National Institute for Public Health
and the Environment
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Agricultural practice and water quality

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Results for 2009 in the derogation monitoring network

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RIVM Report 680717023/2011

Colophon

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Abstract

Agricultural practice and water quality on farms registered for derogation
Results for 2009 in the derogation monitoring network

This report provides an overview of fertilisation practices in 2009 and of water quality in 2009 and 2010 on grassland farms that are allowed to use more animal manure than the limit set in the European Nitrates Directive (derogation). Data from this research can be used to study the consequences for the water quality. The water quality values measured in 2009 reflect agricultural practices in 2008, which was the third year in which the derogation was applied. The water quality values measured in 2010 reflect the consequences of agricultural practices in 2009.

The European Nitrates Directive obliges Member States to limit the use of animal manure to a specified maximum (the application standard animal manure of 170 kg N/ha). A Member State may request permission from the European Commission to deviate from this obligation under specific conditions. In December 2005, the Commission granted the Netherlands the right to derogate from the obligation from 2006 to 2009. On 5 February 2011, this derogation was extended to 2013. One of the underlying conditions of the derogation is that the Dutch government establishes a monitoring network and reports the results each year to the European Commission.

In 2006, the National Institute for Public Health and the Environment (RIVM) and LEI, part of Wageningen University and Research Centre, set up a derogation monitoring network. This measures the effects on agricultural practice and water quality when farmers are allowed to deviate from the European application standard for livestock manure. The derogation monitoring network is part of the Minerals Policy Monitoring Programme (LMM). The agricultural practice was measured on 275 grassland farms and the water quality on 285 grassland farms. The monitoring network covers 300 farms. However, fewer than 300 farms are reported: there were changes to the farms included in the monitoring network and, in retrospect, not all farms applied for derogation or were awarded it.

Keywords:
nitrates directive, derogation decision, agricultural practice, water quality, manure

Rapport in het kort

Landbouwpraktijk en waterkwaliteit op landbouwbedrijven aangemeld voor derogatie
Resultaten meetjaar 2009 in het derogatiemeetnet

Dit rapport geeft een overzicht van de bemestingspraktijk in 2009 en de waterkwaliteit in 2009 en 2010 op graslandbedrijven in Nederland die meer dierlijke mest mogen gebruiken dan in de EU-Nitraatrichtlijn is aangegeven (derogatie). De gegevens uit dit onderzoek kunnen worden gebruikt om de gevolgen voor de waterkwaliteit te bepalen. De waterkwaliteit gemeten in 2009 geeft de gevolgen weer van de landbouwpraktijk in 2008, het derde jaar dat de derogatie in de praktijk werd toegepast. De waterkwaliteit gemeten in 2010 geeft de gevolgen weer van de landbouwpraktijk in 2009.

De Europese Nitraatrichtlijn verplicht lidstaten het gebruik van dierlijke mest te beperken tot een bepaald maximum (de gebruiksnorm dierlijke mest van 170 kg N/ha). Een lidstaat kan de Europese Commissie vragen om onder voorwaarden van deze beperking af te wijken. Nederland heeft in december 2005 derogatie gekregen om van 2006 tot en met 2009 af te mogen wijken van de gestelde norm. Deze derogatie is op 5 februari 2010 verlengd tot en met 2013. Een van de voorwaarden is dat de Nederlandse overheid een monitoringnetwerk inricht en over de resultaten daarvan jaarlijks aan de Commissie rapporteert.

Het Rijksinstituut voor Volksgezondheid en Milieu (RIVM) en het LEI, onderdeel van Wageningen Universiteit en Research Centrum, hebben in 2006 voor Nederland een monitoringnetwerk opgezet. Dit zogenoemde derogatiemeetnet meet de gevolgen voor de landbouwpraktijk en de waterkwaliteit als landbouwbedrijven afwijken van de Europese gebruiksnorm voor dierlijke mest. Het derogatiemeetnet is een onderdeel van het Landelijk Meetnet effecten Mestbeleid (LMM). Van 275 graslandbedrijven is de bedrijfsvoering gemonitord en van 285 bedrijven de waterkwaliteit. Het meetnet omvat 300 graslandbedrijven. Dat er minder dan 300 bedrijven zijn gerapporteerd komt doordat sommige bedrijven achteraf geen derogatie toepasten of toegekend kregen en door bedrijfswisselingen in het meetnet.

Trefwoorden:
nitraatrichtlijn, derogatiebeschikking, landbouwpraktijk, waterkwaliteit, mest

Preface

The National Institute for Public Health and the Environment (RIVM) and LEI, part of Wageningen University and Research Centre, have drawn up this report, commissioned by the Ministry of Economic Affairs, Agriculture and Innovation (EL&I) and the Ministry of Infrastructure and the Environment (I&M). LEI is responsible for the information about agricultural practice and RIVM for the water quality data. RIVM is also the official secretary within this project.

RIVM report 680717001/2007 describes the design of the derogation network and the reporting method used in the annual reports. Annual reports have been released in 2008, 2009 and 2010.

This report provides an overview of agricultural practices in 2009 for all farms in the derogation monitoring network that have registered for derogation. This includes data about fertilisation and the nutrient surpluses realised. Information is also provided about the results of water quality monitoring in 2009 and 2010 at farms in the derogation monitoring network.

The present report covers virtually all the 300 farms participating in the derogation monitoring network. Due to changes in the sample population, such as relocations, variations between the participating farms occur across the years measured. Moreover, in retrospect, not each farm makes use of the derogation in practice. Consequently the numbers of farms in the different regions and water types can vary each year. The 300 farms were already participating in the Minerals Policy Monitoring Programme (LMM) or were recruited and sampled during the sampling campaign.

The authors thank Mr M. van Rietschoten of the Ministry of Economic Affairs, Agriculture and Innovation, Mr K. Locher of the Ministry of Infrastructure and the Environment and Mr G. Velthof and Mr J. Schröder of the Professional Committee for the Fertilisers Act (CDM) for their critical comments. Finally, we would like to thank our colleagues from LEI and RIVM who, each in their own way, have contributed to the development of this report.

Manon Zwart, Co Daatselaar, Leo Boumans and Gerben Doornewaard

29 April 2011

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Summary

Background
The Nitrates Directive obliges EU Member States to limit the use of livestock manure to a maximum of 170 kg of nitrogen per ha per year. A Member State can, under certain conditions, ask the European Commission if it may deviate from this obligation (derogation). In December 2005, the European Commission issued a derogation decision to the Netherlands for the period 2006-2009; in February 2010, this was extended until December 2013. Under this decision, grassland farms with 70% or more grassland may, under prescribed conditions, apply up to 250 kg nitrogen (N) per ha to their land in the form of manure from grazing livestock. In return the Dutch government is obliged to set up a monitoring network in accordance with the requirements stipulated in the derogation decision of the European Commission. Each year the Netherlands must also provide the European Commission with information – based on monitoring and model-based calculations – about the quantities of fertilisers applied to each crop per soil type and about the evolution of water quality.

The derogation monitoring network
In 2006, a new monitoring network was designed and established to monitor the evolution in agricultural practices and water quality as a consequence of the derogation. This network comprises 300 farms that applied for derogation. The derogation monitoring network was set up by expanding the Minerals Policy Monitoring Programme (LMM). By using a stratified random sampling method, the 300 farms are distributed as evenly as possible throughout the Netherlands in terms of region (sand, loess, clay and peat), farm type (dairy farms and other grassland farms) and economic size class, and with this the emphasis is on the sand region. With this approach, the requirement that the derogation decision be representative for all soil types (clay, peat, sand and loess soils), fertilisation practices and cropping patterns – with emphasis on the sand region – is effectuated.

Characteristics of the farmland and the farms in the derogation monitoring network

1 *Characteristics of farms included in the derogation monitoring network for 2009, per region.*

Characteristics	Region				
	Sand	Loess	Clay	Peat	All
Number of farms in the monitoring network	160	20	60	60	300
Number of farms with derogation and fully processed in FADN	158	18	58	59	293
- of which specialised dairy farms	137	15	51	53	256
- of which other grassland farms	21	3	7	6	37
Descriptive characteristics					
Acreage of cultivated land (ha)	48.7	47.7	55.9	61.7	52.7
Percentage grassland	80	74	84	92	83
Milk production (kg FPCM[1]) per ha fodder crop	15,400	13,400	15,500	13,400	14,900

FPCM = Fat and Protein Corrected Milk - this is a comparative standard for milk with different fat and protein contents (1 kg milk with 4.00% fat and 3.32% protein = 1 kg FPCM). The means reported only refer to the 256 specialised dairy farms.

In 2009, the total agricultural area in the derogation monitoring network was 1.8% of the area used by all derogation farms that fulfilled the criteria for inclusion in the network (the sample population). At 52.7 ha (see Table 1), the mean acreage of farms in the derogation monitoring network is larger than that of the sample population (43.9 ha). Dairy farms in the network also produced more milk per hectare, especially in the clay region. The percentage of farmland used as grassland (83%, see Table 1) is slightly higher than in the sample population (81%).

Use of fertilisers

In 2009, farms in the derogation monitoring network used on average 253 kg of nitrogen from livestock manure per ha of cultivated land (see Table 2) and, with this, exceeded the application standard for livestock manure at farm level. On arable land an average of 179 kg per ha was used, whereas on grassland 270 kg nitrogen from livestock manure was applied.

The use of plant-available nitrogen from livestock manure and inorganic fertiliser (calculated with the prevailing statutory availability coefficients) was 283 kg per ha on grassland and 127 kg per ha on arable land (mainly silage maize - see Table 2). On grassland in the sand region and on arable land in the loess region, use was higher than for the 2009 application standards but, at the farm level, the use in all regions was below the nitrogen application standards. Phosphate use from livestock manure and inorganic fertiliser on arable land was on average 94 kg P_2O_5 per ha, slightly above the 2009 phosphate application standard on arable land, while on grassland (102 kg P_2O_5 per ha) in the sand and loess regions the grassland was also fertilised by several kilograms over the phosphate application standards. At the farm level, phosphate use was just below the average for phosphate application standards in the clay and peat regions and several kilograms above that of the sand and loess regions.

2 *Mean use of fertiliser on farms in the derogation monitoring network in 2009, per region*.

Characteristics		**Region**				
		Sand	Loess	Clay	Peat	All
Fertiliser use						
Nitrogen from livestock manure (kg N per ha)	Farm level	255	245	250	253	253
	Arable land[2]	185	181	171	163	179
	Grassland	273	269	269	262	270
Total plant-available nitrogen[1]	Arable land[2]	124	172	131	112	127
(kg N per ha)	Grassland	286	247	313	259	283
Total phosphate[1]	Arable land[2]	95	88	91	100	94
(kg P_2O_5 per ha)	Grassland	103	115	100	97	102

[1] From livestock manure, other organic fertiliser and inorganic fertiliser. The quantity of plant-available nitrogen from livestock manure and other organic fertiliser was calculated using the statutory availability coefficients determined for 2009.

[2] Arable land on grassland farms is mainly used for the production of silage maize (mean 88%).

Crop yield and nutrient surpluses at farm level

On average, yields of 184 kg of nitrogen and 74 kg of phosphate were estimated for silage maize and yields of 259 kg of nitrogen and 86 kg of phosphate were calculated for grassland (Table 3). The mean nitrogen surplus on the soil surface balance in 2009 was calculated to be 208 kg per ha. This surplus decreases in the sequence peat >clay >sand >loess (Table 3). The high surplus in the peat region was partly caused by an average of 75 kg of net nitrogen mineralisation per ha being included in the calculation, whereas in the other regions the net nitrogen mineralisation was negligible. The phosphate surplus in the soil balance is on average 20 kg P_2O_5 per hectare with little difference between the regions.

3 *Mean estimated silage maize yield and calculated grassland yield on all farms that satisfied the selection criteria for applying the calculation method (Aarts et al., 2008) and nutrient surpluses on the soil surface balance on the farms in the derogation monitoring network in 2009, per region.*

Characteristics	**Region**				
	Sand	Loess	Clay	Peat	All
Estimated silage maize yields[1]					
kg N per ha	184	191	189	173	184
kg P_2O_5 per ha	73	77	77	75	74
Calculated yield on grassland[1]					
kg N per ha	254	287	253	270	259
kg P_2O_5 per ha	84	97	86	90	86
Nutrient surpluses per ha cultivated land					
Nitrogen surplus on the soil surface balance (kg N per ha)	196	172	222	237	208
Phosphate surplus on the soil surface balance (kg P_2O_5 per ha)	21	25	20	18	20

[1] The silage maize and grassland yields are based on 178 of 275 farms. The other farms did not satisfy the selection criteria.

Comparison of agricultural practice for the years 2006 to 2009

Comparison of the results for the years 2006 to 2009 reveals that milk production per farm and per hectare have increased. There was also an associated increase in the production of livestock manure, yet due to a greater export of livestock manure in particular, the use of livestock manure remained more or less the same until 2009. In 2009, the stocks of livestock manure decreased, in contrast to the previous 3 years, as a result of which the use of animal manure in 2009 increased in comparison to the previous three years. The phosphate application standards were also stricter in the years 2006-2008, which mainly led to less use of inorganic phosphate fertiliser. In 2009, the use of phosphate fertiliser decreased further. However, the phosphate surplus on the soil balance decreased no more in 2009, partly due to increased use of livestock manure. The consumption of nitrogen fertiliser in 2009 was not different from previous years. The nitrogen surplus in the soil balance rose slightly due to the increased use of livestock manure.

In 2009, the calculated maize yield (kg N and P_2O_5 per hectare) was about the same as the mean for the years 2006-2008. The dry matter yield (ds) was slightly higher in 2009. In 2009, the estimated grassland yield (kg dry matter and P_2O_5 per hectare) was not different from the mean for the years 2006-2008.

The yield in kg N in 2009 was, indeed, well below the mean of the previous three years.

From a comparison of several years, it can be concluded that the use of livestock manure in 2009 was higher than the mean of the previous three years. The decrease in the stocks of livestock manure in 2009, as opposed to the increases in the years 2006-2008, is the most important reason for this. This increased fertiliser use, with constant use of nitrogen fertiliser and slightly decreased use of phosphate fertiliser, did not result in higher crop yields but did lead to slightly higher soil surpluses for nitrogen and phosphate in 2009 compared to the years 2006-2008.

Water quality in measurement year 2009
The water quality measured in 2009 partly reflects the agricultural practices in the third year of derogation (2008) and previous years. The mean nitrate concentration was higher in the sand and loess regions than in the other two regions, just as in previous years.

4 *Quality of the water leaching from the root zone on farms in the derogation monitoring network in 2009: mean nitrate concentration, total nitrogen and phosphorous (in mg/l) and the percentage of farms with a mean nitrate concentration higher than 50 mg/l.*

Characteristic	**Region**			
	Sand	**Loess**	**Clay**	**Peat**
Number of farms	154	18	56	57
Nitrate (NO_3) (mg/l)	39	51	20	7
Nitrate% >50 mg/l	31	56	12	2
Nitrogen (N) (mg/l)	11.5	12.1	6.5	7.7
Phosphorus (P) (mg/l)	0.15	0.04	0.28	0.37

In the sand, clay and peat regions, the nitrate and total nitrogen concentrations in the ditch water were on average lower than in water leaching from the root zone (see Table 5). In the sand and clay regions, the phosphorous concentrations in the ditch water were comparable to those in the water leaching from the root zone. In the peat region, the phosphorous concentrations in the ditch water were lower than in the water leaching from the root zone.

5 *Quality of the ditch water in 2009: mean nitrate concentration, total nitrogen and phosphorous (in mg/l) and the percentage of farms with a mean nitrate concentration higher than 50 mg/l.*

Characteristic	**Region**		
	Sand	**Clay**	**Peat**
Number of farms	29	55	55
Nitrate (NO_3) (mg/l)	26	10	4
Nitrate% >50 mg/l	21	0	0
Nitrogen (N) (mg/l)	7.8	4.3	4.2
Phosphorus (P) (mg/l)	0.12	0.32	0.23

Water quality in measurement year 2010, preliminary results
The table below shows the provisional results for the water quality in 2010. These partly reflect agricultural practices in 2009 (fourth year of derogation). These can therefore be directly linked to the agricultural data that are also stated in this report. The final results will be included in the report for 2012 (these are not expected to strongly deviate from the provisional results).

6 *Quality of the water leaching from the root zone in 2010: mean nitrate concentration, total nitrogen and phosphorous (in mg/l) and the percentage of farms with a mean nitrate concentration higher than 50 mg/l.*

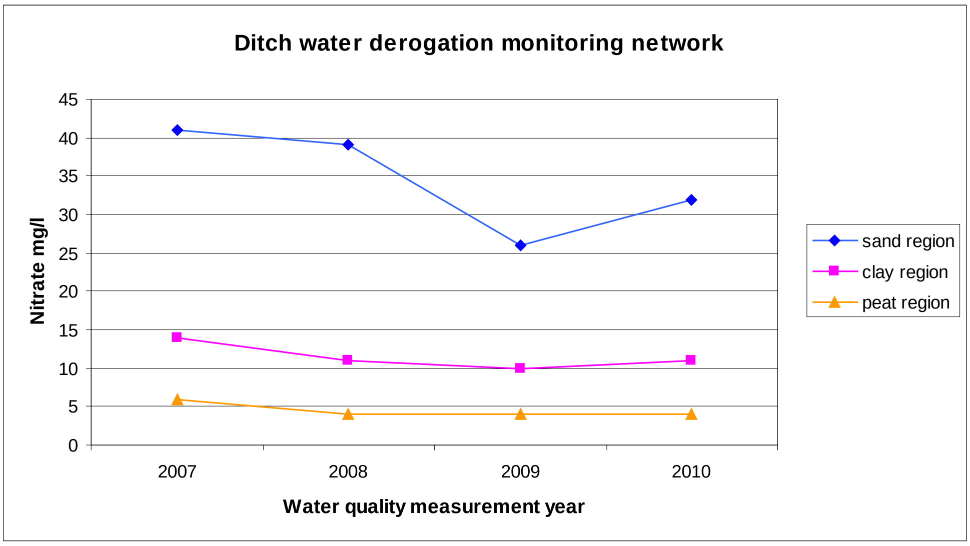
Characteristic	**Region**			
	Sand	**Loess**	**Clay**	**Peat**
Number of farms	158	0	58	59
Nitrate (NO_3) (mg/l)	46	*	28	12
Nitrate % >50 mg/l	41	*	12	3
Nitrogen (N) (mg/l)	13.2	*	8.3	9.7
Phosphorus (P) (mg/l)	0.15	*	0.21	0.43

* At the time of preparation of the present report, results from the loess region were not available: sampling was conducted between October 2010 and March 2011.

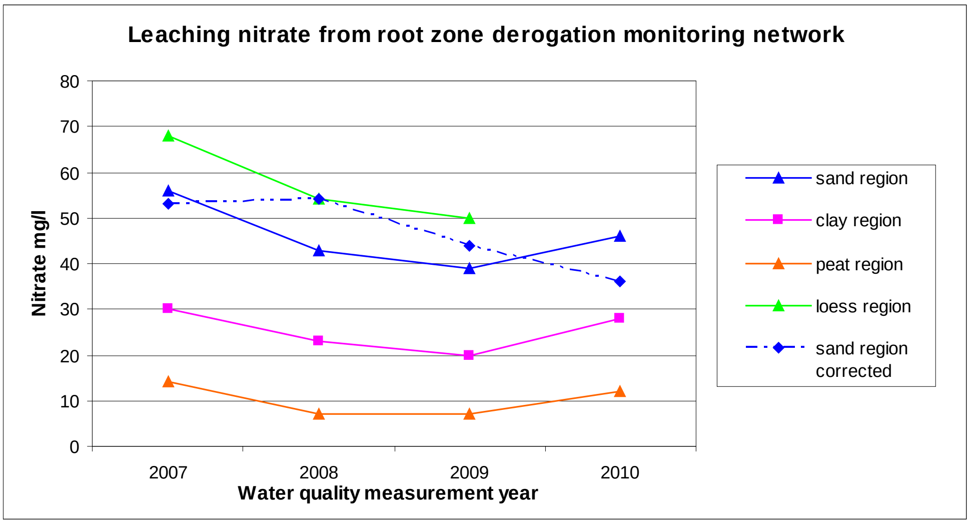
7 *Quality of the ditch water in 2010: mean nitrate concentration, total nitrogen and phosphorous (in mg/l) and the percentage of farms with a mean nitrate concentration higher than 50 mg/l.*

Characteristic	**Region**		
	Sand	**Clay**	**Peat**
Number of farms	30	57	57
Nitrate (NO_3) (mg/l)	32	11	4
Nitrate% >50 mg/l	20	0	0
Nitrogen (N) (mg/l)	9.5	4.4	4.0
Phosphorus (P) (mg/l)	0.14	0.23	0.15

Comparison of water quality results between 2007 and 2010
This year's results are available from four consecutive sampling years (except for the loess region). Therefore, a simple analysis has been performed in which the years are compared. The graphs below shows the results for nitrate leaching from the root zone and ditch water to illustrate the change in concentrations. Figure 9 also shows concentrations for the sand region adjusted for the effects of precipitation.



8 *Illustration of the nitrogen concentrations in the ditch water in successive measurement years.*



9 *Illustration of nitrogen concentrations in the root zone in successive measurement years.*

The conclusion is that most concentrations did not relevantly change during the current measurement period. Where changes were observed these were probably correlated with:

- differences in the precipitation surplus;
- differences in the hydrological conditions.

Only the phosphorus concentrations in ditch water in the clay and peat regions exhibit a relevant difference (Table 50). These concentrations decreased in 2010. It should be noted that this decline was not visible in previous years. Nitrate and nitrogen concentrations also exhibit a relevant decrease in the loess region. The decrease is also mentioned and described in the progress report (Zwart et al., 2010). For this region, fewer than four survey years are available.

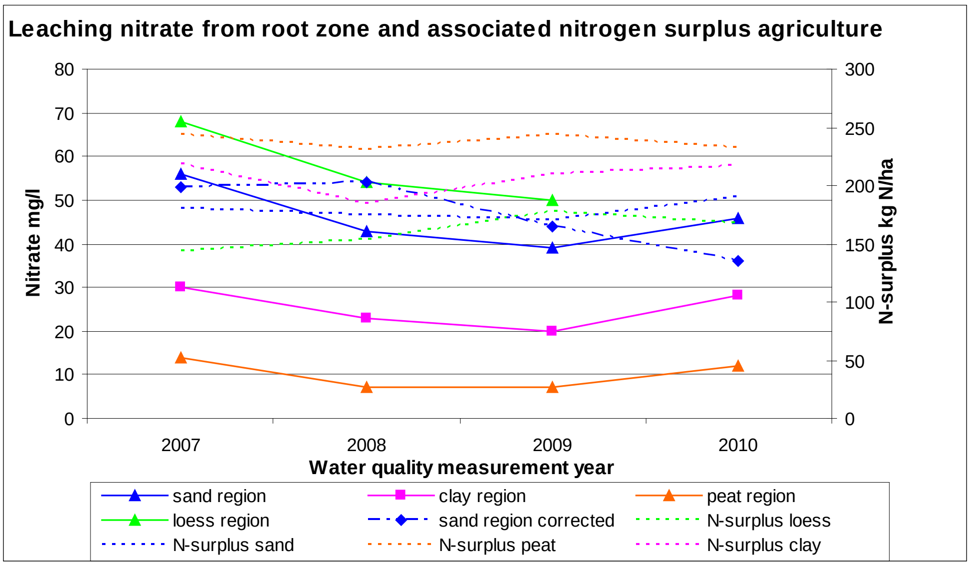
After correction for the effect of precipitation in the sand region, the concentrations appear to have decreased further in 2010 compared to 2008 and

2009. However, it should be remembered that the results for 2010 are only provisional. The final concentrations will be given in the progress report for 2012 and in that report it will also be apparent if this decreasing trend has continued in the 2011 water quality.

Effect of agricultural practice on water quality

Nitrogen

Nitrate concentrations show no relevant decrease in the sand region between 2007 and 2008 after adjusting for weather. The decrease in the nitrate concentration between 2008 and 2009 cannot be adequately explained in terms of the developments in agricultural practice. The decrease in the nitrogen surplus is small, not relevant and has not been observed in all regions. Since 2010 is a very dry year, the adjusted nitrate concentration in groundwater shows a slight decrease in the sand region while the measured concentrations show an increase between 2009 and 2010. The decrease in the adjusted concentrations cannot be explained by the slight increase exhibited by the nitrogen surplus in the sand region. This is illustrated in Figure 10 with a trend line for both agricultural practice and water quality.



10 Illustration of nitrate concentrations leaching from the root zone by soil-type region, together with the N-surplus from agricultural practice.

Phosphate

The phosphate surplus on the soil balance decreased during the measurement period to 2009; in 2009, however, the decrease stopped. The effect of this decrease is not observed in the water quality. Here, both small increases as well as decreases can be seen. In 2010, a relevant decrease in phosphorus concentration was observed in the water quality for the first time. The cause is possibly the strong fixation of phosphate to the soil. The phosphorous concentration in the leaching water and the ditch water is therefore mainly determined by the hydrological conditions.

1 Introduction

1.1 Background

The Nitrates Directive obliges EU Member States to limit the use of livestock manure to a maximum of 170 kg of nitrogen per ha per year. A Member State can, under certain conditions, ask the European Commission if it may deviate from this obligation (derogation). In December 2005, the European Commission issued the Netherlands with a definitive derogation decision under which grassland farms, cultivating at least 70% of their total area as grassland, were allowed to apply up to 250 kg of nitrogen per ha in the form of livestock manure that originates from grazing livestock (EU, 2005). The derogation decision covers the years 2006 to 2009 and was extended in February 2010 to December 2013 (EU, 2010). In return for this, the Dutch government is obliged to collect a wide range of data regarding the effects of the derogation and to report these annually to the European Commission.

One of the obligations of the derogation decision (see Appendix 1) concerns 'the formation of a monitoring network for the sampling of groundwater, soil moisture, drainage water and ditches on farms permitted an individual derogation' (Article 8 of the decision, paragraph 2). The monitoring 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). This monitoring network, which covers at least 300 farms, should be 'representative for all types of soil (clay, peat, sand, and loess), fertilisation practices and crop rotations' (Article 8, paragraph 2). However, within the monitoring network, the monitoring of water quality on farms on sandy soils should be improved (Article 8, paragraph 5). The composition of the monitoring network should remain unchanged during the period (2006-2013) to which the decision applies (Article 8, paragraph 2). During the 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 the minerals policy, the Minerals Policy Monitoring Programme (LMM), under which the water quality and operational management of farms selected for this purpose has been monitored since 1992 (Fraters and Boumans, 2005). It was also agreed that participants in the LMM, who satisfy the conditions, could be regarded as participants in the monitoring network for the derogation. Accordingly, the derogation monitoring network has become part of the LMM. For the LMM the top metre of the phreatic groundwater, the soil moisture and/or the drainage water are sampled, as this is considered to sample the water leaving the root zone (see Appendix 4).

Aside from the obligation to monitor, there is the requirement to report the evolution of the water quality. The report should be based on 'the monitoring of leaching from the root zone, the surface water quality and the 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 yield on grassland farms on which derogation is permitted, to provide the European Commission with an understanding of the management on these farms and the degree to which this has been optimised (Article 10, paragraph 4). This report is intended to meet the aforementioned reporting requirements.

1.2 Previous reports

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

In 2008, the second report was published. This contained the first results from the derogation monitoring network (Fraters et al., 2008). The first year of derogation was 2006. The figures about agricultural practice concerned farm practice under derogation. The water quality data from 2006 relate to the agricultural practice from 2005 and therefore are not yet related to farm practice under derogation.

The third progress report was published in 2009; this contains the data from 2007 (Zwart et al., 2009). A brief comparison is also made between the results from 2006 and 2007, with the caveat placed that water quality data from 2006 related to agricultural practice in 2005. In 2005 there was no derogation and so there was no data set available from which to draw conclusions about trends.

The fourth progress report was published in 2010; this contains the data from 2008 and 2009 (Zwart et al., 2010). A brief comparison of the results from 2007, 2008 and 2009 is also made, with the caveat that this is a very limited data set from which to draw solid conclusions about trends. For the first time, a limited analysis of the relationship between farm results and the associated water quality was conducted.

1.3 Content of this report

This is the fifth annual report about the results of the derogation monitoring network. It reports on the fertilised crop yields and nutrient surpluses. These surpluses are a major determinant for the quantity of nutrients that could potentially wash out.

The results in this report are based on the data as they are defined in the Farm Accountancy Data Network (FADN). In the FADN, the actual situation on the farm is established according to the report offered by the farmer. These data need not necessarily correspond to the data used in enforcement checks. The area used may differ from the area that is recorded in the land registration system of the National Service (DR) of the Ministry of Economic Affairs, Agriculture and Innovation (EL&I), since land belonging administratively to the farm but which is not actually used for fertilisation is not recorded in the FADN. There may also be other animal numbers, other supply and removal of products and other stocks.

Relating the fertilisation determined using the FADN data to the acreages actually used provides the best possible insight into the relationship between agricultural practice and water quality. However, these data cannot be used to assess compliance with the legislation, since this requires the data as recorded by the National Service for the Implementation of Regulations.

Both annual mean nitrate concentrations measured by region and the results of the limited model calculations are included in the analysis of the data. The calculations quantify the influence of confounding factors on the measured nitrate concentrations. In particular, the nitrate concentration in water leaching from the root zone is 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 the nitrate concentration in the uppermost layer of groundwater (Boumans et al., 1997, 2001). This method also corrects for changes in the composition of the group of participating farms, the sample (Fraters et al., 2004). Participants sometimes have to be replaced during the course of the programme (see chapter 2) or changes in the acreage of the participating farms occur. As a result of this, the ratio between the soil types and/or drainage classes on the farms in the derogation monitoring network can change during 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 nitrate concentration measured. A change in the nitrate concentration measured could therefore be caused by a change in the composition of the group of participating farms or changes in the acreage within this group.

Chapter 2 contains a brief description of the design and realisation 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. An explanation of the modelling and analyses performed is also given. Chapter 3 presents and discusses the measurement results of the monitoring in 2009. This chapter also contains the provisional results of the water quality monitoring for 2010. Chapter 4 presents the results from the successive derogation years and compares these with each other.

The relevant articles from the derogation decision granted to the Netherlands by the European Commission (EU, 2005) have been included in Appendix 1. Appendix 2 provides further details about the set-up of the derogation monitoring network. The other appendices provide a detailed justification concerning the registration of data for agricultural practice and the calculation of the fertilisation and the nitrogen and phosphate surpluses (Appendix 3) and how the quality of the water is measured (Appendix 4). Appendix 5 details the methodology applied for weather correction. Finally, Appendix 6 describes the methodology for comparing the results of successive years.

2 Design of the derogation monitoring network

2.1 Introduction

The design of the 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 2009 (see Appendix 1).
Previous reports provided extensive details about the composition of the sample and the choices this entailed (Fraters et al., 2007; Fraters and Boumans, 2005).

The setting up of the derogation monitoring network and the reporting of the results follows the segmenting of the Netherlands into regions, as was done in the Nitrate Directive Action Programme and the fertilisation legislation. Here four regions are distinguished: the sand region, the loess region, the clay region and the peat region. The acreage of farmland in the sand region constitutes about 46% of the approximately 1.92 million hectares of total farmland in the Netherlands. The acreage of farmland in the loess region constitutes approximately 1.5%, in the clay region approximately 40% and in the peat region approximately 12.5% of the total farmland.

The sampling of the water quality for the measurement year 2009 was carried out during the winter of 2008/2009 in the Low Netherlands and in the summer and the rest of 2009 in the High Netherlands. The Low Netherlands covers the clay and peat regions, and those soils in the sand region that are drained via ditches, whether or not in combination with drainage pipes or channels. The High Netherlands covers the other sand and loess soils. The sampling for determining the water quality for 2010 took place in the winter of 2009/2010 and in the summer of 2010 respectively. Farms that submitted an application for derogation but did not use this were not included in this report so as to ensure that the results concerning the effects of using derogation were not confounded. Consequently the number of farms reported on deviates from 300.

The water quality measured in 2009 partly reflects the agricultural practice of 2008 and the preceding years. The extent to which agricultural practice in a previous year affects the measured water quality depends, amongst other things, on the level of and variation in the precipitation surplus in that year. The difference between the Low and High Netherlands is caused by the difference in hydrology. This difference in hydrology also explains the different sampling methods used in the Low and High Netherlands.

As previously stated, all data about agricultural practices relevant for the derogation were registered, for all 300 derogation farms, according to the FADN system (Poppe, 2004). A description of the monitoring of the agricultural characteristics and the methods of calculation of the fertilisation and the nutrient surpluses can be found in Appendix 3. The 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 Design and realisation of the sample

2.2.1 Number of farms in 2009

The derogation monitoring network is a permanent monitoring network. However, the loss of a number of farms is unavoidable. Farms can drop out because:

- at the end of the year they indicate that they do not use the derogation;
- they no longer participate in the LMM because the farm has been sold, because cultivated land is no longer used or because of administrative problems.

Furthermore, although a farm might have been processed in the FADN, it might have proved impossible to fully describe the nutrient flows. This could have been due to the presence of animals from other owners, as a result of which the import and export of feed, animals and manure could, by definition, not be complete or because of administrative errors in the registration of imports and/or exports.

Table 11 shows the planned and actual number of farms in the derogation monitoring network for 2009, per region (sand, loess, clay and peat) and farm type (dairy farms versus other grassland farms).

11 Planned (design) and realised (realisation) number of dairy and other grassland farms per region in 2009.

Farm type	Design/realisation	Sand	Loess	Clay	Peat	All
Dairy	Design	140	17	52	52	261
	Realisation water quality	135	15	49	51	250
	Realisation FADN monitoring	137	15	51	53	256
	For which nutrients flows are complete	132	15	48	52	247
Other grassland farms	Design	20	3	8	8	39
	Realisation water quality	19	3	7	6	35
	Realisation FADN monitoring	21	3	7	6	37
	For which nutrients flows are complete	15	3	5	5	28
Total	Design	160	20	60	60	300
	Realisation water quality	154	18	56	57	285
	Realisation FADN monitoring	158	18	58	59	293
	For which nutrients flows are complete	147	18	53	57	275

Six of the farms that had participated in the FADN in 2008, no longer did so in 2009. These farms were therefore replaced.

The various sections of this report detail the agricultural practice on the following numbers of farms:

- The description of general farm characteristics (section 2.3) concerns all farms that could be processed in FADN in 2009 and that made use of the derogation (= 293).
- The description of agricultural practices in 2009 (section 3.1) concerns all farms for which the nutrient flows in 2009 could be fully completed in FADN (= 275).
- The comparison between agricultural practices in the years 2006 to 2009 (section 4.2) includes all farms that participated in the derogation network in all years (265 farms). For 243 of these farms the nutrient flows could be fully completed in FADN in all years.

2.2.2 *Representativeness of the sample*

The sample population covers 86.6% of the farms and 96.7% of the acreage of all farms that registered for derogation in 2009 and which satisfied the LMM selection criteria (the sample population, Appendix 2). Farms outside the sample population that did sign up for derogation are mainly other grassland farms with a size of less than 16 NGE (Netherlands units of magnitude). With an area of 15,184 ha, 1.8% of the national acreage of the total sample population has been included in the sample (see Table 12).

A minimum number of farms is needed to be able to make a reasoned statement per region. For loess, that minimum has been set at 15 (Fraters and Boumans, 2005). The loess region is relatively small and so it does not have a lot of derogation farms in the sample population. Consequently, a relatively large number of farms are included in the monitoring network (16.0%). Furthermore, the dairy farms in all regions are more strongly represented in the acreage than the other grassland farms. This is because the desired number of sample farms per farm type is derived during the selection and acquisition process 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 the acreage of cultivated land.

12 Area of cultivated land (in ha) in the derogation monitoring network compared to the total area of cultivated land of farms with derogation in 2009 in the sample population, according to the Agricultural Census 2009.

Region	Farm type	Sample population[1]	Derogation monitoring network	
		Area in ha	Area in ha	% of acreage sample population
Sand	Dairy farms	379,173	6818	1.8%
	Other grassland farms	49,936	658	1.3%
	Total	429,110	7476	1.7%
Loess	Dairy farms	4738	736	15.5%
	Other grassland farms	1168	122	10.4%
	Total	5905	858	14.5%
Clay	Dairy farms	207,668	3185	1.5%
	Other grassland farms	29,882	213	0.7%
	Total	237,551	3397	1.4%
Peat	Dairy farms	167,721	3555	2.1%
	Other grassland farms	19,003	146	0.8%
	Total	186,724	3701	2.0%
All	Dairy farms	759,300	14,294	1.9%
	Other grassland farms	99,990	1139	1.1%
	Total	859,290	15,433	1.8%

1 Estimate based on Statistics Netherlands Agricultural Census 2009, processed by LEI. Further information about how the sample population was defined can be found in Appendix 2.

2.3 Description of the farms in the sample

Table 13 describes a number of characteristics of the farms in the derogation monitoring network. This table contains data from all farms in the derogation monitoring network for which the registration in FADN has been fully processed. For comparison, data from companies in the 2009 Agricultural Census (LBT) have been included where these companies are in the sample population (Appendix 2).

13 Description of a number of general farm characteristics in 2009 of the farms in the derogation monitoring network (DM) compared to the mean of the sample population (LBT).

Farm characteristic[3]	Population	Sand	Loess	Clay	Peat	All
Total number of farms:		158	18	58	59	293
Area grassland (ha)	DM	37.0	34.4	46.5	55.2	42.4
	LBT	30.7	29.0	42.3	41.4	35.7
Area silage maize (ha)	DM	9.5	9.0	9.5	7.0	9.0
	LBT	8.0	7.5	5.9	4.0	6.7
Area other arable land (ha)	DM	0.8	4.3	2.6	0.5	1.3
	LBT	1.3	3.1	2.5	1.0	1.6
Total area cultivated land (ha)	DM	47.3	47.7	58.6	62.7	52.7
	LBT	40.1	39.6	50.7	46.4	43.9
Percentage grassland	DM	80	74	83	92	82
	LBT	77	73	83	89	81
Area natural habitat (ha)	DM	0.6	4.3	2.1	0.7	1.2
	LBT	0.7	1.1	1.2	0.7	0.8
Stocking density grazing livestock (GVE per ha)	DM	2.26	2.09	2.31	2.01	2.21
	LBT	2.24	2.10	1.98	1.88	2.11
Percentage farms with housed animals	DM	15	17	10	12	14
	LBT	15	4	5	7	11
Specification livestock density derogation monitoring network (GVE per ha)						
Dairy cattle (including young stock)	DM	2.14	1.91	2.12	1.89	2.07
Other grazing livestock	DM	0.11	0.18	0.18	0.12	0.13
Total housed animals	DM	0.90	0.07	0.40	0.25	0.62
Total all animals	DM	3.16	2.15	2.71	2.26	2.83

Source: Statistics Netherlands Agricultural Census 2009, processed by LEI and Informatienet

[1]DM = Farms in the derogation monitoring network 2009, LBT = Sample population based on Agricultural Census 2009 (Data Statistics Netherlands (CBS), processed by LEI).

[2] GVE = Livestock Unit, this is a comparative standard for animal numbers based on the phosphate production forfeit (phosphate production forfeit dairy cow = 1 GVE).

[3] Areas are given in hectares of cultivated land and the acreage of natural habitats is not included.

An examination of the agricultural characteristics of the sample population and a comparison with the farms from the Agricultural Census (see Table 13) reveals the following differences:

- The mean acreage of cultivated land of the sampled farms is greater than that of the farms in the sample population (52.7 versus 43.9 hectares). This applies to all regions.
- An average of 0.9 ha natural habitat is managed. This area is not included in the calculation of the environmental pressure per hectare of cultivated land (fertilisation, surpluses and the like).
- For the farms sampled, 83% of the acreage is grassland and this is comparable to the mean of the sample population.
- On the farms sampled, an average of 89% of the arable land is used for silage maize (8.7 ha silage maize divided by 9.8 ha total arable land).
- In all regions, the livestock density of grazing livestock on the farms sampled is higher than the mean of the sample population.

- On 13% of the farms in the derogation monitoring network, housed animals as well as grazing livestock are present. In all regions, the percentage of farms in the derogation monitoring network with housed animals is higher than in the sample population. The presence of housed animals was not a criterion during the stratification process.
- Dairy cattle and the associated young stock constitute almost 93% of the grazing livestock present. The group other grazing livestock consists of beef cattle, sheep, goats, horses and ponies.

These differences between the Agricultural Census and the sample population are such that the sample is not disqualified.

Table 14 provides a more detailed description of dairy farms in the derogation monitoring network. As the correct comparative material was not present in the Agricultural Census, for comparative purposes this table contains the weighted mean of the national sample from the Farm Accountancy Data Network (FADN). This table shows that in all regions the dairy farms have a higher acreage and higher milk production than the weighted national mean.

14 Mean milk production and grazing on dairy farms in 2009 in the derogation monitoring network (DM) compared to the weighted mean of dairy farms in the national sample (FADN).

Farm characteristic	Population	Sand	Loess	Clay	Peat	All
Total number of farms in DM		131	14	48	52	245
Kg FPCM farm	DM	744,000	662,500	885,100	917,000	803,700
	FADN	654,400	364,000	846,300	738,300	701,400
Kg FPCM per ha forage crop	DM	15,400	13,700	15,500	13,700	14,900
	FADN	15,300	13,600	14,300	13,100	14,600
Kg FPCM per dairy cow	DM	8530	8,020	8560	8280	8450
	FADN	8640	7610	8380	8290	8490
Percentage farms with grazing	DM	84	100	81	83	84
	FADN	78	100	85	83	81

[1] FPCM= Fat and Protein Corrected Milk. This is a standard used for comparing milk with different fat and protein contents (1 kg milk with 4.00% fat and 3.32% protein = 1 kg FPCM).

Table 14 specifically reveals the following:
- With more than 14,900 kg FPCM, the mean milk production per ha of forage crop is higher than the national mean. In each of the regions, the milk production per hectare of forage crop on the farms sampled is higher than the weighted national mean.
- On the farms sampled, the average milk production per dairy cow present is slightly higher than the national mean.
- Grazing takes place on 84% of the dairy farms sampled. For farms in the derogation monitoring network, this percentage is slightly higher than the national mean.

2.4 Monitoring of water quality

2.4.1 Sampling at farms

In the measurement year 2009, water quality was sampled at the 285 farms participating in the derogation monitoring network that actually used derogation in 2009 (FADN year - see Table 15 and Figure 17). In 2010, 275 derogation farms were sampled in the sand, clay and peat soil regions. The groundwater, drain water or soil moisture were sampled. On the participating farms in the Low Netherlands, the ditch water on the farms was also sampled. The number of farms sampled per region in this period is stated in Tables 15 and 16. The mean sampling frequency is also stated. The difference between 2009 and 2010 is explained by farms that were new in the FADN in 2009 and that have not yet participated in the water quality monitoring network; participation in this network takes place one year later (in this case in 2010). Results for the FADN Year 2009 are linked to Water Quality Year 2010.

15 Number of sampled farms registered for derogation per subprogramme and per region for 2009 and the sampling frequency of the leaching (L) and ditch water (DW). The desired sampling frequency is stated in parentheses.

Year	**Sand region**		**Loess region**	**Clay region**	**Peat region**
	All farms	Of which drained			
2009	154	29	18	56	57
L rounds	1.0 (1)	- (-)	1.0 (1)	3.2 (2-4[1])	1.0 (1)
DW rounds	- (-)	3.8 (4)	- (-)	3.9 (4)	4.0 (4)

1 In the clay region, groundwater is sampled up to 2 times; drainage water is sampled up to 4 times. Depending on the type of farm, the total number of samples will therefore be between 3 and 4 in the best case.

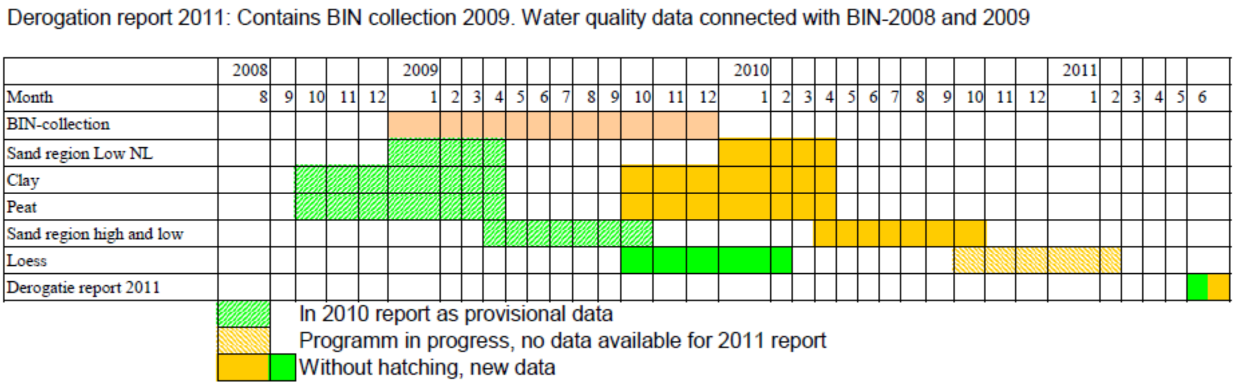
16 Number of sampled farms registered for derogation per subprogramme and per region for 2010 and the sampling frequency of the leaching (L) and ditch water (DW). The desired sampling frequency is stated between parentheses.

Year	**Sand region**		**Loess region***	**Clay region**	**Peat region**
	All farms	Of which drained			
2010	158	30	-	58	59
L rounds	1 (1)	- (-)	- (-)	3.1 (2-4[1])	1 (1)
DW rounds	- (-)	4.0 (4)	- (-)	3.8 (4)	3.6 (4)

* In the loess region 4 farms were sampled in the period October 2010 to February 2011. The results of this sampling were not yet known when this report was compiled.

1 In the clay region, groundwater is sampled up to 2 times; drainage water is sampled up to 4 times. Depending on the type of farm, the total number of samples will therefore be between 3 and 4 in the best case.

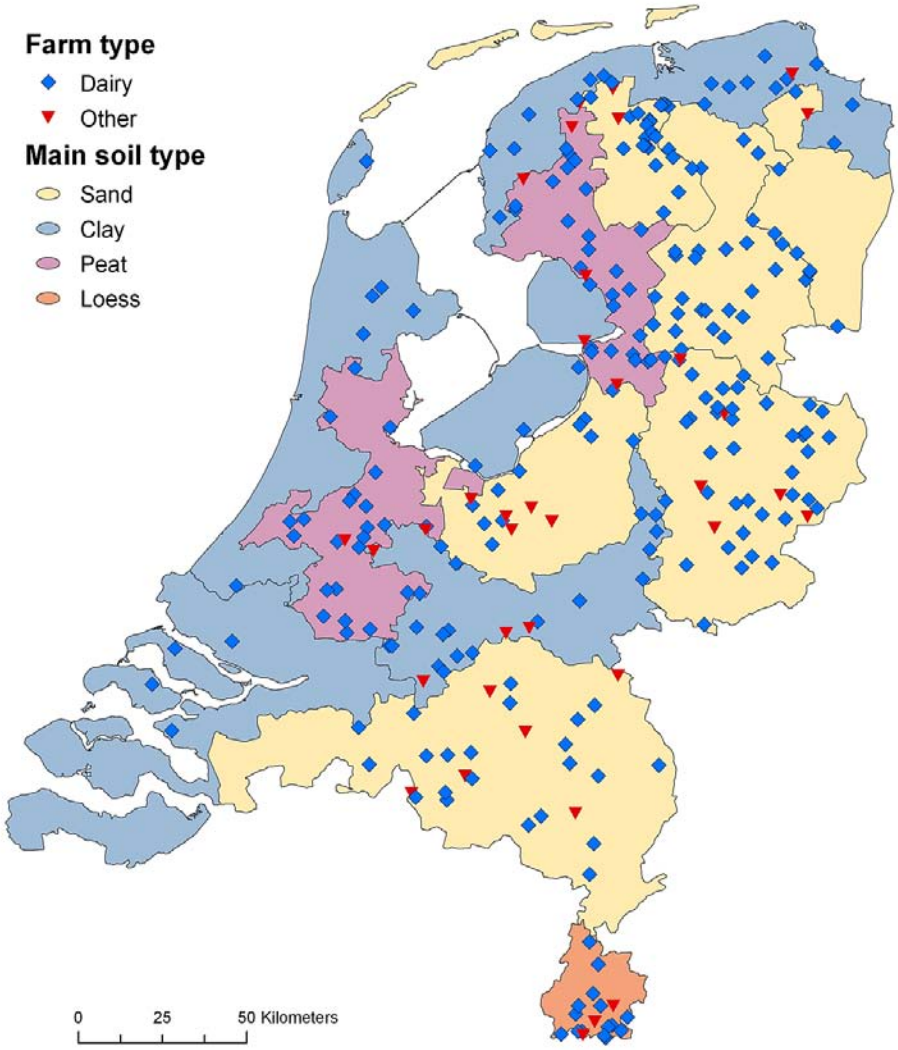
The 2009 water quality sampling occurred in the period between October 2008 and February 2010 and is part of the FADN data from 2008. The 2010 water quality sampling occurred in the period between October 2009 and February 2011 and is part of the FADN data from 2009. The figures for the water quality in the loess region, sampled from October 2010 to February 2011, are not yet available.
The sampling period per region is stated in Figure 17. In addition to this, the sampling in the loess region for 2009 and 2010 was continued in January and February of the following year, as the sampling there was delayed due to frost. A detailed description of the sampling method per region is provided in Appendix 4.



17 Sampling periods for water quality in 2009 (green) and 2010 (yellow) per region per programme.

In this report the water quality data for FADN Year 2009 are still provisional figures. The final figures shall be reported in 2012. Then the data from the loess region for 2010/2011 shall also have been completed and finalised.

Figure 18 shows the distribution of the sampled farms over the main soil type regions. A distinction is also made between dairy farms and other grassland farms. The distribution clearly shows that the focus of the derogation monitoring network lies in the sand region.



18 Location of the 285 grassland farms that participated in the water sampling for the purpose of the derogation monitoring network in 2009.

The soil and drainage characteristics of the farms concerned are given per region in Table 19 for 2009 and Table 20 for 2010. The tables reveal that within a region, other soil types occur in addition to the main soil type after which the region is named. The loess region primarily consists of naturally good-draining soils and the peat region chiefly contains naturally poor-draining soils.

19 Soil type and drainage class (in percentages) per main soil type region on derogation farms sampled in 2009.

Region	Soil types				Drainage class [1]		
	Sand	Loess	Clay	Peat	Poor	Moderate	Good
Sand region	80	0	12	8	41	49	10
Loess region	1	75	24	0	2	3	95
Clay region	13	0	84	3	41	53	6
Peat	13	0	38	49	89	10	0

1 The drainage classes are linked to the groundwater regime classes. The class naturally poor draining contains Gt I to Gt IV, the class moderately draining Gt V, V* and VI, and the class good draining Gt VII and Gt VIII.

20 Soil type and drainage class (in percentages) per main soil type region on derogation farms sampled in 2010.

Region	Soil types				Drainage class [1]		
	Sand	Loess	Clay	Peat	Poor	Moderate	Good
Sand region	81	0	11	8	41	50	10
Loess region	*	*	*	*	*	*	*
Clay region	13	0	84	3	41	53	6
Peat	13	0	37	50	89	10	0

1 The drainage classes are linked to the groundwater regime classes. The class o naturally poor draining contains Gt I to Gt IV, the class moderately draining Gt V, V* and VI, and the class good draining Gt VII and Gt VIII.

* Results from the loess region were not yet available when this report was written.

2.4.2 *Chemical analyses and calculations*

The chemical analyses of the water samples were carried out in an accredited analytical laboratory of RIVM. Table 21 provides an overview of the methods used for the different components. Further details can be found in Wattel-Koekoek et al. (2008).

21 Components analysed with analysis method and detection limit.

Component	Analysis method[1]	Detection limit
Nitrate (NO_3) (mg/l)	IC	0.31 mg l^{-1}
Ammonium (NH_4-N)	CFA	0.064 mg l^{-1}
Total nitrogen (N)	CFA	0.2 mg l^{-1}
Total phosphorus (P)	Q-ICP-MS	0.06 mg l^{-1}

1 Q-ICP-MS : Quadruple inductively coupled plasma mass spectrometry.
IC : Ion chromatography.
CFA : Continuous flow analyser.

An annual mean concentration per component was calculated for each farm. For this calculation, observations with a concentration lower than the detection limit were assigned a value of 0. This allows farm mean concentrations below the detection limit to be calculated.

3 Results for 2009

3.1 Agricultural characteristics

3.1.1 *Nitrogen use via livestock manure*

Table 22 details the use of nitrogen from livestock manure on farms in the derogation monitoring network in 2009. For most of the farms, the manure production was calculated by means of forfeit standards. However, dairy farmers could also choose to deviate from these standards and to calculate a farm-specific manure production using the so-called Guidance (LNV, 2009). This farm-specific manure production was adopted for dairy farms that indicated they were using the so-called Guidance (and who also benefited from this) and for which all of the necessary data were available (n = 41). On all other farms (n = 236) forfeits were used to determine the manure production. A more detailed explanation of the farm-specific and forfeit calculation methods for manure use is provided in Appendix 3.

22 Mean nitrogen use via livestock manure (in kg N per ha) in 2009 on farms in the derogation monitoring network. Means per region.

Description	**Sand**	**Loess**	**Clay**	**Peat**	**All**
Number of farms	147	18	53	57	275
Use of livestock manure					
Produced on farm*	279	233	269	253	268
+ import	11	15	9	15	12
+ stock mutation**	7	9	2	1	5
- export	42	12	29	16	32
Total	255	245	250	253	253
Application standard livestock manure	246	241	246	244	245
Use on arable land***	185	181	171	163	179
Use on grassland***	273	269	269	262	270

* Calculated on the basis of forfeit standards with the exception of dairy farms that indicated they were using the Guidance farm-specific excretion dairy cattle (see Appendix 3).

** A positive inventory mutation is a stock decrease and will correspond to supply.

*** The mean use and the application standards on grassland and arable land are based on 269 farms and 203 farms respectively instead of 275 farms, as on 6 farms the allocation of fertilisers to arable land and grassland did not fall within the confidence intervals and because 66 farms had no arable land.

The following conclusions can be drawn from Table 22:

- at 245 kg per ha, the mean application standard for livestock manure was below the derogation standard of 250 kg N from grazing livestock manure because:
  - o a number of farms had only applied for derogation on a part of their acreage;
  - o a number of farms also applied livestock manure from housed animals for which a standard of 170 kg per ha applies;
- the mean use of nitrogen from livestock manure (253 kg per ha) was several kilograms above the mean application standard;

- the use of nitrogen from livestock manure decreased in the order sand >clay >peat >loess;
- the use of nitrogen from livestock manure on arable land (mainly silage maize) was considerably lower in all regions than the use on grassland.

The use of animal manure in 2009 was 17 kg higher than the mean 236 kg N/ha in 2008 (Zwart et al., 2010). Causes are:

- change in the stock mutation: from a 7 kg increase to a 5 kg decrease means 12 kg more use;
- change (i.e. improvement) to the calculation of the forfeit manure production with an effect of +3 kg;
- a modest decline of 2 kg in manure removal.

For 2009, 22 farms indicated that they worked with farm-specific manure production for their fertilisation plan, but forfeit manure production was used for calculation in the FADN because these farms do not meet all the criteria listed in the 'calculation of grass and maize yields' in Appendix 3.2. Most of these 22 farms have both grazing animals and housed animals and so do not meet the 'no housed animals' criterion. In particular, those farms with housed animals could arrive at distinctly different and probably lower manure productions than are now indicated with the standard manure production figures – by using farm-specific manure production for grazing livestock via the Guide plus the application of the housing balance for housed animals. If these 22 farms are not included, then the use of livestock manure, averaged over the remaining 253 farms, is 249 kg N/ha, 4 kg lower than in Table 22.

The farms in the monitoring network imported and exported livestock manure. As the production was generally higher than the use permitted, the export of manure was on average higher than the import of manure. This applied to all regions. Table 23 provides a more detailed explanation of the import and export of livestock manure.

23 Percentage of farms in the derogation monitoring network that supplied and/or removed livestock manure in 2009. Means per region.

Description	Sand	Loess	Clay	Peat	All
No import and export	25	39	32	28	28
Only export	38	33	38	33	37
Only import	24	17	21	32	25
Both import and export	12	11	9	7	11

Table 23 shows that on 28% of the farms there was no import or export of manure. On 37% of the farms manure was only exported, whereas on 25% of the farms manure was only imported. This manure import can be explained by the fact that the purchase of nutrients via livestock manure in 2009 had a clear economic advantage compared to inorganic fertiliser. On 11% of the farms, there was both import and export of manure.

3.1.2 *Fertiliser use compared to the application standards*

Tables 24 and 25 detail the calculated use of plant-available nitrogen and phosphate from fertilisers. The quantity of plant-available nitrogen from livestock manure is calculated by multiplying the quantity of nitrogen in the livestock manure used (produced on own farm or imported, see Table 22) by the prevailing statutory plant-availability coefficients relevant to the specific situation (see Appendix 3). These tables also contain the mean application standards per ha for arable land (mainly maize acreage) and grassland to allow a comparison of fertiliser use. These mean application standards are based on the acreage of cultivated crops and the soil type classifications as registered in the FADN and the statutory application standards determined for 2009 (Dienst Regelingen, 2006).

The following conclusions can be drawn from Table 24:

- At the farm level, the calculated total (plant-available) nitrogen use was lower in all regions than the nitrogen application standard.
- The calculated total (active) nitrogen use in all regions on both grassland and arable land was less than the application standard except on grassland in the sand region and on arable land in the loess region. This was partly because 84% of the dairy farms used grazing (Table 14), as a result of which a lower statutory nitrogen availability coefficient (45% in 2009) could be used.
- In the clay region, the total (plant-available) nitrogen use is higher than in the other regions due to a higher use of inorganic fertiliser. Also the nitrogen application standards are higher on the clay soils than on other soils.
- In the loess region, the total (plant-available) nitrogen use was lower than in the other regions due to a lower use of both livestock manure and inorganic fertiliser.
- In all regions, the nitrogen fertilisation on arable land, which mostly consists of silage maize, is considerably lower than the nitrogen fertilisation on grassland.

24 Mean nitrogen use from fertilisers (in kg plant-available N per ha) on farms in the derogation monitoring network in 2009. Means per region.*

Description	**Category**	**Sand**	**Loess**	**Clay**	**Peat**	**All**
Number of farms		147	18	53	57	275
Average statutory coefficient of effectiveness of livestock manure in%		50	48	50	49	50
Fertiliser use	Livestock manure	128	118	125	124	126
	Other organic fertiliser	0	0	0	0	0
	Inorganic fertiliser	123	106	154	120	127
	Total mean	251	223	279	244	253
	Nitrogen application standard	256	238	289	281	266
Use of plant-available nitrogen on arable land**		124	172	131	112	127
Application standard on arable land**		158	164	163	166	161
Use of plant-available nitrogen on grassland**		286	247	313	259	283
Application standard on grassland**		280	266	313	292	289

* Calculated according to the prevailing statutory availability coefficients (see Appendix 3).

** The mean use and the application standards on grassland and arable land are based on 269 farms and 203 farms respectively instead of 275 farms, as on 6 farms the allocation of fertilisers to arable land and grassland did not fall within the confidence intervals and because 66 farms had no arable land.

25 Mean phosphate use (in kg P_2O_5 per ha) in 2009 on farms in the derogation monitoring network. Means per region.

Description	Category	Sand	Loess	Clay	Peat	All
Number of farms		147	18	53	57	275
Fertiliser use	Livestock manure	97	100	93	94	96
	Other organic fertiliser	0	0	0	0	0
	Inorganic fertiliser	4	5	4	3	4
	Total mean	101	105	97	97	100
	Phosphate application standard	98	97	98	99	98
Use of phosphate on arable land*		95	88	91	100	94
Application standard on arable land**		85	85	85	85	85
Use of phosphate on grassland*		103	115	100	97	102
Application standard on grassland**		101	100	100	100	100

* The mean use and the application standards on grassland and arable land are based on 269 farms and 203 farms respectively instead of 275 farms, as on 6 farms the allocation of fertilisers to arable land and grassland did not fall within the confidence intervals and because 66 farms had no arable land.

** The mean phosphate application standard on grassland was over 100 kg per ha and on arable land over 85 kg per ha because a small proportion of the plots are phosphate poor or phosphate fixating. On these plots a phosphate application standard of 160 kg per ha was used.

The following conclusions can be drawn from Table 25:

- In the sand and loess regions more phosphate was applied in the form of fertiliser than in the clay and peat regions.
- In the sand and loess regions, the total consumption of phosphate from fertilisers is higher than the phosphate application standard. Since nearly 95% of the phosphate fertiliser comes from livestock manure, the same issues apply to these differences as are mentioned in section 1.3 and in Table 22.
- At an average of 102 kg, the phosphate use on grassland was just above the application standard of 100 kg on grassland. Only in the peat region the phosphate use on grassland was below the application standard.
- However, at 94 kg per ha, the use of phosphate on arable land was higher than the application standard of 85 kg phosphate per ha. This applied to all regions.
- On average 95% of the phosphate was applied via livestock manure.

3.1.3 *Crop yields*

Table 26 shows the mean crop yield, estimated for silage maize and calculated for grassland, on the farms in the derogation monitoring network that satisfied the criteria for applying the calculation method for crop yield. This calculation method is derived from Aarts et al. (2008). In this method the yield from silage maize is estimated by measuring the quantity of ensilaged silage maize. The grass yield is calculated as the difference between the energy requirement of the cattle herd on the one hand and the energy uptake from farm-grown silage maize (and forage crops other than grass) and purchased feed on the other hand. Further information about this method is provided in Appendix 3.

26 Average crop yield (in kg dry matter, N, P and P_2O_5 per ha) for silage maize (estimated) and grassland (calculated) in 2009 on farms in the derogation monitoring network that satisfy the criteria for using the calculation method (Aarts et al., 2008). Means per region.

Description	**Sand**	**Loess**	**Clay**	**Peat**	**All**
Silage maize yields					
Number of farms	86	11	26	19	142
Kg dry matter per ha	16,100	16,400	16,400	14,800	16,000
Kg N per ha	184	191	189	173	184
Kg P per ha	32	33	34	33	32
Kg P_2O_5 per ha	73	77	77	75	74
Yields grassland					
Number of farms	100	11	34	33	178
Kg dry matter per ha	9400	10,800	9800	10,100	9700
Kg N per ha	254	287	253	270	259
Kg P per ha	36	42	37	39	38
Kg P_2O_5 per ha	84	97	86	90	86

Table 26 shows that:

- Estimated mean dry matter yield of silage maize was over 16,000 kg/ha. The yield in the peat region was less than 15,000 kg dry matter per hectare and in the other regions it was more than 16,000 kg dry matter per hectare.
- Per hectare an estimated mean of 184 kg N and 32 kg P (74 kg P_2O_5) was harvested in the form of silage maize.
- At 9700 kg per ha, the calculated grassland yield of dry matter was considerably lower than the estimated silage maize yield. Due to higher N and P levels in grass products compared with silage maize, both the N-yield per hectare and the P-yield per hectare were, however, higher.
- The calculated grassland yields were highest in the loess region and lowest in the sand region.

3.1.4 *Nutrient surpluses*

Tables 27 and 28 detail the nitrogen and phosphate surpluses on the soil surface balance for farms in the derogation monitoring network in 2009. The surpluses are calculated using the calculation method described in Appendix 3.

27 Nitrogen surplus on the soil surface balance (in kg N per ha) for farms in the derogation monitoring network in 2009. Means and 25% and 75% quartiles per region.

Description	Category	Sand	Loess	Clay	Peat	All
Number of farms		147	18	53	57	275
Import farm	Inorganic fertiliser	123	106	154	120	127
	Organic fertiliser	24	25	18	22	23
	Feed	183	120	167	128	165
	Other	10	4	11	6	9
	Total	340	255	350	275	323
Export farm	Milk and other animal products	73	56	77	69	72
	Animals	28	14	15	16	22
	Organic fertiliser	48	13	36	22	38
	Other	4	26	5	7	6
	Total	153	109	132	114	138
Mean nitrogen surplus per farm		187	146	218	162	185
+ Deposition, mineralisation and organic N fixation		52	59	50	119	66
- Gaseous emission*		43	33	46	44	43
Mean nitrogen surplus soil surface balance		196	172	222	237	208
Nitrogen surplus soil surface balance first quartile (25%)		148	138	160	183	156
Nitrogen surplus soil surface balance third quartile (75%)		231	203	257	298	245

* Gaseous emission from housing and storage, during application and grazing.

The following conclusions can be drawn from Table 27:

- The mean nitrogen surplus on the farm gate balance was 185 kg per ha.
- The nitrogen surplus on the farms' balance sheets increases – in the order loess < peat < sand < clay.
- There are considerable differences between the regions with respect to the composition of the nitrogen surplus on the soil surface balance:
  - In the clay region, the surplus on the farm gate balance was the highest because of the relatively high import compared to the other regions, which was not fully compensated by a high export.
  - The sand region had a lower nitrogen surplus on the farm gate balance compared to the clay region, mainly due to a lower import. Since there were no large differences between the clay and sand regions in terms of the import via deposition, mineralisation and biological N fixation and export via gaseous emissions, the nitrogen surplus on the soil surface balance was also considerably lower in the sand region than in the clay region.
  - In the peat region, less nitrogen was imported in the form of feed compared to the sand and clay regions. This lower import was partly caused by the lower number of housed animals in this region. Nitrogen removal by animals, animal products and manure is, however, also lower. The nitrogen surplus on the soil surface balance was higher,

mainly due to the assumption that the mean net nitrogen mineralisation on peat was 75 kg per ha. This was included as import on the soil surface balance.
  - The farms in the loess region were characterised by a low nitrogen surplus. Both import and export were lower on the farm gate balance than in the other regions.
- There is a considerable variation in the nitrogen surplus on the soil surface balance. The 25% of farms with the lowest surplus realised a surplus of less than 156 kg N per ha, whereas for the 25% of farms with the highest surplus, the surplus was in excess of 245 kg N per ha.

28 Phosphate surplus on the soil surface balance (in kg P_2O_5 per ha) for farms in the derogation monitoring network in 2009. Means and 25% and 75% quartiles per region.

Description	Category	Sand	Loess	Clay	Peat	All
Number of farms		147	18	53	57	275
Import farm	Inorganic fertiliser	4	5	4	3	34
	Organic fertiliser	13	16	9	12	12
	Feed	67	49	62	51	62
	Other	5	2	5	3	4
	Total	88	71	80	69	81
Export farm	Milk and other animal products	29	22	30	26	28
	Animals	15	9	9	10	13
	Organic fertiliser	21	6	18	12	18
	Other	1	10	2	2	2
	Total	67	46	59	51	61
Mean phosphate surplus soil surface balance		21	25	20	18	20
Phosphate surplus soil surface balance first quartile (25%)		10	5	8	7	8
Phosphate surplus soil surface balance third quartile (75%)		29	43	30	29	29

The following conclusions can be drawn from Table 28:
- The mean phosphate surplus on the soil surface balance was 20 kg per ha.
- The phosphate surplus on the soil surface balance was highest in the loess region. At 18 kg per ha, the phosphate surplus in the peat region was the lowest.
- On the 25% of farms with the lowest phosphate surplus this surplus was less than 8 kg per ha, whereas for the 25% of farms with the highest surplus this surplus was over 29 kg per ha.

3.2 Water quality

3.2.1 Leaching from the root zone, measured in 2009

In 2009, the concentrations measured in water leaching from the root zone are related to the agricultural practices on the farms in 2008 and the years previous to this. The water quality reported here is therefore related to the agricultural practices during the third year in which derogation was applied.

The nitrate concentrations in the loess region were on average higher than 50 mg NO_3 per litre. The nitrate concentrations in the other regions were on average lower than 50 mg NO_3 per litre (see Table 29). Although the nitrate concentration in the peat region was lower than in the clay region, the total nitrogen concentration was higher. This was due to the higher ammonium concentrations in the groundwater. In 2010, the mean ammonium concentration in the peat region was 5.5 mg N per litre. In the clay and loess regions the concentration was on average lower than 1 mg per litre. In the sand region the mean concentration was 1.6 mg N per litre. The higher ammonium concentration is probably the consequence of nutrient-rich peat layers (Van Beek et al., 2004). The groundwater that is, or has been, in contact with nutrient-rich peat layers often has a similarly high phosphate concentration (Van Beek et al., 2004) and these nutrient-rich peat layers are probably also the cause of the measured higher mean phosphorus concentration in the peat and clay regions compared with the sand and loess regions.

29 Nutrient concentration (in mg/l) in water that leached from the root zone in 2009 on farms in the derogation monitoring network. Mean concentrations per region.

Characteristic	**Region**			
	Sand	**Loess**	**Clay**	**Peat**
Number of farms	154	18	56	57
Nitrate (NO_3)	39	51	20	7
Nitrogen (N)	11.5	12.1	6.5	7.7
Phosphorus (P)	0.15 (46)	0.04 (61)	0.28 (16)	0.37 (5)

[1] The average percentage of farms with concentrations lower than the detection limit of 0.06 mg per litre is indicated in parentheses.

In the sand region, 69% of the farms had a nitrogen concentration lower than 50 mg per litre and in the loess region this was 55% (see Table 30). In the clay and the peat regions, the percentage of farms with a concentration lower than 50 mg per litre was 88% and 98% respectively. Farms in the class concentration class > 50 mg NO_3 per litre exceed the norm.

30 Frequency distribution of the mean farm nitrate concentrations (in mg NO_3per litre) in water that leached from the root zone on farms in the derogation monitoring network per region in 2009, expressed as percentages per class.

Concentration class (mg NO_3 /l)	**Region**			
	Sand	**Loess**	**Clay**	**Peat**
<15	31	6	54	81
15-25	10	0	21	11
25-40	18	28	12	7
40-50	10	11	0	0
>50	31	56	12	2
Number of farms	154	18	56	57

Fifty percent of the farms in the sand region had a nitrogen concentration between 6.5 and 15.4 mg N per litre (see Table 31). For the loess region the figures were more or less the same. For the peat and clay regions, the values were lower.

31 Nitrogen concentrations (in mg N per litre) in water that leached out from the root zone in 2009 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	**Region**			
	Sand	**Loess**	**Clay**	**Peat**
Number of farms	153	18	56	57
First quartile (25%)	6.5	9.2	2.9	5.8
Median (50%)	10.2	12.1	4.4	7.4
Third quartile (75%)	15.4	14.2	7.9	9.5

The phosphorus concentration in the leaching water on 75% of the farms in the loess region was lower than the detection limit of 0.06 mg P per litre and in the sand region lower than 0.12 mg per litre (see Table 32). In the clay region, the phosphorus concentrations for 50% of the farms were between 0.06 and 0.40 mg per litre In the peat region the concentrations were higher.

32 Phosphorus concentrations (in mg P per litre) in water leaching out of the root zone in 2009 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	**Region**			
	Sand	**Loess**	**Clay**	**Peat**
Number of farms	154	18	56	57
First quartile (25%)	0.03	0.03	0.06	0.14
Median (50%)	0.04	0.03	0.20	0.28
Third quartile (75%)	0.12	0.05	0.40	0.42

3.2.2 Ditch water quality, measured in 2008-2009

The quality of the ditch water in the winter of 2008-2009 reported here, reflects the agricultural practices in 2008 and the years prior to this and is related to the third year of the derogation. The provisional peat and clay figures have already been presented in 2010 (Zwart et al., 2010).
The loess region has no derogation monitoring network farms with ditches or drains and is therefore not included in the tables below.

The nitrate concentration in the ditch water on farms in the derogation monitoring network clearly differs between regions. With a mean of 26 mg NO_3 per litre the nitrate concentration was highest in the sand region and with a mean of less than 4 mg per litre, was lowest in the peat region (see Table 33). This also applies to the nitrogen concentration, although the difference between the clay and peat regions is not relevant. The phosphorus concentration in the ditch water was highest in the clay region and lowest in the sand region.

33 Nutrient concentration (in mg per litre) in ditch water in the winter of 2008-2009 on farms in the derogation monitoring network. Mean concentrations per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Number of farms[1]	29	0	55	55
Nitrate (NO_3)	26	*	10	4
Nitrogen (N)	7.8	*	4.3	4.2
Phosphorus (P)	0.12	*	0.32	0.23

* The loess region has no farms with ditches.

1 For clay region only one farm has no ditches and for peat region only two.

In the sand region, 21 of the 29 farms (73%) had a nitrate concentration lower than 40 mg per litre (see Table 34). In the clay and peat regions, none of the companies had a ditch water nitrate concentration above the standard of 50 mg per litre.

34 Frequency distributions of the farm mean nitrate concentrations (in mg NO_3 per litre) in ditch water on farms in the derogation monitoring network per region in the winter of 2008-2009, expressed in percentages per class.

Concentration class (mg NO_3 /l)	Region			
	Sand	Loess	Clay	Peat
<15	45	*	84	96
15-25	21	*	5	2
25-40	7	*	5	2
40-50	7	*	5	0
>50	21	*	0	0
Number of farms[1]	29	0	55	55

* The loess region has no farms with ditches.

1 For clay region only one farm has no ditches and for peat region only two.

Approximately half of the farms in the sand region had a ditch water nitrogen concentration of between 3.5 and 12.2 mg N per litre (see Table 35). In the clay and peat regions at least 75% of the farms have a ditch water nitrogen concentration lower than 5.3 mg per litre.

35 Ditch water nitrogen concentrations (in mg N per litre) in the winter of 2008-2009 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	Region			
	Sand	Loess	Clay	Peat
Number of farms[1]	29	0	55	55
First quartile (25%)	3.5	*	2.3	2.6
Median (50%)	6.0	*	3.4	3.8
Third quartile (75%)	12.2	*	5.1	5.3

* The loess region has no farms with ditches.

1 For clay region only one farm has no ditches and for peat region only two.

On 50% of the farms in the sand region, the ditch water phosphorus concentration was lower than 0.05 mg P per litre (see Table 36). In the peat region, 50% of the farms had a phosphorus concentration between 0.05 and 0.20 mg per litre. The highest concentrations were found in the clay region. Here, 50% of the farms had a phosphorus concentration of between 0.04 and 0.46 mg per litre. In both the peat and the clay regions the concentrations were higher than in the sand region.

36 Ditch water phosphorus concentrations (in mg P per litre) in the winter of 2008-2009 on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	**Region**			
	Sand	**Loess**	**Clay**	**Peat**
Number of farms[1]	29	0	55	55
First quartile (25%)	0.03	*	0.04	0.05
Median (50%)	0.05	*	0.13	0.12
Third quartile (75%)	0.13	*		0.20

* The loess region has no farms with ditches.

1 For clay region only one farm has no ditches and for peat region only two.

Comparison with the provisional figures for 2009 as reported in 2010
The figures are virtually unchanged from what was reported as preliminary figures in 2010. Differences that do appear are due to a small variation in the selection of the derogation farms.

3.2.3 *Provisional figures for the measurement year 2010*

For the fourth water quality measurement year (2010), only provisional results are available – with the exception of the loess region where no results were yet available at the time of drafting this report. ‘Provisional’ means that the results carry a reasonable certainty; however, various cross-checks have not yet been performed. This could mean that several concentrations might change in the final results presented in 2012.

Table 37 shows the frequency distributions in the mean farm nitrate concentrations (mg NO_3 per litre) over the concentration ranges. This is shown, expressed in percentages, for both the water leaching from the root zone and for the ditch water for all farms in the derogation monitoring network per region in 2010. Farms in the concentration class >50 mg NO_3 per litre exceed the norm.

In the sand region, the mean nitrate concentration in water leaching from the root zone was 46 mg per litre and 59% of the farms had a concentration lower than 50 mg per litre. The mean nitrate concentration in water leaching from the root zone in the clay region in 2010 was 28 mg per litre. Of the participating farms, 88% had a nitrate concentration lower than 50 mg per litre (see Table 37). The mean nitrate concentration on farms in the peat region was 12 mg per litre.

The mean nitrate concentration in the ditch water in 2010 in the clay and peat regions was 11 mg per litre and 4 mg per litre respectively for all participating farms (see Table 37) and was therefore far below the standard of 50 mg per litre. In the sand region it was 32 mg per litre, which was higher than in the clay and peat regions but below the standard.

37 Frequency distribution of the mean farm nitrate concentrations (in mg NO_3 per litre) in water that leached from the root zone on farms in the derogation monitoring network per region in 2010, expressed as percentages per class.

Concentration class (mg NO_3/l)	**Water type**						
	Leaching out of root zone				**Ditch water**		
	Sand	**Loess**	**Clay**	**Peat**	**Sand**	**Clay**	**Peat**
<15	23	*	40	73	33	74	93
15-25	12	*	31	8	17	18	4
25-40	17	*	10	14	20	9	4
40-50	7	*	7	2	10	0	0
>50	41	*	12	3	20	0	0
Overall mean	46	*	28	12	32	11	4
Number of farms	158	*	58	59	30	57	57

* Data from the loess region were not yet available when this report was written.

The mean total nitrogen concentration and the frequency distribution in the leaching water for the three regions are given in Table 38. The nitrogen concentrations in the ditch water were lower than those in the leaching water.

38 Nitrogen concentrations (in mg N per litre) in the water leaching from the root zone (left) and in the ditch water (right) in 2010 (provisional figures) on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	**Water type**						
	Leaching				**Ditch water**		
	Sand	**Loess**	**Clay**	**Peat**	**Sand**	**Clay**	**Peat**
Number of farms	158	0	58	59	30	57	57
Mean	13.2	*	8.3	9.7	9.5	4.4	4.0
First quartile (25%)	7.5	*	4.3	6.5	5.5	2.7	2.6
Median (50%)	11.4	*	6.1	7.8	7.5	3.7	3.7
Third quartile (75%)	17.2	*	9.3	12.5	11.8	5.5	4.7

* Data from the loess region were not yet available when this report was written.

The table below details the mean phosphorous concentration and frequency distribution in the leaching water and in the ditch water for the three regions. Like nitrogen, the phosphorus concentrations in ditch water were lower than in leaching water, with the exception of the clay region where the phosphorous concentration in the ditch water was higher than in the leaching water.

39 Phosphorous concentrations (in mg P per litre) in the water leaching from the root zone (left) and in the ditch water (right) in 2010 (provisional figures) on farms in the derogation monitoring network. First quartile, median and third quartile per region.

Characteristic	**Water type**						
	Leaching				**Ditch water**		
	Sand	**Loess**	**Clay**	**Peat**	**Sand**	**Clay**	**Peat**
Number of farms	158	0	58	59	30	57	57
Mean	0.15	*	0.21	0.43	0.14	0.23	0.15
First quartile (25%)	0.03	*	0.06	0.17	0.03	0.04	0.04
Median (50%)	0.04	*	0.15	0.30	0.06	0.15	0.08
Third quartile (75%)	0.12	*	0.31	0.49	0.12	0.34	0.19

Loess farms in the monitoring network have no ditches.

4 Changes in the monitoring network since the derogation

4.1 Introduction

In this chapter, a relationship will be established between agricultural practices and water quality based on results from the derogation monitoring network. This chapter first of all describes the trends in agricultural practice and then the evolution of the water quality. Finally a link is made between the trends in agricultural practice and the evolution of the water quality. This includes results both from this report and from previous reports on the derogation network (Fraters et al., 2008; Zwart et al., 2009 and 2010). For both agricultural practice and water quality four measurement years are available. When making comparisons, it should be realised that a limited series of measurement data for four successive years does not provide sufficient basis for concrete statements about trends and developments.

4.1.1 Method used for comparison of successive years.

In the following sections, the same own method is used to compare both agricultural practice data and water quality data for consecutive derogation years. The purpose of the comparison is to determine whether there are explainable differences between the years. In preparing this report, four consecutive years of data were available:
Agricultural practice: years prior to 2009 (2006, 2007 and 2008);
Water quality: years prior to 2010 (2007, 2008 and 2009).

The comparison method used has been developed by RIVM and LEI such that it can continue to be used in the coming years. A requirement for the method was that it should make any differences that occur easily understandable for the reader.

The basis for the method is the average parameter value of the first three years. For each of the three years, the difference from the average, and then the average difference for the period is calculated. Subsequently, the difference between the value from the current measurement year and the average of the previous three years is determined, and the factor is calculated from the difference between the current measurement year and the average difference. As this factor becomes greater, the current measurement year deviates more than the previous years did on average.

Based on the factor, it is then determined whether a relevant difference exists. For this, the following limits and symbols are used:

≈	no relevant difference;
+/- > 2	relevant difference;
++/- > 5	relevant difference, relatively large;
+++/- > 20	relevant difference, relatively very large.

Where relevant differences occur, the respective differences among the previous years are also considered. If these show a consistent increase or decrease, this is explained in the text.
An explanation of the method used is provided in Appendix 6.

4.2 Trends in agricultural practice

A total of 265 farms took part in the derogation monitoring network and used derogation in all years during the period 2006-2009. Farms that did not participate in one of the years have not been included. Therefore the numbers differ slightly from those reported in section 3.1 and in Fraters et al. (2008) and in Zwart et al. (2009, 2010). As the nutrient flows in 22 of these 265 farms were incomplete in some years, Tables 41, 42, 43, 45 and 46 are based on the results from 243 farms. The calculated crop yields (Table 44) are based on the data from 93 farms that participated in all years and satisfied the criteria for calculating crop yields in all years.

4.2.1 Classification of the farms

Changes in the general farm characteristics over the course of time such as acreage of cultivated land, percentage of farms with grazing and the percentage of grassland are, in general, limited (see Table 40). The quantity of milk produced, expressed as FPCM per farm and per hectare has increased. One reason for this is the expansion of the milk quorum from the European Union by 0.5% in 2007, 2.5% in 2008 and 1% in 2009, but farms have also bought or leased quota. The increase in the milk production was associated with an increase in the area of cultivated land and the stock density. The percentage of farms with housed animals decreased slightly in 2009, just as did the percentage of farms where dairy cows were grazed.

40 General operating characteristics of farms in the derogation monitoring network (DM) in 2009 compared with 2006, 2007 and 2008, the average for the years 2006-2008, the difference (F) and relevance (R); (n = 265).

Farm characteristic	2006	2007	2008	Gem. 06-08	2009	F	R
Number of dairy farms	239	237	239		238		
Number of other grassland farms	26	28	26		27		
Total area cultivated land (ha)	49.6	49.9	51.8	50.4	53.1	2.9	+
Percentage grassland	83	83	82	82	82	-0.6	≈
Percentage farms with housed animals	17	14	14	15	12	-3.0	-
Total livestock density (GVE per ha)	2.46	2.50	2.63	2.53	2.61	1.1	≈
Kg FPCM farm (x 1000)	700	729	773	734	802	2.6	+
Kg FPCM per diary cow (x 1000)	8.45	8.46	8.41	8.44	8.45	0.7	≈
Kg FPCM per ha forage crop (x 1000)	14.2	14.5	15.1	14.6	15.0	1.3	≈
Percentage dairy farms with grazing dairy cattle	89	88	86	88	84	3.2	-

F (difference factor) = number of times that 2009 differed more from the mean than on average during the previous 3 years.

S (significance): ≈ no relevant difference, +/- > 2, ++/-- > 5, +++/--- > 20.

4.2.2 *Use of livestock manure*

The use of livestock manure expressed in nitrogen (N) did not change in the period 2006-2008 (Table 41). In 2006-2008, there was an increase in stocks of livestock manure that turned into a stock decline in 2009: this stock decline was administered in 2009. The use of nitrogen from livestock manure on grassland and arable land varied slightly in the period 2006-2009. Compared to the years 2006-2008, this increased use of livestock manure took place mainly on grassland.

41 Average nitrogen use via livestock manure (kg N per ha) on farms in the derogation monitoring network (DM) 2009 compared with 2006, 2007 and 2008, the average for the years 2006-2008, the difference (F) and relevance (R); (n = 243).

Description	**2006**	**2007**	**2008**	**Gem. 06-08**	**2009**	**F**	**R**
Use nitrogen from livestock manure							
Produced on farm	255	258	262	258	261	1.4	≈
+ Import	9	10	12	10	12	1.8	≈
+ Stock mutation*	-5	-7	-6	-6	5	19.8	++
- Export	19	22	24	22	23	0.8	≈
Total use	240	240	243	241	256	11.5	++
						,	-
Application standard livestock manure	242	248	245	245	245	0.1	≈
Use on grassland**	254	254	258	255	274	9.7	++
Use on arable land***	178	184	178	180	181	0.3	≈

F (difference factor) = number of times that 2009 differed more from the mean than on average during the previous 3 years.

S (significance): ≈ no relevant difference, +/- > 2, ++/-- > 5, +++/--- > 20.

with supply

* A positive inventory mutation is a stock decrease and will correspond to supply.

** The mean use and the application standards on grassland are based on 241 farms as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.

*** The mean use and the application standards on arable land are based on 179 farms as besides a number of farms falling outside of the confidence intervals for the allocation of fertilisers to arable land, a number of farms had no arable land.

4.2.3 *Use of fertilisers compared to the application standards*

Table 42 compares the use of nitrogen fertilisers to the statutory nitrogen application standards.

42 Average nitrogen use (in kg plant-available N per ha) on farms in the derogation monitoring network (DM) 2009 compared with 2006, 2007 and 2008, the average for the years 2006-2008, the difference (F) and relevance (R); (n = 243).

Description	**2006**	**2007**	**2008**	**Gem. 06-08**	**2009**	**F**	**R**
Livestock manure excl. availability coefficient	240	240	243	241	256	11.5	++
Availability coefficient	40.2	40.3	48.8	43.1	49.1	-1.6	≈
Livestock manure incl. availability coefficient	97	97	119	104	125	2.2	+
+ other organic fertiliser	0	0	0	0	0	0.2,	≈
+ inorganic fertiliser	127	128	123	126	127	0.3	≈
Total use	224	225	242	230	253	2.9	+
Farm's nitrogen application standard	290	289	274	285	265	-2.8	-
Use on grassland*	250	251	269	257	281	3.0	+
Application standard grassland	316	314	297	309	287	-2.8	-
Use on arable land**	111	117	128	118	128	1.5	≈
Application standard arable land	165	169	167	167	161	-4.4	-

F (difference factor) = number of times that 2009 differed more from the mean than on average during the previous 3 years.

S (significance): ≈ no relevant difference, +/- > 2, ++/-- > 5, +++/--- > 20.

* The mean use and the application standards on grassland are based on 241 farms as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.

** The mean use and the application standards on arable land are based on 179 farms as besides a number of farms falling outside of the confidence intervals for the allocation of fertilisers to arable land, a number of farms had no arable land.

Table 42 shows several relevant differences. These are partly caused by changes to the standards:

- The statutory effectiveness coefficient for farm-produced grazing livestock manure in the case of grazing dairy cattle has been 45% since 2008, whereas this was 35% in 2006 and 2007. Not only greater use of livestock manure in 2009, but also higher effectiveness coefficients from 2008 lead to a more active use of livestock manure.
- The nitrogen application standards on grassland were also made more stringent in the years 2006-2009.

The use of nitrogen fertilisers in the years 2006-2009 remained fairly constant. The total amount of active nitrogen does increase because of more active nitrogen from livestock manure. Adjustments to the effectiveness coefficient and the increased use of livestock manure reduce the differences between use and nitrogen application standards:

- At the farm level, there is still a 12 kg gap between the use of plant-available nitrogen and the nitrogen application standards. This is approximately 20% of the gap between use and the application standard in 2006 and 2007;

- On grassland, the difference in 2009 was only around 10% of that between 2006 and 2007;
- On arable land, the difference in 2009 was still about 60% of the difference in 2006 and 2007.

Table 43 compares the use of phosphate fertilisers to the statutory phosphate application standards. Table 43 shows a few relevant differences. Just as for Table 42, adjustments to the application standards over the course of time, now for phosphate, play a large role. From Table 43 it can be concluded that:
- The application standards for both grassland and arable land have been lowered each year (by 5 kg phosphate per ha) in the years 2006-2008. Some of the farms have requested a higher application standard for phosphate-poor or phosphate-fixing soils.
- The use of phosphate through fertilising with livestock manure increased in 2009, in particular.
- The use of phosphate from inorganic fertiliser decreased relevantly in 2009 compared to the previous years. The increase in livestock manure is, however, more marked in 2009, so that the total use of phosphate via fertilisation in 2009 is relevantly higher than in the previous years.
- Grassland got more phosphate from fertilisation than arable land in 2009. The opposite was true in the years 2006-2008. Phosphate inorganic fertiliser was applied more often to arable land while an extra supply of livestock manure went to grassland in 2009 (mainly due to the oft-mentioned inventory reduction).

43 Average phosphate use of livestock manure (in kg P_2O_5 per ha) on farms in the derogation monitoring network (DM) 2009 compared with 2006, 2007 and 2008, the average for the years 2006-2008, the difference (F) and relevance (R); (n = 243).

Description	**2006**	**2007**	**2008**	**Gem. 06-08**	**2009**	**F**	**R**
Livestock manure	88	87	90	88	97	10.0	++
+ other organic fertiliser	0	0	0	0	0	0.3	≈
+ inorganic fertiliser	10	7	6	8	4	-2.4	-
Total use	98	95	96	96	101	3.7	+
Phosphate application standard farm	108	103	98	103	98	1.5	≈
Use on grassland*	98	95	96	96	103	5.5	++
Phosphate application standard grassland	110	106	100	105	100	1.5	
Use on arable land**	101	101	98	100	96	2.7	-
Application standard arable land	96	92	87	92	86	-1.6	

F (difference factor) = number of times that 2009 differed more from the mean than on average during the previous 3 years.

S (significance): ≈ no relevant difference, +/- > 2, ++/-- > 5, +++/--- > 20.

* The mean use and the application standards on grassland are based on 241 farms as the allocation of fertilisers to arable land did not fall within the confidence intervals for a number of farms.

** The mean use and the application standards on arable land are based on 179 farms as besides a number of farms falling outside of the confidence intervals for the allocation of fertilisers to arable land, a number of farms had no arable land.

4.2.4 *Crop yields*

The crop yields calculated according to the method described by Aarts et al. (2008). A more detailed explanation of this calculation method is provided in Appendix 3.

44 Estimated crop yield (in kg dry matter, N, P and P_2O_5) for silage maize and calculated yield of grassland on farms in the derogation monitoring network that meet the criteria for applying the method of calculating grassland yields (Aarts et al., 2008) for 2009 compared with 2006, 2007 and 2008, the average for the years 2006-2008, the relative difference (F) and relevance (R); (n = 93).

Description	**2006**	**2007**	**2008**	**Gem. 06-08**	**2009**	**F**	**R**
*Estimated yield silage maize **							
Tonnes dry matter per ha	15.5	14.9	15.5	15.3	16.2	3.3	+
Kg N per ha	205	171	182	186	185	-0.1	≈
Kg P per ha	34	30	31	32	32	0.4	≈
Kg P_2O_5 per ha	78	69	71	73	74	0.4	≈
Calculated yield grassland							
Tonnes dry matter per ha	9.4	10.7	10.0	10.0	9.7	-0.6	≈
Kg N per ha	272	291	273	279	260	-2.3	-
Kg P per ha	36	41	40	39	37	1.0	≈
Kg P_2O_5 per ha	83	94	90	89	85	1.0	≈

F (difference factor) = number of times that 2009 differed more from the mean than on average during the previous 3 years.

S (significance): ≈ no relevant difference, +/- > 2, ++/-- > 5, +++/--- > 20.

* The silage maize yields are based on 80 farms in the years 2006-2009 instead of 93 farms because 13 farms did not grow silage maize in all four years.

The mean yield of silage maize in dry matter, but not in N and P, was higher in 2009 than in the years 2006-2008. The calculated average grassland yields in 2009 did not differ from the averages for the years 2006-2008 except for the yield in kg N. This was lower in 2009 than the average for the years 2006-2008.

4.2.5 Nutrient surpluses on the soil surface balance

45 Nutrient surpluses on the soil surface balance (in kg N/ha) on farms in the derogation monitoring network (DM) 2009 compared with 2006, 2007 and 2008, the average for the years 2006-2008, the difference (F) and relevance (R); (n = 243).

Description	2006	2007	2008	Gem. 06-08	2009	F	R
Import of (inorganic) fertiliser, feed, animals and other products	288	288	295	290	299	2.7	+
Export of milk, animals, feed, manure and other products	114	124	126	121	121	-0.1	≈
Deposition, mineralisation and N fixation	67	66	67	67	67	0.0	≈
Gaseous emission from housing and storage, during grazing and application	42	42	42	42	42	3.2	-
Mean surplus soil surface balance	199	188	194	193	203	2.6	+
Surplus soil surface balance first quartile	152	140	146	146	153	1.8	≈
Surplus soil surface balance third quartile	236	241	230	236	237	0.3	≈

F (difference factor) = number of times that 2009 differed more from the mean than on average during the previous 3 years.

S (significance): ≈ no relevant difference, +/- > 2, ++/-- > 5, +++/--- > 20.

The following conclusions can be drawn from Table 45:

- The average N surplus in the soil balance was higher in 2009 than the average for the years 2006-2008 due to elevated supply.
- Both the calculated import via deposition, mineralisation and nitrogen fixation as well as the calculated emission were more or less the same in all years.

Table 46 shows that the nitrogen surplus on the soil balance in the sand region differed between 2009 and the average for the years 2006-2008. There was no relevant difference in other regions. As more than half of the 243 observations were in the sand region, the nitrogen surplus in the soil balance varies across all regions – also between 2009 and the average of the years 2006-2008.

46 Nitrogen surplus on the soil balance (in kg N per ha) on farms in the derogation monitoring network (DM) 2009 compared with 2006, 2007 and 2008, the average for the years 2006-2008, the difference (F) and relevance (R); (n=243).

Region	**2006**	**2007**	**2008**	**Gem. 06-08**	**2009**	**F**	**R**
Sand (n=131)	180	174	170	174	190	4.7	+
Loess (n=14)	143	154	177	158	168	0.8	≈
Clay (n=44)	218	185	210	204	217	1.0	≈
Peat (n=54)	244	231	244	240	233	-1.1	≈
All farms (n = 243)	199	188	194	193	203	2.6	+

F (difference factor) = number of times that 2009 differed more from the mean than on average during the previous 3 years.

S (significance): ≈ no relevant difference, +/- > 2, ++/-- > 5, +++/--- > 20.

Table 47 shows that the phosphate surplus on the soil surface balance in 2009 did not differ from the mean in the years 2006-2008. This also applies to the supply, removal and soil phosphorus surpluses in the first and third quartile.

47 Phosphate surplus on the soil surface balance (in kg P_2O_5 per ha) on farms in the derogation monitoring network (DM) 2009 compared with 2006, 2007 and 2008, the average for the years 2006-2008, the difference (F) and relevance (R); (n = 243).

Description	**2006**	**2007**	**2008**	**Gem. 06-08**	**2009**	**F**	**R**
Import of (inorganic) fertiliser, feed, animals and other products	76	72	72	73	72	1.0	≈
Export of milk, animals, feed, manure and other products	51	55	55	53	51	-1.1	≈
Mean surplus soil surface balance	25	17	17	20	20	0.1	≈
Surplus soil surface balance first quartile	13	5	6	8	8	-0.1	≈
Surplus soil surface balance third quartile	36	30	26	31	29	-0.4	≈

F (difference factor) = number of times that 2009 differed more from the mean than on average during the previous 3 years.

S (significance): ≈ no relevant difference, +/- > 2, ++/-- > 5, +++/--- > 20.

4.2.6 Agricultural practices summarised

Comparison of the results for the years 2006 to 2009 reveals that milk production per farm and per hectare have increased. The production of livestock manure increased slightly from this. By a decline in the stock of livestock manure in 2009, the use of livestock manure in 2009 was higher than the average of the three previous years and the use of livestock manure in 2009 was also higher than the manure application standard.

Because the use of nitrogen fertilisers in 2009 was not different from that in previous years, the total use of active nitrogen in 2009 was also higher. The total use of active nitrogen in 2009 was still under the slightly stricter nitrogen use standards.
Although the use of phosphate via fertilisation was also higher in 2009 than in the years 2006-2008, the phosphate surplus remained about the same. The use of phosphate via fertilisation in 2009 was, however, higher than the phosphate use standards in 2009.
The estimated silage maize yield in kg dry matter per hectare in 2009 was higher than the average for the years 2006-2008. This was not the case for the yield in kg per hectare of nitrogen and phosphate. The calculated grassland yields varied in 2009 did not vary from the averages for the previous three years.

In conclusion, a higher use of livestock manure in 2009 led to a decline in the stock of livestock manure. The average at farms exceeds the livestock manure application standard and the phosphate application standards. The dry matter yields were thus affected little or not at all. The surplus for nitrogen on the soil balance rose slightly in 2009, phosphate did not.

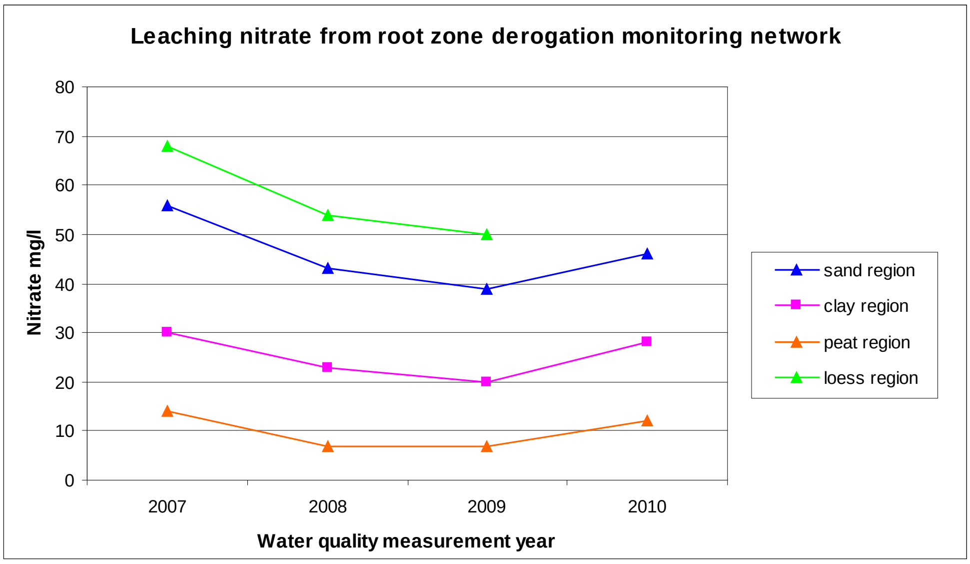
4.3 Evolution of the water quality

In this section, a comparison is made between the water quality measured in the derogation years 2006-2009. Water quality is roughly determined in the years following the use of derogation in agricultural practice, in this case the period 2007-2010. The comparison between the water quality in 2006 (no relationship yet with the derogation year) and 2007 (related to 2006, the first derogation year) is described in the fourth progress report (Zwart et al., 2010).

4.3.1 Development in average concentrations from 2007 through 2010

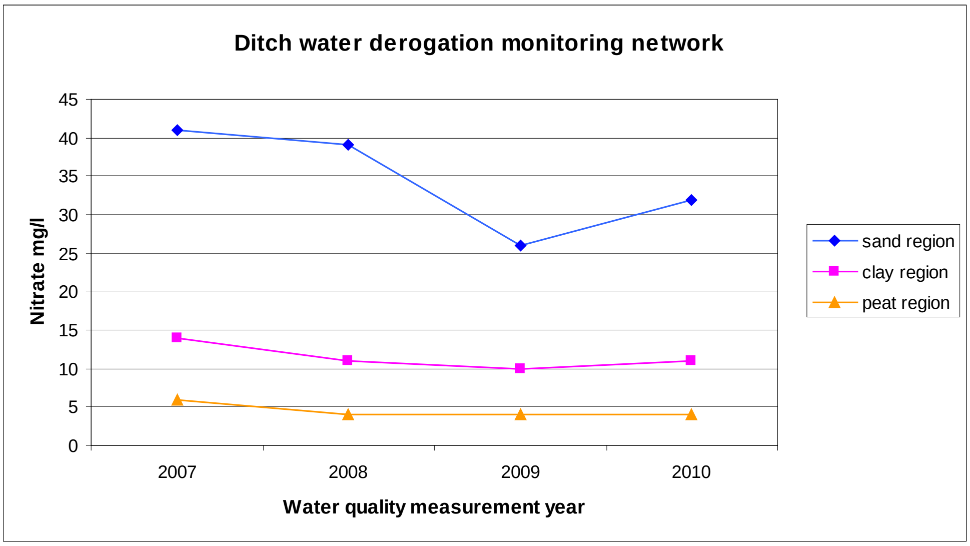
This is the first report for which results are available for several successive sampling years, although it should be noted that the results for 2010 are still provisional at this stage. For the loess region, no data for 2010 are available yet. From this limited series of results the following conclusions can be cautiously drawn. The graphs below provide an initial impression of the trend in concentrations. Whether the increases or decreases are also relevant differences and whether there is a relationship with weather effects is detailed in Tables 50 and 51.

The nitrate concentrations of the water leaching from the root zone were lower on the derogation farms in 2008 and 2009 than in 2007 and show an increase in 2010 (see Figure 48). This can be partly or fully attributed to a lower precipitation surplus in 2007 and in 2010. In the last two monitoring years in the sand, clay and peat regions, the average concentrations were below 50 mg per litre. In the last monitoring year, the average concentration was also below 50 mg per litre in the loess region.



48 Nitrate concentration in water leaching from the root zone on derogation farms in the four regions during the period 2007-2010.

The nitrate concentrations in the ditch water of derogation farms in the peat and clay regions show the same picture as the results for leaching from the root zone (see Figure 49). The results from the sand region in 2009 show a sharp decline followed by an increase in 2010. The graph also reveals that in all regions and years the mean nitrate concentration was less than 50 mg per litre.



49 Nitrate concentration in ditch water on derogation farms in the three regions during the period 2007-2010.

Only the phosphorus concentrations in ditch water in the clay and peat regions exhibit a relevant difference (Table 50). These concentrations decreased in 2010. It should be noted that this decline was not visible in previous years. Nitrate and nitrogen concentrations also exhibit a relevant decrease in the loess region. The decrease is also mentioned and described in the progress report (Zwart et al., 2010). For this region, fewer than four survey years are available.

50 Average nutrient concentrations (mg per litre) in the water leaching from the root zone (leachate) and in ditch water in 2007 through 2010 and the increase or decrease in 2010 compared to previous years.

	2007	2008	2009	mean 2007-2009	2010	F	R
Clay leaching							
Nitrate	27	21	20	23	28	-1.2	≈
Phosphorous	0.27	0.25	0.28	0.27	0.21	-9.4	--
Nitrogen (N)	9.8	6.8	6.5	7.7	8.3	0.29	≈
Clay ditch water							
Nitrate	13	10	10	11	11	0.09	≈
Phosphorous	0.31	0.31	0.32	0.31	0.23	-34	---
Nitrogen (N)	4.6	4.4	4.3	4.4	4.4	0.01	≈
Sand leaching							
Nitrate	56	43	39	46	46	0.03	≈
Phosphorous	0.12	0.18	0.15	0.15	0.15	0.17	≈
Nitrogen (N)	15.7	13.2	11.6	13.5	13.2	0.14	≈
Sand ditch water							
Nitrate	41	39	26	35	32	-0.51	≈
Phosphorous	0.16	0.14	0.12	0.14	0.14	0.01	≈
Nitrogen (N)	11.0	10.7	7.8	9.8	9.5	0.27	≈
Peat leaching							
Nitrate	14	7	7	9.4	12	0.61	≈
Phosphorous	0.52	0.42	0.37	0.41	0.43	-0.05	≈
Nitrogen (N)	10.9	8.6	7.7	9.1	9.7	0.32	≈
Peat ditch							
Nitrate	6	4	4	4.7	4	0.19	≈
Phosphorous	0.23	0.17	0.23	0.21	0.15	-3.1	-
Nitrogen (N)	3.5	4.0	4.2	3.9	4.0	0.30	
Loess leaching							
Nitrate	63	52	50	55	*	*	-#
Phosphorous	0.04	0.04	0.05	0.04	*	*	
Nitrogen (N)	15.5	12.9	11.7	13.4	*	*	-#

F (difference factor) = number of times that 2009 differed more from the mean than on average during the previous 3 years.

S (significance): ≈ no relevant difference, +/- > 2, ++/-- > 5, +++/--- > 20.

*For the loess region, 2010 data, sampled between October 2010 and March 2011, are not yet available.

Based on the 3 available years, a decrease can be observed in nitrate and nitrogen.

4.3.2 *Influence of weather conditions*

The measured nitrate concentration in the sand region declines to a relevant degree in the period 2007-2009, but increases again in 2010. The nitrate concentration in the leaching water is not only influenced by agricultural practice but also by environmental factors such as the groundwater level and the precipitation surplus (see previous reports; Zwart et al., 2009; Zwart et al., 2010). In Table 51, the relevant evaporation is used as a measure of the impact of changes in the precipitation surplus. As the values for evaporation and groundwater levels rise, the nitrate concentration will also rise as long as other factors do not change. The adjusted nitrate concentrations are shown in the table below. An explanation of the method used is provided in Appendix 5.

According to the adjusted nitrate concentrations in the sand region between 2007 and 2008, no relevant change occurred. Compared to 2007/2008, the adjusted nitrate concentrations decreased to a relevant degree in 2009 and 2010.

51 Mean nitrate concentrations (mg NO_3 /l), measured and corrected, in the leaching water in the sand region. The relative precipitation surplus and groundwater level are also given.

Year	Number of farms	Nitrate concentration (measured)	Evaporation (relative)	GWS[1]	Nitrate concentration (corrected)
2007	141	56	1.3	136	53
2008	157	43	0.93	145	54
2009	159	39	1.0	158	44
2010	156	46	1.4	145	36

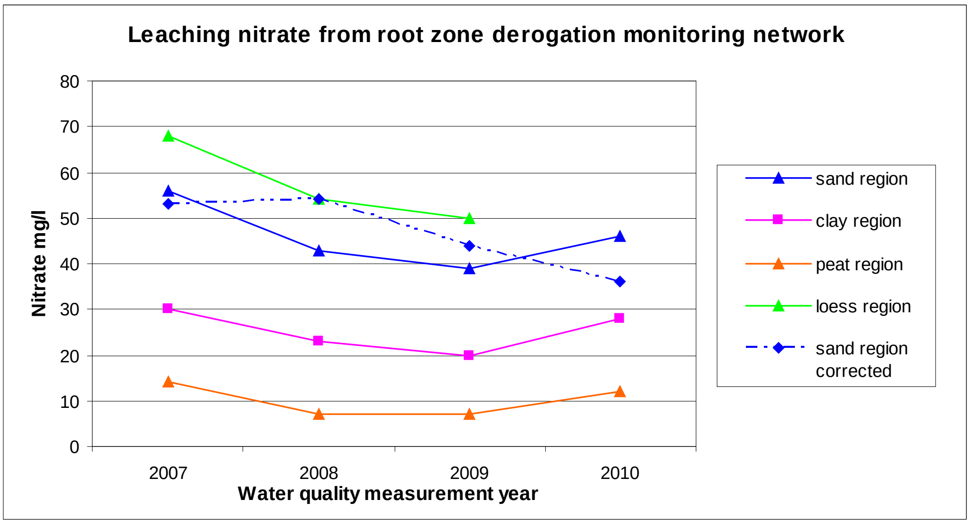
1 Mean groundwater level in cm.

The farms in the table above were selected with the requirement that derogation was used in the preceding year. For this reason, the given number of farms may differ from other tables in this report and in previous reports.

For leaching in the clay region, no clear relationship was found with the precipitation surplus and the groundwater level and so no corrected concentrations can be given. In the peat region, the nitrate concentrations are too low; and in the loess region, the sample is too small to perform a proper correction.

4.3.3 *Water quality summarised*

The nitrate concentration decreased in the period 2007-2010, but the decrease was only relevant in the loess region. The above results show that an increase in nitrate concentration in the sand region occurred between 2006 and 2007 (Zwart et al., 2009) and between 2009 and 2010. These increases are not reflected in the corrected results and are probably caused by climatic differences between the years (dry versus wet years).



52 Nitrate concentrations leaching from the root zone per soil type region in successive measurement years.

The conclusion is that most concentrations did not change to a relevant degree (see Tables 50 and 51). Where changes were observed these were probably correlated with:

- a difference in precipitation surplus (nitrate and total nitrogen in the sand region);
- a difference in hydrological conditions (supply ditch water in the peat region).

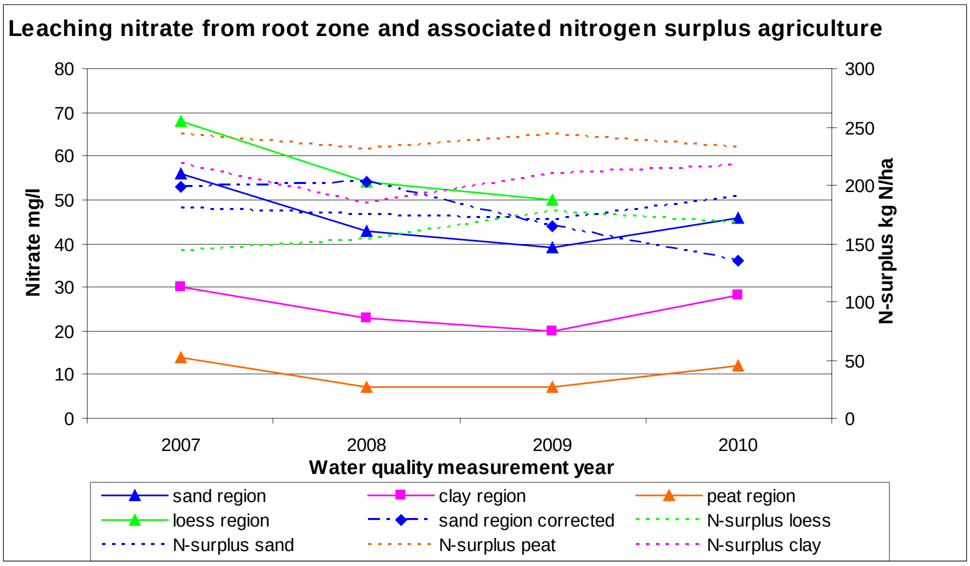
After correction for the precipitation effect, it was found that the concentrations in the sand region had decreased in 2010 compared to 2008 and 2009. It should, however, be noted that the results for 2010 are still preliminary results and that the decline can only be seen after correction. In the progress report for 2012, the final concentrations shall be given and it will also be possible to see if this decreasing trend has continued in the water quality of 2011.

4.4 Effect of agricultural practice on water quality

This section provides a qualitative consideration of the trend in water quality on derogation farms in relation to developments in agricultural practice. Due consideration is given to the fact that a measurement series of four years is not enough to draw well-founded conclusions about trends. The following text is indicative in nature and should be assessed, and where necessary adapted, in subsequent years.

Nitrogen

Water quality as was measured in 2007 was influenced by agricultural practice in 2006 and previous years, the water quality in 2008 by agricultural practice in 2007, and so on. In Figure 53, the trend lines for nitrate concentration in the leaching water and the nitrogen surplus from agricultural practice are shown.



53 Nitrate concentrations leaching from the root zone per soil type region in successive measurement years with the nitrogen surplus from agricultural practice added.

The nitrate concentration shows no relevant decrease in the sand region between 2007 and 2008 after adjusting for weather conditions. This concurs with the unchanged nitrogen use in agriculture. The decrease in nitrate

concentration between 2008 and 2009 cannot be adequately explained, since the decrease in the nitrogen surplus is small and non-relevant (decrease in N-surplus in 2006-2008 was from 180 to 170 kg N per ha).
Since 2010 was a very dry year, the adjusted nitrate concentration in groundwater shows a slight decrease in the sand region while the measured concentrations show an increase between 2009 and 2010. The decrease in the adjusted concentrations cannot be explained by the slight increase exhibited by the nitrogen surplus in the sand region.
In agricultural practice little has changed with respect to both the use of nitrogen and its removal with the crop. The soil nitrogen surplus exhibits no clear trend and there are no relevant differences across the years.

Phosphate
The phosphate surplus in the soil balance decreased during the measurement period to 2009; in 2009, however, the decrease stopped. The effect of this decrease is not observed in the water quality. Here, both small increases as well as decreases can be seen. The cause is possibly the strong binding of phosphate to the soil. The phosphorous concentration in the leaching water and the ditch water is therefore mainly determined by the hydrological conditions. The decrease in 2010 was identified as being the first relevant decline. This cannot be explained by the phosphate used in agriculture that showed an increase in 2009; still, the phosphate surplus remained about the same.

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Appendix 1 The derogation decision, relevant articles

This appendix contains the literal texts of the articles from the derogation decision of the European Commission (EU, 2005) with respect to the monitoring and reporting. This report concerns the years carried out under this decision. On 5 February 2010, the Commission extended the derogation until 31 December 2013.

Article 8 Monitoring

1. Maps showing the percentage of grassland farms, percentage of livestock and percentage of farmland covered by an 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 moisture, streams and shallow groundwater shall be established and maintained as derogation monitoring sites. The monitoring network, corresponding to at least 300 farms to which an individual derogation has been consented, shall be representative of each soil type (clay, peat, sand and sandy loessial soils), fertilisation practice and crop rotation. The composition of the monitoring network shall not be modified during the period of applicability of this decision.
3. The surveys and continuous nutrient analyses shall provide data on local land use, crop rotations and agricultural practices on farms benefiting from an individual derogation. 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 ha per year in manure from grazing livestock is applied.
4. Shallow groundwater, soil moisture, drainage water and streams in farms belonging to the monitoring network shall provide data on nitrate and phosphorus concentrations 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 of all farms benefiting from an individual derogation for the assessment of compliance with the maximum amount of 250 kg nitrogen per ha per year from grazing livestock manure, with total nitrogen and phosphate application standards and conditions on land use.
2. 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 Articles 5 and 6.

Article 10 Reporting

1. The competent national authority shall submit the results of the monitoring, annually, to the Commission, together 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 report shall be submitted to the Commission annually in the second quarter of the year following the year the report concerns.

2. In addition to the data referred to in paragraph 1 the report shall include the following:
   a. data related to fertilisation for all farms which benefit from an individual derogation;
   b. trends in livestock numbers for each livestock category in the Netherlands and at 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. Results obtained in this manner will be taken into consideration by the Commission with regard to a possible new request for derogation by the Dutch authorities.
4. In order to provide elements regarding management on 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.

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

Introduction

This appendix explains the selection and recruitment of the 300 dairy and other grassland farms in the derogation monitoring network in detail. As indicated previously in the main text, the derogation monitoring network has become part of the National Programme for Monitoring the Effectiveness of the Minerals Policy (LMM). The selection and recruitment of farms for the derogation monitoring network is comparable to that of participants in other parts of the LMM. Based on the – then most recent – Agricultural Census data (2005), a sample population was defined for each of the 4 regions. The sample populations were then divided into groups of farms (the strata) having the same groundwater body, farm type and economic size. From this distribution, the desired number of farms for the sample was derived per stratum, which not only considered the proportion of the total surface area of cultivated land in a given stratum (the greater the area of cultivated land in a stratum, the greater the number of farms required in the random sample) but also a minimum representation per groundwater body.

The recruitment of farms was initially targeted at farms in the Farm Accountancy Data Network (FADN; report year 2006). For this, all suitable FADN farms were approached that had applied for derogation in 2006. Once the recruitment under FADN farms had been completed, it was determined which strata needed additional farms. Additional farms were selected from a database, compiled by the National Service for the Implementation of Regulations (DR) of the Ministry of Agriculture, Nature and Food Quality, which contains all farms that had applied for derogation in 2006. Of the additional participants chosen, 15 are also participating in the research project *Koeien & Kansen* [Cows and Opportunities] (www.koeienenkansen.nl).

Replacements for farms that dropped out between 2006 and 2009 were preferably selected from farms that already participate in the LMM and FADN. With this approach, water quality samples from previous years were also available for farms newly admitted to the derogation monitoring network.

Definition of the sample population

Just like the LMM, a limited number of farms from the Agricultural Census database that had registered for derogation were not considered for the sample. The first group of farms excluded from participation in the derogation monitoring network were either very small (economic size smaller than 16 NGE), or extremely large (larger than 800 NGE in size). Farms using organic practices were also excluded as, by definition, organic farms (irrespective of the type of grassland or fertiliser) do not use more than 170 kg nitrogen from livestock manure per ha. Also, a minimum farm size of 10 hectares of cultivated land was adhered to so as to safeguard a certain level of representativeness in the total area. Finally, in the LMM the farm type without livestock contains only arable farms. Market garden enterprises, farms with permanent cultivations and farms with crop combinations are therefore not included in the LMM.

The consequences of the aforementioned selection criteria are illustrated in Tables A2.1 and A2.2. In these tables, the farms (Table A2.1) and the acreages

(Table A2.2) in the sample population have been obtained using data from the Agricultural Census 2009 and a database from the National Service for the Implementation of Regulations which contains more than 24,000 farm relation numbers (BRS) of farms which applied for derogation for the year 2009. As 982 BRS numbers were missing from the Agricultural Census 2009 it has been decided not to include absolute numbers of farms and hectares in the tables. Instead the numbers of excluded farms and hectares of cultivated land have been expressed as a percentage of the more than 22,500 farms for which data were available in the Agricultural Census of 2009.

Table A2.1 Percentage derivation of the number of farms represented in the sample population of the derogation monitoring network in 2009.

	Distribution number of farms		
	Dairy farms	Other grassland farms	Total
All farms registered for derogation in 2009	72.9%	27.1%	100.0%
Farms <16 NGE	0.2%	10.8%	11.0%
Farms >800 NGE	0.0%		0.0%
Organic farms	0.5%	0.2%	0.6%
Farms <10 ha	0.6%	1.1%	1.7%
Farms outside LMM		0.2%	0.2%
Sample population	71.7%	14.8%	86.6%

Source: Statistics Netherlands Agricultural Census 2009, processed by LEI

Table A2.2 Percentage derivation of the acreage of cultivated land represented in the sample population of the derogation monitoring network in 2009.

	Distribution acreage cultivated land		
	Dairy farms	Other grassland farms	Total
All farms registered for derogation in 2009	86.3%	13.7%	100.0%
Farms <16 NGE	0.0%	2.0%	2.0%
Farms >800 NGE	0.1%		0.1%
Organic farms	0.7%	0.1%	0.8%
Farms <10 ha	0.1%	0.2%	0.3%
Farms outside LMM		0.1%	0.1%
Sample population	85.4%	11.2%	96.7%

Source: Statistics Netherlands Agricultural Census 2009, processed by LEI

Tables A2.1 and A2.2 reveal that more than 70% of the derogation farms registered in 2009 and 85% of the associated acreage of cultivated land concerned specialised dairy farms. Furthermore, most of the dairy farms also satisfied the selection criteria for the sample population for the derogation monitoring network. The farms excluded are mainly other grassland farms with a small size in terms of NGE and cultivated land. As a consequence of the selection criteria adopted, almost 13% of the farms registered for derogation (yet only 3.3% of the acreage on which derogation has been applied for) fell outside of the sample design.

Explanation per stratification variable
The derogation decision demands a monitoring network that is not only representative for all soil types but also for all fertilisation practices and crop rotations (Article 8 of the derogation decision). Accordingly, the stratification took place not only per region but also per farm type, economic size (size class) and groundwater body. These variables are explained in this section.

Classification according to farm type
For the classification of farms according to farm type, use was made of the classification based on the NEG classification (Dutch version of EU farm types; Poppe 2004). The NEG classification is a slightly modified version of the EC classification of farms that was introduced by Statistics Netherlands (CBS) for the Netherlands. This classification has retained its name despite the EC having become the EU. The NEG profile of a farm is determined by the extent to which the farm produces specific types of crops and/or keeps certain types of animals. For this, all crop acreages and numbers of animals per animal species present are converted into so-called standard gross margins (SGM). A farm is characterised as 'specialised' when a relative proportion (often at least two-thirds) of the total farm volume comes from a certain type of production (for example, dairy, arable or pigs). Within the NEG profile, eight main farm types can be distinguished of which five are pure and three combined. The five pure, main farm types are: arable, market gardening, permanent cultivation (fruit growing and tree nurseries), grazing livestock and housed animals (intensive livestock farming). Combined farms are classified as crop combinations, livestock combinations and crop and livestock combinations. Each main farm type is further divided into several subtypes. For example, within the grazing animal farms, specialised dairy farms are distinguished.

The main farm types market gardening, permanent cultivations and crop combinations are not represented in the LMM. A total of 0.2% of the farms with derogation (Table A2.1) with 0.1% of the cultivated land acreage do, however, belong to these main farm types. These farms (in total 40 with more than 1000 ha cultivated land) are therefore between 16 and 800 NGE in size, are not organic and have at least 10 ha cultivated land. Farms of these main farm types cannot per definition be dairy farms and therefore the relevant cells in Tables A2.1 and A2.2 are empty.

Within the group of farms that applied for derogation, dairy farms form a large homogenous group (that use almost 85% of the acreage of cultivated land as can be seen from Table A2.2). A good 14% of the acreage is situated on farms of a different type. These farms were also included in the monitoring network so as to gain as representative a sample as possible in terms of crop rotations and fertilisation practices. The roughly 27% non-dairy farms (Table A2.1) can be of various types, but in this publication are described as other grassland farms, as at least 70% of the cultivated land acreage must consist of grassland: otherwise the farm would not be eligible for derogation.

Classification according to economic size
Other than farm type, farms were also classified according to economic size, for which three size classes are distinguished. This prevents farms of a smaller or larger economic size from being overrepresented.

The economic size was also determined using the standard gross margins. The total standard gross margins at farm level were converted into Netherlands Magnitude Units (NGEs) by means of a scaling factor (De Bont et al., 2003).

Classification according to groundwater body per main soil type region
For the Framework Directive Water, a total of twenty groundwater bodies are distinguished in the Netherlands (Verhagen et al., 2006). During the setting up of the derogation monitoring network, a fair distribution (and minimal representation) was strived for in each region to cover the most important groundwater bodies measured in terms of cultivated land area. The municipality in which the farm receives post formed the basis for determining the groundwater body per farm. In municipalities where several groundwater bodies are found, all farms were attributed to the largest groundwater body.

Within the sand region, five groundwater bodies were distinguished as subregions, namely: Eems, Maas, Rhine Central, Rhine North and Rhine East. The other farms (in other groundwater bodies within the region) were attributed to the sixth subregion termed 'other'. The loess region only contains the 'Krijt' [chalk] groundwater body and was therefore not classified further. The peat region was divided into four subregions, namely the groundwater bodies Rhine North, Rhine East, Rhine West and 'other'. Five subregions were eventually distinguished in the clay region. As several groundwater bodies are situated in the southwestern sea clay area (without clear domination) this entire clay area was classified as a separate subregion. A further three groundwater bodies were distinguished as separate subregions: Eems, Rhine North and Rhine West (in so far as this is located outside of the southwestern sea clay area). The fifth subregion concerned the farms in other, not further classified, municipalities.

In Tables A2.3 to A2.6, the numbers of dairy and other grassland farms recruited per main soil type region and the subregions within these, are stated. Figure A2.1 shows the farms and subregions.

Table A2.3 Number of farms realised in the sand region in 2009, per subregion.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
EEMS sand	10	9	1
MAAS sand	29	22	7
RHINE CENTRAL sand	14	9	5
RHINE NORTH sand	29	26	3
RHINE EAST sand	74	69	5
OTHER within sand region	2	2	0
TOTAL SAND REGION	158	137	21

Table A2.4 Number of farms realised in the clay region in 2009, per subregion.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
EEMS clay	7	6	1
RHINE NORTH clay	16	15	1
RIJN WEST clay *	19	16	3
Southwestern sea clay area	4	4	0
OTHER within clay region	12	10	2
TOTAL CLAY REGION	58	51	7

* Concerns farms situated outside of the south-western sea clay area.

Table A2.5 Number of farms realised in the peat region in 2009, per subregion.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
RHINE NORTH peat	15	13	2
RHINE EAST peat	15	13	2
RHINE WEST peat	28	26	2
OTHER within peat region	1	1	0
TOTAL PEAT REGION	59	53	6

Table A2.6 Number of farms realised in the loess region in 2009.

Groundwater body	Total number of farms	Number of dairy farms	Number of other grassland farms
TOTAL LOESS REGION	18	15	3

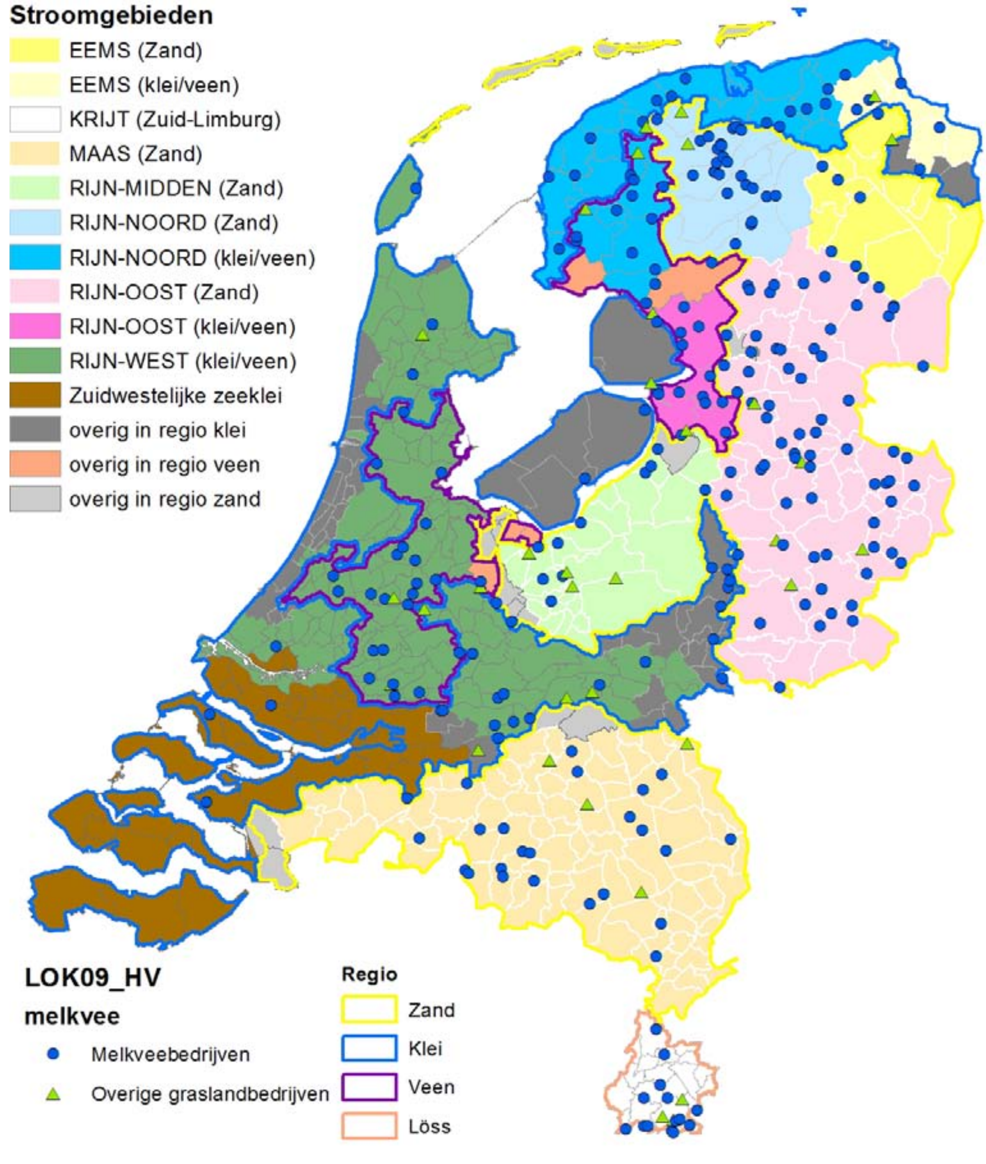


Figure A2.1 Location of dairy farms (o) and other grassland farms (Δ) participating in the derogation monitoring network in 2009 per subregion.

Legend upper left, gives the names over the Water Framework river subbasins and main basins between brackets; names of main basins refer to main soil type within basin. Stroomgebieden = river basins; zand = sand; klei = clay; veen = peat; overig in region ... = other in region ...

Appendix 3 Monitoring of farm characteristics

This appendix provides an explanation of how the data about agricultural practice in the LEI-FADN were monitored and how the fertiliser usage, crop yields (Section A3.2) and nutrient surpluses (Section A3.3) were calculated from these data.

A3.1 Introduction

The LEI is responsible for monitoring the data on agricultural practices as part of the FADN. The FADN is a stratified sample of approximately 1500 farms and horticultural enterprises for which a detailed set of financial-economic and environmental data are maintained. The FADN represents almost 95% of the total agricultural production in the Netherlands (Poppe, 2004). Approximately 45 full-time LEI staff are responsible for collecting and recording the operational data in FADN. They process all the invoices of the participating farms. They also stock take initial and end supplies and additional data such as the crop rotation, grazing system and the composition of the livestock population. Participants receive a report from LEI, which largely contains annual totals (such as profit and loss accounts and a balance). When the data are processed into information for participants or researchers, the outcomes are of course checked for inconsistencies, as in addition to financial flows, many physical flows are registered as well.

Most of the data in FADN are converted into annual totals corrected for stock adjustments. The feed concentrate use per year therefore emerges from the sum of all purchases between two balance dates, minus all sales, plus the starting stock, minus the end stock. The use of fertilisers is known not just on an annual basis but also on a seasonal basis, running from the moment that the preceding crop is harvested until the harvest of the crop.

Fertilisation, yield and nutrient surpluses are expressed per surface unit. For this, the total acreage of the cultivated land is used. This is the acreage that the farm actually fertilises and uses for crop production. Rented land, natural habitat, ditches and built land are not included in this acreage.

A3.2 Calculation of fertilisation and crop yields

According to the derogation decision (EU, 2005) the report should include details regarding the fertilisation and crop yield (Article 10, paragraph 4). This Article states (see Appendix 1) ‘In order to provide elements regarding management on 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'.

For the presentation about fertiliser use, a distinction is made between the four regions (clay, peat, sand and loess). First fertilisation at farm level is reported, thereafter a distinction is also made between fertilisation on arable land and grassland.

Calculation of the fertiliser use

Nitrogen from livestock manure

For the calculation of fertiliser use from livestock manure, the production of manure on the farm is determined first. For nitrogen, this is the net production after subtraction of gaseous nitrogen losses from housing and storage. The manure production for grazing livestock is calculated by multiplying the mean number of animals present by the statutory excretion forfeits (Dienst Regelingen, 2006). An exception to this are those dairy farms that make use of the so-called Guidance (see header 'Farm-specific use of livestock manure' that follows in this appendix). For manure production from housed animals, the number of animals concerned is multiplied by the national excretion forfeits, as stipulated by the Working Group Uniformisation Manure Figures (Van Bruggen, 2007)[1].

Furthermore, the quantity of nutrients is registered for all fertilisers and stock (inorganic fertiliser, livestock manure and other organic fertilisers) imported and exported. In principle, the quantity of nitrogen and phosphate in all imported and exported fertilisers is calculated by means of sampling. If sampling has not taken place, forfeit levels per fertiliser type are used (Dienst Regelingen, 2006). Nutrients in initial and final stocks are always calculated using forfeits (Dienst Regelingen, 2006).

The total quantity of fertiliser used at farm level is subsequently calculated as:

Fertiliser use farm = Manure production + Initial stock - Final stock + Import - Export.

The quantities of fertilisers used on arable land are directly registered within FADN. Besides the type and quantity, the time of application is also recorded. The fertiliser use on grassland is subsequently calculated as:

Fertiliser use on grassland = Fertiliser use farm - Fertiliser use on arable land.

This use on grassland consists of manure that is spread and manure that is directly excreted onto the grassland by grazing livestock (grassland manure). The quantity of nutrients directly excreted on grassland is calculated per type of animal by multiplying the percentage of time on an annual basis that the animals graze, by the excretion forfeits (Dienst Regelingen, 2006).

Farm-specific use of livestock manure

Since 2007, FADN has modified the calculation of the manure production for farms that make use of the Guidance farm-specific excretion dairy cattle. On these farms, manure production is not calculated on the basis of forfeits, but farm-specifically as long as the following criteria are satisfied:

- the farm is a specialised dairy farm (according to NEG classification);
- the dairy herd is at least 67% of the total GVE quantity of grazing livestock;
- no pigs and/or poultry are present on the farm;
- at least 80% of the acreage consists of fodder crops;
- the farm-specific calculation gives a real advantage (i.e. lower excretion) compared to the calculation using forfeits.

[1] This is in contrast to the statutory calculation of manure production on housed animals farms. There the manure production is calculated as supply food and animals minus the removal of animals and animal products.

For the calculation of the farm-specific excretion of the dairy herd, the Guidance farm-specific excretion dairy cattle before 1 January 2009 is used as the starting point (LNV, 2009). All of the sections in this Guidance are adhered to, except for the calculation of the energy uptake from grass (grass silage and fresh grass) and from fresh grass (meadow grass and zero-grazing) and for the empirical relationship between the uptake from grass silage and from fresh grass. Energy uptake expressed in VEM which is the Dutch standard for the net energy content of feeds. For the calculation of the uptake from grass, feed losses from purchased feed (feed concentrate, wet by-products, milk products) have been included in accordance with Aarts et al. (2008).

Nitrogen use

The total nitrogen use is expressed in kg plant-available nitrogen. The quantity of plant-available nitrogen is calculated by multiplying the total quantity of nitrogen in organic fertilisers by the availability coefficient as stated in Table A3.1.

The plant-availability coefficient of nitrogen is lower (35% instead of 60% in 2006 and 2007, 45% instead of 60% since 2008) for all livestock manure produced and applied on the farm if grazing is applied on the farm. Also a lower plant-availability coefficient is calculated for the fertilisation of arable land during the autumn on clay and peat soil. In all other cases, the availability coefficient depends solely on the type of fertiliser.

Phosphate use

Phosphate use is expressed in kg phosphate. The calculation of the use includes all fertilisers with the exception of a part of the phosphate applied via compost and defecation scum.

Table A3.1 Applied availability coefficients (in %) for determination of nitrogen use.

Type fertiliser	Condition	Availability coefficient
Autumn application livestock manure on arable land on clay or peat soil	Liquid manure	30 (2006) 40 (2007) 50 (2008) Ban (2009)
	Solid manure	25 (2006/2007) 30 (2008/2009)
Manure produced by livestock on own farm	Farm with grazing	35 (2006/2007) 45 (2008/2009)
	Farm without grazing	60
Other fertilisers and conditions	Thin fraction and slurry	80
	Liquid manure	60
	Solid manure from pigs, poultry and minks	55
	Solid manure other animal species	40
	Mushroom compost	25
	Compost	10
	Sewage sludge	40
	Other organic fertilisers	50

(Dienst Regelingen, 2006)

Calculation grass and silage maize yield

Design calculation module

The calculation module for determining the grass and silage maize yield in FADN has the same design as the procedure described in Aarts et al. (2005, 2008). The calculation module starts by determining the energy requirement of the dairy herd based on the milk production and growth realised. In FADN all transactions and stock mutations for feed products are registered. This first of all shows what proportion of the energy requirement is covered by purchased feed. Then the energy uptake from farm-produced silage maize and other forage crops (other than grassland) is determined by measurements and levels of the silage supplies insofar as these are available. Otherwise for the farm-produced silage maize and other forage crops an estimate from the farmer and/or their advisor is used. Finally it is assumed that the remaining energy requirement is satisfied by means of grass produced on the farm. The number of days in the grazing season registered in FADN is used to hypothesise a ratio between the energy uptake from fresh grass and that from grass silage.

The aforementioned procedure clarifies how much VEM is obtained by the herd from farm-produced feed. The nitrogen and phosphorous uptake are then calculated by multiplying this VEM uptake by the N:VEM and P:VEM ratios. Finally, the nitrogen, phosphorous, energy uptake and dry matter yields for silage maize and grassland are calculated by increasing the uptakes with the quantity of nitrogen, phosphorous, energy uptake and dry matter lost on average during feed production (only grass) and ensilaging.

Selection criteria
The calculation method used is not applicable for all farms. On mixed farms it is often difficult to clearly separate the product flows between different production units. Therefore, in accordance with Aarts et al. (2008) the method is only used on farms that satisfy the following criteria:
- it is a specialised dairy farm according to the NEG classification;
- the dairy herd is at least 67% of the total GVE quantity of grazing livestock;
- no pigs and/or poultry are present on the farm;
- at least 80% of the acreage consists of fodder crops;
- the countryside premium per ha grassland is no more than 100 euros.

The following selection criteria for the use of the method were not adopted from Aarts et al. (2008):
- at least 15 ha forage crop;
- at least 30 dairy cattle;
- at least 4500 kg milk corrected for fat and protein (FPCM) per cow per year;
- non-organic production method.

These criteria were not considered because in the study of Aarts et al. (2008) they were only used to allow statements to be made about the population of 'typical' dairy farms. In the Derogation Monitor the population has already been determined (permanent monitoring network of 300 farms) and therefore these criteria can be ignored.
Additionally, with respect to the outcomes the following confidence intervals for yields were used in accordance with Aarts et al. (2008):
- silage maize yield: 5000 - 20,000 kg dry matter per ha;
- grassland yield: 4000 - 20,000 kg dry matter per ha.

For yields that fall outside of this range it is assumed that this must have been caused by an error in the registration. The farms concerned are also excluded from the report.

Deviations from Aarts et al., 2008
In several cases, the procedure described by Aarts et al. (2008, 2005) is deviated from because more detailed information was available or because the procedure could not be incorporated in FADN in a comparable manner. It concerns the following items:
1. composition of grass silage and silage maize;
2. supplement for grazing based on the actual number of days in the grazing season;
3. ratio of silage grass to fresh grass based on the actual number of days in the grazing season;
4. conservation and feeds losses.

Ad 1)
In Aarts et al. (2008) the composition of grass silage and silage maize pits is based on provincial averages of the Netherlands Laboratory for Soil and Crop Research (BLGG, 2011). A slightly different method was used in FADN. Since 2006, the composition of the grass silage and maize silage has been recorded per farm in FADN. In the FADN calculation procedure, use is made of this farm-specific composition if at least 80% of all silage pits obtained has been fully sampled. If that is not the case (in one of the silage pits one of the parameters – dry matter, VEM, N or P – is missing), then the national average composition is

used. This average composition of silage maize and grass is detailed in Table A3.2.

Table A3.2 National average composition of grass silage and silage maize in 2009 (website BLGG).

Silage type	***Dry matter (gram per kg)***	***VEM (per kg dry matter)***	***N (gram per kg dry matter)***	***P (gram per kg dry matter)***
Silage maize	353	994	12.0	-1.9
Grass silage	479	920	27.7	3.9

Ad 2)
For the calculation of the energy requirement, a so-called mobilisation charge has been incorporated. This mobilisation charge is, for example, dependent on the grazing. In Aarts et al. (2008) a distinction was made between 3 types of grazing, namely 0 days, 138 days and more than 138 days. Since 2004, the exact number of days in the grazing season has been registered in FADN and so it was decided to use these data in the calculation. For every day of unlimited grazing, 533 VEM (16,000/30) extra mobilisation charge was incorporated per cow and for each day of limited grazing 400 VEM (12,000/30), in accordance with Appendix 2 from the notes Guidance 2009 (LNV, 16,000/30).

Ad 3)
In addition, the ratio of the energy uptake from fresh grass and silage grass is, in contrast to Aarts et al. (2008) based on the number of days in the grazing season and/or zero-grazing registered in FADN. For zero-grazing the percentage of fresh grass varies between 0 and 35%, in the case of unlimited grazing between 0 and 40% and in the case of limited grazing between 0 and 20%. This calculation is also performed in accordance with Appendix 2 from the note Guidance (LNV, 2009).

Ad 4)
The information in Appendix III in Aarts et al. (2008) is not complete with respect to the percentages adopted for conservation losses. To prevent misunderstandings, all percentages used in FADN for the calculation of conservation and feeds losses are shown in Table A3.3.

Table A3.3 Percentages used for conservation and feeds losses.

	Conservation losses				***Feed losses***
Category	**Dry matter**	**VEM**	**N**	**P**	**Dry matter, VEM, N and P**
Wet by-products	4%	6%	1.5%	0%	3%
Additional forage crops consumed	6%	8%	2%	0%	5%
Feed concentrate	0%	0%	0%	0%	2%
Milk products	0%	0%	0%	0%	2%
Silage maize	4%	4%	1%	0%	5%
Grass silage	10%	15%	3%	0%	5%
Meadow grass	0%	0%	0%	0%	0%

Demonstration calculation for grassland and silage maize yield
In Table A3.4 the yields for grassland and silage maize are calculated for a demonstration farm. The calculation of the VEM requirement is not explained further. This is described in detail in Appendix III of the report by Aarts et al. (2008).

Table A3.4 Demonstration calculation for determination of grassland and silage maize yields.

Demonstration of calculation				
Grazing	183 days limited grazing			
Ha grassland	40			
Ha sillage maize	10			
	Quantity	kVEM	N	P
Total VEM uptake = 1.02 * VEM requirement		750,000		
Composition feed concentrates (per kg)	-	960	28	5.0
Use feed concentrates $	200,000	192,000	560	1000
Feed losses	4000	3840	112	20
Net uptake feed conc.	196,000	188,160	548	980
	Quantity	kVEM	N	P
Composition wet by-products (per kg dry matter)	-	1020	12	2.0
Use wet by-products $	20,000	20,400	240	40
Conservation losses	800	1,224	4	0
Fed wet by-products	19,200	19,176	236	40
Feed losses	576	575	7	1
Net uptake wet by-products	18,624	18,601	229	39
	Quantity	kVEM	N	P
Composition additional roughage (per kg dry matter)	-	700	10	2.5
Use additional roughage $	600	420	6	2
Conservation losses	36	34	0	0
Fed additional roughage	564	386	6	2
Feed losses	28	19	0	0
Net uptake additional roughage	536	367	6	1
	Quantity	kVEM	N	P
Total uptake purchasd feed				
(=sum feed conc. + wet by-products + add. roughage)		207,128	572	1020
	Quantity	kVEM	N	P
Composition own silage maize (per kg dry matter)	-	960	11	2.2
Yield crop (from estimation on field)	150,000	144,000	166	330
Conservation losses	6,000	5,760	1	0
Fed own maize silage	144,000	138,240	164	330
Feed losses	7,200	6,912	8	17
Net uptake own maize silage	136,800	131,328	156	314
	Quantity	kVEM	N	P
Net uptake from grass products				
(=totalVEM uptake – uptake purchased feed – production own silage maize)		411,544		
Factor fresh grass (based on recorded grazing system)		20%		
Composition fresh grass (per kg dry matter)	-	990	35	4.8
Net uptake from fresh grass		82,309	2,910	399
(= factor fresh grass * net uptake from grass products)				
	Quantity	kVEM	N	P
Composition grass silage (per kg dry matter)	-	900	32	4.5
Net uptake from grass silage	365,817	329,235	11,706	1,646
(= net uptake from grass products – uptake from fresh grass)				
Feed losses	18,291	16,462	585	82
Fed grass silage	384,108	345,697	12,291	1,728
Conservation losses	38,411	51,855	369	0
Grass yield (leaving field)	422,519	397,552	12,660	1,728
	Quantity	kVEM	N	P
Silage maize yield per ha	15,000	14,400	167	33
Grassland yield per ha	10,563	9,939	317	43

$ use = purchase – sale + stock@begin – stock@end)

A3.3 Calculation of nutrient surpluses

In addition to fertilisation and crop yield the surplus of nitrogen and phosphate on the soil surface balance (in kg N per ha and phosphate in kg P_2O_5 per ha) is also reported on. These surpluses are calculated with the help of a method derived from the approach used and described by Schröder et al. (2007, 2004). This means that in addition to the quantities of nitrogen and phosphate in inorganic and artificial fertilisers, and the quantities of nitrogen and phosphate removed in crops, consideration is also given to other supply categories such as net mineralisation of organic matter in the soil, nitrogen fixation by legumes and atmospheric deposition. The calculation of nutrient surpluses on the soil surface balance assumes an equilibrium situation. It is assumed that in the longer term, the import of organic nitrogen, in the form of crop residues and organic fertiliser, is equal to the annual breakdown. An exception is made to this rule for peat and reclaimed soils for which an import from mineralisation is used of 160 kg N per ha for grassland on peat and 20 kg N per ha for grassland on reclaimed soil and other crops on peat and reclaimed soil. For these soils it is known that net mineralisation occurs as a consequence of the groundwater level management that is necessary to be able to use these soils for agricultural purposes. Schröder et al. (2007, 2004) calculated the surplus on the soil surface balance by using the release of nutrients to the soil as the starting point. In this study, a balance method is used to calculate the surplus on the soil surface balance from the farm data.

The calculation method used for the nitrogen surplus is summarised in Table A3.5. Initially, the surplus on the farm gate balance is calculated by adding the import and export of nutrients registered in the bookkeeping. This surplus is calculated with the inclusion of stock mutations. For nitrogen, the surplus calculated on the farm gate balance is then corrected for import and export categories on the soil surface balance. Similarly, for phosphate the surplus on the soil surface balance is the same as the surplus on the farm gate balance. A more detailed explanation of the calculation methods can be found in the footnotes below the table.

Table A3.5 Calculation method used for determining nitrogen surplus on the soil surface balance (kg N, per ha, per year).

Description categories		**Calculation method**
Import farm	Artificial fertiliser	Quantity [a] * level [e]
	Livestock manure and other organic fertiliser	Quantity [b] *level [h]
	Feed	Quantity [a] * level [e,f]
	Animals	Quantity [b] * level [i]
	Plant products (sowing seed, young plants and seed potatoes)	Quantity [b] * level [g]
	Other	Quantity [b] * level
Export farm	Animal products (milk, wool, eggs)	Quantity [c] * level [j]
	Animals	Quantity [d] * level [i]
	Livestock manure and other organic fertiliser	Quantity [d] * level [h]
	Crops and other plant products	Quantity [d] * level [g]
	Other	Quantity [d] * level
N surplus on the farm gate balance	Import farm - Export farm	
Import soil	+ Mineralisation	160 kg N for peat soil and 20 kg for reclaimed soil [k]
	+ Atmospheric deposition	Differentiated per province[l]
	+ N fixation by legumes	All legumes [m]
Export soil balance	- Volatilisation from housing and storage	Based on animal species, housing system and grazing[n]
	- Volatilisation application and grazing	Artificial fertiliser and livestock manure, based on actual manure production, grazing and application method[o]
N surplus on the soil surface balance	N surplus farm + import soil surface balance - export soil surface balance	

a) Purchase – sale + initial stock – final stock.
b) Purchase + stock decrease.
c) Sale – purchase + final stock – initial stock.
d) Sale + stock increase.
e) N levels inorganic fertiliser, feed concentrate and single feeds via annual reviews supplier. If these are not available then standards are used.
f) N levels for forage crops via quarterly overviews or estimated standards (CVB, 2003).
g) N levels crops and plant products according to Van Dijk (2003).
h) N levels livestock manure and compost according to National Service for the Implementation of Regulations (2006).
i) N levels animals according to Beukeboom (1996).

j) The N level of milk is calculated as the farm-specific protein level/6.38. Other N level animal products according to Beukeboom (1996).

k) For grass on peat: 160 kg N per ha per year, other crops on peat as equally reclaimed soil (irrespective of crop): 20 kg N per ha per year, all other soil types: 0 kg. For FADN farms the areas are established according to the four soil types used by the National Service for the Implementation of Regulations (sand/clay/peat/loess). For the estimation of the mineralisation of reclaimed land use was made of global soil classifications per farm (based on the postal code) according to De Vries and Denneboom (1992).

l) The atmospheric deposition is differentiated each year per province and varied in 2006 between 23 and 40 kg N per ha per year (MNP/CBS/WUR, 2007).

m) N fixation in kg N per ha per year (Schröder, 2006).
- for grass clover: for clover proportion <5%: 10 kg, in the case of clover proportion between 5 and 15%: 50 kg, in the case of clover proportion >15%: 100 kg, proportion of clover according to figures submitted by the participant;
- for lucerne: 160 kg;
- for peas, broad beans, kidney beans and snap peas: 40 kg;
- for other legumes: 80 kg.

n) Emissions from housing and storage are calculated as a function of the livestock species, housing system and grazing system according to Oenema et al. (2000).

o) Volatilisation in the case of grazing: 8% of the N total excreted on grassland (Schröder et al., 2005). In the case of mechanical application on grassland: trailing foot spreader, 10% of N total; trussed beam plough, 6.5% of N total; shallow grassland injector, 3% of N total; aboveground spreading of solid manure, 14.5% of N total. Injection, 1% of N total; aboveground spreading of solid manure, 14.5% of N total (Van Dijk et al., 2004, Table 1).

Appendix 4 Sampling of water on farms

A4.1 Introduction

The derogation decision (EU 2005, see Appendix 1) states that a report must be produced concerning the evolution of water quality based on, for example, regular monitoring of leaching from the root zone and checking of surface and groundwater quality (Article 10, paragraph 1). For this, 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 the water leaving the root zone and ending up in the groundwater and surface water system (Article 8, paragraph 4).

Water sampling

In the Netherlands, the groundwater level is often present just beneath the root zone; the mean groundwater level in the sand region is approximately 1.5 metres below the surface. In the clay and peat regions, the groundwater levels are, on average, even shallower. Only on the push moraines of the sand region and in the loess region is the groundwater level mostly deeper than 5 metres beneath the surface. Therefore, in the majority of situations, leaching from the root zone or leaching into groundwater can be measured by sampling the uppermost metre of the phreatic groundwater. In situations where the groundwater level is deeper (more than 5 metres below the surface) and the soil retains sufficient moisture (loess region), the soil moisture below the root zone is sampled. There is little agriculture on the push moraines in the sand region with a deep groundwater level. Where this does occur, the soil moisture below the root zone is also sampled if possible.

The loading of surface water with nitrogen (N) and phosphorus (P) takes place via run-off and groundwater, in which the travel times are usually longer. In the High Netherlands, only leaching from the root zone is monitored by sampling the uppermost metre of groundwater or of soil moisture under the root zone. In the Low Netherlands, in areas drained via ditches, whether or not in combination with pipe drainage, the travel times are shorter. Here, the loading of surface water is visualised by sampling ditch water in combination with sampling of the uppermost metre of groundwater or water from the drainage pipes (drain water).

Number of measurements per farm

On each farm, groundwater, drain water and soil moisture are sampled at sixteen locations and ditch water at eight locations. The number of measurement locations is 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).

The measurement period and measurement frequency

Sampling takes place in the winter in the Low Netherlands. During the winter, the precipitation surplus here is largely transported via shallow groundwater flows to the surface water. In the summer, especially in the peat region, water from the main rivers is often let into the ditches. Sampling from sand and loess soils in the High Netherlands can take place in both the summer and the winter.

As the available sampling capacity must be spread over the year, the sand region is sampled in the summer and the loess region in the autumn. The measurement period (see Figure A4.1) has been chosen in such a manner that the measurements represent leaching from the root zone and with this provide as good a picture as possible of the agricultural practices in the previous year. Weather conditions can, in practice, result in sampling taking longer or being delayed.

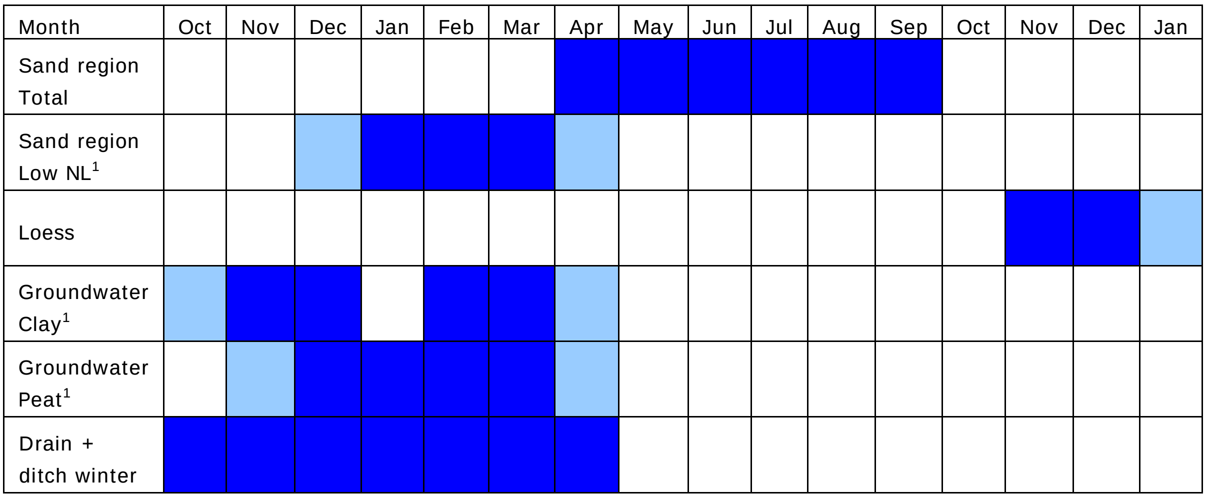


Figure A4.1 Overview of standard sampling periods for determining the water quality per main soil type region.

1 The exact starting date of the sampling depends on the quantity of precipitation. Sufficient precipitation must have fallen before leaching to the groundwater can take place. Under the current regulations sampling never starts later than 1 December.

Soil moisture and groundwater are measured once per year on each farm. The annual precipitation surplus in the Netherlands is approximately 300 mm per year. This quantity of water spreads throughout a soil with a porosity of 0.3 (typical for sandy soil) over a layer of around 1 metre in the soil (saturated soil). Therefore, the quality of the uppermost metre gives a good picture of the annual leaching from the root zone and the loading of groundwater. Other types of soil (clay, peat, loess) generally have a greater porosity. In other words, a sample from the uppermost metre will contain, on average, water from more than just the previous 1 year. A measuring frequency of once per year is therefore sufficient. Previous research has demonstrated that the variation in the nitrate concentration within one year, as well as the variation between years, disappears if dilution effects and variations in the groundwater level are taken into account (Fraters et al., 1997).

From the start of the first sampling season following granting of derogation (1 October 2006), the frequency of the sampling of drain water and ditch water was increased for the Low Netherlands, from two to three rounds per winter (LMM sampling frequency realised up until then) to approximately four rounds per winter (intended LMM sampling frequency) to achieve a better spread over the leaching season. The feasibility of the four rounds depends upon the climatological conditions. Too little precipitation or frost can lead to drains not being sampled. The intended LMM sampling frequency was based on research carried out by Meinardi and Van den Eertwegh in the early 1990s (Meinardi and Van den Eertwegh, 1995, 1997; Van den Eertwegh, 2002). The evaluation of the

LMM programme in the clay areas, in the period 1996-2002, led to the conclusion that there was no reason to change the existing relationship between the number of sampling rounds per farm (realised sampling frequency) and year, and the number of drains sampled per farm and per sampling round (Rozemeijer et al., 2006). The intensification emerges from the European Commission's request for an increased sampling frequency. A frequency of four times per year is equivalent to the proposed sampling frequency for operational monitoring of vulnerable phreatic groundwater that has a relatively fast and shallow run-off (EU, 2006).

Besides the compulsory components of nitrate, total nitrogen and total phosphorus, the chemical analysis of the water samples also included the determination of other water quality characteristics. This was performed to explain the data for the measurements of the compulsory components. These additional components were ammonium nitrogen, ortho-phosphorus and several general characteristics such as conductivity, pH and dissolved organic carbon. The results of these additional measurements have not been included in this report.

The following sections describe the sampling per region in greater detail. The activities were performed according to Standard Operating Procedures (SOPs). The text below refers to the SOPs used by stating the relevant SOP number (SOP Pxxx), and at the end of this appendix an overview of the SOPs concerned is provided.

A4.2 The sand and the loess regions

Standard sampling

The groundwater sampling of the derogation farms in the sand region occurred in the period April 2009 to October 2009 and in the loess region in the period between October 2009 and February 2010 (see Figure A4.2). In these periods, each farm was sampled once.

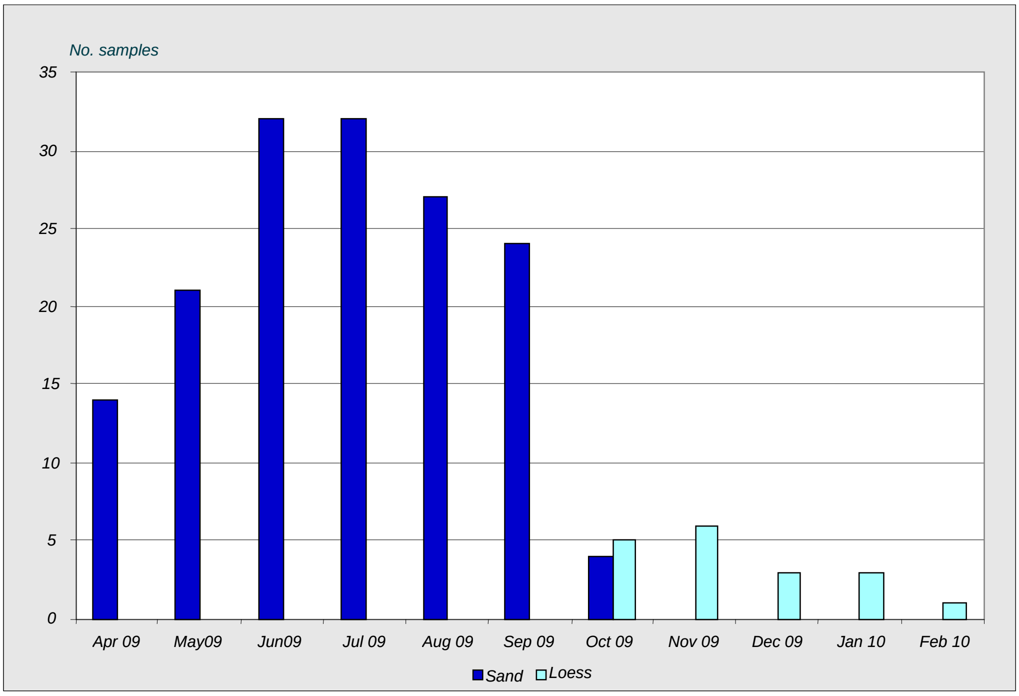


Figure A4.2 Number of samples for groundwater and soil moisture in the sand and loess region per month during the period April 2009 to February 2010.

The sampling was carried out according to the standard sampling method. This was as follows. On each farm, samples were taken from bore holes made at 16 locations. The number of locations per plot depended on the size of the plot and the number of plots on a farm. Within the plot the locations were chosen randomly. Selection and positioning took place according to a protocol (SOP P618). The uppermost metre of groundwater was sampled using the open bore hole method (SOP P213). In the field, the groundwater level and nitrate concentration (Nitrachek method) were determined (SOP P110). The water samples were filtered (SOP P434), conserved (SOP P416) and stored in a cool dark place for transport to the laboratory (SOP P414). In the laboratory, 2 mixed samples were prepared (8 samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

The additional sampling in the low-lying areas
On farms in the sand region, additional ditch water samples were taken during the period October 2008 to April 2009 (see Figure A4.3). This was performed according to the standard method. On each farm two types of ditch sample were distinguished. In principle, there are two ditch types: farm ditches and local ditches. Farm ditches only discharge water originating from the farm. Local ditches carry water from elsewhere; the water leaving the farm is therefore a mixture.

If farm ditches are present, samples were taken downstream (where the water leaves the farm or the ditches) in four of these ditches. Furthermore, in four local ditches, samples were taken downstream to gain an impression of the local ditch water quality. If there were no farm ditches, then samples were taken both upstream and downstream from four local ditches. This provided an impression of the local water quality and the effect of the farm on this. The ditch water sampling types are therefore farm ditch, local ditch upstream and local ditch downstream. The selection of locations for the ditch water sampling was protocolled (SOP P618). The selection is aimed at gaining an impression of the effect of the farm on ditch water quality and excluding effects external to the farm as much as possible.

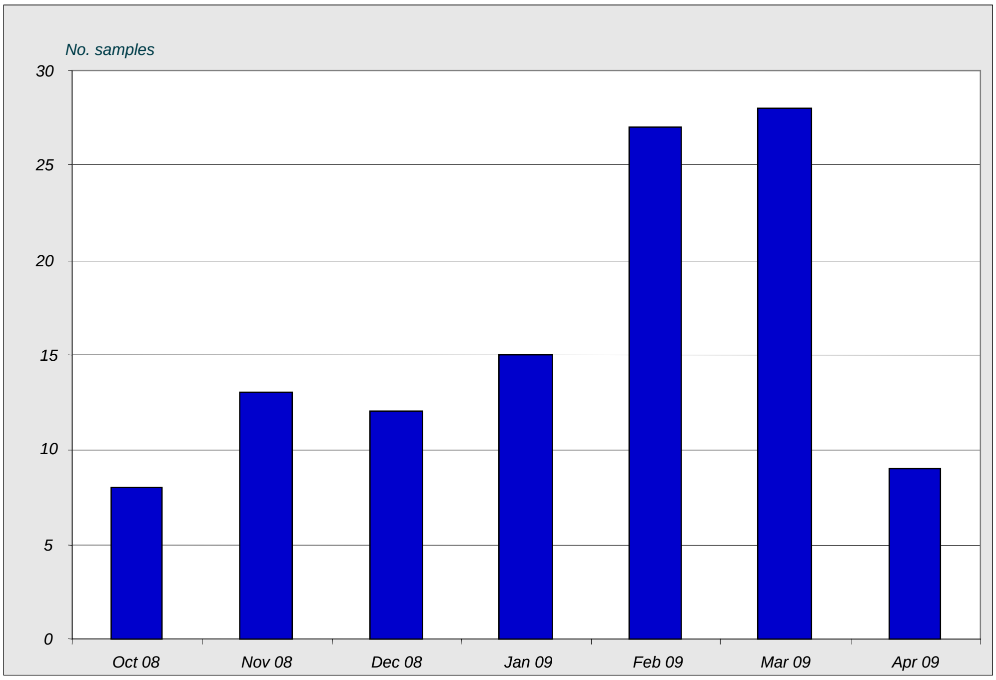


Figure A4.3 Number of samplings of ditch water in the sand region per month during the period October 2008 to April 2009.

During the winter of 2008-2009 ditch water was sampled between one and four times on the farms.

The ditch water samples were taken with a measuring beaker attached to a stick or 'fishing rod' (SOP P430). Water samples were stored in a cool, dry place for transport to the laboratory (SOP P414). In the laboratory, two mixed samples were prepared from these ditch water samples (one per ditch sample type). The individual ditch water samples were analysed for nitrate and the mixed samples were also analysed for total nitrogen and total phosphorus.

A4.3 The clay region

In the clay region, a distinction is made between farms on which the soil is drained with drainage pipes and farms where that is not the case. If less than 25% of a farm's acreage is drained with drainage pipes, or if less than 13 drains can be sampled, then the farm is considered not to be drained. The sampling strategy on drained farms differs from that on non-drained farms.

Drained farms

On the drained farms, drain water and ditch water were sampled in the period October 2008 to April 2009 (see Figure A4.4). On each farm, 16 drainage pipes were selected for sampling. The number of drainage pipes to be sampled per plot depended on the size of the plot. Within the plot the drains were selected on the basis of a protocol (SOP P618). On each farm 2 types of ditch sample were distinguished. For each type of ditch sample, 4 sampling locations were selected.

The selection was performed in accordance with the aforementioned protocol and was aimed at gaining an impression of the effect of the farm on ditch water quality and excluding effects external to the farm as much as possible.

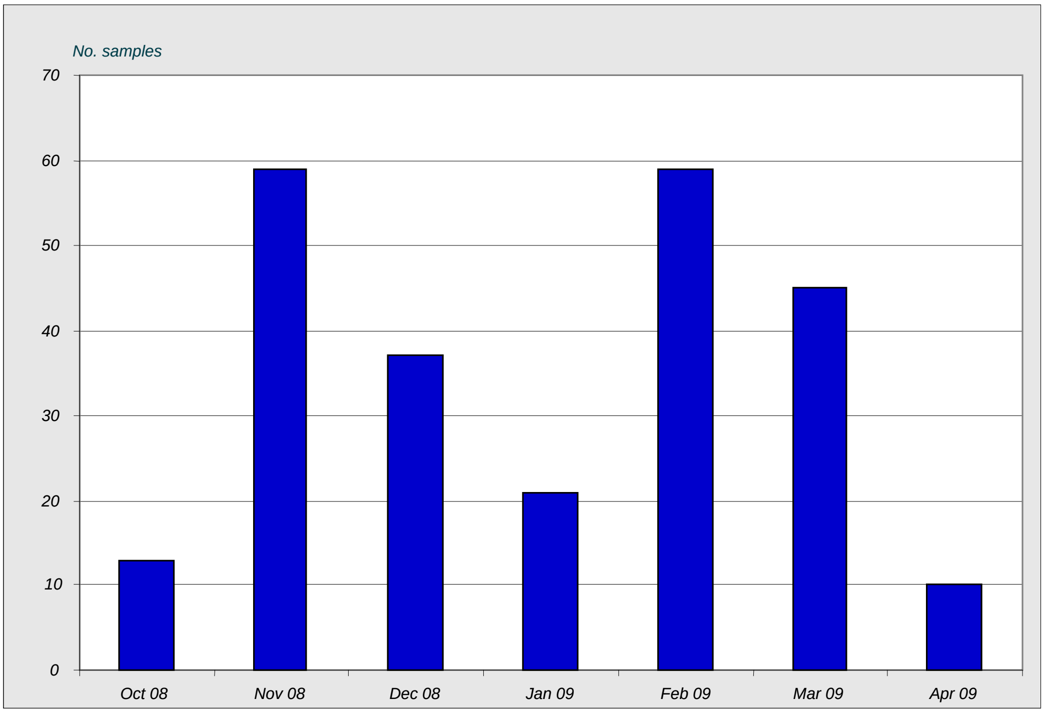


Figure A4.4 Number of samplings of ground-, drain and ditch water in the clay region per month during the period October 2008 to April 2009.

During this winter, the drain water and ditch water were sampled between one and four times as described in the previous section. The sampling was spread over the winter and the period between two samples was at least three weeks.

Water samples were stored in a cool, dry place for transport to the laboratory (SOP P414). In the laboratory, a single mixed sample was prepared on the following day for the drain water samples, and two of the ditch water samples (one per type of ditch sampled). The individual drain water and ditch water samples were analysed for nitrate and the mixed samples were also analysed for total nitrogen and total phosphorus.

Non-drained farms
On non-drained farms, the uppermost metre of the groundwater and ditch water were sampled in the period November 2008 to May 2009 (SOP P618) (see Figure A4.4).

The sampling of the groundwater was similar to that in the sand region. However, instead of the open bore hole method, the closed bore hole method was occasionally used (SOP P435). In the field, the nitrate concentration (Nitrachek method (SOP P110)) was determined at each of the 16 locations. The water samples were filtered (SOP P434), conserved (SOP P416) and stored in a cool, dark place for transport to the laboratory (SOP P414). In the laboratory, 2 mixed samples were prepared (8 samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

The ditch water sampling was similar to that of the drained farms, two types of ditch samples each with four locations. However, an important difference was that sampling took place with a filter lance (SOP P430) and water samples were filtered straightaway in the field (SOP P434) and analysed for nitrate (Nitrachek method (SOP P110)). As well as being filtered, the individual samples were also conserved (SOP P416) and stored in a cool dark place for transport to the laboratory (SOP P414). In the laboratory, two randomly composed mixed samples were prepared from these ditch water samples (one per ditch sample type). The mixed samples were analysed for nitrate, total nitrogen and total phosphorus.

A 4.4 The peat region

In the peat region the uppermost metre of groundwater was sampled once on all farms in the period October 2008 to April 2009 (see Figure A4.5). And ditch water was sampled on three to four occasions in the period October 2008 to April 2009.

The sampling of groundwater was similar to that in the sand and clay regions. However, instead of an open or closed bore hole method, a reservoir tube method was usually used (SOP P435). In the field, the nitrate concentration (Nitrachek method (SOP P110)) was determined at each of the 16 locations. The water samples were filtered (SOP P434), conserved (SOP P416) and stored in a cool, dark place for transport to the laboratory (SOP P414). In the laboratory, 2 mixed samples were prepared (8 samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

Ditch water sampling, carried out at the same time as groundwater sampling, was similar to that of non-drained farms in the clay region. The sampling therefore took place with a filter lance (SOP P430). There were always two types of ditch samples, each with four locations. Water samples were analysed for nitrate straightaway in the field (Nitrachek method (SOP P110)). The individual water samples were filtered (SOP P434), conserved (SOP P416) and stored in a cool dark place for transport to the laboratory (SOP P414). In the laboratory, two mixed samples were prepared from these ditch water samples (one per ditch sample type). The mixed samples were analysed for nitrate, total nitrogen and total phosphorus.

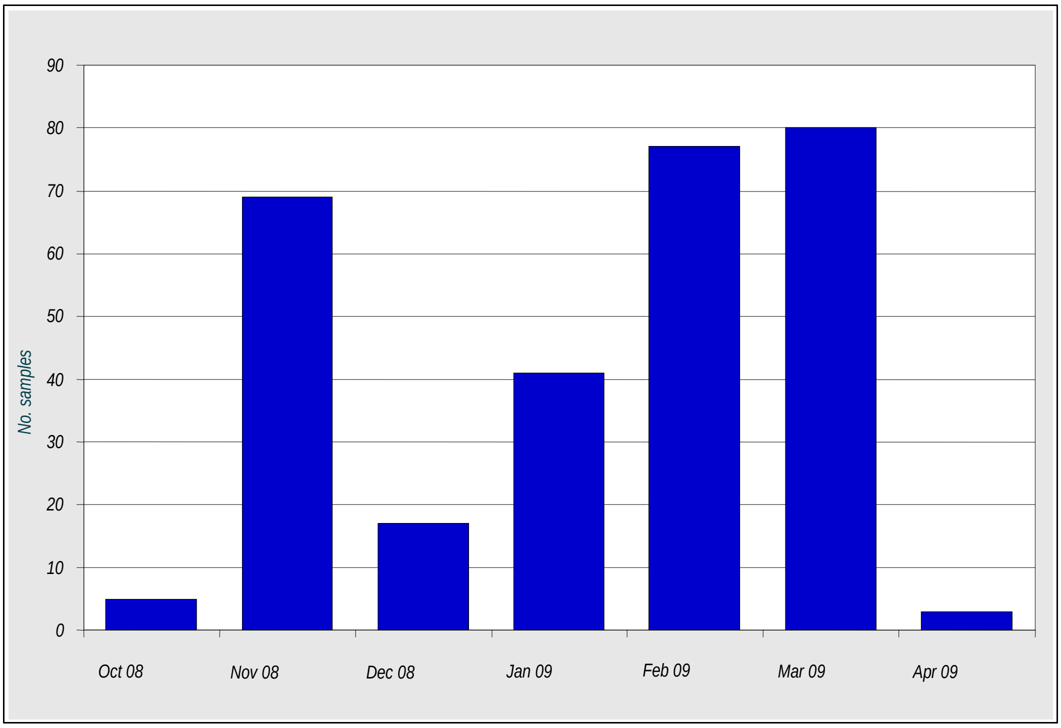


Figure A4.5 Number of samples from groundwater and ditch water in the peat region per month during the period October 2008 to May 2009.

The additional ditch water samples were taken at the same locations as the samples that were taken at the same time for the groundwater sampling. However, the sampling method was not the same, but rather the method used was that for drained farms in the clay region. Sampling therefore took place with a fishing rod and measuring beaker. No analyses took place in the field and the samples were stored in a cool, dry place for transport to the laboratory (SOP P430), but not filtered and conserved. In the laboratory, two mixed samples were prepared on the following day (eight random samples per mixed sample) and analysed for nitrate, total nitrogen and total phosphorus.

Overview of the RIVM Standard Operating Procedures used:

P618: Determination of the location of the sampling points.
SOP number LVM-BW-P618.

P435: Groundwater sampling with a sampling lance and hose pump on sandy, clay or peat soils.
SOP number LVM-BW-P435.

P110: The measurement of the nitrate concentration in an aqueous solution with the aid of a nitracheck-reflectometer (type 404).
SOP number LVM-BW-P110.

P434: Filtering of groundwater or ditch water using a filter bed holder and a 0.45 µm membrane filter.
SOP number LVM-BW-P434.

P416: Method for conserving water samples by adding an acid.
SOP number LVM-BW-P416.

P414: Temporary storage and transport of samples.
SOP number LVM-BW-P414.

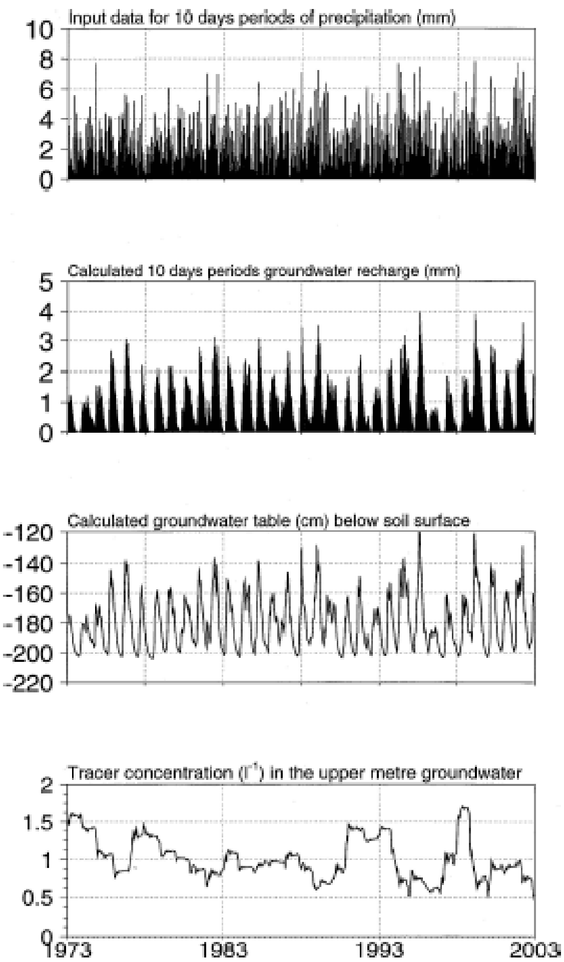
P430: Sampling ditch water or surface water with a modified sampling lance and hose pump.
SOP number LVM-BW-P430.

Appendix 5 Methods for correction for weather

The nitrate concentration of the upper groundwater, which is sampled by the LMM, exhibits fluctuations that cannot be clarified by variations in the agricultural practice alone. Fraters et al. (1998) showed that fluctuations in the precipitation surplus cause fluctuations in the nitrate concentration. For example, it was demonstrated that the 50% reduction in the nitrate concentration between 1993 and 1994 was mostly caused by greater dilution arising from a higher precipitation surplus. Below, a description of the method demonstrating the effect of the precipitation surplus is given.
The effect of a variable precipitation surplus on the nitrate concentration is determined by calculating a ‘precipitation surplus’ variable and then including this variable as an explanatory variable in a statistical model, see Appendix 6. The relationship between nitrate and the ‘precipitation surplus’ variable in the statistical model can be caused by both greater dilution of the nitrate and by increasing denitrification.

The variable ‘precipitation surplus’ is calculated in two steps:

Step 1. First, the leaching from a virtual tracer was calculated by means of a soil simulation model ONZAT (OECD, 1989) using nationally available data about precipitation and evaporation from 16 weather districts. The virtual tracer was applied each day to the soil surface of a standard soil profile with grass, for 8 different drainage situations. The result is a trend in the groundwater level and a tracer concentration for 16 * 8 = 128 situations. The figure opposite shows the trend over a period of 30 years for a given situation, of the precipitation, groundwater suppletion, groundwater level and tracer concentration.



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 the tracer concentration between years. The tracer concentration is inversely proportional to the precipitation surplus.

Step 2. For each temporary drill hole, the weather district, sampling date and the groundwater level measured are used to find an associated tracer concentration in the simulation results (Boumans et al., 2001). Then the tracer concentrations are averaged per farm, so that a farm-averaged tracer concentration (= variable precipitation surplus) is obtained for the farm-average nitrate concentration that is measured in a mixed sample of groundwater from the same temporary drill holes.

Appendix 6 Calculation method for the comparison of various years

For all of the calculations in this report, the basic observation is the annual average concentration on a farm. The calculations that are subsequently performed are unweighted. This means that no corrections are performed for farm acreages, size, et cetera.

Chapter 4 explores two ways of determining whether a change has occurred between monitoring years. First, a simple comparison is made between the previous reporting year and the report year using an own method. The reporting year is 2009 for agricultural practice and 2010 for water quality. Secondly, just for the sand area, an indexed trend line is calculated for nitrate.

An explanation of the two comparison methods is given below.

Simple method
Aim
The aim of the first method is to compare the results from the reporting year as simply as possible with those of previous years. An assessment of the difference between the reporting year and the average of the 3 previous years is then an obvious option. The difference must be assessed by its absolute size but also by its relative size. For example: the difference between 250 and 275 mg per litre of nitrate (25 mg per litre) in absolute terms is relevant, but is relatively (10%) not relevant. The difference between 1 and 2 mg per litre of nitrate is relatively relevant (100% increase) but in absolute terms (1 mg per litre), it is not. For phosphate, this increase in absolute terms is, indeed, relevant. If a difference is relevant in both absolute and relative terms then it may be deemed relevant. In addition to the absolute and relative sizes, the difference may also be assessed against the differences between each of the previous years. For example: if the average of the 3 preceding years is 10 and 20 is discovered in 2010, then it matters whether the 3 preceding years showed as 20, 0 and 10 or as 9, 10 and 11. The relative difference in the first case is smaller than in the latter. In the latter case, the difference between 2010 and the average of the previous 3 years is more relevant. The relative and absolute difference between the average of the reporting year and the 3 previous years, and the relative difference from the average (of the reporting year compared to the 3 previous years) can be used to assess whether the reporting year deviates to a relevant degree from the previous years. These 3 characteristics are linked. It appears that, if the relative difference is large enough, the relative and absolute differences are also relevantly large. Therefore, to limit the size of the tables, only the relative difference (F) is shown. No statistical calculations have been performed, so significant differences cannot be discussed. This means that no statement is made as to the average of the last year based on the averages found in previous years. In previous reports (Zwart et al., 2010), all previous reporting years are compared to previous years but, as the number of preceding years increases, this method becomes more complex. The currently applied own method has the advantage of being able to remain unchanged in subsequent years without increasing the complexity of the tables.

Calculation method
An average value is calculated for the 3 years preceding the reporting year. Subsequently, the absolute difference between the average-year values and the individual annual values is calculated, and then the average of these absolute differences. The difference between the value for the reporting year and the average of the 3 previous years is divided by the average absolute difference from the 3 previous years. The ratio between the differences calculated in this manner, the relative difference, is used as a measure for the change in the reporting year (2009 or 2010) as compared with the previous years. Since the differences from the previous 3 years are determined relative to the calculated average of the previous 3 years, these exceptions are automatically smaller than the difference from the reporting year. We chose to assess a relative difference of greater than 2 as being relevant; see explanation below. This technique is used for the tables in chapter 4 with sets of years, both for agricultural practice data and for water quality.

Explanation of the choice of 2 as the lower limit for a relevant relative difference from the reporting year.
There is only a small difference between the average absolute difference and the standard difference. With a sufficient number (n >20) of annual average concentrations, a ratio of 2 between the standard difference calculated from the previous year and the difference found in the reporting year will be significant. Significance means that the probability of chance is less than 5%. In a smaller number of observations, the ratio must increase in order to be significant. That is why 2 was chosen as the lower limit.

Calculation example
Suppose that in the previous years the values 9, 10 and 11 were discovered and 20 in the reporting year. The average absolute difference from the previous year is 2/3 (.667). The difference from the reporting year is 10. The relative difference, F, is 15; and because this is larger than 2, we conclude that 2010 shows a relevant difference in comparison with the previous years.

In formula:

$$F = ABS(m_r - m) / ((\sum ABS(m_v - m)/n)$$

F	= relative difference;
ABS	= absolute value;
m_r	= value in the reporting year;
m_v	= value from previous year v;
m	= average of the n previous years;
n	= number of previous years.

Indexed trend line
The indexed trend line estimates the annual average nitrate concentrations for the situation *without* the influence of confounding factors such as weather variability.
Water quality can be affected by people, by weather and because old farms are not included in the calculation and new farms are added to the monitoring network. Nitrate reacts the fastest and most clearly to changes in soil load and nitrate occurs most in the sand region. In the peat region, nitrate is hardly present. The clay region occupies an intermediate position. The indexation will improve as more observations become available. Far fewer observations are available from the loess region than from other regions. Due to the above-

mentioned complications, the method delivers no conclusive results in the method in the clay, peat and loess regions. Therefore, no correction will be introduced for these regions.

The sand area is most susceptible to nitrate leaching so that the human impact and the influence of the weather are most noticeable here; in addition, many observations are available. Therefore, the indexed trend line is determined only for nitrate in groundwater in the sand region. To separate the influence of agricultural practice as much as possible from other influences, the Residual Maximum Likelihood technique (REML) is applied (chapter 4, Table 51). This method allows for the fact that the sample contains the same farms investigated in several years but also different farms investigated in several years. This REML method was also used to investigate whether a difference in the precipitation surplus or a difference in the groundwater level could have affected the concentrations found (Table 51). The use of the REML method is described in greater detail in Fraters et al., (2004), Annex 2.

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