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

Minerals Policy Monitoring Programme report 2011-2014

Methods and procedures

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Colophon

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Synopsis

Minerals Policy Monitoring Programme report 2011–2014
Methods and procedures

This report describes the methods and procedures used by the Dutch Minerals Policy Monitoring Programme (LMM) in the years 2011–2014. The LMM provides information on the effects of Dutch minerals policy on agricultural practices and water quality. It plays a role in the accountability and evaluation of the Dutch Fertiliser Law, the European Nitrate Directive and the Dutch derogation of the Nitrate Directive. According to this derogation, the Netherlands has been granted permission under certain circumstances to apply more nitrogen via animal manure than is normally permitted by the Nitrate Directive. It is, however, under an obligation to monitor the effects of the application of larger amounts of nitrogen via animal manure.

Several changes were made in the years 2011–2014 to optimise the monitoring network and to adapt it to changing circumstances. The purpose of this report is to describe all the relevant changes in order to clarify the monitoring methods used.

The RIVM and Wageningen Economic Research (previously known as LEI Wageningen UR) cooperate in the LMM to collect information about agricultural practices and water quality on Dutch farms. Wageningen Economic Research collects financial, economic and environmental data on approximately 450 farms. The RIVM monitors the quality of groundwater, soil moisture, ditch water and/or drainage water on these farms. The participating farms are a representative random sample covering all the soil regions (sand, clay, peat, loess) and farm types (arable, dairy, industrial livestock and other).

Keywords: minerals policy, nitrate directive, water quality monitoring, methods, procedures

Publiekssamenvatting

Landelijk Meetnet effecten Mestbeleid rapport 2011-2014
Methoden en procedures

Dit technische rapport beschrijft de werkwijze van het Landelijk Meetnet effecten Mestbeleid (LMM) in de periode 2011–2014. Het LMM voorziet de Nederlandse overheid van informatie over de effecten van het mestbeleid op de waterkwaliteit en de landbouwpraktijk. Het meetnet vervult daarmee een rol in de verantwoording en evaluatie van de Nederlandse Meststoffenwet, de Europese Nitraatrichtlijn en de Nederlandse derogatie op de Nitraatrichtlijn. Derogatie houdt in dat Nederland, onder voorwaarden, toestemming heeft om meer stikstof met dierlijke mest uit te rijden dan regulier is opgenomen in de Europese nitraatrichtlijn. Een van de voorwaarden is dat de effecten van de een hogere hoeveelheid stikstof uit dierlijke mest worden gemonitord.

In de onderzoeksperiode zijn verschillende wijzigingen doorgevoerd om het meetnet te optimaliseren en af te stemmen op de veranderende omstandigheden. Alle relevante wijzigingen zijn in dit rapport vastgelegd, zodat de gebruikte meetmethoden voor iedereen inzichtelijk blijven.

In het LMM werken Wageningen Economic Research (voorheen het LEI Wageningen UR) en het RIVM samen om informatie te verzamelen over de landbouwpraktijk en waterkwaliteit op landbouwbedrijven in Nederland. Wageningen Economic Reseach verzamelt financiële, economische en milieudata van ongeveer 450 landbouwbedrijven. Het RIVM meet de kwaliteit van het grondwater, bodemvocht, slootwater en/of drainagewater op deze bedrijven. De deelnemende bedrijven zijn een representatieve steekproef van de Nederlandse landbouw, verdeeld over grondsoortregio’s (zand, klei, veen en löss) en bedrijfstypen (melkvee-, akkerbouw-, hokdier- en overige bedrijven).

Kernwoorden: mestbeleid, Nitraatrichtlijn, waterkwaliteit monitoring, methoden, procedures

Contents

Summary

The Dutch Minerals Policy Monitoring Programme (LMM) has a dual role: evaluation monitoring (EM) to assess the effectiveness of Dutch agricultural minerals policy; and derogation monitoring (DM) related to the European Nitrate Directive. This derogation allows the Netherlands a higher maximum permissible load of nitrogen from manure, but one of the conditions of the derogation is that the effects of the application of higher levels of nitrogen are monitored and reported annually. The LMM is a trend monitoring programme that collects information on agricultural practices and water quality on the participating farms. Government policies influence agricultural practices and therefore also fertiliser application and water quality. This report is a follow-up to the 'Minerals Policy Monitoring Programme report 2007–2010' and describes the methods and procedures used by the LMM in 2011–2014. This is the basis of the reports and websites that present the results of the LMM research.

Approximately 340 of the 450 farms included in the EM and the DM programme were selected from the Farm Accounting Data Network (FADN). Wageningen Economic Research collects financial, economic and environmental data from approximately 1,500 farms and registers these in the FADN. These farms are grouped according to farm structure, management type and economic size. The agricultural practice of all farms is described, including the incoming and outgoing flow of nutrients. From the data supplied by the farmers, Wageningen Economic Research calculates the environmental impact of the use of nitrogen and phosphorus. The RIVM organises the monitoring of groundwater, soil moisture, ditch water and/or drainage water. By monitoring ditch water and drainage water it is possible to quantify the nitrogen losses of a farm to surface water. The participating farms are divided into four soil regions (sand, clay, peat and loess) and four farm types are distinguished by the LMM (arable, dairy, industrial livestock and other).

In order to optimise the monitoring network and to adapt to changing circumstances, a number of changes were made in the years 2011-2014. One of the changes is that the soil type regions are now identified by their postcodes instead of by the municipality. This was changed because of the constant reorganisation of municipalities, which caused new borders between the four soil regions in 2011, with the result that some farms were allocated to a different region and therefore also monitored at a different time of year. Additionally, since 2013, the participating LMM farms consist exclusively of EM and DM farms. Special monitoring programmes like 'Cows and Opportunities' and 'Cultivating with a Future' have been discontinued, although the farms participating in these programmes that made use of the derogation are still included in the LMM.

Before the data can be presented and reported, they are checked and analysed. The long-term trends in nutrient concentrations are presented on the RIVM website:

http://www.rivm.nl/Onderwerpen/L/Landelijk_Meetnet_effecten_Mestbeleid/Resultaten/Trends_in_de_nutri_ntconcentraties.

The description of agricultural practices by Wageningen Economic Research can be found on www.agrimatie.nl.

An overview of the LMM monitoring reports, specific reports and scientific publications published by RIVM can be found at: rivm.nl/en/Search/Library. Those of Wageningen Economic Research can be found at: www.wur.nl/en/Research-Results.htm.

Samenvatting

Het Landelijk Meetnet effecten Mestbeleid (LMM) dient twee doelen: Het Basismeetnet (BM) houdt de Nederlandse overheid op de hoogte van de effecten van het mestbeleid. Het Derogatiemeetnet (DM) is nodig om met toestemming van de EU af te wijken van de Europese Nitraatrichtlijn. Aan de derogatie is de opdracht verbonden de effecten van het opbrengen van een hogere hoeveelheid stikstof uit dierlijke mest per hectare te monitoren en jaarlijks te rapporteren. Het LMM is een trendmeetnet dat informatie verzamelt over de landbouwpraktijk en de waterkwaliteit bij het bedrijf. De beleidsmaatregelen van de overheid hebben invloed op de landbouwpraktijk en daardoor ook op het mestgebruik en de waterkwaliteit. Dit rapport is een vervolg op het Minerals Policy Monitoring Programme Report 2007-2010 en legt de gebruikte methoden en procedures van het LMM in de periode 2011-2014 vast. Dit vormt de basis voor de rapportages en websites waar de resultaten van het LMM-onderzoek worden gepresenteerd.

Ongeveer 340 van alle 450 bedrijven voor het Basismeetnet en het Derogatiemeetnet zijn geselecteerd uit het Bedrijven Informatienet (BIN). In het BIN verzamelt Wageningen Economic Research financiële, economische en milieudata van ongeveer 1500 agrarische bedrijven. Deze bedrijven worden gegroepeerd naar bedrijfsstructuur, bedrijfsmanagement en economische aspecten. Van de bedrijven wordt de landbouwpraktijk vastgelegd, waaronder de binnenkomende en uitgaande nutriëntenstromen. Uit de gegevens van de betrokken agrariërs berekent Wageningen Economic Research de milieudruk met betrekking tot stikstof en fosfor. Het RIVM organiseert de bemonstering van grondwater, bodemvocht, slootwater en/of drainagewater. Door de bemonstering van slootwater en drainagewater kunnen ook de stikstofverliezen naar het oppervlaktewater in kaart worden gebracht. Door gestratificeerde selectie wordt er voor gezorgd dat de bedrijven evenwichtig over de verschillende grondsoortregio's en bedrijfstypen verdeeld zijn. De betrokken landbouwbedrijven zijn verdeeld over vier verschillende grondsoortregio's (zand, klei, veen en löss). Daarnaast onderscheidt het LMM vier verschillende typen landbouwbedrijven (melkvee, akkerbouw, hokdieren en overige bedrijven).

In de periode 2011-2014 is een aantal wijzigingen doorgevoerd met als doel het meetnet te optimaliseren en af te stemmen op de veranderende omstandigheden. Zo is gekozen om de hoofdgrondsoortregio's per postcode af te bakenen in plaats van per gemeente, omdat door voortdurende reorganisaties de gemeentegrenzen steeds werden verlegd. Hierbij ontstonden in 2011 nieuwe grenzen tussen de grondsoortregio's en werden soms bedrijven bij een andere regio ingedeeld en daardoor in een andere periode bemonsterd.
Een andere wijziging betreft het aantal programma's binnen het LMM. Sinds 2013 bestaat het LMM-bedrijvenbestand vrijwel uitsluitend uit BM- en/of DM-bedrijven. Speciale programma's binnen het LMM, zoals 'Koeien en Kansen' en 'Telen met toekomst', zijn stopgezet. Bedrijven uit deze programma's die derogatie gebruiken, zijn nog wel als DM-bedrijf in het LMM aanwezig.

De verzamelde data worden voorafgaand aan de presentatie en rapportage gecontroleerd en geanalyseerd. De langjarige trends in de nutriëntenconcentraties worden gepresenteerd op:
http://www.rivm.nl/Onderwerpen/L/Landelijk_Meetnet_effecten_Mestbeleid/Resultaten/Trends_in_de_nutri_ntconcentraties

De resultaten voor de landbouwpraktijk worden gepresenteerd door Wageningen Economic Research op: www.agrimatie.nl.

Een overzicht van de reguliere rapporten, specifieke onderzoeken en wetenschappelijke publicaties die gepubliceerd zijn door het RIVM kan gevonden worden op:
www.rivm.nl/Onderwerpen/L/Landelijk_Meetnet_effecten_Mestbeleid.
En voor Wageningen Economic Research op:
http://www.wur.nl/nl/Expertises-Dienstverlening/Onderzoeksinstituten/Economic-Research/Landelijk-Meetnet-effecten-Mestbeleid.htm

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 in the Netherlands.

The objectives of the LMM are multiple. Originally, the programme was set up to monitor the impacts of the government's agricultural policies on farm management practices and on the water quality on farms. Now, the programme also serves as an instrument to meet the monitoring requirements imposed by the EC (Nitrate Directive and derogation decision, 2005). In addition, LMM data are used to provide scientific support for mineral use standards, to study and assess the relationship between nutrient use and water quality, and for other purposes.

1.2 Agricultural policies and the role of the LMM

Agricultural production in the Netherlands has increased sharply since the 1950s. Key to this production increase were mechanisation and the use of (artificial) fertilisers and pesticides in crop production and feed concentrates in livestock farming.

This intensification of agricultural production has resulted in significant environmental impacts (on air quality, soil and (ground)water). In the 1980s, the Dutch government started formulating and implementing policies and measures to reduce emissions of nutrients from agriculture into the environment. The LMM was initiated in the late 1980s to assess the effectiveness of government policies in limiting the impacts of agricultural emissions on groundwater quality. It should be noted that the origins of the LMM predate the Nitrate Directive or Water Framework Directive.

Annex 1 presents a more detailed 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 (among others use of nutrients) and thereby reduce emissions to groundwater and surface waters.

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

For data reporting, the LMM currently distinguishes four principal soil type regions ('regions' for short) and, depending on the region, three principal farm 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 distinguished	**Farm types distinguished**
Sand region	Dairy farms
Clay region	Arable farms
Peat region	Other farms
Loess region	Industrial livestock farms

Farms are the basic units for monitoring and are selected via stratified random sampling. The principal parameters for stratification are farm type, size of farm and geographical position, expressed in terms of region. These three parameters lead to different strata. These aspects will be explained in more detail in Section 2.

The LMM aims to cover the principal agricultural sectors (in terms of the area they cover) in the Netherlands by using stratification in the selection of farms, with the aim of providing 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 farms per stratum.

The LMM collects a wide range of data related to agricultural management practices and nutrient management. In addition to financial and economical results, the participating farms 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 impact of each participating farm can be assessed. Important indicators in this respect are nitrogen and phosphorous surpluses in the soil balance.

Water quality monitoring takes place by sampling the water leaching from the root zone, ditch water and surface drains. Water leaching from the root zone is investigated by sampling (a) the upper 1 metre of the groundwater, (b) soil moisture or (c) water from subsurface drains. Figure 1.1 gives a schematisation of the different sampling types.

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

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

The LMM comprises two main activities. The major activity of the LMM is data collection, processing and validation. The other activity is data analysis, evaluation and reporting.

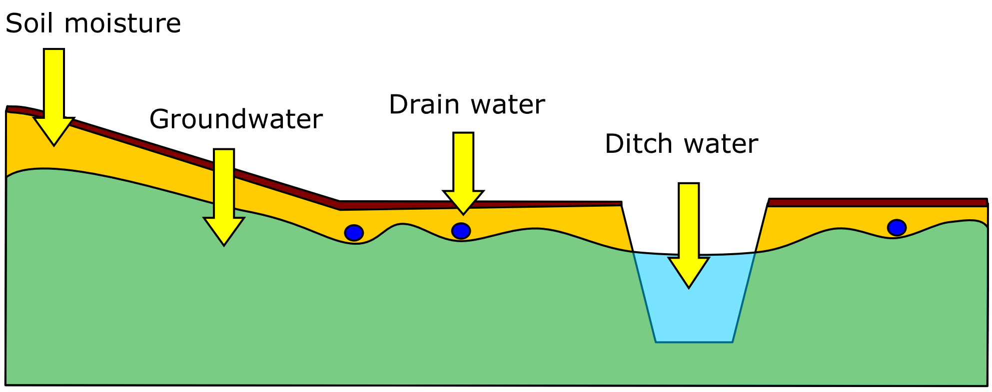

Figure 1.1 Schematisation of the different sampling types: soil moisture, groundwater, drain water and ditch water

1.4 Organisations involved in the LMM

Wageningen Economic Research is responsible for collecting and evaluating data on farming practices and nutrient management.

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

The LMM is implemented under the authority of, and financed by, the Ministry of Economic Affairs.

1.5 Objective of the report

This report is a background document for the LMM as implemented during the period 2011–2014. It intends to record and present information on the programme's principles, assumptions, methodology and procedures.

The report covers water quality monitoring during the years 2011–2014 and the monitoring of agricultural practices during the period 2010-2013 (FADN years). It is assumed that farm management practices during year X will affect water quality during year X + ½, + 1 or + 1½ (and later). This varies with the region and season:

- Peat, clay, sand (winter): X + ½
- Peat, clay, sand (summer): X + 1
- Loess: X + 1½

The results of the LMM are published in other reports and on the relevant websites (see Section 4.3.2).

1.6 Reading guide

This report is structured as follows:

- Section 2: description of the LMM in terms of its set-up and composition;
- Section 3: description of the methodology and planning of data collection activities;
- Section 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 from 2011

In line with the different LMM objectives, data evaluation is carried out in separate sub-programmes.

During the previous reporting period, 2007–2010, the LMM programme was divided into four sub-programmes:

- Evaluation Monitoring (EM) or long-term regular trend monitoring: 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 was to assess the effectiveness of agricultural policies.
- Exploratory Monitoring (VM): to assess the potential impacts on water quality and farm practices of future policy options (ex-ante evaluation). This sub-programme comprised research programmes such as 'Cows and Opportunities' (K&K), which focused on dairy farming, and 'Cultivating with a Future' (TmT), focusing on arable farming.
- Derogation Monitoring (DM): monitoring to meet the requirements of the EU derogation decision. DM has the same objective as EM, but is targeted at grassland farms registered for derogation, which are allowed to apply up to 250 kg nitrogen per ha from grazing animal manure. Of the farms registered for derogation, 300 farms were monitored. DM included so-called reference monitoring (RM), focusing on farms with relatively limited manure use. RM was set up in support of a new derogation application for period 2010–2013. After derogation was granted for this period, in 2010, RM was discontinued.
- Monitoring of specific combinations of 'farm type–region', which were not adequately addressed in other LMM sub-programmes. Examples were:
    - UM sub-programme: monitoring of impacts on soils prone to leaching (dry sandy soils and loess soils);
    - SVZ network: scouting outdoor market gardening crops in the sand region;
    - Extension of the number of arable farms within the LMM, in order to monitor more accurately the leaching of the nitrogen surplus on arable farms.

Since 2011, only EM and DM have been active. The other sub-programmes were discontinued for financial reasons, but the activities and results from them were reported and archived, so questions concerning these programmes can still be answered.

The sub-programmes EM and DM are described in more detail in Sections 2.2 and 2.3. Each programme is defined to meet specific policy requirements or monitoring needs, and data collection is organised differently (see Section 3).

In addition to the cancellation of some of the sub-programmes, other changes in the years 2011–2014 were:

- Implementation of new regional borders;
- Phasing-out of 'North Frisian Woodlands' (NFW) and 'Caring Dairy' (CD) dairy farms;
- Inclusion of more arable farms in the Southern sand region;
- Decrease of monitoring frequency for surface water;
- Groundwater bodies, distinguished in the Netherlands within the framework of the Water Framework Directive (WFD), are not used for stratification of the DM anymore.

The implementation of new regional borders is explained in Section 2.1.2. The (de)selection of farms is discussed in Section 2.1.3. The new DM stratification will be outlined in Section 2.2.3 and the new monitoring frequencies will be given in Section 3.2.

2.1.2 *New regional borders for water quality and agricultural practice data*

In September 2011, a number of changes to the LMM region boundaries were made, following a recommendation by the LMM Feedback Group and principals. Under the proposal, the allocation of a farm to a particular region would be based on the postcode of the farm's address; in other words, it would no longer depend on the predominant soil type in the agricultural section of the relevant municipality, but on the predominant soil type in the agricultural section of the postcode district. The advantage of this new system is that regional boundaries no longer change as municipalities merge and municipal boundaries are rearranged. The new regions are defined on the basis of the predominant soil type per postcode. Fragmentation has been avoided as far as possible. The new system has resulted in changes to the boundaries of the sand, clay and peat regions (see Figure 2.1). The boundaries of the loess region remained virtually unchanged. A new district called 'Dune Areas and Wadden Sea Islands' (Area 14) has been created.

The new regional boundaries have resulted in some farms being 'moved' to another region (see Table 2.1). The results from farms transferring from one winter sampling programme to another have changed little. However, farms transferring from a winter sampling programme to a summer programme, or vice versa, have undergone changes in sampling intensity and frequency. That also implies that older data from a moved farm might not be used anymore in the reporting, as farms switching from winter to summer programme will not have results in the reported season.

Table 2.1 Number of farms moved to another region due to the implementation of the new regional boundaries (LMM14)

Regional borders LMM13		Regional borders LMM14	
Region	**No. of farms**	**Region**	**No. of farms**
Clay	7	Sand	6
		Peat	1
Peat	11	Clay	9
		Sand	2
Sand	16	Clay	14
		Peat	2

The new regional boundaries were introduced in summer 2012 with retroactive effect for all years. They also apply to farms that no longer participate in the LMM programme. This means that historical data sets have been recalculated.

See Hooijboer et al. (2013: appendix 8) for an analysis of the impact of the revised boundaries on the presentation of the results of the derogation network.

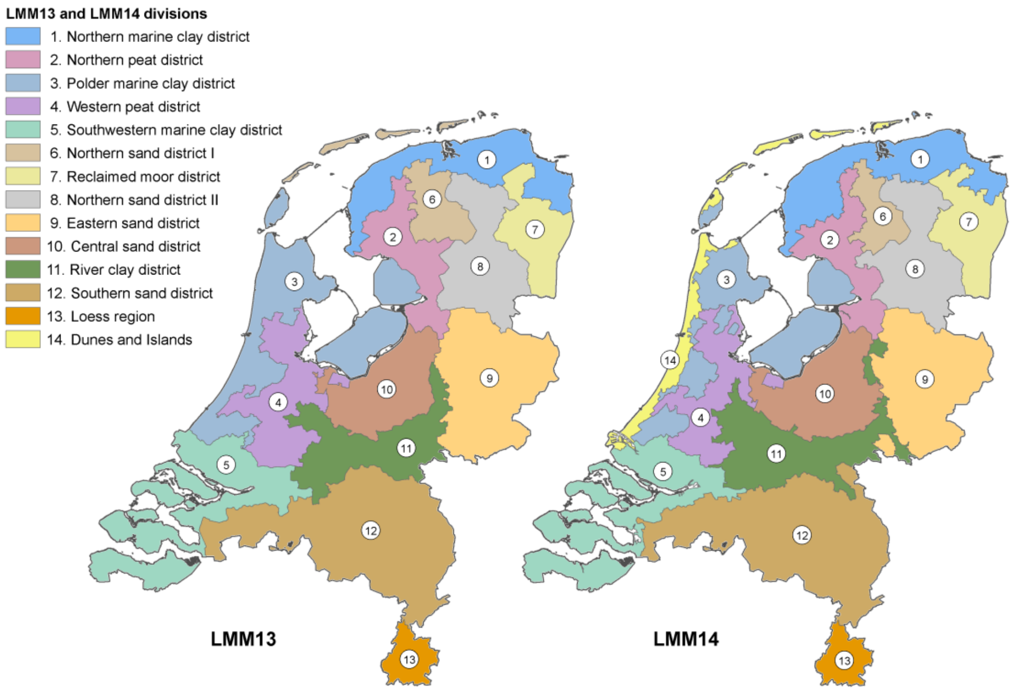

Figure 2.1 Old district boundaries (LMM13) and new district boundaries (LMM14)

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 the LMM are, as far as possible, recruited from the Farm Accountancy Data Network (FADN), a network operated by Wageningen Economic Research, which gathers detailed financial, economic and environmental data from about 1,500 agricultural and horticultural farms. The farms selected for inclusion in FADN are a stratified random sample of all the farms covered by the annual national Agricultural Census. Stratification uses two principal variables: farm type (based on the NSO classification) and economic size (see Annexes 2 and 3). FADN represents about 95% of the total agricultural production in the Netherlands. Poppe (2004) describes the background to and history of FADN in detail.

The LMM uses 'soil type area' as the third stratification variable. Furthermore, it puts minimum limits on the spatial extent of the farms selected (≥ 10 ha) and on their economic size (≥ € 25,000 standard output). Although two of the stratification variables (farm type and economic size) are identical in FADN and the LMM, the criteria applied to the variables differ. For DM, additional selection criteria are applied. Annexes 2 and 3 elaborate on the stratification variables applied in FADN and the LMM.

Fourteen soil type districts make up the four main regions distinguished in the LMM: seven in the sand region, four in the clay region and two in the peat region (Figure 2.2). 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 farm type in a certain region depends on the extent of agricultural land occupied by this type. Farm types that cover only 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 per farm type differs, but remains constant in time. These numbers are defined at the start of a sub-programme, taking into account vulnerability to leaching, the relative importance of the type of exploitation/farm type and the required/desirable number of farms from a policy or statistical perspective (Fraters and Boumans, 2005).

Figure 2.2 Regions with soil type districts distinguished in LMM

In the reporting period 2011–2014, the following general guidelines were used for selecting and recruiting LMM farms:

1. *Overlap between sub-programmes*. Farms already participating in the sub-programme EM are utilised (if registered for derogation) to the extent possible in constituting and maintaining (e.g. for replacement of 'drop-outs') the research sample in the sub-programme DM. Due to this overlap, the information gathered at one farm may be used for more than one sub-programme.

2. *Sequence of recruitment*. In selecting and replacing farms, priority is given to an optimal research sample for EM, followed by DM.
3. *Minimum rotation.* The strategy for the monitoring period 2011–2014 (FADN years 2010–2013) 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 replaced only if the farm no longer meets the criteria in place, or if the owner chooses to cease participation. The aim of a stable research sample notwithstanding, an annual replacement of about 20 to 25 farms has proved to be inevitable.
4. *Maximum utilisation of FADN potential.* While in the past (prior to 2006) the selection of LMM farms focused on farms recently added to FADN, all farms within FADN are now considered as potential LMM participants. An early starting date within FADN or earlier participation in LMM is no impediment to LMM participation.
5. *Additional selection takes place only if FADN is insufficient.* If FADN cannot provide enough LMM candidates, additional farms are selected outside FADN.
    - Additional farms for the EM and DM sub-programmes are then selected by stratified random sampling from the Agricultural Census, applying the relevant sample criteria.
    - Fifteen dairy farms in the DM sub-programme were not selected by random sampling. These farms were approached because of their participation in ongoing research project 'Cows and Opportunities' (K&K).
6. *Inclusion in FADN of additionally selected LMM farms.* All recruited LMM farms are included in FADN (i.e. those supplementary to the 1,500 regular FADN farms are added) so that all agricultural practice data are collected.

2.1.4 Farm types for reporting purposes

The initial focus of the LMM and its predecessor was on the sand region. In the course of the 1990s, the clay region and peat region were included in the programme. Finally, at the turn of the century, the loess region was added to the programme. Prior to 2006, the LMM combined the results from the loess region with those from the sand region. Since then, the LMM has presented and reported on the loess region as a separate region.

The LMM started by monitoring dairy farms and arable farms. In the course of the 1990s 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 into the LMM. Only in the sand region are industrial livestock farms reported as a separate farm type.

The LMM reporting categories (combining region and farm type) are not identical to the strata used for the selection of farms. The reporting of results is done at a higher aggregation level. The Netherlands standard output (NSO) classification farm types, used in farm selection, and the corresponding reporting categories are listed in Table A3.5 of Annex 3.

The farm types distinguished in the 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 the LMM, limited heterogeneity within the farm type is important. A more homogeneous farm type allows a smaller sample size to be used. In all four regions, dairy farms represent a considerable proportion of total land use. In the peat region, the dominance of dairy farms is such that the LMM merely focuses on dairy farms. Figure 2.3 shows the reporting categories in terms of region and farm type for the EM and DM sub-programmes.

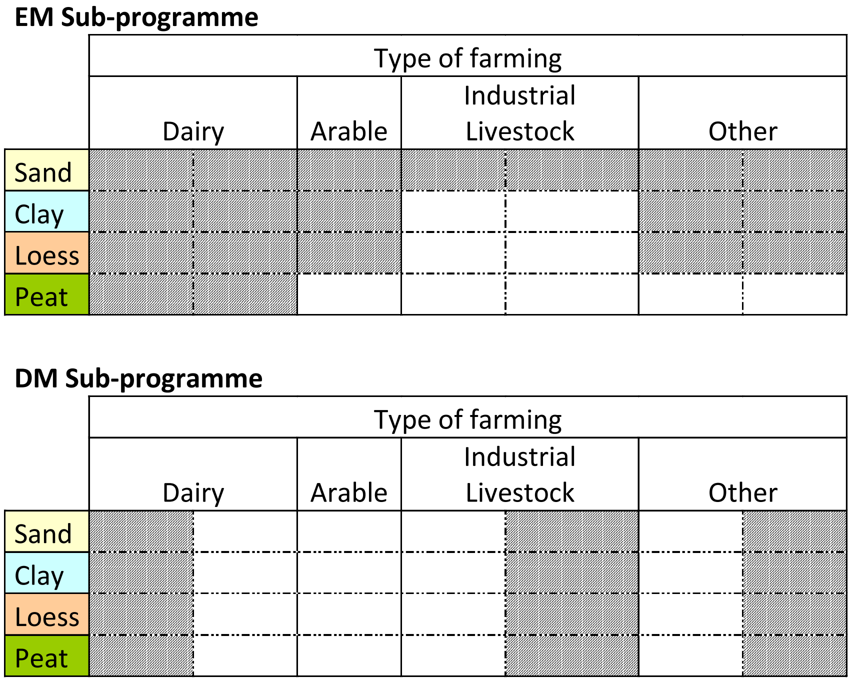

Figure 2.3 Scope of sub-programmes with respect to farm types (simplified). The farm types reported on in the different sub-programmes are hatched. The farm types 'Dairy', 'Industrial Livestock' and 'Other' are divided in two, to address the fact that some EM farms participate in the DM programme as well.

Figure 2.3 illustrates that EM includes various farm types. DM focuses on dairy farms and covers farms with at least 60% of their area used as grassland, although it also includes 'other farms' that have applied for derogation.

The categorisation and stratification used for the selection of farms for the EM sub-programme is shown graphically in Figure 2.4.

<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 four SO size classes

Figure 2.4 Strata used in LMM selection and farm types (numbered) for EM reporting

2.1.5 *Adjustments to LMM calculation models in FADN*

The Netherlands standard output (NSO) classification is described in Annex 3. It was introduced in 2010 and uses expected average agricultural revenue levels (in euros) that can be achieved with a certain crop (per hectare) or livestock (per head) on an annual basis. The sum of all revenue (the SO per hectare of crop and per head of livestock in a farm) is a measure of a farm's overall economic size, expressed in euros. The previous NEG classification, described in De Goffau et al. (2012a), used standard gross margins (sgm = output + direct payments – costs). In the NSO classification crops or livestock that are produced using more external input than crops or livestock that are produced using less external input, count more heavily than in the NEG classification.

The transition from NEG to NSO did not have a major impact on the LMM samples, and the classification of the majority of the farms remained unchanged. A limited number of farms (with multiple specialisations) were reclassified and fell out of the LMM programme due to the NSO classification. These farms were removed from the project and replaced by other farms.
Although the NSO classification started in 2010, the farms since 2001 have provided sufficient information to use this new classification also

for research purposes for comparing effects of change of classification over earlier years. This is also performed within the LMM project.

2.2 The EM and DM sub-programmes

2.2.1 LMM planning for the period 2011–2014

In 2010 the RIVM and Wageningen Economic Research evaluated the organisation and functioning of the LMM (De Klijne et al., 2010). On the basis of this evaluation, they formulated three scenarios for the continuation of the LMM from 2011 onwards. Each of the three scenarios provided opportunities to reduce costs, but it was the third scenario, where both the reporting obligations to Brussels and national policy needs will be met to a limited extent, that was implemented.

This meant that the sub-programmes Exploratory Monitoring (VM) and Monitoring of specific combinations of 'farm type–region' lapsed. The changes to the set-up of the LMM included a decrease in the number of participating farms and a decrease in the monitoring frequency.

Table 2.2 lists the number of farms that were to be included in the different sub-programmes, divided 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 by changes in the management of farms that cause them no longer to meet the selection criteria for a sub-programme.

The LMM focuses more strongly on the sand region than the other regions (Table 2.2). The reasons for this are the larger extent of the sand region and the higher vulnerability of this region to nitrogen leaching in comparison with the other regions.

Table 2.2 Number of farms originally planned for the different sub-programmes during the period 2011–2014 (FADN years 2010–2013)

	Evaluation Monitoring	**Derogation Monitoring**	**Exploratory Monitoring**
	EM	**DM**	**VM**
Clay	60	60	4
Loess	50	20	1
Peat	24	60	3
Sand	109	160	8
Total	**243**	**300**	**16**

	EM	**DM**	**VM**
Dairy farms	109	261	16
Non-dairy farms	134	39	0
Total	**243**	**300**	**16**

2.2.2 *Evaluation monitoring*

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

EM fully follows the general procedures for the selection and recruitment of farms, as presented in Annex 2.

The selection criteria for farms are as follows:

- Farms must have an economic size of at least € 25,000 standard output (SO);
- Farms must have a minimum area of 10 ha;
- The farm type must correspond to one of those listed in Table A3.4 of Annex 3.

Basically, farms are selected from FADN, using random (stratified) selection, for which 56 strata are applied (14 categories in 4 size classes; see Section 2.1.4).

On a national scale, the research sample of the EM sub-programme represents almost 83% of the area of cultivated land and 46% of the total number of farms in the Netherlands. The area of grassland and arable land covered by the land-use units discerned in the LMM ranges from 79% to 90%. For 'other cultivated land' the coverage (36%) is relatively low (see Annex 3).

Until about 2003, the number of farms sampled annually within the EM was around 100 (the number of participating farms was about three times larger as farms were not sampled each year). With the new monitoring sub-programmes since 2004, additional farms were selected, applying the same methodology as for the EM.

Table 2.3 shows the number of farms selected for each soil type region for the EM programme, the DM programme and the combination of both programmes, and the number of farms outside both programmes.

For the DM programme, all the farms that applied for derogation are counted, regardless of whether they have used the derogation or not. When reporting about the EM, all the suitable farms in the LMM-dataset are selected. Most of the farms that were used for DM also qualify for EM.

Note that the number of farms that were monitored outside both programmes decreased from 41 in 2010 to just 1 in 2013 (see Exploratory Monitoring (VM) in Section 2.1.1).

Currently, for a farm there are three options: it can participate in EM, in DM or in both EM and DM.

Table 2.3 The number of farms selected for each soil type region

	Only EM	Only DM	Both EM and DM	Other	Total
2010*	**129**	**60**	**238**	**41**	**468**
Clay	40	13	62	7	122
Loess	22	3	17	9	51
Peat	7	8	44	0	59
Sand	60	36	115	25	236
2011	**118**	**84**	**220**	**30**	**452**
Clay	40	15	56	6	117
Loess	25	1	18	6	50
Peat	5	23	31	0	59
Sand	48	45	115	18	226
2012	**143**	**34**	**283**	**6**	**466**
Clay	45	3	74	0	122
Loess	31	1	19	0	51
Peat	6	8	51	0	65
Sand	61	22	139	6	228
2013	**147**	**35**	**263**	**1**	**446**
Clay	46	3	57	0	106
Loess	31	1	20	0	52
Peat	5	8	51	0	64
Sand	65	23	135	1	224

* The years are the FADN years (see Sections 2.1.4 and 4.3.1). The groundwater sampling was performed between one-half and one-and-a-half years later, depending on the region.

2.2.3 *Derogation Monitoring*

The DM programme encompasses 300 farms with derogation: 160 in the sand region, 60 in the clay region, 60 in the peat region and 20 in the loess region (Fraters and Boumans, 2005; Fraters et al., 2007). The size of the DM sample is fixed (minimum of 300 farms), having been imposed by EC in the derogation decision. Some of the farms already participating in EM were included in DM. Table 2.3 shows that the number of farms is generally reached in the studied years. However, not all farms applying for derogation will use it in the end and farms might stop participating in the monitoring programme during the year. The number of farms in the sand region constitutes more than 50% of the programme's total, since more than 50% of the area of derogation-eligible farms is situated in the sand region. Moreover, an intensification of the monitoring of agricultural practices on sandy soils was one of the EU requirements for the derogation decision.

Because the derogation decision requires the monitoring network to be representative of all soil types, fertilising practices (manure application practices) and crop rotations, all types of farming using derogation were included. This implies that farm types not represented in EM are eligible for DM. One of the selection criteria for the inclusion of a farm in DM is that it is for at least 60% covered with grassland. Until 2013, the formal requirement for obtaining derogation was that at least 70% of the farm's area consisted of grassland (see Fraters et al., 2007). This difference in percentages is related to a difference in timing of recruitment for the monitoring programme vs. the moment of granting derogation, and different definitions of the farming size by the authorities and LMM. Only farms with derogation are eligible for DM. By definition, farms operating according to organic farming principles apply a maximum of 170 kg N per ha from manure and are therefore excluded from DM.

A limited number of LMM farms consist of multiple farms, according to the administration at the authorities. Some of these 'composed LMM farms' are partly registered for derogation. As long as 'composed farms' are at least 60% grassland, they can be selected for DM. In 2013, a threshold for participating DM farms was established: if the proportion of grassland on a DM farm falls below 50%, participation in DM will be stopped.

For DM, the LMM distinguishes two farm types only: specialised dairy farms and other grassland farms. At the start of the programme, stratification was based on the concept of groundwater bodies, distinguished in the Netherlands within the framework of the Water Framework Directive (WFD). This classification was used until FADN year 2012.

Farms already participating in EM form the basis of DM. New farms from the FADN or, in the case of a lack of FADN candidates, the Agricultural Census supplement this base group.

In summary: most DM farms in the LMM are selected randomly from the FADN or the Agricultural Census, following the previously mentioned criteria. Some derogation farms participating in special programmes (as 'Cows and Opportunities', 'Caring Dairy', 'North Frisian Woodlands'), are incorporated in the DM as well. These are not randomly selected. In the current situation, a total of 112 strata are applied: 2 farm types, 4 size classes, and between 1 and 7 soil districts per region.

In Figure 2.5 the years are the FADN years (see Section 4.3.1). The groundwater sampling was performed one-half to one-and-a-half years later to allow the rainwater to leach to either surface water or groundwater. The FADN year 2014 is incomplete because the loess data of that year are not yet incorporated.

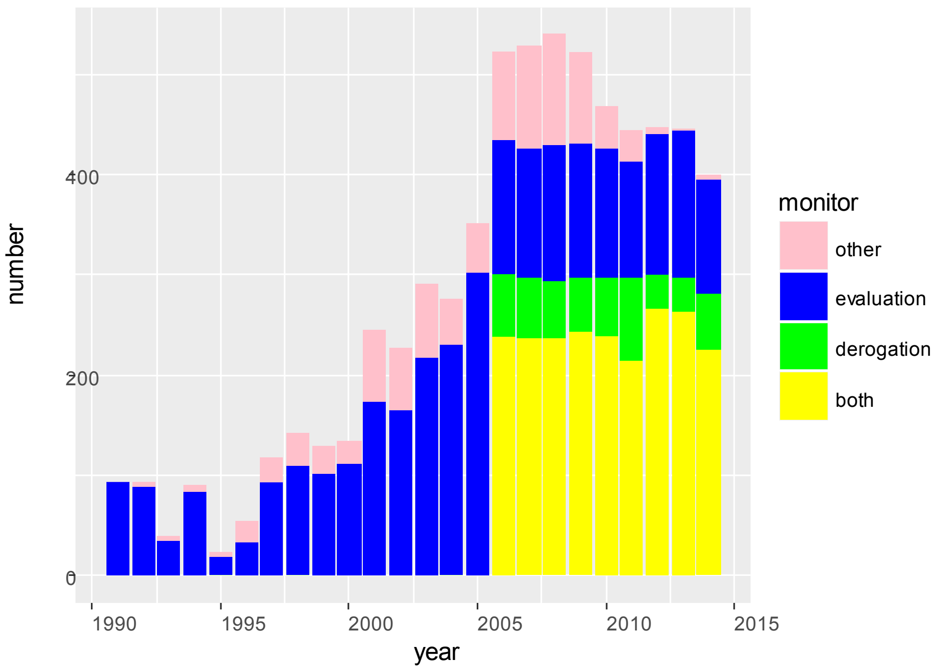

Figure 2.5 Historical overview of the number of farms selected for evaluation and derogation monitoring. The FADN year 2014 is incomplete because the loess data of that year are not incorporated.

2.2.4 LMM overview

Table 2.4 summarises the 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 (see also Annex 2).

Table 2.4 Selection characteristics of the LMM sub-programmes

Sub-programme (min. number of Participants)*	**Criteria**	**Strata**	**Selection mode**
EM (n=243)	• at least € 25,000 (SO) • at least 10 ha • farm type (see Table A3.4, Annex 3)	56 strata (14 categories x 4 size classes)	Fully random selection, from FADN or Agricultural Census
DM (n=300)	• at least € 25,000 (SO) • at least 10 ha • derogation allotted • no organic mode of production	112 strata (2 farm types x 4 size classes x 1–7 soil districts per region)	Random selection from FADN or Agricultural Census, except • 15 farms participating in the 'Cows and Oppor-tunities' (K&K), • 'North Frisian Woodlands' (NFW) and 'Caring Dairy' (CD) dairy farms before they were phased out.

* not taking into account overlap between the sub-programmes

3 Data collection and processing

3.1 Data on agricultural practices

3.1.1 Practical aspects of collecting data on farm practice

Wageningen Economic Research collects and records data on agricultural practices in the Dutch Farm Accountancy Data Network (FADN, see also Section 2.1.3 and Annex 2). Data acquisition follows standard procedures and protocols. There are differences in the range of data that is registered, but these differences are irrespective of the sub-programme or region in LMM.

An administrative technical staff of approximately 45 full-time employees at Wageningen Economic Research are responsible for collecting and registering farm data in FADN. Generally, they have an agricultural as well as an administrative background and so 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 email and telephone and through visits. Personal contact is of the utmost importance if staff are to develop an awareness of the ins and outs of a farm, detailed insights into its characteristics, and a relationship based on mutual trust.

Wageningen Economic Research guarantees participants that data on their farms will be confidential and will not be disclosed or used for tax-collection purposes, but only used anonymously for research purposes. To optimise the efficiency of data acquisition, Wageningen Economic Research utilises electronically recorded data as far as possible, e.g. bank data on payments and expenditures.

The data recording in FADN is extensive, and covers widely diverging aspects of farm management. Wageningen Economic Research staff make an inventory of initial and final stocks, and collect supplementary information on cultivation plans, system of grazing and composition of livestock population, for example. In processing invoices, not only the sums of money involved, but also the type of products/services, the physical quantities and the supplier/customer are recorded. Moreover, to verify the completeness of invoices, these 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, using common principles and standards. All data are recorded centrally and are accessible to researchers only.

In return for their cooperation, participating farmers receive amongst other things a Corporate Social Performance (CSP) report and a comparative assessment report for the relevant farm type. The CSP report contains annual totals (see below) and covers a wide range of sustainability aspects (such as the annual balance sheet and profit/loss account; use of fertilisers, pesticides, energy and water; surpluses or deficits of nutrients on the soil surface balance).

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

On the basis of the data on agricultural practices, a large number of derived indicators are calculated, such as for the application and utilisation of minerals.

Annex 4 lists, per region, the number of farms actually used for data collection.

3.1.2 *Information gathered*

The information collected by Wageningen Economic Research for FADN is wide ranging and very detailed (see Van der Veen, 2006). The farms are grouped according to the following criteria:

- Farm structure (cropped area, cropping plan, soil types, size and composition of livestock population, capacity and characteristics of stables, manure store, etc.);
- Farm management (data on grazing rate, mowing rate, mode and frequency of grassland rejuvenation, use of clover, irrigation, application for and use of derogation, mode and timing of fertiliser application, crop yields, use of concentrates, results of soil tests, fodder consumption, 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 list of data 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 performance analyses such as profit and loss accounts, revenue and profits, credit balance and costs at crop level or product level. On the other hand, it provides technical indicators, such as milk production per cow, the use of minerals in fertiliser and crop yields, and an overview of the average supply and removal of minerals with respect to the soil balance.

For further details of the processing of the corporate information covered in the LMM report, see Section 4.

3.2 Water quality data

3.2.1 *Introduction*

The collection of data on water quality is performed by the following 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 subjected to strict quality control. The RIVM optimises the quality of the work by formulating strict working procedures (to minimise errors), facilitating working conditions as much as possible, and computerising data recording.

3.2.2 *Water sampling*

The method and timing of water sampling is primarily determined by the soil type and the type of water sampled:

- groundwater;
- soil moisture;
- ditch water;
- tile drain water;
- 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 Section 2. The number of samples per farm, the sampling frequency and the method of sampling may differ per sampling sub-project.

Prior to 2004, the LMM focused on water leaching from the root zone. The programme sampled groundwater, water from tile drains and soil moisture. Only in the peat region were ditches sampled. From 2004, the scope was broadened to include the quality of surface water (water in ditches and surface drains) and the number of sampling sub-projects grew (Table 3.1). This development was caused by 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 the quantification of nutrient loss from agricultural land and of leaching into the wider environment ('afwenteling').

Table 3.1 Sampling periods and frequency in the years 2011–2014 (FADN years 2010–2013)

			winter 2010–2011	summer 2011	winter 2011–2012	summer 2012	winter 2012–2013	summer 2013	winter 2013–2014	summer 2014	winter 2014–2015	Sampling frequency (times per season)
Evaluation and Derogation monitoring												
Sand	Winter	Drains and ditches (wet parts)										4 or 3 (arable)
		Groundwater										1
	Summer	Ditches (wet parts)										3
		Groundwater										1
Clay	Winter	Drains and ditches										4 or 3 (arable)
		Groundwater and ditches										2
		Ditches*										2 or 1 (arable)
	Summer	Ditches										3
Peat	Winter	Surface drains and ditches**										4
		Ditches***										3
		Groundwater and ditches										1
	Summer	Ditches										3
Loess	Winter	Soil moisture										1

*) Only farms where groundwater is being sampled – ca. 23 of 105 farms
**) Only farms where surface drains are being sampled – ca. 20 of 60 farms
***) Only farms where surface drains are not being sampled – ca. 40 of 60 farms

Drains and ditches are sampled at the same time if possible. In winter, the interval between the sampling of drains and ditches is three weeks. During summer, the interval between the sampling of ditches is five weeks. A conservative approach is followed, whereby the aim is to sample the same position as the year before. When this is not possible, an alternative procedure or location will be used. Surface drain water and ditch water samples are taken on ca. 20 of the 60 farms in the peat region.
In the sand region, groundwater is sampled in preference to soil moisture. However, when the groundwater level is more than 5 m deep, soil moisture is sampled instead.

At 5% of the farms per region RIVM staff carry out an additional sampling round (‘5th round’), for quality checks of regular sampling.

Since 2011, some changes have been made to the sampling frequency. In the winter, drains and ditches on arable farms (without derogation) are sampled three times instead of four times. The summer sampling of ditches has also been reduced from four to three times. At the same time, the breaks between the rounds in the summer period went to five weeks instead of four weeks.

The last column of Table 3.1 lists the sampling frequency for each of the regions. The periods in which sampling is actually carried out is shown in Figure 3.1. The annual cycle covers about 15 months: from October (year X) until December (year X + 1). An extension to January or February for soil moisture sampling is possible. In the winter, the date when sampling starts in the peat and clay regions depends on the level of precipitation, as sufficient precipitation must have fallen before leaching into groundwater occurs. The sampling of groundwater never starts later than 1 December. The sampling of soil moisture starts in September. Limiting conditions are a temperature below 20 degrees Celsius and no strong rainfall.

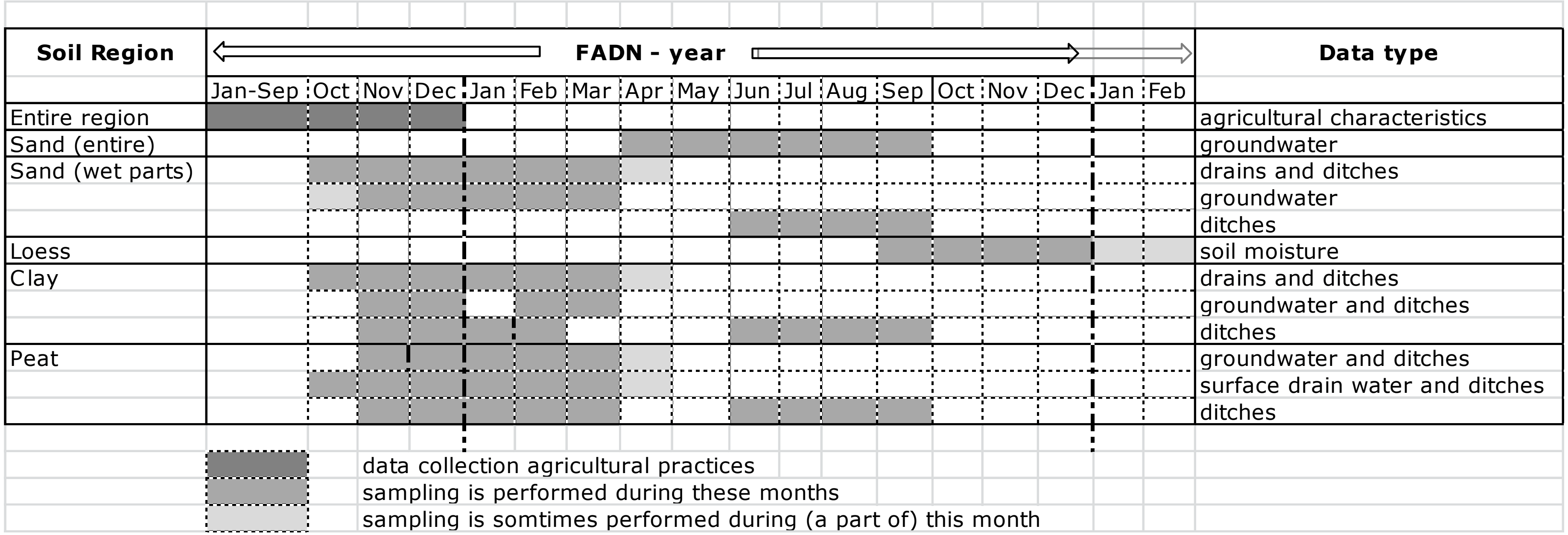

Figure 3.1 Overview of sampling periods, aggregated per region, for the period winter 2010/2011–summer 2014 (FADN years 2010–2013)

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. From this, 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.

Additionally, at some farms the drains are cleared annually in advance of the sampling season.

Sampling methods and procedures
The sampling method depends on the medium sampled. For the sampling of groundwater, the LMM applies different methods depending on the soil type (Annex 5).

Normally, groundwater is sampled from temporary boreholes with or without a screen (depending on the soil type). Water from tile and surface drains is collected in simple jugs. The same method is used for water from ditches when these are sampled separately, but a modified sampling nozzle in combination with a peristaltic pump is used when sampling ditches at the same time as groundwater (this method was used until summer 2014 but was abandoned in winter 2014). Annex 5 provides detailed information on the different sampling methods. Schematic drawings of the different sampling methods are given in Figure 3.2.

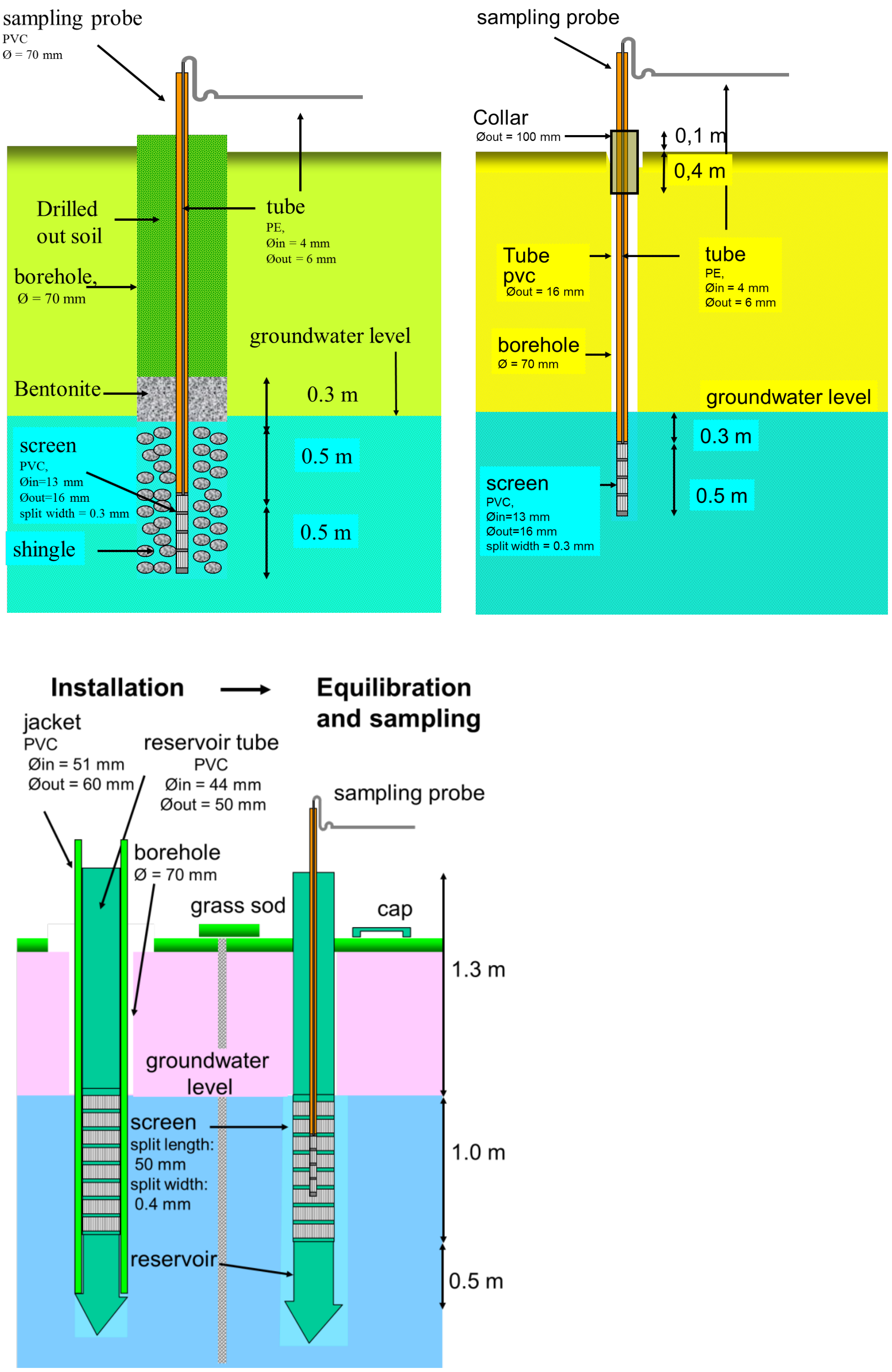

Figure 3.2 Different sampling methods for clay (upper left), sand (upper right) and peat (below)

The water leaching from the root zone (groundwater) tile drains and surface drains is sampled at 16 locations per farm. Water from ditches is sampled at a maximum of 8 locations. The number of samples depends on the number of available ditches type.

Sandy soil, with its coarse texture, is usually quite permeable. Consequently, most of the rainwater surplus infiltrates vertically towards the groundwater. For this reason, samples on sandy soils are normally taken in the top 1 metre of the groundwater. If the groundwater level is more than 5 m below the surface, soil moisture is sampled instead.

Routine (groundwater or soil moisture) 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 (where 25% of a farm's area is drained by tile drains or 50% by ditches), additional sampling is done in winter (Buis et al., 2015a). In those parts, groundwater (or occasionally soil moisture) is sampled once in winter as well, as well as drain water and ditch water 3 (at arable farms) or 4 (at all other farm types) times during winter.

Clay soils are fine grained; usually, they are relatively 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 bodies. In the clay region, the LMM distinguishes drained farms (with tile drains on more than 25% of their area) and undrained farms (less than 25% of the area drained by tile drains).

At drained farms, the LMM samples the drains and ditches (4 or 3 (arable farms) times during winter) (see Figure 3.3). At undrained farms, the LMM samples the top 1 m of the groundwater (2 times during winter) and ditches (4 or 3 (arable farms) times during winter including 2 times during groundwater sampling).

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 also drained towards ditches. For that reason, both groundwater (once per year) and ditch water (4 times per year including once during groundwater sampling) is sampled (Figure 3.5). The LMM samples surface drains at 20 farms, 4 times per year during the winter season. On these 20 farms, the LMM also takes 1 extra ditch water sample during the winter.

In the loess region (where the groundwater table is usually more 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 at a depth of between 1.5 m and 3 m below the surface. The water quality and quantity of the soil moisture are measured in the laboratory.

Since 2008, ditch water has also been sampled during the summer period in the clay and peat regions, as well as in the wet part of the sand region. Since 2011, the number of samples taken has been reduced from four to three.

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, the sampling round and the medium sampled. These pre-printed labels prevent inaccuracies and mistakes in sample identification. If required for conservation purposes, samples are acidified using H2SO$_4$ or HNO_3 (depending on the type of analyses planned). The acids are added to the bottles prior to sampling. All water samples are filtered through 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 is filtered and pre-treated in the field as well (since winter 2014, ditch and groundwater have not been sampled simultaneously). Composite samples of soil moisture are combined in the field. Table 3.2 summarises the sample 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***
Ground-water	• PE • PE • PE	• 125 • 100 • 250	• Yes • Yes • Yes	• Yes (H_2SO_4)* • No • Yes (HNO_3)*	• A • B • C
Drain water	• PE • PE	• 100 • 250	• No** • No**	• No** • No**	A+B+C
Ditch water	• PE • PE	•100 •500 (3-4 samples) •1000 (2 samples) •1500 (1 sample)	• No** • No**	• No** • No**	A+B+C
Soil moisture	• Glass • PE	•720 g for indiv. sample •1,500 g for composite sample	• Not appl. • Not appl.	• No • • No	A+B+C

A: DOC, ortho-phosphate, nitrate, total nitrogen and ammonium
B: chloride, nitrate, nitrite, sulphate, specific conductivity and pH
C: metals and total phosphorus
* The acids are added to the bottles by the supplier
** Filtration and acidification are done in the laboratory

Storage and transport of water samples
The storage and transport of water samples is done in accordance with standard Work Instructions (Annex 5). A portable cool box with cooling elements is used for temporary storage of samples in the field, used during transport between two or more sampling points. After a short interval, the samples are transferred to a fixed or mobile fridge in the fieldwork vehicle.
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 fieldworker is responsible for keeping the samples in a refrigerator at a

constant temperature of +4 °C and a warning temperature lower than +1 °C or higher than +7 °C.

Responsibility for water sampling
The bulk of the fieldwork is outsourced to external parties. The RIVM remains the principal agent with respect to overall planning, first-time visits to new participants, the sampling of groundwater, quality control and executing '5th round' fieldwork (additional control sampling). Annex 6 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 substantial. The number of farm visits (rounds) ranges from 1,883 to nearly 2,000 per year (see Annex 4), and the number of individual water samples taken from roughly 22,560 to 23,400 per year. This results in between 4,300 and 4,545 composite samples per year, for laboratory testing.

Information about water quality for participating farms
After sampling, participants receive a letter report. In addition to the measured parameters on their own farm, the average results of the other farms in the same region are given for comparison.

Figure 3.3 Sampling drainage water

Figure 3.4 Sampling of ditch water using a jug

Figure 3.5 Sampling of groundwater in the peat region. The fieldworker shows a jacket.

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, nitrate and nitrite. The fieldworkers use the following equipment:

- Nitrachek-reflectometer (type 404) for nitrate and nitrite;
- Multimeter WTW Multi 350i with accessory electrodes:
  - WTW Sentix 41 for pH;
  - ConOx for EC, dissolved oxygen and temperature.

Other data recorded in the field are a simple log of the soil layers perforated, the groundwater level and sampling point coordinates. In water samples taken from ditches (ditch water not sampled at the time of groundwater sampling), tile drains, surface drains or soil moisture, no chemical or physical parameters are measured in the field, but only in the laboratory.

Laboratory testing

Until 2012, the RIVM was responsible for testing the water samples using its own laboratory facilities. In 2012, the RIVM's laboratory (people, resources and methods) moved to TNO Applied Environmental Chemistry Laboratory (TNO-AEC). The Dutch accreditation council (RvA) assessed the effect of the relocation on the results. The conclusion is that the relocation has been satisfactorily implemented and that the operations to be accredited are properly carried out by qualified personnel using appropriate resources and facilities. This is recorded in document '2012-10-06 Beoordelingsrapport L026-T01 v2.0'.

Composite samples

Individual samples are transported to the laboratory. A laboratory assistant makes up the composite samples according to field information (output from a hand-held computer). An equal amount of each individual sample is used for each composite sample. The standard method is described in Work Instruction 'het mengen en eventueel filtreren van grond-, drain- en slootwatermonsters' (AC-W-025). However, soil moisture samples are combined in the field instead of the laboratory. Table 3.3 gives a list of possible numbers and types of composite samples per farm.

Table 3.3 number and types of composite samples per farm

	Individual samples	**Composite samples**
Groundwater	16 gw	2 gw
	15-1 gw and 1-15 sm*	1 gw and 1 sm*
maize**	1-16 gw	1 gw
Drain water	16 drw	1 drw
Ditch water	1-4 diw type 1	1 diw
	1-4 diw type 2	1 diw
Soil moisture	16 sm	2 sm
	15-1 gw and 1-15 sm	1 gw and 1 sm

gw groundwater, sm = soil moisture, drw = drain water, diw = ditch water
* only possible for groundwater in the sand region
** extra groundwater samples: (1) where the farm is in the sand region, (2) for dairy farms or crop–livestock combination farms with dairy stock, (3) on plots where maize has been grown for three consecutive years

On permanent maize plots extra groundwater samples are taken:

- If the farm is in the sand region;
- In the case of dairy farms or crop–livestock combination farms with dairy stock;
- If maize has been grown there for three consecutive years.

The maize groundwater samples are put together into a separate composite sample. These individual samples are also used to make a ‘normal’ composite sample representing the entire farm.

Analysis

For each farm and per sampling round composite samples are prepared and tested for a wide range of components. 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:
N-organic = N-total - NO_3 - NH_4 (mg N/l)

Individual samples of ditches, tile drains and surface drains are tested for EC, pH and NO_3 and NO_2.
Samples of soil moisture are tested individually for Cl, NH_4 and NO_3.

Annex 7 gives details of analysis techniques and detection limits.

3.2.4 *Quality control*

Provisions to avoid errors

Because the work in the field is often repetitive, extra efforts have been made to avoid errors. To this end, the following provisions are made:

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

Quality control system

Water sampling fieldwork and the treatment and transport of samples are embedded in a strict quality control system. Elements of this system are:

- Work Instructions for all elements of fieldwork;
- At the start of each monitoring sub-project a kick-off meeting between fieldworkers and supervising staff is held. In addition, several evaluation meetings are held during the year. Usually, fieldworkers visit the head office once a week for new supplies and to discuss progress and programs;

- RIVM staff (fieldwork supervisors and field coordinators) audit the fieldwork, according to a pre-established programme of spot checks; the programme defines the number of spot checks per fieldworker or field team. RIVM staff visit the external fieldworkers once every two or three months and the RIVM fieldworkers once a year. The principal objectives of these field audits are:
  - To verify working methods and ensure that Work Instructions are adhered to;
  - To identify and report on deviations from the work instructions, and to register the wishes and suggestions of fieldworkers;
  - To identify and communicate to fieldworkers actions to correct deviations;
  - To improve the efficiency of fieldwork by evaluating practice and procedures, and adjusting procedures if required.

The laboratory analyses are also embedded in a strict quality control system with Work Instructions and audits. The laboratory is certified.

3.2.5 Data validation

Field staff record, 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 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 test results (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 parameters checked include:

- The value of N-total, which should equal or exceed the sum of N-compounds, measured individually;
- The sum of cations, which, as no bicarbonate is analysed, must exceed the sum of anions;
- The EC (mS/m) measured in the laboratory, which should be in the same order of magnitude as the sum of the cations * 10 (in meq/l);
- The ratio between Na and Cl;
- The concentration of some heavy metals, in relation to the pH;
- Checks on outliers.

In the 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

To locate and describe the farms participating in the LMM, the RIVM uses topographical maps, scale 1:25,000. The planning of the fieldwork also utilises these maps. For the purpose of interpreting the 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 and Schepers, 1998);
- Groundwater regime map (1:50,000) derived from above soil map;
- Map of soils prone to nitrate leaching ('Droge grondenkaart') prepared by Wageningen Environmental Research, which is the outcome of the Government decree 'Besluit zand- en lössgronden' issued in 2001 (Decree to Identify and Define Policies for Soils Prone to Leaching).

To optimise data analysis, each farm participating in the LMM is schematised in a polygon representation, defining individual plots. This is made using auxiliary software (Didger) on the basis of the 1:25,000 topographical maps, and stored in GIS (using ArcGIS). After each monitoring visit, the plot/parcel properties of the farms, such as location and surface area, are checked against the 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.

3.3.2 *Meteorological data*

Meteorological data in the form of 10 day averages 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.

The RIVM uses this meteorological information to apply net precipitation corrections to the water quality data. More detail is given in De Goffau et al, 2012a, Annex 10.

3.3.3 *Information sources related to farm management*

Annual Agricultural Census in the Netherlands

The annual Agricultural Census, which covers all agricultural firms in the Netherlands, describes the structure of the agricultural sector (data on farms, crops grown and animals held/reared). The Agricultural Census, conducted annually by the Netherlands Enterprise Agency (RVO) of the Ministry of Economic Affairs in collaboration with Statistics Netherlands (CBS), can therefore be considered as a complete enumeration.
Data from the census are frequently used in the research work of the LMM. First of all, these data are essential for the purpose of identifying and describing the field of observations (sample population) that is covered by the LMM sample. For example, the Agricultural Census can 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 classes per LMM farm type) are defined annually on the basis of the most recent census data. Moreover, where there are insufficient farms

of a particular farming type in FADN, the selection procedure may draw from the pool of farms in the Agricultural Census.

Netherlands Enterprise Agency (RVO)
The Netherlands Enterprise Agency (RVO) is the agency of the Ministry of Economic Affairs responsible for the implementation of agricultural and nature policy. The Agency 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 Fertiliser and Minerals Policies, the Agency 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 factory farm animals such as pigs and poultry using the 'stable balance').

The RVO utilises a company registration system (Bedrijfsregistratiesysteem: BRS) for gathering information on agricultural farms, whereby a unique BRS number is allocated to each farm covered. This information is important for the LMM research.

The RVO also provides important information and tools relating to manure policies that need to be used to calculate data such as the quantities of nitrogen and phosphorus in livestock manure produced.

Additionally, the data registration in FADN inorporates amongst others the information from the 'base registration of parcels' (BasisRegistratie Percelen; BRP). For each farm, this registration system records annual data on cropped plots (reference date 15 May), and for each cropped plot data are 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, the LMM uses the RVO's annual surveys to identify the farms that have 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 et al., 2015). The WUM comprises representatives from the Ministry of Economic Affairs, Statistics Netherlands (CBS), the Netherlands Environmental Assessment Agency (Planbureau voor de Leefomgeving, PBL), Wageningen University and Research (WUR) and the National Institute for Public Health and the Environment (RIVM).

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

In the day-to-day implementation of the Minerals Policy, dairy farms have to apply different standards for different categories of granivores. Since 2015, the WUM excretions have been the basis for the deviation standards.

For industrial livestock farms animals such as pigs and poultry, the manure production has to be calculated based on a stable balance. From the LMM research, this stable balance cannot be determined for each individual farm and, where information is inadequate to apply the method of stable balances, WUM phosphate excretion defaults are used.

Working Group on National Emission Model for Agriculture (NEMA)
Each year, the NEMA working group calculates emissions to air from agricultural activities in the Netherlands on a national scale. Emissions of ammonia (NH_3) and other N-compounds (NO_x and N_2O) from animal housing, manure storage, manure application and grazing are assessed using a Total Ammoniacal Nitrogen (TAN) flow model.

The NEMA comprises representatives from the CBS, PBL, WUR and RIVM.

In calculations of the emissions to air on farms within FADN, the LMM uses, as far as possible, NEMA emission and TAN factors.

Feed suppliers and research laboratories
Most of the analyses of soil and silage performed in the Netherlands is done by organisations like Eurofins (previously BLGG-agroXpertus). The LMM uses the data from such laboratories in two ways.
The laboratories pass on the results of analyses on soil and silage on LMM farms in digital format to the WER. This procedure facilitates the registration of the results in FADN.
To calculate the farm-specific composition of grass/corn silage, the LMM sometimes uses data published by the laboratories themselves. Where silage is not (fully) analysed, the LMM uses average composition data from laboratories such as Agrofins.

4 Data analysis and data

4.1 Introduction

Information and data deriving from the LMM is disseminated in different ways: via newsletters (paper or digital), (digital) reports, data selection tools and websites.

LMM data are used for many products. The RIVM website provides an overview of the most important frameworks and the related products (www.rivm.nl/Onderwerpen/L/Landelijk_Meetnet_effecten_Mestbeleid/Organisatie_van_het_LMM/Gebruik_resultaten).

The following section describes the data analysis. The presentation of data and the reports are discussed in Section 4.3.

4.2 Data analysis

4.2.1 Data on agricultural practices and mineral management (FADN)

Farms differ in farm management (individual choices of a farmer) and in physical conditions (farm size, hydrology and soil conditions). Section A8.1 in Annex 8 identifies in more detail the indicators of farm dimensions and nutrient management approach.

The LMM reports present and discuss the agricultural practices at participating farms in different ways. The yearly DM report gives insight into the most recent results using unweighted data. In the EM web reports on www.agrimatie.nl, the agricultural practice results of participating farms are weighted and compared with national average values. Both averages are established using a weighting procedure. This section gives a brief description of the procedures.

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

The results for dairy farms (in all regions) and arable farms in the clay, sand and loess regions are published on agrimatie.nl. The bar charts, line graphs and other data are updated annually. The results for the farm types 'other' and 'industrial livestock' are in progress.

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

The agricultural farms covered by the annual Agricultural Census (nearly) represent the full population of agricultural firms in the Netherlands. The 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 600 farms). It should be noted that only part of this research sample is monitored for water quality.

Data on agricultural practice, like those for nutrient 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 are available; only general corporate characteristics from the Annual Census.

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

The weighting process ensures maximum use of the available data. For reasons of reliability, the process not only uses corporate data on farms that are monitored on water quality; all FADN farms that 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 the 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 smaller. In order to draw reliable conclusions, in spite of the limited number of sample farms, Wageningen Economic Research uses a technique to generate additional information.

To generate additional information and to weight the available corporate data, the research sample data are projected onto the available data within the research population. For this purpose Wageningen Economic Research has developed the software tool STARS (Statistics for Regional Studies, see Vrolijk et al., 2005: appendix 1). The 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 with farms in the research population.

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.

Statistical matching uses farm characteristics known for both the research sample farms and the farms in the research population to identify for each farm in the research population a number (three to five) of 'most similar' farms. For this purpose, a distinction is made between characteristics that are identical and characteristics that closely resemble 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 them different weights. All the weights allocated to a sample farm are added up in order to calculate the ultimate weighting factor. 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 weighting the sample results.

4.2.2 *Data on water quality*

Water quality data are normally reported on an annual basis for each water type and farm type. For some combinations of region/water type a distinction is also made between winter and summer.

Aggregating the analysis results to calculate averages

The analysis results from different farms are combined to calculate different averages per group of farms:

- The results for each water type, per round and per farm, averaged to a 'round average' value;
- The round average values aggregated to a 'farm average' value;
- The farm average values averaged to a 'farm type average' or, if desired,
- The farm average values averaged to a 'region average' value, where no distinction is made between farm types.

Minimum number of farms to estimate an average

To determine an average, a minimum of seven farms is required. When fewer farms used both reliability and confidentiality are in a fix. If there are fewer than seven farms in a particular farm type, this group is not represented. However, these farms are used for determining the average of the region (farm type = all).

Dealing with detection limits

The detection limit is the lowest concentration of a substance that still can be measured with the used laboratory equipment. Below this value, the measurement is not precise enough and it therefore cannot be concluded that the substance is present. The concentration is then somewhere between 0 and the detection limit.

Multiple detection limits: use of the highest

If multiple detection limits are reported over the years for a specific parameter per water type, the highest detection limit is used in the calculations. All reported values lower than the highest detection limit are thus considered to be below the detection limit.

Concentrations below the detection limit: equal to 0
The following formula is normally used when dealing with concentrations below the detection limit: corrected concentration = factor * detection limit, where this factor is a value between 0 and 1 (in the rule 0, ½ or 1). In the LMM, in both EM and DM, we generally use the factor 0 (zero). So, if the concentration is less than the limit of detection, the concentration is considered to be zero. If most data are under the detection limit, the calculated average may also be below the detection limit. In that case, the percentage of farms with a value below the detection limit is often reported as additional information.

View in charts and graphs
In tables, percentile values that are lower than the detection limit are shown as '< DT'. Average values below the detection litmit are also reported. The detection limits used, are indicated in the table. In trend charts, where 25% or more of the farms have an average under the detection limit, the limit of detection is shown as a dotted horizontal line in the graph.

Trend determination
- As well as a mere presentation of the parameters measured during a specific year, the long-term trends for the principal nutrients are reported. Long-term trends are presented as:Annual average data as measured, calculated as the unweighted average of the annual farm averages, and
- Corrected nitrogen data, corrected for variations in net precipitation, sample size and sample composition. This method is currently available for dairy farms in the sand and clay regions.

Correction of measured data
To distinguish the effects of government policies on the groundwater quality (notably nitrate concentrations) from the possible impacts of the weather and the sampling distribution, a statistical model is used. This allows the measured data to be 'corrected' for environmental conditions, thereby filtering temporary fluctuations from the long-term trend (see De Goffau et al., 2012a: annex 10).

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 and farming characteristics/farm type). In addition, the model takes into account the prevalence of each farm type in a region.

4.3 Presentation of data

There are some differences in reporting compared with previous years:
- Since 2011, the results of the EM sub-programme have not been included in reports. The data on water quality can be found on the RIVM-LMM website. The results on the agricultural practice can be found on the Wageningen Economic Research website, www.Agrimatie.nl;

- LMM data on water quality derived from the EM sub-programme can be obtained by using the 'Selection' tool on the RIVM website, lmm.rivm.nl.

The next section describes the data selection tools. Sections 4.3.2 and 4.3.3 present the different reports on monitoring results and specific investigations.

4.3.1 *Data selection tools*

Selection tool

As stated above, since 2015 it has been possible to obtain LMM data on water quality derived from the EM sub-programme by using the 'Selection' tool on the RIVM website, lmm.rivm.nl.

Data are presented:
- In tabular form;
- Trend figures;
- Boxplot figures.

Selections can be made by:
- Year;
- Farm category;
- Region type (sand, clay, loess or peat);
- Water type;
- Period (summer or winter);
- Parameter.

It is also possible to export data in CSV format. Results are given per group (region, farm category, water type and period). Only the results of groups with at least seven farms are given.

Data on Agrimatie.nl

Agrimatie.nl gives insight into the people, planet and profit performance of the Dutch agricultural sector. It combines the best available data sources and presents long-term developments on hundreds of indicators of profit (e.g. farm income), people (e.g. spatial quality, animal welfare) and planet (e.g. biodiversity, nutrient uses and losses, and plant health). In short, this website contains all relevant data on Dutch agriculture.

Thanks to interactive charts and clear search and filter functions, visitors can navigate easily through the site. They can also download charts for their own use.

As an example, Figure 4.1 shows the nitrogen soil balance surplus for dairy farms in the Sand region for the period 1991–2014.

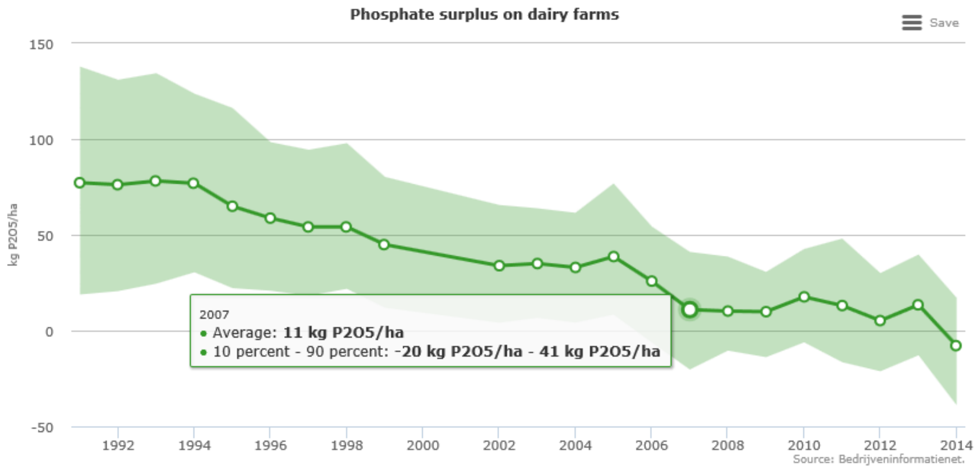

Figure 4.1 Nitrogen soil balance surplus for dairy farms in the Sand region, 1991–2014

4.3.2 *Reports on monitoring results*

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

The results reports often present information for different years combined, with reference to the most recent year of the previous report, which allows an initial comparison of the results between the different years.

In terms of agricultural practices, emphasis is put on the area of agricultural land, classification of farmland, stocking density, milk production, use of organic manure and artificial fertilisers, mineral surpluses and crops yields for grassland and silage maize.

The section on water quality focuses mainly on the nitrogen and phosphorus components:

- Each year, EM water quality results are published on the RIVM website (http://www.rivm.nl/Onderwerpen/L/Landelijk_Meetnet_effecten_Mestbeleid/Resultaten/Basismeetnet). The results for 2011, 2012 and 2013 are currently given, as well as the results of the trend up to 2013. The results for 2014 will be published shortly. Before 2011, these results were published in regular results reports (e.g. De Goffau et al., 2013).
    - Water quality results 2011: http://www.rivm.nl/Onderwerpen/L/Landelijk_Meetnet_effecten_Mestbeleid/Resultaten/Basismeetnet/Waterkwaliteit_2011
    - Water quality results 2012: http://www.rivm.nl/Onderwerpen/L/Landelijk_Meetnet_effecten_Mestbeleid/Resultaten/Basismeetnet/Waterkwaliteit_2012

  - Water quality results 2013: http://www.rivm.nl/Onderwerpen/L/Landelijk_Meetnet_effecten_Mestbeleid/Resultaten/Basismeetnet/Waterkwaliteit_2013
  - Trend results: http://www.rivm.nl/Onderwerpen/L/Landelijk_Meetnet_effecten_Mestbeleid/Resultaten/Basismeetnet/Trends_in_de_nutrintconcentraties
- Each year, the LMM publishes a report on 'Agricultural practices and water quality on farms registered for derogation'. These reports are produced to meet the EC reporting requirements related to the derogation ruling and provide the European Commission with information – monitoring data and model-based calculations – about the quantities of fertiliser applied to each crop per soil type and about the evolution of water quality (e.g. Lukacs et al., 2015, 2016).
- Every four years, the 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 supports 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; Fraters et al., 2016).
- Every four to five years, the LMM contributes to the publication of a report for the ex-post evaluation of the Dutch manure policy act (Hooijboer and De Klijne, 2012). The results are similar to the results of the State Report for the Nitrogen Directive.

Additionally, results reports are produced on specific regions or programmes, such as:
- Minerals Policy Monitoring Programme: 'Overview of the drained soils of the sand region: Agricultural practice and water quality' (Buis et al., 2015, main report and supplementary report);
- 'Water quality on "Cows and Opportunities" farms: Results of ten years of sampling' (Hooijboer and Weijs, 2013);
- Minerals Policy Monitoring Programme: 'The programme in the clay region 1996–2008: Survey report for use in the evaluation of the LMM monitoring programme in the clay region' (Lukacs et al., 2012).

4.3.3 *Specific investigations*
During 2011–2014, specific investigations were carried out. The results of these are not described in this report. Here we provide only a summary of each and a reference to the report in which details can be found:

Effect of filtering on nitrogen and phosphorus in surface water on LMM farms (Vrijhoef et al., 2015)
High concentrations of nitrogen and phosphorus in surface water can have an adverse impact on vulnerable nature and the quality of bathing

water. This RIVM-study shows that the measured concentrations in surface water depend on the way the samples are treated: in filtered samples the concentration of nitrogen and phosphorus is lower than in non-filtered samples.

There are two national monitoring networks in which these concentrations are measured. The LMM and the MNLSO which monitors the quality of agriculturally influenced surface water in which farm emissions predominate such as nearby streams and waterways. Combined results of these monitoring networks can provide a better view on the distribution and sources of nitrogen and phosphorus.

The LMM is a monitoring network focussing on groundwater in temporary wells; these samples must be filtered for proper analyses. To be able to compare them to the groundwater samples, the ditch water samples at LMM-farms are filtered as well. The MNLSO surface water samples are not filtered. The Evaluation of the Fertilisers Act 2012 (EMW2012) found that the monitoring networks do not optimally adjoin one another, one of the reasons being the difference in sample treatment.

In this RIVM study, the effect of filtering was researched and it was found that nitrogen concentrations in ditch water are around 5% higher in unfiltered samples than in filtered samples. Phosphorus concentrations in unfiltered samples are on average 80% higher than in filtered samples. However, the differences between filtered and unfiltered phosphorous concentrations vary greatly, so much so that it was not possible to determine a compensation factor. These results suggest that, in order to compare nutrient concentrations between the two monitoring networks, at least the sample treatment must be the same. This means that for either of these two monitoring networks both filtered and unfiltered samples must be available.

Development of a measuring instrument for direct measurements of average discharge concentrations and loads from drains and greenhouses to surface water (Rozemeijer et al., 2013)

A flow-cap is a small tube that can be attached to the end of a drainage pipe to monitor both the amount of a pollutant sorbed to a specific SorbiCell and the amount of water passing through that cell. The amount of water is monitored by the dissolution of salt from a salt tracer reservoir placed just after the SorbiCell. The flow-cap tubes generally work well under Dutch field conditions. However, the dissolution rate might vary under specific conditions. The SorbiCells and flow-caps were tested in the LMM.

An overview of all LMM reports from its inception till 2016 is given in Annex 9.

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ANNEX 1 The history of the LMM

An extensive overview of the context, methodical concept and historical development of the LMM until 2010 is given in 'Minerals policy monitoring programme report 2007–2010, methods and procedures' (De Goffau et al., 2012a). The present report describes only the important changes in the period 2011–2014.

Figure A1.1 shows a historical overview of the number of farms in each soil region. The monitoring of the farms is performed one-half to one-and-a-half year after the data acquisition, depending on the region. It is assumed that it generally takes one year for changes in farm management to have an influence on the leaching water. The water quality of the farms in the loess region is sampled one-and-a-half year after the data acquisition. Because the quality check of the monitoring data takes time (it was performed in 2015), these data have not yet been published and are absent from the graph. Figure A1.2 shows the number of farms per farm category monitored in the LMM.

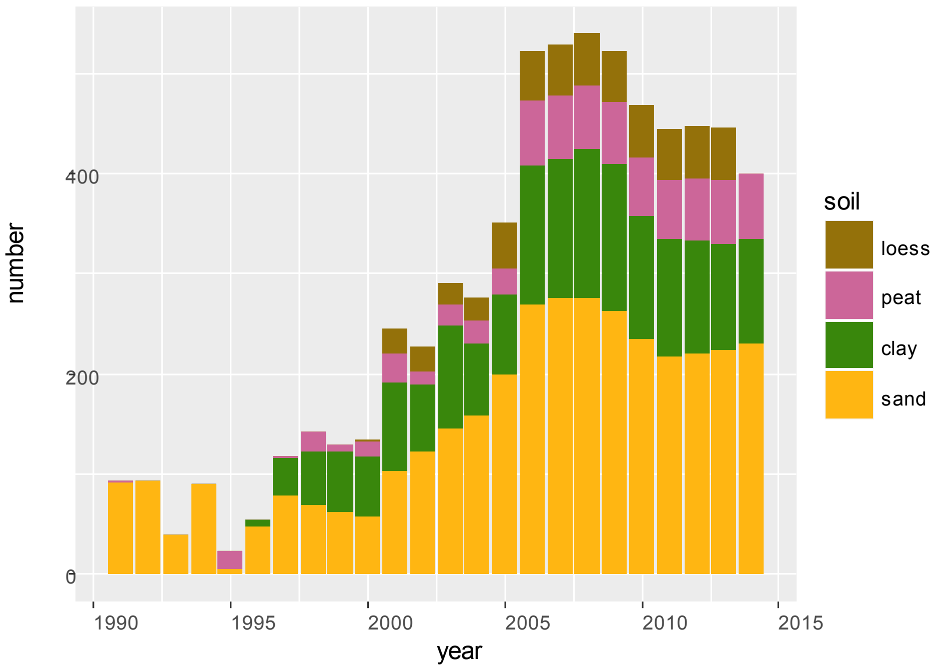

Figure A1.1 Number of farms per soil region monitored in the LMM. The FADN year 2014 is incomplete because the loess data of that year are not incorporated.

Major changes 2011–2014

The major changes in the set-up of the LMM as implemented since 2010 are:

- Discontinuation of sampling at 60 additional derogation farms in the sand and clay regions (sub-programme called Reference Monitoring (RM), complementary to the DM and set up in support

of a new derogation application, focusing on farms with limited manure use);
- Discontinuation of exploratory programmes such as 'Cows and Opportunities' (K&K) and 'Cultivating with a Future' (TmT);
- Sampling frequency of drain water and ditch water reduced to three times per season at arable farms in winter, and at all farm types in summer;
- Loess area recognised as a separate region instead of being treated as part of the sand region;
- Monitoring at arable farms adapted and intensified;
- Definition of industrial livestock farms and other farms in the sand region changed;
- Sampling of ditches disconnected from the groundwater monitoring programme in the peat, clay and sand regions from winter 2014/15;
- Soil regions identified by postcode rather than by municipality (see 2.1.2). The actual soil type of a sampling spot might be different from the predominant soil type of the soil region to which the farm belongs.

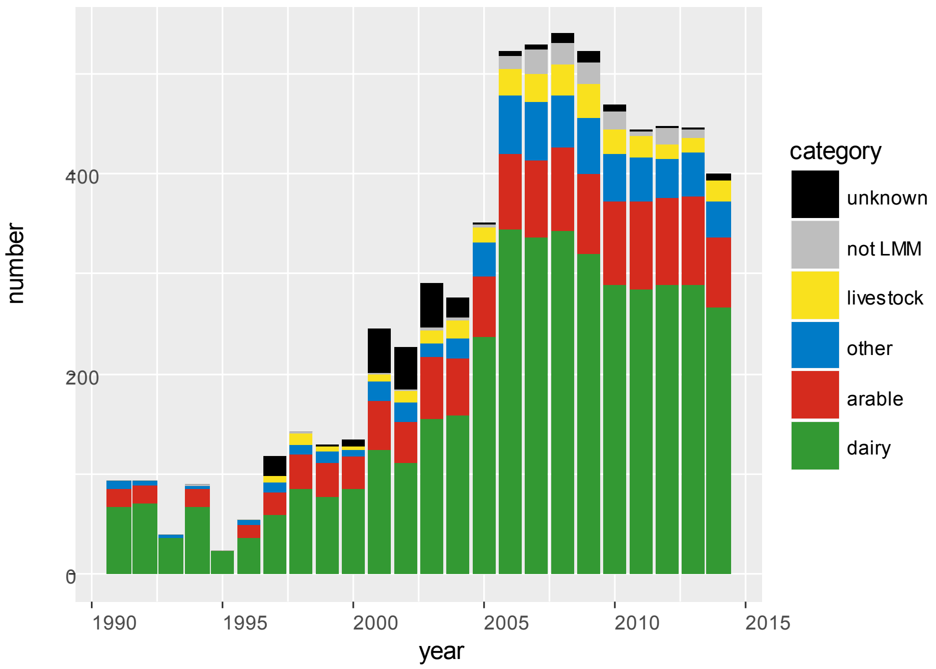

Figure A1.2 Number of farms per farm category monitored in the LMM. The FADN year 2014 is incomplete because the loess data of that year are not incorporated.

Overview of LMM programme changes in relation to policy developments
Table A1.1 provides a summary of the changes in the LMM that are 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) and completed with new information

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 of Minerals 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 of Minerals 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 of Minerals Policy	Preliminary investigation of measuring methods, temporal & spatial variability	Sampling of drain water at 2 locations/farms 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 from 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 farm instead of 48
1995	Peat region: combined scouting and scanning programme at 20 LMB farms, also participating in FADN. (LMB is national soil monitoring network)	Evaluation of first phase of Minerals 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 of Minerals Policy	Study into set-up monitoring programme	Aim to realise a national monitoring network

Year	Changes	Policy impetus	Substantiation	Remarks
1997	Sand region: start of monitoring programme, conversion to revolving network	Evaluation of first phase of Minerals 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 farm costly due to increased heterogeneity
1998 + 2001	Peat region: repeated sampling within programme initiated in 1995	Evaluation of first phase of Minerals Policy, Nitrate Directive	Scouting programme sufficiently advanced	Aim to realise a national monitoring network
1999	Loess region: scouting programme at 1 dairy farm (participating in 'Cows and Opportunities')	Evaluation of first phase of Minerals 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 of Minerals 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 Minerals 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 of Minerals Policy, Nitrate Directive	FADN is a revolving network	Desire to link water quality with agricultural practices
2002	Loess region: continued monitoring, as part of combined sand–loess region	Evaluation of first phase of Minerals Policy, Nitrate Directive	Scouting programme sufficiently advanced	Aim to realise a national monitoring network, in combination with sand region

Year	Changes	Policy impetus	Substantiation	Remarks
2004	Sand region: extension to 54 dairy and other livestock farms	Perspective of derogation	Coverage of soils prone to leaching	Aim to attain 300 (potential derogation) farms within 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 4 years
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	

Year	Changes	Policy impetus	Substantiation	Remarks
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 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 secured	Adequate data expected to be available to underpin the derogation 2014–2017	
2010	Definition of industrial livestock farms and other farms changed		Other farms in all regions similar in type	Programme to report on industrial livestock farms as a separate farm type only in the sand region
2011	General: discontinuation of exploratory programmes such as K&K and TmT	Cutback in expenditure		Part of K&K farms continued in derogation network, therefore sampled at lower intensity than previously
2011	General: discontinuation of monitoring at non-LMM groups (scouting outdoor market gardening crops in the sand region)	Cutback in expenditure		Information lost on water quality at 20% of areas not covered

Year	Changes	Policy impetus	Substantiation	Remarks
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 before 2006 (for winter sampling)	Arable farms excluded from derogation. Summer sampling less important than winter sampling for goals of LMM
2011	Loess area recognised as a separate region		Sufficient participants recruited	
2012	Adapt and intensify arable farming in Southern sand region	Focus on specific policy	Sufficient new participants recruited	In Southern sand region more arable farmers
2012	New stratification method for derogation network		Uniform selection of farms for EM and DM	DM distinguishes two farm type categories only: specialised dairy farms and other grassland farms
2013	Soil region identified by postcode instead of municipality		Fixed borders instead of continually changing (more stable grouping)	Better representation of dominant soil type
2013	Definition of sub-region 'Dunes and Island		Removal of sandy coastal area out of clay region	Better representation of dominant soil type
2014	Sampling of ditches disconnected from groundwater monitoring programme		All ditch water is sampled following one method; no differences in conservation method and timing	From winter 2014/2015

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

A2.1 Composition of FADN

In the Farm Accountancy Data Network (FADN), Wageningen Econmic Research gathers detailed financial, economic and environmental data on about 1,500 agricultural and horticultural farms. FADN represents about 95% of the total agricultural production in the Netherlands. Detailed background information and the history of FADN were described in 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 farms in FADN are selected from the Agricultural Census, a comprehensive annual census of all agriculture and horticulture firms in the Netherlands. The selection of farms is performed using stratified random sampling. The selected farms in FADN therefore constitute a representative sample of nearly all commercially operated farms in the Netherlands.

This section provides a description of the FADN farm selection strategy and the stratification criteria in FADN. These stratification criteria were adopted by the LMM.

The subdivision into strata is based on two parameters: the farm type and the economic size (SO1) of a farm. To identify the farm type, the so-called NSO system is applied. All 41farm types are described in Annex 3.

In 2010, the farm research population of FADN was limited by a farm size of € 25000 SO. Smaller farms were excluded. In 2010, the total number of farms in the annual census amounted to 72,324. The FADN farm research population (meeting the size criterion) consisted of 52,391 farms. This number accounted for 98% of the total agricultural production capacity expressed in SO (Van der Veen et al., 2012). Most of the farms not qualifying for the research population were smaller than € 25,000 SO but some were also excluded because of the area criterion. The recruitment of farms for participation in FADN takes place each year, according to the annual sampling plan (Van der Veen et al., 2012). More than 70 thousand agricultural and horticultural farms operate in the Netherlands. For the accounting year 2009, 1,565 farm reports have

[1] SO, which stands for 'standard output', is a measure of the economic size of agricultural activities and farms. In 2010, the standard output measure was introduced in FADN as the basis for determining a farm's economic size, replacing the previously used Standard Gross Margin (SGM) and accompanying European Size Unit (ESU). Standard output refers to the standard value of gross production. The standard output of an agricultural product (crop or livestock) is the average monetary value of the agricultural output at farm gate price, in euros per hectare or per head of livestock. There is a regional SO coefficient for each product, which is the average value over a reference period (5 years). The Netherlands consists of one region. The sum of all the SO per hectare of crop and per head of livestock in a farm is a measure of its overall economic size, expressed in euros.

been delivered to the European Commission. For 2010, this number was 1,500. The legal obligation of 1,500 farms has been fulfilled. The data are of major importance for the evaluation of the agricultural policies and the monitoring of the economic developments in the agricultural sector. In the design of the selection plan, a stratification based on type of farming and size class has been used. Stratification enables a better control over the representativeness of the sample and contributes to more reliable estimates (Van der Veen et al., 2012).

A2.2 Criteria for selection of farms in the LMM

The monitoring objectives determine the need for data collection and thus the required composition of the groups of farms examined. The LMM focuses on the most common types of land and fertiliser use practices in the Netherlands.

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

In addition to the stratification criteria of 'farm type' and 'economic size (SO)', farms participating in the LMM are grouped and selected on the criterion of 'region'. Although two of the stratification variables (farm type and economic size) are identical in FADN and the LMM, the definition of the criteria within each variable differs. For derogation monitoring (DM) additional selection criteria are applied.

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

- The LMM has grown to an extensive programme with two sub-programmes (DM and EM), each with specific goals and selection criteria.
- To reduce costs, existing FADN farms are favoured. However, for some farm categories (combinations of farm type and region), more farms are needed in the LMM sub-sample than are available in the FADN sample. In those cases, additional farms have to be added to FADN to achieve the required number of farms.
- To reduce costs, the DM programme maximally uses the data from the EM programme.
- During the period of participation, farms within the sample may change in size and even activity. For instance, farms that are selected for the programme as dairy farms might turn out to be in the category 'other farms' in the year of sampling.
- Participation in the LMM has greater impact for a farmer, as, in addition to the data collection for FADN, water samples are taken. Not all farmers in FADN are willing to participate in the LMM.

Therefore, the selection of farms for the LMM programme is not an ideal random design, but a practical solution within the constraints of farms available in the FADN sample and the available LMM budget.

Selecting LMM farms from FADN was a policy decision made at the start of the LMM project. The main advantage of selecting farms from FADN is the reduced cost of monitoring agricultural practices. Moreover, by recruiting 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 FADN, additional criteria are used. In contrast to FADN, some farm types are excluded from the LMM research population. Economic and spatial size criteria are applied in the 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 farm types in terms of area covered in a (soil) region.
2. The LMM research population represents only farms larger than 10 ha. Farms smaller than 10 ha. are excluded. Note that farms with an economic size of less than 25000 Standard Outputs are already excluded from the FADN research sample and therefore also from LMM.

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

a. Geographical position linked to the region
Four main regions, which are named according to their predominant soil types, are distinguished: sand, clay, peat and loess. These four regions represent respectively 47%, 39%, 12% and 1.5% of the total agricultural area of the Netherlands. The four main regions are subdivided into 14 soil type districts: 7 in the sand region, 4 in the clay region and 2 in the peat region. The loess region is not subdivided: it covers the southern part of Limburg. Figure 2.2 in the main text shows the location of the four regions and the 14 soil type districts.

The subdivision into soil type region is linked to Dutch postcode areas. The dominant soil type within a postcode area determines the soil type region allotted to an individual farm. The soil type within a region is not homogeneous. There are instances where a farm is situated in a postcode that, according its postcode area, is in the sand region. The specific farm may, however, be dominated by peat-rich soils. This variation in soils types within a soil type region affects the water quality.

This aspect and the variability of soil types within a region are to be taken into account when considering the water quality on farms with soils dissimilar to that of the region as a whole. The methodology of allotting a farm to a soil type region by postal code was adopted in the past by FADN.

b. Types of farming

In 2012, there were 68,810 farms active in agriculture and horticulture in the Netherlands (Annex 3, Table A3.2). They cultivated a total area of 1.8 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 13% for other fodder crops. The remaining 8% was classed as 'other land' (totalling 144,000 ha, comprising 85,000 ha of outdoor market gardening, 49,000 ha of natural grassland and 10,000 ha glasshouse market gardening). Over 44% of the 1.8 million hectares of cultivated land was in use by dairy farms, 25% by arable farms and 14% by other grazing animal farms. Other farm types occupied 17% of the cultivated land.

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

c. Size of selected farms
Like FADN, the LMM distinguishes four size classes. The SO 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 area 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.

[2] This statement is not exact, as will be explained later. For example, in DM, there are 7 non-dairy farms in the peat region.

The LMM distinguishes four SO size classes. The class boundaries are defined annually per LMM farm category, based on the most recent Agricultural Census. This stratification according to farm size is done in such a way that each stratum represents the same area of cultivated land. From each stratum, an equal number of farms is included in the LMM sample.

This stratification procedure is illustrated by an example from the arable farms in the sand region. According to the Agricultural Census, the LMM research population consists (roughly) of 2,400 farms, covering in total 120,000 ha. Forty of these 2,400 farms are monitored in the LMM. In the stratification process, the research population is divided into four strata, each containing 30,000 ha but different numbers of farms. In each stratum, only 10 sample farms are selected. Therefore each sample farm represents more or less the same surface area but larger farms have a higher chance of being included in the sample than smaller ones.

Table A2.1: Example from 2011 that illustrates the allotment of farms to different size classes for arable farms in the sand region

Size class	**I**	**II**	**III**	**IV**
Total area in Agricultural Census (ha)	30,000	30,000	30,000	30,000
Number of farms in Agricultural Census	1,100	700	400	200
Average area per farm (ha)	27.3	42.9	75.0	150.0
Number of farms in LMM	10	10	10	10
Selection chance	10 in 1,100	10 in 700	10 in 400	10 in 200

In general, large farms are less homogeneous than small ones. In the case of less homogeneous groups, it is important to have a larger number of observations to make reliable estimates. Both in FADN and in the LMM, the greater heterogeneity within larger farms is reflected by a higher chance of being included in the sample.

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

In the preceding sections, some differences were indicated between the research population and stratification in FADN and the LMM. There are also some differences between the 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'. For each stratum the annual farm selection plan makes an inventory of:

- The number of LMM farms already available (farms recruited earlier, and willing to cooperate);
- The number of LMM farms needed;
- The number of farms potentially available for inclusion in the LMM (farms included in FADN and meeting the selection criteria

for the LMM that have not yet been invited to participate in the LMM).

Unlike for FADN, one farm selection plan does not suffice for the LMM, because the LMM consists of two sub-programmes, each with different objectives, specific sampling scopes, selection criteria and stratification requirements. Moreover, the timing of water sampling at participating farms differs over the four regions. A separate 'annual farm sampling plan' is therefore formulated for each LMM sub-programme and for each main region.

The number of sample farms required per farm category is defined for DM and EM in relation to vulnerability (to leaching), the relative importance of the category, and required/desirable numbers of farms from a policy perspective or statistical considerations (Fraters and Boumans, 2005).

Unlike FADN, the LMM does not adjust the allocation of sample farms within a farming category annually (in response to the variation in economic results between farms). Table A2.2 presents the target number of farms per category (56 strata: 14 farm types in 4 size classes) for EM.

Table A2.2 Summary of number of farms per sampling stratum

LMM farm category	**SO class**				**Total**
	I	**II**	**III**	**IV**	
Arable sand	10	10	10	10	40
Industrial livestock sand	3	3	3	3	12
Other sand	3	3	3	3	12
Dairy sand – North	3–4	3–4	3–4	3–4	15
Dairy sand – Central	3–4	3–4	3–4	3–4	15
Dairy sand – South	3–4	3–4	3–4	3–4	15
Total sand region	**27–28**	**27–28**	**27–28**	**27–28**	**109**
Arable clay	7–8	7–8	7–8	7–8	30
Dairy clay	5	5	5	5	20
Other clay	2–3	2–3	2–3	2–3	10
Total clay region	**15**	**15**	**15**	**15**	**60**
Dairy – Northern peat district	3	3	3	3	12
Dairy – Western peat district	3	3	3	3	12
Total peat region	**6**	**6**	**6**	**6**	**24**
Arable loess	5	5	5	5	20
Dairy loess	5	5	5	5	20
Other loess	2–3	2–3	2–3	2–3	10
Total loess region	**12–13**	**12–13**	**12–13**	**12–13**	**50**

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

Recruiting LMM participants from separate strata means that the reliability of the random sample survey is higher than that of a non-stratified sample survey of the same size. Moreover, stratification allows representativeness to be maintained in cases where a selected farm declines to participate (or when an existing participant drops out). A replacement can be sought, corresponding as closely as possible, in terms of farm characteristics (farm type, 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 (farm type, size, location) the lost farm. In the event of a shortage of participating farms, the LMM draws candidates from an adjacent stratum. If there is no potential participant in an adjacent stratum, then the LMM tries to find a replacement outside FADN.

A2.4 Coverage of the LMM research population

Table A2.3 shows for each region the percentage of farms and acreage represented in the LMM research population. The right-hand column shows the LMM sample acreage as a percentage of the total area of cultivated land. The figures at the top of the table are the total population of farms in the four LMM regions in 2012.

From Table A2.3 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 than 30,000 ha the loess region is by far the smallest.
- On a national scale, the LMM research population represents 82.9% of all cultivated land, worked by 46% of all farms. The individual 'acreage coverage' is slightly higher for grassland, arable farming and other fodder crops (81–90%); for 'other cultivated land' the coverage (36%) is relatively low.
- Among the regions, the coverage of total cultivated land varies between 77% in the peat region and 85% in the clay region. For the category 'other cultivated land', the peat region has the highest coverage (52% compared with 36% overall). In the peat region, the research population focuses entirely on specialised dairy farms.

Table A2.3 Distribution of farms and their area over LMM regions: for the Netherlands as a whole and for the LMM research population.

	Number farms	Grassland	Other fodder crops	Arable farm land	Other cultiv. land	Total cultiv. land	Share in total extent
		ha x 1,000	ha x 1,000	ha x 1,000	ha x 1,000	ha x 1,000	(%)
LMM sand region	37,865	447	171	178	67	864	47%
LMM clay region	23,157	316	53	323	66	758	41%
LMM peat region	6,592	164	14	4	8	190	10%
LMM loess region	1,161	10	4	12	2	29	1,6%
Total agri- & horticulture in NL	**68,775**	**938**	**242**	**517**	**143**	**1,841**	**100%**
Research population sand region							
- Dairy farms	8,649	293	82	9	8	392	21%
- Arable farms	2,186	7	14	108	2	132	7%
- Industrial livestock farms	2,467	22	25	20	2	69	3,7%
- Other farms	3,282	66	22	20	13	120	7%
Total	**16,584**	**388**	**142**	**157**	**25**	**712**	**39%**
(in % of sand region)	**44%**	**87%**	**83%**	**88%**	**37%**	**82%**	
Research population clay region							
- Arable farms	4,704	11	9	265	4	290	16%
- Specialised dairy farms	4,896	222	31	9	7	269	15%
- Other farms	1,954	51	6	18	10	85	5%
Total	**11,554**	**284**	**47**	**292**	**21**	**644**	**35%**
(in % of clay region)	**50%**	**90%**	**87%**	**90%**	**32%**	**85%**	
Research population peat region							
- Specialised dairy farms – North	1,441	69	8	0	2	80	4,4%
- Specialised dairy farms –West	1,460	61	3	0	2	67	3,6%
Total	**2,901**	**130**	**11**	**1**	**4**	**147**	**8%**
(in % of peat region)	**44%**	**79%**	**81%**	**21%**	**52%**	**77%**	

	Number farms	Grassland	Other fodder crops	Arable farm land	Other cultiv. land	Total cultiv. land	Share in total extent
Research population loess region							
- Dairy farms	165	5	2	1	0	8	0,4%
- Arable farms	204	1	1	7	0	9	0,5%
- Other farms	159	3	1	2	0	6	0,3%
Total	**528**	**9**	**3**	**10**	**1**	**23**	**1,3%**
(in % of loess region)	**45%**	**83%**	**85%**	**86%**	**39%**	**81%**	
Total LMM research population	31,567	811	204	459	51	1,525	82,9%
% of agri- & horticulture in NL	46%	87%	84%	89%	36%	83%	

Source: CBS Agriculture Census 2012.ANNEX 3 Farm types

A3.1 The NSO typology

The NSO typology is a Dutch version of the EU system for characterising agricultural and horticultural farms. Based on their activities (production of crops and/or animals), farms are classified in ‘farm types’. All cropped areas and numbers of head per animal species are converted into a so-called ‘standaardopbrengst (SO)’ or ‘standard output’. The standard output of a crop or animal refers to its yield (in euros), achievable on an annual basis under normal circumstances. The proportion of the production from specific animals or crops is compared with total production (sum of all SO). This provides a measure of the specialisation of a farm. The degree of specialisation is utilised to define the farm type. A farm is defined as ‘specialised’ if a substantial part of its proceeds (usually at least two-thirds) is derived from one product or mode of production (for example dairy cattle, arable farming or pigs).

The NSO typology distinguishes eight main types of farming, of which five are single-product/production oriented and three comprise combinations of farm activities. The five single-product/production-oriented types of farm are: arable farms, horticulture, permanent cultures (fruit and trees), grazing animal farms and industrial livestock farms. The three combined farm types are ‘crop combinations’, ‘livestock-rearing combinations’ and ‘crop–livestock-rearing combinations’.

A3.2 Recent changes in NSO characterisation

The NSO typology is subject to change. First, in accordance with EU agreements, the SO standards are redefined every three years. The almost continuous shift in ratios between prices and yield among products is the main reason for this triannual redefinition. These changes affect the SO 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 that have appeared or disappeared. Since 2006, the number of products in the Agricultural Census has increased considerably; this is partly due to changes in manure and minerals legislation.

The changes in the NSO characterisation have a limited impact on the size and distribution of the cultivated area within the LMM research population. A modified characterisation, however, may change the allotment of sample farms to LMM strata. When a farm needs to be replaced, the selection of a new farm is made 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 NSO characterisation.

Table A3.1 Summary of (main) types of farming with the NSO characterisation

1 Arable farming – field crops			
1500 1601	Specialist in cereals (other than rice), oilseeds and protein crops Specialist in starch potatoes	1602 1603 1604	Specialist in field vegetables Specialist in feed crops Other arable farming
2 Horticulture farming			
2111 2121 2122 2131	Specialist in vegetables indoor Specialist in flowers and ornamentals indoor Specialist in pot and bedding plants Specialist in indoor mixed horticulture	2210 2221 2310 2320 2331	Specialist in outdoor vegetables Specialist in outdoor flowers and ornamentals Specialist in mushrooms Nursery specialist Various horticulture
3 Permanent cultures			
3500 3610	Specialist in vineyards Specialist in fruit	3699	Various permanent crops combined
4 Grazing animals			
4500 4611 4612 4810	Specialist in dairying Specialist in cattle-rearing and fattening Other cattle Specialist in sheep	4830 4841 4842 4843	Specialist in goats Specialist in horses and ponies Grazing animals, mainly feed crops Other grazing animals
5 Industrial livestock farming (poultry, pigs, fattening calves)			
5111 5121 5131 5211	Specialist in pig-rearing Specialist in pig-fattening Pig-rearing and fattening combined Specialist in layers	5221 5231 5301	Specialist in poultry meat Layers and poultry meat combined Various granivores combined
6 Mixed cropping			
6100	Mixed cropping		
7 Mixed livestock farming			
7300	Mixed livestock, mainly grazing livestock	7400	Mixed livestock, mainly granivores
8 Mixed crop-livestock farming			
8300	Field crops and grazing livestock combined	8400	Various crops and livestock combined

A3.3 Number and area of farm types

Table A3.2 gives a summary of all agricultural and horticultural farms in the Netherlands (numbers and size), based on the CBS Agricultural Census of 2008 (see also Annex 2). The categorisation of farms is done on the basis of the eight main types of farming in accordance with the NEG characterisation (Statistics Netherlands, 2009), in which category 4 (grazing animals) is divided further into ‘dairy farms’ (type 4a) and ‘other grazing animal farms’ (type 4b). The total area of cultivated land has been represented in terms of four forms of land use: grassland, other fodder crops (primarily silage maize), arable farming products and ‘other cultivated land’ (comprising, for example, market gardening crops (outdoor and under glass)).

Table A3.2 Summary of farm categories in the Netherlands (2012)

Farm category	Number of farms	Grass-land (ha x 1,000)	Other fodder crops (ha x 1,000)	Arable farm land (ha x 1,000)	Other cultiv. land (ha x 1,000)	Total cultiv. land (ha x 1,000)	Share in total extent (%)
1) Arable farms	12,016	33	38	382	5	458	25
2) Horticulture farms	9,394	6	4	17	66	93	5
3) Permanent cultures	1,728	1	0	2	17	21	1
4a) Dairy farms	16,902	652	126	20	19	817	44
4b) Other grazing	19,780	188	36	8	21	253	14
5) Instr. livestock	5,661	20	20	27	2	68	4
6) Mixed cropping	833	2	2	25	6	36	2
7) Mixed livestock	819	17	6	2	1	26	1
8) Mixed crop–livest.	1,677	18	10	35	7	71	4
Total (ha x 1,000)	***68,810***	***938***	***242***	***518***	***144***	***1,842***	***100***
Portion of land use (%)		50.9	13.1	28.1	7.8	100.0	

A3.4 The evolution of area per main farm type

Table A3.3 specifies the main types of farming and the area of cultivated land for the four 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 2010 and 2013, the number of agriculture and horticulture farms fell by about 9% (from 72,324 in 2010 to 65,507 in 2014). This reduction does not, or only slightly affects the (relative) areas per main farm type.

Table A3.3 Developments in the area per main farm type, per region

	2010		2011		2012		2013	
Main farm type	**area (ha x 100)**	**(%)**	**area (ha x 100)**	**(%)**	**area (ha x 100)**	**(%)**	**area (ha x 100)**	**(%)**
1) Arable farms	149,800	17%	151,100	17%	152,000	18%	153,200	18%
2) Horticulture farms	53,300	6%	55,100	6%	54,500	6%	54,200	6%
3) Permanent cultures	2,500	0%	2,600	0%	2,300	0%	2,000	0%
4a) Dairy farms	392,800	45%	392,100	45%	392,900	45%	399,400	46%
4b) Other grazing	144,100	16%	142,300	16%	141,100	16%	139,000	16%
5) Instr. livestock	60,400	7%	58,100	7%	55,200	6%	53,700	6%
6) Mixed cropping	12,200	1%	11,600	1%	10,800	1%	12,200	1%
7) Mixed livestock	24,800	3%	21,600	2%	18,900	2%	17,200	2%
8) Mixed crop-livest.	39,200	4%	38,000	4%	36,200	4%	33,400	4%
Total SAND region	879,200	100%	872,300	100%	863,900	100%	864,300	100%
1) Arable farms	295,200	38%	294,100	39%	290,100	38%	295,800	39%
2) Horticulture farms	36,200	5%	37,400	5%	35,900	5%	34,600	5%
3) Permanent cultures	17,100	2%	16,900	2%	16,800	2%	16,500	2%
4a) Dairy farms	268,500	35%	268,300	35%	269,000	35%	274,500	36%
4b) Other grazing	77,400	10%	73,000	10%	74,600	10%	71,900	9%
5) Instr. livestock	13,800	2%	12,300	2%	11,900	2%	12,700	2%
6) Mixed cropping	24,100	3%	23,800	3%	23,900	3%	26,100	3%
7) Mixed livestock	6,200	1%	6,200	1%	5,800	1%	5,200	1%
8) Mixed crop-livest.	31,200	4%	31,700	4%	30,200	4%	27,800	4%
Total CLAY region	769,800	100%	763,700	100%	758,200	100%	765,200	100%
1) Arable farms	4,900	3%	4,800	3%	4,800	3%	5200	3%
2) Horticulture farms	2,300	1%	2,200	1%	2,300	1%	2000	1%
3) Permanent cultures	100	0%	100	0%	100	0%	100	0%
4a) Dairy farms	148,200	77%	146,700	77%	147,000	77%	147,700	78%
4b) Other grazing	33,800	17%	32,800	17%	32,500	17%	31,200	16%
5) Instr. livestock	1,200	1%	1,000	1%	1,000	1%	1,000	1%
6) Mixed cropping	400	0%	400	0%	200	0%	300	0%

	2010		2011		2012		2013	
Main farm type	**area (ha x 100)**	**(%)**	**area (ha x 100)**	**(%)**	**area (ha x 100)**	**(%)**	**area (ha x 100)**	**(%)**
7) Mixed livestock	1,700	1%	1,700	1%	1,100	1%	800	0%
8) Mixed crop-livest.	900	0%	1,200	1%	1,300	1%	1,400	1%
Total PEAT region	**193,400**	**100%**	**190,900**	**100%**	**190,200**	**100%**	**189,600**	**100%**
1) Arable farms	10,100	34%	10,100	35%	10,300	36%	10,300	36%
2) Horticulture farms	200	1%	200	1%	200	1%	200	1%
3) Permanent cultures	1,700	6%	1,600	6%	1,500	5%	1,400	5%
4a) Dairy farms	7,700	26%	8,600	30%	8,000	28%	7,900	28%
4b) Other grazing	4,700	16%	4,400	15%	4,500	16%	4,500	16%
5) Instr. livestock	500	2%	500	2%	400	1%	400	1%
6) Mixed cropping	700	2%	500	2%	500	2%	500	2%
7) Mixed livestock	100	0%	0	0%	100	0%	100	0%
8) Mixed crop-livest.	3,500	12%	3,000	10%	3,100	11%	3,000	10%
Total LOESS region	**29,400**	**100%**	**29,000**	**100%**	**28,500**	**100%**	**28,300**	**100%**
1) Arable farms	460,100	25%	460,200	25%	457,000	25%	464,500	25%
2) Horticulture farms	92,000	5%	94,900	5%	93,000	5%	91,000	5%
3) Permanent cultures	21,300	1%	21,200	1%	20,600	1%	20,100	1%
4a) Dairy farms	817,300	44%	815,600	44%	816,700	44%	829,500	45%
4b) Other grazing	260,100	14%	252,500	14%	252,700	14%	246,600	13%
5) Instr. livestock	76,000	4%	71,900	4%	68,400	4%	67,700	4%
6) Mixed cropping	37,400	2%	36,400	2%	35,500	2%	39,100	2%
7) Mixed livestock	32,900	2%	29,600	2%	25,900	1%	23,200	1%
8) Mixed crop-livest.	74,800	4%	73,700	4%	70,800	4%	65,600	4%
Total Netherlands	**1,871,800**	**100%**	**1,856,000**	**100%**	**1,840,800**	**100%**	**1,847,400**	**100%**

A3.5 LMM reporting categories

For the purpose of selecting and enlisting participants, and for reporting purposes, all farming activities represented in the LMM are aggregated into more or less homogeneous farm types. Table A3.4 shows for each region the farm types distinguished in the LMM and the corresponding NEG business characterisation.

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

Region	**LMM reporting categories with respect to type of farm**	**NSO (main) farm types used in LMM selection**
Sand	Arable farms	NSO main type 1: arable farms NSO type 6100: other mixed cropping <u>on condition that</u> the area of horticultural crops does not exceed 20% of total area
	Dairy farms	NSO type 4500: dairy farms
	Industrial livestock farms	NSO main type 5: industrial livestock farms NSO type 4611: calf-rearing and -fattening farms NSO type 7400: livestock combinations, mainly granivores
	Others	NSO main type 4: farms with grazing animals (excluding NSO types 4500 and 4611) NSO type 7400: livestock combinations, mainly grazing animals NSO main type 8: crops / livestock combinations
Clay and loess	Arable farms	NSO main type 1: arable farms NSO type 6100: other mixed cropping <u>on condition that</u> the area of horticultural crops does not exceed 20% of total area
	Dairy farms	NSO type 4500: dairy farms
	Others	NSO main type 4: farms with grazing animals (excluding NSO types 4500 and 4611) NSO type 7400: livestock combinations, mainly grazing animals NSO main type 8: crops / livestock combinations
Peat	Dairy farms	NSO type 4500: dairy farms

ANNEX 4 Number of farms and locations covered in programme implementation

Table A4.1 Number of farms included for data collection on agricultural practice
Top: Evaluation Monitoring (EM). Bottom: Derogation Monitoring (DM)

AGRICULTURAL PRACTICE – EM

	Clay region				
	Arable		Dairy	Other	Total
2010	31		20	12	63
2011	30		20	11	61
2012	31		20	13	64
2013	30		18	12	60
	Peat region				
	Arable		Dairy	Other	Total
2010			21		21
2011			21		21
2012			24		24
2013			25		25
	Loess region				
	Arable		Dairy	Other	Total
2010	14		23	12	49
2011	18		19	7	44
2012	18		20	11	49
2013	19		21	10	50
	Sand region				
	Arable	Ind. Livestock	Dairy	Other	Total
2010	36	12	42	13	103
2011	39	11	46	10	106
2012	36	12	44	18	110
2013	38	10	44	17	109
	All regions combined				
	Arable	Ind. livestock	Dairy	Other	Total
2010	81	12	106	37	236
2011	87	11	106	28	232
2012	85	12	108	42	247
2013	87	10	108	39	244

AGRICULTURAL PRACTICE – DM*

	Clay region	**Loess region**	**Peat region**	**Sand region**	**All regions combined**
2010	75	19	49	149	292
2011	68	19	54	148	289
2012	67	19	57	152	295
2013	57	18	57	153	285

* See also Lukács et al. (2015, 2016).

Table A4.2 and table A4.3 show the number of farms included for data collection on water quality for EM and DM, respectively. Figure A4.1 and A4.2 show the number of samples taken from different water types. For groundwater these are the number of boreholes drilled. In the loess area no surface water is available and the groundwater is too deep. Therefore, only soil moisture is sampled. The peat region contains surface drains while the sand and clay region, use tile drains.

Table A4.2 Number of farms included for data collection on water quality for evaluation monitoring (EM)

Clay						
Year	Arable	Industrial livestock	Dairy	Not LMM	Other	Total
2010	30		61		11	102
2011	33		55		8	96
2012	32		22	1	12	67
2013	31		19		13	63
Loess						
Year	Arable	Industrial livestock	Dairy		Other	Total
2010	15		19		5	39
2011	18		21		4	43
2012	18		20	3	9	50
2013	19		22	1	9	51
Peat						
Year	Arable	Industrial livestock	Dairy		Other	Total
2010			51			51
2011			36			36
2012			24			24
2013			24			24
Sand						
Year	Arable	Industrial livestock	Dairy		Other	Total
2010	33	17	108		17	175
2011	27	18	100		12	157
2012	36	10	45	5	10	106
2013	38	11	44	3	13	109
All regions combined						
Year	Arable	Industrial livestock	Dairy		Other	Total
2010	78	17	239		33	367
2011	78	18	212		24	332
2012	86	10	111		31	238
2013	88	11	109		35	243

Table A4.3 Number of farms included for data collection on water quality for derogation monitoring (DM)

Year	Clay	Loess	Peat	Sand	All regions combined
2010	73	19	52	150	294
2011	68	19	54	148	289
2012	67	19	57	152	295
2013	57	18	57	153	285

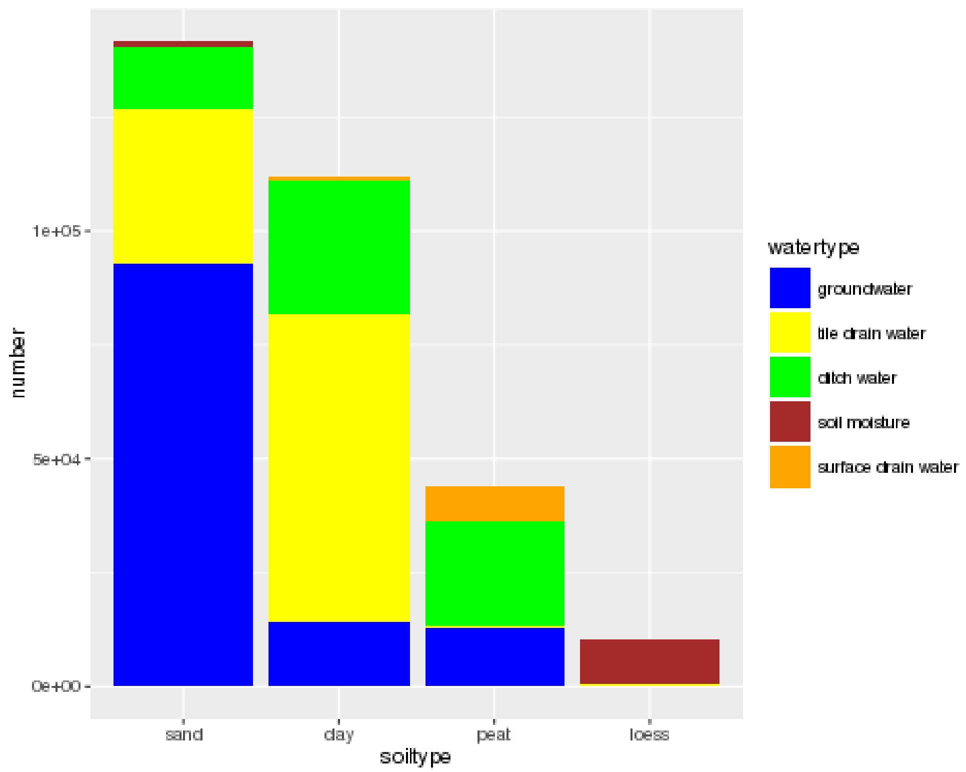

Figure A4.1 Historic overview of the number of samples taken from different water types.

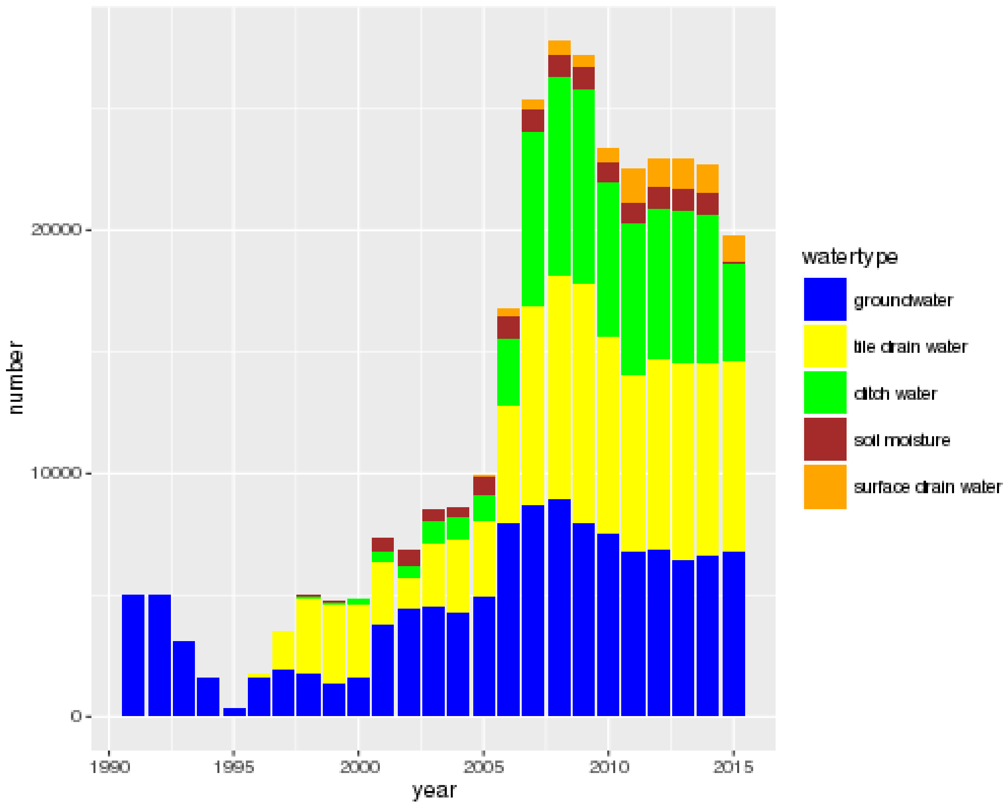

Figure A4.2 The number of samples taken from different water types in the four soil regions during the whole history of the LMM.

ANNEX 5 Work Instructions for field activities

A5.1 Quality control 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). These include instructions for the drilling of boreholes, the sampling of different types of water, field tests (including calibration procedures) and the handling of water samples. A summary of the most Work Instructions most relevant to the fieldwork related to water sampling and water quality testing is presented in Table A5.1 below.

Table A5.1 List of Work Instructions most relevant to the fieldwork related to water sampling and water quality testing

SOP/Doc. No.	Title
MIL-W-4001	Measuring the nitrate concentration in an aqueous solution using a Nitracheck-reflectometer (type 404) [version 3, September 2014]
MIL-W-4002	Use of control sheets [version 3, July 2014] for equipment calibration
MIL-W-4006	Measuring pH, specific conductivity and oxygen content in an aqueous solution using the WTW Multi 350i [version 4, July 2014]
MIL-W-4008	Temporary storage and transportation of samples [version 2, September 2013]
MIL-W-4010	Concise description of soil profile [version 2, July 2013]
BW-W-011	Sampling of surface water/ditch water with a modified sampling nozzle and peristaltic pump [version 2, May 2012]
MIL-W-4012	Sampling of surface water/ditch water using a measuring jug [version 3, September 2013]
MIL-W-4013	Sampling of drain water [version 3, September 2014]
MIL-W-4014	Soil sampling for soil moisture testing using an Edelman auger [version 3, September 2014]
MIL-W-4015	Sampling of groundwater in sand, clay and peat using a sampling nozzle and a peristaltic pump [version 3, December 2013]
MIL-W-4016	The preparation of a RIVM-sampling nozzle for sampling groundwater and ditch water [version 2, January 2013]
MIL-W-4017	Field visits and work site inspections within the Soil and Water Monitoring (BWM) Department [version 2, January 2013]
MIL-W-4018	Safety during fieldwork [version 4, December 2014]
MIL-W-4020	Compiling and archiving of the business information of agricultural firms [version 2, January 2013]
MIL-W-4021	Identifying the position of sampling points [version 5, September 2014]
MIL-W-4022	Recording the temperature in refrigerators [version 2, September 2013]
MIL-W-4023	Data validation and drafting (letter) reports for individual LMM participants [version 3, September 2014]

In the ensuing sections a number of the Work Instructions are presented in detail, with reference to the materials and equipment used, as well as to the methodology. The Work Instructions for water sampling (in groundwater, drain water and ditch water) and the storage and transport of samples are presented in particular detail.

A5.2 Sampling of groundwater using a sampling nozzle in combination with a peristaltic pump on sand, clay and peat (Instruction MIL-W-4015)

MATERIAL

- Location map with all plots and markings of locations where groundwater samples are to be taken;
- Spade;
- Sheet of plastic;
- Manual drilling equipment of various sizes:
  - 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 nozzles, 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 MIL-W-4016);
- Filter gravel: bag with 25 kg content;
- Clay plug material: type Mikolit 00: 25 kg bag;
- Reservoir tube with perforated section (slot size 0.4 mm), length 100 cm, 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;
- Ball valve and tube;
- 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 has not yet been established, determine the position using Work Instruction *MIL-W-4021.*
- If, for some reason, it is necessary to deviate from the point marked on the map, indicate the new point on the map and record the 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 to some clayey soils.

- Drill a hole with 7 cm or 10 cm diameter auger to a depth of 30 cm (just below the arable soil).
- Install the collar in the hole, fully protecting the hole from intrusion 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 with jerking movements, as deep as possible in the hole.
- Often sampling can start within half an hour of installing the sampling nozzle. For the 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 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 of the depth of the groundwater is the ditch water level. A second indicator is the presence of tile drains. If these are present, the depth to be drilled is usually tile drain level minus 1 m.
- Install the sampling nozzle in the borehole and push it, if necessary with jerking movements, 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 20–30 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), the 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 section E for the implementation of the water sampling.

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 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 into 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 the 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 and the 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, measure the water level in the reservoir tube using a sounding lead.
  If insufficient water has entered the reservoir, the sampling point may be moved, after consultation with the fieldwork supervisor (operational manager) or fieldwork coordinator (network manager).
- Empty the reservoir tube by pumping, using the 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.
  If 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 should elapse after installation before the reservoir tubes can be sampled.
- To prevent the water from being contaminated, first clean the sounding lead with demineralized water, and a clean (paper) towel.
- Measure the water level in the reservoir tube with a clean sounding lead.
- While extracting the sounding lead from the reservoir tube, clean the ribbon attached to the sounding lead with a clean towel.
- Reference is made to section E for the implementation of the water sampling.

E **Sampling of groundwater**

- Couple the hose of the sampling nozzle to 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). If the water looks clean (void of silt particles), pumping can be stopped.

Table A5.2 Minimum amount of groundwater to be pumped for flushing for the different sampling methods

Sampling method	Volume to be pumped
Sand	≥1,000 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 will ensure that the PE hose is flushed at least three times (the volume of the 6/4 PE hose is 13 ml per metre).

- If the pumped water is not clear of silt particles, the above flushing prescription is be repeated (five times at most). Alternatively, the fieldwork supervisor or fieldwork coordinator is to be contacted.
- Note the total volume of water pumped.
- *This means in case of using the flow cell, filling up the flow cell has to be included in the total amount of flushing water.*
- Filter the water in accordance with the relevant work plan, or, in the case of outsourced work, in accordance with the terms of reference.
- Fill the sampling bottles and seal them.
- 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 **Follow-up**

- When applying the sand or clay method, mark/indicate on the sampling nozzle (by hand) the soil surface level, and remove 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, remove the reservoir tube from the borehole, for example using the steel lifting jack and lever with chain.
- After sampling, refill the borehole with the material drilled from the borehole at installation. Press intermittently the material into the borehole using the auger. Spread any remaining material and replace the turf removed during installation.
- Clean all augers and nozzles used with a brush, and clean water if necessary, and dry the augers to prevent rusting. Clean the used reservoir tubes with a high-pressure water cleaner, paying specific attention to the slots.

A5.3 Sampling of drain water (Instruction MIL-W-4013)

MATERIAL

- Plan of farms showing all parcels with an indication of all drains to be sampled, plus a step-by-step plan, prepared using the 'Bedrijvenbestand' (farm database), in accordance with Work Instruction MIL-W-4021.
- Writing board with protection against rain, and indelible pen or pencil.
- 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 work plan or consignment.
- Data entry form (Form MIL-F-4002 and MIL-F-4006) and spare forms, in accordance with sub-project description. This form is prepared using 'Bedrijvenbestand+'.

If 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 hand-pump, type Probenahmepumpe 28 supplied by Carl Roth (supplier's code E514.1) (www.carlroth.nl) with accompanying 500 ml collection bottle.
- PE hose Ø 4/6 mm, 2–4 m long and a 1 m PVC tube into which the hose will fit.

PROCEDURE / WORK METHOD

A Selection of drains

The drains to be sampled (16 in total) are spread over the drained parcels of a farm, in accordance with Work Instruction MIL-W-4021. A suggestion for the 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 granted) with a picket, numbered in accordance with the original proposition plan. To prevent the drain water from being contaminated, the drains have to be dug free.

Subsequently, prepare a ‘step-by step plan’. To this end, start from a recognisable, permanent point on the farm (e.g. a causeway, gate, corner of a parcel, or another selected drain) towards a selected drain. Count and note the number of steps and direction on the designated form.

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

After the first sampling, record the selection of locations on the plan and subsequently within the ‘Bedrijvenbestand+’. This information will be 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 is later than the date indicated on the raw data form under ‘sampling AFTER’;
2. It is not a Friday, Saturday or Sunday;
3. At least 80% of the selected drains (at least 13 drains) are producing 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 cut in the ice to allow the sampling of ditch water in combination with drain water. Note on the raw data form, under ‘particulars’, the thickness of the ice cover in centimetres. If the ice sheet on ditches is too thick, only drain water can be sampled. The fact that the ditches were frozen should be registered on the raw data forms.

The sampling procedure for tile drains discharging above ditch water level is presented under C. For the sampling of tile drains discharging below 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 area surrounding 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 cannot be sampled for some other reason, while most of the other drains are discharging, an alternative tile drain should be identified on the same parcel.

** Note 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 it to at least 20%, shaking it and emptying it.
- Register the time required to collect 1 litre of drain water. This gives the discharge rate. Note this time (in minutes and seconds) under the heading 'discharge measurement'.
- Flush the sample bottles once with drain water from the measuring jug, by filling the bottles at least a quarter full, 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 securely.
- Store the bottles in a cool box.

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

When a drain discharges below the surface level of the ditch water, 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 (unpleasant) odour of a sample indicates that drain water has been sampled. Nearby drains discharging above ditch water level may provide an indication of the likeliness of discharge by drains ending below 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. 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 about 1 m long 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 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 slowly flush 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 ditch water level in peat areas

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

A5.4 Sampling of surface water and ditch water using a modified sampling nozzle in combination with a peristaltic pump (Instruction BW-W-011)

MATERIAL

- PVC sampling nozzle with the perforated section (slot size 0.3 mm) 50 cm in length at an angle of 90° 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 work plan or consignment;
- Plan of farm showing all parcels and sites where surface water or ditch water is to be sampled, including survey data from the ditch water points MIL-F-4007, prepared using ‘bedrijvenbestand+’ according to Work Instruction MIL-W-4021;
- Disposable filters accordance with work plan or consignment.

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 their positions using Work Instruction MIL-W-4021.*
- Check whether the indicated type of ditch water matches the current situation. If this is not the case, contact the fieldwork supervisor.
- If, for some reason, no sampling is possible at the site identified, the fieldwork supervisor should be contacted.
- Mark on the plan the new location and note the reason for the deviation under ‘particulars’.
- The ditch water sampling point should be about 10 meters before the point at which the ditch connects with another ditch.
- If there is ice on the ditch, the water may still be sampled, provided the ice is no more than 3 mm thick. Note the presence of ice under ‘particulars’. Only in combination with the sampling of drain water may a hole be made in the ice to sample the ditch water.

- Measure the width of the ditch or water course at the selected location (in metres).
- Measure the difference in height between the water surface and soil surface, using a Secchi disk, sounding lead or rule.
- 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. When water flow is hard to detect, look at the aquatic weeds on the bottom of the ditch, or swirl some silt on the bottom to determinate the flow direction. Keep in mind that the wind can give you a false idea of the flow direction.
- Note 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 weather details.
- Note all particulars, including recent spreading of manure.
- Measure the transparency of the ditch/water course using the Secchi disk in the centre of the ditch/water course.
- If the ditch/water course is more than 4 m wide, submerge the disk 2 m from the bank, attached to a long pole/stick.
- Always hold the stick at the end, thereby ensuring a consistent visual angle.

B Sampling

- Suspend the sampling nozzle, with a float if necessary, in the centre of the ditch/water course.
- *If the width of the ditch/water course exceeds 4 m, the perforated section of the sampling nozzle is to be submerged 2 m from the bank.*
- Make sure the perforated part of the sampling nozzle is 30 cm below the water surface.
- *If this is not possible, the perforated section of the sampling nozzle must be held halfway between the water surface and the bottom of the ditch/water course. Avoid disturbing silt on the bottom*.
- Note the depth of the lowest point of the sampling nozzle below the water surface (standard depth is 30 cm).
- Attach the hose from the sampling nozzle to the suction end of the peristaltic pump.
- Start the pump.
- Pump at least 1 litre of water from the ditch/water course. If the water is (visibly) void of any silt particles, pumping can be stopped.
- If the water still contains silt particles, repeat the above procedure (not more than 5 times). Alternatively, contact the fieldwork supervisor.
- Note the total volume of water pumped.
- Filter the water in accordance with the sub-project description.
- Fill the sample bottles and seal them.
- Switch off the pump.

- Detach the hose of the sampling nozzle from the pump, and insert the hose into the sampling nozzle for the sake of protection.

C **Conservation and transport of samples**

- Transport the water samples under cooled conditions, in accordance with Work Instruction MIL-W-4008.

A5.5 Soil moisture sampling using a Edelman auger (Instruction MIL-W-4014)

MATERIAL

- Spade;
- Edelman auger; Ø 7 cm / Ø 10 cm which is optionally provided with coloured tape to mark the depths by 10 cm each;
- Knife or sturdy spatula;
- Sealable plastic containers;
- Sheet of plastic;
- Weighing machine accurate to within 2 g, with a maximum load of at least 1,000 g;
- Thermometer;
- Cool box;
- Fieldwork vehicle;
- Glass jar(s), minimum content 720 ml;
- PE jar(s), minimum content 1.5 litre, minimum opening of the jar 8 cm;
- Location map with all plots and sampling locations;
- GPS with a minimum accuracy of 10 metres;
- Field/hand-held computer with 2L-inputmodule;
- Plastic cylinder (collar), length of about 50 cm, Ø ±11 cm.

PROCEDURE / WORK METHOD

A. Preparation

- Check that the materials are clean and in good condition.
- Number with a marker pen all the sample trays that are to be used to collect the sample material, as follows:
  - Container number 1 = 120–130 cm deep (= X_0 = *minimal starting depth*);
  - Container number 2 = 130–140 cm deep;
  - Container number 3 = 140–150 cm deep;
  - Container number 4 = 150–160 cm deep (= X_1 = *starting depth*);
  - Container number 5 = 160–170 cm deep;
  - etc.
  - The last tray will be number 18 with sample material from 290–300 cm deep (= X_2 = *end depth*).

The *minimal starting depth* (X_0) is 120 cm to avoid plant roots.

B. Sampling

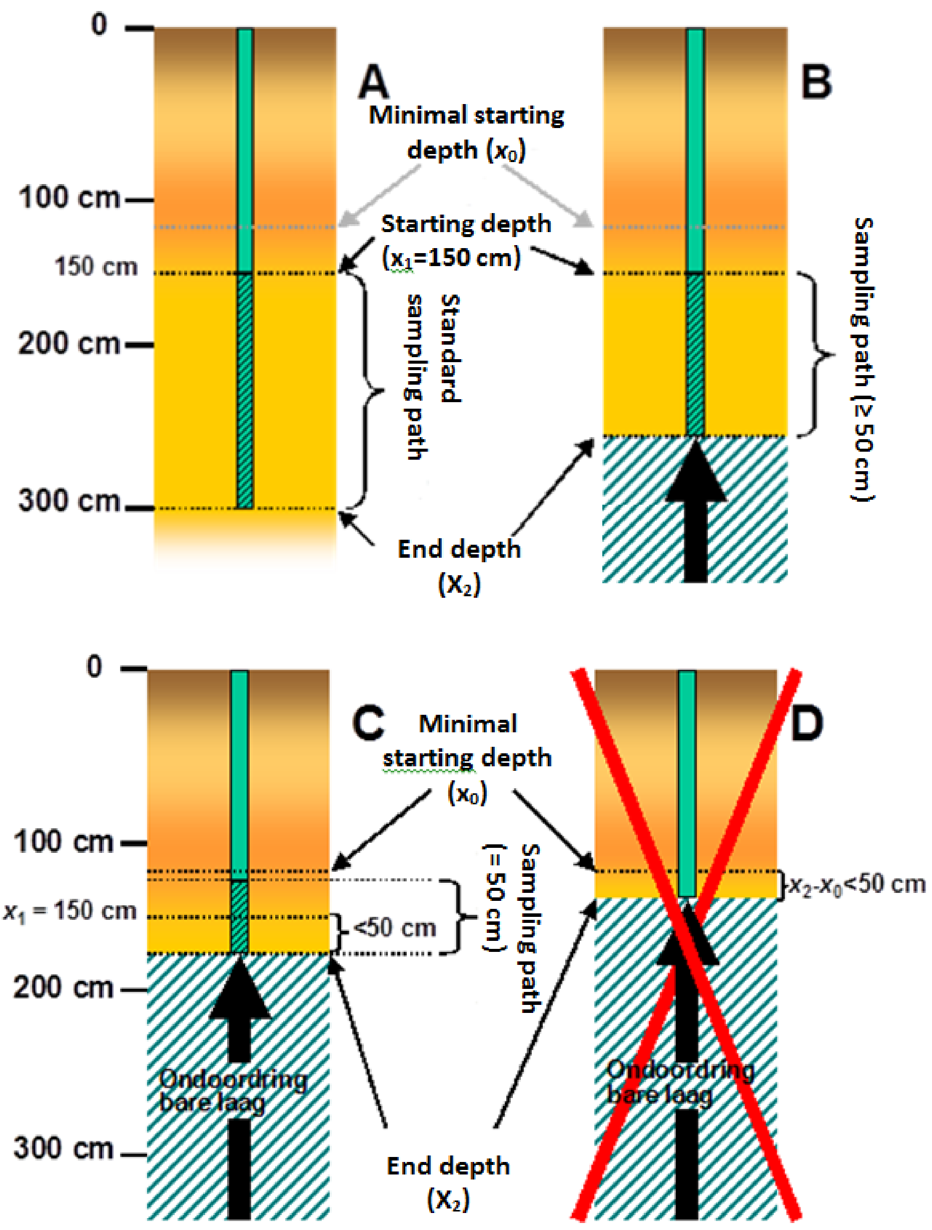

Figure A7.1 Sample path, whether or not hampered by the presence of an impregnable layer. The minimal starting depth (X_0) is 120 cm. The standard sample path is from 150 to 300 cm.

A. 'Deep' soil: will be sampled over the standard sample path.

B. Impregnable layer above the end depth (300 cm) from the standard sampling path: the soil can be sampled over a path from ≥50 cm without adjusting the starting depth (X_1).

C. The soil will be sampled over a range from 50 cm by adjusting the starting depth (X_1).

D. Insufficient depth. The soil cannot be sampled over a range from 50 cm without sampling above the minimal starting depth (X_0): The sample point has to be shifted 10 to 20 metres horizontally.

For 'deep' soils (Figure A7.1-A) the 'standard sampling path' from 150 to 300 cm will apply. However, when an impregnable layer[3] is detected *before the end depth of the standard sampling path is reached*, the following procedure will apply.
(a) The soil must be sampled uniform over a trajectory from a least 50 cm.
(b) The sampling must start below the minimal depth ($X_0 = 120$).
When the soil has insufficient depth, as in Figure A7.1-D, a new bore hole is drilled 10 or 20 m further ahead. Since an impermeable layer might occur at the bottom of the drill hole, a multistage sampling will be used. Initially every 10 cm core starting from the minimal starting depth (X_0) will be put in a separate sealable container.

If it is practically impossible to find suitable sample points, a different minimal starting depth can be selected to avoid plant roots (X_0 value) *after consultation with the fieldwork supervisor (operational manager) or fieldwork coordinator (network manager)*.

Collecting soil samples
Collect the samples according to Work Instruction MIL-W-4014, paragraphs 3.2.1 to 3.2.23.

Preparing individual samples
To determine how much soil is needed from each container to make an individual sample, follow Work Instruction MIL-W-4014, paragraphs 3.2.24 to 3.2.25.

Preparing composite samples
Two composite samples will be always used, regardless of the type of sampling; soil moisture / soil moisture, soil moisture / groundwater or groundwater / groundwater.

When necessary, a temporary proposal how to mix the samples will be given by the fieldwork supervisor in Sample Manager, and will be added to the location map.

Follow-up
Remove the collar and fill the hole by putting back the bored-out soil, if necessary using the Edelman auger to push it back. After filling the hole, replace the turf, if present.

Clean the Edelman auger, knife or spatula and plastic containers with a brush or paper towel and/or clean water. To prevent the augers from rusting, dry them thoroughly.

C. Conservation and transport of samples
Conserve the sampling jars with the soil moisture samples by cooling them to 4º C within 6 hours of sampling.

[3] An impregnable layer is a subsoil layer that is to hard to drill manually. A very dry layer, such as marl, is also considered to be an impregnable layer.

Transport the water samples, according to Work Instruction MIL-W-4008, to their destination.

A5.6 Temporary storage and transport of samples (Instruction MIL-W-4008)

MATERIAL

- Portable cool box;
- Cool box or refrigerator, built into the fieldwork vehicle, with pre-set cooling temperature of +4^{o} C.
- Freezer;
- Frozen cooling elements (< -15^{o} C).

PROCEDURE / WORK METHOD

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

A Temporary storage under controlled temperature conditions

This instruction also applies to the storage of water samples during sampling itself.

- Put the samples in a portable cool box or built-in cool box/refrigerator immediately after they have been taken.
  The built-in cool box or refrigerator should be switched on while travelling to the farm to be sampled, so that the required temperature is achieved in advance.
- Make sure that the sampling bottles stand upright and are stable, to avoid toppling or breakage.
- If a portable cool box is used, it is recommended to use a number a frozen cooling elements – certainly if the outside temperature is above 15^{o} C. The cooling elements should be placed on top of the sample bottles.
- Keep the (closed) portable cool box in 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 if the vehicle is left in the sun.
- Transport or dispatch (by courier) the samples as soon as possible after sampling to the laboratory responsible for testing, or to a storage space with a constant temperature of +4^{o} C (plus or minus 3 ^{o}C).
- Return any used cooling elements to the freezer.
- Clean and wipe dry the cool box after use.

B Transport of samples

- The programme uses two methods of transporting samples to the designated laboratory. Usually the sample-taker himself/herself conveys the samples. If this is not possible (for example, if the sample taker has to remain on site), the samples should be 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. (on the day of sampling) to collect the cool box.

ANNEX 6 Agencies involved in water sampling

Table A6.1 Sampling sub-projects and organisations carrying out water sampling over the period 2011–2014 (FADN years 2010–2013)

Period	**Programme**	**Sampling period**	**Organisation**
Winter 2010/11	‘Cows and Opportunities’ soil moisture (K&K sm)	Oct–Nov	RIVM
	‘Cows and Opportunities’ drains and ditches (K&K dr/di)	Oct–Apr	CBD
	‘Cows and Opportunities’ groundwater (K&K gw)	Dec–Feb	CSO/Tauw
	‘Cows and Opportunities’ ditches (K&K di)	Dec–Mar	CBD
	Scouting market garden vegetable farm drains and ditches (SVG dr/di)	Oct–Apr	CBD
	Clay drains and ditches (CL dr/di)	Oct–Apr	CBD
	Clay groundwater and ditches (CL gw/di)	Nov–Dec/Feb–Mar	Tauw
	Clay ditches (CL di)	Nov–Dec/Jan	CBD
	Loess soil moisture (LO sm)	Sep–Feb	RIVM
	Loess drains and ditches (LO dr/di)	Oct–Apr	RIVM
	Peat groundwater and ditches (PE gw/di)	Nov–Apr	CSO
	Peat surface drain water and ditches (PE sdr/di)	Oct–Apr	CBD
	Peat ditches (PE di)	Nov–Mar	CBD
	‘Cultivating with a Future’	Oct–Apr	CBD
	Sand winter drains and ditches (SW dr/di)	Oct–Apr	CBD
	Sand winter groundwater (SW gw)	Dec–Mar	RIVM
Summer 2011	‘Cows and Opportunities’ groundwater (K&K gw)	July–aug	RIVM
	‘Cows and Opportunities’ ditches (K&K di)	June–Sep	CBD
	Clay ditches (CL di)	June–Sep	CBD
	Peat ditches (PE di)	June–Sep	CBD
	Sand summer groundwater (SS gw)	Apr–Sep	CSO/RIVM/Tauw
	Sand summer ditches (SS di)	June–Sep	CBD
Winter 2011/12	Clay drains and ditches (CL dr/di)	Oct–Apr	CBD/NAK AGRO
	Clay groundwater and ditches (CL gw/di)	Nov–Dec/Feb–Mar	Tauw
	Clay ditches (CL di)	Nov–Dec/Jan	CBD/NAK AGRO
	Loess soil moisture (LO sm)	Sep–Feb	RIVM
	Peat groundwater and ditches (PE gw/di)	Nov–Mar	CSO
	Peat surface drain water and ditches (PE sdr/ di)	Oct–Apr	CBD
	Peat ditches (PE di)	Nov–Mar	CBD
	Sand winter drains and ditches (SW dr/di)	Oct–Apr	CBD/NAK AGRO
	Sand winter groundwater (SW gw)	Nov–Mar	RIVM
Summer 2012	Clay ditches (CL di)	June–Sep	CBD/NAK AGRO
	Peat ditches (PE di)	June–Sep	CBD
	Sand summer groundwater (SS gw)	Apr–Sep	CSO/RIVM/Tauw
	Sand summer ditches (SS di)	June–Sep	CBD/ NAK AGRO

Period	Programme	Sampling period	Organisation
Winter 2012/13	Clay drains and ditches (CL dr/di)	Oct–Apr	CBD/NAK AGRO
	Clay groundwater and ditches (CL gw/di)	Nov–Dec/Feb–Mar	Tauw
	Clay ditches (CL di)	Nov/Feb	CBD/NAK AGRO
	Loess soil moisture (LO sm)	Sep–Feb	RIVM
	Peat groundwater and ditches (PE gw/di)	Dec–Mar	CSO
	Peat surface drain water and ditches (PE sdr/ di)	Oct–Apr	CBD
	Peat ditches (PE di)	Nov–Mar	CBD
	Sand winter drains and ditches (SW dr/di)	Oct–Apr	CBD/NAK AGRO
	Sand winter groundwater (SW gw)	Oct–Mar	RIVM
Summer 2013	Clay ditches (CL di)	June–Sep	CBD/NAK AGRO
	Peat ditches (PE di)	June–Sep	CBD
	Sand summer groundwater (SS gw)	Apr–Sep	CSO/RIVM/Tauw
	Sand summer ditches (SS di)	June–Sep	CBD/ NAK AGRO
Winter 2013/14	Clay drains and ditches (CL dr/di)	Oct–Mar	CBD/NAK AGRO
	Clay groundwater and ditches (CL gw/di)	Nov–Dec/Feb–Mar	Tauw
	Clay ditches (CL di)	Nov–Dec/Jan	CBD/NAK AGRO
	Loess soil moisture (LO sm)	Sep–Dec	RIVM
	Peat groundwater and ditches (PE gw/di)	Nov–Mar	CSO
	Peat surface drain water and ditches (PE sdr/ di)	Oct–Mar	CBD
	Peat ditches (PE di)	Nov–Mar	CBD
	Sand winter drains and ditches (SW dr/di)	Oct–Mar	CBD/NAK AGRO
	Sand winter groundwater (SW gw)	Oct–Mar	RIVM
Summer 2014	Clay ditches (CL di)	June–Sep	CBD/NAK AGRO
	Peat ditches (PE di)	June–Sep	CBD
	Sand summer groundwater (SS gw)	Apr–Sep	CSO/RIVM/Tauw
	Sand summer ditches (SS di)	June–Sep	CBD/ NAK AGRO
Winter 2014/15	Loess soil moisture (LO sm)	Sep–Jan	RIVM

ANNEX 7 Laboratory testing techniques and detection limits

Component/element	Symbol	LOD	Unit	Technique	SOP number	Conservation through/with
Dissolved organic carbon	DOC	0.3	mg/l	infrared (IR)	W-030	H_2SO_4 pH 2 /cooling
Chloride	Cl	0.21	mg/l	ionchromatography	W-060	Nothing
Nitrate	NO_3	0.31	mg/l	ionchromatography	W-060	Filtration and cooling (H_2SO_4 pH 2)
Nitrate	NO_3	0.31	mg/l	ionchromatography	W-060	cooling
Sulphate	SO_4	0.48	mg/l	ionchromatography	W-060	cooling
Nitrate + Nitrite (difference)	NO_3	3	mg/l	photometry/CFA	W-020	cooling
Nitrite	NO_2	0.4	mg/l	photometry/CFA	W-020	cooling
Electro-conductivity	EC(25)	0.5	mS/cm	potentiometry/CFA	W-020	cooling
Acidity	pH			potentiometry/CFA	W-020	cooling
Ortho-phosphate	PO_4	0.04	mg/l	photometry/CFA	W-023	H_2SO_4 pH 2 */ cooling
Total nitrogen	tot-N	0.2	mg/l	photometry/CFA	W-024	H_2SO_4 pH 2 / cooling
Ammonium	NH_4	0.064	mg/l	photometry/CFA	W-027	H_2SO_4 pH 2 / cooling
Aluminium	Al	0.01	mg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Arsenic	As	0.2	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Barium	Ba	1	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Cadmium	Cd	0.05	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Calcium	Ca	0.15	mg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Chromium	Cr	0.5	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Total phosphorous	tot-P	0.05	mg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Iron	Fe	0.05	mg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Potassium	K	0.1	mg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Copper	Cu	0.5	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Lead	Pb	0.2	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Magnesium	Mg	0.05	mg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Manganese	Mn	4	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Sodium	Na	0.2	mg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Nickel	Ni	0.5	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Strontium	Sr	1	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Sinc	Zn	4	µg/l	ICP-MS	W-036	pH 1–2 (HNO_3)
Electro-conductivity	EC(20)	3	µS/cm	potentiometry	W-013	cooling
Acidity	pH			potentiometry	W-013	cooling

* Conservation by acidification is not in accordance with NEN-EN-ISO 5667-3 (2012).

ANNEX 8 Monitoring of agricultural characteristics

This annex relates to the data on agricultural practices and nutrient management (see Section 4.2). Section A8.1 identifies the indicators for farm dimensions and nutrient management. The annex goes on to explain how data from the FADN network are used to calculate farm-specific use of livestock manure (Section A8.2), grass and silage maize yields (Section A8.3) and nutrient surpluses (Section A8.4).

A8.1 Data on agricultural practices and mineral management (FADN)

Farms differ in terms of management (individual choice of a farmer) and in physical conditions (farm size, hydrology and soil conditions). This section describes the categories of farm dimensions and nutrient management. Figure A8.1 shows the different processes and interactions that might take place on a farm, illustrating the kind of management choices a farmer has to make. The actual processes on a farm depend on the farm type (dairy, arable, industrial livestock or other). This section describes the various indicators under two categories: 'characterisation of farms' (farm dimensions) and 'nutrient management'.

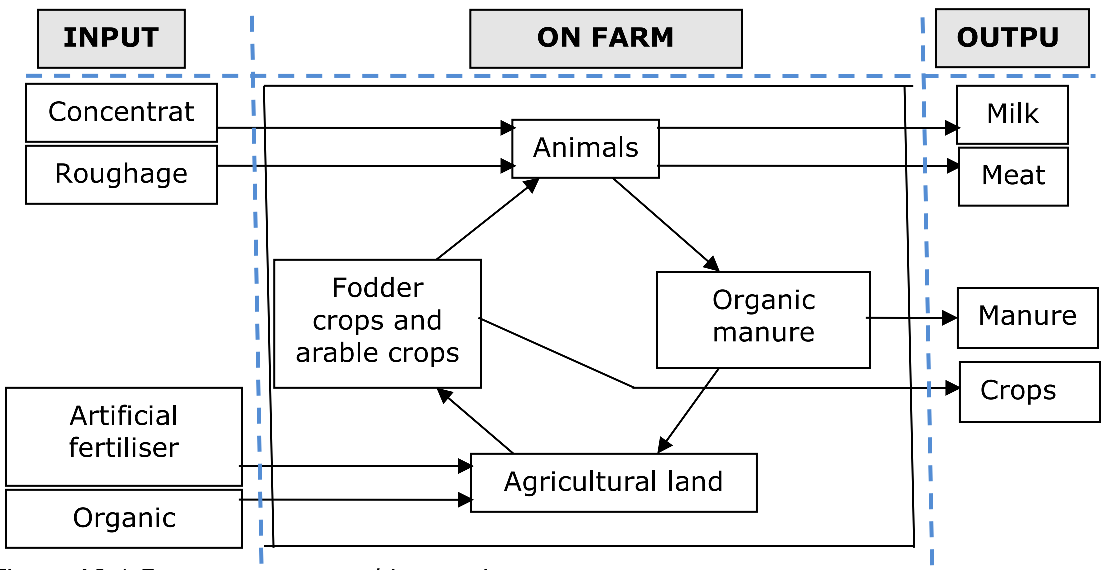

Figure A8.1 Farm processes and interactions

Farm processes as a function of type of farm

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 fertiliser and/or 'imported' organic manure can be used on the farm's agricultural land.
4. The agricultural land mainly produces fodder crops.
5. Fodder crops and inputs of concentrates and roughage are used as fodder for the animals.

Arable farms

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

Industrial livestock farms

1. Animals produce meat and/or eggs 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 fertiliser may 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 to produce feed for her/his own livestock).
5. Self-produced crops and concentrates and roughage from outside are used as feed for the animals.

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

Characterisation of farms

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

- Acreage of cultivated land;
- Livestock density;
- Milk production;
- Classification of cultivated land.

Acreage of cultivated land

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

Livestock density

Livestock density is expressed in Phosphate Livestock Units (LSUs) per hectare of cultivated land. The LSU is a unit used to compare numbers of animals based on their average phosphate production. One adult dairy cow produces 41 kg of phosphate on average per year, which is equivalent to 1 LSU. A dairy cow 1–2 years of age produces 18 kg of phosphate (0.44 LSUs); a dairy cow 0–1 years of age produces 9 kg of phosphate (0.22 LSUs) (Ministry of Agriculture, Nature & Food Quality, 2000).

Milk production

At dairy farms, milk production is reported both in terms of production per dairy cow and per acre. To this end, the 'fat and protein corrected milk' (FPCM) 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 enables a better correlation of production with nutrient and fodder consumption.

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

On arable farms, the production of crops is the primary production objective. For each farm, the acreages and surface percentages of different cash crops (such as potatoes, sugar beet, cereals and pulses) are reported, as well as 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 and the cash crops are considered.

Nutrient management
In the LMM, the nutrient management of farms is characterised by fertiliser usage (consumption) and nutrient surpluses.

Fertiliser use at farm level is reported, and a distinction is made between the use of fertilisers on arable land and on grassland.

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 usage
On-farm use of livestock manure
In order to calculate the use of nutrients in livestock manure, the on-farm production of manure must first be calculated. In the case of nitrogen, this means the net production after deducting the gaseous emissions resulting from stabling and storage. Manure production by grazing livestock is calculated by multiplying the average number of animals present by the applicable excretion standards (Netherlands Enterprise Agency, 2016: tables 4 and 6). This method does not apply to farms that use the guidance document issued for this purpose (see the section below headed 'Farm-specific use of livestock manure'). The nitrogen and phosphate production of livestock is calculated using standardized methods which are annualy updated by the Working Group on Uniform Mineral and Manure Excretions (Statistics Netherlands, 2016).
In principle, the nitrogen and phosphate quantities in inputs and outputs of organic fertilisers are determined by means of sampling. If sampling has not been performed, standard contents for each type of fertiliser are used (Netherlands Enterprise Agency, 2016: table 5). If no sampling

results are available, the output of on-farm-produced manure is calculated on the basis of the farm-specific mineral content per cubic metre of manure, provided the relevant farm uses the Farm-Specific Excretion (BEX) method or the stable balance method. Standard quantities are used for other farms. The total quantity of fertiliser used at farm level is then calculated using the following formula:

Quantity of fertiliser used on farm per year = production + opening stock level – closing stock level + input – output

Farm-specific use of livestock manure
Since 2007, the calculation method for manure production has been modified for farms that make use of the guidance document on farm-specific excretion by dairy cattle (Ministry of Agriculture, Nature & Food Quality, 2010). Manure production on these farms is not calculated on the basis of standard quantities, but separately for each farm (see Section A8.2).

Use of fertilisers on arable land and grassland
The quantities of fertilisers used on arable land are registered directly in the Farm Accountancy Data Network (FADN). The type of fertiliser, the quantities applied, and the time of application are all documented. The quantities of nitrogen and phosphate applied on arable land are calculated by multiplying the quantity of manure (in tonnes or cubic metres) by:

- The nitrogen and phosphorus contents derived from sampling results (if available), or
- The farm-specific mineral content if manure production is calculated separately for each farm (see below), or, if this is not the case,
- The applicable standard nitrogen and phosphorus contents (Netherlands Enterprise Agency, 2016: table 5).

The quantity of fertiliser applied on grassland is calculated as follows:

Fertiliser use on grassland = fertiliser use at farm level -/- fertiliser use on arable land

In the case of farms where grassland accounts for less than 25% of the total cultivated area, fertiliser use on grassland is estimated and the fertiliser use on arable land is calculated as follows:

Fertiliser use on arable land = fertiliser use at farm level -/- fertiliser use on grassland.

The quantity of fertiliser used on grassland comprises fertilisers spread on the land and manure excreted directly by grazing animals onto grassland (grassland manure). The quantity of nutrients in grassland manure is calculated for each animal category by multiplying the calculated excretion by the percentage of the year that the animals spend grazing.

Use of plant-available nitrogen
Total nitrogen use is expressed in kilogrammes of plant-available nitrogen. The quantity of plant-available nitrogen is calculated by multiplying the total quantity of nitrogen in organic fertilisers by the availability coefficients as stated in Netherlands Enterprise Agency (2016: table 3). The quantity of nitrogen from inorganic fertilisers with an availability coefficient of 100% is added to the outcome.

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

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

Lower and upper limits
On LMM farms, fertilisation with inorganic fertilisers, livestock manure and other organic fertilisers must fall within the LMM confidence intervals in order to eliminate any data registration errors. This applies to the separate nitrogen and phosphate quantities, as well as to the total quantities of fertilisers applied (i.e. inorganic fertilisers, livestock manure and other organic fertilisers). Table A8.1 lists the confidence intervals for non-organic dairy farms.

Table A8.1 Lower and upper limits for applied quantities of inorganic fertilisers, livestock manure and other organic fertilisers on non-organic dairy farms, and total quantities of fertilisers applied (inorganic fertilisers, livestock manure and other organic fertilisers), expressed in kilogrammes of nitrogen and phosphate per hectare

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

Calculation of surplus nutrients
Nutrient surpluses are calculated by applying a method derived from the approach used and described by Schröder et al. (2004, 2007). This means that, alongside the input quantities of nitrogen and phosphate in organic and inorganic fertilisers and the output quantities in crops, allowance is also made for other sources of input, such as the net mineralisation of organic substances in the soil, nitrogen fixation by leguminous plants, and atmospheric deposition.

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

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

The calculated nitrogen surplus on the farm gate balance is then corrected to account for input and output items on the soil surface balance. The phosphate surplus on the soil surface balance is equal to the surplus on the farm gate balance. Table A8.2 lists the confidence intervals for surpluses on the farm gate balance. A more detailed explanation of the calculation methods can be found in the following sections of this Annex.

Table A8.2 Lower and upper limits for the surplus on the farm gate balance, expressed in kilogrammes of nitrogen and phosphate per hectare

Nutrient	**Lower or upper limit**	**Kg per hectare**
Nitrogen		
	Lower limit	-250
	Upper limit	800
Phosphate		
	Lower limit	-100
	Upper limit	250

Livestock manure storage rate
The ‘livestock manure storage rate’ relates the storage capacity for livestock manure to its production. A rate of 6 months means that half of the annual production of manure can be stored. When the manure storage rate is above 7 months, farmers may store manure longer than legally obliged (since 2012), enabling them to use it at those periods when crops need it most. The animal manure storage rate capacity is calculated as:

manure storage capacity / (annual livestock manure production/12)

Rate of grazing
The indicator ‘rate of grazing’ provides information on the time dairy cows spend grazing (in the field) during the period May–October. A 100% grazing rate would mean 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 rate 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 rate of mowing indicates how often the grassland is mowed in a year. A mowing rate of 300% means that it is mowed three times per year on average. The mowing rate is calculated as:

*(area of grassland mowed annually / pasture area) * 100%.*

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

A8.2 Farm-specific use of livestock manure

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

- The farm is a specialised dairy farm according to the standard output classification.
- The dairy herd accounts for at least 67% of the total quantity of phosphate LSUs for grazing livestock.
- No pigs or poultry are present on the farm.
- The farm itself has reported that it uses the BEX method.
- Since 1 January 2009, the guidance document on farm-specific excretion by dairy cattle has been used to calculate the farm-specific excretion of the dairy herd (Ministry of Agriculture, Nature & Food Quality, 2010). The calculation method used deviates from the guidance document in two respects (Ministry of Agriculture, Nature & Food Quality, 2010):
- The uptake from silage maize expressed in fodder units (Voedereenheden Melkvee, VEM) is derived directly from the silage maize yields reported by the farmer, corrected for stocks (the method used in Aarts et al., 2008). In the guidance document, the uptake is calculated using a correction method.
- The allocation of fodder units to fresh and conserved grass is calculated on the basis of the net number of grazing hours reported by the farmer, whereas the guidance document (Ministry of Agriculture, Nature & Food Quality, 2010) and Aarts et al. (2008) define three classes based on reported grazing hours.

A8.3 Calculation of grass and silage maize yields

A8.3.1. Calculation procedure

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

It is then assumed that the remaining energy requirement is covered by grass produced on the farm. The number of grazing days registered in FADN is used to calculate a ratio between the energy uptake from fresh grass and the uptake from conserved grass. This procedure can be used to determine the quantity of energy (expressed in fodder units) obtained by the animals from farm-produced feed. The nitrogen (N) and phosphate (P) uptake are then calculated by multiplying the uptake in fodder units (VEMs) by the N:VEM and P:VEM ratios. Finally, the N, P, kVEM and dry-matter yields (in kilogrammes) for grassland are calculated by adding to the uptake the average quantities of N, P, kVEMs and dry matter lost during feed production and conservation.

A8.3.2 Selection criteria

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

- The farm is a specialised dairy farm according to the standard output classification.
- The dairy herd accounts for at least 67% of the total quantity of phosphate LSUs for grazing livestock.
- No pigs or poultry are present on the farm.

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

- At least 15 ha are used for the cultivation of fodder crops.
- There are at least 30 dairy cows.
- Annual milk production is at least 4,500 kg of FPCM per cow.

These criteria were not considered because they were used in Aarts et al. (2008) to make statements about the population of 'typical' dairy farms. In line with Aarts et al. (2008), the following additional confidence intervals for yields were applied with respect to the outcomes:

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

If the yield falls outside this range, it is assumed that this must be caused by a book-keeping error. In that case, the grass and silage maize yields of the farms concerned are also excluded from the report.

A8.3.3 Deviations from procedure described in Aarts et al. (2008)

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

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

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

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

Re. 3
Deviating from Aarts et al. (2008), the ratio of energy uptake from fresh grass to uptake from silage grass was calculated on the basis of the number of grazing days registered in FADN. The percentage of fresh grass varies between 0 and 35% for zero grazing, between 0 and 40% for unlimited grazing, and between 0 and 20% for limited grazing. This calculation is also performed in accordance with the method described in appendix 2 to the guidance document (Ministry of Agriculture, Nature & Food Quality, 2010).

Re. 4
The information in appendix III of Aarts et al. (2008) is not complete with respect to the percentages adopted for conservation losses. To avoid any misunderstandings, the percentages used in FADN to calculate conservation and feed production losses are stated in Table A8.3.

Table A8.3 Percentages used to calculate conservation losses and feed production losses

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

A8.4 Detailed explanation of methods to determine the nitrogen surplus on the soil surface balance

As mentioned in Section A8.2, the nitrogen surplus at farm level is first calculated and then corrected to account for a number of input and output items on the soil surface balance. The phosphate surplus on the soil surface balance is equal to the surplus at farm level. A more detailed explanation of the calculation methods can be found in Table A8.4 below.

Table A8.4 Calculation methods used to determine the nitrogen surplus on the soil surface balance (kg of nitrogen per hectare per year)

Description of items		**Calculation method**	
		Quantity	**Inputs**
Farm inputs	Inorganic fertilisers	Balance of all inputs, outputs and stock changes of inorganic fertilisers	Data obtained from suppliers' annual overviews. If these are not available, standards are used (Nutrient Management Institute, 2013).
	Livestock manure and other organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net consumption (input)	Sampling results or standard quantities (Netherlands Enterprise Agency, 2016: table 5). If farm-specific manure production is known, the output of on-farm-produced manure is corrected accordingly (see Lukacs et al., 2016: section A3.2).
	Feedstuffs	Balance of all inputs and stock decreases of all feed products (feed concentrate, roughage, etc.)	Data obtained from suppliers' annual overviews. If these are not available, standards are used (Centraal Veevoederbureau, 2012).Standards for compound feed in 2006–2009 based on data compiled by Statistics Netherlands (2010, 2011). Since 2010, all compound feed data have been calculated for each farm.Standards for silage grass and silage maize based on annual averages for the different soil type regions (data supplied by Eurofins).
	Animals	Only imported animals	Standard quantities based on Ministry of Agriculture, Nature & Food Quality (2010) and Netherlands Enterprise Agency (2016: table 7)
	Plant products (sowing seeds, young plants and propagating material)	Only imported plant products	Data based on Van Dijk, 2003
	Other	Balance of all inputs, outputs and stock changes of all other products in the case of net consumption (input)	
Farm outputs			

Description of items		Calculation method	
		Quantity	Inputs
	Animals	Balance of outputs and stock changes of animals and meat	Netherlands Enterprise Agency (2016: tables 7 and 8)
	Livestock manure and other organic fertilisers	Balance of all inputs, outputs and stock changes of livestock manure and other organic fertilisers in the case of net production (output)	Sampling results or standard quantities (Netherlands Enterprise Agency, 2016: table 5). If farm-specific manure production is known, the output of on-farm-produced manure is corrected accordingly (see Lukacs et al. 2016: section A3.2).
	Crops and other plant products	Balance of outputs and stock changes of plant products (crops not intended for roughage), stock increases and sales of roughage	Data based on Van Dijk (2003) and Centraal Veevoederbureau (2012).
	Other	Balance of all inputs, outputs and stock changes of all other products in the case of net production (output)	
	Animals	Balance of outputs and stock changes of animals and meat	Netherlands Enterprise Agency (2016: tables 7 and 8)

Description of items		Calculation method: Quantity	Inputs
Nitrogen surplus at farm level		Farm input -/- Farm output	
Input on soil surface balance	+ Mineralisation	For grassland on peat soils: 160 kg of nitrogen per hectare per year (Van Kekem, 2004). Other crops on peat soils and reclaimed peat subsoils (irrespective of crop): 20 kg of nitrogen per hectare per year. All other soil types: 0 kg. In the case of FADN farms, the surface areas are registered according to the four soil types defined by the Netherlands Enterprise Agency (sand, clay, peat and loess). Mineralisation in reclaimed peat subsoils was estimated on the basis of the overall soil classifications of each farm (based on postcode), in accordance with the Alterra soil map, version of 2006	
	+ Atmospheric deposition	The basic data are derived from National Institute for Public Health and the Environment (2016).	
	+ Nitrogen fixation by leguminous plants	Clover on grassland: the quantity of nitrogen fixation depends on the proportion of clover and the grassland yield, and is based on a nitrogen fixation per kg of dry-matter yield in the form of clover of (4.5/100)/2. Other crops (Schröder, 2007): - Lucerne: 160 kg per hectare - Peas, broad beans, kidney beans and French beans: 40 kg per hectare	
Output on soil surface balance	- Volatilisation resulting from stabling, storage and grazing	The calculation method is based on Velthof et al. (2009). Calculations are based on the Total Ammonia Nitrogen (TAN) percentage. If the farm uses a farm-specific calculation method to calculate manure production, the emissions resulting from grazing, stabling and storage are calculated as follows: - Ammonia emissions resulting from stabling and storage: the stable code under the Regulations on the Use of Ammonia in Livestock Farming (*Regeling Ammoniak en Veehouderij*, RAV) is used as a starting point. The total nitrogen emissions are calculated as a percentage of the emitted ammonia nitrogen (based on the RAV emission factor). The emitted ammonia nitrogen is determined on the basis of the TAN percentages in the manure (Van Bruggen et al., 2015). - Ammonia emissions resulting from grazing are calculated as a percentage (2.6%) of the total quantity of ammonia nitrogen excreted on grassland (Van Bruggen et al., 2015). If a farm calculates excretion based on standard quantities, the emissions resulting from grazing, stabling and storage are calculated as follows: - The gross standard-based excretion is calculated by adding the standard-based emission factor to the net standard-based excretion (Groenestein et al., 2005; Tamminga et al., 2004; Oenema et al., 2000). This factor depends on the type of animal	

Description of items		Calculation method: Quantity / Inputs
		(11.3% for dairy cows). The emission factor is preferably updated based on the data in Van Bruggen et al., 2015. - The emissions resulting from grazing are then calculated by multiplying the quantity of nitrogen excreted by grassland manure (net standard-based excretion * grassland fraction) by the emission percentage of the total quantity of ammonia nitrogen excreted on grassland (Van Bruggen et al., 2015). - The emissions resulting from stabling and storage are calculated as the gross standard-based excretion minus the net standard-based excretion.
	- Volatilisation resulting from application	The ammonia emission factors for the application of livestock manure and inorganic fertilisers are based on Velthof et al. (2009) and Van Bruggen et al. (2015). Other gaseous nitrogen emissions during application are not taken into consideration. Emissions resulting from application are calculated as a percentage of the applied ammonia nitrogen based on the emission factors as reported in Velthof et al. (2009: appendix 14). If no information on the application method is available (this has not been the case in the LMM framework since 2010), an average percentage for each soil type is applied. This standard is derived using the MAMBO method (De Koeijer et al., 2012). Agricultural Census data on application methods are used for this purpose. The methods are classified according to soil type and land use type, and linked to an emission factor and a Total Ammonia Nitrogen (TAN) factor.
Nitrogen surplus on the soil surface balance		Nitrogen surplus on farm + input on soil surface balance – output on soil surface balance

ANNEX 9 Overview of LMM reports from its start till 2016

2016
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2015
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