Statistics Netherlands

Report

Methodological description of extending the Materials Monitor with Water

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remarks The views expressed in this paper are those of the author(s) and do not necessarily reflect the policies of Statistics Netherlands.

Contents

1. Introduction

1.1 Background

Statistics Netherlands (CBS) has developed a Materials Monitor in recent years. This is a product in which all material flows from, to and within the Netherlands are described in the form of physical supply and use tables (SUT) that are consist with the National accounts (NA). The Monitor was last published as a report in 2013 (CBS, 2013)[1].
The Ministry of Economic Affairs (EZ) commissioned the extension of the Materials Monitor with the supply and use of water in the Dutch economy. This report provides an overview of the method that has led to this extension. This also includes wastewater production as well as the treatment and the return flows of water to the environment again. This report provides an overview of the method that has led to this extension.

1.2 Current Materials Monitor

The basis of the current Materials Monitor is the monetary SUT from the National accounts by Statistics Netherlands. The SUT shows per sector which goods they make and which they use. Physical SUTs can be derived by transforming the monetary SUT into a physical SUT on the basis of price information. Wherever possible Statistics Netherlands uses its statistics with physical data to improve the results from the first step. The tables also include non-product data such as emissions to air, waste and use of raw materials, and non-industrial data on the environment.

For the sake of quality and consistency the physical supply and use per commodity and sector are balanced and made equivalent. This is done by adding supplementary information on material flows such as waste and emission to air. The differences are edited manually or else fitted automatically. The result is a consistent and integrated, physical SUT of the Dutch economy.

1.3 Extending the Materials Monitor with water

The dimension “water” was not an integral part of the method of the Materials Monitor. Statistics Netherlands has compiled statistics on water for years in its environmental statistics and its environmental accounts e.g. on water consumption, water extraction and the production and treatment of wastewater. The water statistics and water accounts [2] publish these figures in standardised formats. These figures form the basis for the extension of the Materials Monitor with the dimension water.
To give water its proper place in the monitor, we carried out several feasibility studies in this project, which resulted in a fully integrated SUT. This has been compiled for 2008, 2010 and 2012.

This is a methodological report accompanying the PSUT tables that resulted from the study <link (in Dutch)>. This report serves as a ‘reader’ and explanation of the tables and as a description of the method used to achieve the figures. A brief description of the results and summary tables can be found <here (in Dutch)>.

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[1] http://www.cbs.nl/NR/rdonlyres/F0325ADE-2F98-4B63-9931-D85A43574007/0/2013Monitormateriaalstromenpub.pdf

[2] Physical water flow accounts (PWFA), according to the concepts and definitions of the ‘System of Economic and Environmental Accounts for water’ (SEEA_Water). This serves as the standard for compiling the SUT for water, or ‘the Physical Supply and Use tables (PSUT).

In this section we explain which flows are shown in the SUT Water, which key concepts are used and how the figures were compiled.

1.3.1 Scope of flows in SUT Water

Three main flows can be distinguished within the physical SUT Water (‘from the environment to the economy’, ‘within the economy’ and ‘from the economy to the environment’). The tables describe the exchange of water between the environment and the economy, both the abstraction[3] from the environment as the ‘return flows’ including losses flowing back to the environment, and the exchange of water between the sectors within the economy. The flows are shown in the columns of the extensive tables, the rows show the industries (sectors) or ‘entities’ (called ‘regkols’ in Dutch National Accounts, households, imports, exports and the environment). In the summary tables the ‘entities’ are shown in restricted groups and the rows and columns are shown in reverse.

From the environment to the economy

The domestic water system has two fresh water sources, namely fresh surface water and groundwater[4]. Furthermore water is extracted from salt surface water (marine). All this water is used for production and consumption. PSUT distinguishes between non-process water (that is water for household purposes and personal care) and process water, where process water is divided into water included in products and water used for cleaning, cooling, services and other purposes.

In the supply tables the abstraction of water is registered as supplied by the environment. The same quantity of water is registered in the use tables as water available for intermediate consumption with the industry that carries out the abstraction. In most cases the water is used by the entity that extracted the water. The various purposes for which the water is actually used are always distinguished here. Rain water that is used directly within the economy or right after it is gathered is not included, nor is rain water gathered in the storm sewers.

From the economy to the economy

Water abstracted from the environment can be distributed to other economic actors, after treatment or untreated. The water goes from one to the other economic actor, but it remains in the economy. Besides the use by enterprises, the use table also shows the final consumption by households and the rest of the world (exports). In the supply table these items come back as ‘supplied by water companies’ and ‘the rest of the world’ (imports). The Netherlands has had a small negative trade balance for drinking water, or net imports, for years.

Apart from the ‘visible’ physical water flows, water in products is also taken into account. After all there is water in the raw materials and auxiliary products that circulate among economic actors, and water can be added to raw materials and products during the production process. These quantities are shown in the use table. Finally a given quantity of water remains in the products supplied, be it finished or semi-manufactured products. These quantities are presented in SUT as supplied by the industry under ‘water in product’.

In the chain starting with extracting water and ending with using it in production and consumption activities, there will be water that is no longer or not fully used by the user. Some of this used water will flow from the economy (production activity) to the economy

[3]The quantity of water extracted from a source in a given period whether temporarily or permanently.

[4] Soil water is a third major source in the domestic fresh water system but it is not taken into account in this project. This is because in the context of the Materials Monitor it is considered a flow from the environment to the environment. Soil water as a flow from the environment to the economy is part of the SUT or PSUT in the standard water accounts.

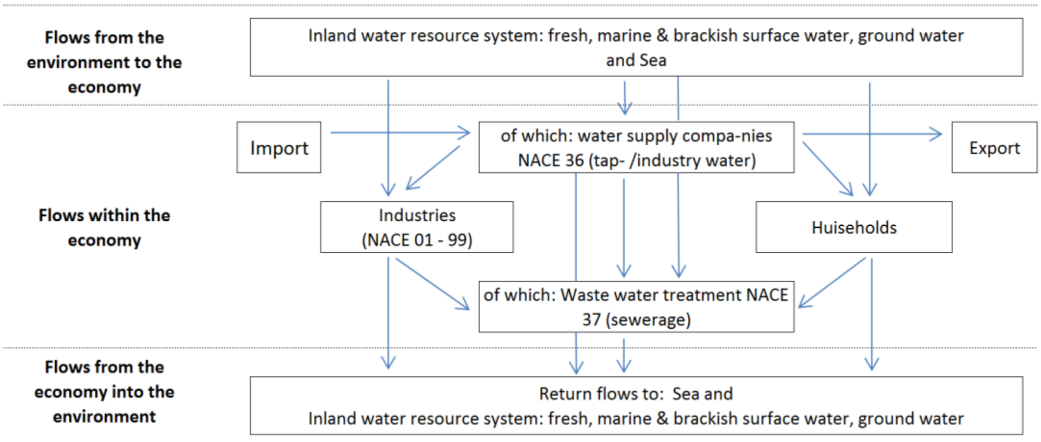
(wastewater treatment) and is called wastewater. This water can be discharged in the sewage system, the Urban Waste Water Treatment Plants (UWWTP) or resupplied, sometimes after some form of wastewater treatment in dedicated waste water treatment facilities on site, to other economic entities for reuse. This reuse is probably not fully observed.
Wastewater supplied by wastewater treatment plants or other economic entities are registered in the supply table in the correct industry (regkol) under item 'to wastewater treatment' and item 'to industry'. In the use tables these quantities are included in wastewater treatment under 'wastewater collection and treatment' and in the correct receiving industry (regkol) under 'industry (reuse of water)'.

From the economy to the environment
Water will also flow back to the environment, these are the 'return flows'. The return flows can come directly from the economic entity and the households or from a wastewater treatment plant. In the supply table these water flows are shown as being supplied by the industry (regkol) or households involved under 'wastewater collection and treatment' or 'to the environment', while a distinction is made between fresh and salt surface water and the soil. Per industry the discharge (supply table) has to correspond with the total water intake (use table), corrected for the flows of 'water in product' and 'water losses'.

To create a complete 'balance' in the water volumes of the three main flows described, we need to take water losses into account. Water losses consist of water flows that do not reach their desired destination, or disappear from stock or from the product. Water is mainly lost through evaporation, e.g. from crops or during distribution e.g. through leaking or theft. Loss is registered as such in the supply table for the industry involved. Corresponding volumes are recorded in the use table as 'return flows' for the entity environment under 'water losses'. This excludes evaporation from crops based on extractions of soil water in agriculture that originally stem from precipitation.

The figure below schematically shows the three main flows.

1.3.1.1 Illustration of the physical flows between the environment and the economy and within the economy



Source: SEEA-Water, 2012; Figure III.2 Detailed description of physical water flows within the economy. Statistics Netherlands, figure adjusted for this project.

Summarised, the rows in the SUT consist of 'economic entities'; that is the various industries (regkols), households, imports, exports and the environment. The columns are made up from various sections that provide information about:

- Abstraction of water from the environment, including extractions/crop absorption;

- Distribution and use of water by the various industries (regkols) and households in the economy, including water in products;
- Production and flows of wastewater (often towards wastewater collection) and reused water (between households and businesses).
- 'Return flows', in which a distinction is made in the return flows into fresh surface water, salt surface water and soil. Also water losses due to vaporizing (including evapotranspiration as a result of sprinkling and irrigation) are considered 'return flows'.

1.3.2 Key concepts in SUT Water

Below we listed the key concepts that are useful for a correct interpretation of the table.

Tap water (drinking water) This is water of drinking water quality extracted and produced by water companies. This is purified fresh ground or surface water that is transported through the water mains system.

Extraction /absorption by crops Soil water or soil humidity (irrespective of whether the water in the soil comes from precipitation or from irrigation or sprinkling) that is extracted from the soil by products, mainly crops and plants.
Extraction is a special category in the tables. Extraction occurs from the sources of the 'inland water' system and the North Sea and concerns salt and fresh and brackish surface and groundwater. Absorption by plants from the water sources in the soil can originally come from precipitation as well as from irrigation or sprinkling. Water from irrigation or sprinkling does not constitute more than five percent of the total uptake by crops. The use table shows that uptake/absorption by plants (crops) occurs mainly in agriculture. The supply table shows total extraction as supplied by the entity 'the environment'. Extractions (absorption) with crops are registered in the tables for the sake of consistency with the material flows. This is done to enable further monitoring of water flows in the economy, in this case the water flows that enter the economy with the raw materials and products. The large flow of water from the soil absorbed by crops and then evaporated (transpiration), is not included in the tables. On the other hand, what is fully recorded in the tables is the surface and groundwater extracted for irrigation or sprinkling purposes in agriculture and horticulture that lands on the soil or substrate etc. and that is absorbed by plants regardless of whether it is evaporated (under extraction). This evaporation is shown as water loss. Extractions that return directly to the environment, without having been supplied, are also excluded. For instance sand used for raising the surface, where the water in the sand flows back directly to the environment.

Groundwater This is water pumped up from the subsoil (the saturated zone) or that comes to the surface, in other words abstraction. The composition can be fresh, salt or brackish.

Industrial water This is also called 'other water'. This water is not of drinking water quality (but of higher or lower quality). This can be filtered or unfiltered water, semi-manufactured, distilled water, demineralised water, etc. It is supplied by either a specialised industrial water company, another (industrial) company or by a regular water company through a special dedicated water distribution network.

The environment The environment in the use table means the various sources from which water is abstracted; fresh and salt surface water and groundwater and soil water (only the part of the abstraction by plants that ends up in the crop and product). Most of the soil water, which is absorbed by crops and evaporates, is not taken into account in the tables and this report. In the supply table the item ‘environment’ means the destinations of used water. This is either fresh surface water, salt surface water, groundwater, the soil or the atmosphere.

Non-process water Household water used for taking showers, drinking, flushing toilets, cleaning, watering plants, etc.

Abstraction Abstracting groundwater or surface water (fresh, salt of brackish) from water bodies or water sources (resources) in the natural environment. This is usually done by technical means, e.g. pumps.

Fresh surface water This is water from inland waterways such as rivers, lakes, canals (except groundwater), transition waters, as far as its chemical consistency is concerned, that is made available for economic activities by extraction.

Salt surface water This is the surface water that comes from the sea or coastal waters, also known as marine water. In this study we also include the brackish to salt water in transition water like the delta of the Scheldt River and the Wadden Sea.

Process water This is water used during the production process. A distinction is made in process water between water included in the product, water for cooling, cleaning, services and other applications. For instance: household water consumption by people working in hotels or restaurants is considered non-process water. But when the clients make use of the bathroom facilities this is considered process water for services.

***Regkol* (Industry)** The extension of the Materials Monitor with water, uses a simultaneous classification of 133 industries. This in line with the industry classifications used in the monetary accounts or the monetary SUT system of NA. These industries are called regkols in the SUT system.

Return flow This concerns the water flow from the economy directly back into the environment.

Water supply Water leaves/flows out of an economic unit. Water supply is the sum of the water supplied to other economic units and the water flow to the surrounding environment. Water supply to the environment is also called ‘return flow’. Water supply in the economy is water supplied/submitted by one economic unit to another. Water supply in the economy is used after subtracting the losses in distribution.

Water use This concerns water use by Dutch activities. Water use is the sum of water used in the economy and water use from the surrounding environment. Water use in the economy is the intake of water from one economic unit distributed by another economic unit. In the system this constitutes internal water delivery. Water use from the surrounding environment is water abstracted from the environment by the economic units/the users themselves. Water users in the economy are households, industry (manufacturing), agriculture and other industries.

1.3.3 Brief description of the research method

The extension of the Materials Monitor with physical quantities of water was studied and carried out in the four methodological steps described below.

SUT – Water types The supply and use of water in the Dutch economy is added to the Materials Monitor. The method used is based on a pilot carried out in 2013 in which water flows in the

Netherlands were studied (Pfister et al., 2013). Water is distinguished for all industries in the Materials Monitor including wastewater collection and treatment. The distinctions are fresh and salt surface water, groundwater, tap water of drinking water quality and industrial water (other water).

Distinctions in process water In this section we studied the feasibility of distinguishing process and non-process water in the total quantity of water from "SUT- Water types". Furthermore we studied if process water can be subdivided into water included in products and water for cooling, cleaning, services and other process purposes.

Industrial wastewater The results from the section "Distinctions in process water" serve as input for adding the wastewater flows and return flows to the Materials Monitor. For the various industries and households we estimated the released wastewater flows, divided into wastewater collection and treatment (sewer), industry (reuse water), soil, salt surface water, fresh surface water and the atmosphere (water loss).

Confrontation with urban wastewater treatment plant (UWWTP) data In this section the dry weather discharge by households and companies is confronted with the influent of urban wastewater treatment plants (UWWTP). This takes into account rainwater and unintended dilution of sewage that flow into the urban wastewater treatment plants as well as the combined sewer overflow and leaks in the sewer system. In this section we analyse the entire return flow (water flowing from the economy via the sewage system and urban wastewater treatment plants back into the environment). Reuse after the treatment of its own wastewater in treatment facilities on site is not included because it is not fully known. Also water supplied to other economic entities for use or reuse is probably not fully observed.

Integration of water, wastewater and balancing items The various figures were confronted at the end. To achieve balanced physical SUT tables for water, we balanced water extraction, water use, wastewater production, water in products and discharge into the environment with other return flows. The final item in the balanced table is water loss during the production process.

The first four steps are explained in chapters 3 through 6. This is preceded by a description of the sources used. The last step of integration and balancing is a technical process that is not described in detail in this report, but is included in the results of the PSUT tables. For the method as a whole and therefore also in interpreting the figures in the tables it is important to emphasise that this is a feasibility study. The results are partly based on estimates, supported by expert knowledge, but largely based on already available statistics and studies about this issue.

2. Sources

Before addressing the methodology in some detail, we will first discuss the main sources. We may refer to them when dealing with the methodology. First we will discuss the data used and then the major studies and reports.

2.1 Data

- LEI – The Agriculture Economics Institute of Wageningen University (LEI) has developed a business information network ('Bedrijven-Informatienet', BIN) which supplies figures on water extraction and use by agriculture and horticulture. Data are available on the total quantity of water extraction - extraction from the environment and use of tap (drinking) water - for the various sectors in agriculture and horticulture and for several years (time series). BIN uses a limited sample survey of over 1,000 holdings in agriculture and horticulture that have been followed intensively for several years. The sample survey is in line with European formats through the Farm Accountancy Data Network (FADN). The sample is drawn from the population of agricultural holdings that are included in the agricultural census. LEI has supplied rough data to Statistics Netherlands on commission for several years. Each year Statistics Netherlands examines whether or not an update is required. Some 'processing' of the LEI data is needed to get the desired aggregates for the extraction of surface water as well as for groundwater.
- Agricultural census, or 'Farm Structure Survey', FSS. This is an integral observation of all agricultural holdings in the Netherlands, using a lower threshold that is based on the holding's economic size. The Standard Output is used as the measure of economic size. Once every three years or so questions are included about farms' water use, particularly about irrigation. There are some minor criticisms about this source: it does not provide an overall picture of all water use because various years are missing and the questions have changed over time. For this reason the source is only used as a control tool.
- Electronic annual environmental reports (e-AER; in Dutch: e-MJV)[5]: through the e-AERs returned by companies we gather data about waste materials and emissions to air and water of about 500 companies in manufacturing and in the energy and the environment sector. Only companies engaged in activities described in annex 1 of the EC-Regulation Polutant Release and Transfer Register, PRTR are under obligation to report, but only when they exceed the threshold for one or more substances in the distinguished list of substances or for waste. The industrial classification of the companies is known from the International Standard Industrial Classification of all economic activities, either NACE rev.2 or ISIC rev 4 [6].
  - The e-AER also contains a water module. This module is used to collect data about the extraction of surface water and groundwater, as well as the use of tap (mains) water. That data is made available from the key companies in the industrial sector. Statistics Netherlands extrapolates the individual water data of this selection of companies to the total population and to the populations per category of the International Standard Industrial Classification (NACE or ISIC) by using the data per company and per NACE class (see 'PRODCOM data' below). Not all NACE classes in

[5] http://www.e-mjv.nl/

[6] Standard Industrial Classifications (Dutch SBI 2008, NACE or ISIC). The Dutch Standaard Bedrijfsindeling (SBI 2008) is based on the activity classification of the European Union (Nomenclature statistique des activités économiques dans la Communauté Européenne, NACE) and on the classification of the United Nations (International Standard Industrial Classification of All Economic Activities, ISIC).

manufacturing are sufficiently covered by the data from the e-AER. In those cases we made estimates based on other sources, including old figures from the National Water Survey on water use by industry (see National Water Survey on water use by industry, NWS below).

- PRODCOM data: these data are used to determine the extraction of fresh surface water and groundwater as well as tap (mains) water use by companies in SBI2008 (3-digit) categories 15-37 that are not in the e-AER register. For de NACE 3 digit categories that are represented by a sufficient number of individual companies, the data on water production and tap water are extrapolated to national totals. Raising is done with the physical and/or monetary production data from the PRODCOM statistics and also in part with labour figures. The summed water data of the individual companies with an e-AER are raised on the basis of the ratio of the production of the individually registered companies and the total production of the industry (NACE).

- National Water Survey on water use by industry (NWS; CBS, 2004). This NWS survey was held every five years, the last time on reporting year 2001. In this survey, questions were asked about water use by companies and for example a distinction was made for water use for cooling. Electricity plants and large companies were observed in full. Smaller companies were included in a sample survey. In total the NWS survey covered some 7,500 business units.
  - For industries (NACE Rev.2) at the 3-digit level in manufacturing that were not represented with an e-AER, water extraction and water use are estimated on the basis of historical data from this survey on water in : a. Mining and quarrying (NACE 11), b. manufacturing (NACE 15 to 37), c. 'Public utilities' with Electricity, gas, steam and warm water (NACE 35). For a full description of the method used, see Graveland, 2006.
  - The survey data were also used to distinguish water used for cooling within process water.
- Labour accounts (LA)[7]. The Labour accounts are a product compiled by Statistics Netherlands based on registrations and surveys. They provide information about the number of fulltime equivalents by industry (regkol). This was used to derive the quantity of tap water per industry for household purposes (personal care).
- National Groundwater Register ('Landelijk Grondwater Register', LGR)[8]. This register was a result of the introduction of the Water Act and came about in 2009. In here one aims to integrate the 12 existing provincial groundwater registers and recently also the groundwater registers from the Dutch water boards. In this Act the legal tasks and powers pertaining to groundwater in the Netherlands were laid down. The Interprovincial consultation body (IPO), together with the Province of Overijssel and TNO DINO made sure that the provinces and water boards have access to this central groundwater register (LGR), so they can perform these tasks. The National Groundwater Register contains data on:
  - all extractions for which registration or notification is obligatory;
  - all permits for extracting groundwater and/or infiltrating water;
  - the administrative data including the purpose for which water is extracted etc.;
  - technical information, including water quantities abstracted;
  - geographical information.

  The National Groundwater Register is still being developed. The data on reporting years 2008-2012 that we used for this study do not fully reflect all groundwater extraction.

[7] http://www.cbs.nl/nl-NL/menu/methoden/dataverzameling/2008-ar.htm
[8] https://www-new.lgronline.nl/lgr-webclient/

- Integral survey on the design and functioning of all urban wastewater treatment plants (UWWTP) in the Netherlands. Statistics Netherlands carries out this survey among the Water boards on behalf of various other government bodies such as Rijkswaterstaat and RIVM.[9] The results are published in seven StatLine publications, including Process data on wastewater treatment[10]. These publications provide insight in the total volume of influent and the return flows of treated wastewater to the environment (effluent).
- Materials Monitor. For the Materials Monitor we made calculations for the plausibility of the balancing items on the loss/inclusion of water in product and water 'included' with the extraction of raw materials/products. Based on the supply and use of products/waste by industry and the quantities of water it contains, we calculated the volume of water flows coming with products into and flowing out of the different industries. On the basis of this we made an estimate of the net water intake and the water loss (e.g. through evapotranspiration). This is a rough estimate which nevertheless gives a fair indication of the water flows through products.
- VEWIN. VEWIN is the Association of Dutch Water Companies. VEWIN registers are a key source for the figures on total tap (mains) water supply, e.g. for household use. These figures are used by Statistics Netherlands[11]. VEWIN is also the main source for the substantial groundwater and fresh surface water extraction by the water companies.

2.2 Literature

The data above were supplemented by a desktop study. This was especially important for the aspects 'distinction of process water' and 'Confrontation with wastewater treatment data'. Below we highlight the most important reports and studies for each topic.

Distinctions in process water

- Vlaamse Milieumaatschappij (MIRA) - Berekening van het watergebruik in 2002 en analyse van het watergebruik in de periode 1991-2002 (2004)[12]*; This study provides an analysis of water use in Flanders in the period 1991 – 2002. The purpose for which water is used (cooling and other) is distinguished from the source (drinking water, groundwater, surface water, precipitation and 'other water').*
- RIVM- Toepassing WAPRO; versie 1999 (2000)[13]*; This report addresses water consumption within the target groups; consumers, industries (14 sectors), agriculture, trade and services and government. There is a distinction made in surface, ground and tap water used for cooling and for other purposes. It also includes a forecast based on economic and demographic scenarios.*
- EIM- Industriewater in Nederland (2009)[14]*; It is a report on the competition in the different market segments of the industrial water sector in the Netherlands. It maps industrial water use by purpose.*
- LEI- Watergebruik in de agrarische sector 2009-2010, naar stroomgebied in Nederland (2013)[15]*;* LEI calculated figures on water use in agriculture for the annual publications by

[9] Rijkswaterstaat is the executive agency of the Ministry of Infrastructure and the Environment, responsible for the Dutch main road network, the main waterway network, the main water systems, and the environment in which they are embedded. RIVM is the National Institute for Public Health and the Environment. In Dutch: 'Rijksinstituut voor volksgezondheid en milieu').

[10] http://statline.cbs.nl/Statweb/publication/?VW=T&DM=SLNL&PA=70152NED&D1=0,18&D2=0&D3=0&D4=a&HD=150616-0902&HDR=T&STB=G1,G2,G3

[11] http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82883NED&D1=0&D2=1&D3=4-9&HDR=T&STB=G1,G2&VW=T

[12] http://www.milieurapport.be/upload/main/miradata/MIRA-T/02_themas/02_14/water_O&O_01.pdf

[13] http://rivm.openrepository.com/rivm/bitstream/10029/9647/1/703717007.pdf

[14] http://www.vemw.nl/~/media/VEMW/Downloads/Public/Water/Rapport%20Industriewater%20in%20Nederland.ashx

[15] http://edepot.wur.nl/256293

Statistics Netherlands *The environmental accounts* and *Compendium voor de Leefomgeving*. In these calculations a distinction is made by types of water and purposes.

Confrontation with data from urban wastewater treatment plants (UWWTP)

- *TNS-Nipo*[16]*- Watergebruik Thuis 2013*; VEWIN commissions TNS-Nipo a study every three years about water use at home among over 1,000 respondents. The report shows in detail what tap water is used for and developments in this over the years.
- *DELTARES & TNO- Effluenten RWZI's, regenwaterriolen, niet aangesloten riolen, overstorten en IBA's (2015)*[17]*;* This factsheet includes a calculation method for the emissions resulting from effluents of urban wastewater treatment plants (UWWTP), rain water sewers and storm drains. Ratios are calculated for each source (precipitation and dry weather household effluent and other) about the quantities of materials/emissions in rain water and spillage sewers. We used those ratios in our current study to determine the volumes of water.
- *STOWA- HAAS- Hemelwaterafvoer; analyse systematiekonderzoek naar kwantificering van hemelwaterafvoer naar de riolering en de RWZI.*[18]*;* It has become routine in recent years to make more calculations in the wastewater chain, including measuring precipitation, supply to the urban wastewater treatment plants and storm drains. In the report by STOWA these data are applied in order to analyse more closely how the sewage system functions.
- STOWA- Rioolvreemd water; onderzoek naar hoeveelheden en oorsprong water (2003)[19]*; This study was conducted because there were differences between the theoretical wastewater flow rate and the actual influent at urban wastewater treatment plants. The difference is explained by unintended dilution of sewage (via unintentional infiltration/ drainage of groundwater and/or inflow of storm water etc. via inappropriate connections including yard drains, roof drains, etc.) entering the sewage system (often by leaks). STOWA has developed a methodology for quantifying this unintended dilution of sewage, which is called the DroogWeerAfvoer Analyse Systematiek (DWAAS).*

Now that we have discussed the sources, we can work out the method in some detail. The various aspects are used to structure this. We distinguish three main flows: from the environment to the economy, from the economy to the economy (or within economy) and from the economy to the environment.

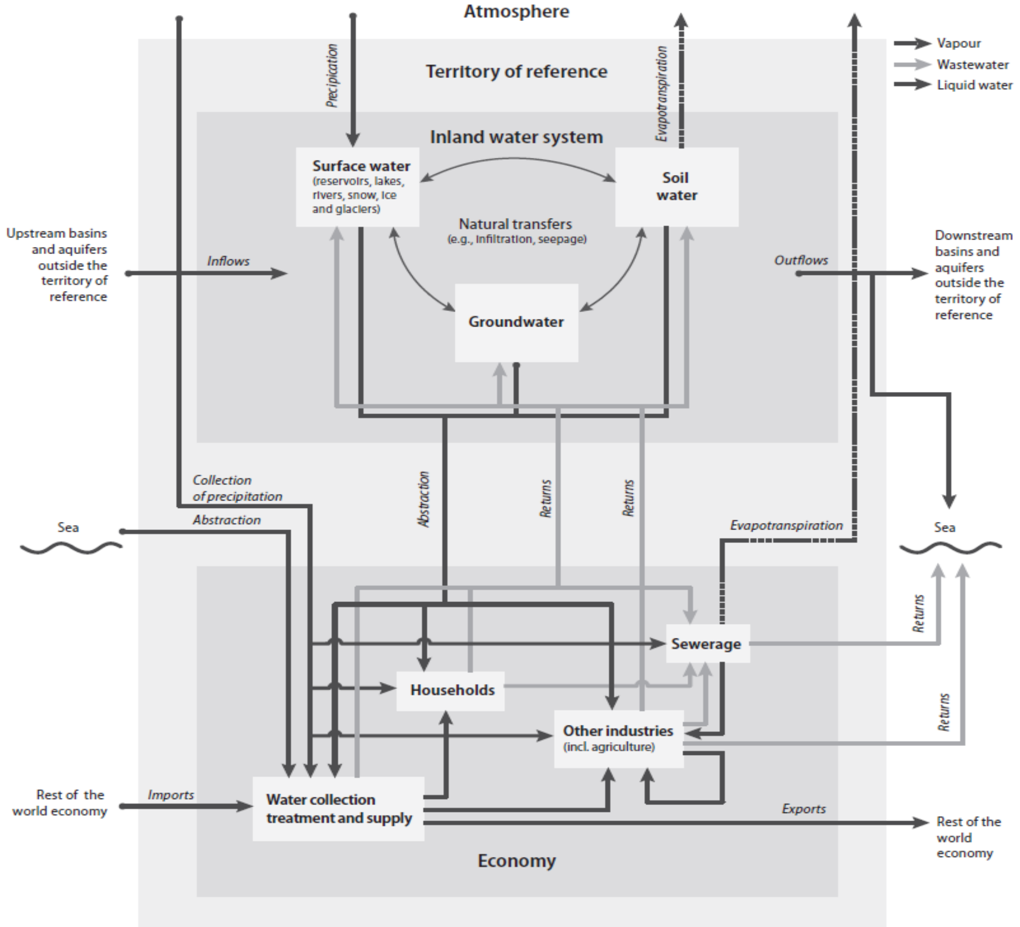
[16] http://www.vewin.nl/SiteCollectionDocuments/Publicaties/Watergebruik_Thuis_2013.pdf
[17] http://www.emissieregistratie.nl/ERPUBLIEK/documenten/Water/Factsheets/Nederlands/Effluenten%20RWZI%20(berekend).pdf
[18] http://stedelijkwaterbeheer.stowa.nl/Upload/publicaties/STOWA%202009-24.pdf
[19] http://stedelijkwaterbeheer.stowa.nl/Upload/publicaties2/2003_08.pdf

3. SUT – Water types

3.1 Introduction

In the physical SUT, water is categorised into various types of water in the conceptual division of main flows in supply and use, namely: A. water volumes *extracted from the environment* (abstraction from the environment by the economy), B. *physical water flows within the economy* (with transactions) and C. *water return flows from the economy to the environment*. Statistics Netherlands has carried out several studies prior to compiling the physical SUT Water dealing with how to make water statistics (water use and wastewater) and SEEA - water accounts (physical SUT water, water resources (assets) en water emission accounts) (see CREEA work in Pfister, et al., 2013; Baas & Graveland, 2014, Graveland en Baas, 2012; Baas & Graveland, 2011; CBS, 2015). For a schematic representation between water assets (stocks/resources) and water flows in terms of supply and use, see figure 3.1.1. The figure shows the relationship between the assets in the inland water system together with the salt surface water and the flows to the economy, within the economy and the return flows to the environment again.

3.1.1. Main water flows between the environment, incl. the inland water system and the economy



Source: SEEA-Water, 2012; Figure II.2 Main flows within the inland water resource system and the economy.

In each of the three main flows we distinguish four water types from the environment, four flows within the economy, and three return flows to the environment. These nine water types are discussed in detail below.
So in the **first main water flow** we look into the flow of water from the environment to the economy. This involves the following four water types/water flows *a.* ***groundwater****, b.* ***fresh surface water****, c.* ***salt surface water****, d.* ***extraction****.*
Two categories of physical water flows that are important for production or consumption in the Netherlands fall outside the scope of this study. Namely the relatively limited flow of water collected from 'precipitation'. This is particularly important in horticulture where precipitation is collected in basins or reservoirs above ground near the greenhouses. This water is often used for irrigating crops in horticulture, in combination with other water sources. Furthermore part of the households collect rain water in small quantities. The second water flow that is partially outside the scope of this study is soil water/soil moisture (and part of the 'indirect supply' to plants from groundwater via soil water) that stem from precipitation that plants extract from the soil. Only extraction from precipitation water that enters the economy contained by products is included in the tables, and not the large quantity that evaporates from the crops/plants. Abstraction for sprinkling/irrigation is fully considered, including the evapotranspiration (water loss). [20]

In the **second main stream,** the flows within the economy, we distinguish four major water types/water flows in the physical SUT: a. Water of drinking water quality, in short ***tap (mains) water***; b. ***Industrial water*** or 'other water', usually transported like drinking water and c. ***Water in products***. This is the flow that enters the economy with the products, or the water contained by the products that are traded/consumed in the Dutch economy or that may end up leaving the Netherlands. Water in products plays a role in the manufacture of dairy products, which uses a great deal of raw milk. The fourth water flow is the flow of water after it is used in the economy but that is still within the economy. This is d. ***(untreated) Wastewater***, a flow from companies and households transported through the sewer system to the urban wastewater treatment plants (UWWTP). Here water is treated at a cost into the quality that can be returned to the environment, usually to the surface water. The selection of (manufacturing) companies that treat and/or reuse their own wastewater as well as the wastewater of other companies are also included in this category, because wastewater is supplied within the economy with the relevant monetary transaction. This flow is probably not fully observed though. The wastewater that companies treat themselves, and may reuse themselves, and which they subsequently return to the environment does not come in this category but in the next one, from the economy to the environment. This study does not include a possible fifth flow within the economy, water supply between companies as warm water/hot steam. This is a relatively limited flow which often also includes return flows. Moreover not enough solid data are available about this.

The **third main flow** consists of the return flows from the economy to the environment. Return flows of water from the economy can flow into fresh surface water, salt surface water or back into the soil (especially in agriculture). Three water types are distinguished in the third main flow: a. Wastewater that flows back to the environment after treatment in the urban wastewater treatment plants (NACE 37) so that its quality is sufficient to release into the

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[20] The commission with the Ministry was formulated as follows: *'Growing arable and horticultural products are not assigned to the economy but to the environment in the Materials Monitor. So what does not have to be calculated is the intake of water and the evapotranspiration of moisture by arable and horticultural crops and products'.* For consistency with the material flows we decided, as the project progressed, to incorporate the extraction of materials from the soil, which is the water that is extracted with raw material/products. This is done to further monitor water flows in the economy, in this case the water flows that enter the economy with the raw materials/products.

surface water. A considerable amount of the wastewater produced in the Netherlands is treated by the companies themselves with a wastewater treatment facility on the production locations. This is subsequently reused (recycled) or returns to the environment because it is discharged into the surface water or otherwise. b. Apart from treated wastewater there are considerable return flows from the economy to the environment. A well-known return flow is the volume of cooling water used in power plants or in manufacturing that is returned to the environment, usually mostly or entirely into the domestic fresh water system or downstream in the direction of the sea. c. Then there are the return flows to the environment related to the evaporation by cooling towers and crops (transpiration). This flow is recorded as a loss. In agriculture we only include the share that is extracted by agriculture for sprinkling/irrigation, which is absorbed by the product and then evaporates into the atmosphere. In this way the water that enters the product after irrigation is accounted for. Evaporation of water from wet soil surfaces, hard surface, and surface water is outside the scope of the study. It is not part of the economy anywhere and merely flows from one environmental compartment to another.

3.2 Method

Physical SUT tables have the same structure as monetary SUT tables and are compiled as part of the standard NA and other physical accounts such as the energy accounts and the material flows accounts described by the Materials Monitor. This uniformity in format makes it possible to compile hybrid supply and use tables where physical and monetary information are presented side by side. After this, the relevant indicators can be derived, such as water productivity by industry or sector or for monitoring development of water efficiency in the economy.
Below we will briefly explain the steps needed for compiling the basic Physical water SUT (the water PSUT) from the available data sources. We make the basic PSUT first and extend it later to make further breakdowns, as to include process water etc. The sources described in chapter '2.1 Data' are used to make the basic Water SUT, that is without the division into process water and non-process water. This is explained elsewhere in the report.

The basic PSUT consists of three main flows with: 1.extraction of water from the environment for the economy; 2. supply of various types of water to users in the economy and; 3.the return flow from the economy to the environment.
The data required for compiling the water figures by water type and industry, need data in several data blocks derived from a number of sources. These are briefly described below. For agricultural sector (7 distinct industries; regkols) we used LEI information on the extraction of ground, surface and tap water use. For agricultural services and forestry we divided water use on the basis of persons employed.
For the block of the manufacturing industries, including environmental services with recycling and dismantling (Regkol that relate to NACE 4 or 5-digit; 6009-38300, excl. 36000), we combined the available (and recent) data from the water module, being part of the e-AER, and raised them to detailed industry (regkol) levels with PRODCOM data. This applies to the extraction of groundwater and fresh and (separately) salt surface water as well as the supply of tap (drinking) water and (separately) industry water. For the missing industries in manufacturing (regkols; NACE-3-digit) we then used the National Water Survey on water use by industry (manufacturing), where we took into account the influence of economic developments over time (volume measures) and water efficiency improvements over time per industry or sector. Both e-AER and the National Water Use Survey sometimes divide the information per sector further by using labour account figures (on the number of employees and self-employed by industry; regkol) to achieve the desired level of detail in the sectors, that is at 'regkol level'.

The groundwater and surface water extractions by the water companies (NACE 36 (5-digit); regkol 36000) are based on VEWIN data.

For the remaining sectors, namely for the economic block of the services sectors (NACE (5-digit); Regkol 41100-97000), soil water extraction was determined as far as it was possible on the basis of the National Groundwater Register, LGR. This is assigned to the correct industries (regkols) through meta information accompanying the source data. Tap water use in the services sectors is assigned to industries (regkols) by combining it all with Labour Account figures. Surface water extraction in the services sectors is not known but expected to be limited or simply irrelevant in quantity and is therefore not included. So far the descriptions of the first two main flows of the basic SUT – water. The sources required for the third main flow, the treatment and methods for compiling these figures are described in detail elsewhere in this report, and are therefore not outlined here.

4. Distinctions in process water

4.1 Introduction

In "SUT water types" the total available volumes of water are calculated per industry (regkol) in the use table. This water originates sometimes directly from the environment and is extracted by the entity itself. In the supply table this flow is shown as supplied by the environment. Abstractions of water as part of material extractions are a separate item as flows from the environment to the economy.
Some of the available water in the use table does not directly come from the environment but from the economy. Think of industrial water and tap (drinking) water. In the supply table these flows are shown as supplied by the sectors Wastewater collection and treatment (37) and Water abstraction and distribution (36).
Water can also be contained by the products, including waste, used by the distinguished activities (regkols). This is shown in the use table as 'water in product'. For instance the large volume of milk taken as input by the dairy industry for processing. During the production process water can be added to the product. This will show as 'in product' for the various types of water. In the end an amount of water can remain in the product supplied to another economic entity. This is shown in the supply table as 'water in product'. The water included in the product that evaporates in the production process comes under water loss.
Industries use the water for various purposes. In the first place process water and non-process water can be distinguished, where process water can be subdivided by purpose: in product, cooling, cleaning, services and other applications.

4.2 Method

To determine the share of water used for cooling we took the Water use from the National Water Survey (NWS) by the (manufacturing) industry survey on 2001 as or point of departure. For this, the statistics based on NACE Rev.1 / ISIC Rev.3 (CBS: SBI-1993) had to be converted to the industry classification used in Dutch National Accounts ('regkol'). However, the NACE or ISIC codes cannot always be linked directly to a 'regkol', leading to some discrepancies. Therefore, and because the figures refer to 2001, we mainly used the survey as background information.
To determine if industries (regkols) include water in the product, we estimated the net water intake and water loss within the industry. These calculations are based on the supply and use of products and waste by the industry (according to the Materials Monitor), combined with the water content of the products involved. By balancing the various flows related to water in the product, we estimated whether or not and how much water was included in the product during the production process. We took into account that some water evaporates during the production process and that rain water may be included in the product.
Assigning the types of water to the right destinations in case the data were lacking was done by using desktop studies and expert knowledge available at Statistics Netherlands. For some types of water we had another source available and/or we could apply a different methodology.

Tap water (mains water) We assumed that of all the types of water only tap water is used as non-process water (for personal care). Therefore we first divided the volume of tap water per industry into process and non-process water. Here we took the average tap water use per fulltime equivalent (FTE) in 2008. This average was calculated for those industries that probably use all tap water as non-process water. Here we distinguished between locally bound and non-

locally bound sectors, because the average tap water use per FTE is likely to be lower among non-locally bound industries.
For 2010 and 2012 we took into account that water has been used more efficiently over time. On the basis of the report of the VEWIN (2014) we calculated an efficiency (improvement) rate and applied it to 2010 and 2012 from the average water use per FTE in 2008. The average water use per FTE we calculated matched what was in the literature[21].
Next we had to assign the process tap (mains) water to the other purposes. The main sources we used for this, apart from the sources we mentioned earlier, were studies by LEI (2013) and RIVM (2000). Total water use by private households is taken from StatLine[22], based on figures by VEWIN (2010, 2011 & 2013). These are entirely categorized as non-process water.

Industrial water The use of industry water was studied in 2009 by EIM (Zeijden et al., 2009). This study was apart from the sources in chapter '2. Sources' and expert knowledge were used to found the assignment of industrial water to various purposes.

Salt surface water Few companies make use of salt surface water. These companies could be traced through the e-AERs. So it was possible to determine for most industries what they used the salt surface water for. It turned out to be cooling mostly.

Groundwater The total groundwater abstraction per industry is based on the volumes published earlier by Statistics Netherlands[23]. For some industries groundwater extraction was hitherto unknown. The volumes for these industries are based in the current study on information from the National Groundwater Register (LGR). The same is true for the assignment of groundwater use to the various purposes.
For the companies with the largest extractions and for many manufacturing companies (in total more than 600 companies) we looked up its industry following the NACE Rev.2 / ISIC Rev.4 (SBI 2008) classification, in the general business register ('Algemeen Bedrijven Register', ABR). Next the industries were assigned on the basis of the company name[24] and description of the abstraction license holder. In this way we could assign 90 percent of the groundwater abstracted to an industry. The remaining 10 percent of the groundwater was then assigned to those industries with extraction according to LGR. The LGR is not complete so we estimated or raised the data for some provinces.
Sometimes there is more than one purpose, sometimes no clear reason for the extraction is registered in the LGR. If there are several purposes we averaged the volume over the first three purposes maximally. Groundwater used for soil energy systems is not taken into account. The same is true for other abstraction where the abstraction is about as large as the infiltration, because on balance no water is extracted from the environment.

[21] For instance https://www.milieubarometer.nl/voorbeelden/kantoor/ & http://www.infodwi.nl/uploadedFiles/Infodwi/05_-_Voorwaarden_normen_en_uitwerking/WB%202.1%20B%20okt%202011.pdf

[22] http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82883ned&D1=0&D2=1&D3=5,7,l&HDR=T&STB=G1,G2&VW=T

[23] http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=82883ned&D1=1&D2=0,6-16,22-38&D3=5,7,l&HDR=T,G2&STB=G1&VW=T

[24] The name in the LGR can refer to the company extracting groundwater as well as the company that will extract the water for another company. So there is no uniform assignment of the industry (regkol) on the basis of the name.

5. Wastewater and return flows from industry

5.1 Introduction

Wherever water is used, you get wastewater. We estimated this wastewater flow for the various Industries (regkols) and for households. Not all water used is actually discharged. Some of the water can be included in products. Moreover some part is released into the atmosphere, as in the case of evapotranspiration (water loss). The remaining water that is not reused is discharged. Discharges can be into the environment (direct discharges to the soil or surface water), also called 'return flows'. Water can also be discharged on the sewer system, to the economy. This is the wastewater flow. Via urban wastewater treatment plants (UWWTP, the economy) water is released into the environment after treatment.

5.2 Method

The methods for estimating wastewater flows from households and industrial (manufacturing) and non-industrial sectors differ from each other and are discussed separately. In all cases water intake is the starting point. Then we estimated how much water left the company in the end. We took water losses into account and the issues related to water in products we discussed before.

Industrial (manufacturing) sectors- In discharges we distinguish direct discharges, or 'return flows', and indirect discharges. In the SUT Water, indirect discharges are considered wastewater. Direct discharges by industry (manufacturing) are almost fully observed in the e-AERs. For calculating indirect discharges it is not sufficient to subtract direct discharges from total water intake. Water loss and water in products items also have to be included in the calculations. The assumption for water loss is that some 5 percent of total water intake is lost in the production process. On the basis of individual company records in the e-AERs and the literature this did not seem true for all industries, so the share of water loss was adjusted. In first instance we tried to calculate indirect discharges as follows:

Indirect discharges = total water intake - /- direct discharges -/- water intake in product during process -/- water loss

The results turned out not to be equally plausible for all industries. This can be explained in part because there is a lot of customising when the e-AER data are raised from a selection of companies per industry to the complete population in CBS statistics, as for including total water use by industry. The direct discharges according to the e-AER thus cannot be directly turned into industry (regkol) levels and confronted with total water use from 'SUT- Water types'.
In an alternative method it is assumed that all surface water, both fresh and salt (marine), and industrial water are fully discharged into the environment (direct discharges). This is not always the case. But equally, not all tap water and groundwater is discharged into the sewer system. The assumption is that the underestimates and overestimates will balance each other out. Here too we took water in products and water losses into account.
The methods were confronted and the alternative method turned out to be more plausible. Despite this, customising also took place at the detailed industry level (balancing), for instance when the e-AER proved that companies in a given industry discharge a significant amount of tap water and/or groundwater on fresh surface water bodies.

The assumption is that all direct discharges are discharged onto fresh surface water, except intakes of salt surface water and groundwater for well point drainage. Intakes of salt surface water are also fully discharged on salt surface water. The ratio for discharging groundwater from well point drainage is taken as 20/40/40 percent for sewer/fresh surface water/soil respectively. Because there is a preferred sequence for discharging groundwater from well point drainage [25] by Rijkswaterstaat, water boards and municipalities: 1, soil, 2. fresh surface water, 3. sewage system. Discharging into the soil or fresh surface water is not always possible though. On the basis of the groundwater register LGR we determined in which industries groundwater is mainly used for well point dewatering.
The use table shows that water supply companies extract most groundwater and surface water. Most of this water goes into the product. The supply table shows this as mains water supplied by the industry (regkol) Water (NACE 36).

Non-industrial sectors- Non-manufacturing industrial sectors primarily use tap (mains) water, particularly as non-process water. In some cases groundwater is primarily abstracted for well point drainage. Agriculture not only uses tap water and groundwater but also fresh surface water for sprinkling and for watering cattle. Water losses mainly play a big role in agriculture, and to a lesser degree in construction. For instance with transpiration from crops and cattle.
For the non-industrial sectors we assumed that all tap water is discharged into the sewer, excluding water losses and water included in the product during the production process. There are a few exceptions, such as agriculture and construction, but also sports clubs. In these cases we determined per industry how much of the tap water is discharged into the soil and fresh surface water. This is based on the purposes for which the tap water is used, the literature and expert knowledge.

In agriculture water loss and flows related to water in products tend to play a major role, such as in crop growing. A third of the water sprinkling is taken up by crop roots. While about 90 percent of this water that enters the plants evaporates and 10 percent is used for growth (AEQUATOR, 2015;Marcelis & Arkesteijn, 2008). Compared to total abstraction, the abstraction from sprinkling/irrigation is very limited, barely five percent. Evapotranspiration is considered 'water loss'. In the current study this excludes evaporation from products/crops, of water uptake originally stemming from precipitation. In other words: evaporation of water uptake that does not come from sprinkling/irrigation by the farm holding is not included in the study.

Water loss for non-manufacturing industries is usually estimated at around 5 percent. According to our calculations, households have water losses of close to 10 percent of the tap water used (see *households*). We estimate the water loss among non-manufacturing industries lower, because water there is mainly used for purposes in which relatively little water is lost (flushing, washing hands, etc.). There are exceptions. In industries, where relatively much water is used for preparing food/drinks or cleaning, water loss tends to be greater (about 10 percent). There are also a few industries where a very small part of the tap water used is discharged into the sewer. We base the estimate for these industries mainly on the purposes for which the tap water is used, e.g. sports clubs (sprinkling) and cattle farms (watering).

In groundwater intake the LGR groundwater register is used to try and get an indication of the purposes for which the groundwater is used, and if there is any infiltration. On the basis of this information and expert knowledge we estimated the discharges of groundwater into surface water, the soil and the sewer. Non-manufacturing industries (regkols) mainly extract groundwater in well point drainage and to a lesser degree for sprinkling. In well point drainage

[25] See for example http://www.bronbemalen.nl/16

we used the same ratio (share) as with manufacturing industries. In some cases the LGR gave us a reason to deviate from this ratio, for instance when groundwater was mainly used for other purposes such as sprinkling. In these cases we did some customising. For groundwater, just like for tap water we assumed a water loss of around 5 percent, unless there was a reason to deviate from this found in the literature, LGR and e-AER or given by experts.
In the intake of fresh surface water - occurring only in agriculture among the non-manufacturing industries - we assumed that nothing is discharged into the sewer. Fresh surface water, excluding water losses and water in product is mostly discharged into the soil and partly onto fresh surface water bodies. Water loss and water in products play a major role in fresh surface water use by agriculture, as mentioned before.
There are several industries, like maritime shipping and fishing, for which we assumed that they discharge part of their wastewater into marine surface water.

Households- The total drinking (mains) water use has been taken from StatLine, as we mentioned earlier. Not all of the total water use by private households (VEWIN, 2010, 2011 & 2013) is discharged into the sewer system. First of all some households are not connected to the sewer system. This is less than 1 percent of the total number of households (DELTARES & TNO, 2015). Secondly, some of the water is 'lost' through evapotranspiration.
We estimated the share of drinking/mains water discharged into the sewer on the basis of the VEWIN-report (2014). We estimated the water loss per category of water use. Only a small quantity of the water destined for cleaning ends up in the sewer. Also drinking water, coffee/ tea are not included directly as water use, but it is included indirectly through urine[26]. In contrast with the calculations by VEWIN we included 'wash basin in the toilet' and 'rinsing the bath' as water use categories.

The final estimate is that slightly over 90 percent of drinking/mains water use by households ends up in the sewer. The rest is mainly evaporated through evapotranspiration (water loss). Of the less than 1 percent of the households that are not connected to the sewer, about two thirds discharges into fresh surface water and the rest into the soil (CIW/CUWVO, 1999). We assumed that the water loss of these households does not differ from that of the households that are connected.

[26] http://mens-en-gezondheid.infonu.nl/diversen/121039-urine-wat-kun-je-eraan-aflezen.html & https://www.ntvg.nl/system/files/publications/a1757.pdf & http://www.dommel.nl/algemeen-glm/rioolwater/het-riool.html

6. Confrontation with wastewater treatment data

6.1 Introduction

On the basis of an integral CBS survey about the design and functioning of all urban wastewater treatment plants (UWWTP) in the Netherlands we know the total influents of the urban wastewater treatment plants[27]. In this study we confronted earlier results on wastewater with the influent of the urban wastewater treatment plants. During the confrontation we took into account the combined sewer overflows and the rainwater collected by sewers and transported to the urban wastewater treatment plants. Earlier studies show that there is a discrepancy between the theoretical wastewater flow rate discharged into the sewer system and the influent to the UWWTP. This is caused by unintended dilution of sewage [28] through leaking sewers and also 'drainage' by the sewer system, and inflow from connections to the sanitary sewer system, by dewatering systems, various types of drains, permanent well pointing, soil decontamination et cetera. This extra inflow in the sewage system is often called 'unintended dilution of sewage' (Voorhoeve & Kerk, 2003; Oosterhuis, 2005). For the confrontation, we estimated the water volumes of combined sewer overflows, separated rainwater sewers, rain supply and unintended dilution of sewage (together at least half the total influent of the UWWTP, see STOWA[29]) and the sewage that leaves the sewer system through leakage and exfiltration of sewage in the soil and in groundwater.

Precipitation entering the separated rainwater sewer or storm sewer is returned to the surface water without any further treatment, and sometimes it infiltrates into the soil, e.g. in wadis. This water does not enter the economy and is not taken into account. We made attempts to estimate these volumes, but the results varied wildly. The confrontations of the various sources and the choices made play a role in balancing the final PSUT for Water. In the next section we will discuss the calculations of the volumes of combined sewer overflows and leaks and rain supply and unintended dilution of sewage entering the UWWTP.

6.2 Method

Combined sewer overflows- in combined sewage systems these are the emergency outlets into the environment. With downpours, where great volumes of water come down within a brief period, these emergency drains serve to relieve the urban wastewater treatment plants (UWWTP) and the sewer system. Some untreated sewage water is released onto fresh surface water bodies. These extra water flows, result in peaks into pollution to fresh surface water. Rijkswaterstaat uses a model to calculate the water flows (volumes) with the 'loads' of the various substances. In this calculation method the pollution load and route are determined (incl. storm drains). This quantification is based on actual measuring (DELTARES & TNO, 2015).

These aspects have been applied by us to estimate the volumes of overflow from the combined sewer overflows. We assumed that the distribution of the pollution loads over the various routes is proportional to the distribution of the volumes of water involved. In the calculation method we distinguished precipitation and dry weather discharge including household wastewater (dwa-hh) and other dry weather discharge (dwa-overig), mainly from companies**.**

[27] http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=70152NED&D1=0,18&D2=0,12-23&D3=0&D4=20,22,24&HDR=T,G3&STB=G1,G2&VW=T
[28] Infiltration: when groundwater enters the defect sanitary sewer system. Exfiltration: when wastewater enters groundwater via the leaks in the sewer system
[29] http://www.saniwijzer.nl/content/content.asp?menu=1005_000000_000000_000000

Dry weather discharge was already calculated in previous steps. The volume of precipitation was calculated on the basis of the average precipitation (StatLine[30]) and the surface of open paved urban area with sewers (TNO, DELTARES & PBL, 2015).

Precipitation- During most of the year there is dry weather discharge (dwa). The sewer system also serves to collect water from precipitation. STOWA has developed the HAAS (Hemelwater Afvoer Systematiek) method to gain insight in the volumes of precipitation entering the UWWTP. With the HAAS method analyses were made for the different sewer systems. On the basis of these we could estimate the share of rain water in the registered day sums (volumes) of the sewage pumping stations. About 30 percent of the total influent in the UWWTP consists of precipitation (Wieringen, 2009).

Unintended dilution of sewage - knowledge about the actual way the sewer system functions had so far been based on theories. Currently it is more often routinely measured. In a STOWA study in 1996 the share of non-sewage water that enter the sewers unintentionally, either via infiltration and/or inflow in UWWTP was estimated at between 20 and 30 percent, and around 30 percent in Hoogheemraadschap West-Brabant, Delfland and Regge en Dinkel (STOWA, 1996). In 2003 STOWA developed the DWAAS method to quantify this unintended dilution of sewage. The daily flow rates were measured for a year and compared with the theoretical dry weather influent at the UWWTP, so that the volumes of water that entered the sewer system unintended via infiltration and/or inflow could be derived. Based on five pilot areas used as examples the study claims that 25 percent of water volumes from unintended dilution of sewage is not unusual when compared to dry weather influent (Voorhoeve & Kerk, 2003).

The DWAAS method has subsequently been applied to UWWTP. The methodology seems to be reliable, based on this. On average 25 percent of the influent of UWWTP stem from unintended dilution of sewage. The results for three UWWTP in Regge en Dinkel matched this national average with a share varying between 22 and 26 percent (Oosterhuis, 2005).

In a report by Waterschap Hollandse Delta on 2013/2014[31] the water board indicates that it fully observed the 2014 unintended dilution of sewage, because of its study. In 2013/2014 the shares of water volumes caused by unintended dilution of sewage per UWWTP averaged between 20-30% a year. On the basis of the above we assume that 25 percent of the total influent of UWWTP is caused by unintended dilution of sewage.

Leaks- On the basis of the findings from the literature we estimated the loss through leaking at 5 percent (Rietveld & Geilvoet, 2007 & VPB, 2008).

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[30] http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=80182ned&D1=10&D2=210-216&HDR=T&STB=G1&VW=T

[31] http://www.wshd.nl/binaries/content/assets/wshd---website/common/schoon-en-voldoende-water/2015_waterwerken_2013_2014.pdf

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