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

Minerals Policy Monitoring Programme

Minerals Policy Monitoring Programme Report 2007-2010

Methods and Procedures

National Institute for Public Health and the Environment
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Minerals Policy Monitoring Programme Report 2007-2010

Methods and Procedures

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LEI
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Abstract

Mineral Policy Monitoring Programme Report 2007–2010
Methods and procedures

Since 2006, the role of the Minerals Policy Monitoring Network (LMM) has widened. This change in scope has affected the organisation of the programme, as well as its methods and procedures. In this report RIVM and LEI Wageningen UR have documented these changes in the set-up of the programme and the associated changes in methods and procedures. Monitoring results are reported separately.

Objective of the LMM, prior and after 2006
The objectives of LMM are monitoring the water quality on farms and explaining the results in relation to agricultural practice on those farms. Up to 2006, the results of the LMM were primarily used to assess the effectiveness of Dutch agricultural mineral policies. Since then, LMM was expanded with a so-called derogation-monitoring network. This network monitors the impacts associated with the EU derogation, adjudicated to the Netherlands, for the permissible amounts of nitrogen from manure on grassland farms.

Modifications
The expansion of LMM tasks was accompanied by various modifications in the programme. First, the number of farms monitored has increased considerably. Secondly, since 2006 the network consists of a stationary group of farms. Prior to that, monitoring was done on a revolving group of farms from the total number of participating farms. Thirdly, the sampling frequency for water quality monitoring has gone up. Finally, the interest in the quality of surface water has gradually increased; at the onset, LMM focused largely on groundwater, water from drains and soil moisture.

Keywords:
minerals policy, nitrate directive, water quality monitoring

Rapport in het kort

Landelijk Meetnet effecten Mestbeleid rapport periode 2007-2010
Methoden en procedures

Sinds 2006 zijn de taken van het Landelijke Meetnet Effecten Mestbeleid (LMM) verbreed. Dit is van invloed is geweest op de organisatie, en op de methoden en procedures die in het meetnet zijn gebruikt. Het RIVM en LEI Wageningen UR hebben de veranderingen in de meetnetopzet evenals de methoden en procedures in dit rapport beschreven. De meetresultaten zelf verschijnen separaat.

Doel LMM, voor en na 2006
Het doel van het LMM is om de kwaliteit van water op landbouwbedrijven te volgen en te verklaren in relatie tot de bedrijfsvoering op die landbouwbedrijven. Tot 2006 zijn de resultaten van het LMM hoofdzakelijk gebruikt om de effectiviteit van het Nederlandse mestbeleid te toetsen. Sindsdien is het LMM uitgebreid met een zogenoemd derogatiemeetnet. Dit meetnet volgt de effecten van de uitzonderingspositie die de EU aan Nederland heeft verleend (derogatie) voor de toegestane hoeveelheid stikstof uit dierlijke mest op graslandbedrijven.

Veranderingen
Als gevolg van de uitbreiding van taken zijn een aantal veranderingen in het LMM doorgevoerd. Als eerste is het aantal bedrijven dat het LMM monitort aanzienlijk vergroot. Ten tweede bestaat sinds 2006 het meetnet uit een vaste groep bedrijven. Voor die tijd werd uit het totale aantal geselecteerde bedrijven steeds een wisselende groep bedrijven gevolgd. Ten derde is de frequentie van waterbemonstering verhoogd. Ten slotte is de aandacht voor de kwaliteit van het oppervlaktewater gaandeweg toegenomen; oorspronkelijk richtte het LMM zich vooral op grondwater, drainwater en bodemvocht.

Trefwoorden:
mestbeleid, nitraatrichtlijn, monitoring waterkwaliteit

Contents

ANNEXES

Summary

Originally, the Minerals Policy Monitoring Programme (LMM) was set up as an instrument for evaluating the effectiveness of Dutch agricultural mineral policies. LMM monitors the agricultural practices and water quality on farms representing different farming categories. The programme focuses on those farming categories, which, in terms of acreage, dominate the Dutch agricultural sector.

Meanwhile, LMM plays a supporting role in evaluating the 4-yearly national action programmes within the framework of the European Nitrate Directive. Since 2006, the programme fulfils a role in meeting the EC’s obligations linked to the derogation granted to the Netherlands. Finally, LMM investigates at limited scale, the likely impacts from future mineral policy options.

The two major LMM sub-programmes, corresponding to the objectives mentioned above are the Evaluation Monitoring (EM) and Derogation Monitoring (DM). The Exploratory Monitoring (VM) sub-programme was executed in support of future policy options. Furthermore, LMM undertook a number of additional programmes, complementary to the regular monitoring sub-programmes, covering issues not adequately covered in the regular programmes.

In the period 2007-2010, the number of farms participating in LMM was roughly between 500 and 540. If criteria permit, farms are used as much as possible for more than one sub-programme. The majority of farms participating in LMM have been selected by stratified random sampling from the Farm Accountancy Data Network (FADN). The parameters used for stratification are ’type of farming’, ’economic size of a farm’ and ’soil type region’ (’region’ for short). The LMM distinguishes four main regions: the sand region, clay region, peat region and loess region.

Data gathered for characterisation of the agricultural practices comprise varied information on the operational management of farms (amongst others: acreage, crops cultivated, head of cattle, production data of crops/cattle/milk, stocks, investments, etc.). Using these verifiable basic data, inferred information is calculated or derived, such as the nutrient surplus on the soil balance.

The objective of water quality monitoring is to assess as early and as directly as possible the leaching into the environment of nutrients caused by fertilizing practices. To this end, LMM monitors on the one hand the water leaching from the root zone, and on the other hand the quality of surface water. The water leaching from the root zone is sampled on farming plots in the upper meter of the groundwater, tile drain water and/or soil moisture. The quality of the surface water is monitored in ditches and surface drains. While the emphasis of monitoring is on nutrient concentrations, a wide range of chemical parameters is analysed.

The current report describes how LMM is organised, how farms are recruited, which information is collected and the methods of data collection and analysis.

Samenvatting

Het Landelijk Meetnet effecten Mestbeleid (LMM) is oorspronkelijk opgezet als instrument bij de evaluatie van de Nederlandse mestwetgeving. Het LMM onderzoekt de landbouwpraktijk en waterkwaliteit op diverse categorieën agrarische bedrijven. Het meetnet is gericht op die bedrijfscategorieën die in de Nederlandse context, qua oppervlak, dominant zijn.

Ondertussen speelt het meetnet een ondersteunende rol bij het opstellen van het vierjaarlijkse nationale actieprogramma’s in het kader van de Europese Nitraatrichtlijn. Sinds 2006 vervult het meetnet een rol bij de door de Europese Commissie verleende derogatie. Tenslotte wordt binnen het LMM op beperkte schaal onderzoek gedaan naar de mogelijke effecten van toekomstige maatregelen binnen het mestbeleid.

De twee belangrijkste LMM deelprogramma’s, corresponderend met eerder genoemde doelstellingen zijn de evaluerende monitoring (EM) en derogatie monitoring (DM). Het deelprogramma verkennende monitoring (VM) werd uitgevoerd ter ondersteuning van toekomstige mestbeleid opties. Daarnaast voerde het LMM een aantal aanvullende programma’s uit, complementair aan de reguliere deelprogramma’s, met als doel aspecten te onderzoeken die onvoldoende aan bod kwamen in de reguliere programma’s.

Het aantal landbouwbedrijven dat aan het LMM deelneemt lag in de periode 2007 tot 2010 tussen circa 500 en 540. Bedrijven worden, wanneer de criteria dat toelaten, zoveel mogelijk gebruikt voor meer dan één deelprogramma. Het merendeel van de aan het LMM deelnemende bedrijven is geselecteerd met behulp van een gestratificeerde aselecte steekproef uit het Bedrijven Informatienet (BIN) van het LEI. De stratificatieparameters zijn bedrijftype, economische grootte van een bedrijf en grondsoortregio (kortweg ‘regio’). Het LMM onderscheidt vier regio’s: de zandregio, kleiregio, veenregio en lössregio.

De gegevens die verzameld worden ter karakterisering van de landbouwpraktijk, omvat veelsoortige informatie over bedrijfsvoering (arealen, verbouwde gewassen, aantallen dieren, productie van gewassen/vlees/melk, mestgebruik, voorraden investeringen, etc.) Met behulp van deze verifieerbare basisinformatie worden afgeleide parameters berekend, zoals nutriëntoverschotten op de bodembalans.

Het doel van het volgen van de waterkwaliteit, is om zo snel mogelijk en op een zo direct mogelijke manier het uitspoelen van nutriënten naar het milieu vast te stellen. Hiertoe onderzoekt het LMM enerzijds het water dat uitspoelt uit de wortelzone, en anderzijds de kwaliteit van het oppervlakte water. Het uitspoelende water wordt bemonsterd als de bovenste meter van het grondwater, drainwater en/of bodemvocht. De kwaliteit van het oppervlaktewater wordt gevolgd in sloten en greppels. Hoewel focus ligt op nutriëntconcentraties in het water, wordt ook een breed scala aan andere parameters geanalyseerd.

Het voorliggende rapport beschrijft hoe het LMM is opgezet, hoe bedrijven geselecteerd worden, welke informatie verzameld wordt plus de manier waarop de informatie wordt verzameld en geanalyseerd.

1 INTRODUCTION

1.1 The Minerals Policy Monitoring Programme

The Minerals Policy Monitoring Programme (LMM) is a national monitoring programme collecting information on farm management practices and water quality on farms.

The objectives of the LMM are multiple. Originally, the programme was set up to monitor the impacts of the government's agricultural policies on the water quality on farms in relation to farm management practices. Now, the programme also serves as an instrument to meet the monitoring requirements imposed by the EC (Nitrate Directive and derogation decision). In addition LMM-data are used to provide scientific support for setting the mineral use standards. Data are also exploited to study and assess the relation between water quality and nutrient use.

Finally, the programme provides information for ex-ante evaluations to assess the likely effects of future policy options (special research programmes like 'Cows and Opportunities' (K&K) and 'Cultivating with a Future' (TmT)).

1.2 Agricultural policies and the role of LMM

Agricultural production in the Netherlands has increased sharply since the fifties and sixties of last century. Key to this production increase were mechanization, the application of (artificial) fertiliser and pesticides in crop production and feed concentrates in livestock farming.

This intensification of agricultural production has resulted in significant environmental impacts (impacts on the quality of air, soil and (ground)water). In the eighties the Netherlands' Government commenced formulating and implementing policies and measures to reduce emissions of nutrients from agriculture into the environment.

The LMM was initiated by the end of the eighties of last century to assess the effectiveness of government policies in limiting the impacts from agricultural emissions on groundwater quality. It is noted that the origins of LMM predate the onset of the Nitrate Directive or Water Framework Directive.

Annex 1 presents a more elaborate description of the development of sector policies and in parallel the development of the LMM monitoring network.

1.3 Outline of assumptions and methodology

The underlying assumption of the LMM is that government policies can affect farm practices and thereby reduce emissions to groundwater and surface waters.

Furthermore, it is assumed that changes in farm practices (use of nutrients) will affect the water quality on farms. Changes in water quality can only be detected with some time lag.

The monitoring of water quality aims to assess the impacts from fertilising practices as directly as possible (minimum interference), with the shortest time delay. To this end, the programme samples, on-farm, the water leaching from the root zone (corresponding with the precipitation surplus). The programme also monitors the quality of surface waters as a more indirect indicator.

For data reporting, LMM currently distinguishes four major soil type regions ('regions' for short) and, depending on the region, three principal farming types (Table 1.1).

'Industrial livestock farming' is distinguished as a separate (fourth) type of farming in the sand region only.

Table 1.1 Reporting units for data evaluation

Regions	**Types of farming distinguished**
• Sand region	• Dairy farming
• Clay region	• Arable farming
• Peat region	• Other (grazing livestock farming)
• Loess region	• (Industrial livestock farming)

Farms are the basic units for monitoring. Farms are selected via stratified random sampling. The principal parameters for stratification are farming type, size of farm and geographical position, expressed as the region of a farm. These aspects will be explained in more detail in chapter 2.

With the limited amount of resources available, LMM ensures full coverage of the target agricultural sector by using stratification in the selection of farms. The LMM intends to provide reliable conclusions at the level of the classification units (LMM categories: combination of region and farm type) shown in Table 1.1. At the level of the individual strata, this is usually not possible due to the limited number of elements per stratum.

LMM collects a wide range of data related to agricultural management practices and nutrient management. In addition to the financial and economical results, the participating farms also provide information on the amount of in- and outgoing manure and nutrients and other aspects of farm management. This information is recorded in the Farm Accountancy Data Network (FADN). On the basis of these data, the environmental pressure on each participating farm can be assessed. Important indicators in this respect are nitrogen and phosphorous surpluses on the soil balance.

Water quality monitoring takes place by sampling the water leaching from the root zone, ditchwater and surface drains. Water leaching from the root zone is investigated by sampling either the upper one meter of the groundwater, soil moisture or water from subsurface drains.

LMM tests various parameters to describe the water quality. Important parameters are nitrogen and phosphorous components as indicators for the nutrient leaching from agricultural soils.

Besides fertilising practices, various other (natural) factors affect water quality on farms. Therefore LMM also collects information on relevant environmental conditions (meteorology, soil, groundwater regime, water management practice).

The LMM comprises two main activities. One activity of LMM is data analysis, evaluation and reporting. This work could not be done without the other major LMM activity of data collection, data processing and data validation.

1.4 Implementing agencies and principals

LEI (a research institute within the Wageningen University and Research Centre) is responsible for collecting and evaluating data on farming practices and nutrient management.

The National Institute for Public Health and the Environment is the agent responsible for monitoring and analysing the water quality at participating farms.

The LMM is implemented under the authority of, and financed by two ministries: the Ministry of Infrastructure and Environment and the Ministry of Economic Affairs, Agriculture and Innovation.

1.5 Objective of the report

This document is a background document for the LMM as implemented during the period 2007-2010. The report intends to record and present information on the programme's principles, assumptions, methodology and procedures.

The report covers the water quality monitoring during the years 2007-2010 and the corresponding monitoring of agricultural practices during 2006-2009 (it is assumed that farm management practices during year x will affect water quality during year x+1 and later). The LMM data reports or result reports, published separately, focus on the results only.

The LMM result reports and the background document are published with the aim to make the information collected available to a wider public. The reports also provide transparency and accounting for the activities and results of the monitoring effort.

1.6 Reading guide

After the current chapter, this report contains the following topics:
- Chapter 2: description of LMM organisation in terms of set-up and composition;
- Chapter 3 description of the methodology and planning of data collection activities;
- Chapter 4: overview of methods of data analysis and data presentation.

2 LMM SET-UP AND COMPOSITION

2.1 LMM organisation

2.1.1 Sub-programmes as organising structure for data evaluation

In line with the different LMM objectives, data evaluation is organised in separate sub-programmes. Each sub-programme is defined to meet specific policy requirements or monitoring needs. Data collection is organised differently (see chapter 3).

During the reporting period, the LMM programme was organised in four sub-programmes. These sub-programmes, briefly presented below, are elaborated in more detail in sections 2.2 and 2.3.

- Evaluation Monitoring (EM) or long-term regular trend-monitoring network aims to describe and assess the quality of water at randomly selected farms in relation to current and past environmental stresses from agricultural practices and policy decisions (ex-post evaluation). The main purpose of this sub-programme is to assess effectiveness of agricultural policies.
- Exploratory Monitoring (VM) investigates impacts on water quality and farm practices from future policy options (ex-ante evaluation). This monitor comprises research programmes such as 'Cows and Opportunities' (K&K) which focuses on dairy farming and 'Cultivating with a Future' (TmT), focusing on arable farming.
- Derogation Monitoring (DM) is set up to meet the requirements of the EU derogation decision (monitoring of at least 300 grassland farms with derogation). The most important element in the DM is the derogation network, with the same objective as the EM, but addressing grassland farms registered for derogation. These farms are allowed to apply up to 250 kg nitrogen per ha from grazing animal manure. The DM also comprised a so-called Reference Monitor (RM), focussing on farms with relatively limited manure use. The RM is complementary to the DM, set-up in support of a new derogation application.
- Monitoring of specific combinations of 'farming type – region', which are not adequately addressed in other LMM sub-programmes. Examples are:
    - Monitoring of impacts on soils prone to leaching (sandy soils and loess soils): UM sub-programme.
    - The SVZ-network (scouting outdoor market gardening crops in the sand region).
    - Extension of the number of arable farms within LMM, in order to monitor with more accuracy the leaching of the nitrogen surplus on arable farms.

The objectives of the sub-programmes DM, RM and UM can be considered as complementary to the EM and VM, while the monitoring efforts within the EM and VM are indispensable for realizing the objective of the DM and UM.

2.1.2 2006 beginning of a new phase in the LMM

Prior to 2006 LMM gradually evolved into a country-wide monitoring network. In the years 2006 and 2007 LMM experienced fundamental changes and a major expansion. These changes were associated with putting into operation the new nitrate action programme and the obligations arising from the EC's adjudication of derogation for the period 2006-2009. Some of the changes taking place in the years 2006-2007 are:

- Set up of a new Derogation monitoring network.
- The regular trend monitoring network was strengthened by adding the loess region as a separate region of data collection and data assessment (prior to 2006 the sand region and loess regions ware considered together).
- Transition of a revolving network into a stationary network.
- Increase in monitoring frequency, especially of surface water.

The year 2006 is a transition year, in which water quality is already monitored at farms within the derogation network, while no information on agricultural practices was available at the same farms for the preceding year 2005.

2.1.3 Selection and recruitment of farms

The LMM focuses on the most common types of land use and fertiliser practices found in the Netherlands.

Farms participating in LMM are, to the extent possible, recruited from the Farm Accountancy Data Network (FADN), a network operated by LEI. In FADN, LEI gathers detailed financial, economical and environmental data of about 1,500 agricultural and horticultural farms. The farms selected in FADN are a stratified random sample from all farms covered by the annual national Agricultural Census. Stratification uses two principal variables: type of farming activity (based on the NEG-classification up to 2010; now using NSO-classification) and economic size (see Annex 2 and 3). FADN represents about 95% of the total agricultural production in the Netherlands.
Poppe (2004) describes background information and history of FADN in detail.

The LMM uses the 'region' as the third stratification variable. Furthermore LMM puts a size limit on the spatial extent of farms selected (≥ 10 ha) and on their economic size (16 ≤ NGE ≤ 800).

Although two of the stratification variables (farming type and economic size) are identical in FADN and LMM, the criteria applied for the variables differ. For the DM-, RM- and UM sub-programmes, additional selection criteria are applied. Annex 2 and 3 elaborate on the stratification variables applied in FADN and LMM.

Thirteen soil type districts make up the four main regions distinguished in LMM: six in the sand region, four in the clay region and two in the peat region (Figure 2.1). The loess region covers the Southern part of Limburg.

Unlike FADN, the LMM sample does not include all farm types. The decision to include a specific type of farming in a certain region depends on the extent of agricultural land occupied by this type. In this way, farm types that only cover a small percentage of the land (or form a very heterogeneous group, like horticulture) are excluded from the sample. The number of sample farms required in the sample per farm type differs between farm types, but remains constant in time. These numbers have been defined at the onset of a sub-programme, taking into account vulnerability to leaching, the relative importance of the type of exploitation/type of farming, and the required/ desirable numbers of farms from policy perspective or statistical considerations (Fraters and Boumans, 2005).

Figure 2.1 *Regions with soil type districts distinguished in LMM*

In the reporting period 2007-2010, the following general guidelines were used for selecting and recruiting LMM farms:

1. *Overlap between sub-programmes*. Farms already participating in one of the sub-programmes are utilised to the extent possible in constituting and maintaining (e.g. for replacement of 'drop-outs') the research sample in a sub-programme. Due to this overlap, the information gathered at one farm may be exploited for more than one sub-programme. For example, farms initially recruited for the EM may also participate in the DM (if registered for derogation). Farms recruited for the DM, can be used for analysis within the EM, if the EM selection criteria are met.
2. *Sequence of recruitment*. In recruiting and replacing farms, priority is given to an optimal research sample for the EM, followed by DM, UM and than RM.
3. *Minimum rotation.* The strategy for the monitoring period 2007-2010 (FADN years 2006-2009) is to use a fixed group of participants. Prior to 2006 a 'revolving' sample was used with periodic replacement of participants (in accordance with FADN-practice). Since 2006, a participant is only replaced if it does not meet (any longer) the criteria in place, or if the owner chooses to stop participation. For farms no longer meeting the criteria for a sub-programme, but whose owner is still

willing to participate in LMM, possibilities are investigated for incorporation in an alternative sub-programme. Notwithstanding the aim of a stable research sample, an annual replacement of about 20 to 25 firms proves to be inevitable.

4. *Maximum utilisation of FADN potential.* While in the past selection of LMM farms focussed on farms newly recruited in FADN, now all farms within FADN are considered as potential LMM participants. The starting date within FADN or earlier participation in LMM is no impediment for LMM participation.
5. *Only in case of insufficient FADN potential, additional selection takes place.* If FADN cannot provide enough LMM candidates, additional farms are selected outside FADN.
   - Additional farms for the EM, DM, RM en UM sub-programmes are then selected by stratified random sampling from the Agricultural Census applying the relevant sample criteria. While EM and VM are the first resource for DM farm selection, also farms beyond these programmes have been selected. Examples are the sixteen NFW-farms and ten CD-farms, two research projects outside LMM.

     > Noordelijke Friese Wouden (NFW) is composed of a group of dairy farmers in the northern sand region, who try to meet the environmental targets of the government by efficient mineral management. To achieve this, these farmers seek the consent and support within the national and European, environmental policies.
     >
     > Caring Dairy (CD) is group of eleven dairy farmers who aim at sustainability on-farm practices; an important aspect of their endeavour is maximising the cattle grazing during the summer period. Ten farms are included in the DM and one farm participates in the RM.

   - Additional selection in the VM-programme is not done at random. In these projects farms were approached because of their participation in ongoing research projects (sixteen dairy farms in 'Cows and Opportunities' (K&K), and twelve arable farms in the programme 'Cultivating with a Future' (TmT)
6. *Inclusion in FADN of additionally selected LMM farms.* With the exception of some TmT-farms, data on agricultural practices of all additionally recruited LMM farms are included in FADN (supplementary to the 1,500 regular FADN farms).

2.1.4 Farming categories for reporting purposes

The initial focus of LMM and its predecessor was on the sand region. In the course of the nineties of last century the clay region and peat region were included in the programme. At about the turn of the century, the loess region was the last one to be added to the programme (see also Annex 5, section A5.1). Prior to 2006, LMM combined the results for the loess region with those of the sand region. Since then, the LMM presents and reports on the loess region as a separate region.

LMM started with monitoring dairy farms and arable farms. In the course of the nineties also industrial livestock farms and other farms (livestock combination farms and crop-livestock combination farms, excluding specialised dairy farms: Table A3.4 of Annex 3) were incorporated in LMM. Only in the sand region, the programme reports on industrial livestock farms as a separate type of farming.

The LMM reporting categories (combining region and farming type) are not identical to the strata used for selection of farms. Reporting of results is done at a higher aggregation level. The NEG farming types, used in farm selection, and the corresponding reporting categories are listed in Table A3.4 of Annex 3.

Farm types distinguished in LMM are aggregated in such a way that the clusters are fairly homogeneous in terms of land use and fertilising practice. For a trend monitoring network like LMM, limited heterogeneity within the type of farming is important. A more homogeneous farming type category allows a smaller sample size. In all four regions, dairy farms represent a considerable part of total land use. In the peat region, the dominance of dairy farms is such that LMM merely focuses on dairy farms.

Figure 2.2 shows the reporting categories in terms of region and type of farming for the EM-, DM-, RM- and VM sub-programmes.

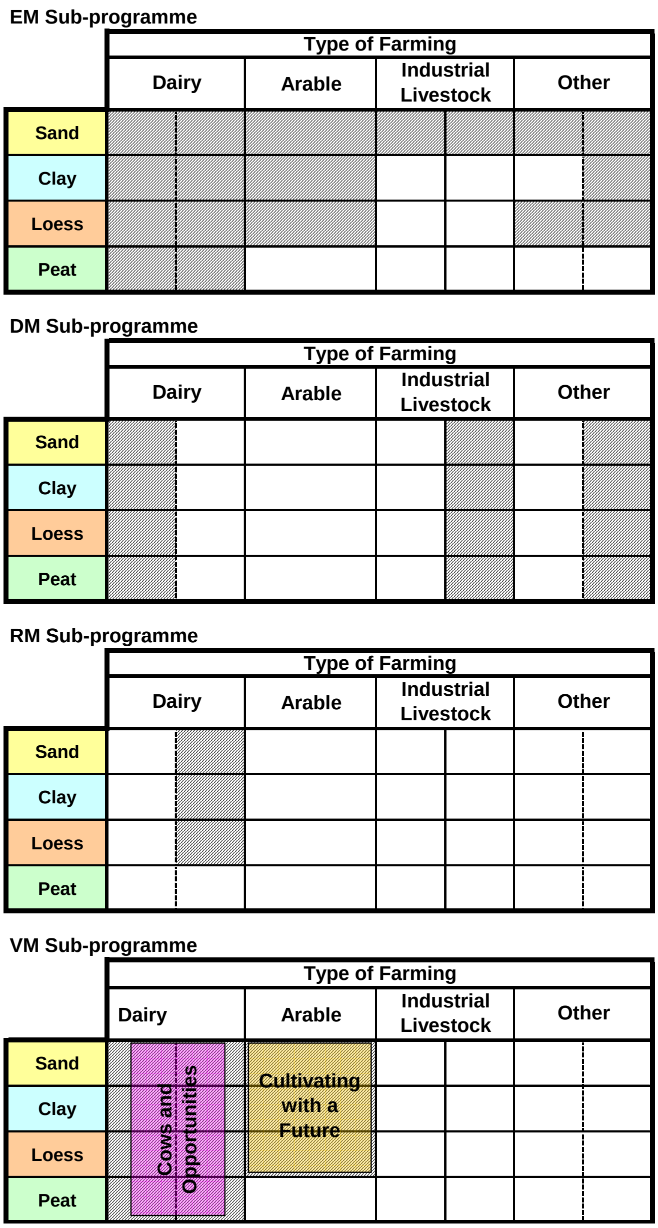

Figure 2.2 Scope of sub-programmes with respect to farming categories (simplified). The farming categories reported on in the different sub-programmes are hatched. The farming type 'other' is divided in two because the definition of this farming type is not identical for the sand/loess region vs. the clay region. The same applies to the farming category 'dairy' in the DM sub-programme vs. the RM sub-programme; both sub-programmes address specific parts of the research population of dairy farms.

Figure 2.2 illustrates that the EM includes various farming types. The DM and RM investigate farms with at least 70% of their acreage used as grassland. The DM primarily focuses on dairy farms; however, also 'other farms', which have applied for derogation, are included. The RM merely includes dairy farms. The UM aims at all farming types situated in the sand region and the loess region. The VM programmes address dairy farms and specialised arable farms.

The categorisation and stratification used for selection of farms and for reporting in the EM sub-programme is shown graphically in Figure 2.3.

<table>
<tr><th rowspan="2">Region</th><th rowspan="2">Soil type district</th><th colspan="4">Farm type</th></tr>
<tr><th>Dairy</th><th>Arable</th><th>Industrial Livestock</th><th>Other</th></tr>
<tr><td rowspan="3">Sand</td><td>North</td><td>1*</td><td rowspan="3">4</td><td rowspan="3">5</td><td rowspan="3">6</td></tr>
<tr><td>Central</td><td>2</td></tr>
<tr><td>South</td><td>3</td></tr>
<tr><td rowspan="4">Clay</td><td>Marine north</td><td rowspan="4">7</td><td rowspan="4">8</td><td rowspan="4"></td><td rowspan="4">9</td></tr>
<tr><td>Marine central west</td></tr>
<tr><td>Marine south west</td></tr>
<tr><td>River clay</td></tr>
<tr><td>Loess</td><td></td><td>10</td><td>11</td><td colspan="2">12</td></tr>
<tr><td rowspan="2">Peat</td><td>North</td><td>13</td><td rowspan="2"></td><td rowspan="2"></td><td rowspan="2"></td></tr>
<tr><td>West</td><td>14</td></tr>
</table>

_____ boundary between strata
- - - boundary between substrata
* each cell (1,2,…14) contains 3 NGE size classes

Figure 2.3 Strata used in LMM selection and Farming categories (numbered) for EM reporting (farming category 9 comprises a sub-set of farm types included in farming categories 6 and 12)

2.2 The EM sub-programme

The EM, the regular trend-monitoring network, is LMM's oldest and most encompassing LMM sub-programme in terms of categories reported on and representativeness of Dutch agricultural practice. The main purpose of the sub-programme is to assess effectiveness of agricultural policies.

This sub-programme fully follows the general procedures for selection and recruitment of farms, as presented in Annex 2.

The selection criteria for farms are as follows:
- Farms have an economic size between 16 and 800 NGE;
- Farms have a minimum acreage of 10 ha;
- The farming type corresponds to one of those listed in Table A3.4 of Annex 3.

Farms are exclusively selected from the FADN, using random (stratified) selection. For the stratification 42 strata are applied (14 categories in 3 size classes, see Figure 2.3)

On a national scale, the research sample of the EM sub-programme represents 81% of the area of cultivated land and 46% of the total number of farms. The area of grassland and arable land covered by the land-use units discerned ranges from 82% to 86%. For 'other cultivated land' the coverage (26%) is relatively low (see Annex 3).

Till about 2003, the number of farms sampled annually within the EM was around 100 (the number of participating farms was about 3 times larger). With the new monitoring sub-programmes since 2004, additional farms were selected applying the same methodology as for the EM. When selected by using the same procedure as applied for the EM farms, a farm is considered to qualify for EM evaluation. In the period 2006-2009 between 365 and 390 farms qualified for EM-evaluation.

2.3 The other sub-programmes

Derogation Monitoring (DM)
According to planning DM comprises 300 farms with derogation, of which 160 in the sand region, 60 in the clay region, 60 in the peat region and 20 in the loess region. The number of farms in the sand region constitutes more than 50% of programme's total, in line with the fact that more than 50% of the acreage of derogation farms is situated in the sand region. Moreover, an intensification of monitoring of agriculture on sandy soils was one of the EU requirements linked to the derogation decision.

Because the derogation decision demands the monitoring network to be representative for all soil types, fertilising practices (manure application practices) and crop rotations, it was decided not to exclude any type of farming. This implies that farm types not represented in the EM, are also eligible for the DM. One of the selection criteria for inclusion of a farm in the DM is a minimum acreage of grassland of 60%. The formal requirement for obtaining derogation is that at least 70% of the farm's acreage consists of grassland (see Fraters et al., 2007). This difference in percentages is related to different timing of recruitment vs. the moment of granting derogation, and different definitions of the farming unit by the authorities and LMM.

Only farms with derogation are eligible for the DM. Farms, which have registered for derogation, but which produce by organic farming, are excluded from the DM. By definition, farms based on organic farming principles only apply a maximum amount of 170 kg N per ha from manure.

For the DM, LMM distinguishes two farming type categories only: specialised dairy farms and other grassland farms. Stratification related to 'location' is based on the concept of groundwater bodies, distinguished in the Netherlands within the framework of the Water Framework Directive (WFD). For the WFD the Netherlands has twenty groundwater bodies (see box on next page).

Farms already participating in the LMM form the basis of the DM: either farms which are part of the EM, the VM (15 of the 16 farms participating in project 'Cows and Opportunities') plus the extra group of farms participating in the Noord Friese Wouden Project (16 farms) and 10 farms from 'Caring Dairy'. New farms from the Agricultural Census have supplemented this base group.

In summary: DM farms were selected randomly from the FADN or the Agricultural Census, and partly in a non-random way. A total of 78 strata are applied: 2 types of farming, in 3 size classes, distinguishing 1 to 5 groundwater bodies per region.

Use of groundwater bodies for farm selection in the DM
For constituting the DM, the objective was a maximum scatter (and minimum degree of representation) over the most important groundwater bodies (important in terms of acreage of agricultural land). For attributing a groundwater body to an individual farm, the municipality in which the farm receives its mail is guiding. In municipalities underlain by 2 or more groundwater bodies, farms have been allotted to the largest groundwater body. Within the sand region, five groundwater bodies have been discerned as sub-region: Eems, Maas, Rijn-Midden, Rijn-Noord and Rijn-Oost. Remaining farms (in other groundwater bodies in de sand region) were allotted to a sixth sub-region: "other". The loess region only comprises the groundwater body Cretaceous; therefore, this region was not subdivided any further. The peat region was subdivided into four sub-regions: the groundwater bodies Rijn-Noord, Rijn-Oost, Rijn-West and 'other'. Within the clay region, five sub-regions were discerned in the end. Because the south-western marine clay region comprises several groundwater bodies (without a clear dominant one), this part of the clay region was classified as one separate sub-region. In addition to this, three groundwater bodies were distinguished: Eems, Rijn-Noord and Rijn-West (as far as outside the south-western marine clay sub-region). The fifth sub-region comprises farms in other municipalities, not yet classified.

Reference Monitor (RM)
At inception, a total of 65 farms were planned for the RM (35 in the sand region, 25 in the clay region and 5 in the loess region); no representation was deemed necessary in the peat region. In comparison with the DM, RM farms use less manure, but it was anticipated that they would use a similar amount of total nitrogen. At the start in 2006, the selection of RM-farms focused on dairy farms, which had not applied for derogation. It turned out that those farms generally did not qualify for participation in the RM. After consultation with the principals (ministries involved) selection was shifted to derogation dairy farms with relatively limited use of manure.

In the end, non-organic dairy farms with an estimated manure production of less than 220 kg N/ha (estimate based on number of cattle and acreages from the Agricultural Census) and not utilising any imported manure were selected. Farms were partly derived from the FADN, but most of the farms participating in RM had to be selected from outside. Within RM 30 strata are distinguished: 1 type of farming for 3 size classes, while distinguishing 1 to 5 groundwater bodies per region (the peat region was not considered).

By the end of 2009, principals and the LMM management decided to discontinue this sub-programme, not deemed essential for the scientific underpinning of a new derogation request.

Exploratory Monitor (VM)
The VM comprises farms participating in research projects. The LMM is normally not the lead organisation in such research; rather contributing, The LMM participates in the VM programmes 'Cows and Opportunities' (K&K) and 'Cultivating with a future' (TmT). These projects are executed under the responsibility of external institutes. The 16 farms in K&K, not covered by FADN since 2004, were included in FADN again in 2006.

The aim of farms participating in TmT is the sustainable application of crop protection products and fertilisers, and the propagation of these methods on a wide scale. LMM considers the participants in TmT as a complement to the EM sub-programme. Information is acquired for arable farms in the sand region, clay region and on reclaimed peat land. The regular LMM sub-programmes only represent these types of farms to a limited extent.

Specific combinations

a. Scouting outdoor market gardening in the sand region (SVZ)

Due to their limited spatial extent, the farming type 'horticulture' is not included in the regular LMM sub-programmes. Because of the specific issues found at outdoor market gardening farms in the sand region, LMM initiated a separate scouting programme for this type of farming. For this project, one farm was selected from FADN and the remaining eleven farms ware selected from various sources. For selection, twelve strata are distinguished: four principal crops (strawberries, leeks, asparagus and greens) in three size classes.

b. Monitoring of soils susceptible to leaching (UM)

Around 2005, the LMM results showed that the water quality (in terms of nitrate concentration) on non-dairy farms in the sand region and loess region lagged behind the improvements observed in other regions and for dairy farms. However, this conclusion was based on a very limited number of farms. There was a gap in knowledge, especially with respect to arable farms in areas with deep groundwater tables. This situation prompted organising a monitoring effort focusing on soils prone to leaching (UM sub-programme). In practice, this has led to intensified monitoring in the loess region and the extension of the group of arable farms in the sand region.

The selection criteria and stratification method for the UM are the same as applied for the EM. The sole extra selection criterion is the dominance of sand or loess in the soil of the participating farms. The whole sand and loess region is included in the UM programme. The FADN was an important source of participating farms; however, the largest part of farms in the loess region has been obtained by selecting from outside the FADN.

The data reports for the period 2007-2010 do not give a separate account of the UM sub-programme, since this sub-programme only served to strengthen the results of the EM, DM/ RM and/or VM sub-programmes.

2.4 LMM overview

The ensuing Table 2.1 summarises the minimum target number of participating farms, the selection criteria, the number of strata plus stratification variables and the mode of selection used in the different sub-programmes.

For each sub-programme a certain number of farms are selected (see Annex 2 and Table 2.1). A considerable number of farms are used in more than one monitoring sub-programme. This multiple use of farms in different sub-programmes allows minimizing the data acquisitions work. Figure 2.4 schematically presents the overlap between sub-programmes in terms of participating farms. The size of the rectangles is roughly proportional to the number of farms in each sub-programme, for the 2007–2010 situation.

The size of the DM sample is fixed (minimum of 300 farms), being imposed by EU in the derogation decision. While establishing the DM some of the farms already participating in the EM were included. Figure 2.4 shows that a considerable number of the DM sample farms also qualify for evaluation under the EM sub-programme. The RM-sample has no overlap with other sub-programmes, as its participants were not selected fully at random, nor do they qualify for DM evaluation.

Table 2.1 Selection characteristics of the LMM sub-programmes

Subprogram-me (min. number of Participants)*	Criteria	Strata	Selection mode
EM (n=171)	- between 16 and 800 NGE - at least 10 ha - farming type (Table A3.4, Annex 3))	42 strata (14 categories x 3 size classes)	Fully random selection from FADN
DM (n=300)	- between 16 and 800 NGE - at least 10 ha - enjoy derogation - no organic mode of production	78 strata (2 types of farming x 3 size classes x (1 to 5 groundwater bodies per region))	Part selected at random from FADN or Agricultural Census and part selected not at random
RM (n=65)	- between 16 and 800 NGE - at least 10 ha - farming type 'dairy farming' - no organic mode of production - fertiliser application ≤220 kg n/ha	30 strata (1 type of farming x 3 size classes x 1 to 5 groundwater bodies per region, except for the peat region)	Partly derived from FADN; additional at random selection from Agricultural Census
UM (n=200)	- between 16 and 800 NGE - at least 10 ha - farming type (Table A3.4, Annex 3) - underlain by at least 50% sand or loess soil	42 strata (same as for EM)	Partly derived from FADN; additional random selection from Agricultural Census, especially in the loess region
SvZ (n=11)	- between 16 and 800 NGE - at least 10 ha - primarily outdoor market gardening crops	12 strata (4 principal crops (strawberry, leeks, asparagus, greens) x 3 size classes),	1 from FADN; remainder recruited additionally, from various sources
VM K&K (n=16)	Participant of project 'Cows and Opportunities'	Not applicable	Fully additional recruitment from K&K- project
VM TmT (n=12)	Participant of project 'Farming with Future'	Not applicable	2 farms included in LMM; 10 recruited additionally from TmT project

* not taking into account overlap between the sub-programmes

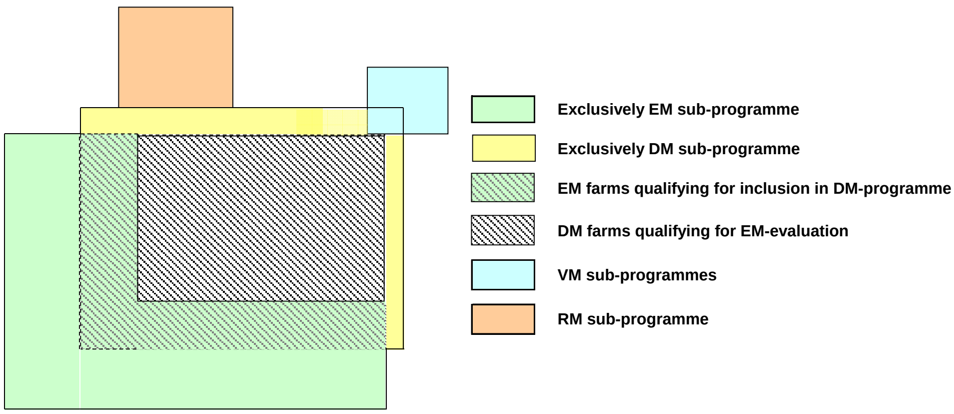

Figure 2.4 Schematic representation of overlap in participating farms within different sub-programmes.

2.5 LMM planning for the period 2007 - 2010

Fraters and Boumans (2005) present the original planning for the LMM for 2004 and thereafter. However, the EC demanded additional monitoring in the derogation decision (EC, 2005). For this reason, the LMM planning was adjusted in 2006. The changes in the LMM planning comprised an increase in the number of participating farms and an intensification of the monitoring frequency. The principal demands of the

EC deviating from the original planning related to a minimum number of 300 farms for the DM network (to be sampled annually), and the use of a fixed (stationary) network instead of a ‘revolving’ network.

Annex 4 lists the number of farms planned for the different sub-programmes. The table shows the numbers itemised per region, and per broad category ‘dairy’ and ‘non-dairy’ farms.

The composition of the pool of LMM participants and the number of farms in each of the sub-programmes is subject to some fluctuation. This is caused by farms dropping out, or due to changes in the operational management of farms, causing farms no longer meeting the selection criteria for a sub-programme.

The number of farms actually monitored is smaller than the sum of participants in the different sub-programmes. Many farms are used in more than one sub-programme. Figure 2.4 illustrates this overlap of farms in the different sub-programmes.

The LMM focuses on the sand region (Figure 2.5). The reason for this is the larger extent of the sand region and the higher vulnerability of this region to nitrogen leaching compared to other regions.

With the start of the DM and UM, the number of farms fit for EM evaluation has increased considerably to nearly 400. Before the establishment of the DM and UM, the number of farms in the EM was about 120.

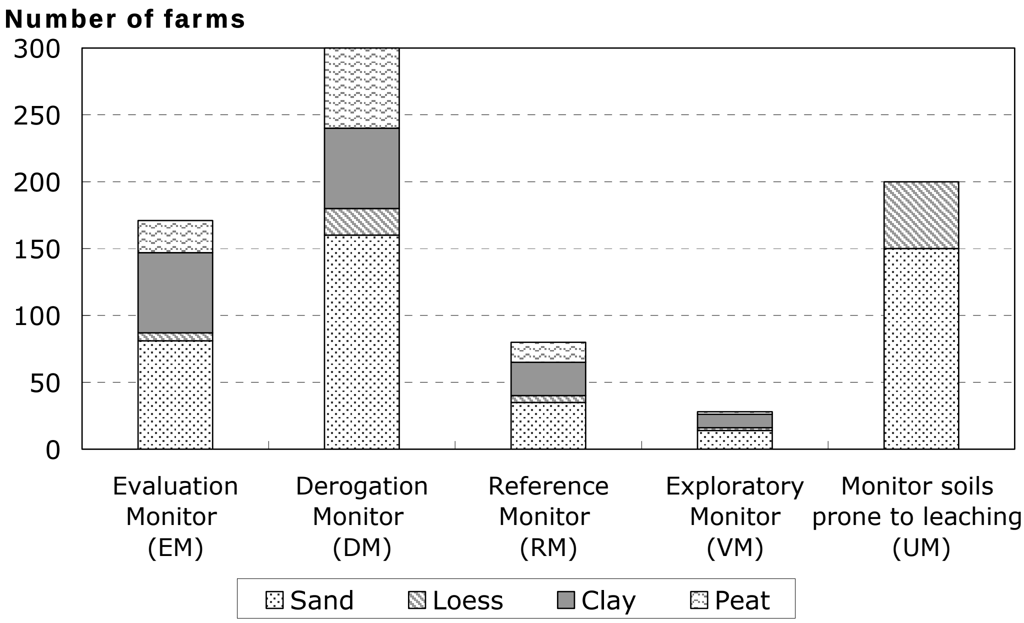

Figure 2.5 Number of farms planned per region, differentiated for LMM sub-programmes Note: the numbers do not refer to unique farms; a farm may participate in more than one sub-programme.

Figure 2.6 illustrates the composition of the different monitoring sub-programmes in terms of farming type. Table 2.2 lists, per region, the planned number of dairy and other grassland farms within the DM. The numbers are given per main soil type region. A total of 261 dairy farms and 39 other grassland farms were foreseen for the network (Fraters, et al., 2007).

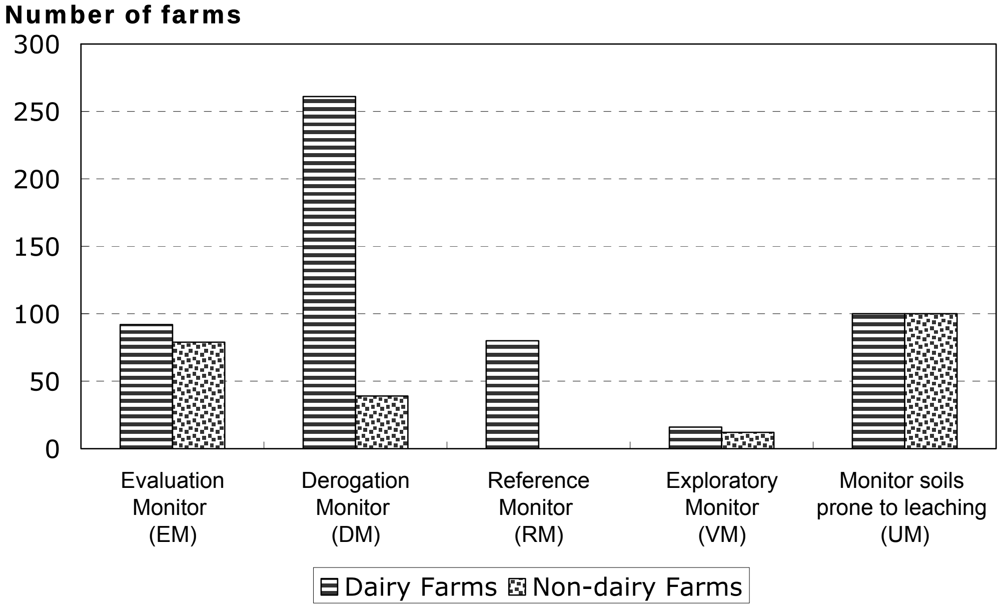

Figure 2.6 Number of farms planned for the different sub-programmes with break down per type of farming. Note: the numbers do not refer to unique farms; a farm may participate in more than one sub-programme)

Table 2.2 Proposed number of farms (dairy farms and other grassland farms) in the Derogation Monitor per region

	Sand	Loess	Clay	Peat	Total
Specialized dairy farms	140	17	52	52	261
Other grass-land farms	20	3	8	8	39
Total	160	20	60	60	300

While the DM largely consists of dairy farms, this farming type also dominates the farms qualifying for EM evaluation. To support policy making for arable farms in the sand region (impact of 'use standards' on and leaching from arable land), it was felt that more information was needed for this type of farming. Therefore, in 2007 additional arable farms were recruited in the sand region for the EM (see section 2.3 on monitoring soils susceptible to leaching).

The detailed planning in terms of number of farms sampled per sampling sub-project, the number of individual field measurements and water samples, and the number of laboratory tests (LMM planning in 2006) is presented in Annex 4. The actual number of site visits and numbers of samples taken is shown in Annex 5.

3 DATA COLLECTION AND PROCESSING

3.1 Data on agricultural practices

3.1.1 Practical aspects of data acquisition on farm practice

LEI collects and records data on agricultural practice. Data acquisition is done following a standard procedure and protocol. This procedure is identical for each farm, irrespective of the sub-programme, region or type of farming.

Administrative technical staff at LEI are responsible for the acquisition and recording of data on farm management practice. Generally, they have an agricultural as well as an administrative training. Therefore, they are well qualified to collect information on both financial as well as technical and economic matters. They stay in regular contact with the participating farmers by mail, phone and visits. Personal contacts are of utmost importance to be aware of the ins and outs of a farm, to have detailed insight into the farm's characteristics and to develop a relationship based on mutual trust. It is essential that these LEI-employees live and work in the same region as the farms for which they are contact person.

LEI guarantees participating farms that data on their farms are not disclosed. Data are used anonymously for research purposes. Confidentiality in the relationship between farmer and LEI is the key stone for the smooth and open flow of information. To optimize efficiency of data acquisition LEI utilises as much as possible electronically recorded data, as from banks on payments and expenditures.

This rule of confidentiality of data does not apply to all VM-farms. Farmers within the K&K sub-programme volunteered to participate; they are interested in improving their management practices and presenting themselves to the outside world. For the farms in the TmT sub-programme however, LMM strives to keep information confidential.

The data recording in FADN is extensive, and covers widely diverging aspects of farm management. LEI staff takes inventory of initial and final stocks, and collects supplementary information such as cultivation plans, system of grazing and composition of livestock. In processing invoices, not only the sums of money involved are recorded, but also the type of products/services, the physical quantities and the supplier/customer. Moreover, to verify the completeness of invoices, invoices are linked to electronic payments. It goes without saying that, while being processed into information for participants or researchers, the data are checked for consistency.

The staff responsible for data acquisition also processes the data of the individual farms, using common principles and standards. All data are recorded centrally, being accessible for researchers only.

In return for their cooperation, participating farmers receive amongst others a farm report and a comparative assessment report for the relevant type of farming. The participant's report primarily contains annual totals (such as the annual balance sheet and profit / loss account).

Most data in FADN are converted into annual totals, corrected for changes in stock. The annual consumption of concentrates for example is deduced from the sum of all purchases between the starting date and end date of the annual balance (minus all sales) plus stock at the beginning minus stock at the end of the period under review. The use of fertiliser is not only recorded on an annual basis but also per growing season, which runs from the moment the previous crop is harvested up to and including the harvest of the season's actual crop.

Based on the data on agricultural practices a large number of derived indicators are calculated, for example on the application and utilisation of minerals.

Annex 5 lists, per region, the number of farms actually used for data collection: Table A5.1 for data on agricultural practice and Table A5.2 for data on water quality.

3.1.2 *Information gathered*

The information collected by LEI for the FADN is wide ranging and very detailed (see Van der Veen, 2006). The data can be grouped as follows:

- Farm structure (cropped area, cropping plan, soil types, size and composition of livestock, capacity and characteristics of stables, manure depots, etc.);
- Farm management (data on grazing, mowing rate, mode and frequency of grassland rejuvenation, use of clover, irrigation, application for and use of derogation, mode and timing of fertilizer application, crop yields, use of concentrates, results of soil tests, fodder consumption and milk production, etc.);
- Data on financial and economic aspects (transactions for ingoing and outgoing product, costs and benefits allotted to crops and livestock species, appreciation of permanent means of production available, stocks at the beginning and end of the year, input of own labour and capital, etc.).

The above enumeration, dealing with the facts compiled and registered, is non-exhaustive. From the basic data collected, a wide range of corporate information is deduced for further research and for use by the owners themselves. On the one hand this inferred information provides financial economic results and performances like profit and loss accounts, the farm income and farm profits, credit balance and cost price at crop level or product level. On the other hand more technical indicators are derived, such as milk production per cow, the use of minerals in fertilizer, crop yields, culminating in a total overview of the average supply and removal of minerals with respect to the soil balance. For a further elaboration on the processing of the corporate information covered in the LMM report, reference is made to chapter 4.

3.2 Water quality data

3.2.1 *Introduction*

Collection of data on water quality consists of a number of steps: sampling, field testing and sample treatment, storage of samples and transport to laboratory, laboratory testing, data validation and data storage. This whole process, involving thousands of samples per year is subject to strict quality control. The approach of LMM is to optimise the quality of the work by formulating strict working procedures, facilitating working conditions as much as possible, computerisation of data recording, and minimisation of errors (see below under: 'provisions for optimising water sampling) .

3.2.2 *Sampling of water*

Media sampled and corresponding sampling sub-projects
Method and timing of water sampling is primarily determined by soil type and by the medium sampled (groundwater, soil moisture, ditch water, tile drain water and surface drain water). For this reason water sampling is organised in different 'sampling sub-projects', independent from, and cross cutting the sub-programmes described in chapter 2. The number of samples per farm, frequency of sampling, and the method of sampling may differ per sampling sub-project.

Prior to 2004, LMM focussed on water leaching from the root zone. The programme sampled groundwater, water from tile drains and soil moisture. Since 2004, attention has widened to include the quality of surface water (water in ditches and surface drains). The number of sampling sub-projects has grown (Table 3.1). This development is to be attributed to the increased interest in the groundwater – surface water relationship (recommendations of the Spiertz Committee; Velthof, 2000) and the monitoring obligations related to the Nitrate Directive and the derogation decision (see Annex 1). This new approach enables assessment of the degree of nutrient loss from agricultural land and leaching into the wider environment ('afwenteling').

Table 3.1 Listing of sampling sub-projects in operation in the period 2007-2010, as a function of region and monitoring sub-programme

Sampling sub-project			prior to 2007	winter 2006-2007	summer 2007	winter 2007-2008	summer 2008	winter 2008-2009	summer 2009	winter 2009-2010	summer 2010	Sampling frequency (times per season)
For EM/DM/RM sub-programmes												
Winter	Sand	Drains and ditches (wet parts)										4
		groundwater (wet parts)										1
	Clay	Drains and ditches										4
		Groundwater										2
		Ditches (extra rounds)										4
	Peat	Surface drains and ditches										4
		Ditches (extra rounds)										4
		Groundwater										1
	Loess	Soil moisture										1
Summer	Sand	Groundwater										1
		Ditches (wet parts)										4
	Clay	Ditches										4
	Peat	Ditches										4
For VM sub-programmes												
Winter	**Cows & Opportunities**											
		Soil moisture										1
		Drains and ditches										4
		Groundwater										1
		Ditches (extra rounds)										4
Summer		Groundwater										1
		Ditches										4
Winter	**Cultivating with a future**											
		Drains and ditches										4
Summer		Groundwater										1
		Ditches										4
For Scouting market garden crops Sand Region												
Winter		Drains and ditches										4
Summer		Groundwater										1
		Ditches										4

sampling during winter
sampling during summer
existing sampling sub-project
initiated in 2006
initiated in 2007
initiated in 2008

This table shows that most of the sampling sub-projects continued from previous years (hatched diagonally) while some were initiated during the reporting period. Prior to 2006, ditch water was already sampled during the winter period in the sand, clay and peat regions. New sampling sub-projects for the summer period began in 2007 and 2008. A new scouting program for monitoring at farms producing outdoor market garden crops in the sand region started in the winter of 2007.

In addition to these routine sampling sub-projects, one campaign was held in 2009 to sample the water from springs and brooks in the loess region. This was a research activity, as a follow-up to an earlier campaign in 2001 (Hendrix and Meinardi, 2004).

Although methodology and timing of some of the sampling sub-projects is largely identical (for example sampling for the VM sub-programmes versus EM/DM/RM sub-programmes), the sub-projects are listed separately because the number of sampling points per farm may differ, they are planned separately and because implementing agents may be different.

The last column of Table 3.1 lists the sampling frequency for each of the sampling sub-projects. The periods in which sampling is actually executed is shown in Figure 3.1; the annual cycle covers about 15 months.

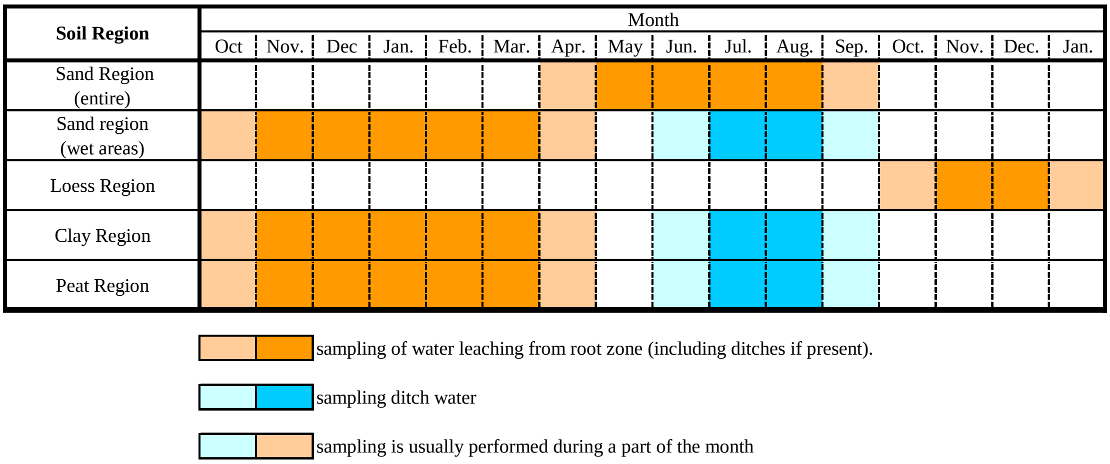

Figure 3.1 Implementation period of sampling sub-projects, aggregated per region

Preparatory fieldwork

Prior to the start of water sampling, RIVM staff visit each new LMM farm. During this first visit, general information is collected through a standardised survey. Based on this visit a so-called field file is prepared containing farm-related information such as a map of the various parcels of land and the position of sampling points.

Sampling methods and procedures

The sampling method depends on the medium sampled. For the sampling of groundwater LMM applies different methods in each region (Annex 7).

Normally, groundwater is sampled from temporary boreholes with or without screen (as a function of the soil type). Water from tile drains, ditches and surface drains is collected by using simple jugs. Annex 7 provides detailed information on the different sampling methods.

In the regular monitoring programmes the water leaching from the root zone (groundwater) is sampled at 16 locations per farm. Water from ditches is sampled at 8 locations, from tile drains and surface drains at 16 locations. For the purpose of the VM sub-programme, groundwater samples are taken at 48 locations per farm.

Sandy soil with its coarse texture is usually quite permeable. Consequently, most of the rain water surplus infiltrates vertically towards the groundwater. For this reason, samples on sandy soils are normally taken from the top 1 meter of the groundwater (see Figure 3.2). If the groundwater level is deeper than 5 m below the surface, soil moisture is sampled. Routine sampling takes place in the summer period (once per year). At a subset of the farms, located in the wet parts of the sand region, additional sampling is done during winter. In those parts groundwater is sampled (once), as well as drain water and ditch water (4 times during winter). Sampling of drain water is illustrated in Figure 3.3.


Figure 3.2 Open auger boring for sampling of groundwater on sandy soils

Clay soils are fine grained; usually, they are impervious. Only part of the rainfall surplus infiltrates to the groundwater. The remainder is drained (either overland or through tile drains) towards ditches, and ultimately to larger surface water. In the clay region LMM distinguishes drained farms (tile drains on more than 25% of a farm's acreage) and undrained farms (less than 25% of the acreage drained by tile drains).

At drained farms, LMM samples the drains and ditches (4 times during winter). At undrained farms, LMM samples the top 1 m of the groundwater (2 times during winter) and ditches (4 times during winter including 2 times during groundwater sampling).

Also in the peat region, where water is often abundant (shallow groundwater table), the rainfall excess partly recharges the groundwater but most of the excess is drained towards ditches. For that reason, both groundwater (once per year) and ditch water is sampled (4 times per year including once during groundwater sampling). Since 2007, LMM samples surface drains at 12 farms, 4 times per year during the winter season.

In the loess region (with the groundwater table usually deeper than 5 m below ground level) it is not possible to sample groundwater by hand boring using the open auger method. Here the unsaturated soil is sampled from a depth of 1.5 to 3.0 m below the surface. The laboratory test the water quality of the soil moisture.

Since 2008 ditch water is also sampled during the summer period (4 times) in the clay region and peat region, as well as in the wet part of the sand region.

Sample containers and sample conservation
Field staff, responsible for water sampling, are equipped with sample containers (bottles), suitable for the different analyses, stickered with pre-printed labels specifying the farm visited, sampling round and medium sampled. These pre-printed labels prevent inaccuracies and mistakes in sample identification. If required for conservation purposes, samples are acidified in the field, using H_2SO_4 or HNO_3 (depending on the type of analyses planned). Since the end of 2010, acids are now being added to the bottles by the laboratory prior to sampling. All water samples are filtered over a 45 μm, 300 mm^2 membrane filter. Groundwater samples are filtered in the field.

Samples of drain water and ditch water are filtered in the laboratory. However, ditch water sampled at the time of groundwater sampling are filtered and pre-treated in the field as well.

Table 3.2 summarises the sampling bottles used and their characteristics per medium sampled.

Table 3.2 Characteristics of sample containers for different water types

Medium sampled	Type of bottle	Volume (ml)	Filtration in field	Acidified	Analysis package*
Groundwater	Glass** PE PE	100 100 250	Yes Yes Yes	Yes (H_2SO_4) No Yes (HNO_3)	A B C
Tile drain water	PE PE	100 250	No*** No***	No*** No***	B A+C
Ditch water	PE PE	100 500 (3-4 samples) 1000 (2-3 samples) 1500 (1 sample)	No*** No***	No*** No***	B A+C
Soil moisture	Glass PE	720 for indiv.sample 1500 for composite sample	Not appl. Not appl.	No No	-- A+B+C

* A: DOC, ortho-phosphate, total nitrogen and ammonium
B: chloride, nitrate, nitrite, sulphate, specific conductance and pH
C: metals
** In 2010 a 125 ml PE bottle replaced the glass bottle
*** Filtration and acidification done in laboratory

Figure 3.3 Sampling of underwater drains using electrical pump

Storage and transport of water samples
Storage and transport of water samples is done in accordance with a standard Work Instructions (Annex 7). For the (temporary) storage of samples in the field, there are two options or a combination of both. Option I is the use a portable cool box with cooling elements; this option is often used as temporary solution during transport

between two or more sampling points. After short intervals, the samples are transferred to a fixed or mobile fridge in the fieldwork vehicle, which represents the Option II.

Normally, the samples are transported to the laboratory on the day of sampling itself. This is done by the fieldworker or by sending one or more cool boxes by courier service. If this is not possible, the field-worker is responsible for keeping the samples in a refrigerator at a constant temperature of +4 °C.

Provisions for optimising the quality of water sampling
All aspects of water sampling and the subsequent steps of treatment, storage and transport to the laboratory are described in detail in different 'Work Instructions', previously called 'standard operating procedures' (Annex 7). Further information is given in section 3.2.4.

Because the work in the field often has the character of assembly line work, extra efforts have been made to avoid errors. In this framework, the following provisions are made:

- Use of pre-printed labels for sample bottles;
- Use of handheld computer with pre-formatted menus for data recording of field data (Figure 3.4);
- Strict quality control of recorded information. The data collected in the field are transferred, at least once per week, to the Fieldwork Supervisor at RIVM´s headquarters. Before data storage in the central database, data are checked for completeness and consistency. Any issues are cleared with the fieldworker.

Figure 3.4 Hand-held computer used for recording of field data

Implementing agents of water sampling
The bulk of the fieldwork is outsourced to external parties. RIVM remains the principal agent with respect to overall planning, first time visits of new participants, sampling of groundwater, quality control and for fieldwork in special monitoring programmes (VM and scouting).

In the past, farmers themselves used to be involved in sampling of water on their farm. This was limited to the sampling of water from ditches and drains. To ensure uniformity in work procedures and a better quality control, this practice of sampling by farmers themselves stopped after the 2006-2007 winter season.

Annex 8 provides a summary of the agents responsible for the different sampling sub-projects.

Number of samples taken

The effort involved in visiting participating farms for water quality sampling is quite substantial. The number of individual water samples taken per year ranges from roughly 16,700 to 27,700. This resulted in between 2,600 and to 5,600 composite samples, for laboratory testing. The number of farm visits (rounds) ranged from 1,000 to nearly 2,500 (see Annex 5, Table A5.3). The year 2007 is a transitional year in which the programme was developed.

The performance for some of the years however, is below the targets (for details compare Annex 4 and 5). This 'underperformance' is due to difficulties in the timely recruitment of new farms, and the correct categorisation of farms (sometimes farms had to be rejected after recruitment, as they failed to meet all the selection criteria).

3.2.3 *Testing of water quality*

Field testing

Samples of groundwater are tested in the field for temperature, pH, specific electrical conductance (EC), dissolved oxygen content and nitrate. For this purpose, the programme originally used the following equipment:

- For pH: a WTW pH 196, WTW pH 197 or pH 197i pH/mv-meter, with temperature compensation
- For EC: a WTW LF 196, WTW LF 197 of 197i conductivity meter with temperature compensation;
- For dissolved oxygen: a WTW OXI 196, WTW OXI 197 or 197i oxygen meter with automatic temperature, atmospheric pressure and salinity compensation
- Nitrate: Nitrachek-reflectometer (type 404).

In the course of 2006 and 2007 the individual devices to measure pH, EC and dissolved oxygen were replaced by multimeters combining the functionality:

- WTW Multi 350i multimeter with accessory electrodes (WTW Sentix 41 for pH; TetraCon 325 of ConOx for EC; CellOx 325 of ConOx for dissolved oxygen)

Other data recorded in the field are a simple log of soil layers perforated, the groundwater level and sampling point coordinates. In water samples taken from ditches, tile drains, surface drains or soil moisture no chemical or physical parameters are measured in the field, but in the laboratory.

Laboratory testing

For each farm and per sampling round, one to four composite samples are prepared and tested on a wide range of components. RIVM's own laboratory facilities are responsible for testing the water samples. The parameters analysed are:

- General characteristics: EC, pH and DOC (dissolved organic carbon);
- Nitrogen compounds: NO_3, NH_4 and total nitrogen (N-total);
- Phosphorus compounds: ortho-phosphate (PO_4) and total phosphorus;
- Macro-elements: Na, K, Mg, Ca, SO_4, Cl;
- Trace elements: Fe, Al, As, Ba, Cd, Cr, Cu, Mn, Ni, Pb, Sr, Zn.

Concentrations of N-organic are calculated as follows:

$$\text{N-organic} = \text{N-total} - NO_3 - NH_4 \text{ (mg N/l)}$$

Individual samples of ditches, tile drains and surface drains are tested for EC, pH and NO_3. Samples of soil moisture are tested individually for Cl, NH_4 and NO_3.

Annex 9 lists details on analysing techniques and detection limits.

3.2.4 *Quality control*

The fieldwork for water sampling, treatment of samples and transport is embedded in a strict quality control system. Elements of this system are:

- Work instructions for all elements of fieldwork (see also under 'Provisions for optimising the quality of water sampling' in section 3.2.2);
- At the start of each monitoring sub-project a kick-off meeting is held between fieldworkers and supervising staff. In addition, several evaluation meetings are held during a year. Usually, fieldworkers visit head office once a week, for new supplies, and to discuss progress and programs;
- RIVM staff (fieldwork supervisors and field coordinators) make surprise visits (field audits) to fieldworkers, according to a pre-established programme of spot checks; the programme defines the number of spot checks per field-worker or field team. The principle objectives of these field audits are:
  - verifying working methods and assuring that work instructions are adhered to;
  - identifying and reporting on deviations from the work instructions, and also to register wishes and suggestions from the side of the field-workers;
  - identifying and communicating to fieldworkers corrective actions in order to correct deviations
  - improving the efficiency of fieldwork by evaluating practice and procedures, and adjusting procedures if required.

3.2.5 *Data validation*

The field staff records, on site, all field data related to the sampling of groundwater, drain water and soil moisture in a hand-held computer. Information from this hand-held computer is transferred, normally once a week, to the RIVM database at RIVM's headquarters. In the process of transferring the data, the information is checked by the fieldwork supervisors for administrative and logical consistency.

After laboratory testing, the laboratory results are compared with the field tests (for EC, NO_3 and pH). If inconsistencies or irregularities are found, all available information is checked to detect the possible cause. Mistakes are corrected, and where possible inconsistencies removed. Checks are made on the laboratory test results to detect any mistakes or unlikely results. The checks used are:

- The value of N-total should equal or exceed the sum of N-compounds, measured individually;
- As no bicarbonate is analysed, the sum of cations must exceed the sum of anions;
- The EC measured in the laboratory should be in the same order of magnitude as the sum of the cations (in meq/l) x 100;
- Ratio between Na and Cl;
- Concentration of some heavy metals, in relation to the pH.

In case of inexplicable or physically/chemically impossible data, such data are marked and removed from the database used for data analysis.

3.3 Use of secondary data

3.3.1 Map material

For locating and describing the farms participating in LMM, RIVM uses topographic maps, scale 1:25,000. The planning of fieldwork also utilises these maps. For the purpose of interpretation of water quality data other maps are utilised:

- Soil map of the Netherlands (1:50,000), aggregated into 7 main soil types, with grid cells of 50 x 50 m resolution (source: Van Drecht, G. and Schepers, E., 1998)
- Groundwater regime map 1:50,000 derived from above soil map.
- Map of soils prone to nitrate leaching ('Drogegrondenkaart') prepared by Alterra. This map is the outcome from of the Government decree 'Besluit zand- en lössgronden' taken in 2001 (decree to identify and define policies for soils prone to leaching).
- Soil map of the Netherlands (1:50,000), reworked by Alterra in 2006. Contains recent information on the status of peat soils, especially in the north-eastern part of the Netherlands. This map will replace the obsolete soil map mentioned above.

To optimise data analysis, each farm participating in LMM is schematised in a polygon representation, defining individual plots. This polygon representation is made using auxiliary software (Didger) on the basis of the 1:25,000 topographic maps, and stored in GIS (using ArcInfo). After each monitoring visit, the plot/parcel properties of farms, such as location and surface area, are checked versus properties recorded earlier, and adjusted, if necessary, to represent new field (ownership or use) conditions. This information is combined with the soil map and groundwater regime map. The resulting overlays are interpreted and used to produce tables listing fractions with respect to soil type and groundwater regime. These data are incorporated in the programme's database (BASE).

3.3.2 Meteorological data

Meteorological data in the form of decade values of precipitation and evaporation are collected from the data made available by the Royal Netherlands Meteorological Institute (KNMI). These data are collected for 15 stations representing the 15 weather districts.

RIVM uses this meteorological information for applying net-precipitation corrections to water quality data; see Annex 10.

3.3.3 Various information sources related to farm management

<u>Annual Agricultural Census in the Netherlands</u>
The annual Agricultural Census describes the structure of agricultural sector (data on farms, crops grown and animals held/reared) covering (nearly) all agricultural firms in the Netherlands. The Agricultural Census can be considered as a complete enumeration, held annually by the Regulations Office ('Dienst Regelingen') of the Ministry of Economic Affairs, Agriculture and Innovation in collaboration with the agency 'Statistics Netherlands' (CBS).

Data from this census is frequently exploited in the research work of LMM. First of all these data are essential for the purpose of identifying and describing the different target research populations, distinguished as sampling space for LMM. For example the Agricultural Census enables to compare the characteristics of LMM sample farms with the 'average farm' in the sample population. Also for the purpose of stratification (preceding the selection of participants), the strata boundaries (size categories per LMM farm type) are defined annually on the basis of the most recent census data.

Moreover, in case of insufficient farms in FADN for a specific farming type, the selection procedure may draw from the pool of farms in the Agricultural Census.

Regulations Office ('Dienst Regelingen')
The Regulations Office is the implementing agency of the Ministry of Economic Affairs, Agriculture and Innovation (EL&I), responsible for the implementation of Agricultural and nature policy. In this capacity, the Office plays an important role in providing policy information to agricultural firms in the Netherlands, as well as in gathering information from those firms.

In the context of the fertilizer and mineral policies, the Regulations Office issues information on legal standards (application standards, fixed excretion indicators, operational efficiency coefficients, etc.) and prescribes calculation systems (for example for calculating the excretion of indoor-fed cattle using the 'stable balance').

For gathering of information on agricultural firms the Regulations Office utilizes a company registration system (Bedrijfsregistratiesysteem: BRS), in which a unique BRS number is allocated to each farm covered.

The information available from the Regulations Office is important for the LMM research. The information material on policy for instance, presents for LMM an important tool to calculate, in a correct and comprehensive manner, the data for individual farms. In doing so the cooperation with other research projects, such as 'Cows & Opportunities' is maximized.

Additionally, the data registration in FADN utilises amongst others the information from the 'base registration of parcels' (BasisRegistratie Percelen; BRP). This registration system records annually for each firm data on cropped plots (reference date 15th May). For each cropped plot data is available on crop type, area, user code (property, non-recurrent lease, etc.), secondary crop (yes/no; if yes: which crop) and use as pasture (yes/no; if yes: with or without grazing).

Finally, LMM exploits the annual surveys of the Regulations Office to identify the farms, which applied for derogation

Working Group on Uniform Data for Animal Excretion (WUM)
Annually, the WUM calculates and publishes the standards for manure production and mineral excretion per animal category (Van Bruggen, 2007). The WUM comprises representatives from the Ministry of ELI (Regulations office and knowledge Directorate), 'Statistics Netherlands' (CBS), the Environmental Planning Office (Planbureau voor de Leefomgeving), the Animal Sciences Group (ASG-Wageningen UR) and LEI Wageningen UR.

The calculation methodology takes the mineral balance per individual animal as point of departure. The excretion of minerals is determined from the difference between the intake of minerals in forage and the incorporation of minerals in animal products.

In the day-to-day practices of the minerals policy, dairy farms are not allowed to use the WUM-standards for calculating their manure production. The regulations apply deviating standards for different categories of granivores. For indoor-fed cattle, the manure production has to be calculated based on a stable balance.

In the LMM research, the excretion by indoor-fed cattle cannot be determined for all individual farms. In case information is inadequate to apply the method of stable balances, the researcher falls back on the WUM-excretion standards.

Feed suppliers and research laboratories
Most of the analyses on soil and silage performed in the Netherlands is done by organizations like BLGG-agroXpertus. LEI uses the data from such laboratories in two ways. To the extent practical, the laboratories transmit to LEI the results of test on soil and silage on LMM farms in digital format. This procedure facilitates the registration of the results in FADN.

For calculating the farm-specific composition of grass/corn silage, LMM sometimes uses the data published by the laboratories themselves. In case silage is not (fully) analysed, LMM uses average composition data resulting from BLGG analyses.

4 DATA ANALYSIS AND DATA PRESENTATION

4.1 Introduction

In conjunction with the current background report, LMM periodically publishes reports on monitoring results. The objective of these reports is a presentation of the most relevant results of the monitoring activities. In-depth interpretation and explanation of the results is outside the scope of the result reports, except for descriptive registration of differences between years and/or reporting categories, extreme values, etc. Data interpretation and explanation is subject of separate scientific analysis and reporting.

There are two other regular reports exploiting the information collected in LMM:

- Annually, LMM publishes a report on 'Agricultural practices and water quality on farms registered for derogation'. These reports are prepared to meet the EC reporting requirements related to the derogation ruling. These reports provide the European Commission with information – monitoring data and model-based calculations – about the quantities of fertilizer applied to each crop per soil type and about the evolution of the water quality (e.g. Buis et al., 2012)
- Every 4 years LMM contributes to the publication of a report with background information on the 'status and trends of the aquatic environment and agricultural practice'. This report is prepared in support of the Netherlands Member State Report within the framework of the Nitrates Directive. It provides an overview of current agricultural practices and the status of groundwater quality and surface water quality in the Netherlands. It also outlines trends in water quality evolution and assesses the time scale of changes in water quality due to modified farm practices. The report evaluates the implementation and impacts of the measures in the Action Programmes and forecasts the evolution of water quality (e.g. Baumann et al., 2012 and Zwart et al., 2008).

It is noted that the above two types of reports do not aim to provide a full review of all data collected; such a full review falls under the purview of the result reports.

The result reports for the period 2007-2010 data will present information for different years combined, preferably with reference to the most recent year of the previous report, allowing an initial comparison of the results between the different years.

In terms of agricultural practices emphasis will be put on the acreage of agricultural land, classification of farmland, stocking density, milk production, the use of organic manure and artificial fertilizer and mineral surpluses.

The section on water quality focuses on nutrients (nitrogen and phosphorus components). This part will also present topics of special interest.

4.2 Presentation of data

4.2.1 Data on agricultural practices and mineral management

All farms are unique due to differences in farm management (individual choice of a farmer) and differences in physical conditions (farm size, hydrology and soil conditions). This paragraph identifies the indicators for farm dimensions and mineral management. Figure 4.1 shows the different processes and interactions possibly taking place on a farm, illustrating the kind of management choices a farmer has to make. The actual processes on a farm depend on the type of farming (dairy, arable, industrial livestock or other). This section describes the various indicators under two categories: 'characterisation of farms' (farm dimensions) and 'mineral management'. Finally, this paragraph presents the methods of data presentation.

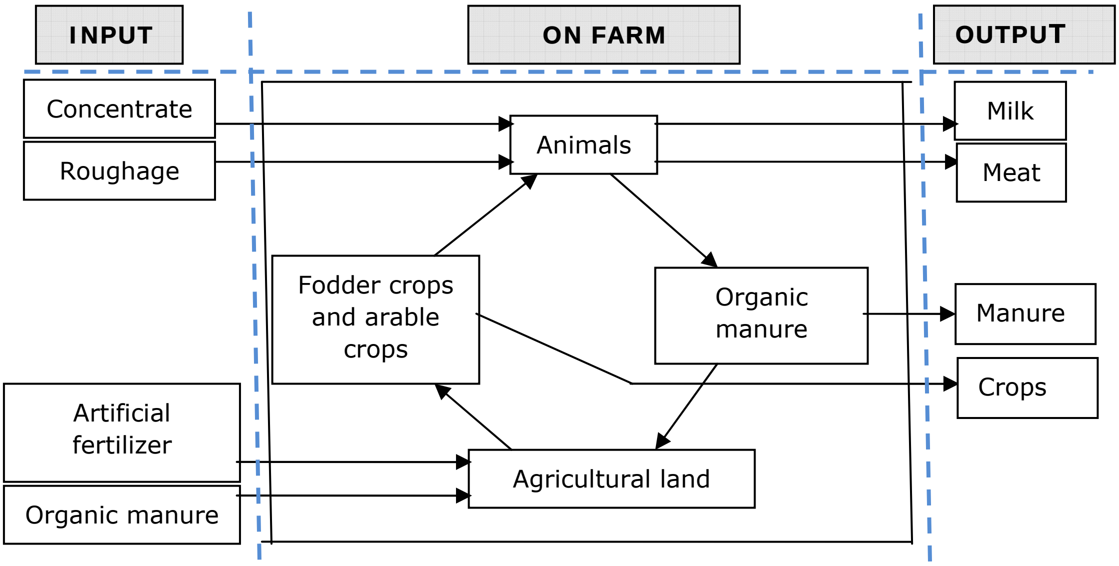

Figure 4.1 Farm processes distinguished

<u>Farm processes as function of type of farm</u>

Dairy farms

1. Animals produce milk, meat and organic manure
2. On-farm produced organic manure is (partly) used on the farm's own agricultural land or removed from the farm
3. In addition to on-farm produced organic manure, artificial fertilizer and/or 'imported' organic manure can be used on the farm's agricultural land
4. The agricultural land produces fodder crops
5. Fodder crops and input of concentrates and roughage are used as fodder for the animals

Arable farms

1. 'Imported' organic manure and artificial fertilizer are used on the farm's own agricultural land
2. The agricultural land produces crops, most of which is removed from the farm for processing or consumption elsewhere.

Industrial livestock farms

1. Animals produce meat and manure
2. On-farm produced organic manure is (partly) used on the farm's own agricultural land or removed from the farm
3. In addition to on-farm produced organic manure, artificial fertilizer can be used on the farm's agricultural land
4. The agricultural land produces fodder crops and/or arable crops, dependent on the farmer's choice whether he wants to produce feed for his own livestock.
5. Self-produced crops and concentrates and roughage from outside are used as feed for the animals

On other farms, combinations of the different processes take place.

<u>Characterisation of farms</u>

LMM uses data on agricultural practices to establish a general characterisation of farms. Farms are characterised based on the following parameters:

- Acreage of agricultural land;
- Stocking density;
- Milk production;
- Classification of farm land.

Acreage of agricultural land

Fertiliser application and nutrient excess are expressed per surface unit. For these parameters, the total area of farmland is applied. This total area is the land used by the farmer for crop production and on which fertiliser is applied. Land leased out, stretches of natural land, ditches, built-up or paved surfaces are not included in the figure for total area.

Stocking density

The stocking density is expressed in phosphate GVEs per hectare of farmland. GVE is the Dutch acronym for Livestock Unit. For each livestock species, a corresponding GVE is defined. The phosphate content in the manure of an average dairy cow has been defined as 1 GVE. LMM distinguishes between industrially reared livestock (mostly pigs, poultry and calves) and grazing animals (primarily dairy cattle, other cows, sheep, goats and horses). This grouping is based on the classification as applied in the 'System of Application Standards' (van Dijk et al., 2006), in use since 2006. To assess the grazing situation at dairy farms LMM distinguishes between milk cows, young cattle and other grazing animals.

Milk production

At dairy farms, milk production is reported both in terms of the production per head of cattle, as per surface unit. To this end, the FPCM or 'Fat and Protein Corrected Milk' parameter is applied. This measure relates to milk production with a correction for fat content and protein content, according to the formula:

$$FPCM = kg\ milk * (0.337 + 0.116 * fat\ content + 0.06 * protein\ content)$$

This correction on the amount of milk enables a better correlation with mineral and fodder consumption.

Classification of farmland

Since the mineral requirements and mineral uptake differ per crop, water quality of percolating water may be a function of the crop produced. On dairy farms, the production of fodder crops is the main objective of land use. In its analysis of crop production on dairy farms, LMM distinguishes between grass, green maize, other fodder crops and crops sold on the market. The category 'other fodder' includes crops such as mangold (mangelwurzel), alfalfa and cereals used as fodder. Crops not produced for fodder are considered to be sold on the market.

On arable farms, the production of crops is the primary production objective. For each farm, the acreage of different crops (such as potatoes, sugar beets, cereals, pulses) is reported, as well as the surface percentage of fallow land and land for fodder crops.

On industrial livestock farms and farms grouped under 'other', the production objective is often a combination of crops. For these farms, both the fodder crops as well as the cash crops are considered.

Mineral management

In LMM, the mineral management on farms is characterised by fertiliser use (consumption) and mineral surplus. On dairy farms, information pertaining to the use of grassland (degree of grazing and mowing) and the storage capacity of organic manure is also taken into account.

Calculation of fertiliser use

On farms, animal manure, artificial fertiliser and other organic fertilisers are the dominant sources of minerals entering the soil. If the application of minerals exceeds the removal through crop harvesting, there is a risk of losses and leaching of minerals into the environment.

Animal manure

To assess the amount of animal manure applied, first the production of manure on the farm itself is calculated. With respect to nitrogen, the net production is considered with deduction of gaseous losses from stables and manure storage and manure spreading. The manure production is calculated by multiplying the average number of animals with the fixed excretion factors, established by the Working Group on Uniform Data for Animal Excretion ('Werkgroep Uniformering Mestcijfers'; van Bruggen, 2007).

Next, the amount of nutrients in all animal manure supplied to or removed from the farm is recorded. In principle, the amount of nitrogen and phosphate in all manure supplied or removed is registered by sampling. In case no sampling was done, fixed values per type of manure are used (Regulations Office, Ministry of LNV 2006). The minerals content in initial and final stocks is always calculated based on fixed values.

The total amount of manure utilised on a farm is calculated as:

Use of manure = production + initial stock – final stock + import - export

Artificial fertiliser and other organic fertiliser

In addition to minerals from manure, most farms also apply nutrients to the soil derived from artificial fertiliser and other organic fertilisers. These substances are not produced at the farm. Therefore, their amounts are calculated as:

Use of artificial and other organic fertiliser = initial stock – final stock + import -export

The amounts of nitrogen (N) and phosphate (P_2O_5) of the substances referred to are derived from the annual reports of the suppliers of the fertilizing substances. The amount of minerals in 'other organic fertiliser' is added to the amounts used in animal manure, to arrive at the total amount of organic fertiliser.

Calculation of surplus minerals

Surpluses (in terms of kg N per ha and kg P_2O_5 per ha) serve as an indicator for the amounts of N and P available for leaching from the root zone. The surpluses are calculated following the procedures described by Schröder et al. (2007, 2004). Apart from the amounts of N and P supplied and removed in organic fertiliser and artificial fertiliser, these procedures also take other terms into account: net nitrogen mineralization of organic material on peat soils, nitrogen fixation by crops (papilonaceae), atmospheric deposition and nitrogen losses by ammonia emission. For calculating the nutrient surpluses on the soil balance, the method assumes an equilibrium situation. The assumption is that in the long run the input of organic N from crop residue and organic fertiliser equals the annual decomposition. Peat and reclaimed peat soils form an exception to this rule. For these two soil types, an additional input from mineralization is postulated: 160 kg N/ha for grassland on peat soils, and 20 kg N/ha for other crops on both peat and reclaimed peat soils. It is known that these soils show a net mineralization due to the control of the groundwater level, necessary to render these soils suitable for agriculture. Schröder et al. (2004, 2007) calculate the nutrient surplus on the soil balance by taking the application of nutrients to the soil as point of departure. The LMM applies a 'balance method' to estimate the surplus on the soil balance using farm operating data.

Animal manure storage rate
'Animal manure storage rate' relates the storage capacity for animal manure to its production. A figure of 100% means that half of the annual production of manure can be stored. When the manure storage rate is above 100%, farmers have the possibility to store manure for a longer period, enabling them to use the manure exactly at those periods (spring and early summer) when crops need it most. The animal manure storage rate capacity is calculated as: (manure storage capacity / (0.5 * annual animal manure production)) * 100%.

Rate of grazing
The indicator 'rate of grazing' provides information on the time cows spend grazing (in the field) during the period May-October. A 100% grazing rate would imply that the cows were feeding in the field for 24 hours a day for the full period. In reality, this value is not attainable, as cows are generally milked twice a day in the stable. A score of more than 80% is high, indicating that, outside milking hours, the cows are permanently in the field. The degree of grazing is calculated as: (number of grazing hours of dairy cows in the period May-October / (184 days * 24 hours / day)) * 100%.

Rate of mowing
The 'mowing rate' indicates how often the grassland is mowed over a year. A mowing rate of 300% means that the grass is mowed three times per year on average. The mowing rate calculates as: (area of grassland mowed annually / pasture area) * 100%.

The combination of the indicators 'rate of grazing' and 'rate of moving' provides information on the overall use of grassland.

<u>Methods of presentation in result reports</u>
The result reports present all parameters collected and calculated in the form of tables, in terms of averages and number of observations. For a limited number of parameters (notably for the use of nutrients) a graphical presentation of the results is shown with the 10% level, the average and the 90% level. Figure 4.2 shows an example. These figures help to compare different soil types within a farming type and indicate whether the distribution is normal.

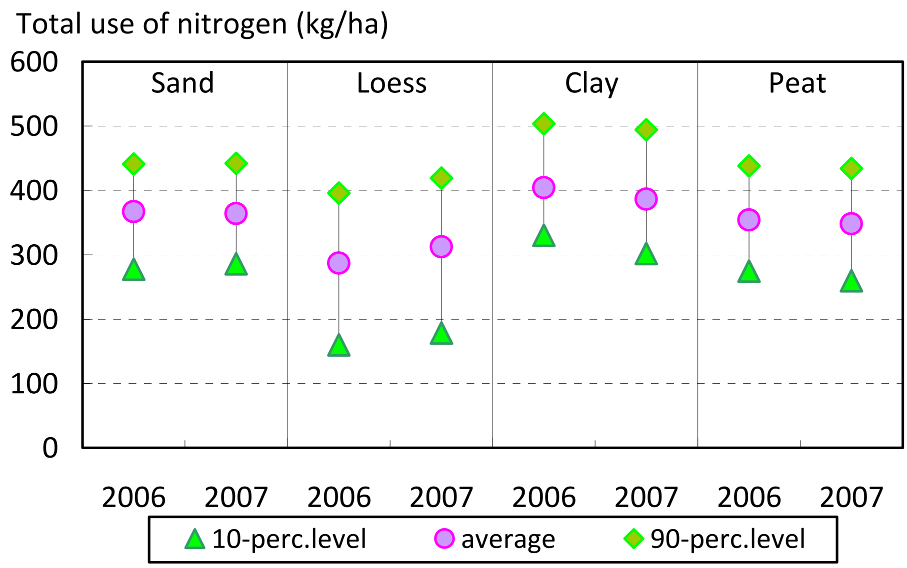

Figure 4.2 Total nitrogen use via manure per soil type at dairy farms. Example of graphics used in result reports

4.2.2 *Data on water quality*

For reporting on water quality, data can be organised as a function of different characteristics.

- sub-programme;
- medium sampled;
- year of sampling
- time (season) of sampling;
- type of farming;
- region;

It is impossible or at least confusing to incorporate all information related to the above characteristics into one graph or table. In the result reports, the emphasis will be on farms in the EM-sub-programme, including those farms qualifying for evaluation in the EM-sub-programme (many of the randomly selected DM participants).

Within this main division, a distinction is made whenever relevant between the quality of water leaching from the root zone (groundwater, soil moisture and water from tile drains) and surface water (ditches and surface drains).

For the farms qualifying for the EM sub-programme all parameters measured will be presented in tables on the LMM web site. These tables show, per region and type of farming, the principal statistical characteristics: number of observations, average, standard deviation, cumulative distribution and percentage of farms exceeding target value or standard. For a limited number of parameters (notably the nutrients) a graphical presentation is shown of the most relevant results. This is done using box-plots or other graphical representations. These plots show a number of consecutive years in one graph, and for different farming types in one region. Figure 4.3 shows an example of such a box-plot, presenting the NO_3 characteristics for different types of farming, measured in the sand region during the years 2006, 2007 and 2008.

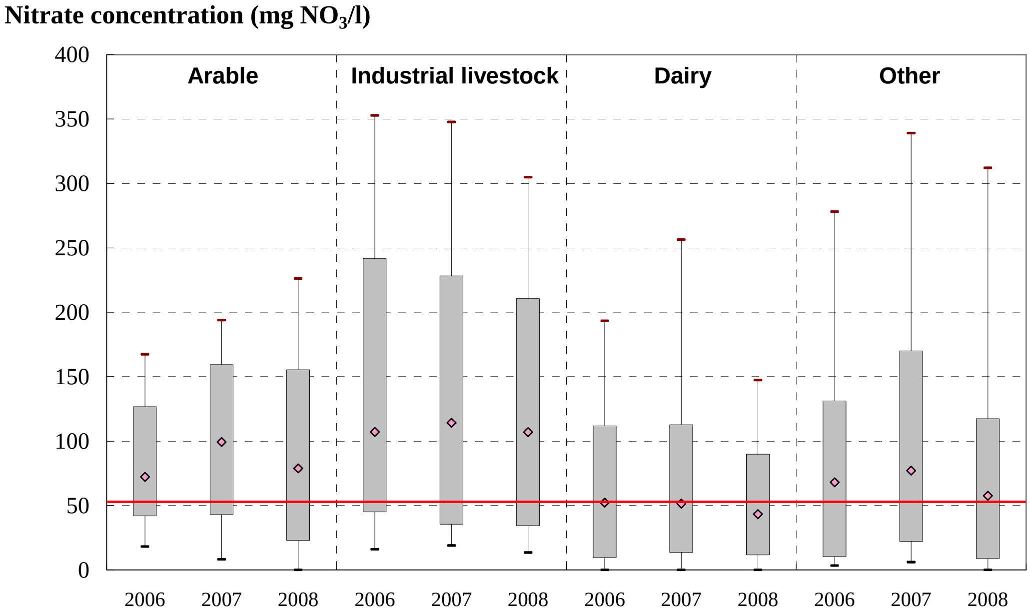

Figure 4.3 Example of box-plot showing statistical features for the farm-averaged nitrate concentrations measured in the water leaching from the root zone in the sand region, for arable farms, industrial livestock farms, dairy farms and other farms (maximum, 90% level, median, 10% level and minimum).

For the other sub-programmes the result reports are les elaborate, focusing on nutrients only. Limited attention is paid to the DM sub-programme, since the sub-programme is the subject of an annual assessment report, submitted to the EC (Buis et al. 2012, Zwart et al., 2009, 2010 and 2011, and Fraters et al. 2008).

4.2.3 Differences in reporting compared to previous years

The result reports of the 2007-2010 period have a slightly different set-up in comparison with the annual report for the years 2003-2006:

- Water quality information is reported for all farms for which information is available, and not only for those for which also data on agricultural practices is available.
- The reports present information for the loess region separately; this information is no longer merged with the sand region.
- The previous annual report focused on the quality of water leaving the root zone for the EM sub-programme (including DM farms qualifying for the EM). In the new result reports a separate section will be devoted to the DM-RM sub-programmes, while more attention will be paid to water quality in ditches and surface drains.
- Information on water quality will be graphically presented, allowing the information for different years to be combined in one graph.
- The new result reports will no longer present all water quality data collected. They will focus on main findings. Data on the characteristics of all parameters will be made available on the RIVM web-site.

4.3 Evaluation of data on agricultural practices

The LMM result reports present and discuss the agricultural practices at participating farms, using unweighted (non-weighed) data. A separate paragraph subsequently compares the non-weighed data on the use of minerals and mineral surpluses with national average values. This section describes how national averages are established.

In depicting the impacts on agricultural practice, LMM focuses on the long-term developments in mineral use and mineral surpluses at LMM's farm categories.

The results in the form of line graphs, for dairy farms (in all regions) and arable farms in the clay, sand and loess region, are published on LEI's LMM website. The starting year for these graphs is 1991/1992, except for the loess region where lines start in 2006. The graphs are updated annually. The results for the farm categories 'other' and 'industrial livestock' are not yet published.

For the evaluation of the agricultural practices, the data on mineral use of individual farms in the sample are adjusted (processed) by allocating weights, on the basis of the weighed average value of the average farm in the research population (box below).

> To avoid confusion about the terminology used, it is noted that all agricultural farms covered by the annual Agricultural Census represents the full population of agricultural firms in the Nederlands. LMM covers a sub-set of this full population, called the LMM 'research population'.
>
> A sub-set of the LMM research population is included in FADN. These 'LMM research farms in FADN' are called the 'research sample' (the FADN sample covers about 1,500 farms, while the LMM-research sample consists of about 500 farms). It is noted that only part of this 'research sample' is monitored on water quality.
>
> Data on agricultural practice, like mineral use, are available for the research farms (because of their participation in FADN). For the remainder of farms in the LMM 'research population' no data on agricultural practice is available; only general corporate characteristics from the Annual Census.

The reason for applying a weighing process is the LMM sample design. As in FADN, LMM uses a stratified, disproportional sample for selecting farms. 'Disproportional' implies in this case that even for the same type of farming, there are differences in probability of inclusion (see Annex 2 paragraph A2.2). This sample design necessitates the application of a weighing procedure when considering individual farms.

The weighing process assures maximum use of the data available. For the sake of reliability, the process not only uses corporate data of farms that are monitored on water quality; all FADN-farms, which have belonged to the LMM research population since 1991, are taken into consideration. This group of LMM research farms is considerably larger and less susceptible to change than the sample of LMM farms at which water quality is monitored.

The trends investigated in LMM pertain to sub-samples of specific farm types in specific regions and sub-regions. It is obvious that with higher levels of zooming-in (lower aggregation levels) the number of sample farms will be less. In order to draw reliable conclusions, in spite of the limited number of sample farms, LEI uses a technique to generate additional information.

To generate additional information and to weigh available corporate data, the 'research sample' data are projected on the available data within the research population. For this purpose LEI has developed the software tool STARS (Statistics for Regional Studies, see appendix 1 in Vrolijk *et al.*, 2005). Input for this tool is a file comprising available FADN-data (results of agricultural practices and characteristics of individual farms) and corresponding characteristics of the farms in the 'research population' (available from the Agricultural Census). The corresponding farm characteristics (known as imputation variables) constitute the basis for comparing and matching farms in the 'research sample' and farms in the 'research population'

It is assumed that farms showing resemblance in farm characteristics will also show similarity in the variables to be generated.

Statistical matching uses farm characteristics, known for both the 'research sample' farms as well as for the farms in the 'research population', to identify for each farm in the 'research population' a number (three to five) of 'most resembling' farms. For this purpose, one can distinguish characteristics, which should be fully identical, and characteristics that should resemble as closely as possible the corresponding characteristics of the farm in the research population. The characteristics used for best possible resemblance are differentiated in terms of their relative importance by allotting different weights.

After identifying the group of best resembling sample farms for one farm in the research population, the weight in question (each farm in the research population has a total weight of 1), is allocated to the group of most resembling sample farms, in proportion to the degree of resemblance. The sample farm with the best resemblance receives the highest weight. (It is unlikely that each of the sample farms with the best resemblance resembles equally well the research population farm).

All weights allocated to a sample farm are added-up, in order to calculate the ultimate weighting factors. The weighting factors obtained in this way (the sum of which should equal the number of farms in the research population) are subsequently used for weighing the sample results.

The core assumption in statistical matching is that farms showing resemblance in the imputation variables will also be comparable with respect to the target variables.

4.4 Evaluation of water quality data

The result reports present a first assessment of the water quality data obtained, in terms of mean, highest and lowest concentrations for the different media monitored, regions and types of farming, also pinpointing difference or fluctuations between the years of reporting as well as between seasons. The reports do not provide a scientific assessment of causes of the results obtained.

The reports briefly address the differences in results, if any, between EM, DM and RM.

Aside from a mere presentation of parameters measured during a specific year, also the long-term trends for principal nutrients are reported. Long-term trends are presented as:

- Annual average data as measured, calculated as the average of the annual farm averages, and
- data, corrected for variations in net precipitation, sample size and sample compositions. This method is currently available for the sand and clay region.

Correction of measured data
To discern the effect of government policies on the groundwater quality (notably nitrate concentrations) from the possible impacts from the weather and the sampling distribution, a statistical model has been utilised (Boumans et al., 2001). The method takes into account variables that may affect the nitrate concentrations measured. The variables considered are precipitation surplus (or groundwater recharge), soil type,

drainage class (three classes have been distinguished based on different classes of groundwater regime [grondwatertrappen]) and farming characteristics (farm type). In addition, the model takes into account the size of each farm type in a region.

This statistical model allows for the 'correction' of measured data for environmental conditions, thereby filtering temporary fluctuations from the long-term trend (see Annex 10).

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ANNEX 1 Background of the LMM

Context
In the second half of last century, it became clear that the intensification of production by the agricultural sector had negative impacts on the environment. Government introduced policies to reduce these impacts. In parallel, the government needed instruments to monitor the effects of its policies. The LMM is one of the government's instruments that performs this monitoring.

The content and programming of LMM has evolved over the course of time. This evolution reflects the changes in agricultural policy and changing monitoring needs to meet the requirements set by national and EU regulations. In addition, modifications were implemented for further refinement and optimisation of activities, and to fill gaps in knowledge.

Methodical concept (Fraters et al., 2012)
The earliest methodical monitoring of groundwater quality on farms was done during the second half of the eighties. Initially monitoring focused on water leaching from the root zone. Water leaching from the root zone (the upper one meter of the groundwater, tile drain water and soil moisture) is the most suitable medium for a quick detection of impacts from mineral policy measures. On a national scale, there was limited experience with techniques for sampling water leaching from the root zone. Up to then, such sampling techniques were primarily applied for research purposes. These techniques had to be made fit for application in a national monitoring network.

For optimum detection of any possible effects, the most appropriate technique had to be identified and developed further for each soil type. The Netherlands has four main soil types: sand, clay, peat and loess. From a practical and financial point of view, it was not feasible to design and implement four different soil-specific monitoring networks at the same time.

It was decided to develop subsequent monitoring programmes for each major soil type (see Figure A1.1). The Netherlands was subdivided into four soil regions (called regions). The first stage in each of these regions consisted of a scouting programme. A scouting programme can be considered as a preliminary investigation to obtain a general idea of the water quality in the region and for testing and developing appropriate sampling methods. The farms used in the scouting programmes were selected from farms already participating in programmes of other research institutes.

A scanning programme (second stage) followed the scouting phase in each region. The objective of the scannng programme was to record and define the starting situation (point of departure), both in terms of agricultural practice as well as water quality. Farms taking part in the scanning programmes were selected from FADN. The same farms were sampled during a number of successive years. The scanning programmes also served to investigate ways and methods for the most effective and efficient set-up of monitoring programmes (third stage).

After completing a scanning programme in a region, LMM set-up a monitoring programme (network). In the first period of the monitoring network (phase1) LMM used a 'revolving' network. In this approach the programme actively replaced participating farms after a period of six to seven years. Sampling was done every three years, except for the clay region; here sampling was done annually. In 2006/2007 (phase 2) LMM converted to a stationary network, with annual sampling at all farm. There were some deviations from the developments of the monitoring set-up as described. Deviations resulted from policy decisions and decisions related to specific conditions in a region.

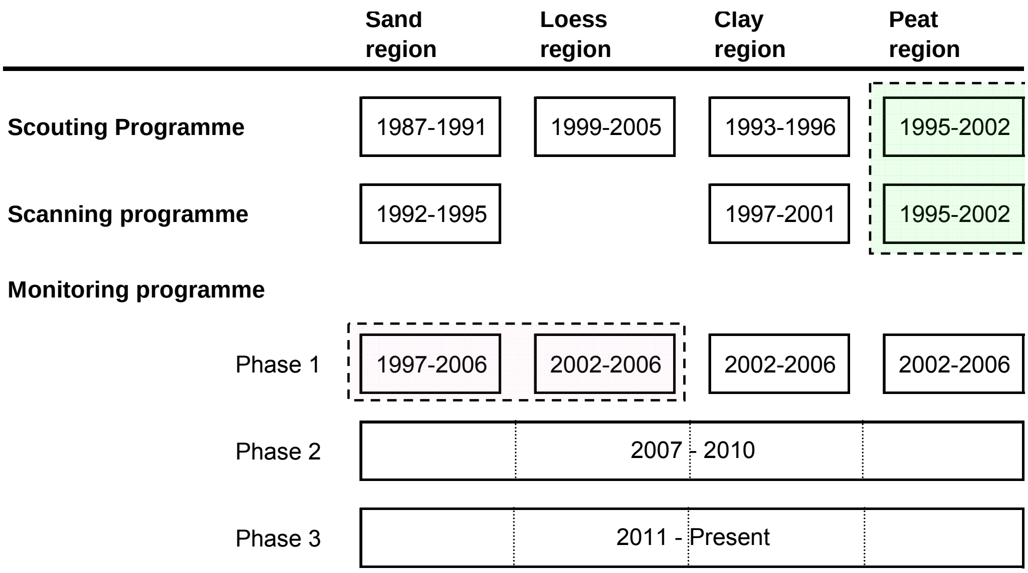


Figure A1.1. Simplified overview of the development of the LMM (scanning programmes and monitoring programmes), including preliminary investigations (scouting programme), in the period 1987–present.

- A combined scouting programme – scanning programme was conducted in the peat region in the period 1995-2002.
- The monitoring programme in the loess region in the period 2002-2006 was accommodated in a combined sand region-loess region; partly, it was synchronously implemented with a scouting programme. It is only since 2007 that LMM comprises a complete and stand-alone monitoring programme in the loess region.

Prior to 2006, a 'revolving' monitoring network was the basis of programme design. Participating farms were subdivided into three groups. While one third of the farms (group 1) would be sampled for the first time, one third of farms (group 2) would be sampled for the second time, and group 3 would be sampled for the third and last time during their seven years of participation. This revolving character of the sample (replacement of farms) corresponded to the identical set-up of the FADN participants.

<u>Historical development</u>
The LMM began in 1992 in the sand region with measuring the situation and the trend in water quality and agricultural practices. The start of the programme was consequential upon the evaluation of the first phase of the minerals policy. This evaluation concluded that there was a need for a dedicated monitoring effort of the quality of soil, groundwater and small-scale surface water. Such monitoring would enable assessing the effectiveness of policy measures (LNV, 1991). The initial scanning programme comprised about 100 farms, belonging to four groups of dairy farms and one group of arable farms in the northern part of the Netherlands (Van Swinderen, 1994).

In 1996 the decision was taken to develop LMM further in the sand regions and to extend the programme to the clay region and peat region. In 1997 LMM started a full-scale monitoring programme in the sand region. In the same year a scaning programme was set up for the clay region, in three soil types districts (sub-regions): three in the marine clay districts and one river clay district. As a follow-up to the measurements done in 1995 at farms participating in the National Monitoring Network

Soil Quality (LMB), it was decided to implement a combined scouting programme – scanning programme in the peat region.

In 1999, LMM initiated a research programme into the best methods of measuring leaching in the loess region. This was done at a farm participating in the 'Cows & Opportunities' project.

From 2002 onwards the LMM developed rapidly (Figure A1.3). This rapid development is partly due to increasing pressure from the European Committee on the Netherland's government to modify its legislation, to comply with the regulations of the Nitrate Directive. In 2003 the European Court of Justice sentenced the Netherlands for non-compliance with the Nitrate Directive obligations. This judgement induced amendments in Dutch mineral policies, and led in 2004 to changes in the LMM (Fraters en Boumans, 2005). Furthermore, in 2000 the so-called Spiertz Committee conducted a study into the prioritisation of research and monitoring of phosphate and nitrogen (Velthof, 2000).

The Spiertz Committee recommendations inspired a number of internal LMM studies into possibilities for improving the programme's set-up, including additional measurement. Above developments and studies resulted in increased attention within LMM for monitoring the impacts on surface water on farms. For the Nitrate Directive not only addresses prevention of high nitrate concentrations in groundwater, but also the prevention and suppression of eutrophication of surface water. Besides, in wet (low-lying) areas, policy impacts might be more easily measured in surface water than in groundwater.

Since 2002, there has been a monitoring programme for each region (Figure A1.2). For the loess region this was a combined programme with the sand region. Only in 2007, after reorganising LMM in relation to the establishment of a derogation-monitoring network, the loess region was also allocated its own fully fledged monitoring network.

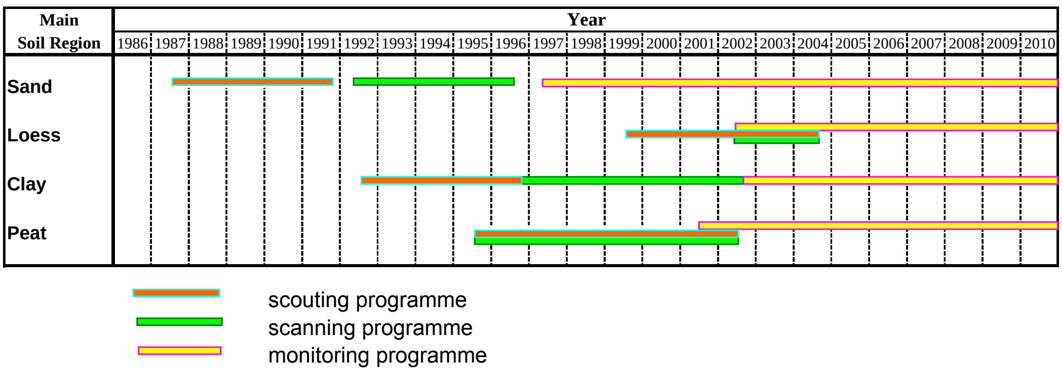


Figure A1.2 Chronology of developing monitoring programmes per region

In the sand region, the existing progamme was continued in 2002. At about 80 farms the programme sampled during the summer period, as in the previous years, the top one meter of the groundwater. During the winter of 2004/2005 an extra programme was initiated to measure the impacts on surface water in the wet parts of the sand region. Up to the winter of 2006/2007, this sub-programme included 30 farms, where groundwater, tile drain water and ditch water were sampled during the winter period. These 30 farms were selected from the pool of farms already participating in the existing programme for the sand region.

In the winter of 2002/2003 LMM started a new programme in the clay region, also including farms not drained by tile drainage. At those farms, LMM sampled the groundwater instead of tile drain water. Moreover, the sampling of drain water was expanded with a method for sampling drains discharging below the ditch water level. Since then, LMM also sampled ditch water, in addition to groundwater and drain water.

From the winter of 2002/2003 onwards, also a revolving monitoring programme was started in the peat region, comprising 12 farms. However, starting in the winter of 2004/2005, this number was increased to 24 (Fraters en Boumans, 2004).

In 2006-2007 LMM underwent important modifications and a major expansion (Figure A1.3). These changes were linked to putting into effect the new nitrate action programme and to the obligations arising from the EC's derogation decision.

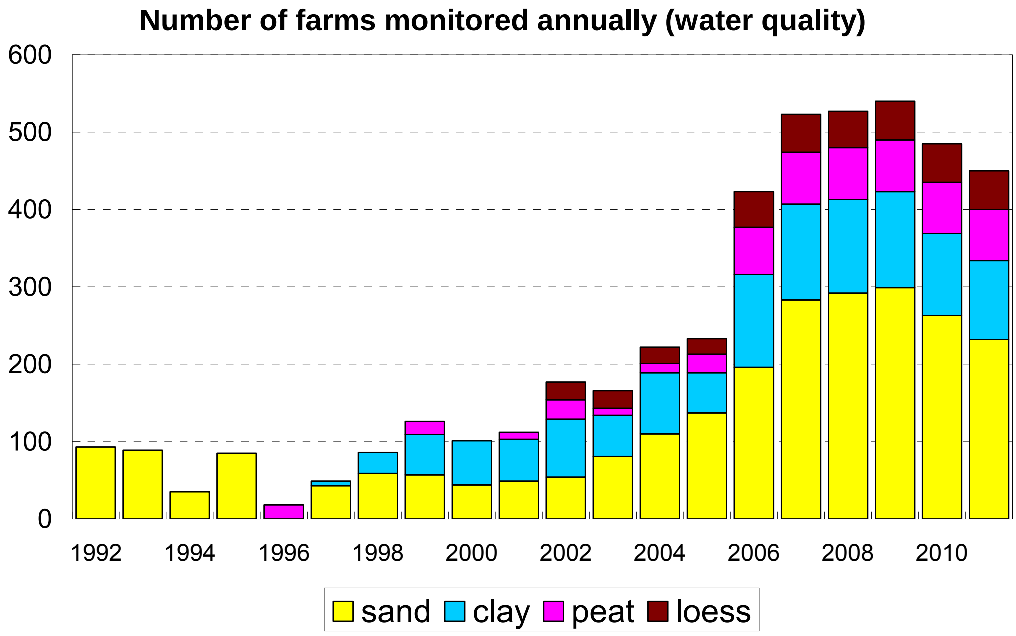


Figure A1.3 Evolution of the number of farms per region monitored in LMM

As from 2007, LMM consists of two separate, but fully integrated monitoring networks: the regular trend-monitoring network and the derogation-monitoring network. 2006 is a year of transition; water quality is already monitored on derogation farms, without information on agricultural practice being available for the year 2005. To meet the requirement of 300 derogation farms, farms in the trend-monitoring network that enjoy derogation are also counted in the derogation monitoring network. In the period 2007-2010 there was an extra objective; that is collecting adequate monitoring data for supporting and underpinning a new derogation (period 2010-2013). For this purpose, LMM enlisted 60 dairy farms with relatively limited manure production, but which qualified for derogation.

The trend-monitoring network was strengthened by making the loess region a separate region, instead of treating the region in the combined sand-loess region. Also the group of arable farms in the sand region was enlarged. In this way arable farms could be distinguished as a separate category, no longer comprised in the category 'other'. From that time onwards, this last group 'other' consisted of industrial livestock farms and other livestock farms. Both modifications were inspired by lagging behind of improvements in water quality, both at farms in the loess region, as well as at arable farms in the sand region.

Another important change in LMM in 2007 was the permanent conversion of a revolving monitoring network into a network with fixed participants. Since 2007, participating farms were only replaced if they stopped participation in FADN themselves, or if they no longer met selection criteria.

Major modifications in programme set-up

The major modifications in the set-up of the LMM as implemented since 2004 comprise:

- Switch from a ’revolving’ network towards a ‘stationary’ network (since 2006).
- Prior to 2006 water quality on farms was sampled with a frequency of once per two or three years. Since 2006, sampling has taken place annually.
- The formation of a separate derogation monitoring network, covering at least 300 grassland farms.
- The number of farms with an above average share of soils prone to leaching (in the sand region and loess region), was increased to enable the assessment of policy impacts on these types of soils.
- Start-up of additional monitoring during the winter period, in the wet parts of the sand region. It was assumed that the effects on water quality differ between wet parts and dry, higher parts of the sand region.
- In general, LMM paid more attention to the monitoring of surface water quality (ditches and surface drains) in the lower parts of the Netherlands (in the clay region, the peat region and the wet parts of the sand region). This increased interest enables assessing the degree of loss of nutrients from agricultural land into the wider environment (‘afwenteling’).In addition to the regular winter monitoring, LMM also started monitoring of surface water during the summer months. The modifications were prompted by:
  - The recommendation of the Spiertz Committee;
  - In its derogation decision of 2005 the EC demands reporting on the evolution of the water quality of surface water and groundwater. The derogation decision prescribes: “*the upper part of the groundwater, soil moisture, drain water and/or ditchwater on derogation farms shall be sampled in order to assess the leaching from the root zone to the groundwater and surface water*”.

Overview of LMM programme changes in relation to policy developments

Table A1.1 provides a summary of the changes in LMM related to policy developments

Table A1.1 Chronological outline of evolution and changes in the LMM linked to policy decisions and regulatory changes (Fraters et al. 2012)

Year	Changes	Policy impetus	Substantiation	Remarks
1986	Sand region: scouting programme at 10 NMI dairy farms and some arable farms	Preliminary results of evaluation of first phase Mineral Policy	Preliminary investigation of measuring methods, temporal & spatial variability	Use of temporary boreholes within plots, instead of permanent wells next to a plot
1992	Sand region: start of 3-year scanning programme on FADN farms; 20 arable farms (only in the North) and 80 dairy farms	Evaluation of first phase Mineral Policy	Study into set-up monitoring programme	Sampling of upper groundwater, once per summer, with 48 boreholes per farm
1993	Clay region: scouting programme at 20 farms within existing research programmes	Evaluation of first phase Mineral Policy	Preliminary investigation of measuring methods, temporal & spatial variability	Sampling of drain water at 2 locations/farm during winter, with continuous monitoring of discharge
1994	Sand region: scale down of scanning programme to 40 farms, with 2 x sampling during summer instead of 1 x		Study of measuring strategy; no difference with preceding years	Discussion about appropriate moment for sampling during summer season
1995	Sand region: 1 year extension of scanning programme on 100 farms		50% reduction of nitrate content in 1994, without change in fertilizer use	16 boreholes per firm instead of 48
1995	Peat region: combined scouting and scanning programme at 20 LMB farms, also participating in FADN	Evaluation of first phase Mineral Policy	Preliminary investigation of measuring methods, temporal & spatial variability	Sampling of groundwater (16 boreholes) and ditch water (8 ditches) during winter
1996	Clay region: start of scanning programme, targeting 60 farms	Evaluation of first phase Mineral Policy	Study into set-up monitoring programme	Aim to realize a national monitoring network
1997	Sand region: start of monitoring programme, conversion to revolving network	Evaluation of first phase Mineral Policy, Nitrate Directive	FADN is a revolving network	Desire to link water quality with agricultural practices
1997	Sand region: adjust sample of arable farms and dairy farms, and complement with industrial livestock farms and crop-livestock combination farms	Nitrate Directive	Better coverage of sand region; sample more representative	Increased number of types of farming costly due to increased heterogeneity
1998 + 2001	Peat region: repeated sampling within program initiated in 1995	Evaluation of first phase Mineral Policy, Nitrate Directive	Scouting programme sufficiently advanced	Aim to realize a national monitoring network
1999	Loess region: scouting programme at 1 dairy farm (participating in Cows & Opportunities)	Evaluation of first phase Mineral Policy	Preliminary investigation of measuring methods, temporal & spatial variability	Sampling of soil
2002	Clay region: continuation of programme, switching to revolving network	Evaluation of first phase Mineral Policy, Nitrate Directive	FADN is a revolving network	Desire to enable a direct link between water quality and agricultural practices
2002	Clay region: additional sampling of groundwater and ditch water; improved sampling of drain water	Nitrate Directive, eutrophication	More representative picture of impacts from mineral policy	Especially in the River Clay District better coverage by sampling of groundwater
2002	Peat region: continuation of programme; initially 12 farms; switching to revolving network	Evaluation of first phase Mineral Policy, Nitrate Directive	FADN is a revolving network	Desire link water quality with agricultural practices
2002	Loess region: continued monitoring, as part of combined sand-loess region	Evaluation of first phase Mineral Policy, Nitrate Directive	Scouting programme sufficiently advanced	Aim realizing a national monitoring network, in combination with sand region

Table A1.1 (continued)

Year	Changes	Policy impetus	Substantiation	Remarks
2004	Sand region: extension with 54 dairy and other livestock farms	Perspective of derogation	Coverage of soils prone to leaching	Aim to attain 300 (potential derogation) farms within a period of 4 years
2004	Sand region; extension with specific monitoring in wet parts	Nitrate Directive, eutrophication	More representative picture of impacts from mineral policies	
2004	Peat region: extension of monitoring from 12 to 24 farms	Perspective of derogation	More representative picture of impacts from mineral policies	Striving for more reliable information on peat region. Aim to attain 300 derogation farms within a 4 year period
2004	Peat region: specific monitoring of surface drains on selected farms (10)	Nitrate Directive, eutrophication	More representative picture of impacts from mineral policies	Research showed a clear influence of surface-drain water on ditch water quality
2006	General: start of derogation monitoring network, within LMM	Derogation		Integrated execution of LMM monitoring networks
2006	General: change from revolving to stationary network; no active replacement of farms	Derogation	FADN transformed from revolving network to stationary network	Replacement of participants only in case of termination by participant, or non-compliance with selection criteria
2007	General: sampling frequency of drain water and ditch water increased to 4 times / season	Derogation	Target frequency	Frequency informally required by EC was 12 times / year
2007	Sand region: extension of group of arable farms (40)	Heightened interest in arable farms	Current number of 12 inadequate to make reliable assessment	
2007	Loess region: set-up of stand-alone monitoring network	Heightened interest in loess region	Current number of 6 inadequate to make reliable assessment	In period 2002-2005 water quality info based on scouting programme. Farms not yet included in FADN
2008	General: start of sampling of ditch water during summer season (4 times)	Nitrate Directive, eutrophication, derogation	Eutrophication is a summer phenomenon, while sampling so far was done during winter	Frequency informally required by EC was 12 times / year
2010	Sand and clay region: discontinuation of sampling at 60 additional derogation farms (Reference Monitoring network)	Derogation 2010-2013 has been secured	For underpinning the derogation 2014-2017 adequate data is expected to be available	
2011	General: discontinuation of Exploratory programmes such as K&K and TmT	Cutback in expenditure		Part of K&K farms will continue in derogation network, but will be sampled at lower intensity
2011	General: discontinuation of monitoring at non-LMM groups	Cutback in expenditure		Info lost on water quality at 20% of areas not-covered
2011	General: sampling frequency of drain water and ditch water reduced to 3 times per season at arable farms in winter, and at all farm types in summer	Cutback in expenditure	Sampling frequency corresponds to frequency realised before 2006 (for winter sampling)	Arable farms excluded from derogation. Summer sampling less important than winter sampling
2011	Peat region: sampling of surface drains at all farms in the regular trend monitoring network	Nitrate Directive, eutrophication	Exploratory survey completed. Inclusion in trend monitoring network	
2011	Loess area recognised as a separate region		Sufficient participants recruited	

ANNEX 2 The Farm Accountancy Data Network (FADN) and LMM farm selection

A2.1 The composition of FADN

In FADN, LEI gathers detailed financial, economic and environmental data on about 1,500 agricultural and horticultural firms. FADN represents about 95% of the total agricultural production in the Netherlands. K.J. Poppe describes in detail background information and history of FADN (Poppe, 2004).

The primary aim of FADN is to determine farm incomes and business analyses of agricultural holdings (farms); to this end farm data are collected. FADN is an important data source for the evaluation of the income of farms and the impacts of the EU Common Agricultural Policy (Vrolijk at al., 2010). The FADN sample and sample stratification are primarily optimised towards this goal.

The firms in the FADN have been selected from the Agricultural Census, a comprehensive annual census of all agriculture and horticulture firms in the Netherlands. Selection of farms is done by using stratified random sampling. The selected farms in the FADN constitute a representative sample of nearly all commercially operated farms in the Netherlands.

This section provides a description of the delineation of the FADN sample and the stratification criteria in the FADN and as used in LMM.

The subdivision in strata is done on the basis of two parameters: type of farming activity and economic size (EGE[1]) of a farm. To identify 'type of farming', the so-called 'NEG-system' is applied. For a clarification on all 41 types of farming considered, reference is made to Annex 3.

In 2006 the research population of the FADN was delimited by a farm size of 16 EGE at the lower end and 1,200 EGEs at the top end (Figure A2.1 and A2.2). An upper and lower farm size has been applied to limit the monitoring effort in relation to the benefits of additional information. In 2006, the total number of farms in the annual census amounted to 79,435. The FADN research population (meeting the size criteria) consisted of 60,353 farms. This number accounted for 87.2% of the total agricultural production capacity (Vrolijk et al., 2009). Most of the farms not qualifying for the research population did not meet the lower boundary size requirement.

Recruitment of farms for participation in FADN takes place annually, according to a sampling plan, which is also renewed every year. In 2006 (which is the year a large part of the LMM farms were selected), the sampling plan distinguished 29 types of farming and 3 EGE size classes, resulting in 87 strata.

[1] EGE, which stand for 'Europese Grootte Eenheden' or 'European Size Units' is a measure for the economical size of agricultural activities. To calculate EGE, all cropped surfaces and numbers of animals per species are converted into so-called 'brutostandaardsaldi (bss)' or 'gross standardardised yield'. Subsequently, the total bss at farm level is converted into EGEs applying fixed factors. For a considerable period of time the FADN-population included farms between 16 and 800 NGE ('Nederlandse Grootte-Eenheden' or Netherlands Size Units). In 2002 the concept of EGE was introduced, and the FADN population was extended to include firms between 16 to 1200 EGE (at that time corresponding to 13.8 to 1036 NGE). Because of the tendency of upscaling in greenhouse farming, the FADN upper limit has been raised further to 2,000 EGE. The defining parameters like bss, NGE and EGE are redefined every 2 years, partly to adjust for price level changes (LEI, 2009a).

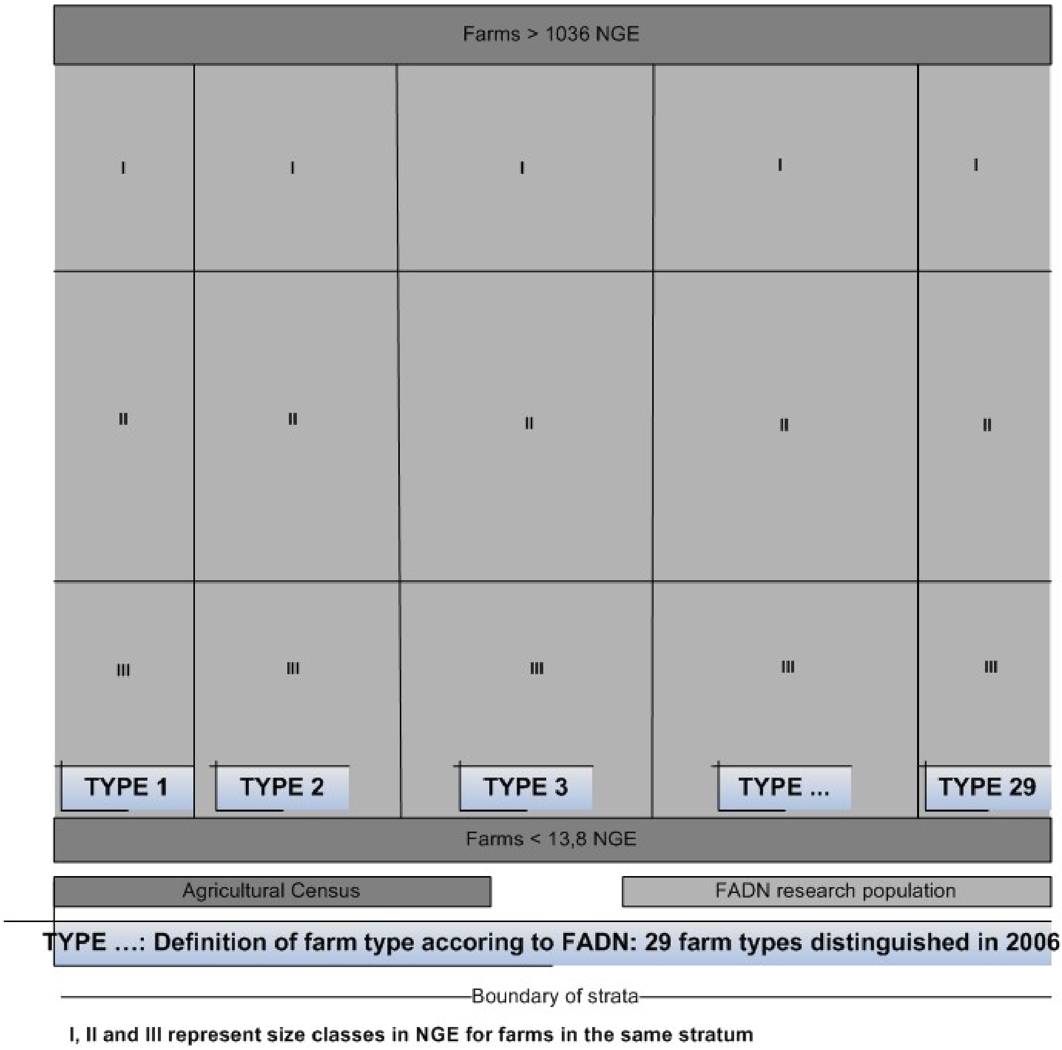


Figure A2.1 Research population and stratification within FADN

To determine the required number of farms per stratum, the data variability between firms is considered. The number of firms of different types of farming increases with larger variability. This procedure enhances cost effectiveness; moreover, it reduces the risk of distortion by outliers. The latter implies that FADN uses a disproportionally stratified sample, with different chances of inclusion, among the types of farming activity. The higher heterogeneity within larger farms is reflected by the higher chance of being included in the sample.

From 2000 onwards, the FADN policy aims at minimum rotation of participating firms. This implies that firms will only be replaced if they did no longer meet the requirements of the relevant stratum as specified in the annual sampling plan. Replacement also becomes necessary when a firm stops its participation, either because a firm ceases operation or because the owner now longer wishes to participate. Prior to 2000, farms were replaced after (on average) 7 years of participation in FADN.

A2.2 Selection criteria of farms in LMM

Farms participating in LMM are selected on the basis of the monitoring or research objectives. The monitoring or research objectives determine the need for data collection and thus the required composition of the group of farms examined. The LMM focuses on the most common types of land use and fertiliser practices practiced in the Netherlands.

The goals of LMM differ from those of FADN. Therefore, LMM uses its own delineation of the research population and stratification criteria.

In addition to the stratification criteria of 'type of farming' and 'economic size', farms participating in LMM have been grouped and selected on the additional criterion of 'region'. Although two of the stratification variables (farming type and economic size) are identical in FADN and LMM, the definition of the criteria within a variable differs. For the DM, RM and UM sub-programmes, additional selection criteria are applied.

In principle, LMM farms constitute a randomly selected sub-sample from the FADN. The actual selection of farms in LMM, however, deviates from this principle. There are five main considerations explaining this deviation:

- The LMM had grown to an extensive programme with multiple sub-programmes, each with specific goals and selection criteria.
- For farm categories (cross-sections of farming type and region), more farms were needed in the LMM sub-sample than were available in the FADN sample. In those cases, additional farms had to be added to the FADN to achieve the required number of farms.
- To reduce costs, overlap between sub-programmes has been maximized;
- To reduce costs, the number of additional farms had to be minimized in favour of existing FADN farms.
- During the period of participation, farms within the sample may change in farm size and even farm type. For instance, farms that are selected for the programme as dairy farms might turn out to be part of the category 'other farm' in the year of sampling.

Therefore, selection of farms for the LMM programme is not a matter of filling in the ideal research sample, but finding the best solutions within the constraints of farms available in the FADN sample and the available LMM budget.

Selecting LMM farms from the FADN is a policy decision made at the start of the LMM project. The main advantage of selecting farms from the FADN is the reduced cost of monitoring agricultural practice. Moreover, by recruiting the LMM participants from the FADN sample, the evolution in water quality and environmental pressure on farms can be linked to the economic performance of the farms investigated.

Delineation of the LMM research sample
To derive the LMM research sample from the FADN, additional criteria are used. Unlike in FADN, some farming types are excluded from the LMM research population, while deviating economic size criteria and additional spatial size requirements (>10 ha.) are applied in LMM. This makes the LMM research sample (at least with respect to the EM sub-programme) a sub-sample of the FADN research sample. The following differences are noted between the FADN and LMM research samples:

1. The LMM research population does not represent all types of farming, but only the most important farming types in terms of area covered in a (soil)region.
2. The LMM research population only represents the farms larger than 10 ha. Farms smaller than 10 ha. are excluded.
3. The economic size boundaries of the LMM research population differ from those of the FADN. LMM excludes the largest farms (>800 NGE) and the smallest farms (<16 NGE). Initially, when the LMM sample was defined, the upper and lower size boundaries for LMM coincided with the FADN limits. In recent years the FADN upper limit has been increased to 1,200 NGE. Within LMM this increase has not (yet) been introduced.

The delineation of the LMM research population in relation to the FADN research population is visualised in Figure A2.2.

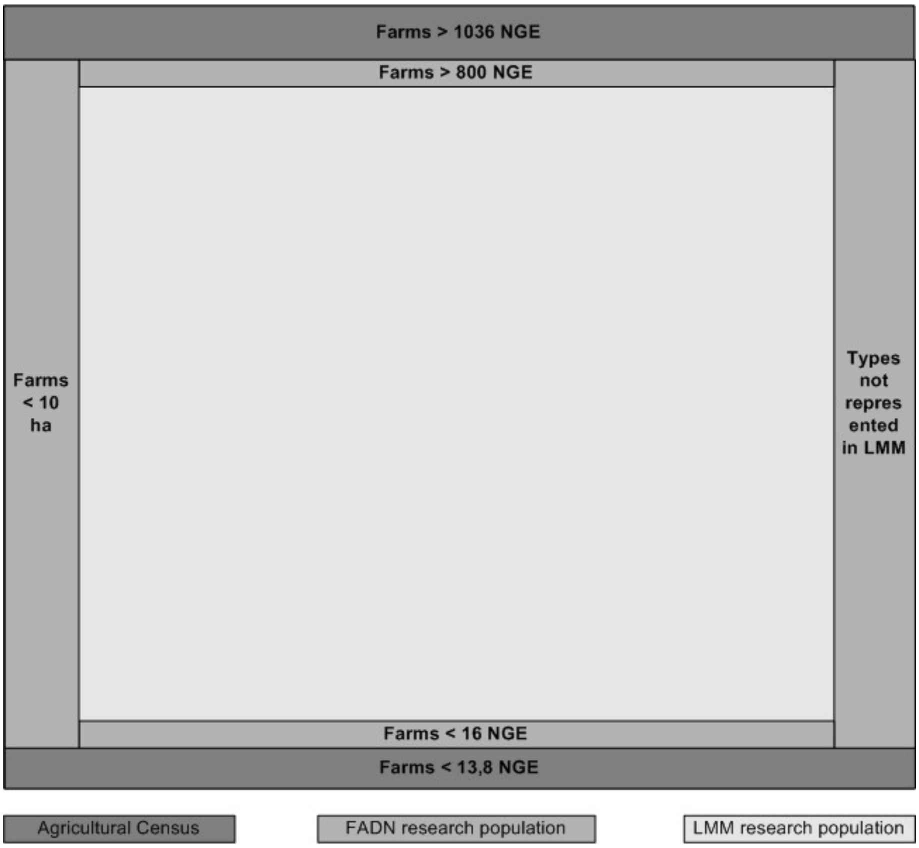


Figure A2.2 LMM research population as a sub-sample of the FADN research population (FADN boundaries pertain to the 2007 set-up). In terms of acreage coverage, the LMM research population covers over 80% of the census population; in terms of population the coverage is roughly 40%.

The criteria used for the selection of LMM farms are elaborated below:

a. Geographical position linked to the region
Four main regions are distinguished: sand, clay, peat and loess. These four regions represent respectively 47%, 39%, 12% and 1,5% of the total agricultural area.
The 4 main regions are subdivided into 13 soil type districts, of which six in the sand region, four in the clay region and two in the peat region. The loess region is not subdivided: it covers the southern part of Limburg. Figure 2.1 in the main text shows the location of the 4 main regions and the 13 soil type districts.

This sub-division is established using the register of municipalities at the time of the 2006 Agricultural Census (see Annex 6). The subdivision in soil type area is linked to individual municipalities. The dominant soil type within a municipality, determines the soil type area allotted to an individual farm.

> The soil type within a region is not homogeneous. There are instances that a farm is situated in a municipality that, according to the soil map, is dominated by sand. This causes the farm to belong to the sand region, although the specific farm may be dominated by peat-rich soils. This variation in soil types within a region affects the water quality as assessed in a certain region.
> Due to amalgamation of local government, the subdivision (and therefore the size) of regions has undergone changes. After merging municipalities, located in different regions, only one region will be representative for the new municipality. This aspect and the variability of soil types within a region are to be taken into account when considering water

quality on farms with soils dissimilar from the region. The methodology of allotting a region to a farm was adopted in the past by FADN, allowing for simple administrative criteria. For the purpose of water quality monitoring, a revision of the methodology would be desirable, using the dominant soil type of the farm as the characteristic feature

b. Type of farming
In 2008, there were 75,152 farms in the Netherlands, active in agriculture and horticulture (Annex 3, Table A3.2). They cultivated a total acreage of 1.9 million hectares. Grassland dominated with nearly 51% of the total cultivated area. About 28% of the cultivated land was in use for arable agriculture and 14% for other fodder crops. The remaining 7% was occupied by 'other land' (totalling 134,000 ha, of which 88,000 ha of outdoor market gardening, 36,000 ha of natural grassland and 10,000 ha glasshouse market gardening). Over 44% of the 1.9 million hectares of cultivated land was in use by dairy farms, 24% by arable farms and 14% by other grazing animal farms. Other farm categories occupied 19% of the cultivated land.

Given the limited sampling capacity, the LMM focuses on the dominant forms of land use and fertilizing practices found in the Netherlands. The decision to include a specific type of farming in the research population of a certain region depends on the extent of agricultural land for the various NEG-types present in that region. Unlike the geographical position (region), the type of farming is a determining factor whether a firm is eligible for inclusion in the LMM. Due to the limited extent covered by farms of the NEG main types horticulture (type 2), permanent cultures (type 3) and crop combinations (type 6), these farming types are not included in the LMM[2].

c. Size of selected farms
As in FADN, LMM distinguishes three size classes (in FADN year 2006, 4 size classes were distinguished). The NGE class boundaries are defined annually per LMM farm category, based on the most recent Agricultural Census. This stratification on farm size is done in such a way that each size class represents the same acreage of cultivated land. This implies that a) each sample farm represents more or less the same surface area and that b) larger farms are more widely represented than smaller ones.

The following example illustrates the allotment of farms to different size classes:

Suppose that, according to the Agricultural Census, there are 900 arable farms on clay, covering in total 90,000 ha. The class boundaries are chosen in such a way that each class contains the same acreage with reference to the Agricultural Census total; in this example 30,000 ha each. The class representing small-size farms will contain a larger number of farms. The above example is illustrated below in tabular form:

Stratification on size class in LMM

Size class	*I*	*II*	*III*
Total acreage in Agric.Census.	30,000	30,000	30,000
Number of farms in Agric.Census.	450	300	150
Number of farms in LMM	4	4	4
Average acreage per farm	67	100	200
Selection chance	4 on 450	4 on 300	4 on 150

The scatter of results in size class I is larger than in size class III. To enable reliable inferences, size class III requires less participating farms than size class I. For this reason the number of farms in the sample of each size class can be the same. Consequently, larger farms have a stronger representation than smaller farms in terms of acreage included.

[2] This statement is not fully exact as will be explained later on. For sub-programmes other than the EM, exceptions have been made. For example in the DM, there are 7 non-dairy farms in the peat region. Other examples are the farms classified as Specialist market garden vegetables – outdoor (type 2), included in the scouting programme SVZ

A.2.3 General procedure for selection and recruitment of farms in LMM

In the preceding paragraphs, some differences were indicated between the research population and stratification in FADN and LMM. There are also some differences between LMM and FADN in the procedures for the selection and recruitment of farms.

As in FADN, a stratified sample is used for the selection and recruitment of LMM farms. The sample is made in accordance with a pre-established 'farm selection plan'. Based on the most recent information, the 'farm selection plan' makes for each stratum an inventory of:
- the number of LMM farms already available (farms recruited earlier, and willing to cooperate in the sampling of water on their farms);
- the number of LMM farms needed;
- the number of farms, potentially available for inclusion in LMM (farms included in FADN and meeting the selection criteria of LMM, and which have not been approached for participation in LMM).

Unlike for FADN, one farm selection plan does not suffice for LMM, because LMM consists of different sub-programmes, each with different objectives, specific sampling scopes, selection criteria and stratification. Moreover, the timing of water sampling at participating farms differs over the four regions. Therefore, the information on currently available participants and those to be replaced also becomes available in stages. A separate 'farm sampling plan' is formulated for each LMM sub-programme and for each main region.

The number of sample farms required per farm category differs between categories, but remains constant in time. These numbers required have been defined at the onset of a sub-programme in relation to vulnerability (vulnerability to leaching), the relative importance of the type of exploitation, and required/desirable numbers of farms from policy perspective or statistical considerations (Fraters and Boumans, 2005).

Unlike FADN, LMM does not adjust annually (in response to the variation in results between farms) the allocation of sample farms within a farming category. For illustration purpose, Table A2.1 presents the target allocation of number of farms per category (42 strata: 14 farming types in three different size classes) for the EM.

The aim is to have an equitable distribution in terms of farm size within each farm category (stratum). For the selection of participants in the clay region (all types of farms) and the sand region (other farms than dairy farms) LMM aims at a maximum geographical spread, to avoid over-concentration in parts of the respective regions.

By recruiting LMM participants from separate strata, the reliability of the random sample survey is higher than of a non-stratified sample survey of the same size. Moreover, stratification also allows maintaining representativeness in case a selected firm declines participation (or when an existing participant stops). A replacement can be sought, corresponding as much as possible, in terms of farm characteristics (type of farming, farm size and region), with the farm that has dropped out.

If a selected farm refuses participation (or if a participant drops out), LMM tries to find a replacement, which resembles as much as possible (type of farming, size, location) the lost farm. In case of a shortage in participating farms, LMM draws candidates from an adjacent stratum.

Table A2.1 Summary of number of farms per sampling stratum in the EM.

LMM farm category	NGE-class			Total
	I	II	III	
Arable sand	4	4	4	12
Industrial livestock sand	4	4	4	12
Other sand	4	4	4	12
Dairy Sand-North	5	5	5	15
Dairy Sand-Central	5	5	5	15
Dairy Sand-South	5	5	5	15
Total sand region	**27**	**27**	**27**	**81**
Arable clay	8	8	8	24
Dairy clay	8	8	8	24
Other clay	4	4	4	12
Total clay region	**20**	**20**	**20**	**60**
Dairy Northern peat district	4	4	4	12
Dairy Western peat district	4	4	4	12
Total peat region	**8**	**8**	**8**	**24**
Arable loess	0 tot 1	0 tot 1	0 tot 1	2
Dairy loess	0 tot 1	0 tot 1	0 tot 1	2
Other loess	0 tot 1	0 tot 1	0 tot 1	2
Total loess region	**2**	**2**	**2**	**6**

A2.4 Coverage of the LMM research population

Table A2.2 shows for each region the percentage of farms and acreage represented in the LMM research population. The rightmost column shows the LMM sample acreage as percentage of the total area of cultivated land. The top of the table presents the total population of farms and acreage in 2008, disaggregated for the 4 main LMM regions.

From Table A2.2 it can be concluded that:

- Over 85% of all farms and all cultivated land are situated in the sand and clay regions. With an acreage of less that 30,000 ha the loess region is by far the smallest.
- On a national scale, the LMM research population represents 81% of all cultivated land, used by 46% of all farms. The individual 'acreage coverage' is slightly higher for grassland, arable farming and other fodder crops (82 to 86%); for 'other cultivated land' the coverage (26%) is relatively low.
- Among the regions, the coverage of total cultivated land varies between 75% in the peat region to 83% in the sand region. For the category 'other cultivated land' the sand region has the highest coverage (39% compared to 26% overall). In the peat region, the research population focuses entirely on specialised dairy farms; this leads to the limited acreage of 'other cultivated land', and 'arable farm land' in to be left out from the LMM sample.

Table A2.2 Distribution of number of farms and their acreage over LMM regions: for the Netherlands as a whole and for the LMM research population.

	Number farms	Grassland (ha x1,000)	Other fodder crops (ha x1,000)	Arable farm land (ha x1,000)	Other cultiv. land (ha x1,000)	Total cultiv. land (ha x1,000))	Share in total extent (%)
- LMM sand region	39,603	476	195	168	54	893	46
- LMM clay region	26,034	293	56	350	72	769	40%
- LMM peat region	8,327	203	21	6.8	7.2	237	12
- LMM loess region	1,188	11	4.7	12	1.7	29	1.5
Total agri-& horticulture in NL:	75,152	982	276	536	134	1,929	100
Research population sand region							
- Dairy farms	9,921	314	91	9.5	4.8	419	22
- Arable farms	2,081	5.0	17	97	0.6	119	6.2
- Industr. Livestock farms	1,352	5.6	14	7.4	0.5	27	1.4
- Other farms	5,229	94	38	26	15	173	9.0
Total	18,583	419	159	140	21	739	38%
(in % of sand region)	47%	88%	82%	83%	39%	83%	
Research population clay region							
- Arable farms	4,814	8.3	8.2	269	2,4	288	15
- Specialised Dairy farms	4,449	191	31	9.2	3.1	233	12
- Other farms	2,481	63	8.0	24	6.6	101	5.3
Total	11,744	262	47	302	12	623	32
(in % of clay region)	45%	90%	84%	86%	17%	81%	
Research population peat region							
- Specialised Dairy farms North	1,648	77	11	0.7	1,1	89	4.6
- Specialised Dairy farms West	2,047	82	5.6	0.5	0,7	89	4.6
Total	3,695	159	17	1.3	1,7	178	9.2
(in % of peat region)	44%	78%	80%	18%	24%	75%	
Research population loess region							
- Dairy farms	169	5.0	1.7	0.9	0.1	7.7	0.4
- Arable farms	185	0.6	1.0	6.6	0.0	8.2	0.4
- Other farms	223	4.2	1.2	2.4	0.2	8.0	0.4
Total	577	10	3.8	10	0.3	24	1.2
(in % of loess region)	49%	87%	82%	84%	20%	81%	
Total LMM research population	34,599	849	227	453	35	1,564	81.1
% of NL agri-& horticulture	46%	86%	82%	84%	26%	81%	

Source : CBS Agriculture Census 2008

ANNEX 3 Types of farming distinguished

A3.1 Clarification of the NEG-characterisation

The NEG-typology is a Dutch version of the EU system to characterise agriculture and horticulture firms. Based on their activities (production of crops and/or animals) farms are classified in types of farming. All cropped areas and numbers of head per animal species are converted into so-called 'brutostandaardsaldi (bss)' or 'gross standardardised yield'. The 'bss' of a crop or animal refers to its yield (proceeds minus allotted cost), achievable on annual basis under normal circumstances. The proportion of the production from specific animals or crops is compared to the total production (sum of all bss). This provides a measure for specialisation of a farm. The degree of specialisation is utilised to define the type of farming. A farm is defined as 'specialised' if a substantial part of the farm's proceeds (usually at least two-third) is derived from one product or mode of production (for example dairy cattle, arable farming or pigs).

The NEG-typology discerns eight main types of farming of which five are single-product/production oriented and three comprise combinations of farming types. The five single-product/production oriented types of farming are: arable farming, horticulture, permanent cultures (fruit and trees), grazing animal farms and industrial livestock farming. Combined farm types are grouped into 'crop combinations', 'livestock-rearing combinations' and 'crop-livestock rearing combinations'. Table A2.1 shows the 41 NEG farming types, under the eight main types of farming, as distinguished in 2009.

A3.2 Recent changes in NEG-characterisation

The NEG-typology is subject to changes. First of all, in accordance with EU agreements, the 'bss' and NGE are redefined every two years. The almost continuous shift in ratios between prices and yield between products is the main reason for this bi-annual redefinition. These changes affect the bss value of each crop and animal.

In addition, minor modifications occur in the list of products and animals used. These modifications relate to animal species or crops, newly appeared on or vanished during the year considered from the list of the Agricultural Census. From 2006 onwards, the number of products in the Agricultural Census has increased considerably; this is partly due to changes in manure and mineral legislation.

The changes in the NEG characterisation have limited effect in terms of impacts on the size and distribution of the cultivated acreage within the LMM research population. A modified characterisation, however, may change the allotment of sample farms to LMM strata. When a farm needs replacement, selection of a new farm is done using the most recent Agricultural Census and FADN data. In this way, due allowance is made for developments in types of farming and also for changes in the NEG characterisation.

Table A3.1 Summary of (main) types of farming with the NEG-characterisation, used in 2009

1 Arable farming – Field crops			
1310	Specialist cereals, oilseed and protein crops (COP)	1430	Field vegetables
1410	Specialist root crops	1448	Other root crops
1420	COP and root crops combined	1449	Other arable farming
2 Horticulture farming			
2011	Specialist market garden vegetables – outdoor	2022	Specialist flowers /ornamentals – under glass
2012	Specialist market garden vegetables – under glass	2023	Other flowers / ornamentals
2013	Other market garden vegetables	2033	Specialist mushrooms
2021	Specialist flowers /bulbs - outdoor	2039	Other horticulture farms
3 Permanent cultures			
3210	Fruit growing	3490	Other permanent cultures/crops
3480	Tree nurseries		
4 Grazing animals			
4110	Highly Specialised dairy farming – milk production	4410	Sheep farming
4120	Spec. dairy farming – milk production + cattle rearing	4420	Cattle / sheep farming
4370	Other dairy farming	4430	Goat farming
4380	Calf rearing & fattening	4447	Horse and pony farms
4390	Other (bovine) cattle farming	4448	Grassland farms
		4449	Other grazing animal farming
5 Industrial livestock farming (poultry, pigs and fattening calves) (hokdieren)			
5011	Specialist pig rearing	5022	Specialist poultry-meat
5012	Specialist pig fattening	5023	Layers and poultry-meat combined
5013	Other pig farms	5031	Pigs and poultry combined
5021	Specialist layers	5032	Other types of livestock farming
6 Mixed cropping			
6010	Horticulture and permanent cultures	6090	Other mixed cropping
7 Mixed livestock farming			
7100	Mixed livestock, mainly grazing	7200	Mixed livestock, mainly granivores
8 Mixed crop – livestock farming			
8100	Field crops – grazing livestock combined	8200	Various crops and livestock combined

Source: CBS (2009) http://www.cbs.nl/nl-NL/menu/methoden/classificaties/overzicht/-neg/default.htm

A3.3 Number and acreage of farming types

Table A3.2 shows a complete summary of agriculture and horticulture farms in the Netherlands (numbers and size), based on the CBS Agricultural Census of 2008 (see also Annex 1). Categorisation of farms is done based on the 8 main types of farming in accordance with the NEG characterisation (CBS, 2009), in which category 4 (grazing animals) is divided further into 'dairy farms' (type 4a) and 'other grazing animal farms' (type 4b). The total acreage of cultivated land has been represented in terms of 4 forms of land use: grassland, other fodder crops (primarily green maize), arable farming products and the remainder 'other cultivated land' (comprising for example market gardening crops (outdoor and under glass)).

Table A3.2 Summary of agriculture and horticulture farms, per farming category in the Netherlands (2008)

Farming Category	Number of farms	Grassland (ha x1,000)	Other fodder crops (ha x1,000)	Arable farm land (ha x1,000)	Other cultiv. land (ha x1,000)	Total cultiv. land (ha x1,000)	Share in total extent (%)
Arable farms	11,175	18	44	398	3	463	24
Horticulture farms	8,542	4	3	14	53	74	4
Permanent Cultures	4,328	3	2	4	31	41	2
Dairy farms	18,588	671	141	21	10	842	44
Other grazing animals	20,295	216	30	9	21	275	14
Industr. Livestock farms	5,545	12	21	11	1	45	2
Mixed cropping farms	1,315	4	4	29	8	45	2
Mixed livestock farms	1,649	23	10	6	2	40	2
Mixed livestock-cropping farms	3,715	32	22	44	6	104	5
Total (ha x1,000)	*75,152*	*982*	*276*	*536*	*134*	*1,929*	100
Portion of land use (%)		50.9	14.3	27.8	7.0	100	

A3.4 The evolution of acreage per main type of farming

Table A3.3 specifies the main types of farming, the acreage of cultivated land for the four main regions in the period 2006 – 2009. The specification is based on the eight NEG main types of farming, in which NEG type 4 (grazing animals) has been subdivided into three groups: dairy farms (designated as type 4a), calf rearing and fattening farms (which were added to 'industrial livestock farming'; type 5) and other grazing animals (designated as type 4b).

Between 2006 and 2009, the number of agriculture and horticulture farms fell with about 8% (from 79,435 in 2006 to 73,008 in 2009). This reduction does not, or only slightly affect the (relative) acreages per main type of farming.

Table A3.3 Developments in the acreage per main type of farming[1], per region[2]

Main type of farming*	2006 acreage (ha)	2006 (%)	2007 acreage (ha)	2007 (%)	2008 acreage (ha)	2008 (%)	2009 acreage (ha)	2009 (%)
1) Arable farms	148,933	17	144,136	16	143,361	16	142,032	16
2) Horticulture farms	25,798	3	24,318	3	24,639	3	23,854	3
3) Permanent cultures	14,663	2	15,724	2	17,097	2	17,666	2
4a) Dairy farms	428,936	48	416,286	47	421,534	47	425,871	48
4b) Other grazing	126,112	14	130,139	15	135,593	15	128,122	15
5) Industr. livestock	47,490	5	51,494	6	51,930	6	51,478	6
6) Mixed cropping	17,210	2	13,913	2	15,299	2	16,172	2
7) Mixed livestock	30,418	3	31,057	4	29,672	3	27,279	3
8) Mixed crop-livest.	60,142	7	57,469	6	54,013	6	51,064	6
total SAND region	899,702	100	884,536	100	893,138	100	883,538	100
1) Arable farms	302,707	40	305,272	40	304,721	40	306,040	40
2) Horticulture farms	45,090	6	46,293	6	47,442	6	45,794	6
3) Permanent cultures	18,673	2	19,930	3	19,823	3	19,953	3
4a) Dairy farms	226,757	30	227,720	30	234,008	30	238,199	31
4b) Other grazing	77,183	10	78,903	10	78,468	10	75,565	10
5) Industr. livestock	4,699	1	5,857	1	6,147	1	6,157	1
6) Mixed cropping	31,766	4	29,663	4	28,423	4	29,050	4
7) Mixed livestock	8,598	1	8,406	1	7,976	1	8,915	1
8) Mixed crop-livest.	40,440	5	42,134	6	42,368	6	39,457	5
total CLAY region	755,913	100	764,178	100	769,376	100	769,131	100
1) Arable farms	4,877	2	5,325	2	5,043	2	5,294	2
2) Horticulture farms	1,663	1	1,761	1	1,879	1	1,537	1
3) Permanent cultures	2,385	1	2,365	1	2,429	1	2,101	1
4a) Dairy farms	177,240	76	177,252	75	179,290	76	179,465	76
4b) Other grazing	40,945	17	43,143	18	41,486	17	40,790	17
5) Industr. livestock	1,596	1	1,990	1	2,081	1	2,018	1
6) Mixed cropping	927	0	1,236	1	677	0	575	0
7) Mixed livestock	1,937	1	1,466	1	1,527	1	1,458	1
8) Mixed crop-livest.	2,696	1	1,764	1	2,923	1	2,356	1
total PEAT region	234,265	100	236,303	100	237,335	100	235,594	100
1) Arable farms	10,153	34	10,389	35	9,753	33	9,983	34
2) Horticulture farms	114	0	87	0	76	0	59	0
3) Permanent cultures	1,493	5	1,533	5	1,612	5	1,714	6
4a) Dairy farms	8,083	27	7,661	26	7,650	26	7,578	26
4b) Other grazing	3,828	13	3,798	13	4,231	14	4,137	14
5) Industr. livestock	235	1	275	1	296	1	228	1
6) Mixed cropping	726	2	792	3	818	3	804	3
7) Mixed livestock	594	2	650	2	566	2	473	2
8) Mixed crop-livest.	4,598	15	4,129	14	4,421	15	4,242	15
total LOESS region	29,824	100	29,314	100	29,424	100	29,217	100

[1] The types of farming discerned are based on 8 NEG main types of farming of the NEG-characterisation; NEG-type 4 (grazing animals was subdivided in three: dairy farms (designated as type 4a), calf rearing and fattening (included in type 5) and other grazing animals (designated as type 4b).

[2] Regions are linked to municipalities (Annex 6); amalgamation of local government may cause changes in size of the regions.

A3.5 LMM reporting categories

For the purpose of selection and enlistment of participants, and for reporting purposes, all farming activities represented in the LMM have been aggregated into more or less homogeneous farming types. Table A3.4 shows for each region the farming types distinguished in the LMM and the corresponding NEG-business characterisation.

Table A3.4 Summary of farming types distinguished within LMM per region.

Region	LMM reporting categories with respect to type of farming	NEG-(main) farming types used in LMM selection
Sand and loess*	Arable farming**	NEG main type 1: arable farms
	Dairy farming***	NEG types: 4110: highly specialized dairy farms 4120: specialized dairy farms 4370: other dairy farms
	Industrial livestock farming ****	NEG main type 5: industrial livestock farms NEG type 4380: calf rearing and fattening
	Others	NEG main types: 7: livestock combinations 8: crops / livestock combinations 4: farms with grazing animals (excluding NEG types 4110, 4120, 4370 and 4380)
Clay	Arable farming**	NEG main type 1: arable farms
	Dairy farming	NEG types: 4110: highly specialized dairy farms 4120: specialized dairy farms 4370: other dairy farms
	Others	NEG main types: 8: crops / livestock combinations 4: farms with grazing animals (excluding NEG types 4110, 4120, 4370 and 4380)
Peat	Dairy farming	NEG types: 4110: highly specialized dairy farms 4120: specialized dairy farms

* As from 2007, the loess region is distinguished as a separate region for reporting. Prior to this the data from the loess regions were combined with those of the sand region.

** Due to changes in the farming practice, a limited number of arable farms should be classified under 'other mixed cropping' (type 6090). As long as at least 80% of the acreage is covered by arable farming crops, those farms will continue to be considered as 'arable farms'.

*** The distinction between dairy farms and other farms in the sand region has been used from 2007 onwards. The definition of farm types before 2007 can be found in Fraters & Boumans (2005).

**** In the loess region, the group of industrial livestock farms is too small to constitute a separate class; here they have been included in the category 'others'.

ANNEX 4 Number of farms planned in LMM set-up

Table A4.1 presents the number of farms per reporting category, according to the revised planning. The planning provided for 15 farms in the RM in the peat region. Eventually, this provision was cancelled. Instead, the allocation was used for setting up the SVZ research programme and selection of additional farms for the TmT research programme, thereby focusing more on the sand and loess regions. Table A4.1 does not show the number of farms in the programme SVZ, since this programme was not included in the original planning.

Table A4.1 Number of farms originally planned for the different sub-programmes during the period 2007-2010 (FADN years 2006-2009)

	Evaluation Monitor (EM)	Derogation Monitor (DM)	Reference Monitor (RM)	Exploratory Monitor (VM)	Monitor soils prone to leaching (UM)	Total
Sand	81	160	35	14	150	452
Loess	6	20	5	2	50	83
Clay	60	60	25	10	0	155
Peat	24	60	15	2	0	101
Total	171	300	80	28	200	791

	Evaluation Monitor (EM)	Derogation Monitor (DM)	Reference Monitor (RM)	Exploratory Monitor (VM)	Monitor soils prone to leaching (UM)	Total
Dairy Farms	92	261	80	16	100	549
Non-dairy Farms	79	39	0	12	100	242
Total	171	300	80	28	200	791

Table A4.2 shows the scope of field and laboratory work linked to implementation of the LMM programme.

Table A4.2 Scope of field activities and laboratory testing for water quality assessment according to 2006 planning

Year	Sampling sub-project								Total
	sand-summer	sand-winter	clay	peat	loess	SVZ	K&K	TmT	
Number of farm visits for sampling									
2006	194	161	258	88	50		31		782
2007	276	245	374	281	50		31		1.257
2008	276	290	434	322	50		31		1.403
2009	276	290	434	322	50		31		1.403
2010*	266	530	936	512	50	68	67	12	2.441
Number of individual field samples and field tests									
2006	3.104	3.500	6.192	1.456	800		1.402		16.454
2007	4.416	5.400	8.976	3.976	800		1.402		24.970
2008	4.416	6.480	10.416	4.480	800		1.402		27.994
2009	4.416	6.480	10.416	4.480	800		1.402		27.994
2010*	4.256	8.400	14.176	5.744	800	1.472	1.690	1.808	38.346
Number of laboratory tests on composite samples									
2006	512	462	807	261	109		624		2.775
2007	734	710	1.165	750	109		624		4.092
2008	734	845	1.344	843	109		624		4.499
2009	734	845	1.344	843	109		624		4.499
2010*	700	1.325	2.348	1.191	109	188	588	188	6.637

* provisional estimate

ANNEX 5 Number of farms covered in programme implementation

Table A5.1 Number of farms included for data collection on agricultural practice Top: Evaluation Monitor (EM). Bottom: Derogation Monitor (DM)

AGRICULTURAL PRACTICE -EM

	Clay region				Total
	Arable		Dairy	Other	
2006	25		49	15	89
2007	24		51	13	88
2008	28		49	13	90
2009	28		52	14	94

	Loess region				Total
	Arable		Dairy	Other	
2006	14		19	7	40
2007	14		18	9	41
2008	14		18	9	41
2009	13		18	9	40

	Peat region				Total
			Dairy		
2006			58		58
2007			57		57
2008			57		57
2009			58		58

	Sand region				Total
	Arable	Ind.Livestock	Dairy	Other	
2006	37	17	128	26	208
2007	36	20	119	27	202
2008	35	17	124	24	200
2009	34	16	122	27	199

	All regions combined				Total
	Arable	Ind.Livestock	Dairy	Other	
2006	76	17	254	48	395
2007	74	20	245	49	388
2008	77	17	248	46	388
2009	75	16	250	50	391

AGRICULTURAL PRACTICE - DM

	Clay Region	Loess Region	Peat Region	Sand Region	All Regions Combined
2006	57	18	59	149	283
2007	54	20	59	151	284
2008	53	18	57	147	275
2009	55	19	58	148	280

Table A5.2 Number of farms included for data collection on water quality. Top: Evaluation Monitor (EM). Bottom: Derogation Monitor (DM)

WATER QUALITY - EM

	Clay region				Total
	Arable		Dairy	Other	
2007	25		49	15	89
2008	24		48	14	86
2009	28		49	13	90
2010	28		53	14	95

	Loess region				Total
	Arable		Dairy	Other	
2007	14		19	7	40
2008	13		18	10	41
2009	14		18	10	42
2010	14		18	10	42

	Peat region				Total
			Dairy		
2007			57		57
2008			58		58
2009			56		56
2010			57		57

	Sand region				Total
	Arable	Ind.Livestock	Dairy	Other	
2007	37	18	129	31	215
2008	38	20	118	31	207
2009	35	20	125	23	203
2010	33	16	120	29	198

	All regions combined				Total
	Arable	Ind.Livestock	Dairy	Other	
2007	76	18	254	53	401
2008	75	20	242	55	392
2009	77	20	248	46	391
2010	75	16	248	53	392

WATER QUALITY - DM

	Clay Region	Loess Region	Peat Region	Sand Region	All Regions Combined
2007	59	18	59	159	295
2008	56	20	57	155	288
2009	56	18	57	154	285
2010	56	18	57	158	289

Table A5.3 Number of farm visits, number of individual water samples and composite samples for laboratory testing for all LMM sub-programmes

		Number of rounds (farm visits)				Number of individual water samples				Number of composite samples			
		2007	2008	2009	2010	2007	2008	2009	2010	2007	2008	2009	2010
Clay	Regular	281	378	472	464	5.034	7.345	7.839	7.425	810	1.104	1.282	1.252
	Summer ditches		430	452	459		1.555	1.630	1.643		757	793	807
Loess	Regular	48	53	54	53	774	884	894	882	104	121	118	113
Peat	Regular	229	251	267	254	2.327	2.460	2.552	2.281	552	586	617	538
	Summer ditches		246	260	258		1.378	1.402	1.393		449	464	458
	Drains	22	28	38	34	343	430	591	520	22	28	38	34
Sand	Regular	270	262	263	241	4.610	4.407	4.519	4.114	658	638	643	584
	Summer ditches		191	197	207		518	538	572		312	323	349
	Winter	148	230	285	262	2.629	4.106	4.570	4.567	391	601	736	701
Cows & Opportunities	Regular	35	42	50	52	1.011	1.106	1.146	1.206	134	151	161	171
	Summer ditches		33	34	31		136	132	128		62	68	65
Cultivating w. Future	Regular		4	27	35		192	847	1.217		17	143	184
	Summer ditches			22	28			73	103			38	47
Market Garden crops Sand	Regular		33	48	49		751	933	1.052		97	135	141
	Summer ditches		23	25	23		50	52	51		36	41	37
	Total	1.033	2.204	2.494	2.450	16.728	25.318	27.718	27.154	2.671	4.959	5.600	5.481

ANNEX 6 List of municipalities arranged per soil type district

Table A6.1 Municipalities within LMM soil type districts (1 – 13)

Northern marine clay district (1)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
3	Appingedam	53	Winsum	83	Menaldumadeel
5	Bedum	56	Zuidhorn	104	Nijefurd
7	Bellingwedde	58	Dongeradeel	140	Littenseradiel
9	Ten Boer	63	het Bildt	710	Wûnseradiel
10	Delfzijl	64	Bolsward	1651	Eemsmond
14	Groningen	70	Franekeradeel	1661	Reiderland
24	Loppersum	72	Harlingen	1663	DeMarne
39	Scheemda	79	Kollumerland c.a.	1722	Ferwerderadiel
52	Winschoten	81	Leeuwarderadeel	1987	Menterwolde
Northern peat district (2)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
51	Skarsterlân	91	Sneek	653	Gaasterlân-Sleat
55	Boarnsterhim	98	Weststellingwerf	683	Wymbritseradiel
80	Leeuwarden	166	Kampen	1708	Steenwijkerland
82	Lemsterland	193	Zwolle	1896	Zwartewaterland
Polder marine clay district (3)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
34	Almere	400	Den Helder	518	’s-Gravenhage
50	Zeewolde	405	Hoorn	529	Noorder-Koggenland
171	Noordoostpolder	412	Niedorp	532	Stede-Broec
184	Urk	416	Langedijk	534	Hillegom
303	Dronten	420	Medemblik	537	Katwijk
358	Aalsmeer	429	Obdam	553	Lisse
361	Alkmaar	432	Opmeer	558	Wester-Koggenland
362	Amstelveen	441	Schagen	567	Nieuwerkerk a/d IJssel
364	Andijk	448	Texel	575	Noordwijk
366	Anna Paulowna	451	Uithoorn	576	Noordwijkerhout
370	Beemster	453	Velsen	579	Oegstgeest
373	Bergen	458	Schermer	599	Rotterdam
375	Beverwijk	459	Wervershoof	603	Rijswijk
377	Bloemendaal	462	Wieringen	627	Waddinxveen
383	Castricum	463	Wieringermeer	629	Wassenaar
388	Enkhuizen	466	Wognum	637	Zoetermeer
392	Haarlem	476	Zijpe	645	Jacobswoude
394	Haarlemmermeer	492	Bergschenhoek	995	Lelystad
395	Harenkarspel	493	Berkel en Rodenrijs	1525	Teylingen

Table A6.1(continued) Municipalities within LMM soil type districts (1 – 13)

Western peat district (4)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
305	Abcoude	457	Weesp	595	Reeuwijk
310	De Bilt	478	Zeevang	608	Schoonhoven
311	Breukelen	479	Zaanstad	610	Sliedrecht
313	Bunschoten	480	Ter Aar	623	Vlist
317	Eemnes	482	Alblasserdam	626	Voorschoten
329	Loenen	483	Alkemade	632	Woerden
331	Lopik	484	Alphen aan den Rijn	638	Zoeterwoude
333	Maarssen	491	Bergambacht	643	Nederlek
363	Amsterdam	497	Bodegraven	644	Ouderkerk
365	Graft-De Rijp	499	Boskoop	689	Giessenlanden
381	Bussum	512	Gorinchem	693	Graafstroom
384	Diemen	513	Gouda	694	Liesveld
385	Edam-Volendam	523	Hardinxveld-Giessendam	707	Zederik
393	Haarlemmerliede c.a.	546	Leiden	736	De RondeVenen
415	Landsmeer	547	Leiderdorp	852	Waterland
424	Muiden	563	Moordrecht	880	Wormerland
425	Naarden	569	Nieuwkoop	1672	Rijnwoude
431	Oostzaan	571	Nieuw-Lekkerland	1673	Liemeer
437	Ouder-Amstel	589	Oudewater	1696	Wijdemeren
439	Purmerend	590	Papendrecht	1916	Leidschendam-Voorburg
450	Uitgeest				
Southwestern marine clay district (5)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
489	Barendrecht	597	Ridderkerk	715	Terneuzen
501	Brielle	606	Schiedam	716	Tholen
504	Dirksland	611	Cromstrijen	717	Veere
505	Dordrecht	612	Spijkenisse	718	Vlissingen
511	Goedereede	613	Albrandswaard	779	Geertruidenberg
517	’s-Gravendeel	614	Westvoorne	826	Oosterhout
530	Hellevoetsluis	617	Strijen	851	Steenbergen
531	Hendrik-Ido-Ambacht	622	Vlaardingen	867	Waalwijk
556	Maassluis	642	Zwijndrecht	870	Werkendam
559	Middelharnis	654	Borsele	1676	Schouwen-Duiveland
568	Bernisse	664	Goes	1695	Noord-Beveland
580	Oostflakkee	677	Hulst	1709	Moerdijk
584	Oud-Beijerland	678	Kapelle	1714	Sluis
585	Binnenmaas	687	Middelburg	1719	Drimmelen
588	Korendijk	703	Reimerswaal		

Table A6.1(continued) Municipalities within LMM soil type districts (1 – 13)

Northern sand district I (6)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
59	Achtkarspelen	74	Heerenveen	88	Schiermonnikoog
60	Ameland	85	Ooststellingwerf	90	Smallingerland
65	Dantumadeel	86	Opsterland	93	Terschelling
				737	Tytsjerksteradiel
Reclaimed moor district (7)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
18	Hoogezand-Sappemeer	47	Veendam	765	Pekela
37	Stadskanaal	48	Vlagtwedde	1680	Aa en Hunze
40	Slochteren	114	Emmen	1681	Borger-Odoorn
Northern sand district II (8)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
15	Grootegast	109	Coevorden	1690	DeWolden
17	Haren	118	Hoogeveen	1699	Noordenveld
22	Leek	119	Meppel	1701	Westerveld
25	Marum	160	Hardenberg	1730	Tynaarlo
106	Assen	180	Staphorst	1731	Midden-Drenthe

Table A6.1(continued) Municipalities within LMM soil type districts (1 – 13)

Eastern sand district (9)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
141	Almelo	175	Ommen	1509	Oude IJsselstreek
147	Borne	177	Raalte	1700	Twenterand
148	Dalfsen	183	Tubbergen	1735	Hof van Twente
150	Deventer	189	Wierden	1742	Rijssen-Holten
153	Enschede	197	Aalten	1773	Olst-Wijhe
158	Haaksbergen	222	Doetinchem	1774	Dinkelland
163	Hellendoorn	240	Groenlo	1859	Berkelland
164	Hengelo	262	Lochem	1876	Bronckhorst
168	Losser	294	Winterswijk	1955	Montferland
173	Oldenzaal	301	Zutphen		
Central sand district (10)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
200	Apeldoorn	267	Nijkerk	340	Rhenen
203	Barneveld	269	Oldebroek	342	Soest
228	Ede	273	Putten	345	Veenendaal
230	Elburg	279	Scherpenzeel	351	Woudenberg
232	Epe	302	Nunspeet	355	Zeist
233	Ermelo	307	Amersfoort	376	Blaricum
243	Harderwijk	308	Baarn	402	Hilversum
244	Hattem	327	Leusden	406	Huizen
246	Heerde	339	Renswoude	417	Laren
				1581	Utrechtse Heuvelrug
River clay district (11)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
196	Rijnwaarden	274	Renkum	344	Utrecht
202	Arnhem	275	Rheden	352	Wijk bij Duurstede
209	Beuningen	281	Tiel	353	IJsselstein
213	Brummen	282	Ubbergen	356	Nieuwegein
214	Buren	285	Voorst	545	Leerdam
216	Culemborg	289	Wageningen	620	Vianen
221	Doesburg	293	Westervoort	668	West-Maas en Waal
225	Druten	296	Wijchen	733	Lingewaal
226	Duiven	297	Zaltbommel	738	Aalburg
236	Geldermalsen	299	Zevenaar	797	Heusden
241	Groesbeek	304	Neerijnen	874	Woudrichem
252	Heumen	312	Bunnik	1705	Lingewaard
263	Maasdriel	321	Houten	1734	Over-Betuwe
265	Millingen aan de Rijn	335	Montfoort	1740	Neder-Betuwe
268	Nijmegen				

Table A6.1(continued) Municipalities within LMM soil type districts (1 – 13)

Southern sand district (12)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
743	Asten	845	Sint-Michielsgestel	975	Swalmen
744	Baarle-Nassau	846	Sint-Oedenrode	977	Thorn
748	Bergen op Zoom	847	Someren	983	Venlo
753	Best	848	Son en Breugel	984	Venray
755	Boekel	855	Tilburg	988	Weert
756	Boxmeer	856	Uden	993	Meerlo-Wanssum
757	Boxtel	858	Valkenswaard	1507	Horst aan de Maas
758	Breda	860	Veghel	1652	Gemert-Bakel
762	Deurne	861	Veldhoven	1655	Halderberge
766	Dongen	865	Vught	1658	Heeze-Leende
770	Eersel	866	Waalre	1659	Laarbeek
772	Eindhoven	873	Woensdrecht	1667	Reusel-De Mierden
777	Etten-Leur	879	Zundert	1669	Roerdalen
784	Gilze en Rijen	885	Arcen en Velden	1670	Roggel en Neer
785	Goirle	889	Beesel	1671	Maasdonk
786	Grave	893	Bergen	1674	Roosendaal
788	Haaren	907	Gennep	1679	Ambt-Montfort
794	Helmond	914	Haelen	1684	Cuijk
796	’s-Hertogenbosch	918	Helden	1685	Landerd
798	Hilvarenbeek	920	Heythuysen	1702	Sint-Anthonis
808	Lith	925	Hunsel	1706	Cranendonck
809	Loon op Zand	929	Kessel	1711	Echt-Susteren
815	Mill en Sint-Hubert	933	Maasbracht	1721	Bernheze
820	Nuenenc.a.	934	Maasbree	1723	Alphen-Chaam
823	Oirschot	941	Meijel	1724	Bergeijk
824	Oisterwijk	944	Mook en Middelaar	1728	Bladel
828	Oss	946	Nederweert	1771	Geldrop-Mierlo
840	Rucphen	957	Roermond	1937	Heel
844	Schijndel	964	Sevenum		
(South Limburg) Loess region (13)					
ID.No	**Municipality**	**ID.No**	**Municipality**	**ID.No**	**Municipality**
881	Onderbanken	935	Maastricht	971	Stein
882	Landgraaf	936	Margraten	981	Vaals
888	Beek	938	Meerssen	986	Voerendaal
899	Brunssum	951	Nuth	994	Valkenburg a/d Geul
905	Eijsden	962	Schinnen	1729	Gulpen-Wittem
917	Heerlen	965	Simpelveld	1883	Sittard-Geleen
928	Kerkrade				

ANNEX 7 Work Instructions for field activities

A7.1 Quality control by using a system of Work Instructions

All field activities are performed in accordance with written Work Instructions, previously (prior to 2010) called 'standard operating procedures' (SOPs). There are Instructions for the drilling of boreholes, the sampling of different types of water, the tests performed in the field and the handling of water samples. A summary list of most relevant Work Instructions is presented in Table A7.1 below

Table A7.1 Listing of Work Instructions most relevant for the fieldwork related to water sampling and water quality testing

SOP/Doc.No.	Title
BW-W-001	Measuring the nitrate concentration in an aqueous solution using a Nitracheck-reflectometer (type 404)[version 1, 24 May 2011]
BW-W-002	The use of control sheets [version 1, 24 May 2011] for equipment calibration
BW-W-003	Measuring pH in an aqueous solutions using a WTW pH 196 or 197(i) meter [version 1, 24 May 2011]
BW-W-004	Measuring the specific conductivity in an aqueous solution using a WTW LF 196 or 197(i) conductivity meter [version 1, 24 May 2011]
BW-W-005	Measuring the oxygen concentration in an aqueous solution using an OXI 196 or 197(i) meter [version 1, 24 May 2011]
BW-W-006	Measuring pH, specific conductivity and oxygen content in an aqueous solution using the WTW Multi 350i [version 2, 20 October 2011].
BW-W-007	Measuring the pH in an aqueous solution, using indicator strips [version 1, 24 May 2011].
BW-W-008	The temporary storage and transportation of samples [version 1, 24 May 2011].
BW-W-009	Method of conserving water samples by adding an acid [version 1, 24 May 2011].
BW-W-010	Concise description of soil profile [version 1, 24 May 2011].
BW-W-011	Sampling of surface water/ditch water with a modified sampling nozzle and peristaltic pump [version 1, 24 May 2011].
BW-W-012	Sampling of surface water/ditch water using a measuring jug [version 1, 29 March 2011].
BW-W-013	Sampling of drain water [version 1, 29 March 2011].
BW-W-014	Soil sampling for soil moisture testing using an Edelman auger [version 1, 25 May 2011].
BW-W-015	Sampling of groundwater in sand, clay and peat using a sampling nozzle and a peristaltic pump [version 1, 25 May 2011].
BW-W-016	The preparation of a RIVM-sampling nozzle for sampling groundwater and ditch water [version 1, 24 May 2011].
BW-W-017	Field visits and work site inspections within de Soil and Water Monitoring (BW-M) Department [version 1, 24 May 2011].
BW-W-018	Safety during fieldwork [version 2, 20 June 2011].
BW-W-020	Compiling and archiving of business information of agricultural firms [version 1, 20 June 2011].
BW-W-021	Identifying the position of sampling points [version 3, February 2012]
BW-W-022	Recording of temperature in refrigerators [version 1, 24 May 2011]
BW-W-023	Data validation and drafting (letter) reports for individual LMM-participants [version 1, 24 May 2011]

In the ensuing sections a number of the Work Instructions will be presented in terms of material / equipment used, as well as methodology. The Work Instructions for water sampling (in groundwater, drain water and ditch water), and storage and transport of samples will be presented in some more detail.

A7.2 Sampling of groundwater using a sampling nozzle in combination with a peristaltic pump on sand, clay and peat (Instruction BW-W-015)

MATERIAL

- Location map with all plots and markings of locations where groundwater sample is to be taken;
- Spade;
- Sheet of plastic or tarpaulin
- Various size manual drilling equipment:
  - Edelman auger; Ø 7 cm / Ø 10 cm;
  - Sand pump or suction borer (piston sampler); Ø 7 cm / Ø 10 cm;
  - Bailer; Ø 7 cm / Ø 10 cm;
  - River side drill; Ø 7 cm / Ø 10 cm;
  - Van der Horst auger (drill for soft clay); Ø 7 cm / Ø 10 cm;
- Plastic cylinder (collar): length of about 50 cm, Ø ±11 cm;
- Sampling nozzle, in various lengths, of PVC material with a 50 cm perforated section (slot size 0,3 mm) and external graduation (RIVM design, in accordance with Work Instruction BW-W-016 [3]);
- Filter gravel: bag with 25 kg content;
- Clay plug material: type Mikolit 00, : bag with 25 kg content;
- Reservoir tube with perforated section (slot size 0,4 mm), length 100 cm, a reservoir section of 50 cm, with a glued tip at the bottom end; total length 285 cm, $Ø_{int}$ 4,5 cm, $Ø_{ext}$ 5,0 cm;
- External tube: length 300 cm; $Ø_{int}$ 5,2 cm, $Ø_{ext}$ 6,0 cm (PVC, impact resistant, yellow);
- Sealing caps for reservoir tubes (HDPE, 50 mm);
- PE hose/tube: $Ø_{int}$ 4 mm, $Ø_{ext}$ 6 mm;
- Peristaltic pump;
- Lifting jack (dompbok), lever and chain;
- Sounding lead;
- High pressure water cleaner.

PROCEDURE / WORK METHOD

A **Position of sampling point**

- Proceed to sampling point, using location map with marking of locations. If the position of the sampling Point was not established yet, determine position of the sampling point use Work Instruction *BW-W-021* [5].
- If, for some reason, one has to deviate from the point marked on the map, indicate deviated point on the map and record reason for deviation.
- Remove turf, using spade. Keep turf separate, for replacing after sampling. On arable land drilling can start immediately.
- Put piece of plastic next to borehole, to display material drilled.

Depending on the monitoring sub-project (sand, clay or peat) a selection has to be made of one of the following sampling methods.

B **Sampling in sand; install sampling nozzle according to open borehole method**

This method can be used if the soil material in the groundwater-saturated zone is sufficiently loose (not-compacted) to cause spontaneous slumping of the borehole. The method also requires a swift and profuse influx of groundwater. The above conditions apply primarily apply to sandy soils, but may also be applicable for some clayey soils.

- Drill with 7 cm or 10 cm diameter auger a hole to a depth of 30 cm (just below the arable soil).
- Install collar in the hole, fully protecting the hole from entering of loose soil. Ensure that the collar protrudes from the surface, facilitating removal after sampling.
- Continue drilling with a 7 cm diameter auger up to a maximum depth of 75 cm below the groundwater level. This depth is reached upon wetting of the first connector cover of the drilling rod. Take into account that in the presence of clay (causing a slower influx of groundwater), the groundwater level may be underestimated.
- Install the sampling nozzle in the borehole and push it, if necessary jerkily, as deep as possible in the hole.
- Often sampling can start within half an hour after installing the sampling nozzle. For sampling methodology, reference is made to section E of this Instruction.

C **Sampling in clay; install sampling nozzle according to closed borehole method**

This method is applicable if the soil material in the groundwater-saturated zone is sufficiently stiff (compacted) to resist spontaneous slumping of the borehole. This condition is usually found in clay soils.

- Drill with a 7 cm diameter auger up to a maximum depth of 75 cm below the groundwater level. This depth is reached upon wetting the first connector cover of the drilling rod. Take into account that in an increasing clay content may slow down the influx of groundwater, resulting in a possible underestimation of the groundwater level. An indirect indicator for the depth of the groundwater is the ditch water level. A second indicator is the presence of tile drains. If present, the depth to be drilled is usually tile drain level minus one meter.
- Install the sampling nozzle in the borehole and push it, if necessary jerkily, as deep as possible into the hole.
- Pour filter gravel around the sampling nozzle, up to a depth of about 50 cm above the top of the perforated section.
- Pour on top of this filter pack a 20 to 30 cm thick layer of clay granules.
- Fill in the remaining borehole with lumps of clay from the drilled material. This clay serves to prevent an inflow of water from the surface.
- In the presence of cattle the sampling nozzle may be topped just below ground level. Make sure that the tube within the nozzle is not damaged. Seal the borehole with a paving stone.
- When all sampling points on a farm are equipped with a sampling nozzle (or alternatively at the end of a day) a boreholes and sampling nozzles should be pumped clean.
- Connect the tube in the sampling nozzle to the suction-side of the peristaltic pump.
- Start the peristaltic pump and remove, through the nozzle, all water present in the borehole.
- Leave the sampling points to recover for 1 to 7 days (because of slow influx of water in clay soils), before points are sampled.
- Reference is made to Work Instruction BW-W-015 for the sampling procedure

D **Sampling in peat; install sampling nozzle according to 'Peat' method**

- Drill with a 7 cm diameter auger up to the top of the peat.
- Continue drilling with a Van der Horst or Edelman auger up to about 1.5 m below the groundwater level. The Van der Horst auger is less sturdy than the Edelman auger. Therefore, beware of encountering hard lumps of peat or non-decayed branches of remains of trees.
- If so required, clean the borehole with a bailer until the slush has more or less gone.

- Slide a reservoir tube inside the external tube and install the combination in the borehole.
- Press both tubes in the borehole up to the correct depth. The correct depth is reached when the top of the perforated section of the reservoir tube is just below groundwater level.
- Remove the external tube. Avoid smearing and clogging the slots in the perforated section of the reservoir tube, by avoiding its rotation or upward movement.
- Record time and date of installation.
- Close the hole around the reservoir tube with e.g. the turf or some of the drilling material, in order to prevent the inflow of surface water.
- Measure (with sounding lead) and record (in cm) the distance between the top of the reservoir tube up to surface level.
- Close off the reservoir tube with the designated sealing cap.
- After installation of the reservoir tubes or at the end of the day of installation, and prior to pumping the tube for flushing purposes, the water level in the reservoir tube is to be measured using a sounding lead.

  In case insufficient water has entered the reservoir, the sampling point location may be shifted after consultation with the fieldwork supervisor (operational manager) or fieldwork coordinator (network manager).
- Empty the reservoir tube by pumping, using a peristaltic pump and 2.5 m hose (PE 4/6 mm). Special attention should be given to removing the mud from the tube's reservoir part.

  In case the inflow of water exceeds the pumping rate, pumping is to continue for 5 minutes at maximum capacity.
- Note the time of pumping.
- At least one day after installation should elapse before the reservoir tubes can be sampled. Prior to sampling, the water level in the reservoir tube should be measured using a sounding lead.
- Reference is made to section E for implementation of the water sampling.

E **Sampling of groundwater**

- Couple the hose of the sampling nozzle with the suction side of the peristaltic pump.
- Remove by pumping (flush) a certain amount of groundwater (depending on the sampling method selected; see table below). In case the water is visibly clean (void of silt particles) pumping can be stopped.

Table A7.2 Minimum amount of groundwater to be pumped for flushing for the different sampling methods

Sampling method	**Volume to be pumped**
Sand	≥1000 ml
Clay	≥100 ml[1]
Peat	≥100 ml[1]

[1] The borehole tube or reservoir tube has already been flushed after installation. Therefore flushing can be limited to a smaller volume. Applying these minimum recommandations the PE hose will be flushed at least three times (the volume of the 6/4 PE hose is 13 ml per meter.

- In case the pumped water is not void of silt particles, the above slushing prescription is be repeated (five times at most). Alternatively the fieldwork supervisor or fieldwork coordinator is to be contacted.
- Note down the total volume of water pumped.
- Filter the water in accordance with the relevant work plan, or, in case of outsources work, in accordance with the terms of reference.
- Fill the sampling bottles and seal the same bottles.
- Shut down the pump.

- Decouple the hose of the sampling nozzle from the peristaltic pump, and insert (for the sake of protection) the hose into the sampling nozzle.

F **Conserving and transport of samples**
- Conserve water samples in conformity with Work Instruction BW-W-009.
- Note down the amount (in ml) of acid added per sampling bottle.
- Transport the samples under controlled temperature conditions (cooled) in conformity with Work instruction BW-W-008, to their destination.

G **Follow-up**

- When applying the sand method or clay method, mark/indicate on the sampling nozzle (with the hand) the soil surface level, and pull the nozzle from the borehole.
- Identify the end of the wet part of the nozzle, and measure, using the grade marks on the nozzle, the depth of the water table below the soil surface.
- Measure also the length between the top of the perforated section and the top of the wet part of the nozzle.
- Record both measurements (cm). Round off to the nearest value of 5 or 10 (cm)
- When applying the peat method pull out the reservoir tube from the borehole, for example using the 'dompbok' and lever with chain.
- After sampling, refill the borehole with the material drilled from the borehole at installation. Press intermittently the material in the borehole using the auger. Spread any remaining material and put back in place the turf removed during installation.
- Clean all augers and nozzles used with a brush, and clean water if necessary, and wipe dry the augers to prevent rusting. Clean the used reservoir tubes using a high-pressure water cleaner, paying specific attention to the slots.

A7.3 Sampling of drain water (Instruction BW-W-013)

MATERIAL
- Plan of farms showing all parcels with indication of all drains to be sampled, plus a step-by-step plan, prepared using the 'Bedrijvenbestamd' (farm data base), in accordance with Working Instruction BW-W-021.
- Writing board with protection against rain, and pen or pencil for inedible writing.
- Stopwatch or watch with second hand.
- Plastic measuring jug with 1 litre capacity.
- Spade.
- Pickets and felt-tip pen (inedible ink), to mark drain locations in the field.
- Sampling bottles. Type of bottles, labelling and pre-treatment in accordance with workplan or consignment.
- Data entry form (Form BW-F-002 and BW-F-006), and spare forms, in accordance with sub-project description. This form is prepared using 'Bedrijvenbestand+'.

In case drains discharge below the ditch water level, other requisites are:
- Electronic Peristaltic pump, e.g. electronic 12 V peristaltic pump supplied by Eijkelkamp, with matching battery loader; or a handpump, type Probenahmepumpe 28 (suppliers code E514.1) supplied by Carl Roth. (www.carlroth.nl) with accompanying 500 ml collector bottle.
- PE hose Ø 4/6 mm, 2-4 m long and a PVC tube of 1 m, in which the hose fits.

PROCEDURE / WORK METHOD

A **Selection of drains**

The drains to be sampled (16 in Totaltotal) are spread over the drained parcels of a farm, in accordance with Working Instruction BW-W-021. A proposition for a spread of the drains is marked on the plan. On the basis of the plan, the sample taker looks for suitable drains, and marks those drains (if permission is there) with a picket, numbered in accordance with the original proposition (plan). If necessary, the drains

Subsequently the sample taker prepares a 'step-by step plan'. To this end the sample taker takes off from a recognizable, permanent point on the farm (e.g. a causeway, gate, corner of a parcel, or an other selected drain) towards a selected drain. He/she counts and notes down the number of steps and direction on the designated form.

If for some reason the proposition cannot be followed (for exampled because of no/low discharge drains, or because no drain can be found), the location of this observation point is relocated within the parcel. This new location is identified on the plan, and the step-by-step plan is adjusted. If there is no replacement available within the parcel to be sampled, the sample taker should contact the fieldwork supervisor.

After the first time sampling, the selection of locations made by the sample taker is recorded on the plan and subsequently within the 'Bedrijvenbestand+'. This information is the basis for any future sampling.

B **Pinpointing the time of sampling**

Sampling can proceed if the three following conditions are met simultaneously:

1. The date should be later than the date indicated on the raw data form under 'sampling AFTER';
2. Day other than Friday, Saturday or Sunday;
3. At least 75% of the selected drains (at least 12 drains) produce sufficient discharge.

During frosty weather, drains may still be discharging, while ditches are frozen. The thickness of the ice sheet permitting, a hole may be hewn into the ice to allow the sampling of ditch water in combination with drain water. Note down on the raw data form, under 'particulars', the thickness of the ice cover in centimeters. If the ice sheet on ditches is too thick, only drain water can be sampled, but no ditch water. This condition of frozen ditches should be registered on the raw-data entry forms.

The sampling procedure of tile drains discharging above the ditch water level is presented under C. For sampling of tile drains discharging below the ditch water level, reference is made to section D.

C **Sampling of tile drains discharging above the ditch water level**

- Proceed to the tile drain to be sampled, using the information described under A. Drains to be sampled are normally marked with a picket. These pickets may disappear in the course of time, for example during cleaning of the ditch. If necessary a new picket should be installed.
- If required clear the surrounding of the tile drain with the spade, and clean the bottom, to prevent contamination of the measuring jug.
- Check, using the measuring jug, whether the drain produces sufficient discharge (i.e. at least 0.2 l per minute). If the flow is adequate, use this water to rinse the jug, and subsequently empty the jug. If the tile drain does not produce enough water, or if the drain can not be sampled for some other reasons, while most of the other drains do discharge, an alternative tile drain should be identified on the same parcel.

    ** Note down the number of steps and direction from the drain location originally selected;*
    ** If the relocation is permanent, the new location is to be indicated on the plan of the farm, and the step-by-step plan should be adjusted.*

  The alternative drain should be situated on the same parcel. If no alternative drain is available on the same parcel, the fieldwork supervisor should be contacted.

- Rinse the measuring jug once more, by filling the jug for at least 20%, shaking and emptying the jug.
- Register the time required to collect 1 l of drain water. This gives the discharge rate. Note down this time (in minutes and seconds) under the heading 'discharge measurement'.
- Flush the sample bottles once with the drain water from the measuring jug, by filling the bottles at least a quarter, replacing the lids, and shaking vigorously.
- Empty the sample bottles, refill the bottles completely with drain water from the measuring jug and cap the bottles properly.
- Store the bottles in a cool box.

D **Sampling of tile drains discharging below the ditch water level in clay areas and sand areas.**

When a drain discharges below the ditch water surface, there is a risk of sampling the ditch water instead of the water from the drain. For this reason, as under B, the drain in question should be tested for sufficient discharge. The assumption is made that, if the drain discharges, the pressure is sufficiently high to prevent mixing of ditch water and drain water within the tile drain.

Since there is no simple way of measuring the discharge, this aspect has to be judged visually. If there is discharge, this can be visible on the ditch's water surface (turbulence, disturbance), or silt loosened at the drain mouth may be transported by the drain's discharge into the ditch. If the water is sufficiently clear, discharge from a drain may be detected from the movement of aquatic weeds. An object may be inserted in the water in front of the drain to observe any movement. Sometimes the (deviating odour) of a sample indicates that drain water is sampled. Nearby drains, discharging above the ditch water level may provide an indication of the likeliness of discharge by drains ending below the ditch water level.

In the absence of any of these clues, the procedure for selecting an alternative drain should be followed (described in section C).

- If the flow of a drain is ascertained, the drain data are noted down. A negative value should be used for the depth between the top of the drain and the ditch surface water level. The discharge should be noted as 'N.A.'.
- Insert a PVC pipe of about 1 m length into the tile drain, and insert through this PVC pipe a hose as far as possible into the drain. Under certain circumstances the PVC pipe may not be convenient or required; for example in the case of bends/curves in the drain, or if there is little manoeuvring space at the end of the drain. Leave the material at rest for about 1 minute to allow unsettled silt to flush from the drain. Subsequently, switch on the peristaltic pump or use the hand pump, and flush at a quiet pace about 1 litre. Use this water to flush the measuring jug or collector bottle.
- Fill the measuring jug or collector bottle with drain water and follow the procedure as described under C.

E **Sampling of tile drains discharging below the ditch water level in peat areas.**

When drains, connecting surface drains to a ditch, discharge below the ditch water level, water can be sampled from the surface drain. In that situation, no discharge measurement is possible.

A7.4 Sampling of surface water and ditch water using a modified sampling nozzle in combination with a peristaltic pump (Instruction BW-W-011)

MATERIAL

- PVC-made sampling nozzle with the perforated section (slot size 0.3 mm) of 50 cm length at an angle of 90° related to the remainder of the nozzle (RIVM-design).
- Float for sampling nozzle.
- Secchi disk.
- Measuring tape.
- Telescopic stick/stake; length 2m.
- Backpack or sampling vehicle, such as a Quad.
- PE hose Ø 4/6 mm.
- Peristaltic pump, e.g. electronic 12 V peristaltic pump supplied by Eijkelkamp.
- Sampling bottles in accordance with sub-project description.
- Plan of farm showing all parcels and marking of sites where surface water of ditch water has to be sampled.
- Disposable filters.
- Measuring equipment.

PROCEDURE / WORK METHOD

A General observations

- Proceed to sampling locations, indicated on plan of participating farms.
  If the location of sampling points has not yet been identified, determine positions of sampling points using Working Instruction BW-W-021.
- If, for some reason, no sampling is possible at the site identified, the fieldwork supervisor should be contacted. Mark on the plan the deviated location and note down the reason for the deviation.
- Estimate the width of the ditch or water course at the selected location.
- Measure the difference in height between the water surface and soil surface, using a measuring tape.
- Measure the transparency of the ditch/water course by using the Secchi disk in the centre of the ditch/water course.
- In case the width of the ditch/water course is more than 4m, the disk is submerged at 2 m from the bank, attached to a long pole/stick.
- Always clench the stick at its end, thereby always assuring an identical visual angle.
- Measure at the same time the depth of the ditch/water course (at the centre or at 2 m from the bank), using the Secchi disk or a sounding lead by lowering it to the bottom.
- Observe and record any water flow and its direction.
- Note down and describe any discharge points (except for tile drains) and report these points to the fieldwork supervisor. Relocating the sampling point may be required.
- Estimate the degree of coverage of ditch/water course surface.
- Note any details about the weather during sampling, such as the cloudiness, amount of precipitation and air temperature.

B Sampling

- Suspend the sampling nozzle, if so required with float in the centre of the ditch/water course.
  When the width of the ditch/water course exceeds 4 m, the perforated section of the sampling nozzle is submerged at 2 m from the bank.
- Make sure the perforated part of the sampling nozzle is situated at 30 cm below the water surface.
  If not possible, the perforated section of the sampling nozzle has to be put halfway between the water surface and the bottom of the ditch/water course. Avoid swirling any silt from the bottom.

- Note down the depth of the lowest point of the sampling nozzle below the water surface (standard depth is 30 cm).
- Attach the hose of the sampling nozzle to the suction end of the peristaltic pump.
- Start the pump.
- Pump at least 1 litre of water from ditch/water course. If the water is (visibly) void of any silt particles, pumping can be stopped.
- Repeat the above procedure (not more than 5 times) if the water still contains silt particles. Alternatively, contact the fieldwork supervisor.
- Note down the total volume of water pumped.
- Filter the water in accordance with the sub-project description.
- Fill the sapling bottles and seal these bottles.
- Switch off the pump.
- Detach the hose of the sampling nozzle from the pump, and insert the same in the sampling nuzzling for the sake of protection.

C **Conserving of samples and transport**

- Conserve the water samples according to Work Instruction BW-W-009.
- Note down the amount of conserving acid used (in ml) for each sampling bottle.
- Transport the water samples under cooled conditions, in accordance with Work Instruction BW-W-008

A7.5 Temporary storage and transport of samples (Instruction BW-W-008)

MATERIAL

- Portable cool box.
- Cool box or refrigerator, built-in in fieldwork vehicle, with pre-set cooling temperature of +4 °C.
- Freezer.
- Frozen cooling elements (< -15 °C).

PROCEDURE / WORK METHOD

The Soil and Water Operational Department uses two methods for storing and transporting samples under controlled conditions. The first method is the use of a portable cool box, if so desired, in combination with cooling elements. The second possibility is the use of a cool box or refrigerator, built into the fieldwork vehicle.

A **Temporary storage under controlled temperature conditions**

This aspect also includes the cooled storage of water samples during sampling itself.

- Put the samples in a portable cool box or built-in cool box/refrigerator, immediately after taking a sample.
  The cooling in the built-in cool box or refrigerator should preferably be switched on during travelling towards the farm sampled, producing the required cooling temperature at an earlier stage and for a longer period.
- Make sure that the sampling bottles stand upright and stable, avoiding toppling or breakage.
- If a portable cool box is used, it is recommended to use a number a frozen cooling elements; certainly so if the outside temperature is above 15°C. The cooling elements should preferably be placed on top of the sampling bottles.
- Position the closed portable cool box at a cool, dark location.
  Refrain from putting the cool box in a sunny place. Preferably place it in the shade of a car or a building. Never leave the cool box unattended in the fieldwork vehicle, since the temperature may rise sharply when left in the sum.
- Apply the conservation procedure of water samples within 4 to 8 hours after sampling, in accordance with Work Instruction BW-W-009.
- Transport or dispatch (by courier) the samples a quickly as possible after sampling to the laboratory responsible for testing, or to a refrigerator or cooled space with a constant storage temperature of +4 °C.

- Return any used cooling elements into the freezer.
- Clean and wipe dry the cool box used.

B **Transport of samples**

- The programme uses two methods for transporting the samples to the designated laboratory. Usually the sample taker himself/herself brings in the samples. If this is not possible, for example if the sample taker has to remain on site, the samples are dispatched by courier (TNT) at the end of the day of sampling, packed in a cool box.
- Fill out one consignment note/bill of lading as completely as possible.
- Call the courier (TNT) before 2 p.m. (after sampling and at the same day of sampling) to order the cool box to be collected.

ANNEX 8 Agencies involved in water sampling

Table A8.1 Sampling sub-projects with organisations carrying out water sampling

Period	Programme	Project Code	Contractor
Winter 2006/07	Koeien en Kansen bodemvocht (K&K bv)	EBN06	RIVM
	Koeien en Kansen drains and ditches (K&K dr/di)	EDN06	AB/participating farmer
	Koeiene en Kansen grondwater (K&K-gw)	EGN06	RIVM
	Clay drains and ditches (CL-dr/di)	KDN06	AB/participating farmer
	Clay groundwater (CL-gw)	KGN06	IDDS
	Clay ditches (CL-di)	KSN06	RIVM
	Loess soil moisture (LO-sm)	LBN06	RIVM
	Peat groundwater and ditches (PE-gr/di)	VGN06	IDDS
	Peat ditches (PE-di)	VSN06	AB
	Sand winter drains and ditches (SW-dr/di)	ZDN06	AB/participating farmer
	Sand winter groundwater (SW-gw)	ZGN06	RIVM
Summer 2007	Sand summer groundwater (SS-gw)	ZGZ07	IDDS/Grontmij/RIVM
	Koeien en Kansen (K&K de Marke)	MGO07	RIVM
Winter 2007/08	Koeien en Kansen bodemvocht (K&K bv)	EBN07	RIVM
	Koeien en Kansen drains and ditches (K&K dr/di)	EDN07	AB/participating farmer/RIVM
	Koeiene en Kansen grondwater (K&K-gw)	EGN07	IDDS/RIVM
	Koeien en Kansen ditches (K&K-di)	ESN07	AB
	Scouting market garden vegetables drains and ditches (SVG-dr/di)	GDN07	AB/participating farmer/RIVM
	Clay drains and ditches (CL-dr/di)	KDN07	AB/participating farmer/RIVM
	Clay groundwater (CL-gw)	KGN07	IDDS
	Clay ditches (CL-di)	KSN07	AB
	Loess soil moisture (LO-sm)	LBN07	RIVM
	Loess drains and ditches (LO-dr/di)	LDN07	RIVM
	Peat groundwater and ditches (PE-gr/di)	VDN07	AB/participating farmer
	Peat groundwater (PE-gw))	VGN07	Grontmij
	Peat ditches (PE-di)	VSN07	AB
	Sand winter drains and ditches (SW-dr/di)	ZDN07	AB/participating farmer
	Sand winter groundwater (SW-gw)	ZGN07	IDDS/RIVM
Summer 2008	Koeiene en Kansen grondwater (K&K-gw)	EGZ08	RIVM
	Koeien en Kansen ditches (K&K-di)	ESZ08	RIVM
	Clay ditches (CL-di)	KSZ08	RIVM
	Koeien en Kansen (K&K de Marke)	MGO08	RIVM
	Scouting market garden vegetables groundwater (SVG-gw)	GGZ08	RIVM
	Scouting market garden vegetables ditches (SVG-di)	GSZ08	RIVM
	Peat ditches (PE-di)	VSZ08	RIVM
	Sand summer groundwater (SS-gw)	ZGZ08	IDDS/Grontmij/RIVM
	Sand summer ditches (SS-di)	ZSZ08	RIVM

Table A8.1 (continued) Sampling sub-projects with organisations carrying out water sampling

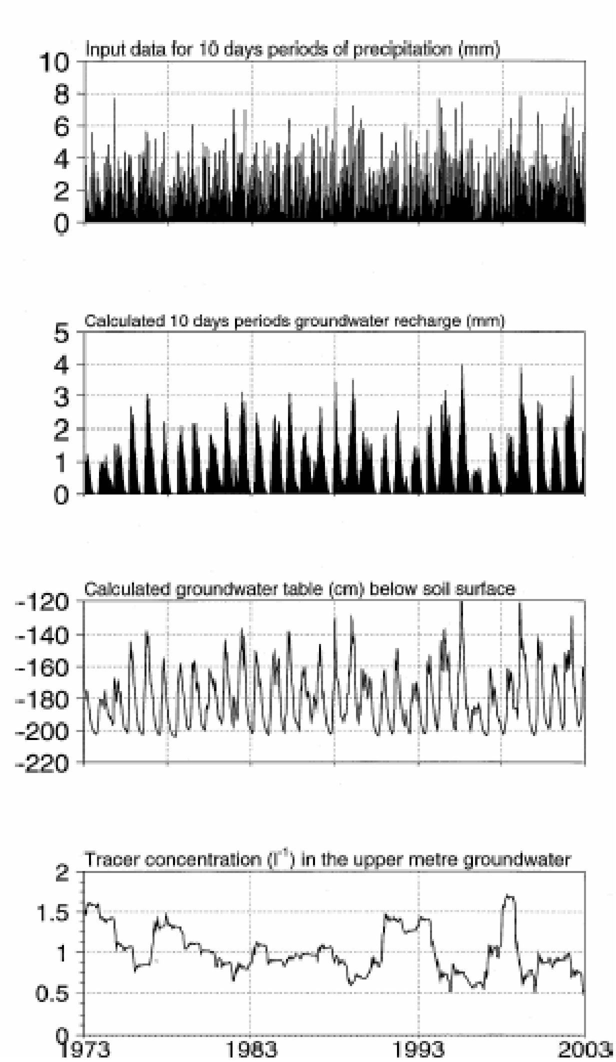
Periode	Progr.	Project Code	Uitvoerder
Winter 2008/09	Koeien en Kansen bodemvocht (K&K bv)	EBN08	RIVM
	Koeien en Kansen drains and ditches (K&K dr/di)	EDN08	CBD/Polychem Intertek
	Koeien en Kansen grondwater (K&K-gw)	EGN08	RIVM
	Koeien en Kansen ditches (K&K-di)	ESN08	CBD/Polychem Intertek
	Scouting market garden vegetables drains and ditches (SVG-dr/di)	GDN08	CBD/Polychem Intertek
	Clay drains and ditches (CL-dr/di)	KDN08	CBD/Polychem Intertek
	Clay groundwater (CL-gw)	KGN08/KGV09	IDDS
	Clay ditches (CL-di)	KSN08	CBD/Polychem Intertek
	Loess soil moisture (LO-sm)	LBN08	RIVM
	Loess drains and ditches (LO-dr/di)	LDN08	RIVM
	Telen met Tokomst drins and ditches (TMT-dr/di)	ADN08	CBD/Polychem Intertek
	Peat groundwater and ditches (PE-gr/di)	VDN08	CBD/Polychem Intertek
	Peat groundwater (PE-gw))	VGN08	Grontmij
	Peat ditches (PE-di)	VSN08	CBD/Polychem Intertek
	Sand winter drains and ditches (SW-dr/di)	ZDN08	CBD/Polychem Intertek
	Sand winter groundwater (SW-gw)	ZGN09	RIVM
Summer 2009	Koeiene en Kansen grondwater (K&K-gw)		
	Koeien en Kansen ditches (K&K-di)	ESZ09	CBD
	Clay ditches (CL-di)	KSZ09	CBD
	Koeien en Kansen (K&K de Marke)	MGO09	RIVM
	Scouting market garden vegetables groundwater (SVG-gw)	GGZ09	RIVM
	Scouting market garden vegetables ditches (SVG-di)	GSZ09	CBD
	Telen met Toekomst grondwater (TMT-gw)	AGV09/AGZ09	RIVM
	Telen met Toekomst ditches (TMT-di)	ASZ09	RIVM
	Peat ditches (PE-di)	VSZ09	CBD
	Sand summer groundwater (SS-gw)	ZGZ09	IDDS/Grontmij/RIVM
	Sand summer ditches (SS-di)	ZSZ09	CBD
Winter 2009/10	Koeien en Kansen bodemvocht (K&K bv)	EBN09	RIVM
	Koeien en Kansen drains and ditches (K&K dr/di)	EDN09	CDB
	Koeiene en Kansen groundwater clay (K&K-gw clay)	EGN09	IDDS
	Koeien en Kansen groundwater peat (K&K-gw peat)	EGN09	RIVM
	Koeien en Kansen ditches (K&K-di)	ESN09	CBD
	Scouting market garden vegetables drains and ditches (SVG-dr/di)	GDN09	CBD
	Clay drains and ditches (CL-dr/di)	KDN09	CBD
	Clay groundwater (CL-gw)	KGN09/KGV10	IDDS
	Clay ditches (CL-di)	KSN09	CBD
	Loess soil moisture (LO-sm)	LBN09	RIVM
	Loess drains and ditches (LO-dr/di)	LDN09	RIVM
	Loess springs and brooks (LO-spring/brook)	LSZ09/LSN09	RIVM
	Telen met Tokomst drins and ditches (TMT-dr/di)	ADN09	CBD
	Peat groundwater and ditches (PE-gr/di)	VDN09	CBD
	Peat groundwater (PE-gw))	VGN09	Grontmij
	Peat ditches (PE-di)	VSN09	CBD
	Sand winter drains and ditches (SW-dr/di)	ZDN09	CBD
	Sand winter groundwater (SW-gw)	ZGN09	RIVM
Summer 2010	Koeiene en Kansen grondwater (K&K-gw)	EGZ10	RIVM
	Koeien en Kansen ditches (K&K-di)	ESZ10	CBD
	Clay ditches (CL-di)	KSZ10	CBD
	Koeien en Kansen (K&K de Marke)	MGO10	RIVM
	Scouting market garden vegetables groundwater (SVG-gw)	GGZ10	RIVM
	Scouting market garden vegetables ditches (SVG-di)	GSZ10	CBD
	Telen met Toekomst grondwater (TMT-gw)	AGZ10	RIVM
	Telen met Toekomst ditches (TMT-di)	ASZ10	CBD
	Peat ditches (PE-di)	VSZ10	CBD
	Sand summer groundwater (SS-gw)	ZGZ10	IDDS/Grontmij/RIVM
	Sand summer ditches (SS-di)	ZSZ10	CBD

ANNEX 9 Laboratory Testing Techniques and detection limits

Component / element	Symbol	Detection Limit	Unit	technique	Relevant SOP number
- Dissolved organic carbon	DOC	0.3	mg/l	infrared (IR)	P509
- Chloride	Cl	0.21	mg/l	ionchromatography	P492
- nitrate	NO3	0.31	mg/l	ionchromatography	P492
- sulphate	SO4	0.48	mg/l	ionchromatography	P492
- nitrite	NO2	0.4	mg/l	photometry/CFA	P483
- electro-conductivity	EC(25)	0.5	mS/cm	potentiometry/CFA	P483
- acidity	pH	n.a.p.		potentiometry/CFA	P483
- ortho-phosphate	PO4	0.04	mg/l	photometry/CFA	P500
- total nitrogen	N-tot	0.2	mg/l	photometry/CFA	P502
- ammonium	NH4	0.064	mg/l	photometry/CFA	P505
- aluminium	Al	0.01	mg/l	ICP-MS*	P515
- arsenic	As	0.2	µg/l	ICP-MS*	P515
- barium	Ba	1	µg/l	ICP-MS*	P515
- cadmium	Cd	0.05	µg/l	ICP-MS*	P515
- calcium	Ca	0.15	mg/l	ICP-MS*	P515
- chromium	Cr	0.5	µg/l	ICP-MS*	P515
- total phosphorous	P-tot	0.05	mg/l	ICP-MS*	P515
- iron	Fe	0.05	mg/l	ICP-MS*	P515
- potassium	K	0.1	mg/l	ICP-MS*	P515
- copper	Cu	0.5	µg/l	ICP-MS*	P515
- lead	Pb	0.2	µg/l	ICP-MS*	P515
- magnesium	Mg	0.05	mg/l	ICP-MS*	P515
- manganese	Mn	4	µg/l	ICP-MS*	P515
- sodium	Na	0.2	mg/l	ICP-MS*	P515
- nickel	Ni	0.5	µg/l	ICP-MS*	P515
- strontium	Sr	1	µg/l	ICP-MS*	P515
- zinc	Zn	4	µg/l	ICP-MS*	P515

ANNEX 10 Correction of water quality for weather effects

The nitrate concentration of the upper groundwater shows fluctuations. These fluctuations cannot be explained by variations in the agricultural practices 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 primarily caused by greater dilution due to 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 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 eight 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 recharge, 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 borehole, the weather district, sampling date and 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.

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