristics of farms participating in the derogation monitoring network (DMN) in the 2006-2011 period

Farm characteristic	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Number of dairy farms	251	247	253	249	252	256
Number of other grassland farms	43	48	43	44	42	34
Total area of cultivated land (hectares)	49	50	51	52	52	53
Proportion of grassland (%)	83	83	82	82	83	83
Proportion of farms with pigs and poultry (%)	12	13	12	10	10	8
Total livestock density (Phosphate Livestock Units per hectare)[1]	3.0	3.1	2.7	2.8	2.9	2.8
Kilogrammes of FPCM per dairy farm (x 1,000)	697	731	779	813	860	869
Kilogrammes of FPCM per dairy cow (x 1,000)	8.4	8.4	8.4	8.5	8.7	8.6
FPCM production per hectare of fodder crop (x 1,000 kg)	14	14	15	15	16	16
Percentage of dairy farms where dairy cows are grazing in May-October period	89	88	86	83	79	78
Percentage of dairy farms where dairy cows are grazing in May-June period	86	84	82	80	76	76
Percentage of dairy farms where dairy cows are grazing in July-August period	88	88	86	83	79	78
Percentage of dairy farms where dairy cows are grazing in September-October period	87	87	84	80	74	71

[1] Phosphate Livestock Unit (LSU) is a standard used to compare numbers of animals based on their standard phosphate production. One adult dairy cow produces 41 kg of phosphate on average, which is equivalent to 1 Phosphate LSU. One young animal 1-2 years of age produces 18 kg of phosphate (0.44 Phosphate LSU); one young animal 0-1 years of age produces 9 kg of phosphate (0.22 Phosphate LSU).

Compared to the previous reports, some changes in the data for the 2006-2010 period have occurred. In this report, the number of dairy farms has decreased by 5 to 12 farms and the number of other grassland farms has increased by 5 to 12 farms. The proportion of farms with pigs and poultry has decreased by 4 to 6 percentage points in this report. This is caused by the fact that the LMM programme in 2011 started using Standard Output (SO) units instead of Dutch Size Units (*Nederlandse Grootte-Eenheid*, NGE) as a measure of economic size. The new units are applied with retroactive effect. See Appendix 2, section A2.4 for further information.

Table A5.2 Average nitrogen usage in livestock manure (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2011 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Number of farms	272	278	276	268	278	278
Use of nitrogen in livestock manure						
Produced on farm	263	266	267	266	280	276
+ Inputs	8	10	10	10	8	11
+ Changes in stocks[1]	-4	-8	-7	-1	-8	-5
- Outputs	23	30	31	31	39	36
Total use	244	238	239	243	242	246
Use on grassland[2]	256	251	257	261	255	259
Use on arable land[3]	183	183	175	170	162	175

[1] A negative change in stocks is a stock increase and corresponds to output of manure.
[2] The average use on grassland is based on the following numbers of farms: 263 (2006), 263 (2007), 254 (2008), 251 (2009), 256 (2010) and 254 (2011), as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.
[3] The average use on arable land is based on the following numbers of farms: 195 (2006), 192 (2007), 195 (2008), 191 (2009), 186 (2010) and 190 (2011), as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms, and some farms had no arable land. The allocation of fertilisers to arable land or grassland fell outside the confidence intervals on the following numbers of farms: 9 (2006), 15 (2007), 22 (2008), 17 (2009), 22 (2010), and 24 (2011) farms. The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 59 (2008), 60 (2009), 70 (2010) and 64 (2011) farms.

Table A5.3 Average nitrogen usage (in kg of plant-availabble nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2011 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Number of farms	272	278	276	268	278	278
Livestock manure excluding availability coefficient	244	238	239	243	242	246
Availability coefficient	39	40	48	48	49	49
Livestock manure including availability coefficient	94	94	114	117	118	121
+ Other organic fertilisers	0	0	0	0	0	0
+ Inorganic fertilisers	128	126	122	125	124	123
Total use	223	221	236	242	241	244
Nitrogen application standard applicable to farm	289	286	270	261	259	260
Use on grassland[1]	247	247	265	268	266	270
Nitrogen application standard for grassland	315	313	295	284	281	282
Use on arable land[2]	110	115	124	123	116	123
Nitrogen application standard for arable land	156	157	156	153	154	157

[1] The average use on grassland is based on the following numbers of farms: 263 (2006), 263 (2007), 254 (2008), 251 (2009), 256 (2010) and 254 (2011), as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.
[2] The average use on arable land is based on the following numbers of farms: 195 (2006), 192 (2007), 195 (2008), 191 (2009), 186 (2010) and 190 (2011), as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms, and some farms had no arable land. The allocation of fertilisers to arable land or grassland fell outside the confidence intervals on the following numbers of farms: 9 (2006), 15 (2007), 22 (2008), 17 (2009), 22 (2010), and 24 (2011) farms. The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 59 (2008), 60 (2009), 70 (2010) and 64 (2011) farms.

Table A5.4 Average use of phosphate (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2011 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Number of farms	272	278	276	268	278	278
Livestock manure	88	85	88	88	86	86
+ Other organic fertilisers	0	0	0	0	0	0
+ Inorganic fertilisers	10	7	6	4	3	3
Total use	99	93	94	92	89	90
Phosphate application standard applicable to farm	108	103	98	98	91	90
Use on grassland[1]	100	95	98	95	92	92
Phosphate application standard for grassland	111	106	100	101	94	94
Use on arable land[2]	91	88	83	77	72	77
Phosphate application standard for arable land	95	90	85	85	77	73

[1] The average use on grassland is based on the following numbers of farms: 263 (2006), 263 (2007), 254 (2008), 251 (2009), 256 (2010) and 254 (2011), as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.
[2] The average use on arable land is based on the following numbers of farms: 195 (2006), 192 (2007), 195 (2008), 191 (2009), 186 (2010) and 190 (2011), as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms, and some farms had no arable land. The allocation of fertilisers to arable land or grassland fell outside the confidence intervals on the following numbers of farms: 9 (2006), 15 (2007), 22 (2008), 17 (2009), 22 (2010), and 24 (2011) farms. The numbers of farms without arable land were as follows: 68 (2006), 71 (2007), 59 (2008), 60 (2009), 70 (2010) and 64 (2011) farms.

Table A5.5 Crop yields (in kg of dry matter, nitrogen, phosphorus and P_2O_5 per hectare) for grassland (calculated) and silage maize (estimated) on farms participating in the derogation monitoring network that meet the criteria for application of the grassland yield calculation method (Aarts et al., 2008), during the 2006-2011 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Estimated silage maize yield						
Number of farms	152	142	155	164	163	167
Tonnes of dry matter per hectare	15	15	16	16	16	16
Kilogrammes of nitrogen per hectare	185	175	186	188	187	190
Kilogrammes of phosphorus per hectare	29	29	30	31	30	31
Kilogrammes of P_2O_5 per hectare	67	66	70	71	69	70
Calculated grassland yield						
Number of farms	206	199	202	209	220	221
Tonnes of dry matter per hectare	9.3	9.3	8.9	9.2	9.3	9.8
Kilogrammes of nitrogen per hectare	273	282	249	255	255	274
Kilogrammes of phosphorus per hectare	35	38	38	35	36	38
Kilogrammes of P_2O_5 per hectare	79	87	86	81	83	87

Table A5.6 Nitrogen surplus on soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2011 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Number of farms	272	278	276	268	278	278
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	324	329	339	333	352	336
Outputs of milk, animals, feedstuffs, manure and other products	139	158	155	148	167	165
Deposition, mineralisation and nitrogen fixation	59	58	58	55	52	58
Gaseous emissions from stabling and storage, during grazing and application	52	56	57	53	56	54
Average surplus on soil surface balance	193	173	185	187	180	175
Surplus on soil surface balance (25th percentile)[1]	135	119	126	132	129	128
Surplus on soil surface balance (75th percentile)[2]	243	228	230	222	216	219

[1] Upper limit of the 25 percent of farms with the lowest surplus on the soil surface balance.
[2] Lower limit of the 25 percent of farms with the highest surplus on the soil surface balance.

Table A5.7 Nitrogen surplus on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2011 period of the different soil regions

Region	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Sand Region (N = 137-144)	177	168	166	169	165	163
Loess Region (N = 15-20)	136	137	143	131	157	148
Clay Region (N = 63-69)	195	152	215	207	175	166
Peat Region (N = 46-53)	255	231	219	232	240	229
All farms (N = 268-278)	193	173	185	187	180	175

Table A5.8 Phosphate surplus on the soil surface balance (in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network (DMN) in the 2006-2011 period

Description	*2006*	*2007*	*2008*	*2009*	*2010*	*2011*
Number of farms	272	278	276	268	278	278
Inputs of (inorganic) fertilisers, feedstuffs, animals and other products	85	80	83	82	89	82
Outputs of milk, animals, feedstuffs, manure and other products	59	68	68	65	73	70
Average surplus on soil surface balance	26	12	15	17	16	12
Surplus on soil surface balance (25th percentile)[1]	11	-2	2	3	4	0
Surplus on soil surface balance (75th percentile)[2]	38	28	27	28	28	27

[1] Upper limit of the 25 percent of farms with the lowest surplus on the soil surface balance.
[2] Lower limit of the 25 percent of farms with the highest surplus on the soil surface balance.

Table A5.9 Average nutrient concentrations (in mg/l) in water leaching from the root zone and ditch water in the 2007-2012 period

	2007	2008	2009	2010	2011	2012
Water leaching from root zone in Clay Region						
Number of farms	62	64	64	64	63	59
Nitrate	25	16	15	19	14	11
Phosphorus	0.36	0.4	0.32	0.25	0.27	0.33
Nitrogen	9.0	6.1	5.5	6.3	5.2	4.7
Ditch water in Clay Region						
Number of farms	61	60	63	63	62	58
Nitrate	12	8.6	6.9	9.7	6.3	5.3
Phosphorus	0.33	0.36	0.35	0.22	0.27	0.25
Nitrogen	4.3	4.0	3.7	4.2	3.5	3.2
Water leaching from root zone in Sand Region						
Number of farms	143	142	142	143	142	147
Nitrate	60	46	41	49	40	36
Phosphorus	0.07	0.07	0.07	0.09	0.11	0.1
Nitrogen	16	14	12	14	12	11
Ditch water in Sand Region						
Number of farms	30	32	34	34	35	35
Nitrate	35	34	26	31	25	19
Phosphorus	0.11	0.11	0.21	0.12	0.09	0.11
Nitrogen	9.6	9.7	8.2	9.2	7.7	6.6
Water leaching from root zone in Peat Region						
Number of farms	49	49	48	48	49	51
Nitrate	15	6.0	6.3	13	6.9	4.2
Phosphorus	0.51	0.39	0.32	0.44	0.37	0.42
Nitrogen	11	9.7	8.2	11	9.4	8.0
Ditch water in Peat Region						
Number of farms	49	48	47	47	48	50
Nitrate	5.9	4.2	3.5	3.7	3.7	2.8
Phosphorus	0.21	0.13	0.15	0.14	0.15	0.16
Nitrogen	3.7	4.2	4.3	4.1	4.6	4
Water leaching from root zone in Loess Region						
Number of farms	18	18	20	18	19	
Nitrate	71	52	50	50	56	
Phosphorus	0.02	0.03	0.02	0.03	0.41	
Nitrogen	18	13	12	12	14	

References

- Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2008). Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmaïs op melkveebedrijven. Wageningen, Plant Research International, Report No. 208.

Appendix 6 Method for calculating the corrected nitrate concentration

The method for calculating the corrected nitrate concentration consists of two steps. First, a calculation is performed to determine the variation in leaching water concentrations due to precipitation surplus variations. Secondly, an indexed trend line for nitrate is calculated by estimating the annual average nitrate concentrations for a hypothetical situation without variation due to the precipitation surplus and other confounding factors.

A6.1 Effect of the precipitation surplus

The nitrate concentrations in the top metre of groundwater as sampled in the LMM programme display variations that cannot be explained solely by variations in agricultural practices. Fraters *et al.* (1998) have shown that variations in the precipitation surplus cause variations in nitrate concentrations. For example, it was demonstrated that the 50 percent reduction in nitrate concentrations between 1993 and 1994 was mainly caused by greater dilution and/or greater denitrification arising from a higher precipitation surplus. Below, we describe the method that can be used to demonstrate the effect of the precipitation surplus.

The effect of a variable precipitation surplus on nitrate concentrations is determined by calculating a 'precipitation surplus' variable, and including it as an explanatory variable in a statistical model (see below). The relationship between the nitrate concentration and the 'precipitation surplus' variable in the statistical model can be caused by greater nitrate dilution as well as greater denitrification.

The 'precipitation surplus' variable is calculated in two steps:

Step 1. First, the leaching of a virtual tracer is calculated in the ONZAT soil simulation model (OECD, 1989) using national data about precipitation and evaporation in 16 weather districts.

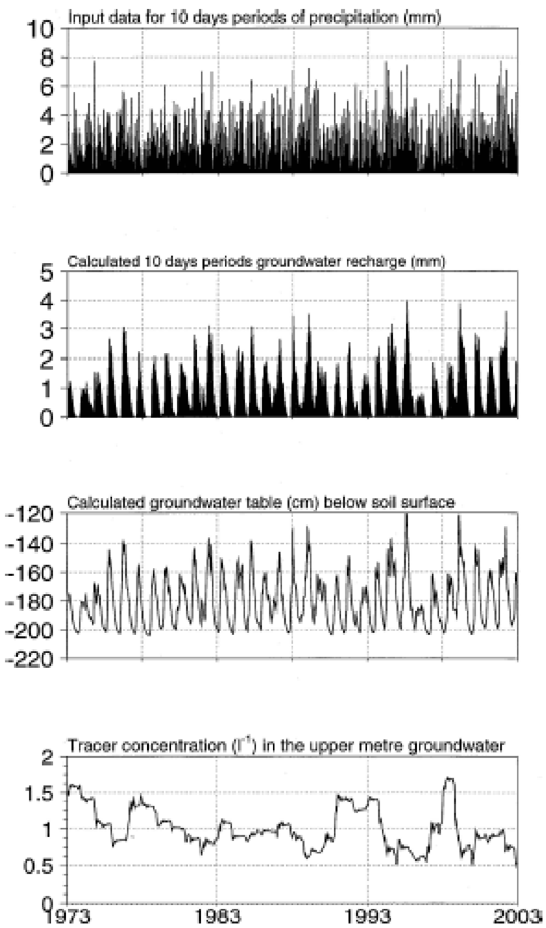

Figure A6.1 Precipitation, groundwater recharge, groundwater level and tracer concentration trends over a 30-year period

The virtual tracer is applied daily to a standard soil profile with grass, for eight different drainage situations. The result is a groundwater level trend and tracer concentrations for 15 x 8 = 120 situations. Figure A5.1 shows the precipitation, groundwater recharge, groundwater level and tracer concentration trends over a 30-year period for a given situation.

From the figure it can be concluded that variations in the precipitation surplus can cause a two-fold or even a three-fold variation in tracer concentrations from year to year. The tracer concentration is inversely proportional to the precipitation surplus.

Step 2. For each temporary drill hole, the weather district, the sampling date and the measured groundwater level are used to look up the associated tracer concentration in the simulation results (Boumans *et al.*, 2001). The average tracer concentration on each farm is then calculated to obtain a farm-average tracer concentration for the farm-average nitrate concentration, which has been measured in a compound sample of groundwater from the same temporary drill holes.

A6.2 Indexed trend line for nitrate

The indexed trend line is used to determine estimates of the annual average nitrate concentrations for a hypothetical situation *without* the influence of confounding factors such as weather variability and sample composition.

The water quality can be affected by human activity, by weather conditions and because old farms are excluded and new farms added to the monitoring network. The nitrate concentration reacts most quickly and clearly to changes in soil loads, and nitrate concentrations are highest in the Sand Region. Hardly any nitrate is found in soils in the Peat Region. The Clay Region occupies an intermediate position. The indexation will improve as more observations become available. A much smaller number of observations are available for the Loess Region than for the other regions. Due to the previously mentioned complicating factors, the method does not produce conclusive results for the Clay, Peat and Loess Regions. Therefore, no correction will be introduced for these regions.

As the Sand Region is the most susceptible to nitrate leaching, the effects of human activities and weather conditions are most noticeable here. In addition, a large number of observations are available for this region. To establish the clearest possible distinction between the effects of agricultural practices and other influences, the REsidual Maximum Likelihood (REML) method was applied (see Chapter 4, Table 4.10). This method makes it possible to take account of the fact that the same farms have been monitored in different years, and that different farms have been monitored in different years. The REML method was also used to investigate whether the measured concentrations could have been affected by differences in the precipitation surplus or the groundwater level (see Table 4.10). Further information on using the REML method may be found in Fraters *et al.* (2004), Annex 2.

References

- Boumans, L.J.M., B. Fraters and G. van Drecht (2001). Nitrate in the upper groundwater of 'De Marke' and other farms. NJAS - Wageningen Journal of Life Sciences 49: 163-177.
- Fraters, D., L.J.M. Boumans, G. van Drecht, T. de Haan and D.W. de Hoop (1998). Nitrogen monitoring in groundwater in the sandy regions of the Netherlands. Environmental Pollution 102 (SUPPL. 1): 479-485.
- Fraters, B., P.H. Hotsma, V.T. Langenberg, T.C. van Leeuwen, A.P.A. Mol, C.S.M. Olsthoorn, C.G.J. Schotten and W.J. Willems (2004). Agricultural practice and water quality in the Netherlands in the 1992-2002 period. Background information for the third EU Nitrate Directive Member States report. Bilthoven, RIVM Report No. 500003002.
- OECD (1989). Compendium of environmental exposure assessment methods for chemicals. Paris, Environment Directorate, Organisation for Economic Co-operation and Development, Environment monographs 27.

Appendix 7 Fertiliser data reported by National Service for the Implementation of Regulations

A7.1 Introduction

During the 2006-2009 period, the National Service for the Implementation of Regulations (*Dienst Regelingen*, DR) reported on fertiliser use based on its own data (see, for instance, National Service for the Implementation of Regulations and Netherlands Food and Consumer Product Safety Authority, 2011). The fertiliser use calculated by DR sometimes deviated from the calculated fertiliser use based on data of farms participating in the derogation monitoring network ('DMN farms') of the Minerals Policy Monitoring Programme (LMM). Such differences were especially apparent in 2009. The Agricultural Economics Research Institute (LEI) was therefore asked to analyse these differences in detail. This Appendix compares the calculated fertiliser use data in this report with the fertiliser use calculated by DR, and provides an explanation of any differences that are found.

The LMM calculations are aimed at calculating the fertilisation rates as accurately as possible, using as much farm-specific information as possible. The fertiliser use calculations performed by DR serve a different purpose, as these are chiefly aimed at discovering possible offenders. The DR calculations make use of various assumptions and margins of error to provide greater assurance in the case of observed violations. These assumptions and margins of error may result in considerable differences in calculated fertiliser use. There are also differences in the population. The LMM population is a sample of the Agricultural Census data that excludes very small farms. The DR data concern all farms included in the Agricultural Census that have applied for derogation.

Table A7.1 shows the fertiliser use in 2011 on farms to which derogation has been granted, based on DR data and incorporating the results of LMM derogation monitoring.

Table A7.1 Fertiliser use in kg per hectare on farms to which derogation has been granted according to DR data, fertiliser use in kg per hectare on farms according to LMM derogation monitoring results, and differences between these source data in 2011 for both nitrogen and phosphate

			Difference between LMM and DR data	
Item	*LMM*	*DR*	*In kg/ha*	*In %*
Nitrogen in livestock manure	246	193	53	28%
Nitrogen in inorganic fertilisers	123	110	13	12%
Nitrogen in other organic fertilisers	0	4	-3	-88%
Total nitrogen	369	306	63	21%
Phosphate in livestock manure	86	69	17	24%
Phosphate in inorganic fertilisers	3	3	0	5.6%
Phosphate in other organic fertilisers	0	2	-1	-70%
Total phosphate	90	74	16	22%

A7.2 Summary and analysis of differences

A7.2.1 Nitrogen and phosphate in livestock manure
The calculated quantity of nitrogen in livestock manure is 53 kg per hectare higher according to LMM data than according to DR data. This difference amounts to 17 kg per hectare for phosphate in livestock manure.

Table A7.2 Analysis of differences in the use of livestock manure on farms to which derogation has been granted, according to DR data and according to LMM derogation monitoring results in 2011 for nitrogen

	Nitrogen	
Item	*kg N/ha*	*Percentage*
Reported LMM value (A)	246	
Reported DR value (B)	193	
Reported DR value ≥ 10 hectares, ≥ 25,000 SO units and within LMM confidence intervals (C)	210	
Difference observed in similar population (A – C)	36	
Caused by		
Use of BEX* method by DR	23	64%
DR population ≥ 10 hectares, ≥ 25,000 SO units and within LMM confidence intervals, versus LMM derogation farms with DR data	-2.3	-6%
Stocks	-2.0	-6%
Inputs and outputs	0.7	2%
Use of BEX* method in LMM programme	-7.1	-20%
Standard-based excretion by dairy cows	6.9	19%
Standard-based excretion by other cattle	10	28%
Standard-based excretion by other grazing animals	1.4	4%
Standard-based excretion by animals in stables	5.5	16%

Source: Processed DR and FADN data
* The abbreviation BEX stands for *Bedrijfsspecifieke Excretie* (Farm-Specific Excretion) (National Service for the Implementation of Regulations, 2010).

Table A7.2 summarises the reasons for these differences:

- Approx. one-third of the difference of 53 kg per hectare found in Table A7.1 (210 – 193 = 17 kg) is due to differences in populations. Farms smaller than 10 hectares and smaller than 25,000 SO units are excluded from the LMM programme, but not from the DR data. In addition, the LMM programme uses confidence intervals (see Appendix 3), so that farms with improbably high or low quantities of fertilisers are excluded from the data set. Fertiliser use on the excluded farms is substantially lower.
- Until 2010, DR calculated all excretion quantities on the basis of standards. As of 2011, dairy farmers can indicate in their Agricultural Census report if they are currently using or planning to use the Farm-Specific Excretion (BEX) method (National Service for the Implementation of Regulations, 2010). Past experience with farms inspected for compliance with the application standards has shown that implementation of the BEX method frequently results in substantial reductions in nitrogen and phosphate excretions compared to the standard-based excretion quantities. If a dairy farmer states that he is using or planning to use the BEX method, the National Service for the Implementation of Regulations brings the nitrogen and phosphate excretions by cattle more in line with the actual excretion

quantities (based on assumptions). This has resulted in a difference of nearly 23 kg of nitrogen per hectare, for farms in the DR dataset with a size of 10 hectares or more and an economic size of 25,000 SO units or more, that fall within the LMM confidence intervals. This accounts for over 60 percent of the difference found in Table A7.1.

- The 278 LMM observations may be considered as a sample from the much larger DR population of farms with a size of 10 hectares or more, an economic size of 25,000 SO units or more, and falling within the LMM confidence intervals. If the fertiliser use on these 278 farms is calculated based on DR data, the result deviates by more than 2 kg from the results for the much larger DR population. This may be considered a sampling difference and explains approx. 6 percent of the difference.
- In addition, the stocks, inputs and outputs registered in the LMM programme frequently differ from the DR data. FADN participants are requested to report the actual situation, which may differ from the DR data. The net effect of these discrepancies in 2011 was limited: the calculated LMM fertiliser quantities were approx. 1 kg per hectare lower than the quantities registered by DR. In 2009 the net effect was in the opposite direction. The net difference in 2010 was in the same direction as in 2011, but exceeded the difference in 2011 by a factor of five.
- The difference in acreage between the LMM results and the LMM results calculated using DR data amounted to 0.09 hectares. This does not affect the differences.
- The remaining difference of 17 kg per hectare is accounted for by differences in the method used to calculate excretion quantities. The following aspects should be taken into account:
  a. The standard-based excretion in the LMM programme is determined with greater accuracy than in the DR data, for a number of reasons. DR is not always able to calculate excretion by dairy cows because it lacks data on milk supplies or urea levels. In more than 300 DR observations, the milk supplies, urea levels and numbers of dairy cows were known, but the excretion by dairy cows was nevertheless not calculated. Furthermore, the LMM programme takes the stable system into account when determining the standard quantities. The stable system is not registered in the DR data, so the lower standard quantities for solid manure are selected. On the other hand, DR does not classify excretion by hobby animals as 'Excretion', but as 'Other organic fertilisers'. In addition, the excretion by pigs and poultry may be calculated differently.
  b. The BEX method is used by approx. one-third of the farms participating in the LMM programme. As a result, the use of nitrogen in livestock manure according to the LMM data is over 7 kg of nitrogen per hectare lower than according to the DR data. The BEX method is applied in the LMM programme for all farms that report using the BEX method, provided that sufficient reliable data are available. In the DR system the BEX method is also applied, at approx. 40 percent of dairy farms. The effect of this has been accounted for under the second bullet of this list.

Nitrogen in inorganic fertilisers and other fertilisers
The differences in the use of nitrogen in inorganic fertilisers and other fertilisers are minor compared to the differences in the use of nitrogen in livestock manure. They can largely be explained by the following factors:

- The farms excluded due to sampling limitations and confidence intervals use less fertilisers.

- DR classifies excretion by hobby animals as 'Other organic fertilisers'.

Phosphate
The nitrogen-phosphate ratio in cattle manure is reasonably stable. This also applies to other organic fertilisers. The differences in Table A7.1 for phosphate in livestock manure and other organic fertilisers are caused by the same factors as for nitrogen. In the case of phosphate in inorganic fertilisers, the difference found in Table A7.1 is small.

The differences do not give cause to adjust the LMM calculation method, either for nitrogen or for phosphate.

A7.3 Data sources

We used the following data sources to compare DR and LMM figures for 2011:
- Farm Accountancy Data Network (FADN) of the Agricultural Economics Research Institute (LEI): this concerns the 298 farms that qualified for derogation monitoring (DM) in 2011. We mainly analysed the fertilisation data, but also used other FADN data about these farms. The farms are all participants in the LMM programme and will therefore be referred to below as 'LMM farms', and the data provided as 'LMM data'.
- Data supplied by the National Service for the Implementation of Regulations (*Dienst Regelingen*, DR): this concerns 23,998 registration numbers (BRS numbers) of farms that applied for derogation in 2011. Ten BRS numbers have been added which are included in the 298 LMM farms, but not in the 23,998 BRS numbers.
- Data from the 2011 Agricultural Census concerning the 23,998 BRS numbers. In the case of 2,128 BRS numbers, no number could be found in the 2011 Agricultural Census, leaving 21,870 BRS numbers with Agricultural Census data.

On LMM farms, fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers must fall within the LMM confidence intervals. This applies to the separate quantities of nitrogen and phosphate, as well as the total quantities of fertilisers applied (i.e. inorganic fertilisers, livestock manure, and other organic fertilisers). The relevant table may be found in Appendix 3.3.

Furthermore, LMM farms with anaerobic digestion installations are also excluded, as well as farms that did not actually make use of the exemption in the year concerned (this applied to eight farms in 2011). Consequently, the number of LMM farms used for derogation monitoring purposes in 2011 decreased from 298 to 278.

A7.4 Detailed results

A7.4.1 Nitrogen in livestock manure

Differences in population
Table A7.3 shows the production, inputs, outputs, initial stocks and closing stocks of livestock manure expressed in kg of nitrogen per hectare for the 23,998 DR observations, excluding farms without cultivated land. Of these 21,983 DR observations, 1,797 observations fell outside the confidence intervals. Approximately 40 percent of these 1,797 observations concerned

farms smaller than 10 hectares. The DR data set also included 3,011 farms smaller than 10 hectares or smaller than 25,000 SO units which did fall within the confidence intervals.

Table A7.3 Excretion (= production), inputs, outputs, stocks and use of livestock manure in kg of nitrogen per farm and per hectare, according to DR data for BRS numbers in 2011 that applied for derogation in 2011

		Cultivated land			
	No cultivated land	*Total*	*Outside confidence intervals*	*< 10 ha or < 25,000 SO units*	*≥ 10 ha and ≥ 25,000 SO units*
Number of farms	2,015	21,983	1,797	3,011	17,175
Acreage of cultivated land (hectares)	0	38	30	11	44
Use of nitrogen in livestock manure (kg)		192	77	162	210
Use of nitrogen in livestock manure BEX method → standard-based (kg)		212	89	163	233
Quantity of nitrogen in initial stocks (kg)		95	158	72	92
Quantity of nitrogen in closing stocks (kg)		95	147	66	95
Initial stock – closing stocks (kg of nitrogen)		-0.3	11	6.4	-2.6
Inputs – outputs (kg of nitrogen)		-23	-173	33	-17
Nitrogen excretion (= nitrogen production) (kg)		216	239	123	229
Nitrogen excretion (= nitrogen production) (kg) BEX method → standard-based		235	252	124	252

Source: Processed DR data

Use per hectare was determined by calculating the use per hectare for each farm, and then averaging the results. Farms without cultivated land were excluded, to avoid dividing by zero. Table A7.3 shows that the BRS numbers with 10 or more hectares of cultivated land and an economic size of 25,000 or more SO units used more nitrogen in livestock manure per hectare than BRS numbers with less cultivated land or an economic size of less than 25,000 SO units. The main reason for this was that the quantity of nitrogen excreted per hectare was almost twice as high. As noted before, the LMM data are limited to farms with at least 10 hectares of cultivated land and an economic size of at least 25,000 SO units. Therefore, only the 17,175 DR observations with at least 10 hectares of cultivated land and an economic size of at least 25,000 SO units (the far right column in Table A7.3) were taken into account in the comparison with the LMM results. Of these 17,175 DR observations, 278 observations (DR in LMM) were linked to the same number of LMM observations (see section A7.3).

Table A7.4 shows that the entire group of derogation farms in the 2011 DR data set with at least 10 hectares of cultivated land, at least 25,000 SO units and falling within the LMM confidence intervals, had a smaller average surface area (44 hectares compared to 53 hectares).

Table A7.4 Use, inputs minus outputs, stock differences and excretion (= production) of livestock manure in 2011, classified according to type of animal, expressed in kg of nitrogen per hectare, according to DR and LMM data for farms participating in the LMM derogation monitoring network and for DR derogation farms with at least 10 hectares of cultivated land, an economic size of at least 25,000 SO units, and with fertiliser use falling within the LMM confidence intervals

	DR ≥ 10 ha, ≥ 25,000 SO units	*LMM*	*LMM in DR*	*LMM - LMM in DR*
Number of farms	17,175	278	278	
Acreage of cultivated land (hectares)	44	53	53	0
No. of Phosphate LSUs per hectare	2.3	2.5	2.5	0.0
Results per hectare				
Use of nitrogen in livestock manure (kg)	210	246	203	43
Use of nitrogen in livestock manure BEX method → standard-based (kg)	233	253	231	22
Initial stock – closing stocks (kg of nitrogen)	-2.6	-5.5	-3.5	-2.0
Inputs – outputs (kg of nitrogen)	-17	-24	-25	1
Nitrogen excretion (= nitrogen production) (kg)	229	276	231	44
Nitrogen excretion (= nitrogen production) (kg) BEX method → standard-based	252	283	259	24
- Of which dairy cows	173	195	188	7
- Of which other cattle, excluding white veal calves	66	71	61	10
- Ditto after correction for type of fertiliser	*74*	*71*	*69*	*2*
- Of which sheep, goats and horses	4.4	3.2	1.9	1.4
- Ditto after adding excretion by hobby animals	*4.1*	*3.2*	*2.5*	*0.7*
- Of which animals in stables, including white veal calves	9.0	14.1	8.5	5.5

Source: Processed DR and FADN data

This DR population was also characterised by less intensive farming (2.33 Phosphate LSUs per hectare compared to 2.52 Phosphate LSUs per hectare) than the LMM derogation farms according to the DR data. According to the LMM data, the differences are slightly greater. According to the LMM calculation, the use of nitrogen in livestock manure on the 278 LMM derogation farms amounted to almost 253 kg per hectare (calculations for all LMM farms performed based on standard quantities), whereas the figure of 246 kg for 278 LMM farms is stated in Table A7.1.

Differences in calculated excretion quantities
The excretion quantities stated in Table A7.4 have been rendered comparable based on standard quantities, as excretion quantities in the LMM and DR systems are arrived at by means of different, incompatible methods. The calculations for approx. one-third of the LMM farms represented in Table A7.1 were performed in accordance with the Farm-Specific Excretion (BEX) method (refer to the guidance document on farm-specific excretion by dairy cattle). For nearly 40 percent of the farms in Table A7.1, the calculations of DR data are based on the assumption that the relevant farms use the BEX method.

According to the LMM calculations, the use of nitrogen in livestock manure on LMM derogation farms was 20 kg (253 kg compared to 233 kg) higher than according to the calculations based on DR data. Fertiliser use on DR derogation farms was slightly higher (233 kg compared to 231 kg) than on LMM derogation farms when calculated based on DR data.
The differences between the calculations according to LMM data and calculations according to DR data mainly concern the excretion quantities (24 kg). Because the stock increases were higher according to the LMM calculations and net exports were slightly lower than according to the DR calculations, the difference in the use of livestock manure was smaller (22 kg).

The 24 kg difference in excretion quantities concerns the following groups of animals:

- Dairy cows (7 kg): the LMM figures included all the milk produced, i.e. not only supplies, but also milk fed to young animals or pigs, and waste milk. This resulted in milk production per cow that was 100 kg higher than if the calculations had been performed based on DR data. This corresponds with a difference of 1.2 kg in nitrogen excretion per hectare. DR is not always able to calculate excretion by dairy cows because it lacks data on milk supplies or urea levels. In 26 DR observations, the milk supplies, urea levels and numbers of dairy cows were known, but the excretion by dairy cows was nevertheless not calculated. Out of a total of 278 LMM observations, there were eight cases in which the excretion by dairy cows according to DR data was zero, whereas excretion by dairy cows was known according to the LMM data. This resulted in an increase in nitrogen excretion of 4.8 kg per hectare based on LMM data compared to the excretion based on DR data.
- Other cattle, excluding white veal calves (10 kg): for this group of animals, DR apparently used the standard excretion quantities for solid manure, which are lower than those for liquid manure. According to the 2008 Agricultural Census (the most recent Agricultural Census which requested information on solid cattle manure versus liquid cattle manure), approx. 55 percent of young animals up to 1 year old, 95 percent of young female animals older than 1 year and intended for breeding, and 70 percent of beef cattle and grazing and suckler cows, are accommodated in stables with liquid manure. By taking into account the differences in excretion quantities between solid and liquid manure systems in respect of the percentages for these specific groups of animals, the excretion quantity in the calculations based on DR data will increase by 8.4 kg of nitrogen per hectare. This means that hardly any difference remains between the LMM and DR calculations.
- Sheep, goats and horses: 50 percent (0.7 kg) of the 1.4 kg difference between the LMM calculations and the DR calculations is caused by the fact that DR regards groups of animals with less than 350 kg of nitrogen

excretion as 'hobby animals'. It classifies excretion by these animals under 'Other organic fertilisers'. These hobby animals are mainly sheep and horses.

- Animals in stables, pigs and poultry (5.5 kg): The LMM and DR systems possibly do not use exactly the same calculation method for the excretions of animals in stables, pigs and poultry.

A7.4.2 Nitrogen in inorganic fertilisers and other organic fertilisers
Table A7.5 specifies the use of nitrogen in inorganic fertilisers and other organic fertilisers, calculated for all 23,998 BRS numbers in the DR data set excluding the 2015 BRS numbers without cultivated land (DR > 0 hectares), as well as for the 17,175 BRS numbers with at least 10 hectares of cultivated land, an economic size of at least 25,000 SO units, and with fertiliser use falling within the LMM confidence intervals (DR ≥ 10 hectares, ≥ 25,000 SO units).

Table A7.5 Use in 2011 of nitrogen in inorganic fertilisers and other organic fertilisers, expressed in kg of nitrogen per hectare according to DR data and LMM data for farms in the LMM derogation monitoring network, for DR derogation farms with cultivated land and for DR derogation farms with at least 10 hectares of cultivated land, an economic size of at least 25,000 SO units, and with fertiliser use falling within the LMM confidence intervals

	DR > 0 ha	*DR ≥ 10 ha, ≥ 25,000 SO units*	*LMM*	*LMM in DR*	*LMM - LMM in DR*
Number of farms	21,983	17,175	278	278	
Acreage of cultivated land (hectares)	38	44	53	53	0
Results per hectare					
Inorganic fertilisers	109	117	123	110	12
Other organic fertilisers	3.8	1.5	0.5	1.2	-0.7
Ditto after excluding excretion by hobby animals	*0.7*	*0.6*	*0.5*	*0.5*	*-0.1*

Source: Processed DR and FADN data

The DR results per farm for the 21,983 BRS numbers with cultivated land differed from the DR results for the 17,175 BRS numbers with at least 10 hectares of cultivated land, an economic size of at least 25,000 SO units, and fertiliser use falling within the LMM confidence intervals. For the group as a whole, the use of nitrogen in inorganic fertilisers was lower, but the use of nitrogen in other organic fertilisers was higher. The main reason for this is the inclusion of BRS numbers with fertiliser use that fell outside the LMM confidence intervals.

In respect of the much smaller group of LMM derogation farms for which DR data were also available, the use of nitrogen in inorganic fertilisers calculated according to LMM data was more than 10 percent higher than if the calculations had been performed using DR data. There was virtually no difference in the use of nitrogen in other organic fertilisers, after the DR data had been corrected for nitrogen excretion by hobby animals.

A7.4.3 Phosphate in livestock manure, inorganic fertilisers and other organic fertilisers

The nitrogen-phosphate ratio in cattle manure is reasonably stable. This also applies to other organic fertilisers. The differences in Table A7.1 for phosphate in livestock manure and other organic fertilisers are caused by the same factors as for nitrogen. In the case of phosphate in inorganic fertilisers, the difference found in Table A7.1 is small. The derogation farms required almost the entire margin provided by the application standards for phosphate in livestock manure, so their scope for using phosphate in inorganic fertilisers was extremely limited.

References

- National Service for the Implementation of Regulations (*Dienst Regelingen*, DR) (2010). Handreiking bedrijfsspecifieke excretie melkvee, version effective as of January 2010. Assen, National Service for the Implementation of Regulations, Ministry of Agriculture, Nature & Food Quality.
- National Service for the Implementation of Regulations (DR) and Netherlands Food and Consumer Product Safety Authority (NVWA) (2011). Resultaten van controles op en kengetallen van landbouwbedrijven aangemeld voor derogatie alsmede kengetallen van de Nederlandse veehouderij. Ministry of Infrastructure and the Environment; Ministry of Economic Affairs, Agriculture and Innovation; National Service for the Implementation of Regulations, Ministry of Economic Affairs, Agriculture and Innovation; Netherlands Food and Consumer Product Safety Authority, Ministry of Economic Affairs, Agriculture and Innovation; The Hague.

Appendix 8 Consequences of new regional borders for water quality and agricultural practice data

A8.1 Introduction

In September 2011 the clients discussed and approved a proposal for a number of changes to the LMM region boundaries, following a positive recommendation from the LMM Feedback Group. Under the proposal, the allocation of a farm in a particular region (based on the postcode of the farm's postal address) will no longer depend on the predominant soil type in the agricultural section of the relevant municipality, but on the predominant soil type in the agricultural section of the postcode district (4PCC). The advantage of this new system is that regional boundaries will no longer change as municpalities merge and municipal boundaries are rearranged. The new regions have been defined based on the predominant soil type per postcode. Fragmentation has been avoided as far as possible. The new system has resulted in changes to the boundaries of the Sand, Clay and Peat Regions (see Figure A8.1). The boundaries of the Loess Region remained virtually unchanged. A new area called 'Dune Areas and Wadden Sea Islands' (Area 14) has been created. No derogation farms are located in this area.

The new regional boundaries have resulted in some farms being 'moved' to another region. These farms are retained in the LMM system, but are included in another programme. The results of farms transferring from one winter sampling programme to another are hardly affected by these changes. Farms transferring from a winter sampling programme to a summer programme or vice versa will undergo changes in sampling intensity and frequency.

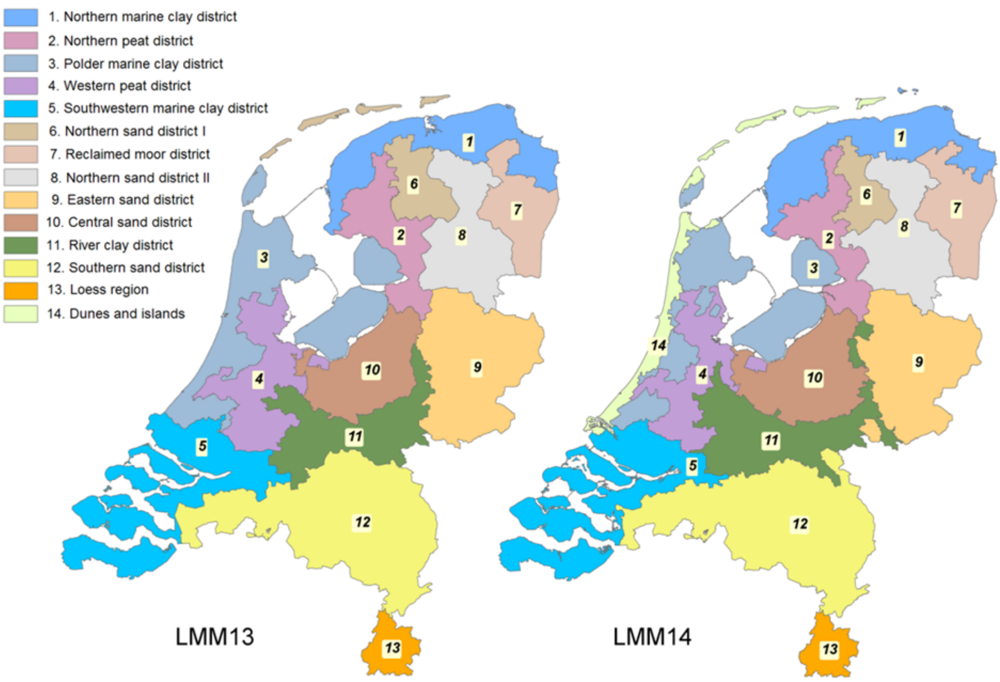

Figure A8.1 Map showing old regional boundaries (LMM13) and new boundaries (LMM14)

In this Appendix we analyse the impact of the revised boundaries on the presentation of the results of the derogation monitoring network. The considerations with respect to data processing are discussed in section A8.2. We also discuss the number of farms transferring to another region (section A8.3), the effects on predominant soil type and drainage class (section A8.4), and the impact on nitrate concentration trends (section A8.5). The consequences for soil surplus trends are described in section A8.6. Conclusions are given in section A8.6.

A8.2 Considerations with respect to data processing

The reported results are indicative and are based on the data and scripts used by RIVM for the 2012 Derogation Report (Buis *et al.*, 2012). The following aspects and considerations must be taken into account:

a. The new regional boundaries have been implemented with retroactive effect for all years. They also apply to farms that no longer participate in the LMM programme. This means that historical data sets will be recalculated.
b. In order to analyse the results of farms transferring to another region, we used the X,Y coordinates of the postal address as recorded in the LMM database. For active LMM farms only, we checked if farms were allocated to the same region by LEI and RIVM. (Farms are allocated to a region based on these organisations' own data, and differences in approach have resulted in discrepancies at an earlier stage.) This process was completed for the older farms prior to the final 2013 Derogation Report. A farm's postal address may be located in one region, while some or all of the plots are located in another region. How

often this situation occurs has not yet been determined. The data in this Appendix have not been corrected to account for such situations.

c. Depending on the region, the samples are taken at different times of year. Standard samples in the Clay and Peat Regions are taken during the winter season. Regular sampling in the Sand Region is carried out during the summer period. If a farm moves to another region, only those results are selected that are based on samples taken during the standard period for the new region. The same applies to water types: only the standard water types for the region are selected. As a result, not all derogation farms in a particular region have been included in the determination of averages.

A8.3 Numbers of farms

Following the introduction of the new regional boundaries, there are still enough farms available in the LMM programme in each region for participation in the derogation monitoring network (see Table A8.1). There are farms in the Clay, Sand and Peat Regions that have been transferred to another region. There are no changes to the number of farms in the Loess Region. The number of farms in the Clay Region has increased more than in other regions, whereas the volume of data for the Peat Region has decreased.

Table A8.1 Number of farms with available data on the quality of water leaching from the root zone and the quality of ditch water, specified per year under the old and new regional boundaries

Region	*2007*	*2008*	*2009*	*2010*	*2011*
Leaching water in Clay Region					
Old boundaries	57	57	57	57	57
New boundaries	62	64	64	64	63
Ditch water in Clay Region					
Old boundaries	56	56	56	56	56
New boundaries	61	60	63	63	62
Leaching water in Sand Region					
Old boundaries	160	157	159	159	158
New boundaries	143	142	142	143	142
Ditch water in Sand Region					
Old boundaries	23	25	30	30	31
New boundaries	30	32	34	34	35
Leaching water in Peat Region					
Old boundaries	60	61	60	60	59
New boundaries	49	49	48	48	49
Ditch water in Peat Region					
Old boundaries	61	60	59	59	58
New boundaries	49	48	47	47	48
Leaching water in Loess Region					
Old boundaries	17	18	20	18	#
New boundaries	18	18	20	18	#

A8.4 Effects on predominant soil type and drainage class

Under the new regional boundaries, the predominant soil type within each region accounts for a greater proportion of the total surface area of that region (Table A8.2, Table A8.3). Consequently, the share of the other soil types within that region decreases. There are no changes in the distribution of soil types in the Loess Region. The changes in the distribution of drainage classes are less clear. An increase in the proportion of poorly drained soils is only observed in the Peat Region.

Table A8.2 Distribution of soil types and drainage classes (in percentages) in each region, based on derogation farms sampled in 2010 under the old regional boundaries

Region	*Soil type*				*Drainage class*[1]		
	Sand	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	80	0	12	8	42	49	9
Loess	2	76	22	0	2	3	95
Clay	14	0	83	3	43	51	6
Peat	12	0	39	50	89	11	0

[1] The drainage class is linked to the water table class (*Grondwatertrap*, Gt). The 'Poor natural drainage' class encompasses water table class Gt I through Gt IV, the 'Moderate drainage' class encompasses water table class Gt V, Gt V* and Gt VI, and the 'Good drainage' class encompasses water table class Gt VII and Gt VIII.

Table A8.3 Distribution of soil types and drainage classes (in percentages) in each region, based on derogation farms sampled in 2010 under the new regional boundaries

Region	*Soil type*				*Drainage class*[1]		
	Sand	*Loess*	*Clay*	*Peat*	*Poor*	*Moderate*	*Good*
Sand	88	0	4	8	40	51	9
Loess	2	76	22	0	2	3	95
Clay	6	0	89	5	46	50	4
Peat	11	0	31	58	94	6	0

[1] The drainage class is linked to the water table class (*Grondwatertrap*, Gt). The 'Poor natural drainage' class encompasses water table class Gt I through Gt IV, the 'Moderate drainage' class encompasses water table class Gt V, Gt V* and Gt VI, and the 'Good drainage' class encompasses water table class Gt VII and Gt VIII.

A8.5 Impact on nitrate concentration trends

The transfer of farms from one region to another mainly affects the nitrate concentrations in the Sand Region and Clay Region (Figure A8.2 and Figure A8.3).

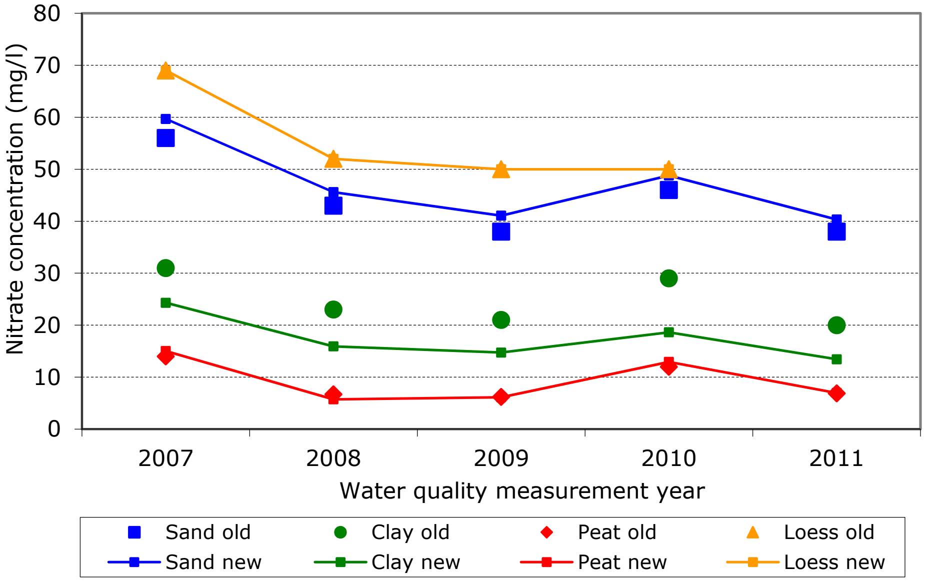

Figure A8.2 Average nitrate concentrations in water leaching from the root zone on derogation farms in the four regions during the 2007-2011 period

Under the new regional boundaries, the average nitrate concentrations in water leaching from the root zone is higher in the Sand Region and lower in the Clay Region. The difference between the old and new situation is negligible in the Peat Region (Figure A8.2 and Table A8.4). The average nitrate concentration in the Sand Region during the five measurement years does remain below the standard of 50 mg NO_3/l. The increase in the Sand Region is caused by the transfer to another region of a number of farms with mainly peat and clay soils. As a result, the proportion of farms with non-standard soil types and lower nitrate concentrations has decreased, while the proportion of farms with sandy soils has increased (Table A8.2 and Table A8.3). This effect is reversed in the Clay Region.

Table A8.4 Average nitrate concentrations (in mg/l) in water leaching from the root zone and in ditch water in the 2007-2011 period, under the old and new regional boundaries

	2007	*2008*	*2009*	*2010*	*2011*
Leaching water in Clay Region (drain water and groundwater)					
Old boundaries	31	23	21	29	20
New boundaries	25	16	15	19	14
Ditch water in Clay Region					
Old boundaries	14	10	8.7	11	7.7
New boundaries	12	8.6	6.9	9.7	6.3
Leaching water in Sand Region (groundwater and soil moisture)					
Old boundaries	56	43	38	46	38
New boundaries	60	46	41	49	40
Ditch water in Sand Region					
Old boundaries	39	39	27	32	25
New boundaries	35	34	26	31	25
Leaching water in Peat Region (groundwater)					
Old boundaries	14	6.7	6.2	12	6.9
New boundaries	15	6.0	6.3	13	6.9
Ditch water in Peat Region					
Old boundaries	5.9	4.2	3.5	4.1	3.7
New boundaries	5.9	4.2	3.5	3.7	3.7
Leaching water in Loess Region (soil moisture)[1]					
Old boundaries	71	52	50	50	#
New boundaries	71	52	50	50	#

[1] No data were available for the Loess Region at the time of the 2012 Derogation Report (Buis *et al.*, 2012).

The nitrate concentrations in ditch water have decreased in the Sand Region as well as the Clay Region (Figure A8.3 and Table A8.4). In the Clay Region, the new regional boundaries have less impact on concentrations in ditch water than on concentrations in water leaching from the root zone. In the Sand Region, the impact is most significant in 2007 and 2008. The data for the 2007-2008 period include six new farms transferring from another region. Three new farms have been included in the 2009-2011 period (Table A8.4). The six new farms included in 2007 and 2008 have a significant impact on nitrate concentrations due to the relatively small size of the population. (In 2007 and 2008, ditch water samples were taken on 23 and 25 farms on sandy soils, respectively.)

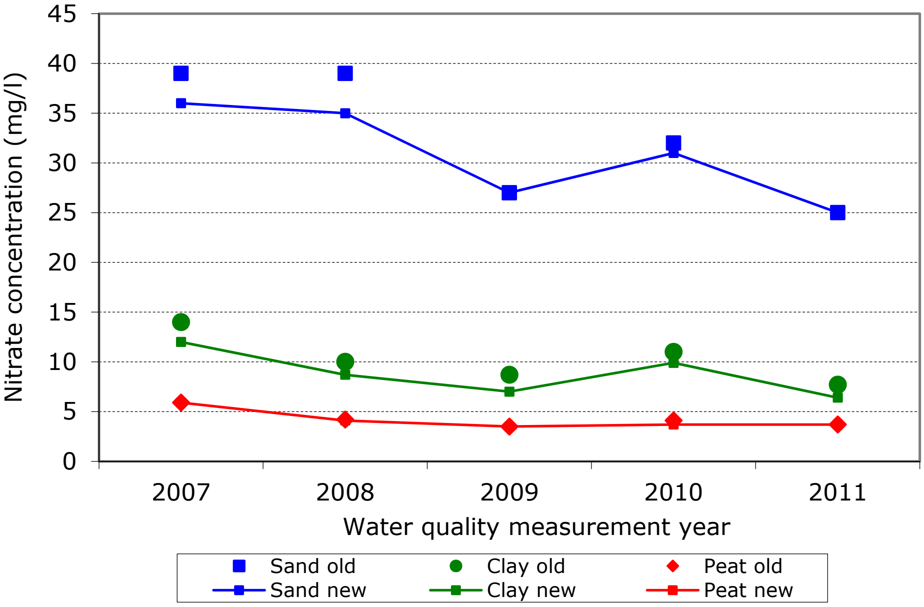

Figure A8.3 Average ditch water nitrate concentration on farms participating in the derogation monitoring network in three regions during the 2007-2011 period

A8.6 Impact on nitrogen soil surplus trends

The transfer of farms from one region to another has limited impact on the nitrogen soil surpluses in the Clay Region and Peat Region (Table A8.5). Under the new regional boundaries, the average nitrogen soil surplus is higher in the Peat Region and lower in the Clay Region. The difference between the old and new situation is negligible in the Sand Region (Figure A8.4 and Table A8.5). The increase in the Peat Region is caused by the transfer to another region of a number of farms with mainly peat and clay soils. As a result, the proportion of farms with non-standard soil types and lower nitrogen soil surpluses has decreased, while the proportion of farms with peat soils has increased (Table A8.2, Table A8.3, Table A8.5). This effect is reversed in the Clay Region.

Table A8.5 Average nitrogen soil surpluses (in kg/ha) during the 2006-2010 period, under the old and new regional boundaries

	2006	*2007*	*2008*	*2009*	*2010*
			Sand		
Old boundaries	178	171	173	191	167
New boundaries	181	171	172	190	169
			Loess		
Old boundaries	133	141	161	163	166
New boundaries	133	141	161	163	166
			Clay		
Old boundaries	210	183	208	217	193
New boundaries	195	178	202	213	180
			Peat		
Old boundaries	245	227	241	236	233
New boundaries	258	240	250	242	247

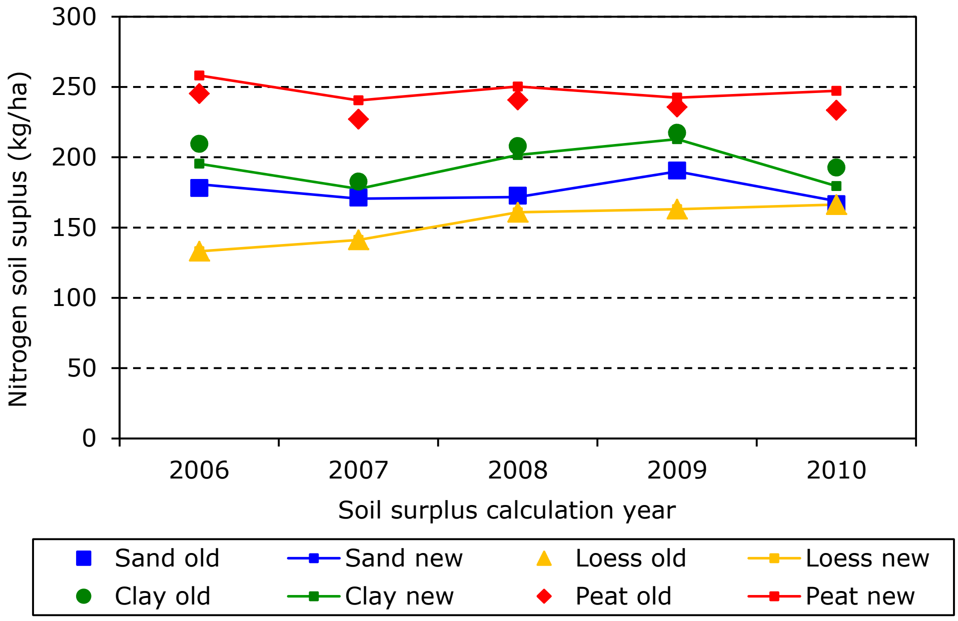

Figure A8.4 Average nitrogen soil surpluses (in kg/ha) on derogation farms in the four regions during the 2006-2010 period

The nitrogen soil surpluses are higher on peat soils than on other soil types, because grassland on peat soil is characterised by substantially higher nitrogen mineralisation (additional mineralisation of 160 kg per hectare of grassland).

A8.7 Conclusions

The proportion of non-standard soil types (i.e. soil types other than the predominant type) decreases under the new regional boundaries. As a consequence, the nitrate concentrations in water leaching from the root zone increase in the Sand Region and decrease in the Clay Region. However, the average nitrate concentrations in water leaching from the root zone in the Sand

Region remain below the 50 mg/l standard, and display the same downward trend under both the new and the old regional boundaries. The nitrate concentrations in ditch water are declining in both the Clay Region and the Sand Region. The nitrogen soil surpluses are increasing in the Peat Region and decreasing in the Clay Region, although the long-term trend is unaffected. We can conclude that the new regional boundaries result in slight differences between the regions, but do not have a major impact on the national picture.

References

- Buis, E., A. van den Ham, L.J.M. Boumans, C.H.G. Daatselaar and G.J. Doornewaard (2012). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2010 in het derogatiemeetnet. Bilthoven, RIVM Report No. 68071028.

Appendix 9 Adjustments to LMM calculation models in the Farm Accountancy Data Network

Consequences for fertilisation, yields and surpluses in the Derogation Monitor
Joan Reijs, Gerben Doornewaard, Marga Hoogeveen and Co Daatselaar

A9.1 Introduction

In recent years, the Agricultural Economics Research Institute (LEI) has thoroughly revised the calculation models used in the Farm Accountancy Data Network (FADN) to calculate figures relating to the Minerals Policy Monitoring Programme (LMM). This Appendix describes the changes that have been introduced. We first describe the overall aim and general approach to adjusting the calculation models. We then describe the impact of these adjustments on all figures registered in the Derogation Monitor for 2010 (the year reported on in the previous report). Thirdly, we describe the effects of these changes on the nitrogen and phosphate surplus trends during the entire reporting period of the Derogation Monitor (Fraters *et al.*, 2008; Zwart *et al.*, 2009; Zwart *et al.*, 2010; Zwart *et al.*, 2011; Buis *et al.*, 2012).

A9.2 Overall aim and general approach to adjusting the calculation models

The models were adjusted in order to achieve the following aims and effects:

1. Create a clear distinction between data, standards and calculation rules
2. Use as much farm-specific information as possible
3. Update all standards and emission factors

Re 1
The old LMM models were fully programmed in the FADN data registration system (known as ARTIS). Because these models did not clearly separate data, standards and calculation rules, they were difficult to maintain and checking the results was time-consuming. In some cases, the applicable standards had been incorporated into the calculation rules. The new models[3] have been reconstructed ‘from the ground up’ (i.e. on the basis of data registered and processed in FADN), so that both the standards and the calculation rules are much easier to maintain. Furthermore, a strict separation has been established between data processing (ARTIS) and calculation rules (GAMS software). As a result, it is much easier to verify data because we can determine if illogical results are caused by errors in the calculation rules or errors in the basic data registered by the bookkeepers (TAMs).

Re 2
Farms are increasingly using farm-specific information to calculate their nutrient utilization. This information was used in the LMM models if available, but it was also ignored or not used optimally in some cases. The new models have been designed to ensure that farm-specific information is used as effectively as possible. This helps us to capitalise on the continually growing number of farms

[3] We refer to ‘old’ and ‘new’ models mainly because of these changes in the setup. No major changes have been made to the calculation system proper (see Chapter 3).

using tools like the Farm-Specific Excretion (BEX) method and Kringloopwijzer (2013).

Re 3
The standards and emission factors used in the new models have been carefully reviewed, resulting in adjustments in many cases. These adjustments are described in further detail below. In implementing the adjustments, we have taken the latest scientific insights and policy developments into account as far as possible. Examples include the updating of the gaseous emission factors based on Velthof *et al.* (2009), and improved harmonisation with the calculation rules used in the guidance document on farm-specific excretion by dairy cattle.

A9.3 Impact of adjustments on figures in Derogation Monitor

A9.3.1 Introduction
In this section we discuss all the key figures included in Chapter 3 of this report, based on the same tables as used in the report. We will first describe the nature of the changes in general terms. The results of the Derogation Monitor for FADN year 2010 (Buis *et al.*, 2012) are then presented in three formats. The first column of Tables 9.1 through 9.6, Table 9.8 and Table 9.9 contains the figures included in the previous report (Buis *et al.*, 2012). The third column (new model based on current population) contains the value calculated using the new models. Compared to the first column, the figures in the third column have been calculated using a different method (new vs. old models), and based on a different number of farms. No data can be reported for a number of farms (under the new as well as the old method), as they did not comply with certain checks. The second column (old model based on current population) therefore contains the hypothetical current values if the old models had been applied to the same population as in the third column (new model based on current population). The number of farms included is lower than the number used in the main text of the reports, as 'drop-outs' under both the new and the old models are excluded. The second column always uses the same excretion calculation method (BEX method or standard-based), whereas a different manure production calculation method can be selected under the new and the old models.
The differences between the figures in the second and third column are discussed in each case. These differences can only be attributed to the effect of the new models. In this context 'new models' must be interpreted in the broadest sense of the word, i.e. including changes to standards, data registration procedures, and calculation rules. The findings are explained at the foot of each table.

A9.3.2 Farm characteristics
Tables A9.1 and A9.2 provide an overview of farm characteristics. These tables are organised in the same manner as Tables 2.3 and 2.4 in Chapter 2 of this report.

Table A9.1 Overview of a number of general characteristics in 2010 of farms participating in the derogation monitoring network (DMN), compared to average values for the Agricultural Census (AC) sample population

Farm characteristic[1]	*Buis et al., 2012*	***Old** model (current population)*	***New** model (current population)*	*Absolute difference (new – old)*	*Relative difference (new / old)*
Number of farms	294	294	294		
Grassland area (hectares)	42.7	42.6	42.5	-0.1	100%
Area used to cultivate silage maize (hectares)	8.8	8.8	8.9	0.0	100%
Other arable land (hectares)	1.0	1.1	1.0	0.0	97%
Total area of cultivated land (hectares)	52.5	52.5	52.4	-0.1	100%
Percentage of grassland	83	83	83	0	100%
Natural habitat (hectares)	1.1	1.2	1.2	0.1	105%
Grazing livestock density (Phosphate Livestock Units per hectare)[2]	2.27	2.27	2.31	0.03	101%
Percentage of farms with stable animals	14	14	10	-4	70%
Specification of livestock density on farms in derogation monitoring network (Phosphate Livestock Units per hectare)[2]					
Dairy cattle (including young animals)	2.14	2.14	2.15	0.00	100%
Other grazing livestock	0.13	0.13	0.16	0.03	124%
Stable animals (total)	0.62	0.62	0.60	-0.02	97%
All animals (total)	2.89	2.89	2.91	0.01	100%

Source: FADN and Statistics Netherlands Agricultural Census 2011, data processed by LEI.

[1] Surface areas are expressed in hectares of cultivated land, excluding natural habitats.

[2] Phosphate Livestock Unit (LSU) is a standard used to compare numbers of animals based on their standard phosphate production (the standard phosphate production of one dairy cow is equivalent to one Phosphate Livestock Unit).

Table A9.2 Average milk production and grazing on dairy farms participating in the derogation monitoring network (DMN) in 2010, compared to the weighted average for dairy farms in the national sample (FADN)

Farm characteristic	*Buis et al., 2012*	***Old** model (current population)*	***New** model (current population)*	*Absolute difference (new – old)*	*Relative difference (new / old)*
Number of farms in DMN	253	252	252		
FPCM production per farm (kg)	859,977	859,969	859,965	-4	100%
FPCM production per hectare of fodder crop (kg)	15,913	15,917	15,867	-50	100%
FPCM production per dairy cow (kg)	8,673	8,673	8,673	0	100%
Percentage of farms with grazing	79	79	79	0	100%

[1] FPCM = Fat and Protein Corrected Milk, a standard used to compare milk with different fat and protein contents (1 kg of milk with 4.00 percent fat content and 3.32 percent protein content = 1 kg of FPCM).

Surface areas

- In the LMM system, fertiliser quantities, yields and surpluses are divided by the total area of cultivated land in order to report figures per hectare. Natural habitats are not taken into consideration here. This has not been changed in the new models.
- In the new models the total area of cultivated land has decreased by an average of 0.1 hectare compared to the old models. This is caused by a minor adjustment to the definition of 'grassland'. Grassland used for purposes other than the production of fodder (e.g. yards, camping sites) is excluded in the new models.
- In addition, the crops are classified according to a new system, resulting in a minimal shift from the 'Silage maize' category to the 'Other arable land' category.
- The percentage of grassland has remained unchanged.

Numbers of animals

- The LSU standards applied to the various categories of animals have changed.
- These changes have resulted in a very slight increase in the total livestock density (from 2.89 to 2.91 Phosphate LSUs per hectare).
- As of 2010, pink veal calves are classified as grazing animals rather than stable animals (National Service for the Implementation of Regulations, 2013). This has resulted in a slight shift from stable animals to grazing animals, and a decrease in the percentage of farms with pigs and poultry from 14 percent in the old models to 10 percent in the new models.

Milk production

- In the LMM system, milk production per farm, per cow and per hectare is calculated based on supplied milk, plus milk used for on-farm dairy production, plus milk used for on-farm consumption or feed production. This method is used in the old as well as the new models.
- The differences in milk production per farm, per hectare and per cow are negligible.
- As the calculation methods for grazing have not changed, the number of farms with grazing has remained unchanged.

A9.3.3 Nitrogen in livestock manure

Table A9.3 provides an overview of the average use of nitrogen in livestock manure. This table is organised in the same manner as Table 3.1 in Chapter 3 of this report.

Table A9.3 Average use of nitrogen in livestock manure (in kg of nitrogen per hectare) in 2010 on farms participating in the derogation monitoring network

Description	*Buis et al., 2012*	***Old** model (current population)*	***New** model (current population)*	*Absolute difference (new – old)*	*Relative difference (new / old)*
Number of farms	280	271	271		
Produced on farm[1]	277	274	270	-4	98%
+ Inputs	10	9	9	0	98%
+ Changes in stocks[2]	-8	-8	-8	0	99%
- Outputs	34	30	29	0	99%
Total	246	245	241	-4	98%
Livestock manure application standard	246	N/A			
Use on arable land[3]	166	167	163	-4	98%
Use on grassland[3]	260	259	255	-4	99%

[1] Calculated on the basis of standard quantities, with the exception of dairy farms that reported they were using the guidance document on farm-specific excretion by dairy cattle (see Appendix 3, section A3.2.1).
[2] A negative change in stocks is a stock increase and corresponds to output.
[3] The average use data and the application standards for grassland and arable land are based on 274 farms and 201 farms, respectively, instead of on 280 farms. This is because on 6 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 73 farms had no arable land.

Manure produced on farm (excretion)

- Both in the new and in the old models, manure production in FADN is calculated partly on the basis of standard quantities and partly according to the farm-specific method. Farm-specific manure production on dairy farms is calculated using the BEX method, while manure production on factory farms (with mainly pigs and/or poultry) is calculated using the 'stable balancing method'. The farm-specific method for calculating manure production is only used in the Derogation Monitor if the farm meets the criteria used by Aarts *et al.* (2008), if the farmer reports that he is using the BEX method, and if the calculation results are plausible. Calculations for the other farms are performed using the standard quantities given in Tables 4 and 6 (National Service for the Implementation of Regulations, 2013).
- This analysis is based on the data of 271 farms. A consistent method has been used to calculate the excretion quantities of these 271 farms. The farm-specific calculation method is used for 68 farms, and the standard-based calculation method is used for the remaining 203 farms.
- In the old models, Table 6 (National Service for the Implementation of Regulations, 2013), which contains data about standard-based excretion by dairy cows, had not been updated in the FADN. In 2010 the old models still used the 2009 standards, which allow for higher quantities than the 2010 standards. For the 203 farms where production was calculated based on standard quantities, this means that the new models result in an average nitrogen excretion per hectare that is 3.8 kg (1.5 percent) lower than in the old models.
- The BEX method has been reprogrammed to eliminate a number of inconsistencies with the BEX method as described in the guidance document. These inconsistencies mainly concerned the calculation of fodder

requirements and fixation of nitrogen and phosphorus in animals. The BEX calculation method may also results in differences in fodder composition compared to the old models (also see the section A9.3.5). There remain two differences between the BEX calculation system as described in the guidance document and the BEX calculation system in the Farm Accountancy Data Network (based on Aarts *et al.*, 2008):

- o In FADN, we have not adopted the revised calculation method applied in the guidance document for energy uptake from silage maize expressed in fodder units (VEM). As in Aarts *et al.* (2008), the energy uptake from silage maize in FADN is still derived directly from the silage maize yields reported by the farmer, corrected for stocks.
- o In FADN, the allocation of fodder units to fresh vs. conserved grass is calculated based on the net number of grazing hours reported by the farmer, whereas the guidance document and Aarts *et al.* (2008) define three classes based on reported grazing hours.

- For the 68 farms where excretion quantities are calculated using the farm-specific method, the model adjustments result in an average decrease of the excretion quantity of 5.3 kg of nitrogen per hectare (2 percent).
- When we consider the entire population, the calculated nitrogen excretion (nitrogen in livestock manure produced on-farm) decreased on average by 4.2 kg per hectare (1.6 percent) compared to the old models.

Inputs, outputs and stock changes for livestock manure

- Compared to the old models, the new models use revised standards and calculation methods for the composition of manure.
  - For inputs of livestock manure, calculations are usually performed using farm-specific contents derived from sampling results. If no sampling results are available, we can fall back on the standard quantities stated in Table 5 (National Service for the Implementation of Regulations, 2013). This approach was used in the old model and continues to be applied in the new model.
  - For outputs of on-farm manure, calculations are also performed using sampling results (if available). If no sampling results are available, the standard contents (Table 5 in National Service for the Implementation of Regulations, 2013) are corrected in the new models to account for farm-specific manure production. For instance, if application of the farm-specific excretion (BEX) method produces an excretion of 90 percent of the standard excretion quantity, outputs of on-farm manure are estimated at 90 percent of the quantity calculated using the standard contents in the aforementioned Table 5 (National Service for the Implementation of Regulations, 2013). The standard contents are used if the BEX method is not applied.
  - Both in the old and in the new models, the contents in stocks of on-farm manure are based solely on standard contents (using so-called ‘manure codes’, refer to Table 5 in National Service for the Implementation of Regulations, 2013). In future, the composition of stocks may be corrected to account for on-farm excretion (if calculated using the BEX model), but this has not been implemented yet.

  - Contents in stocks of externally supplied manure are determined based on sampling results. If such results are not available, calculations are performed based on standard contents (Table 5 in National Service for the Implementation of Regulations, 2013). In the new models, sampling results are used more frequently.
  - The standard-based composition of liquid cattle manure (Table 5 in National Service for the Implementation of Regulations, 2013) was adjusted with effect from 2010. The nitrogen content was reduced from 4.5 to 4.2 g/kg. This change was not incorporated into the old models, but has now been included in the new models.

- The changes described above have only a limited effect (less than 2 percent) on the calculated quantities of nitrogen in inputs, outputs and stock changes in 2010. It should be noted that the impact on individual farms may be considerable, and is expected to increase in future as a growing number of farms calculate their manure production using the BEX method.

Nitrogen in livestock manure at farm level
- Both in the old and in the new models, the quantity of nitrogen in livestock manure at farm level is calculated as follows: production (excretion) + initial stocks + inputs – closing stocks – outputs. This concerns the quantity of nitrogen after deducting gaseous emissions resulting from stabling, storage and grazing, but prior to application.
- The new models produce an average total quantity of nitrogen in livestock manure that is 4 kg per hectare (2 percent) lower than in the old models. This is caused by the previously described changes in excretion, inputs, outputs, and stock changes. In general terms, we can state that a 4 kg decrease in excretion will also result in a 4 kg reduction in fertiliser use.
- The application standard for livestock manure has not been calculated in the new model, as we cannot define with certainty the portion of the surface area to which derogation may be applied. The derogation application is linked to a BRS number. The surface area registered in FADN does not necessarily correspond to the surface area registered under the relevant BRS number of the farm concerned. Furthermore, FADN farms sometimes have multiple BRS numbers. By consequence, it is impossible to determine the surface area to which derogation applies, and therefore also impossible to calculate the exact application standard for livestock manure.

Allocation of nitrogen in livestock manure to arable land and grassland
- In the new model, the allocation of nitrogen in livestock manure to arable land and grassland is calculated according to a slightly different method than in the old model. In both cases the quantity of manure applied to arable land (expressed in tonnes or cubic metres) is considered a fixed variable. In the old model, this quantity was always multiplied by the applicable standard (Table 5 in National Service for the Implementation of Regulations, 2013) to calculate fertiliser use on arable land. In the new model, farm-specific standards will be used as much as possible. On-farm manure is treated in the same way as output manure (see above), while contents based on sampling results are used for externally supplied manure.
- The quantity of fertiliser applied on grassland is calculated as the closing entry: Fertiliser use on grassland = Fertiliser use at farm level -/- Fertiliser use on arable land. In the case of farms where grassland accounts for less than 25 percent of the total cultivated area, the fertiliser use on grassland is

calculated based on allocations, and the fertiliser use on arable land is calculated as the closing entry. However, this situation does not occur on derogation farms.

- On average, these changes produce only very limited changes in the allocation of nitrogen in livestock manure to grassland and arable land. Both for arable land and grassland, the average quantity of nitrogen in livestock manure decreases by 4 kg per hectare. Of course, the changes may result in more significant differences for individual farms.

A9.3.4 Use of fertilisers
Tables A9.4 and A9.5 provide an overview of the average use of nitrogen and phosphate in fertilisers. These tables are organised in the same manner as Tables 3.3 and 3.4 in Chapter 3 of this report.

Table A9.4 Average use of nitrogen in fertilisers (expressed in kg of plant-available nitrogen per hectare)[1] on farms participating in the derogation monitoring network in 2010

Description	*Item*	*Buis et al., 2012*	***Old** model (current population)*	***New** model (current population)*	*Absolute difference (new – old)*	*Relative difference (new / old)*
Number of farms		280	271	271		
Average statutory availability coefficient for livestock manure (%)		50	49	49	0	99%
Fertiliser use	Livestock manure	123	121	118	-4	97%
	Other organic fertilisers	0	0	0	0	100%
	Inorganic fertilisers	120	121	124	3	102%
	Total average fertiliser use	243	242	241	-1	100%
	Nitrogen application standard	263	261	259	-3	99%
Use of plant-available nitrogen on arable land[2]		122	119	117	-2	98%
Application standard for arable land[2]		158	160	154	-6	96%
Use of plant-available nitrogen on grassland[2]		269	267	266	-1	100%
Application standard for grassland[2]		284	282	281	-1	100%

[1] Calculated on the basis of the applicable statutory availability coefficients (see Appendix 3).
[2] The average use data and the application standards for grassland and arable land are based on 274 farms and 201 farms, respectively, instead of on 280 farms. This is because on 6 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 73 farms had no arable land.

Use of plant-available nitrogen in fertilisers

- The quantity of plant-available nitrogen in livestock manure (Table A9.4) is calculated based on the availability coefficients stated in Table 3 (National Service for the Implementation of Regulations, 2013). The availability coefficient depends on farm-related and environmental factors as well as the time of fertilisation (refer to Table 3, National Service for the Implementation of Regulations, 2013). The calculation method is rather complex and has been reprogrammed in the new models.

- The revised calculation method has produced a slightly lower availability coefficient (49.5 down from 50.0). Combined with the 4 kg decrease in the use of nitrogen in livestock manure (as described above), this lower average availability coefficient results in a 4 kg decrease in the average quantity of plant-available nitrogen in livestock manure.
- The quantity of plant-available nitrogen in inorganic fertilisers and other organic fertilisers is calculated by multiplying the applied quantity by the relevant content percentage. If the composition of the supplied fertilisers is known, these data are used. If the composition of the supplied fertilisers is not known, the standard composition is used. When the models were revised, the standard compositions of all fertiliser types were also updated.
- This update of the standards has resulted in a 2 percent increase in the quantity of nitrogen in inorganic fertilisers in 2010 (from 121 to 124 kg). The quantity of plant-available nitrogen in other organic fertilisers has also increased slightly, but remains very low at 0.2 kg of nitrogen per hectare.
- The net effect of these changes is that the average total quantity of plant-available nitrogen has decreased by 1 kg (less than 1 percent).

Table A9.5 Average use of phosphate in fertilisers (in kg of P_2O_5 per hectare) in 2010 on farms participating in the derogation monitoring network

Description	*Item*	*Buis et al., 2012*	***Old** model (current population)*	***New** model (current population)*	*Absolute difference (new – old)*	*Relative difference (new / old)*
Number of farms		280	271	271	0	
Fertiliser use	Livestock manure	86	86	86	-1	99%
	Other organic fertilisers	0	0	0	0	109%
	Inorganic fertilisers	3	3	3	0	103%
	Total average fertiliser use	89	90	89	-1	99%
	Phosphate application standard	91	91	91	0	100%
Use of phosphate on arable land[1]		81	81	72	-9	89%
Application standard for arable land[1, 2]		80	79	77	-2	97%
Use of phosphate on grassland[1]		91	91	93	1	102%
Application standard for grassland[1, 2]		93	94	94	0	100%

[1] The average use data and the application standards for grassland and arable land are based on 274 farms and 201 farms, respectively, instead of on 280 farms. This is because on 6 farms the allocation of fertilisers to arable land did not fall within the confidence intervals, and because 73 farms had no arable land.

[2] Because no classification is available, figures are based on the averages in the Combined Data Collection 2010, which show that 10 percent of agricultural land has a low phosphate

status and 20 percent has a neutral phosphate status. Consequently, it must be concluded that 70 percent of agricultural land has a high phosphate status (Van den Ham *et al.*, 2011, based on DR data). In order to qualify for the application standard pertaining to land with 'low' or 'neutral' phosphate status, farmers must submit a soil analysis to the government. If no analysis is submitted, the low phosphate application standard associated with the 'high' phosphate status class is automatically applied, in accordance with the provisions of the Fertilisers Act. A phosphate application standard of 120 kg per hectare applies to plots with low phosphate contents or a high level of phosphate fixation.

Use of phosphate in fertilisers

- Both in the old and in the new models, the quantity of phosphate in livestock manure at farm level is calculated as follows: production (excretion) + initial stocks + inputs – closing stocks – outputs. These calculations take account of the same changes in inputs, outputs and stocks as is the case for the nitrogen calculations. In 2010, the phosphate content in the standard composition of livestock manure was adjusted (from 1.9 to 1.7 grammes of phosphate per kg; see Table 5 in National Service for the Implementation of Regulations, 2013).
- Due to the changes described above, the average use of phosphate in livestock manure decreased by 1 percent from 86.4 to 85.7 kg of phosphate per hectare.
- In connection with the updated standard composition of fertilisers, the use of phosphate in inorganic fertilisers has increased by 3 percent and the use of phosphate in other organic fertilisers has increased by 9 percent. However, the increase amounts to less than 0.5 kg in absolute terms.
- The net effect of these changes is that the total quantity of phosphate used in fertilisers has decreased by less than 1 kg (1 percent).
- In the new models, the use of phosphate on arable land has decreased by 11 percent compared to the old models. This is caused by a change in the calculation of the quantity of livestock manure applied to arable land. In addition to the reduced standard content (from 1.9 to 1.7 grammes per kg), farms using the BEX method correct the standard to account for farm-specific excretion (see description above). Decreased fertilisation on arable land has resulted in increased fertilisation on grassland, as the quantity of fertiliser applied to grassland is calculated as the closing entry (total use of fertilisers on farm minus use of fertilisers on arable land). The 2 percent increase in fertiliser use on grassland, compared to the 11 percent decrease in fertiliser use on arable land, can be explained by the fact that the acreage of grassland on these farms is almost five times the acreage of arable land.

Application standards

- The average application standards for grassland and arable land are calculated by multiplying the crop areas registered in FADN by the application standards stated in Tables 1 and 2 (National Service for the Implementation of Regulations, 2013). This calculation procedure has been redesigned to make it clearer which standards apply to which surface areas.
- Phosphate differentiation has been applicable since 2010 (depending on the phosphate status of the soil). In the old LMM models, a manual correction was applied to account for phosphate differentiation. In the new models, the application standard for each separate farm is derived from the phosphate status.
- The newly calculated application standards are lower than in the old models, particularly for arable land. The average nitrogen application standard for

arable land is 6 kg (4 percent) lower, while the average phosphate application standard is 2 kg (3 percent) lower.
- The revised calculation method has hardly any effect on the average application standards for grassland.
- The average nitrogen application standard for the entire farm (calculated as the weighted average of the standards for arable land and grassland) has decreased slightly (by 1 percent). The average phosphate application standard remains virtually unchanged.

A9.3.5 Grassland and silage maize yields
Table A9.6 provides an overview of the average crop yield. This table is organised in the same manner as Table 3.5 in Chapter 3 of this report.

General description of changes
The system described in Aarts *et al.* (2008) is used to calculate the grassland and silage maize yields. In the old model, we deviated from the method applied by Aarts *et al.* (2008) in a number of respects. These deviations are described in Appendix 3 of this report in each case. The deviations concerned:
1. Composition of silage grass
2. More specific grazing data
3. Different use of loss percentages

Re 1
In Aarts *et al.* (2008), the calculations are performed using provincial average compositions of silage grass and silage maize pits. In the old LMM models, the calculations were performed using farm-specific data on silage grass pit composition (if available) and a national average if no farm-specific information was available. In the new LMM models, we use farm-specific information and average values for the different soil types (sand, loess, clay, peat).

Re 2
In Aarts *et al.* (2008), the grazing supplement and the allocation of energy uptake to fresh grass vs. conserved grass are calculated based on three grazing categories, whereas the old LMM model used the exact number of grazing days and hours to calculate these two figures (see also section A9.3.2 in this Appendix). The new LMM models retain the system of the old LMM models.

Re 3
In the old LMM models, the method used to calculate the conservation losses differed slightly from the method used in Aarts *et al.* (2008). The new LMM models precisely copy the method used in Aarts *et al.* (2008). This means that the calculated losses for grassland have increased slightly.

Table A9.6 Average crop yields (in kg of dry matter, nitrogen, phosphorus and P_2O_5 per hectare) for silage maize (estimated) and grassland (calculated) in 2010, on farms participating in the derogation monitoring network that meet the criteria for application of the calculation method (Aarts et al., 2008).

Description	*Buis et al., 2012*	***Old** model (current population)*	***New** model (current population)*	*Absolute difference (new – old)*	*Relative difference (new / old)*
Silage maize yields					
Number of farms	146	125	125		
Kg of dry matter per hectare	15,601	15,624	15,984	360	102%
Kg of nitrogen per hectare	183	183	186	3	102%
Kg of phosphate per hectare	31	31	30	-1	97%
Kg of P_2O_5 per hectare	71	71	68	-2	97%
Grassland yields					
Number of farms	193	157	157		
Kg of dry matter per hectare	9,659	9,572	9,415	-157	98%
Kg of nitrogen per hectare	257	254	260	6	102%
Kg of phosphate per hectare	37	36	37	1	102%
Kg of P_2O_5 per hectare	85	83	85	2	102%

Impact on results

- The adjusted calculation method has resulted in a slight increase in the dry matter yields of silage maize, at the expense of grassland. The grassland yields decreased by 2 percent, while the silage maize yields increased by 2 percent.
- The changes in the nitrogen and phosphate yields do not always correspond with the changes in dry matter yields. This is caused by the more frequent use of farm-specific data on the composition of silage maize and conserved grass, and regional instead of national averages (if farm-specific data are not available).
- On average, the nitrogen and phosphate contents for grassland are slightly higher than in the old models.
- In the case of silage maize, the nitrogen contents are similar to the old models and the phosphate contents are slightly lower.

A9.3.6 Surpluses

Changes in the calculation of farm surpluses

The mineral or nutrient balance at farm level is the basis of data registration in FADN. This balance specifies the consumption (input) and production (output) of nitrogen and phosphate as accurately as possible.
No fundamental changes have been introduced in the system used. The quantities, nitrogen contents and phosphate contents of all transactions and stocks of physical products are registered or calculated, either on the basis of farm-specific sampling results or on the basis of standards. The changes concern

1) different classification of the underlying items in the mineral balance, and
2) an update of all standards used.
The second change affects the level of the surplus, while the first change actually does not constitute more than a change in presentation (as the LMM system so far does not include efficiency figures). Table A9.7 provides an overview of the mineral balance under the new models.

Table A9.7 New arrangement of the mineral (nutrient) balance

Consumption (input)	Feedstuffs	Balance of all inputs and stock decreases of all feed products (feed concentrate, roughage, etc.)
	Inorganic fertilisers	Balance of all inputs, outputs and stock changes of inorganic fertilisers
	Organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net consumption (input)
	Plant products	Concerns only inputs of plant products
	Animals	Concerns only inputs of animals
	Other products	Balance of all inputs, outputs and stock changes of all other products in the case of net consumption (input)
Production (output)	Animal products	Balance of all inputs, outputs and stock changes of all milk and other animal products
	Animals	Balance of outputs and stock changes of animals and meat
	Plant products	Balance of outputs and stock changes of plant products (crops not intended for roughage), and stock increases and sales of roughage
	Organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net production (output)
	Other products	Balance of all inputs, outputs and stock changes of all other products in the case of net production (output)

The standards needed to be updated because obsolete data were used in a number of cases. In some cases, the applicable standards had been incorporated into the calculation rules. The new, more structured set-up creates a strict separation and makes it easier to maintain standards. The applicable standards are based on the following data sources:

- Animals and animal products: guidance document on farm-specific excretion by dairy cattle (Ministry of Agriculture, Nature & Food Quality, 2010) and Table 7 (National Service for the Implementation of Regulations, 2013) (stable balance)
- Crops and plant products: Van Dijk, 2003
- Feed products: fodder value tables (Centraal Veevoederbureau, 2012)
- Livestock manure: National Service for the Implementation of Regulations (2010-2013)
- Inorganic fertilisers: Nutrient Management Institute fertiliser database (2013)

For products that are not included in these databases, the standards are based on Internet search queries among suppliers.

For conserved grass, silage maize and compound feed, the farm-specific nitrogen and phosphate contents are used to estimate inputs, outputs and stock changes if possible. In the case of conserved grass and silage maize, the data are based on pit sampling results. If no sampling results are available, a standard for the relevant soil type region is used.
In the case of compound feed, the information in the new models is derived from the annual overviews of feed suppliers, whereas the old models used data on standard compositions. As of 2010, almost all farms make use of these annual overviews. With retroactive effect to 2006, the compound feed composition in the new models has been adjusted in line with the average composition data reported by the Working Group on Uniform Mineral and Manure Figures (WUM) (Statistics Netherlands, 2010).
In the new model, the inputs, outputs and stocks of animals and animal products are calculated in full conformity with the calculation rules provided in the guidance document on farm-specific excretion by dairy cattle (Ministry of Agriculture, Nature & Food Quality, 2010) and the 'stable balancing method' (Table 7, National Service for the Implementation of Regulations, 2013). In addition to data on the numbers of animals, weight data are also used if this information is available in FADN. The old models used several obsolete standards (Beukeboom, 1996) and an obsolete method to calculate the quantities of nitrogen and phosphate in milk.
The quantification of inputs, outputs and stock changes of livestock manure is described in section A9.3.3.

Impact on farm surpluses

Tables A9.7 and A9.8 provide an overview of the calculated surpluses and their composition. These tables are organised in the same manner as Tables 3.6 and 3.7 in Chapter 3 of this report.

Table A9.8 Nitrogen surplus on the soil surface balance (in kg of nitrogen per hectare) in 2010 on farms participating in the derogation monitoring network

Description	*Item*	*Buis et al., 2012*	***Old** model (current population)*	***New** model (current population)*	*Absolute difference (new – old)*	*Relative difference (new / old)*
Number of farms		280	271	271		
Farm inputs	Inorganic fertilisers	120	121	124	3	102%
	Organic fertilisers	15	13	10	-3	74%
	Feedstuffs	174	169	192	23	114%
	Animals	5	4	2	-2	56%
	Other (including plant products)	6	5	2	-3	33%
	Total	319	312	329	17	106%
Farm outputs	Milk and animal products	75	75	78	3	104%
	Animals	23	20	20	-1	96%
	Organic fertilisers	46	41	37	-4	90%
	Other (including plant products)	2	2	14	12	682%
	Total	146	139	149	10	107%
Average nitrogen surplus per farm		173	173	180	8	104%
+ Deposition		31	31	24	-7	77%
+ Mineralisation		22	22	24	2	109%
+ Biological nitrogen fixation		5	5	5	-1	88%
- Gaseous emissions resulting from stabling and storage		30	30	33	3	111%
- Gaseous emissions resulting from application		12	11	19	9	180%
- Gaseous emissions resulting from grazing		4	4	1	-3	24%
Average nitrogen surplus on soil surface balance		185	186	179	-7	96%

[1] Gaseous emissions resulting from stabling and storage, and during application and grazing.

Inputs of inorganic fertilisers

- As described in section A9.3.4 of this Appendix, the inputs of inorganic fertilisers in the new models increased by 2 percent for nitrogen and 3 percent for phosphate as a result of the updated standards.

Inputs of feed products

- The inputs of feed products increased by 14 percent (23 kg) for nitrogen and 18 percent (11 kg) for phosphate. This increase is caused by two factors:
  - From 2010 onward, the new models perform almost all calculations using farm-specific composition data for compound feed, whereas the old models still used standard-based quantities in many cases. This has resulted in an increased input of feed products compared to the old models.
  - In the new models, all stock increases and sales of roughage are regarded as outputs of 'Other products' (including plant products),

whereas in the old models these outputs were netted with inputs of feed products. This has also resulted in an increased input of feed products.

Table A9.9 Phosphate surpluses on the soil surface balance (in kg of P_2O_5 per hectare) in 2010 on farms in the derogation monitoring network

Description	*Item*	*Buis et al., 2012*	***Old** model (current population)*	***New** model (current population)*	*Absolute difference (new – old)*	*Relative difference (new / old)*
Number of farms		280	271	271		
Farm inputs	Inorganic fertilisers	3	3	3	0	103%
	Organic fertilisers	7	7	5	-2	75%
	Feedstuffs	62	60	71	11	118%
	Animals	3	2	1	-1	59%
	Other (including plant products)	2	2	0	-1	24%
	Total	77	73	80	7	110%
Farm outputs	Milk and animal products	29	30	31	2	105%
	Animals	13	12	11	0	96%
	Organic fertilisers	22	19	17	-2	89%
	Other (including plant products)	1	1	5	4	650%
	Total	65	61	64	3	105%
Average phosphate surplus on soil surface balance		12	12	16	4	138%

Inputs and outputs of organic fertilisers

- As explained in section A9.3.3 of this Appendix, there are hardly any changes in the new models with respect to inputs, outputs and stock changes of organic fertilisers. The changes in inputs and outputs apparent in Tables A9.8 and A9.9 are the effect of changes in classification, and cancel each other out.

Inputs and outputs of animals

- Both inputs and outputs have decreased, for nitrogen as well as phosphate (Tables A9.8 and A9.9). In part, these differences are the effect of changes in classification and cancel each other out. The updated standards for inputs and outputs of animals have resulted in a slight net increase (inputs – outputs) in outputs of nitrogen (5 percent) and phosphate (6 percent) in animals.

Inputs and outputs of other products (including plant products)

- The classification system for this category was also changed. The average net output (output – input) of other products (mainly plant products) has increased by approx. 15 kg of nitrogen and 5 kg of phosphate. This was mainly caused by changes in classification. Sales and stock changes of roughage are now designated as outputs of plant products, and no longer netted with inputs of feed products.
- If feed and other products (including plant products) are totalled, the net input has increased by 8 kg of nitrogen (5 percent) and 5 kg of phosphate

(9 percent). This is caused by the updated standards for feed products and especially by the more specific composition of compound feed.

Outputs of milk and other animal products

- The updated standards for milk and other animal products have resulted in an increase in the average output of nitrogen by 4 percent (3 kg per hectare) and an increase in the output of phosphate by 5 percent (2 kg per hectare).

Mineralisation

- The standard quantities for the calculation of mineralisation have remained unchanged: 160 kg of nitrogen per hectare per year for grassland on peat soil, and 20 kg of nitrogen per hectare per year for all other crops on peatland and reclaimed peat subsoils. The calculation method for mineralisation has changed, however.
- In the new models, mineralisation on peat soils is calculated according the farm-specific method by multiplying the aforementioned standard quantities with the surface area covered by grassland on peat soils and arable land on peat soils. Data about reclaimed peat subsoils has not been registered in FADN since 2006. In the new LMM models, the proportion of reclaimed peat subsoils at farm level is derived from the postcode. In the old models, mineralisation on reclaimed peat subsoils has not been calculated at farm level since 2006. Instead, the proportion of reclaimed peat subsoils was estimated per region.
- In 2010, the different calculation method resulted in an increase in the average mineralisation (9 percent, 2 kg of nitrogen per hectare).

Nitrogen fixation

- The method used to calculate nitrogen fixation in grass clover has been changed. In the old models, nitrogen fixation was calculated based on the clover proportion estimated by the farmer. The following standard quantities were used:
  - Clover proportion less than 5 percent: 10 kg of nitrogen per hectare
  - Clover proportion 5 to 15 percent: 50 kg of nitrogen per hectare
  - Clover proportion more than 15 percent: 100 kg of nitrogen per hectare

  In the new models, the quantity of nitrogen fixation depends on the grassland yield, and is expressed per kg of dry matter:
  - 0 to 1 percent clover: 0 kg
  - 1 to 5 percent clover: 0.03 kg
  - 5 to 15 percent clover: 0.1 kg
  - More than 15 percent clover: 0.2 kg

  The method used here is derived from Kringloopwijzer (2013).
- The method used to calculate nitrogen fixation in other crops has remained unchanged. The following standard quantities were used:
  - Lucerne: 160 kg of nitrogen per hectare
  - Peas, broad beans, kidney beans and French beans: 40 kg of nitrogen per hectare
  - Other leguminous plants: 80 kg of nitrogen per hectare
- In 2010, the revised calculation method for nitrogen fixation in clover resulted in a decrease of 0.7 kg of nitrogen per hectare (12 percent).

Nitrogen deposition

- The data on nitrogen deposition (processed to obtain provincial averages) are derived from RIVM calculations. This method has not been changed. In the old models, the level of nitrogen deposition was kept constant at the 2002 level (average of 31 kg of nitrogen per hectare).
- The new models use annual deposition data (RIVM, 2013). LEI converts these data into averages for each province. Compared to the 2002 level, the average was substantially lower in 2010 (24 kg of nitrogen per hectare), and slightly lower in 2011 (28 kg of nitrogen per hectare).
- The deposition levels from 2006 onwards will generally be lower than previously reported, because annual data are used.
- In the new models, the input of nitrogen by means of deposition in 2010 was 7 kg per hectare (23 percent) lower than in the old models.

Gaseous nitrogen emissions

The emission factors for emissions resulting from accommodation in stables, grazing and application of livestock manure have been changed. The new models are based on Velthof *et al.* (2009). In the new models, ammonia emissions are calculated based on the Total Ammonia Nitrogen (TAN) percentage.

Emissions resulting from application

- The ammonia emission factors for application of livestock manure and inorganic fertilisers have been adjusted based on the insights in Velthof *et al.* (2009). Other gaseous nitrogen emissions resulting from application are not taken into consideration, neither under the old models nor under the new models.
- Emissions resulting from application are calculated as a percentage of the applied ammonia nitrogen based on the emission factors as reported in Appendix 14 in Velthof *et al.* (2009). If no information on the application method is available, the new models use a regional standard. This standard is derived using the MAMBO method (De Koeijer *et al.*, 2012). In the old models, 5 percent of the applied quantity of nitrogen was assumed in this case. In the new models, the application method is known for a much larger proportion of farms.
- In 2010, the changes described above led to an increase in gaseous emissions resulting from application that amounted to 9 kg of nitrogen per hectare (increase of 80 percent). A comparable increase in emissions resulting from application will also apply to other years.

Emissions resulting from grazing, stabling and storage

- Other gaseous emission are included here.
- For farms that use a farm-specific calculation method for manure production, emissions resulting from grazing, stabling and storage are calculated as follows:
    - Ammonia emissions resulting from stabling and storage: the stable code under the Ammonia and Livestock Farming Regulations (*Regeling Ammoniak en Veehouderij*, RAV) is used as a starting point. The total nitrogen emissions are calculated as a percentage of the emitted ammonia nitrogen (based on the RAV emission factor).
    - Ammonia emissions resulting from grazing are calculated as a percentage (3.5 percent) of the total quantity of ammonia nitrogen excreted on grassland.

- For farms where excretion is calculated based on standard quantities, the emissions resulting from grazing, stabling and storage are calculated as follows:
    - The gross standard-based excretion is calculated by adding the standard-based emission factor to the net standard-based excretion (Oenema *et al.*, 2000). This factor depends on the type of animal (11.3 percent for dairy cows).
    - The emissions resulting from grazing are then calculated by multiplying the nitrogen excreted in grassland manure (net standard-based excretion * grassland fraction) by 3.5 percent and then multiplied by the fraction of the total quantity of ammonia nitrogen in manure.
    - The emissions resulting from stabling and storage are calculated as the gross standard-based excretion minus the net standard-based excretion.

- In the old models, the standard-based calculation method was also applied to farms that used the farm-specific method to calculate manure production. Furthermore, the old models used an emission factor for grazing that amounted to 8 percent of the total nitrogen quantity (now 3.5 percent of the total quantity of ammonia nitrogen).
- Compared to the old models, the nitrogen emissions resulting from grazing have decreased by 3 kg of nitrogen per hectare (from 4 to 1 kg per hectare), while the nitrogen emissions resulting from stabling and storage have increased by 3 kg of nitrogen per hectare (from 30 to 33 kg of nitrogen per hectare).

Soil surpluses
As a result of the previously described changes, the average nitrogen soil surplus in the Derogation Monitor in 2010 has decreased by 7 kg per hectare (4 percent), while the phosphate surplus has increased by 4 kg per hectare (38 percent).

Summary of the main effects
The main effects of the changes in the calculation models on the results in the Derogation Monitor in 2010 (Buis *et al.*, 2012) may be summarised as follows:
1. When we consider the entire population, the calculated nitrogen excretion (nitrogen in livestock manure produced on-farm) decreased on average by 4.2 kg per hectare (1.6 percent) compared to the old models.
2. The changes have only a limited effect (less than 2 percent) on the calculated quantities of nitrogen in inputs, outputs and stock changes of livestock manure in 2010. It should be noted that the impact on individual farms may be considerable, and is expected to increase in future as a growing number of farms calculate their manure production using the BEX method.
3. The net effect of these changes is that the average total quantity of phosphate and plant-available nitrogen in fertilisers has decreased by less than 1 percent.
4. In the new models, the use of phosphate on arable land has decreased by 11 percent compared to the old models. This is caused by a change in the calculation of the quantity of livestock manure applied to arable land. Decreased fertilisation on arable land has resulted in a 2 percent increase in fertilisation on grassland.

5. The newly calculated application standards are lower than in the old models, particularly for arable land. The average nitrogen application standard for arable land is 6 kg (4 percent) lower, while the average phosphate application standard is 2 kg (3 percent) lower. The revised calculation method has hardly any effect on the average application standards for grassland.
6. The adjusted calculation method has resulted in a slight increase in the dry matter yields of silage maize, at the expense of grassland. The grassland yields decreased by 2 percent, while the silage maize yields increased by 2 percent.
7. The changes in the nitrogen and phosphate yields do not always correspond with the changes in dry matter yields. This is caused by the use of more specific nitrogen and phosphate contents. On average, the nitrogen and phosphate contents for grassland are slightly higher than in the old models. In the case of silage maize, the nitrogen contents are similar to the old models and the phosphate contents are slightly lower.
8. In the new models, more farm-specific information about the composition of feed concentrates is used. In addition, all standards used have been updated. This has resulted in a net increase in inputs amounting to 8 kg of nitrogen (5 percent) and 5 kg of phosphate (9 percent) in feed and plant products.
9. The input of inorganic fertilisers in the new models has increased by 2 percent for nitrogen and 3 percent for phosphate as a result of the updated standards.
10. The updated standards for inputs and outputs of animals have resulted in a slight net increase (inputs – outputs) in outputs of nitrogen (5 percent) and phosphate (6 percent) in animals.
11. The updated standards for milk and other animal products have resulted in an increase in the average output of nitrogen by 4 percent (3 kg per hectare), and an increase in the output of phosphate by 5 percent (2 kg per hectare).
12. The different calculation method has resulted in an increase in average mineralisation of 9 percent (2 kg of nitrogen per hectare).
13. The revised calculation method for nitrogen fixation in clover has resulted in a decrease of 0.7 kg of nitrogen per hectare (12 percent).
14. The deposition levels from 2006 onwards will generally be lower than previously reported, because annual data are used. Nitrogen inputs through deposition in 2010 were 7 kg per hectare (23 percent) lower than in the old models.
15. The updated calculation method for gaseous emissions resulting from application resulted in 2010 in an increase of 9 kg of nitrogen per hectare (80 percent).
16. Compared to the old models, the nitrogen emissions resulting from grazing have decreased by 3 kg of nitrogen per hectare (from 4 to 1 kg per hectare), while the nitrogen emissions resulting from stabling and storage have increased by 3 kg of nitrogen per hectare (from 30 to 33 kg of nitrogen per hectare).
17. All the changes described above affect the calculated surpluses, sometimes in opposite directions. The net effect is a decrease in the nitrogen soil surplus of 7 kg per hectare, and an increase in the phosphate surplus of 4 kg per hectare (38 percent).

A9.4 Effects on trends in surpluses during 2006-2010 period

A9.4.1 Introduction

The new LMM models not only affect the results for 2010 and beyond, but also affect the results of previous years. The new models are expected to have the same general effects on previous years as they did on the 2010 results, but there may be slight variations from year to year. In this section, we describe how the changes to the calculation models affect the nitrogen and phosphate soil surpluses of previous years in the Derogation Monitor (Fraters *et al.*, 2008; Zwart *et al.*, 2009; Zwart *et al.*, 2010; Zwart *et al.*, 2011; Buis *et al.*, 2012).

A9.4.2 Trends in nitrogen soil surpluses

Figure A9.1 provides an overview of the nitrogen surpluses on the soil surface balance (in kg of nitrogen per hectare) on farms participating in the derogation monitoring network, under the old and the new models (based on the same population). For the purposes of comparison, we have also included the reported averages in Buis *et al.* (2012), which were calculated using the old models. We have also included the trend line for the 2006-2011 period as presented in Chapter 4 of this report (calculated using the new models).

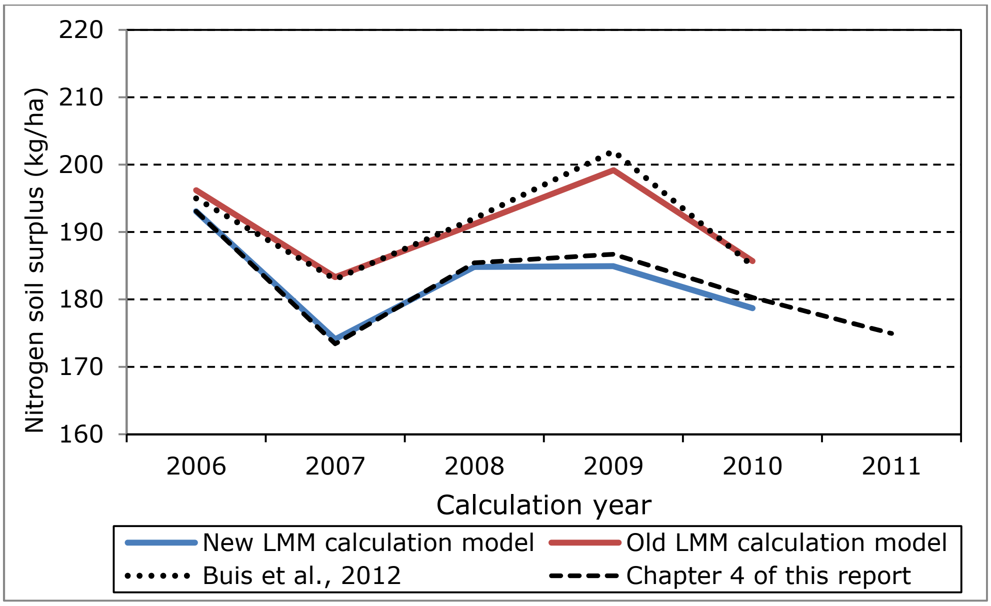

Figure A9.1 Trends in nitrogen surpluses on the soil surface balance (expressed in kg of nitrogen per hectare) on farms participating in the derogation monitoring network, under the old and the new model (based on the same population). For the purposes of comparison, we have also included the reported averages in Buis et al. (2012), which were calculated using the old models. We have also included the trend line for the 2006-2011 period as presented in Chapter 4 of this report (calculated using the new models).

The effects described in section A9.3 of this Appendix also apply to previous years. Figure A9.1 shows that the nitrogen soil surpluses as calculated using the new models, are lower than the surpluses calculated using the old models in all years. However, the difference does not stay the same from year to year. In

2006 the difference amounted to 3 kg of nitrogen per hectare, in 2007 it amounted to 9 kg, in 2008 it amounted to 6 kg, in 2009 it amounted to 14 kg, and in 2010 it amounted to 7 kg. The relative difference does not exceed 5 percent in any year, except in 2009 (see below). The surplus trend in the new models does not differ significantly from the trend in the old models. In the new models, the nitrogen surplus ranges from 174 to 193 kg of nitrogen per hectare, whereas it ranged from 183 to 199 kg in the old models.

In 2009 the high surplus in the old models is notable. In 2009 different standards were used in the old models to calculate the initial and closing stocks of livestock manure and animals. This discrepancy was discovered when the models were adjusted. As a result, the estimated outputs of animals and livestock manure were too low in 2009. This error has been corrected in the new model, resulting in an additional difference of 6 kg between the new and the old models.
The figure also shows that the data used in this Appendix (continuous lines) deviate slightly from the data presented in Chapter 4 of this report (dotted lines). These discrepancies are caused by the fact that a slightly different population of sampled farms has been used in this Appendix.

A9.4.3 Trends in phosphate soil surpluses

Figure A9.2 provides an overview of the phosphate surpluses on the soil surface balance (expressed in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network, under the old and the new models (based on the same population). For the purposes of comparison, we have also included the reported averages in Buis *et al.* (2012), which were calculated using the old models. We have also included the trend line for the 2006-2011 period as presented in Chapter 4 of this report (calculated using the new models).

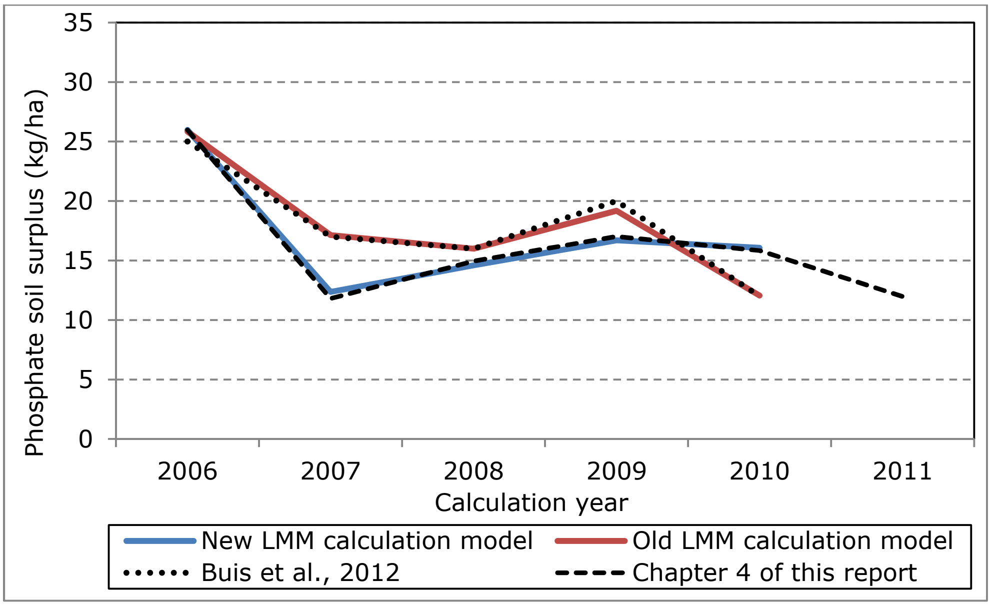

Figure A9.2 Trends in phosphate surpluses on the soil surface balance (expressed in kg of P_2O_5 per hectare) on farms participating in the derogation monitoring network, under the old and the new model (based on the same population). For the purposes of comparison, we have also included the reported averages in Buis et al. (2012), which were calculated using the old models. We have also included the trend line for the 2006-2011 period as presented in Chapter 4 of this report (calculated using the new models).

Figure A9.2 shows that the absolute difference in phosphate surpluses between the old and the new models remains limited, ranging from 0 to 5 kg during the 2006-2010 period.
Chapter 3 of this Appendix explained that the new models produced a higher phosphate surplus in 2010 than the old models. Figure A9.2 shows that this does not apply to all years. In the new models, the phosphate surplus in the 2006-2009 period is actually lower than in the old models. These lower surpluses in the new models may be explained by the following factors:

- The adjusted standard for compound feed applied during the 2006-2009 period. As described in section A9.3 of this Appendix, this standard is based on the data about the average composition of feed concentrates as reported by WUM. Compared to the previous standard for feed concentrates, the nitrogen content calculated by WUM is 13 to 17 percent higher, while the P_2O_5 content is 6 to 10 percent lower in the 2007-2009 period. As of 2010 this standard has lost almost all relevance, because calculations are performed based on farm-specific composition data in almost all cases. In 2010 the supply of feed products (calculated on the basis of farm-specific supplies of feed concentrates) was significantly higher than in the old models.
- This may also be caused by the different method used to calculate stock changes of livestock manure and animals under the old models in 2009. The correction of this 'error' in the old models resulted in an additional difference of approx. 2.5 kg of phosphate in 2009.
- The increased output of phosphate in milk and other animal products compared to the old models. As explained in section A9.3 of this Appendix, the output was also higher in 2010, but it was compensated by higher inputs of feed concentrates.

References

- Aarts, H.F.M., C.H.G. Daatselaar and G. Holshof (2008). Bemesting, meststofbenutting en opbrengst van productiegrasland en snijmais op melkveebedrijven. Wageningen, Plant Research International, Report No. 208.
- Beukeboom, J.A. (1996). Forfaitaire gehalten voor de mineralenboekhouding. Ede, Informatie- en Kennis Centrum Landbouw.
- Buis, E., A. van den Ham, L.J.M. Boumans, C.H.G. Daatselaar and G.J. Doornewaard (2012). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2010 in het derogatiemeetnet. Bilthoven, RIVM Report No. 68071028.
- Centraal Veevoederbureau (2012). Tabellenboek Veevoeding. Lelystad, Centraal Veevoederbureau.
- De Koeijer, T.J., G. Kruseman, P.W. Blokland, M.W. Hoogeveen and H.H. Luesink (2012). Mambo: visie en strategisch plan 2012-2015. Wettelijke Onderzoekstaken Natuur & Milieu. Werkdocument 308. Agricultural Economics Research Institute, Wageningen University & Research Centre.
- Fraters, B., J.W. Reijs, T.C. van Leeuwen and L.J.M. Boumans (2008). Landelijk Meetnet Effecten Mestbeleid. Resultaten van de monitoring van waterkwaliteit en bemesting in meetjaar 2006 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717004.
- Kringloopwijzer (2013). http://www.verantwoordeveehouderij.nl/index.asp?pzprojecten/projectkaart.asp?IDProject=503 (16 April 2013).
- Ministry of Agriculture, Nature & Food Quality (2010). Guidance document on farm-specific excretion by dairy cattle, version effective as of 2010. The Hague, Ministry of Agriculture, Nature & Food Quality, www.minlnv.nl (16 April 2013).
- National Institute for Public Health and the Environment (2013). Grootschalige concentratie- en depositiekaarten. http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl0189-Vermestende-depositie.html?i=3-17 (16 April 2013).
- National Service for the Implementation of Regulations (*Dienst Regelingen*, DR) (2013). Tabellen mestbeleid 2010-2013. http://www.drloket.nl/onderwerpen/mest/dossiers/dossier/publicaties-mest/tabellen-2010-2013. Assen, National Service for the Implementation of Regulations, Ministry of Agriculture, Nature & Food Quality (16 April 2013).
- Nutrient Management Institute (2013). Fertiliser database. http://www.nmi-agro.nl/sites/nmi/nl/nmi.nsf/dx/databank-meststoffen.htm. Nutrient Management Institute (16 April 2013).
- Oenema, O., G.L. Velthof, N. Verdoes, P.W.G. Groot Koerkamp, G.J. Monteny, A. Bannink, H.G. van der Meer and K.W. van der Hoek (2000). Forfaitaire waarden voor gasvormige stikstofverliezen uit stallen en mestopslagen. Wageningen, Alterra, Report No. 107.
- Statistics Netherlands (2010). Gestandaardiseerde berekeningsmethode voor dierlijke mest en mineralen. Standaardcijfers 1990-2008. The Hague, Statistics Netherlands.
- Statistics Netherlands / Agricultural Economics Research Institute (2011). Land- en tuinbouwcijfers 2011. The Hague / Heerlen, Statistics Netherlands; The Hague, Agricultural Economics Research Institute of Wageningen University & Research Centre.

- Van Dijk, W. (2003). Adviesbasis voor de bemesting van akkerbouw- en vollegrondsgroentegewassen. Lelystad, Praktijkonderzoek Plant en Omgeving, Report No. 307.
- Van den Ham, A., G.J. Doornewaard and C.H.G. Daatselaar (2011). Uitvoering van de Meststoffenwet. Evaluatie Meststoffenwet 2012: deelrapport ex post. The Hague, Agricultural Economics Research Institute of Wageningen University & Research Centre, Report No. 2011-073.
- Velthof, G.L., C. van Bruggen, C.M. Groenestein, B.J. de Haan, M.W. Hoogeveen and J.F.M. Huijsmans (2009). Methodiek voor berekening van ammoniakemissie uit de landbouw in Nederland. WOT Report No. 70. WOT Natuur & Milieu, Wageningen.
- Zwart, M.H., G.J. Doornewaard, L.J.M. Boumans, T.C. van Leeuwen, B. Fraters and J.W. Reijs (2009). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2007 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717008.
- Zwart, M.H., C.H.G. Daatselaar, L.J.M. Boumans and G.J. Doornewaard (2010). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2008 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717014.
- Zwart, M.H., C.H.G. Daatselaar, L.J.M. Boumans and G.J. Doornewaard (2011). Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie. Resultaten meetjaar 2009 in het derogatiemeetnet. Bilthoven, RIVM Report No. 680717022.

A.E.J. Hooijboer et al.

RIVM report 680717035/2013

This is a publication of:

National Institute for Public Health and the Environment

P.O. Box 1 | 3720 BA Bilthoven
The Netherlands
www.rivm.nl

005310

May 2013