Farm System Management and Governance for Good Water Quality and Drinking Water Supplies

FAIRWAY REPORT series

Lessons Learned and Recommendations for Water Safety Plans

Editors:

Cors van den Brink (Royal HaskoningDHV)

Sarah Zernitz (Royal HaskoningDHV)

Alma de Vries (Royal HaskoningDHV)

March 31st 2021

Deliverable 2.4

This report was written in the context of the FAIRWAY project

www.fairway-project.eu

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 727984

DOCUMENT SUMMARY	
Project Information	
Project Title	Farm systems that produce good water quality for drinking water supplies
Project Acronym	FAIRWAY
Call identifier	H2020-RUR-2016-2
Topic	RUR-04-2016 Water farms – improving farming and its impact on the supply of drinking water
Grant agreement no	727984
Dates	2017-06-01 to 2021-11-31
Project duration	54 months (6 months extension)
Website addresses	www.fairway-project.eu www.fairway-is.eu
Project coordination	Stichting Wageningen Research, NL
EU project representative & coordinator	Lara Congiu (REA)
Project scientific coordinator	Gerard Velthof
EU project officer	Gaetan Dubois (DG Agri)
Deliverable information	
Title	**Lessons Learned and Recommendations for Water Safety Plans**
Authors	Van den Brink, Zernitz and de Vries (eds)
Author email	Cors.van.den.brink@rhdhv.com
Deliverable number	Deliverable 2.4
Workpackage	WP2
WP Lead	NIVA
Type and dissemination level	Report, Public
Editor	Van den Brink, de Vries and Zernitz
Due date	2021-03-31
Publication date	2021-03-31
Copyright	© FAIRWAY project and partners

CONTENTS

Lessons Learned and Recommendations for Water Safety Plans

van den Brink, Zernitz and de Vries (eds.)

EXECUTIVE SUMMARY

Safe drinking water is vital for the health and wellbeing of all. However, providing safe drinking water can be a complex challenge. With this document the FAIRWAY team strives to stimulate the improvement of drinking water safety across the European Union by sharing context, best practices and lessons learned on Water Safety Planning (WSP) for both small and large water supplies. This task is executed in close collaboration with the 13 FAIRWAY case studies.

The WSP is a step-wise approach to ensure the safety of drinking water. It is a comprehensive risk assessment and risk management approach, that covers all steps in the water supply. The goal of a WSP is to ensure, through good water supply practice, that drinking water is safe.

In the study it was found that in all FAIRWAY case study countries RA/RM is embedded in national regulations. There are differences between case studies whether the same regulations apply to large and small supplies. Also the responsible authority/authorities vary between the case studies. Although, in most case studies the water supply company is responsible for RA/RM. In many case study countries some form of agreed methodology for RA/RM / Water Safety Planning is in place.

Key lessons learned are that 1) engagement of stakeholders is essential during all phases of RA/RM / Water Safety Planning; 2) the designation of a process owner helps in bringing together departments and stakeholders, spreading information throughout organizations and providing congruence between different RA/RM systems; and 3) an agreed upon methodology and content enhances the effectiveness of Water Safety Planning and cooperation and communication between those involved.

The information received from the FAIRWAY case study leaders mainly applies to large supplies. Nevertheless, some recommendations are made for small supplies based on general information on water safety planning and experience and procedures participating countries apply for small supplies. Regarding small supplies a main challenge relates to the limited availability of specialized knowledge and expertise, and access to information and technical support. It is recommended to assess the risks, for example via a quick scan, by analysing the specific vulnerability and local threats. Furthermore, small suppliers can be aided by developing networks for cooperation, for example in such a way that small suppliers can cooperate with large suppliers to get access to necessary competence and knowledge.

1. INTRODUCTION

The overall objective of the FAIRWAY project is to review current approaches and measures for the protection of drinking water resources against pollution caused by pesticides and nitrate from agriculture. Further, the project goes on to identify and further develop innovative measures and governance approaches for a more effective drinking water protection. This document delves in the topic of Water Safety Planning (Task 2.4) for adequate drinking water protection for small- and large supplies.

1.1 BACKGROUND

Waterborne diseases are still an important health concern in the world. Many people all over the world lack access to safe drinking water. This has significant health consequences and impedes socio-economic development. During the Millennium Development Goals (MDG) era, the access to improved water supplies has increased. However, monitoring was focused on the access to water. With the start of the Sustainable Development Goals era, this has changed. Through Sustainable Development Goal 6, "*countries around the world have expressed strong political will to ensure drinking-water is universally safe"* (World Health Organization, 2017, iii). Coupled to SDG6 is an indicator which facilitates the measurement of the SDG target 6.1 (By 2030, achieve universal and equitable access to safe and affordable drinking-water for all). With this, the attention has shifted to improving water quality of water supplies – ensuring that the water supplied is safe.

Safe drinking water is vital for the health and wellbeing of all. However, providing safe drinking water can be a complex challenge. "*An estimated 663 million people remain without access to an improved source of drinking-water. Many more still lack access to safe drinking-water, with at least 1.8 billion people relying on water sources that are faecally contaminated"* (World Health Organization, 2017, iii). In order to ensure the safety of a supply, proactive water supply system management is required (World Health Organization, 2017). Since the mid-1970s European drinking water policy is in place. This has proved to be an important element for ensuring high drinking water quality throughout the European Union. The European Drinking Water Directive (DWD) lays down the obligations for Member States in "*providing clean and wholesome water to all citizens receiving their drinking water through a water supply serving more than 50 persons, through a smaller commercial water supply or through a supply which is public."*[1] The European Drinking water Directive (DWD) 98/83/EC set the legal framework to protect human health from the adverse effects of any contamination of water intended for human consumption by ensuring that it is wholesome and clean. Preventive safety planning and risk-based elements were only considered to a limited extent in Directive 98/83/EC.

The evaluation of the DWD (EC 2016) assessed the coherence with the Water Framework Directive (WFD) and identified a missing link in the DWD as regards protecting drinking water resources. Therefore, the 2018 proposal for a recast of the DWD is introducing a risk based approach from abstraction to tap, and improving communication between Member States' authorities and water suppliers to ensure there is a full governance cycle for water. The proposal aims to improve coherence between the two Directives and ensure that the polluter pays principle and the precautionary principle both apply.

[1] Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption, http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998L0083&from=EN.

On 16 december 2020, the European Parliament formally adopted a revised Drinking Water Directive. The revised Drinking Water Directive comes as a result of the REFIT evaluation, the implementation of the Commission's response to the European Citizens' Initiative 'Right2Water' and as a contribution to meeting the targets of the Sustainable Development Goals.[2]

The limited reliance on a risk-based approach was identified as one of the areas in which improvement could be made (Klaassens, 2015). Furthermore, the Right2Water initiative displayed that part of the population, in particular marginalised groups, has no access to water intended for human consumption. Providing such access is a commitment under Goal 6 of the Sustainable Development Goals (SDGs) of the United Nations 2030 Agenda for Sustainable Development.

The concept of a water safety plan introduced in 2004 by the WHO has become more important in particular in response to microbiological-related challenges. It offers opportunities to concentrate time and resources on risks that matter and to avoid analyses on non-occurring parameters, in particular in small supplies with risks easy to survey (EC, 2016). These elements of a risk-based approach are uptaken in the recap of the DWD.

Thus, the renewed Drinking Water Directive is not restricted to obligations related to the monitoring and sampling of water supplies. In effect, it requires Member States to identify, analyse and assess risks to the safety of the supply. This requires a risk assessment / risk management approach (RA/RM) based on the following three components:

1. *"Identification of the hazards associated with the catchment areas for abstraction points ("risk assessment and risk management of the catchment areas for abstraction points of water intended for human consumption"), in line with the WHO Guidelines and Water Safety Plan Manual.*
2. *A possibility for the water supplier to adapt monitoring to the main risks and to take the necessary measures to manage the risks identified in the supply chain from the abstraction, treatment, storage and distribution of water ("risk assessment and risk management of the supply system").*
3. *An assessment of the potential risks stemming from domestic distribution systems, such as Legionella or lead ("risk assessment of the domestic distribution systems"), with special focus on priority premises. Those assessments should be regularly reviewed, inter alia, in response to threats from climate-related extreme weather events, known changes of human activity in the abstraction area or in response to source-related incidents. The risk-based approach should ensure a continuous exchange of information between competent authorities and water suppliers."* (European Commission, 2020)

The risk-based approach should be applied by all water suppliers, including small water suppliers, as the evaluation of Directive 98/83/EC showed deficiencies in its implementation by those suppliers. The second River Basin Management Plans (RBMP) shows that for drinking water protection, most member states have defined, or are in the process of defining, specific zones including specific water protection measures and apply basic measures. In several countries, there are also supplementary measures. Safeguard zones around drinking water abstractions are established for nearly 80% of the RBMPs (EC 2019a). While basic measures are mandatory in most cases, the supplementary measures are mostly applied on a voluntary basis and are linked to the EU Rural Development Programs under the Common Agricultural Policy (CAP). Safeguard zones and drinking water

[2] https://ec.europa.eu/commission/presscorner/detail/en/ip_20_2417

protected areas are established in a majority of EU countries and occupy large surfaces of the countries (up to 21% of country size for safeguard zones) (CIS, 2017/18).

Despite these efforts for drinking water protection, representatives from the water service companies pointed out in the consultation of the Fitness Check of the WFD (EC 2019b) that the need to treat drinking water is increasing, which comes at a cost to consumers.

An example of a RA/RM approach is the Water Safety Plan (WSP) approach. The Water Safety Plan framework is defined as the systematic approach to ensure water safety, covering all stages of water supply production and distribution from catchment to consumer. The concept of WSPs was introduced in the third edition of the WHO Guidelines for Drinking-water Quality (GDWQ) and the International Water Association (IWA) Bonn Charter for Safe Drinking Water in 2004. Water Safety Planning is promoted as the approach that can ensure that the water supplied is safe. The approach of Water Safety Planning has been adopted worldwide. A survey carried out by WHO and IWA in 2017 shows that since its introduction in 2004 WSPs have been implemented in 93 countries, representing every region of the world (World Health Organization, 2017, 2). However, 30% of the implementing countries have not yet moved from the early adoption stage to wider implementation (World Health Organization, 2017, 2). Especially for small supplies, WSP adoption has been low. Furthermore, the quality of drinking water that is supplied by these small systems does not always meet the standards as laid out in the European Drinking Water Directive 98/83/EC.

Agriculture is one of the sources of pollution that can be identified in the Water Safety Plan. Agriculture is the biggest source of pesticides and nitrate pollution in European fresh waters (call text). The quality of groundwater and surface water (used to produce drinking water) impacts greatly the level and cost of treatment. Diffuse pollution as a result of the use of pesticides and fertilisers remains an obstacle to achieving the Water Framework Directive objectives (call text). Monitoring this pollution is challenging, since there is a high number of registered pesticides, the analyses are costly, and there is a need for samples to be taken during periods of application and use and in diverse weather conditions. Furthermore, the time dynamics, with the delay between activities above the ground and the reaction in the groundwater is challenging. The Water Safety Plan, as a RA/RM approach, is a tool that helps to overcome these challenges and can help to improve/preserve the quality of drinking water resources from agricultural pollution.

It has been 15 years since the Water Safety Plan approach was first coined. Over the years, research has been done on uptake, and manuals/guides have been produced on how to set up a Water Safety Plan. This document, with a focus on agricultural pollution, goes into depth on how to carry out the specific steps of the assessment of vulnerability, hazards and risks. Through this, it aims to raise awareness on the benefits of water safety planning, build capacity for successful WSP implementation, and contribute to the development of appropriate monitoring and decision-support tools that help to develop and implement governance models to preserve the quality of drinking water resources.

1.2 OBJECTIVE

The aim of Task 2.4. (Water Safety Plans) is to strengthen the use of Water Safety Plans with involvement of all relevant actors by investigating critical issues for diffuse pollution of small supplies and private spring-water supplies with nitrate and pesticides in several case studies.

With this document the FAIRWAY team strives to stimulate the improvement of drinking water safety across the European Union by sharing context, best practices and lessons learned on Water Safety Planning for both small and large water supplies. This document provides in fulfillment of the deliverable corresponding the task.

- D2.4 Report with recommendations for Water Safety Plans (chapter 4).

This task is executed in close collaboration with the 13 FAIRWAY case study sites.

The report builds further on Milestone 2.5, which is a learning module safety plan carried out with stakeholders. This Milestone has been delivered in January 2020.

1.3 ACKNOWLEDGEMENTS

We are grateful to our partners in the FAIRWAY project who have contributed to collecting data for this report; in particular everyone who has taken time answering questionnaires and reading this report.

2. APPROACH AND METHODOLOGY

2.1 LITERATURE REVIEW

To start the task and to prepare stakeholder involvement, a brief literature review was done to learn more about water safety planning, for small and large water supply systems. Literature was found on integrated risk assessment and risk management, as well as the current use of WSP in Europe. Different reports from the WHO and IWA were examined and academic literature was consulted. The literature review can be found in chapter 3. The used sources in chapter 5.

2.2 INVOLVEMENT OF CASE STUDIES

An integral and essential aspect of the FAIRWAY Project is the element of case studies. Thirteen case studies, in eleven countries, are part of FAIRWAY (see Figure 1). These case studies generate practical experiences, which are analysed within the work packages to identify the barriers and success factors associated with achieving water quality targets. In each case study a so-called Multi-Actor Platform (MAP) has been set up to facilitate effective cooperation between actors of different sectors and levels, including farmers, advisors, drinking water companies, scientists and policy makers. Each case is led by a so-called case study leader (CSL) and/or MAP leader who is linked to one of the FAIRWAY project partners.

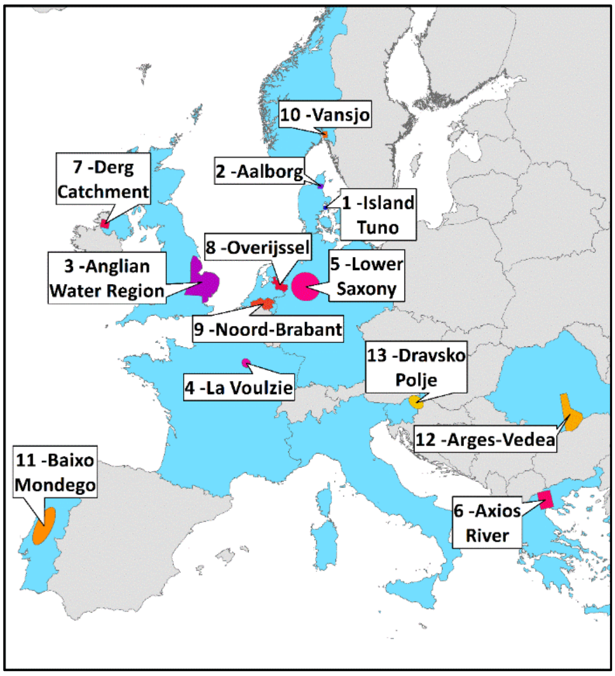


Figure 1 European map with FAIRWAY case study sites

To derive information and lessons learned on Water Safety Planning from the case studies, questionnaires have been sent out to case study leaders in two rounds. While answering questionnaires, CSL were free to involve other stakeholders from the MAP. In the first questionnaire CSL were asked whether a Water Safety Plan (or equivalent) is in place within their case study location. In total nine out of thirteen CSL have indicated to have a WSP in place. Four case studies indicated to not have a WSP in place in their case study area (see Table 1).

- For the Danish case Tunø it was indicated that there is no specific requirement for setting up a WSP since the case is supplying less than 750.000 m³ /year.
- For the French case no specific WSP exists, but it is part of an existing Water Sanitary Safety Management Plan.
- In the Greek case study no WSP exists.
- In Slovenia there is no legal basis yet for WSP. However, it was indicated that water companies have to establish internal control on the basis of HACCP (Hazard Analysis Critical

Control Point)[3] system. Introduction of WSP is foreseen by amendment of legislation on drinking water.

Table 1 Result first questionnaire on having a WSP

Case study	Case study country	Case study name	Water safety plan in place?	Comments
1	Denmark	Tunø	No	No specific requirement for setting up WSP. Public water supply systems supplying more than 750.000 m3 /year must introduce ISO22000, or a system based on HACCP (or equivalent).
2	Denmark	Aalborg	Yes	
3	United Kingdom	UoL Anglian region England	Yes	
4	France	France Voulzie	No	No WSP, but part of Water Sanitary Safety Management Plan.
5	Germany	Lower Saxony	Yes	
6	Greece	North Greece	No	
7	Northern Ireland	Northern Ireland	Yes	
8	Netherlands	Overijssel	Yes	
9	Netherlands	Noord Brabant	Yes	
10	Norway	Vansjø	Yes	
11	Portugal	Baixo Mondego e Baixo Vouga	Yes	
12	Romania	Arges-Vedea	Yes	
13	Slovenia	Dravsko Polje	No	No legal basis yet for WSP in Slovenia. Water companies have to establish internal control on the basis of HACCP system. Introduction of WSP is foreseen by amendment of legislation on drinking water.

In the second round, questions were asked to distill more details on the Water Safety Plan approach: on the register of water supplies, risk assessment and management, communication and awareness, and roles and responsibilities. The questionnaire is included in annex 4. The following countries have shared more in-depth information on Water Safety Planning either by answering the questionnaire or by sharing literature / reports on local WSP:

- United Kingdom (UoL Anglian region England)
- The Netherlands (Overijssel and Noord-Brabant)
- Norway (Vansjø)
- Slovenia (Dravsko Polje)
- Denmark (Aalborg and Tunø)
- Romania (Arges-Vedea)
- Portugal (Baixo Mondego)
- Greece (North Greece)
- Germany (Lower Saxony)

[3] "The Hazard Analysis and Critical Control Point (HACCP) is a process control system, in which hazards are determined in eacht step of the under-process product. Control measures are implemented to eliminate hazards. (Tavasolifar et al., 2012).

Some case studies could not provide more in-depth information for various reasons:

- Northern Ireland: No further information about the WSP could be provided. The reasons for this is that the local WSP is an internal document that was developed by Northern Ireland-Water staff without involvement of external organisations or stakeholders.
- France Voulzie: The case study leader of the French case study does not work for the organization that is responsible for the Water Sanitary Safety Management Plan. Therefore no further information could be provided.

The provided information from the case studies on their Water Safety Plan approach has been analysed. This has resulted in lessons learned and recommendations for water safety planning for both large and small supplies (chapter 4).

2.3 LEARNING MODULE

The report builds further on Milestone 2.5, which is a learning module safety plan carried out with stakeholders. This Milestone has been delivered in January 2020. The learning module aims to guide the reader through the process of assessing vulnerability, hazards and risks, and identifying mitigation measures. These specific steps of the WSP approach relate to the availability, use and interpretation of data. The learning module can be found in Annex 3.

The learning module has been carried out with the Greek case study leader on January 13, 2020, since no WSP is in place for this case study. It was a valuable exercise since it showed the challenges that are faced in Greece, and displayed that the WSP can be an instrument for the management of the water supply in the broadest sense (Chapter 1.6 of Annex 3). The WSP, for example, helps in the deliberation and substantiation of the decision to either take measures at the source, to dilute or purify the water, or to leave the abstraction site. Furthermore Water Safety Planning has the potential to promote continuation and long-term vision, and the WSP approach can aid in building trust among the public, stakeholders and government agencies that the water supplied is safe. The learning module and the evaluation by the Greek case study can be found in Annex 3.

3. WATER SAFETY PLANNING

3.1 IMPORTANCE OF RISK ASSESSMENT / RISK MANAGEMENT APPROACH

Drinking water is monitored to ensure that it is safe and of adequate quality, as the final product of the production chain. Monitoring this final product has been the norm and standard practice in order to assess whether it is of sufficient quality. However, risks might be detected too late, or are possibly not detected at all. This has consequences for public health. For this reason, risk based approaches for the drinking water supply system as a whole have come into being (Van den Berg et al., 2019).

This change in paradigm is closely related to the emergence of the concept of "due diligence". The concept means the prevention of foreseeable harm at reasonable cost. "*Demonstration of due diligence requires showing that all reasonable measures have been taken in advance to prevent the occurrence of negative health consequences"* (Medema et al., 2003, 23). When an effect is identified that could possibly have an adverse effect, an approach should be used that is precautionary and assesses and manages the risks.

The goal of a risk management approach is to assure safe drinking water. Hrudey et al. (2006) point the attention to the need to consider what is *safe.* They argue that the concept of safety has impeded the debates about risk management for years, and propose a notion of safety as "*a level of risk so negligible that a reasonable, well-informed individual need not be concerned about it, nor find any rational basis to change his/her behaviour to avoid such a small, but non-zero risk. [....] In the context of drinking water, and given our current capability for reducing risks, this notion of safe drinking water should mean that we do not expect to die or become seriously ill from drinking or using it."* (Hrudey et al., 2006, 3).

Hrudey et al. (2006, 3) define four characteristics of risk management for safe drinking water, as described by the Walkerton Inquiry:

- *"Being preventive rather than reactive.*
- *Distinguishing greater risks from lesser ones and dealing first with the former.*
- *Taking time to learn from experience; and*
- *Investing resources in risk management that are proportional to the danger posed."* (Hrudey et al., 2006, 3).

Hazard Analysis Critical Control Point (HACCP) is an example of a RA/RM approach. The HACCP approach came into being in the 1990s through the projects of Pillsbury Company in their research on food production for the US space program. The principles and approach of HACCP have since been applied in the food sector for food safety management. HACCP is based on three principles: understanding the system, prioritizing the risks, and establishing control measures to reduce the risks. In 1994, Havelaar investigated the use of HACCP for drinking water supply systems. Back then, some countries already required a HACCP approach, since water supply was regulated through regulations for food protection. A number of utility companies started to apply the HACCP principles. The ‘Catchment to consumer’ approach to risk management, as illustrated below, is based on the HACCP principles (Fewtrell and Bartram, 2001).

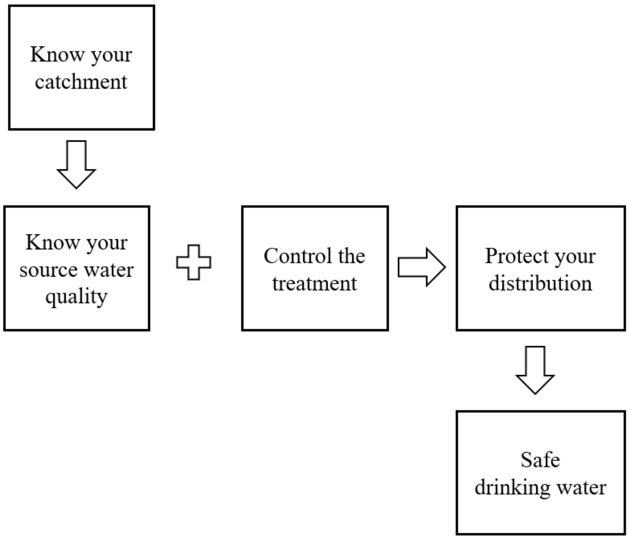


Figure 2 ‘Catchment to consumer’ approach to risk management of the safety of drinking water (Medema, 2003)

A group of experts started to investigate the potential to create more coherence between risk assessment and -management approaches for water-related microbial hazards. This has led to the Stockholm Framework, which further examined the use and value of HACCP for drinking water supplies (Fewtrell and Bartram, 2001). Consequently, the ‘Framework for Safe Drinking-water’ was defined in the third edition of the WHO Guidelines for Drinking Water Quality. This included the setting of health-based targets, an RA/RM approach and independent surveillance (van den Berg et al., 2019) This RA/RM approach was coined the Water Safety Plan (WSP).

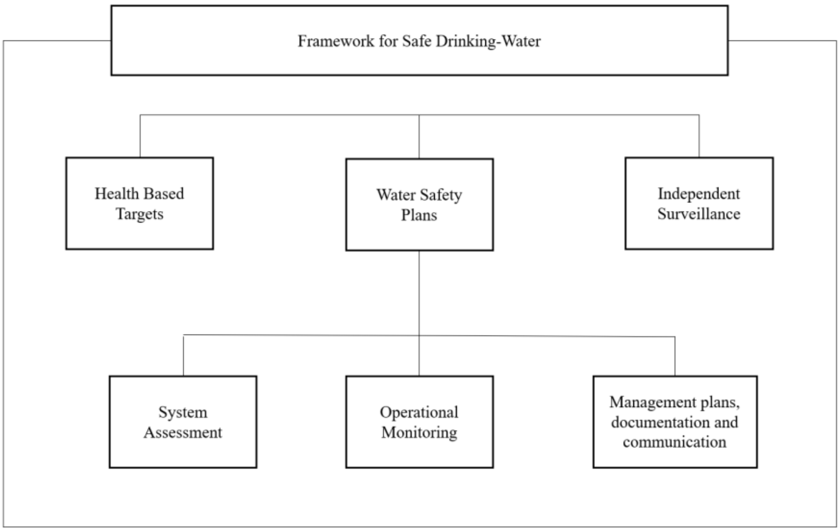


Figure 3 Framework for Safe Drinking Water (Davison et al., 2005)

3.2 THE WATER SAFETY PLAN

The main starting point for the setting of water quality standards worldwide are the World Health Organization Guidelines. The Guidelines for Drinking-water Quality (GDWQ) is one of the three guidelines concerned with water quality. All three have the main aim of improving health. An instrument that is promoted in this context is the Water Safety Plan (WSP).

The WSP is a step-wise approach to ensure the safety of drinking water. It is a comprehensive risk assessment and risk management approach, that covers all steps in the water supply. The goal of a WSP is to ensure, through good water supply practice, that drinking water is safe. This means:

- *"to prevent contamination of source waters;*
- *to treat the water to reduce or remove contamination that could be present to the extent necessary to meet the water quality targets; and*
- *to prevent re-contamination during storage, distribution and handling of drinking-water."* (Davison et al., 2005, 11).

These objectives apply to all kinds of water supplies, regardless the size or complexity (Drinking Water Inspectorate, 2005). A WSP has three components:

- System assessment: The WSP team identifies the potential hazards, the level of risk these potential hazards pose, and the control measures that can ensure that the water supply is safe.
- Operational monitoring: monitoring of the control measures.
- Documentation of management arrangements: Documentation of the system assessment, operational monitoring, management procedures, supporting programmes etc.

These three components are divided in eleven steps, from assembling the team to revising the WSP, as can be seen in Box 1. This report focuses on steps three and four.

Preparation:

1. *Assemble the WSP team*

System assessment:

2. *Describe the water supply system*
3. *Identify the hazards and assess the risks*
4. *Determine and validate control measures, reassess and prioritize the risks*
5. *Develop, implement, and maintain an improvement/upgrade plan*

Operational monitoring:

6. *Define monitoring of control measures*
7. *Verify the effectiveness of the WSP*

Management and communication:

8. *Prepare management procedures*
9. *Develop supporting programmes*

Feedback:

10. *Plan and carry out periodic review of the WSP*
11. *Revise the WSP following an incident*

Box 1: WSP steps

An important element of the WSP approach is that it combines both content and process. On the content side, it is about describing the water supply system, assessing hazards and risks and determining measures. But of similar importance is the status of the WSP and its place in the organization, the mandate of the team, the budget and management commitment. This management commitment is essential for a WSP to be succesfull (Drinking Water Inspectorate, 2005).

It is important that the WSP and the approach is embedded within the organization, and is part of the operating/management procedures rather than being a one-time activity. The WSP has two unique characteristics. The WHO (2011) argues that it is easily adaptable to different socioeconomic systems, and it can be effectively applied at different levels and scales.

3.3 Small and Large Water Supply Systems

Often a distinction is made between small and large water supply systems. However, the definitions used to describe small- and large-scale supply systems differ widely between (and even within) countries. Often, the characterization of the supply is based on specific criteria like population size, type of supply technology, quantity of water supplied, size of the supply area etc. This FAIRWAY report however distinguishes between small and large water supply systems because of their characteristics that affect Water Safety Plan implementation. Small supplies face challenges in setting up and implementing a WSP. These challenges relate to administration, management, operation and the regulatory context (WHO, 2011). It is those challenges that set small systems distinctly apart from large supplies, and thus define them in this context. Box 2 describes the challenges typically faced by small water supplies.

Challenges for small supplies:

- Small supplies are regulated in a different way than larger supplies. Under the EU Drinking Water Directive, systems that supply less than 10 m^3 a day / fewer than 50 individuals can be exempt from the requirements of the Drinking Water Directive (DWD). National governments thus do not have to put in place regulatory requirements for small systems. In the case that regulatory requirements are in place, enforcement is often weak, which is often a result of their large number or their geographical spread.
- Requirements related to monitoring freqencies are often based on population size. This means that small supplies are only monitored a few times a year, or exempt from monitoring. Furthermore, often reporting is not required. This results in a low availability of data on drinking water quality of small supplies.
- As a result of few political attention and lack of organization, financial and political support is hard to leverage.
- Low level of awareness and knowledge of water-related risks.
- Little political priority due to lack of sense of responsibility among local decision-makers.
- Lack of personnel with specialized knowledge.
- Difficult access to information and technical support as a result of the large geographical spread.
- Lack of knowledge on relevant international standards and approaches.
- High vulnerability to contamination as a result of a lack of integrated approaches for water resource protection.
- Limited use of water treatment technologies.
- More vulnerable to breakdown, as a result of poor maintenance and lack of electricity.
- Greater capital costs for technical installations.
- Lack of financial mechanisms to cover the costs for monitoring, maintenance and operation.

Box 2 Challenges for small water supplies (as adapted from WHO, 2011)

During a FAIRWAY field visit very small drinking water supplies were examined in Romania. In the picture below, a Roma family and their small (private) drinking water wel can be seen. These wells are mostly 10-20 m depth, in the first aquifer below a shallow clay layer on top.

In the recap of the Drinking Water Directive there is special attention to vulnerable groups in society and their access to water intended for human consumption. Member States are asked to pay specific attention to vulnerable and marginalised groups, such as refugees, nomadic communities, homeless people and minority cultures such as Roma and Travellers, whether sedentary or not. Examples of measures to improve access that are mentioned in the recap of the DWD are providing alternative supply systems, such as individual treatment devices, providing water through the use of tankers, such as truck and cisterns, and ensuring the necessary infrastructure for camps.

Figure 4 Roma family and their small (private) drinking water well in Romania

Examples of Water Safety Plans, both of large and small supplies, can be found in Annexes 1 and 2 respectively. Annex 1 provides an example of a Water Safety Plan for a Dutch public drinking water supply. It shows the following elements of the WSP: description of the water system and the surroundings, water quality and quantity, land use of recharge area, risks and relevant developments, and remaining problems/tasks. Annex 2 provides an example of a Water Safety Plan for a small supply in the Netherlands. The factsheet is made for small-scale abstraction sites, which include water supplies for drinking water consumption other than those for public drinking water supply. These are mainly privately owned groundwater abstractions used by third parties as drinking water (e.g. campsites and holiday parks) as well as industrial sites, that abstract groundwater for food production.

4. LESSONS LEARNED & RECOMMENDATIONS

4.1 INTRODUCTION

Based on more in-depth analysis of experiences with Water Safety Planning in the case studies, an analysis is carried out on lessons learned and recommendations for Water Safety Planning. This chapter offers recommendations to responsible authorities on Water Safety Planning for both large and small supplies. However, the case studies only include large supplies.[4] Therefore, mainly information on large supplies is gathered. However, from field visits within case study countries, it is seen that (very) small supplies do exist. Therefore, some of the case studies have provided information on how is dealt with small supplies. This information is used to formulate some recommendations for Water Safety Planning for (very) small supplies. This chapter starts with an overview of information gathered on Water Safety Planning in the case studies. In the second part recommendations are provided on WSP.

4.2 INFORMATION ON WSP IN THE CASE STUDIES

The following tables give an overview of the information gathered on Water Safety Planning in the case studies, specifically within three themes:

- How is Water Safety Planning (RA/RM) organised in the case study country (regulations and responsibilities)? And are there differences in how this is organized for (very) small and large supplies? – Table 2.
- How is the risk assessment and risk management executed? Are there differences in how RA/RM is carried out for (very) small and large supplies? – Table 3.
- How are stakeholders involved in Water Safety Planning (RA/RM)? (How) does this contribute to increased protection or support for measures? Are there differences between (very) small and large supplies? – Table 4.

[4] Definition of small supplies according to the European Drinking Water Directive: small supplies are those supplying less than 1,000 cubic meters per day or serving less than 5,000 persons.

Table 2 How is Water Safety Planning (RA/RM) organised in the case study country (regulations and responsibilities)? And are there differences in how this is organized for (very) small and large supplies?

Case study information	National regulation	Responsibilities
Denmark **Tunø and Aalborg**	The Order on Quality Assurance of Public Water Supply systems is the Danish implementation of WSP and the Drinking Water Directive. In this order (section 4.) it is stated that public water-supply systems supplying more than 750,000 m^3 of water per year must meet the requirements of § 3 by introducing ISO22000, or systems based on HACCP (Hazard Analysis Critical Control Points) or equivalent systems. This ISO standard does not apply to small supplies. Different method of quality assurance must be introduced by smaller supplies. In Denmark there are around 50.000 private wells. For private wells there is a low degree of regulations and no demands on monitoring the quality.	Keep and maintain register of water supplies: municipalities, state and water works. RA/RM and WSP: water works and the municipalities.
United Kingdom **UoL Anglian region England**	RA/RM is covered in regulation 27 and 28 of the Water Quality regulations set by Department for Environment, Food and Rural Affairs in the UK. Regulation covers all sizes of public water supply. Private Boreholes are covered by Private Borehole Regulations, which are enforced by Local Council, which submit a risk assessment as defined by the Private Water Supply Regulations.	Asset register for boreholes: Water company. Register for abstraction licencing purposes: Environment Agency. RA/RM: Water company (main actors: Water Quality Risk Team and Water Resources and Catchment Team). Check and audit RA: Drinking Water Inspectorate.
Germany **Lower Saxony**	RA/RM is covered in Drinking Water Act.	
The Netherlands **Overijssel and Brabant**	It is worked out in the procedure to set-up Drinking Water Protection Files and embedded in the WFD-activities & procedures. The obligation for RA/RM only applies to large drinking water abstractions. Small / Industrial abstractions have either no obligation to report regularly or report to the industrial food safety authority.	Province (regional government) is responsible for RA/RM.

Case study information	National regulation	Responsibilities
Norway **Vansjø**	The drinking water regulation "Forskrift om vannforsyning og drikkevann" of 2017 implements the Drinking Water Directive (98/83/EF) and is intended to follow the main principles of water safety plans. The regulation applies to all drinking water supplies, but there are less detailed requirements for very small water supply systems (<10 m^3).	Register of drinking water supplies: Norwegian Food Safety Authority (NFSA). Water suppliers provide info through online-form to NFSA. Data transferred to Waterworks Register (Norwegian Institue of Public Health). RA/RM: water supply company.
Portugal **Baixo Mondego e Baixo Vouga**	In Portugal, there is no legislation that defines the obligation to develop a WSP. Although, Law-Decrete 152/2017 (water for human consumption) refers the mandatory risk assessment in the water supply management systems.	Register and RA/RM: Drinking water authority: Águas do Centro Litoral.
Romania **Arges-Vedea**	Law no. 458/2002 with its subsequent modifications done by Ordinance no. 22/2017 transposes the European Directive no. 83/1998 related to the quality of water for human consumption with is subsequent modifications done by the European Directive no. 1787/2015. These are mandatory for large size water supplies and is considered as good practice for small and very small water supplies.	Register: country offices for public health. RA/RM: water suppliers and country offices for public health through their laboratories for water quality analyses. In case of household supply (private wells) the risk assessment is the responsibility of the owner. If there are supplies (public wells) which serve a small community, the risk assessment is the responsibility of the County office for public health together with the mayor of the village.
Slovenia **Dravsko Polje**	RA/RM is embedded in national regulations, in the Decree on drinking water supply and Rules on drinking water obligational to all public suppliers.	Register: Slovenian Environmental Agency. RA/RM: public water supply company (owned by local municipality).

Table 3 How is the risk assessment and risk management executed? Are there differences in how RA/RM is carried out for (very) small and large supplies?

Case study information	How is RA/RM executed?
Denmark **Tunø and Aalborg**	Aalborg Waterworks is certified after four standards: • ISO 14001 (environmental management). • OHSAS 18001 (safety management). • ISO 22000 (Food Safety). • Quality and Management system in the electricity field. A water safety plan for a large supply in Denmark is a combination of these certifications, environmental status reports, action plans and groundwater protection plans. For large supplies the ISO22000 standards apply, which do not apply to smaller ones (17.000-750.000 m^3 per year). Smaller water supplies must introduce quality assurance by: 1) mapping water supply and quality thereof; 2) mapping water supply's operating procedures; 3) assess the risk of contamination of the water from the overall production system; 4) draw up an action plan; 5) continuously monitor and document that the supply has implemented the planned measures. In Denmark there are around 50.000 private wells. For private wells there no demands on monitoring the quality.
United Kingdom **UoL Anglian region England**	Every water company has the ability to risk assess following the template of Regulation 28 of the Water Supply (Water Quality) Regulations. All sources - large and small are treated the same in terms of risk assessment process. One size fits all. Training wise- modules that internal Anglian Water staff do in relation to Reg 28. Vulnerability of aquifer to pollution is assessed, and hazards are identified. Methods used: GIS datasets, catchment walkovers, history of sample results, investigations, modelling. Risks are identified in different stages of the water supply system: catchment risks, treatment risks, supply risks, customer risks – all link in together. Risks are scored in low, medium and high risks. Based on Source-Pathway-Receptor model a database is used, which draws from a number of different AW internal datasets and the outputs from onsite assessments/audits. It calculates the risk for specific hazard groups, based on a number of pre-defined components. Likelihood is incorporated into the scoring mechanism. Risk scores are validated on an annual basis using actual sample data and risk scores adjusted accordingly.
Germany **Lower Saxony**	Methodological guidance of DIN ENG 15975-2. This is equal to WHO WSP format.

Case study information	How is RA/RM executed?
The Netherlands **Overijssel and Brabant**	RA/RM is executed by the Drinking Water Protection File. In a national platform the table of content is agreed on and the province is in charge of the process to set-up these DWPF. The DWPF describes the status of a drinking water abstraction, assesses the vulnerability, assesses risks (both physical and from lacking protection policy) and formulates measures to overcome these risks / meet the WFD of simple purification effort. The Province chaires the project team which sets up the DWPF and is in charge of involving all relevant stakeholders. Stakeholders are asked to provide info about potential risks, check that info and are also consulted about possible measures in which they are involved. For small supplies: in certain instances a quick-scan of the risks is carried out.
Norway **Vansjø**	Guidance document on RA/RM is available. The methodology for risk mapping is optional. There is however a guiding document on increased security and response in the water supply ("Økt sikkerhet og beredskap i vannforsyningen") which provides a suggested framework in line with the Norwegian standard NS-EN 15975-2 (Security of drinking water supply - Guidelines for risk and crisis management - Part 2: Risk management). If the water supply chooses a risk-based approach to provide fewer samples than the minimum requirement, NS-EN 15975-2 or an equivalent method has to be applied. The emergency response plan is required to comply with the regulation on emergency response planning ("Forskrift om krav til beredskapsplanlegging og beredskapsarbeid, mv.") which applies the methodology for risk and vulnerability assessments (ROS-analyse). The Water Safety Plan for Vansjø/MOVAR consists of two parts. Part A identifies the risks: it describes the water supply system, identifies the vulnerable users, identifies risks, and lists incidents. Part B assesses the risks on the basis of criteria on probability and consequences. Furthermore it assesses the measures. For small supplies: Online guidance is provided on drinking water from wells.
Portugal **Baixo Mondego e Baixo Vouga**	A technical guide is provided describing the methodology: Risk assessment in the water supply management systems, from abstraction to distribution (ERSAR Technical Guide nº 7). Electronic platform tool – NADIA. The WHO WSP steps are followed: team, description of the system, control measures, evaluation matrices, improvement plan, management supporting procedures. To identify hazards information on previous events is used. Risk assessment is carried out based on the probability of occurrence and assessment of consequences. For small supplies without professional management: They are private and no assessment or control is performed.

Case study information	How is RA/RM executed?
Romania **Arges-Vedea**	National technical standards. It is mandatory for large size water suppliers to accomplish WSP. In case of small and very small water suppliers is considered as good practice to accomplish WSP.
Slovenia **Dravsko Polje**	In Slovenia a HACCP* system is in place for RA/RM and an Action Plan is developed.

* Hazard Analysis Critical Control Point

Table 4 How are stakeholders involved in Water Safety Planning (RA/RM)? (How) does this contribute to increased protection or support for measures? Are there differences between (very) small and large supplies?

Case study information	Stakeholder involvement
Denmark **Tunø and Aalborg**	Municipalities and water works.
United Kingdom **UoL Anglian region England**	There are many stakeholders who interact with the supply of water from source to tap who are consulted as part of the RA process, both internally and externally. Multiple stakeholders, such as farmers, emenity, horse owners, are also involved in terms of catchment management. Water Quality risk team and Water Resources and Catchment Team are the main actors involved.
The Netherlands **Overijssel and Brabant**	Province (authority), drinking water company, municipalities, water boards, agricultural lobby organization (main stakeholders). Depending on specific issues, other stakeholders may be involved: railway, industry, national water authority.
Norway **Vansjø**	In process of identifying vulnerable users, municipal doctor and regional branches of the NFSA can be involved. Water company: owns the assessments, the emergency response plan and emergency response in itself. Municipalities that own the drinking water company: client and affected. Other water works: support/cooperation. The National Food Safety Authority: authority and guide.
Portugal **Baixo Mondego e Baixo Vouga**	Different departments within water company: administration areas, company's entrepreneurial sustainability, laboratory, water supply, communication, maintenance and engineering. Both customers and authorities (health authorities; Portuguese Environment Agency) gave their opinion.
Romania **Arges-Vedea**	Water suppliers: accomplishing the RA/RM and WSP; county offices for public health: supervising the RA/RM and WSP; operators from foodstuff activity area, local medical stuff, end users: inform of any possible hazard event.
Slovenia **Dravsko Polje**	Drinking Water Supply Company. Municipalities. Ministry for environment. Ministry of Health checks water quality at users' homes.

Organization of Water Safety Planning / RA/RM in the case studies:

Table 2 shows the information gathered on the organization of Water Safety Planning / RA/RM in the case studies. This relates to regulations on RA/RM and roles and responsibilities.

In all case study countries RA/RM is embedded in national regulations. There are differences between case studies whether the same regulations apply to large and small supplies. Furthermore, the responsible authority/authorities vary between the case studies. Although, in most case studies the water supply company is responsible for RA/RM. This is often combined with a specific role for the local/regional/national government. In the Netherlands, the provincie carries primary responsibility for RA/RM of the water supplies as they are the responsible authority to protect groundwater used for drinking water purposes. Lastly, it can be seen that within the water supply company or authority different departments and teams are involved in RA/RM. This requires coordination between different departments/teams within the organizations.

Risk assessment and risk management:

Table 3 shows the information gathered on the execution of risk assessment and risk management.

In many case study countries some form of agreed methodology for RA/RM / Water Safety Planning is in place. This is disseminated in different forms, such as a guidance document, template, content page, regulatory standards, or an electronic tool. In some case studies this specific method is optional and adaptations can be made. In other case studies, the responsible authority/organization is obligated to follow this specific method. The Norwegian case study of Vansjø shared that standardized methods, and an agreed upon methodology, enable better and more effective communication between drinking water suppliers.

In some of the case studies the WHO WSP elements or steps are followed. In others, other systems for RA/RM are used, such as systems based on HACCP principles or ISO standards. The WHO WSP approach is a comprehensive risk assessment and risk management approach, that covers all steps in the water supply. It can be seen that in some case studies multiple RA/RM approaches are used for the different steps in the water supply. The combination of the outcomes of all RA/RM approaches gives an overview of the hazards from source to tap. This could also mean that the outcomes of RA/RM end up in different documents.

In some case study countries, for example Denmark and the Netherlands, different methods for RA/RM are in place for large and small supplies. These distinct methods reflect both the different challenges that small supplies face in water safety planning and the fact that for small water supplies usually less information is available, such as the recharge area and travel times of the abstracted water.

Involvement of stakeholders:

Table 4 shows the information gathered on the involvement of stakeholders in risk assessment and management.

In most case studies the involvement of stakeholders is limited to the different teams within the water supply company and government. RA/RM is often carried out by experts, based on expert knowledge, using data and modelling. In the case studies in the United Kingdom and the Netherlands stakeholders are actively involved in water safety planning. In the UK stakeholders who interact with the water system from source to tap are consulted as part of the RA/RM process. Furthermore, stakeholders are involved through the catchment management system. In the Netherlands it is explicitly mentioned that stakeholders are involved in a process, coordinated by the regional government (Province), to develop drinking water protection files (DWPF) and consequently a program of measures. Stakeholders such as the Water Boards, Agricultural organizations and municipalities (and for specific issues: railway, industry, national water authority) are involved in identifying the vulnerability of the system, assessing the hazards and the risks. The Dutch case study shares that through this process consensus is created about the risks. Consequently, this paves the way for agreeing on measures as well. Even so, the Portuguese case study has shared that the interactions with the stakeholders should be deepened.

4.3 RECOMMENDATIONS FOR LARGE SUPPLIES

Based on the analysis of Water Safety Planning in the case studies, three recommendations can be made for large supplies, i.e.

- Water Safety Planning – a process with a process owner.
- Agreement on methodology and content.
- Involvement of stakeholders.

These recommendations are described below.

Water Safety Planning – a process with a process owner

Water Safety Planning is a process, rather than a product. It is a process in which several organizations or departments/teams are involved. Furthermore, in some cases it consists of several parallel processes. This poses some challenges:

- Different teams could be involved. This complicates the spreading of knowledge on vulnerability, hazards and risks within the organization.
- Information on -and outcomes of RA/RM of different elements of the water supply could end up in different places, rather than being collected together and combined in one output.
- Parallel processes of RA/RM (different RA/RM processes for elements of the water supply system) could also mean that risks are estimated and prioritized differently.

This shows the importance of a process owner, who is responsible for -and coordinates this process of Water Safety Planning. This could be an authority (national, regional or local government), because then enforcement could be easier. The process owner could also be the water supply company, since then the interests of the water supply and knowledge/expertise is bundled.

The process owner can bring together departments and stakeholders, can spread information throughout organizations and aids in providing congruence between different RA/RM systems (if they do exist).

Agreement on methodology and content

Working towards more harmonization and generic arrangements for a RA/RM could improve current practices, developing a more uniform and transparent approach to RA/RM. The case studies show that the existence of an agreed upon methodology enhances the effectiveness of Water Safety Planning in several ways. Firstly, a structured RA/RM approach contributes to a comprehensive overview of all risks – and enables a strategic planning of the Water Safety Planning (see f.i. paragraph 4.6). Secondly, a generic approach enhances the communication and cooperation between water supply companies. Thirdly, harmonization of the approach enables the evaluation of the RA/RM results at the scale of a water company, province or country, which can help to substantiate strategic decisions in protection policy. Fourtly, the need for a harmonized approach is amplified in case of a large incident.

Involvement of stakeholders

In densely populated areas groundwater protection is increasingly competing with other interests and themes, such as agriculture, urban & industrial functions or the energy transition (geothermal energy). It can therefore no longer be considered as a stand-alone theme, but should be considered in a social context. Furthermore, groundwater protection is increasingly seen as a complex environmental problem (Simpson & De Loë, 2020), rather than a relatively simple and predictable problem. The Dutch case shared that the interest of groundwater protection compared to other interests is usually low. In addition, the timescale of groundwater protection compared to the political or social timescale is long, which enhances the competition with other interests.

It is therefore important to engage stakeholders in the risk assessment and risk management of a water supply. In the Netherlands stakeholders are involved in this process, coordinated by the regional government (Province), to develop drinking water protection files (DWPF) and consequently a program of measures. Stakeholders such as the Water Boards, Agricultural organizations and municipalities are involved in identifying the vulnerability of the system, assessing the hazards and the risks. Through this process consensus is created about the risks. Consequently, this paves the way for agreeing on measures as well. The Portuguese case shares that the interactions with the stakeholders should be deepened. In the UK stakeholders are consulted as part of RA/RM and involved in terms of catchment management.

Stakeholder involvement was also mentioned by the Greek case while evaluating the learning module: ‘the module educates all kinds of stakeholders’. On the other hand it was added that ‘the implementation of a WSP, selection of measures, and final application is not always a matter of all stakeholders’. The Danish case study of Tunø also illustrates the need for stakeholder involvement. The drinking water abstraction of the small island Tunø suffered from a strong increase of nitrate concentrations in the groundwater by the public drinking water facility in the nineties of last century. As the nitrate concentrations exceeded the standards, urgent action was needed. Regional authorities (the former county) assisted by agricultural scientists analysed the site, recovered the source of the nitrate pollution and presented scenarios. The economic most feasible scenario consisted of a change of agricultural land-use (permanent grass rather than leek) facilitated by contracts which were favourable for the farmers. This scenario resulted in a quick reduction of the nitrate concentrations resulting in safe nitrate levels in the abstracted groundwater. Just a few years ago, the contracts finished and as part of the EU-FAIRWAY project the process was evaluated. Several key stakeholders have been interviewed and most of the farmers ignored that there had been a problem at all. They still believed that the press and authorities created the problem and that the only reason for accepting the solution were the favourable conditions of the contracts.

This example illustrates that a sound scientific solution not necessarily results in stakeholder engagement and solving a real-world problem. Key lesson learned is that engagement of stakeholders is essential during all phases of the project: the phase of the identification of the problem, assessment of the problem, scenarios to solve the problem and in the phase of implementing the solution.

4.4 RECOMMENDATIONS FOR SMALL SUPPLIES

As mentioned before, the information received from the FAIRWAY case study leaders mainly applies to large supplies. However, based on field visits carried out within the EU-FAIRWAY project and some specific information provided by some case studies, it is known that small supplies are present in the participating countries. Therefore some recommendations are made for small supplies based on general information on water safety planning and experience and procedures participating countries apply for small supplies.

As discussed in Chapter 3, small systems typically face challenges that set them distinctly apart from large supplies in the context of Water Safety Planning. One of those challenges relate to the limited availability of specialized knowledge and expertise, and access to information and technical support. The experience in the case study of Norway can aid in overcoming this challenge. In Norway an information brochure is specifically targeted at small suppliers. Furthermore, small suppliers are encouraged to have an agreement with larger suppliers to get access to necessary competence and knowledge. Small suppliers can be aided by developing networks for cooperation.

In some case studies a specific method is provided for small supplies. This is for example the case in Denmark and the Netherlands. Such a method specifically aimed at small supplies can help to overcome the challenges that are faced by small supplies in water safety planning, for example the lack of availability of specific data. Annex 2 shows a quick-scan, an example of a WSP for a very small water supply in the Netherlands, and explains how RA/RM is executed for a small privately-owned supply in the Netherlands. This quick scan focusses on:

- Assessment of vulnerability of the groundwater abstraction by assessing the characteristics of the subsoil and soil types.
- Assessment of potential sources near the groundwater abstraction.

Based on this quick scan of the specific vulnerability and threat of the resource, a rough indication of the risks can be made.

5. REFERENCES

Bartram, J. (2009). *Water safety plan manual: step-by-step risk management for drinking-water suppliers*. World Health Organization.

BTO, 2018. REFLECT: beoordeling van de risico's van landgebruik voor grondwaterwinningen. Herziene versie van het instrument uit 1999, inclusief Implementatie van de keileemkaart.

CIS Working Group Groundwater 2017/2018. "Questionnaire on better consideration of drinking water resource protection in river basin management planning". Draft summarizing report.

Davison, A., Howard, G., Stevens, M., Callan, P., Fewtrell, L., Deere, D., Bartram, J., & World Health Organization. (2005). *Water safety plans: managing drinking-water quality from catchment to consumer* (No. WHO/SDE/WSH/05.06). Geneva: World Health Organization.

Drinking Water Inspectorate (2005). A brief guide to drinking water safety plans. *Obtainable from http://www. dwi. gov. uk*.

European Commission (2016). 'REFIT Evaluation of the Drinking Water Directive 98/83/EC' SWD(2016) 428 final.

European Commission (2017) 'Agriculture and sustainable water management in the EU'. SWD(2017) 153

European Commision (2019a). "Implementation of the Water Framework Directive (2000/60/EC) and the Floods Directive (2007/60/EC), Second River Basin Management Plans, First Flood Risk Management Plans". Brussels, 26.2.2019 SWD(2019) 30 final.

European Commision (2019b). "Fitness Check of the Water Framework Directive, Groundwater Directive, Environmental Quality Standards Directive and Floods Directive. Brussels, 10.12.2019 SWD(2019) 439 final.

Fewtrell, L., & Bartram, J. (Eds.). (2001). *Water quality: guidelines, standards & health*. IWA publishing.

Hrudey, S. E., Hrudey, E. J., & Pollard, S. J. (2006). Risk management for assuring safe drinking water. *Environment International*, *32*(8), 948-957.

Hulsmann, A., & Smeets, P. (2011). Towards a guidance document for the implementation of a risk-Assessment for small water supplies in the European Union. *Overview of best practices. Nieuwegein: KWR Watercycle Research Institute*.

Klaassens, E., Kros, H., Romkens, P., de Vries, W., Hulsmann, A., Schellekens, J., (2015). *Study to support The COM Evaluation of the EU Drinking Water Directive.* Ecorys Rotterdam.

Mayr, E., Lukas, A., Aichlseder, W., & Perfler, R. (2012). Experiences and lessons learned from practical implementation of a software-supported water safety plan (WSP) approach. *Water Science and Technology: Water Supply*, *12*(1), 101-108.

Medema, G. J., Payment, P., Dufour, A., Robertson, W., Waite, M., Hunter, P., Kirby, R., & Andersson, Y. (2003). Safe drinking water: an ongoing challenge. *Assessing Microbial Safety of Drinking Water*, *11*.

Royal HaskoningDHV, 2019. Gebiedsdossiers Leggeloo.

Simpson, H. C., & De Loe, R. C. (2020). Challenges and opportunities from a paradigm shift in groundwater governance. *Hydrogeology Journal*, *28*(2), 467-476.

Tavasolifar, A., Bina, B., Amin, M. M., Ebrahimi, A., & Jalali, M. (2012). Implementation of hazard analysis and critical control points in the drinking water supply system. *International Journal of Environmental Health Engineering*, *1*(1), 32.

van den Berg, H. H. J. L., Friederichs, L., Versteegh, J. F. M., Smeets, P. W. M. H., & de Roda Husman, A. M. (2019). How current risk assessment and risk management methods for drinking water in The Netherlands cover the WHO water safety plan approach. *International journal of hygiene and environmental health*, *222*(7), 1030-1037.

Van den Brink, C., M. Buitenkamp, J. van Essen and A. Nass (2005). Gebiedsdossiers als instrument voor gebiedsgericht grondwaterbeschermingsbeleid [Drinking water protection files as an instrument for regional groundwater protection policy; in Dutch]. Bodem no. 3, p. 122-124.

Van den Brink, C and S. Wuijts (2016). Towards an effective protection of groundwater resources: putting policy into practice with the Drinking Water Protection File. Water Policy. Water Policy 18 (2016) 635–653. doi: 10.2166/wp.2015.197

World Health Organization. (2011). Small-scale water supplies in the pan-European region: background. challenges. improvements.

World Health Organization. (2012). *Water safety planning for small community water supplies: step-by-step risk management guidance for drinking-water supplies in small communites*. World Health Organization.

World Health Organization. (2017). *Global status report on water safety plans: a review of proactive risk assessment and risk management practices to ensure the safety of drinking-water* (No. WHO/FWC/WSH/17.03). World Health Organization.

Wuijts, S., van Rijswick, H. F. M. W., & Dik, H. H. J. (2008). Gebiedsdossiers voor drinkwaterbronnen, uitwerking van risico's en ontwikkeling van maatregelen. *RIVM rapport 73430103.*

E.2 Institutional sources:

Council Directive (EC) 98/83/EC of 3 November 1998 on the quality of water intended for human consumption. Retrieved from: http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31998L0083&from=EN.

European Commision (2020). *Proposal for a Directive of the European Parliament and of the council on the quality of water intended for human consumption (recast).* Brussels, 26 October 2020. Retreived from: https://data.consilium.europa.eu/doc/document/ST-6230-2020-REV-3/en/pdf.

6. ANNEX

Annex 1: Example water safety plan – Large supply

Annex 2: Example water safety plan – Small supply

Annex 3: Learning Module

Annex 4: Questionnaire

ANNEX 1: EXAMPLE WATER SAFETY PLAN – LARGE SUPPLY

The following chapter provides an example of a water safety plan for a Dutch public drinking water supply. The original document was written in Dutch and contains 9 chapters, namely:

1. Introduction
2. Extraction characteristics
3. Policy
4. Description of vicinity and water system
5. Water: quality and quantitiy
6. Spatial use of recharge area, risks and relevant developments
7. Remaining tasks for the extraction
8. Definitions
9. References

Parts of the document are translated that are relevant as a supporting example for the learning module on developing a WSP. Consequently in the following paragraphs only parts of chapter 2 and 4 – 7 are given.

Chapter 2 Extraction characteristics

Groundwater extraction site and depth

The Leggeloo groundwater protection zone is located north-west of the village of Dwingeloo, to the north of the N855 provincial road and to the east of the N371 trunk road. The groundwater extraction site with a single extraction field lies within the groundwater protection zone.

Water extraction at Leggeloo started in 1972. This is phreatic extraction, where the 3 extraction wells are located at a depth of 40-70 m below ground level. The third extraction well went into operation in 2017. The ground level is at a level of approx 9.5 m+NAP (Amsterdam Ordnance Datum).

Figure 0-1 shows the location of the water extraction area, the groundwater protection zone and the survey area. The survey area is the outer contour of the 100-year zone of the recharge area for both extraction points. The Leggeloo groundwater protection zone lies entirely in Drenthe Province.

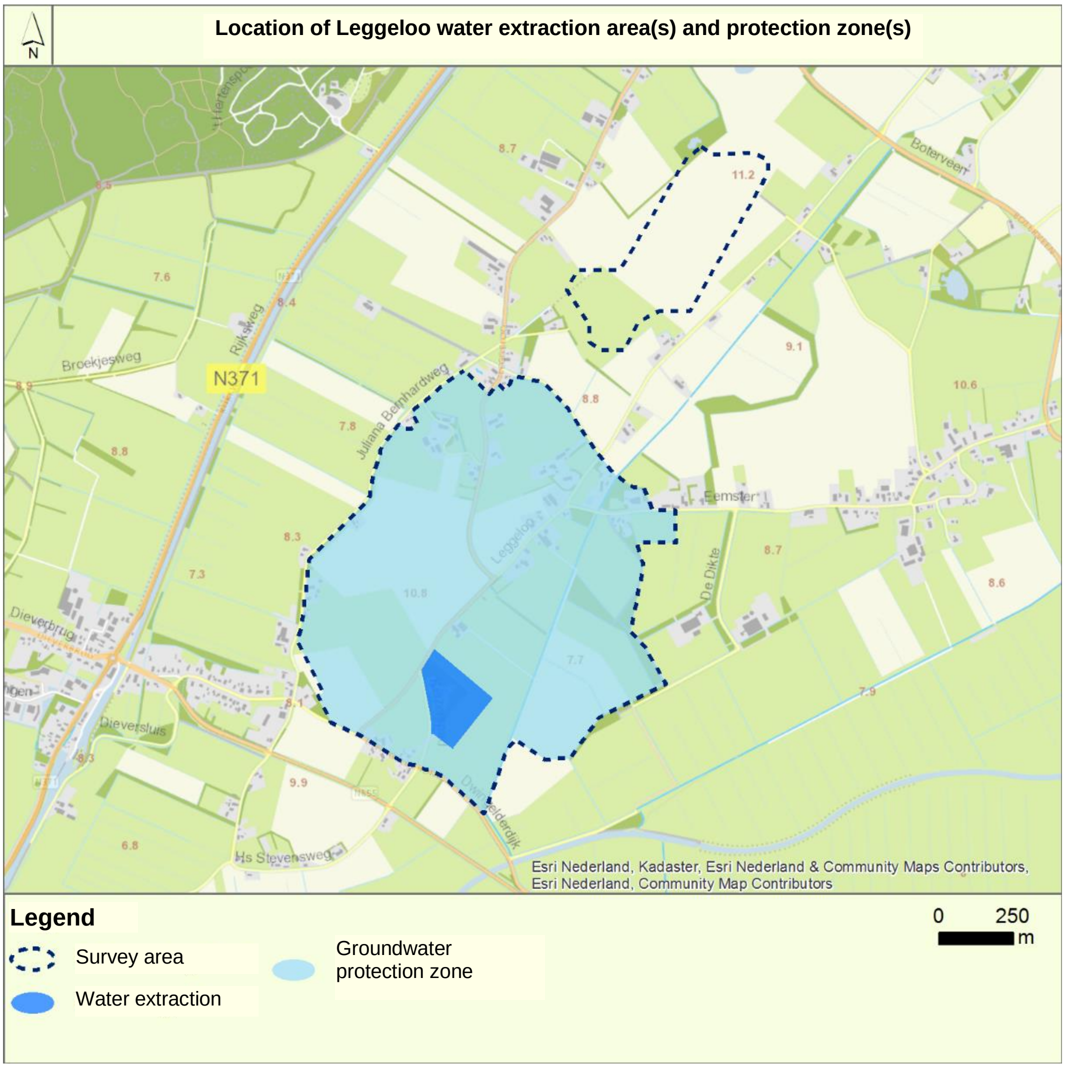


Figure 0-1 Location of water extraction area and groundwater protection zone for groundwater extraction

Supply area
Figure 0-2 shows the WMD supply area. The Leggeloo pumping station mainly provides the outlying areas of the Westerveld municipality with drinking water.

Figure 0-2 Supply area for the WMD groundwater extraction points

Extraction quantities
The permitted extraction flow for the Leggeloo extraction site is 1 million m^3/year. An average of 0.65 million m^3/year was extracted over the period 1989-2017. Figure 0-3 shows the total annual flows for the period 1990-2017.

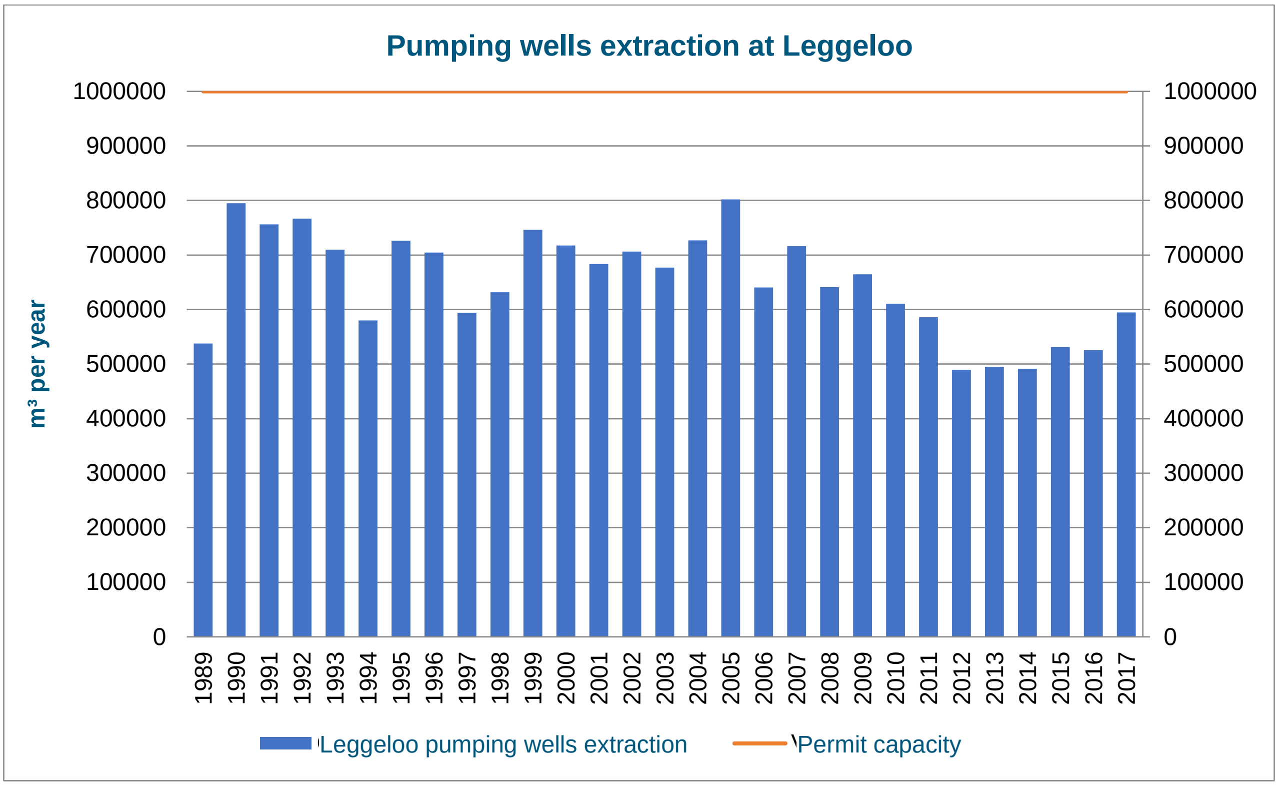


Figure 0-3 Quantity of groundwater actually extracted at Leggeloo

Extraction history

Water consumption in the Diever/Dwingeloo area started to rise sharply at the end of the 1960s. As a result of this, it was predicted that the supply capacity of drinking water from Beilen would be inadequate during peak periods. Several possible solutions were considered to boost the supply capacity, and a decision was finally taken to erect a new pumping station in the area. In 1970, a permit was granted for the Leggeloo pumping station for the extraction of 1 million m³/year. The pumping station began operating in 1972.

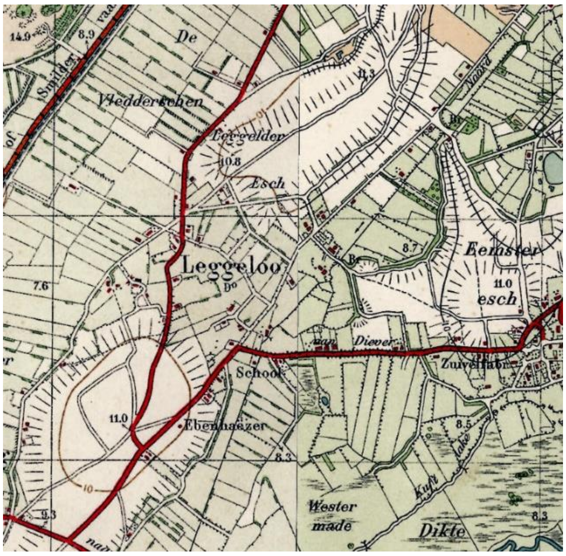


Figure 0-4 shows an old topographical map (1935) of Leggeloo and vicinity. By comparison with the current topographical map of Leggeloo, the changes at ground level have remained limited, with agriculture forming the most important land use.

Figure 0-4 Historical map of Leggeloo 1935 (source: www.topotijdreis.nl)

Chapter 4 Description of vicinity and water system

Recharge area and protection zones

Three types of groundwater extraction methods can be distinguished: (1) phreatic extraction, (2) semi-confined extraction and (3) confined extraction. Confined extraction is extraction from a deeper aquifer beneath a relatively impermeable protective layer. This may also be a thick covering layer with extremely high resistance. Semi-confined extraction is extraction from the first aquifer (phreatic layer) beneath a covering layer offering limited resistance. Phreatic extraction is extraction from the first aquifer without the presence of a covering or other layer above offering resistance. This classification of extraction methods, distinguishing between geohydrological structure and the presence of separating layers, provides an indication of the hydrological vulnerability. Apart from hydrological vulnerability, there is also hydrochemical vulnerability, depending on the composition of the sediment in the subsoil (See Section 4.4).

A distinction is made between the following types of protection zones around an extraction point (not all of which have to be present at an extraction point):

- Water extraction area.
- Groundwater protection zone.
- Deep borehole ban zone.

The time that the groundwater needs to reach the wells of the groundwater extraction site forms the basis for the boundaries of the areas. The water extraction areas are the zones immediately around the extraction wells. The water that is pumped up within one year to produce drinking water is found in these areas. The groundwater protection zones and/or areas with a zone where deep boreholes are banned are located around the water extraction area. These areas contain the water that will reach the pumping wells in the aquifer being pumped out within 25 years.

The recharge areas for the groundwater extraction points are also shown. The recharge area is defined by the surrounding boundary of the source area for the groundwater extraction. The source area is the area into which water infiltrates and then flows through the soil to the extraction point. The boundaries of all the areas are based on geohydrological model calculations (Royal Haskoning, 2008 and Royal Haskoning, 2009). Figure 0-5 shows the 100-year zone of the recharge area for Leggeloo, along with the groundwater protection zone, the water extraction area and the survey area. The survey area for this drinking water protection file is (bounded by) the outer contour of the groundwater protection zone and the 100-year zone of the recharge area for the Leggeloo extraction.

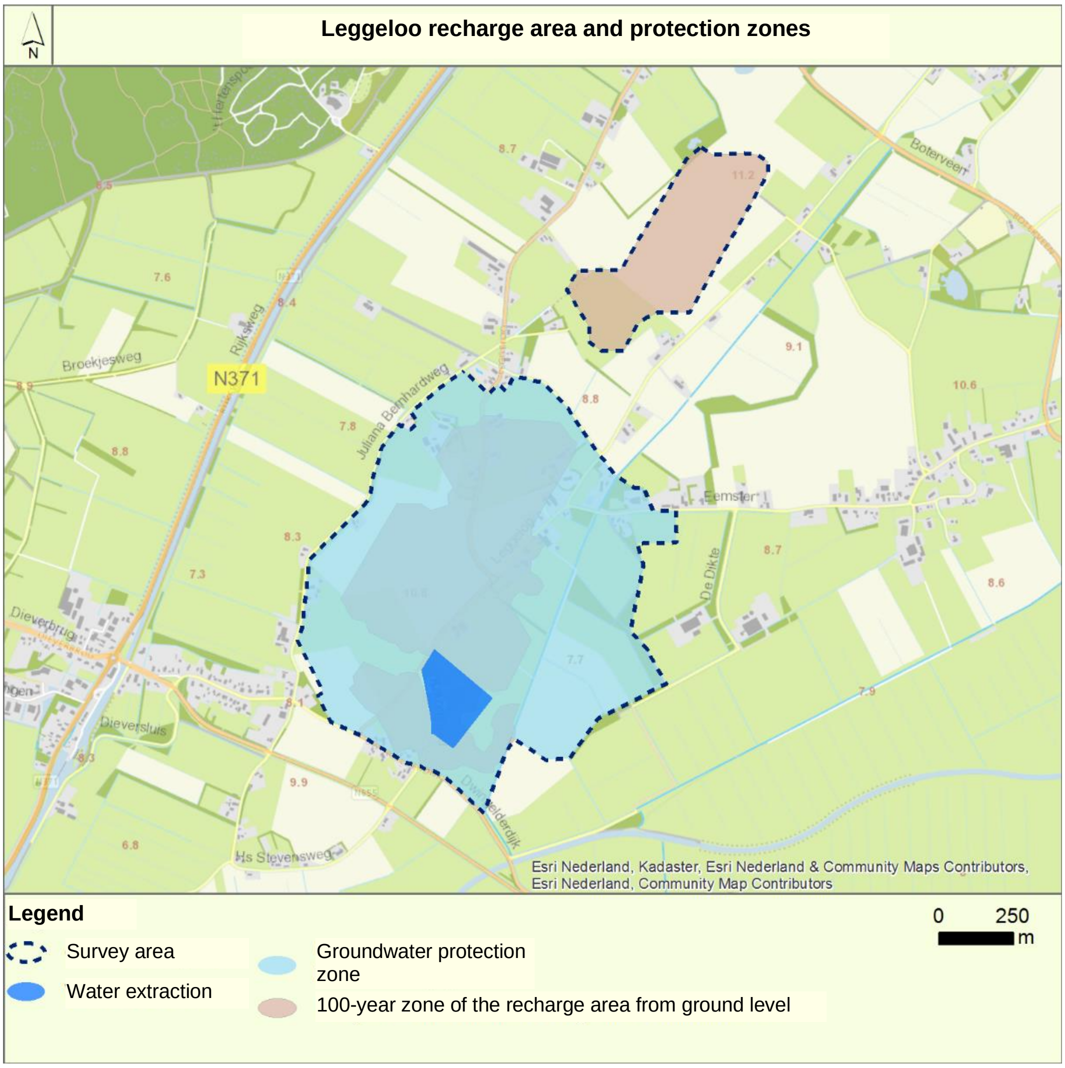


Figure 0-5 Recharge area, groundwater protection zone and water extraction area

Geo-hydraulics

The geohydrological structure is shown schematically in Figure 0-6. This figure shows the aquifers and covering clay and loam layers that occur at the Leggeloo extraction site.

Groundwater is extracted from a coarse sand aquifer to a depth of approximately 40 up to approximately 70 m below ground level. The coarse sand turns into fine sands towards the surface. Some (boulder) clay is found only here and there very localised and shallow, with the result that the hydrological vulnerability is great.

The layer being pumped is sealed on the underside by a relatively impermeable intermediate layer, which is not present everywhere. Below the relatively impermeable intermediate layer there is again a layer of fine sand on top of the hydrological basis.

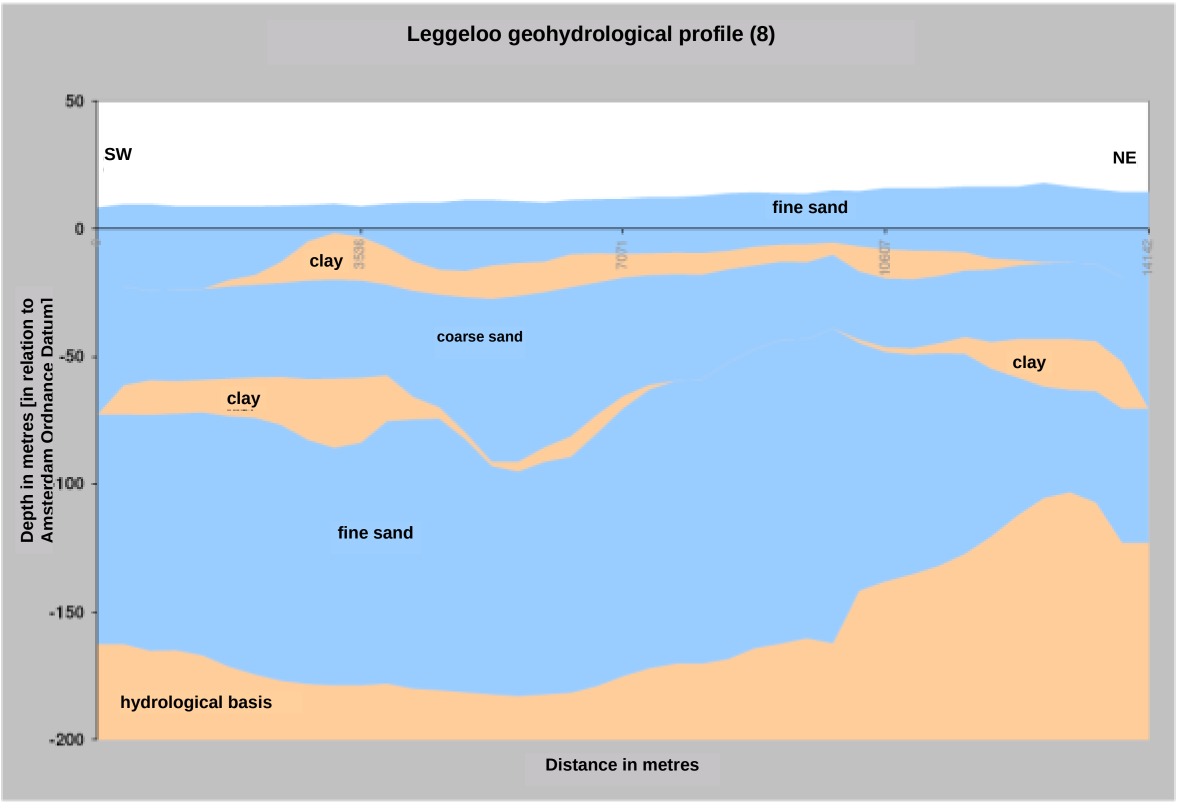


Figure 0-6 Schematic view of the subsoil at the groundwater extraction site

Soil

The soil map for the area is shown in Figure 0-7. This shows that the soil in the groundwater protection zone consists of podzol soils, earth soils, moor soils and peat. The soil map also shows where (shallow) boulder clay occurs in the area.

The upper soil in the sandy areas is vulnerable as a result of limited organic matter and lutum content. The upper soil is relatively invulnerable to leaching in the peat areas as a result of high organic matter content. Nitrate and organic micro-pollutants break down under the influence of organic material. However, polar compounds scarcely adsorb to organic material. Modern herbicides and pesticides are often polar compounds. This means that sandy and peat areas are vulnerable to many modern herbicides and pesticides.

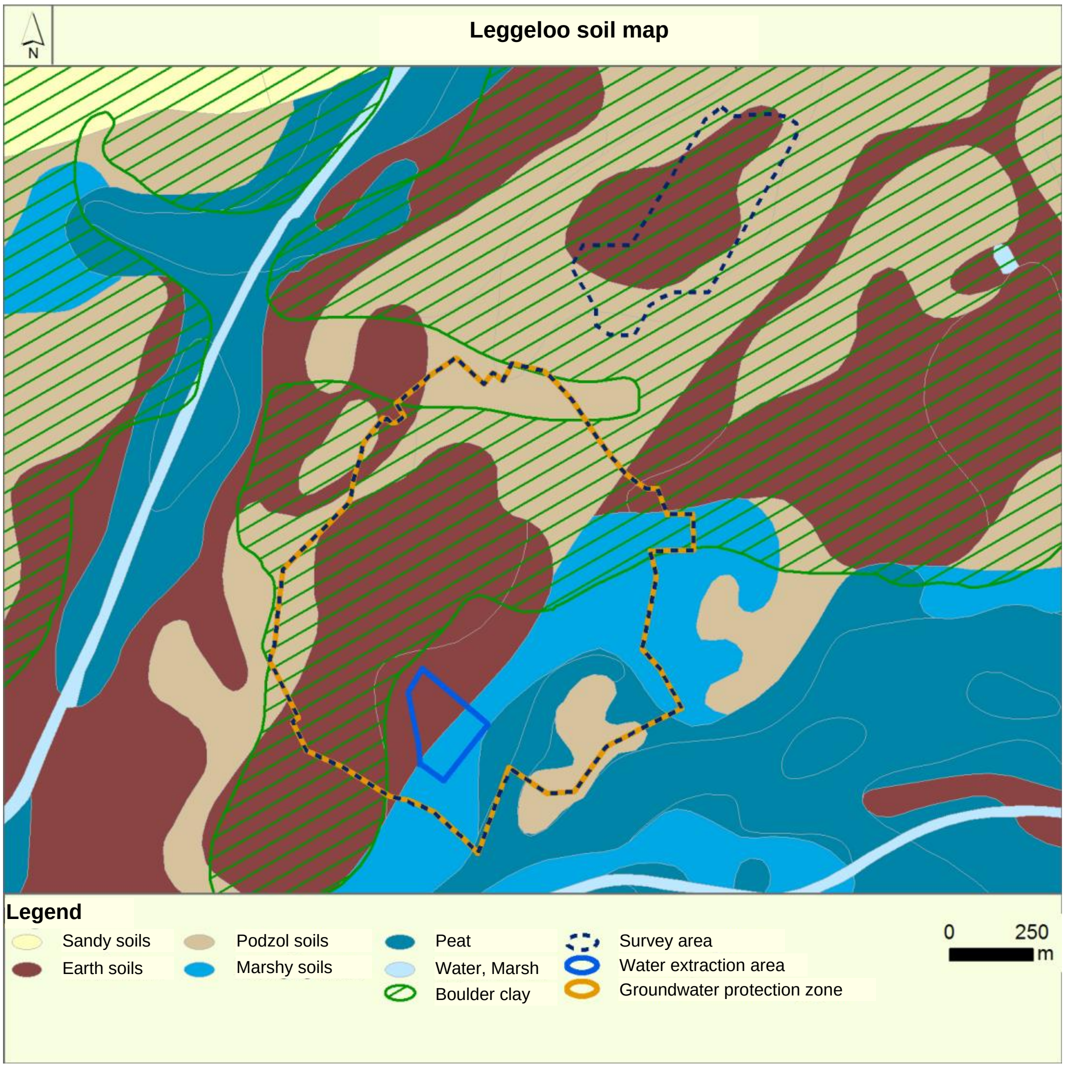


Figure 0-7 Soil map of the recharge area (source: BasisRegistratieOndergrond (BRO)

Vulnerability

The Leggeloo extraction site has been classified as vulnerable. This section provides a more detailed explanation of the vulnerability based on the hydrological and hydrochemical information available.

The more vulnerable an extraction site is, the greater the risk that contaminants may penetrate the extraction wells from ground level. The hydrological and hydrochemical properties of the subsoil determine the vulnerability:

Hydrological vulnerability – speed with which the water reaches the extraction wells.

Hydrochemical vulnerability – the extent to which contaminants in the subsoil are broken down or adsorbed (captured).

An extraction site is more vulnerable to the extent that the water arrives more quickly at the extraction wells from ground level and where contaminants in the subsoil are not broken down or adsorbed.

Hydrological vulnerability

The retention time distribution of the water extracted (response curve) determines the hydrological vulnerability. The response curve for Leggeloo has been determined using a groundwater model. The response curve provides an age distribution (flushing time) of the water extracted. The response curve of the Leggeloo extraction site is shown in Figure 0-8. At the Leggeloo extraction site, approx. 60% of the water has an age of less than 120 years. Virtually no groundwater is extracted from the Leggeloo extraction site with a retention time of less than 10 years.

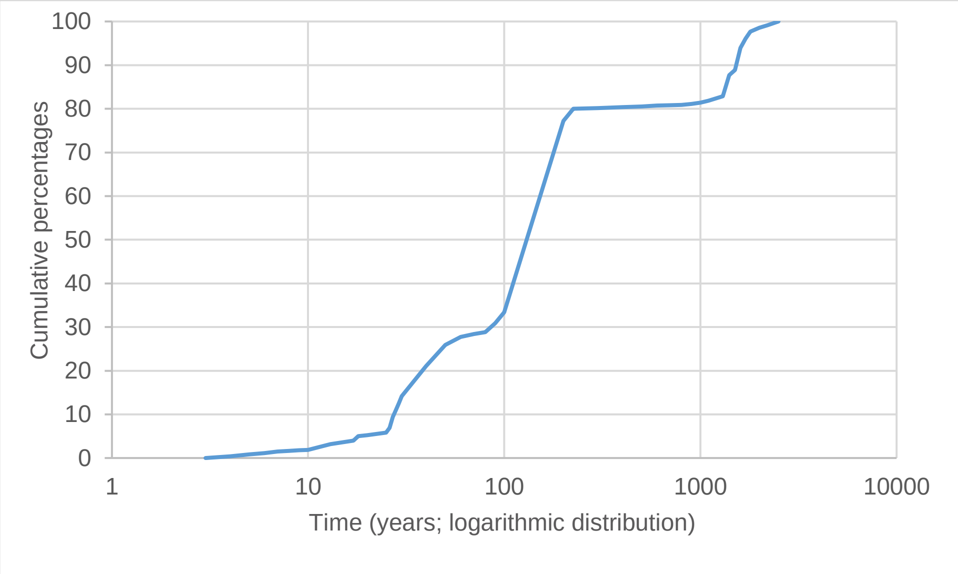


Figure 0-8 Leggeloo response curve (Royal Haskoning, 2008)

Hydrochemical vulnerability

Geochemistry

The water extracted at the Leggeloo groundwater extraction site is oxic. Substances degradable in an oxic environment, such as oil, VAH and PAH, and herbicides and pesticides, such as Bentazon, MCPP and triazines, are broken down in the aquifer from which the water is extracted. The actual decomposition of the substances depends on the presence of the suitable micro-biology and the presence of organic material. In addition, (heavy) metals may be captured (adsorbed) in the oxic part of the soil. This means that groundwater extraction is vulnerable to substances that break down in an oxic environment.

Groundwater extraction is also vulnerable to substances that are broken down in the anoxic part of the soil, such as nitrate, trichloromethane (chloroform) and chlorates, and to substances that persist in an oxic or anoxic environment, such as BAM and MTBE and trichloroethene (tri) and tetrachloroethene (per).

Soil vulnerability

Many soil chemical processes occur in the soil, or more specifically in the topsoil (the uppermost 1.2 m of the soil). The organic matter and lutum contents exert a major influence on processes in the topsoil. Processes such as capture (adsorption), conversion and decomposition reduce the leaching of substances and make for reduced vulnerability for the substances concerned. In certain cases, conversion may lead to new (occasionally even more harmful) substances.

REFLECT (BTO, 1999) is a method that has been developed in order to assess the risks from spatial functions to groundwater extraction based on the characteristics of these functions and the vulnerability of the subsoil. REFLECT calculates the vulnerability of the extraction based on scores for soil type, thickness of the covering layer and the travel time from ground level to the extraction point.

The REFLECT method was first used for the first generation of drinking water protection files (2012) in the Netherlands. In drawing up the second generation of drinking water protection files, additional insights into soil structure are now available. This concerns a new boulder clay map that describes the occurrence and thickness of boulder clay in greater detail. This provided the impulse to updating the REFLECT methodology and to determining the vulnerability once more.

*Implementation of the boulder clay map for the second generation drinking water protection files*In the REFLECT boulder clay map method, the vulnerability in the groundwater protection zones is calculated on the basis of retention times, the soil map, REGIS and the boulder clay map. A point to note when using additional information sources is that they often overlap with the original source files Soil Map and/or REGIS. A processing round in GIS was carried out in order to prevent double-counting of protective layers and thus an underestimate of the vulnerability score. For additional information on the method, reference is made to the BTO report *REFLECT (2018): assessment of the risks of land use for groundwater extraction. Revised version of the instrument from 1999, including implementation of the boulder clay map.*

Result of vulnerability calculation
The vulnerability of the topsoil for the Leggeloo extraction site is shown in Figure 0-9. The score for this vulnerability aspect provides an indication of the extent to which substances leach from ground level via the topsoil to the shallow groundwater. In the case of extraction for which no recharge area from ground level has been calculated, a low score for the travel time within the deep borehole ban zone has been used. This is to gain an indication of the vulnerability of the topsoil in the vicinity of the groundwater extraction site. Colour allocation: the redder the colour, the more vulnerable the area.

Water supply
Drents Overijsselse Delta water board has indicated that water supply is possible in the area of the Leggeloo extraction site. The Leggeloo extraction site falls within the Haarsluis and Dieversluis water inlet properties. Water supply is possible via the Drentsche Hoofdvaart. Partly from the north (Haarsluis) and partly from the property to the west of the extraction site. The RWZI Dieverbrug and the surrounding agricultural polders influence the water quality of the Drentsche Hoofdvaart, among other things.

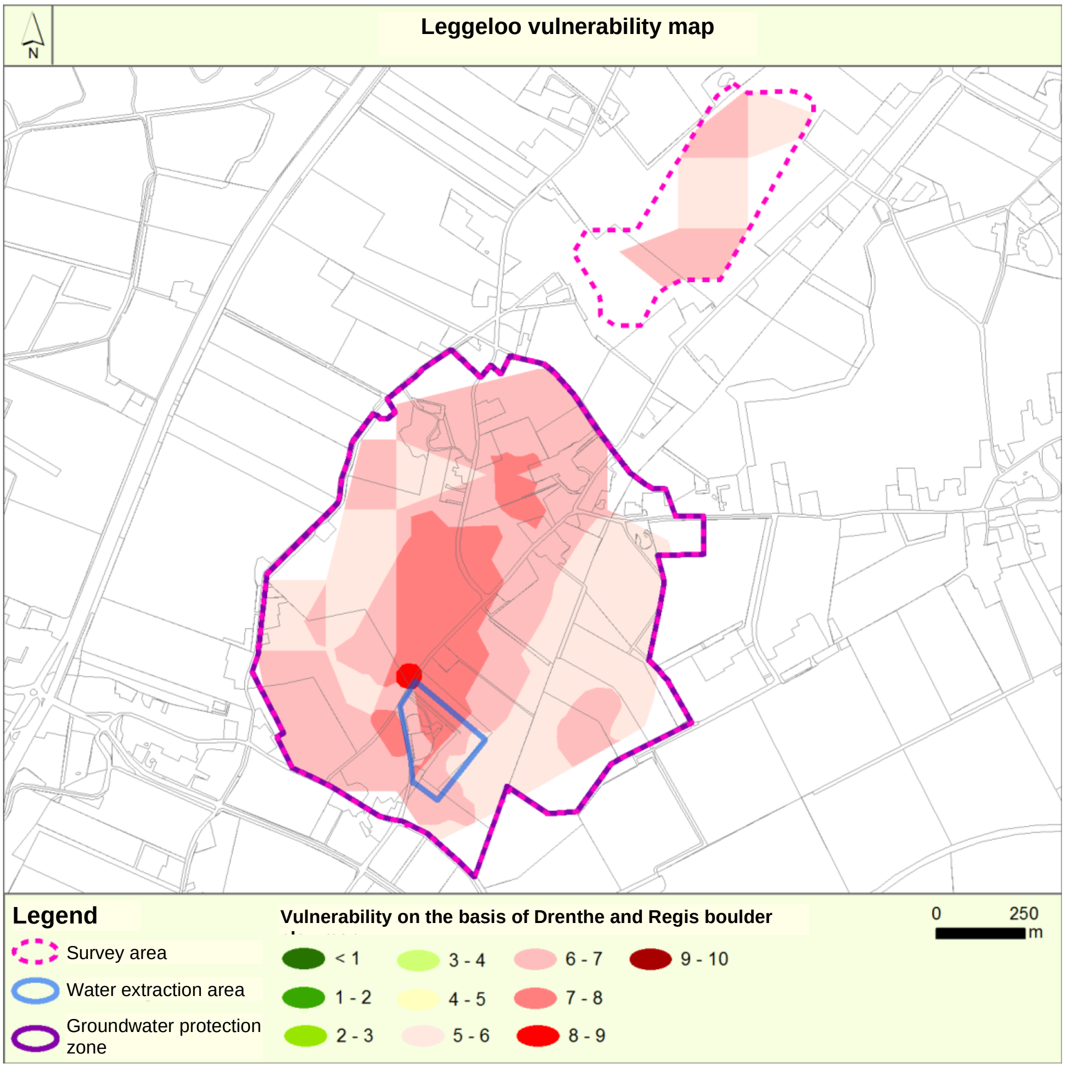


Figure 0-9 Topsoil vulnerability, determined using the REFLECT method (2018)

Chapter 5 Water: quality and quantity

Water quality monitoring by WMD

The quality of the groundwater in the water extraction area and the groundwater protection zone is constantly monitored by WMD. WMD monitors the water quality at three points in the operational process (see box below). The following sections provide a summary of the water quality. In this analysis, only those substances are mentioned that are found in elevated concentrations in the pumping wells or in the observation wells.

Water quality monitoring

1. ***Clean water*** after the last purification stage and at the clients' taps. This monitoring is a statutory obligation in accordance with the Drinking Water Regulations. The parameters to be monitored and the monitoring frequency are stipulated in the Drinking Water Regulations. The standards that the clean water must meet are stated in the Drinking Water Decree. In this way, good quality drinking water for consumers is legally regulated. The monitoring consists of microbiological and chemical parameters, and a number of indicators: operational, organoleptic and threshold parameters. An overview of the parameters and standards may be found in Appendix A of the Drinking Water Decree (http://wetten.overheid.nl/BWBR0030111/2018-07-01#BijlageA).

2. ***Raw water*** is the water from the extraction wells before it goes to the purification plant. These readings are also a statutory obligation in accordance with the Drinking Water Regulations. The water quality does not yet have to meet the standards of the Drinking Water Decree: after all, the water will still undergo purification before being supplied to the consumer. WMD tests the quality of the raw water to the standards of the Drinking Water Decree for indicative purposes. This also clarifies the parameters for which the purification is necessary. Sampling the raw water takes place in the collected raw water and in the individual extraction wells. The readings from the water in the individual extraction wells differ from those in the collected raw water because the quality of the different pumping wells is mixed here. One or several extraction wells often cause elevated levels of a particular parameter in the collected raw water. Conducting analyses of the individual extraction wells provides insight into whether contamination occurs in a single extraction well, or is found across the well field. Information is obtained by this means about the area of origin of contamination.

3. Water from ***observation wells*** inside the groundwater protection zone. The observation wells for water quality are spatially distributed around the water extraction area. The aim of the readings in observation wells is to discover contaminants before they reach the extraction wells. In this way, measures can still be taken where necessary. The water from the observation wells is analysed for a range of substances contained in the Drinking Water Decree, where the expectation is that they are relevant to groundwater extraction.

The clean water from the groundwater will in principle always meet the requirements of the Drinking Water Decree. Whenever limits are exceeded, this is reported to the Human Environment and Transport Inspectorate (ILT) and arrangements are then made regarding the measures to be taken to prevent the limits being exceeded again.

WMD and the Groningen Water Company have an agreement via the North Water Laboratory (WLN) with ILT to supply data from individual pumping wells instead of data from (mixed) raw water per groundwater extraction site. This extensive method is an operational choice for greater insight. Assessment of the raw water quality compared with the threshold levels in the WFD Protocol for monitoring and testing drinking water sources, WFD (September 2015), is carried out for the individual extraction wells.

The threshold levels in the WFD Protocol are derived from the standards for drinking water in the Drinking Water Decree (2011).

Apart from WMD, the quality of the groundwater is also analysed with piezometers of the Groundwater National Monitoring Network (LMG) and the Groundwater Provincial Monitoring Network (PMG). The objective of these monitoring networks is aimed at the overall groundwater quality. The filters of the piezometers are placed at three depths. The shallow filters (shown as Filter 1) are mostly placed between eight and 12 metres below ground level and the deep filters (shown as Filter 3) in general between 20 and 27 metres below ground level. There is also an intermediate filter (shown as Filter 2), but this is a reserve filter that is monitored only sporadically. The monitoring network for the Water Framework Directive (WFD) is made up of a selection of the LMG and the PMG. This monitoring network is used to monitor the groundwater quality for the Water Framework Directive.

Classification of raw water quality (extracted groundwater)

Use has been made of analysis results from WLN of the pumping wells, the raw water and observation wells at the Leggeloo extraction site, for the summary of the quality of the extracted groundwater (raw water and the individual extraction wells taken together). For the summary, use has been made of the water quality data from the period 2012-2018. A test has been conducted for both the combined raw water and the individual pumping wells against the threshold levels in the WFD Protocol for monitoring and testing drinking water sources, WFD (September 2015).

The following sections discuss the water quality on the basis of the following substance groups:

- Macroparameters.
- Organic micro-pollutants.
- Indicators of agricultural stress.

Macroparameters

The water extracted in Leggeloo is partially aerobic and has a relatively high chalk content (calcareous). The water quality analyses show that the extraction is vulnerable to the leaching of nitrates. The progression of the nitrate concentration can be seen in the figure below. The nitrate content is below 75% of the threshold level (a threshold value which is decided upon within the projectteam of the Drinking Water Protection Files).

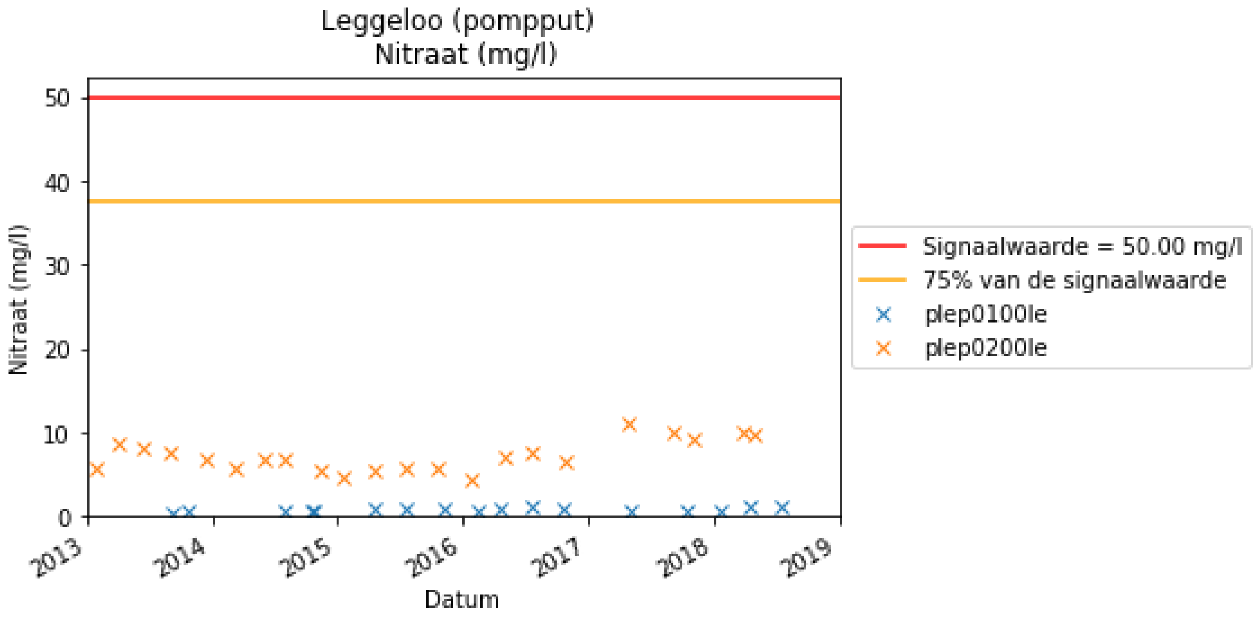


Figure 0-10 Nitrate build-up (extraction well)

The hardness of the water lies below the limit for softening. A general indicator for anthropogenic impact on the extracted water or the occurrence of silting is the chloride content monitored (contents > 20 mg/l roughly indicate an anthropogenic impact). The chloride content is shown in the figure below. This shows that chloride is elevated at 1 extraction well, the trend is stable.

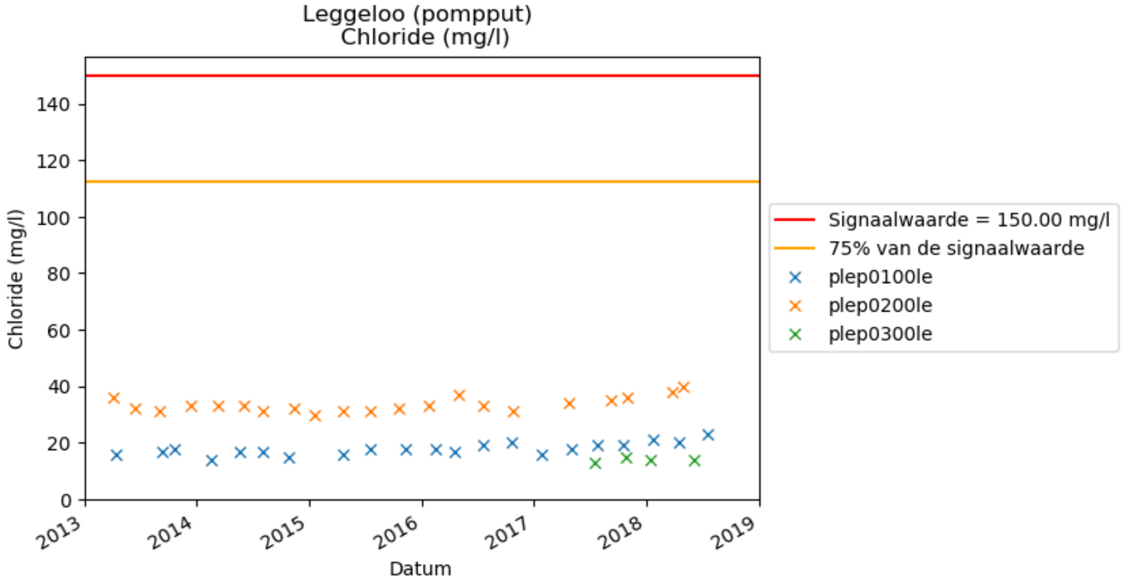


Figure 0-11Chloride build-up (extraction well)

Organic micro-pollutants

Tests were conducted for analysing the organic micro-pollutants against the threshold levels in the WFD Protocol for monitoring and testing drinking water sources and against the standards in the Drinking Water Decree. The threshold level in the Protocol for crop protection chemicals and new substances occurring in groundwater is 0.1 µg/l[5]. The testing for Leggeloo has been conducted using the data from 2012 up to and including 2017. An overview of the substances found in the individual extraction wells is shown in *Table 0-1*. The Leggeloo groundwater extraction site consisted of 2 pumping wells up to 2017. A new pumping well, LEPP03, was put into operation in 2017. No organic micro-pollutants have yet been found in this pumping well.

locatie	type	filtnr	bkf	okf	1,2-dichloorpropaan	2,6-dichloorbenzamide (BAM)
	-	-	m mv	m mv	ug/l	ug/l
plep0100le	pompput	pp1	37.5	61.5	0.14	
plep0200le	pompput	pp2	46	69	0.16	0.17

<	Above the reporting value, but below 0.075 µg/l
getal	Above 0.075 µg/l, but not above 0.01 µg/l
getal	Above 0.01 µg/l

Table 0-1 Overview of organic micro-pollutants found in individual extraction wells (the figures are the last values monitored above 0.075 µg/l)

Herbicides and pesticides

The chemical 2,6-dichlorobenzamide (BAM) was found to a level above the threshold level in 1 extraction well at Leggeloo. BAM is the degradation product of dichlobenil (a herbicide that has now been banned). The build-up of BAM is shown in the figure below.

[5] A distinction is made for the degradation products of crop protection chemicals and biocides on the basis of human toxicological relevance. The threshold level of 0.1 µg/l applies only to degradation products of crop protection chemicals and biocides relevant to human toxicology.

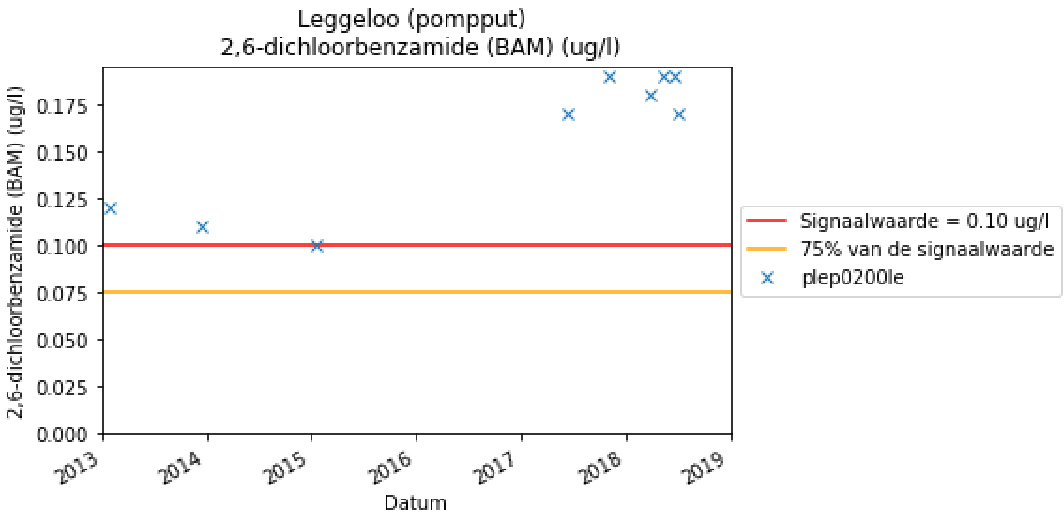


Figure 0-12 BAM build-up in extraction wells

In addition, the herbicide MCPP is also found systemically in low concentrations at pumping well plep0002 (below the threshold level). The progression of MCPP is shown in the figure below.

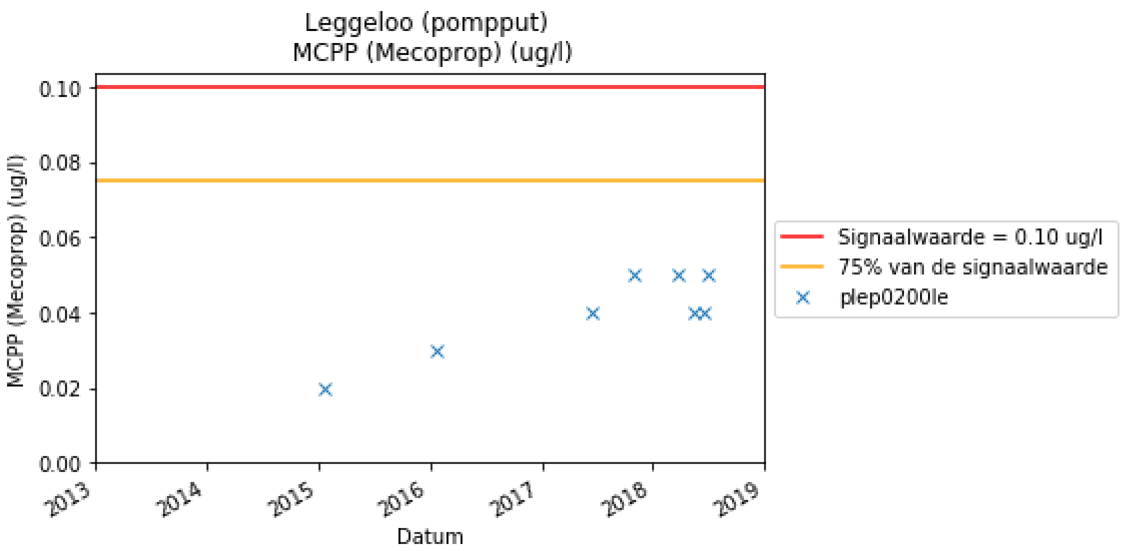


Figure 0-13 MCPP build-up (extraction well)

Other organic micro-pollutants

The substance 1,2-dichloropropane is found systemically at 2 pumping wells. 1,2-dichloropropane is a contaminant of the now banned soil fumigant DD (active substance 1,3-dichloropropene). The concentration progression of 1,2-dichloropropane over time in the 2 pumping wells may be seen in the figure below. The threshold level of 0.1 µg/l is regularly exceeded.

No 1,2-dichloropropane has yet been found in the newest pumping well, LEPP0300.

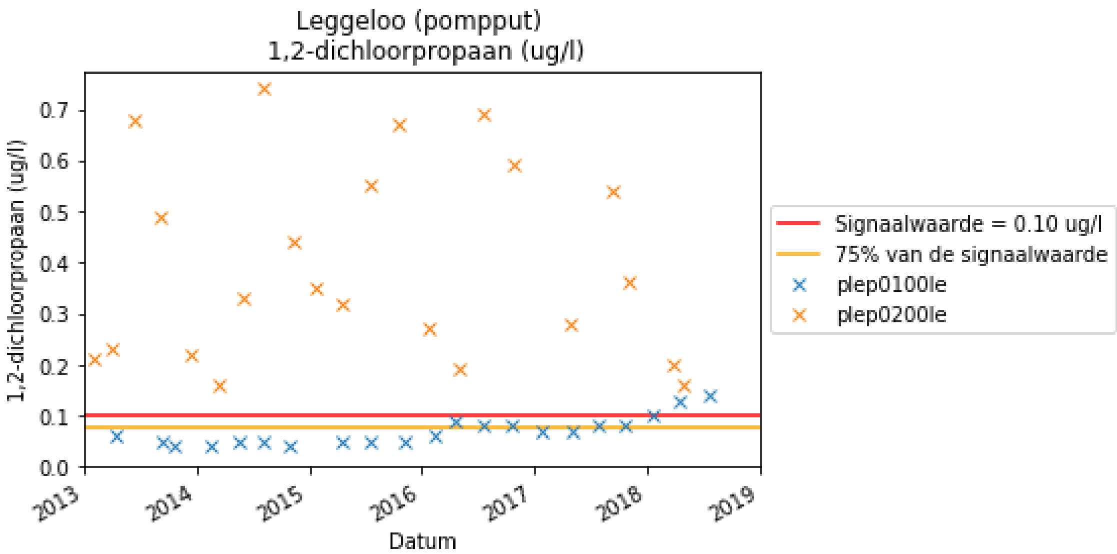


Figure 0-14 The concentration progression of 1,2-dichloropropane over the period 2012-2018 (extraction well)

Indicators of agricultural stress

As a result of the travel times of the groundwater from ground level to the groundwater extraction point, the effects of manure/fertiliser use on the raw water quality manifest with a (long) delay. Depending on the geochemical properties of the subsoil, the effects of manure/fertiliser use may manifest in different ways in the composition of the groundwater. Elevated levels of nitrate and sulphate are indicators for agricultural stress on the groundwater. In addition, depending on the presence of chalk in the subsoil, increased hardness or elevated levels of heavy metals (such as nickel and zinc) may be an indication of high stress from agriculture (see box).

Effects of eutrophication on the groundwater

In oxygenated soils, ammonium and organic nitrogen from manure/fertiliser are converted to nitrate and acid. The soil is limed to counter acidification, with a resultant increase in the hardness of the groundwater. In low-oxygen soils, nitrate is broken down under the influence of bacteria and converted to nitrogen gas in the presence of organic material and/or pyrite. This process is called denitrification, and it is an anaerobic process.

If the nitrate comes into contact with pyrite (an iron sulphide) deeper in the subsoil, the nitrate is converted to nitrogen gas just as in oxygenated soils. Sulphate is released on oxidation of pyrite, and this is associated with the production of acid, which may in turn lead to chalk dissolving with a resultant increase in hardness. In addition, pyrite oxidation may be associated with the dissolving of certain heavy metals (zinc, arsenic and (primarily) nickel). Depending on the level of acidity, these heavy metals may or may not be captured (adsorbed).

Analysis of the raw water quality reveals that nitrate at low levels is present (< 10 mg/l) and that the build-up of sulphate is stable (see figure below).

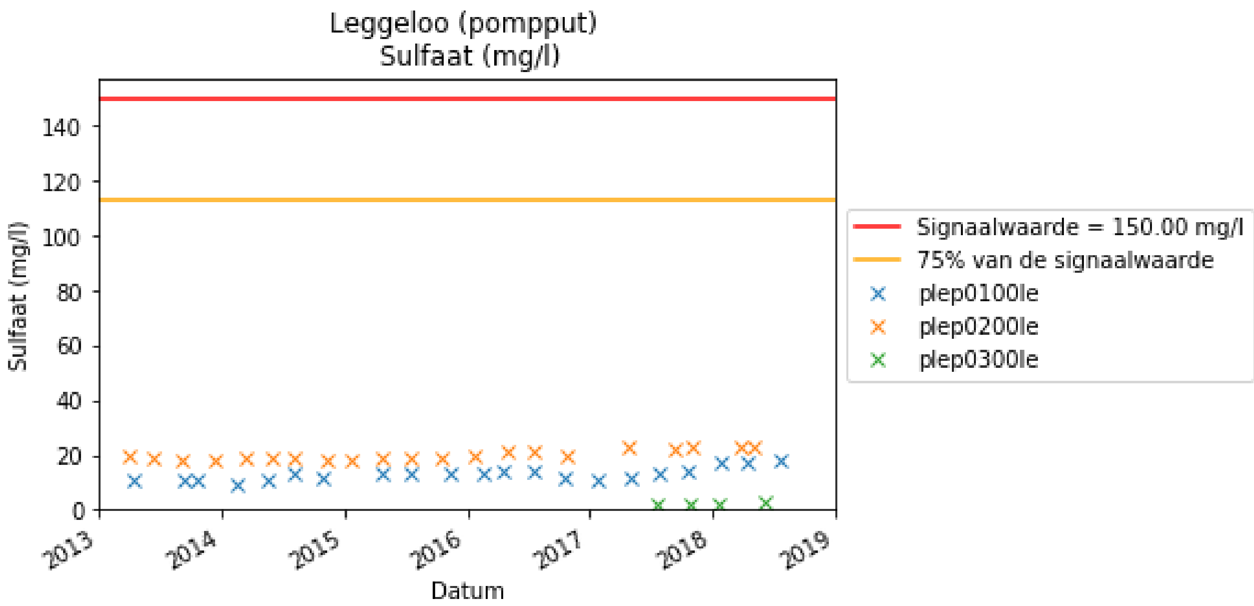


Figure 0-15 Sulphate levels in extraction wells

Classification of groundwater quality in the groundwater protection zone and the 100-year zone

The monitoring data provided by WMD piezometers based on the analysed data over the period 2012-2018 have been used to describe the groundwater quality in the protection zone of the extraction site. The following sections discuss the water quality on the basis of the organic micro-pollutants, including herbicides and pesticides and macroparameters.

Figure 0-16 shows the location of the different stations around the Leggeloo extraction site. The monitoring network consists of 3 monitoring wells with multiple observation filters.

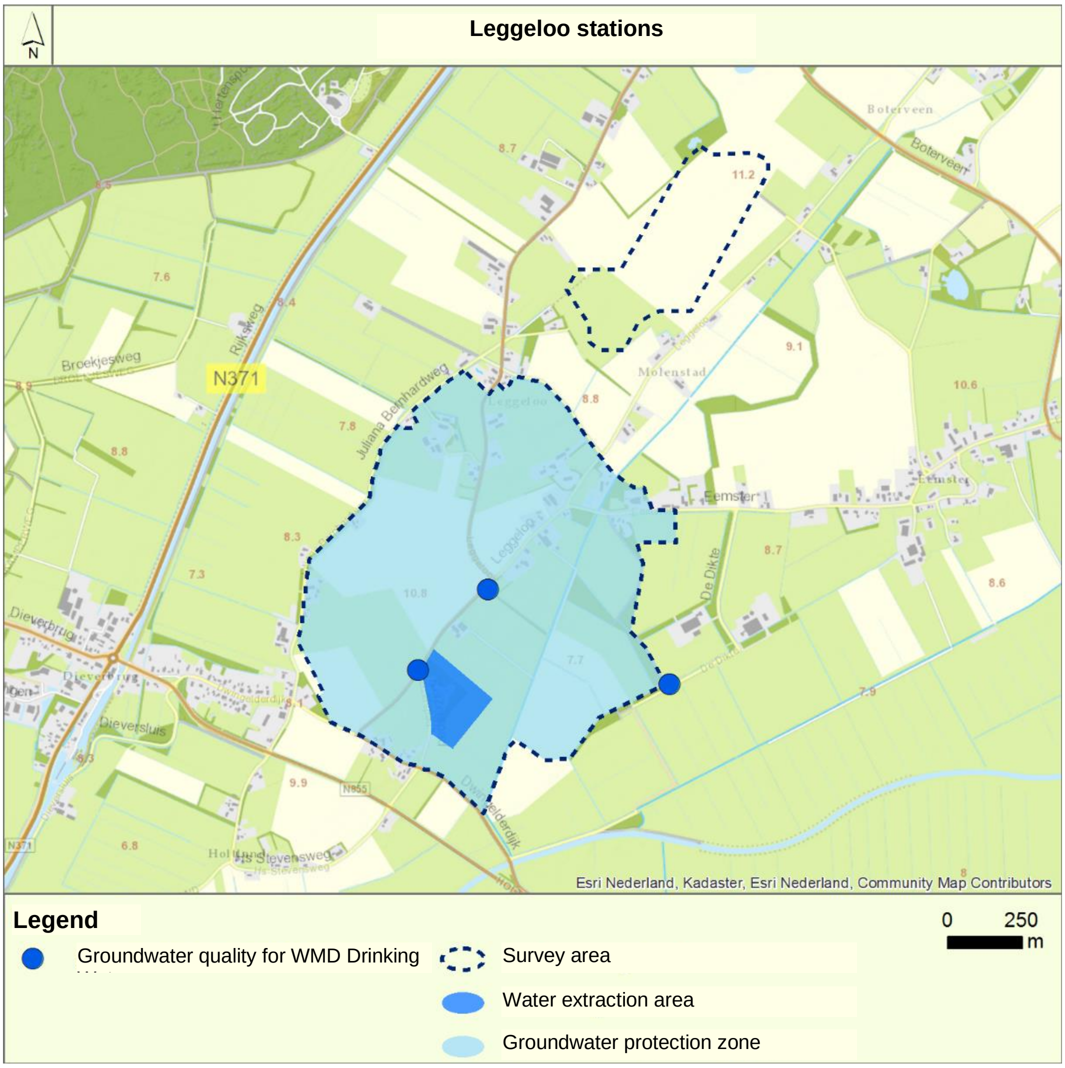


Figure 0-16 Leggeloo stations

Macroparameters

The testing reveals not only that the extraction wells are susceptible to nitrate leaching, but also that high concentrations of nitrate are monitored in the observation wells. The nitrate concentrations of the different observation wells may be seen in the figure below. The highest concentrations are monitored in LEWP14. In this station, which lies approx 30 m-bs, nitrate concentrations of more than 200 mg/l are monitored. The station lies on the north-western boundary of the water extraction area.

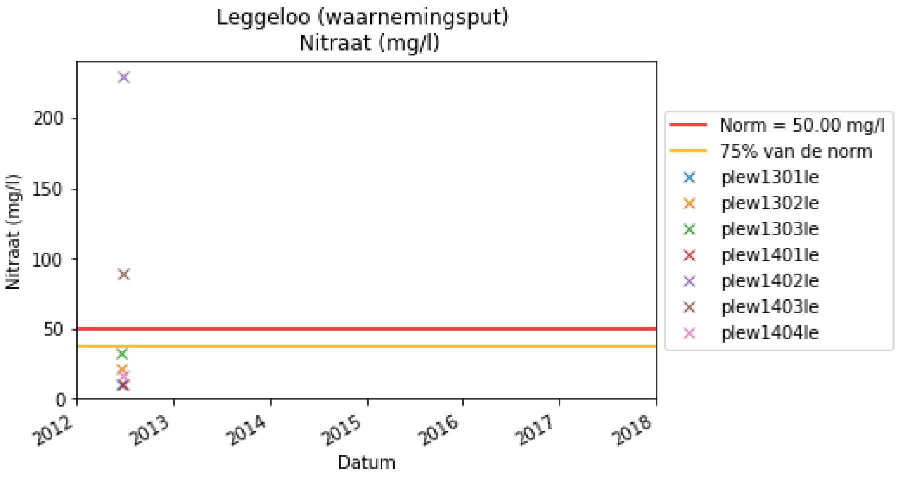


Figure 0-17 Nitrate concentration in monitoring network

Organic micro-pollutants
The testing reveals that the substances BAM and 1,2-dichloropropane are also found in the monitoring network above the threshold level. The progression is shown in the figures below.

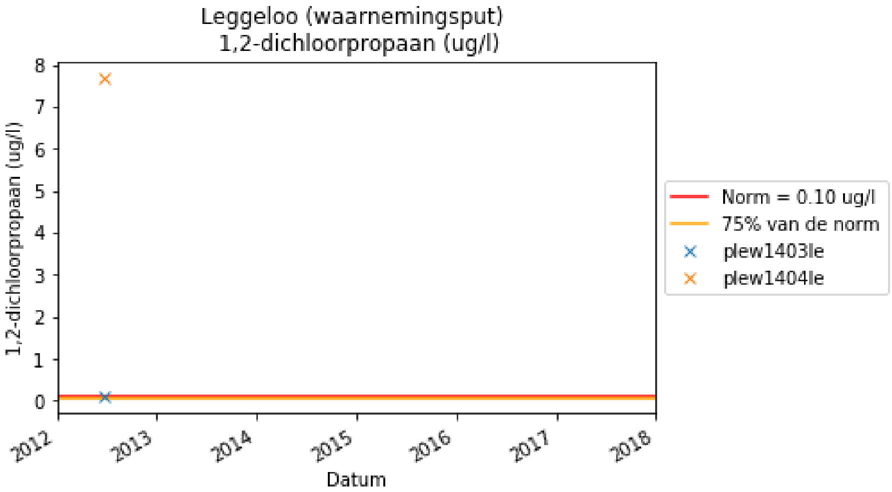


Figure 0-18 Build-up of 1,2-dichloropropane in monitoring network

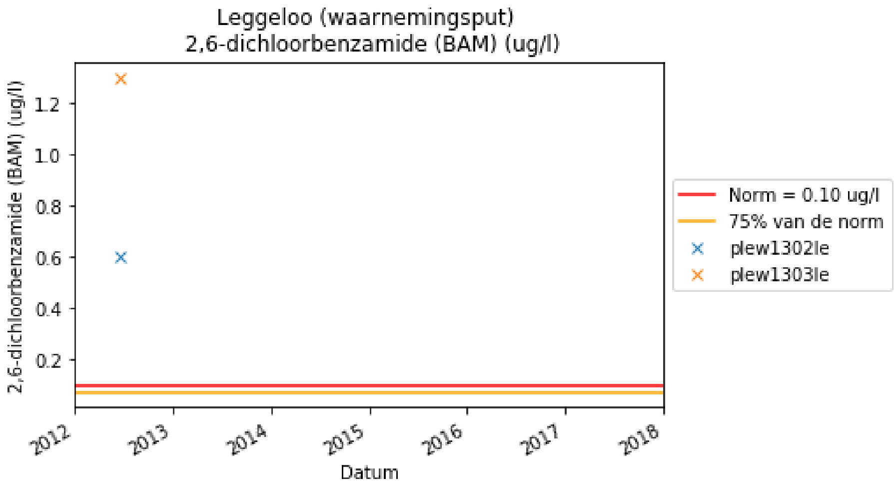


Figure 0-19 BAM build-up in monitoring network

Water treatment

The water extracted in Leggeloo is partially aerobic and has a relatively high chalk content (calcareous). The hardness of the water lies below the limit for softening. The raw water extracted is purified on-site by WMD using a standard method for groundwater by means of aeration and filtration. Substances that are naturally present (such as ammonium, manganese and iron) are removed by this means. Rather more intensive aeration occurs to remove the 1,2-dichloropropane present. The clean water (mains water) produced thus meets the statutory requirements.

Water quantity

For this section, a test has been conducted on whether the permitted quantity of groundwater to be extracted can in fact be used. For this, a study has been made in coordination with the province and WMD of whether there are developments/risks related to an inability to use the permitted extraction capacity to the full (for example, limitations with a view to nature, pumping up brackish groundwater, preventing soil contamination being drawn in).

At Leggeloo, the full extraction capacity can be used, and there are no limitations with respect to the permit. There are no risks in the way of extracting the total permitted quantity.

Chapter 6 Spatial use of recharge area, risks and relevant developments

Land use

The land use in the water extraction area consists primarily of pasture and woodland (Figure 0-20). Land use in the groundwater protection zone is primarily pasture and arable farming (including flower bulb growing adjacent to the water extraction area). The hamlets and villages of Leggeloo, Veldhuizen, Holtland and Dieverbrug are located partially within the groundwater protection zone. To the west of the groundwater protection zone in Dieverbrug, there are a number of business premises, shops and hospitality sector businesses.

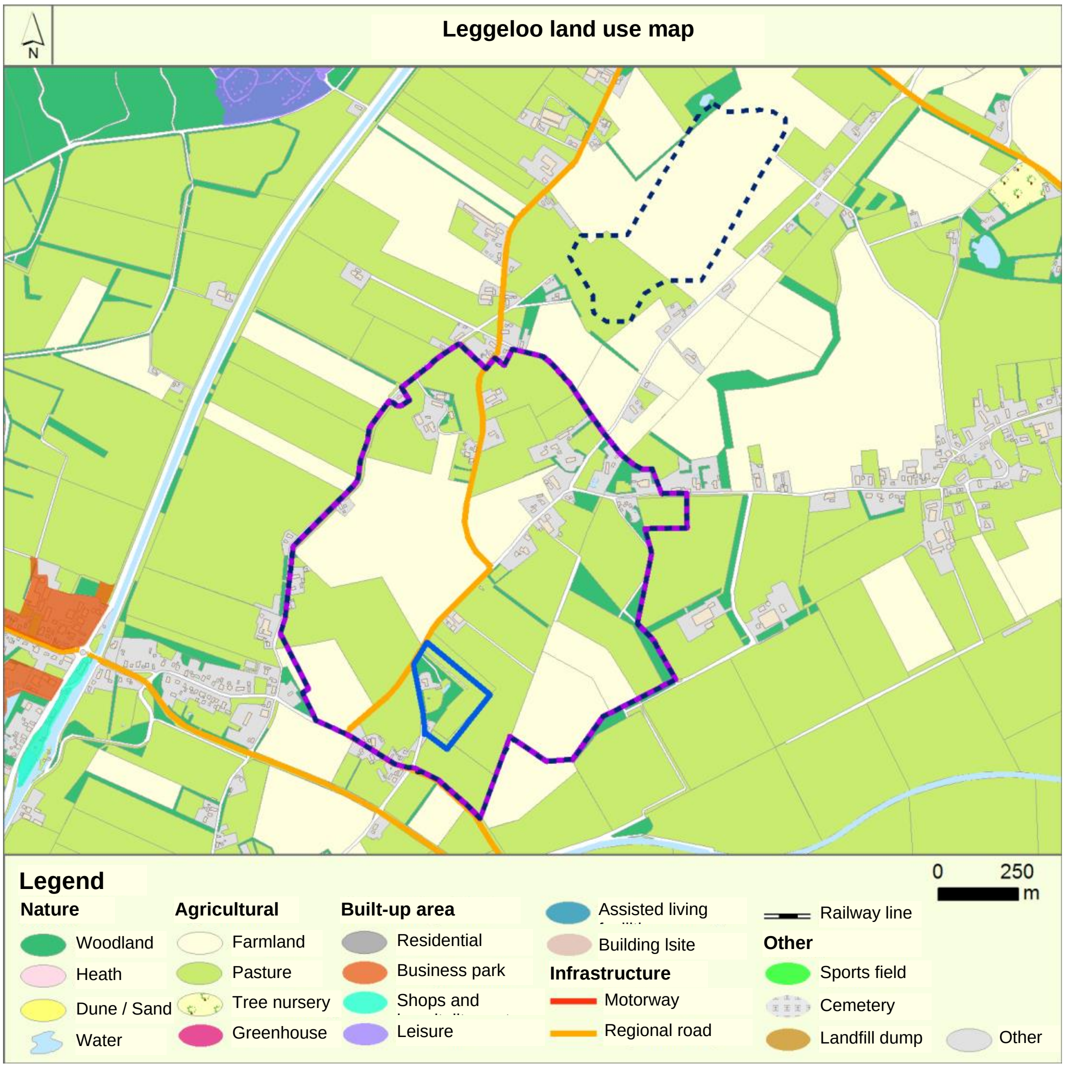


Figure 0-20 Land use

Underground use

Other permitted groundwater extraction sites adjacent to the WMD groundwater extraction site that lie in the area surrounding the water extraction area have been mapped on the basis of data from Drenthe Province and the Drents Overijsselse Delta water board (Figure 6-2). Permanent extractions have been mapped on the basis of the data received.

These extraction sites can be subdivided into four categories: industrial extraction, thermal energy storage (TES) systems[6], extraction for watering animals and extraction for sprinkling/irrigation. The extraction sites and geothermal energy systems are shown in Table 0-2. Two industrial extraction points are known in the area, along with a number of closed geothermal energy systems. The extraction sites consist of extraction for agriculture (watering animals and sprinkling/irrigation). The extraction sites are shown in Table 0-2. No industrial extraction sites are known in the area.

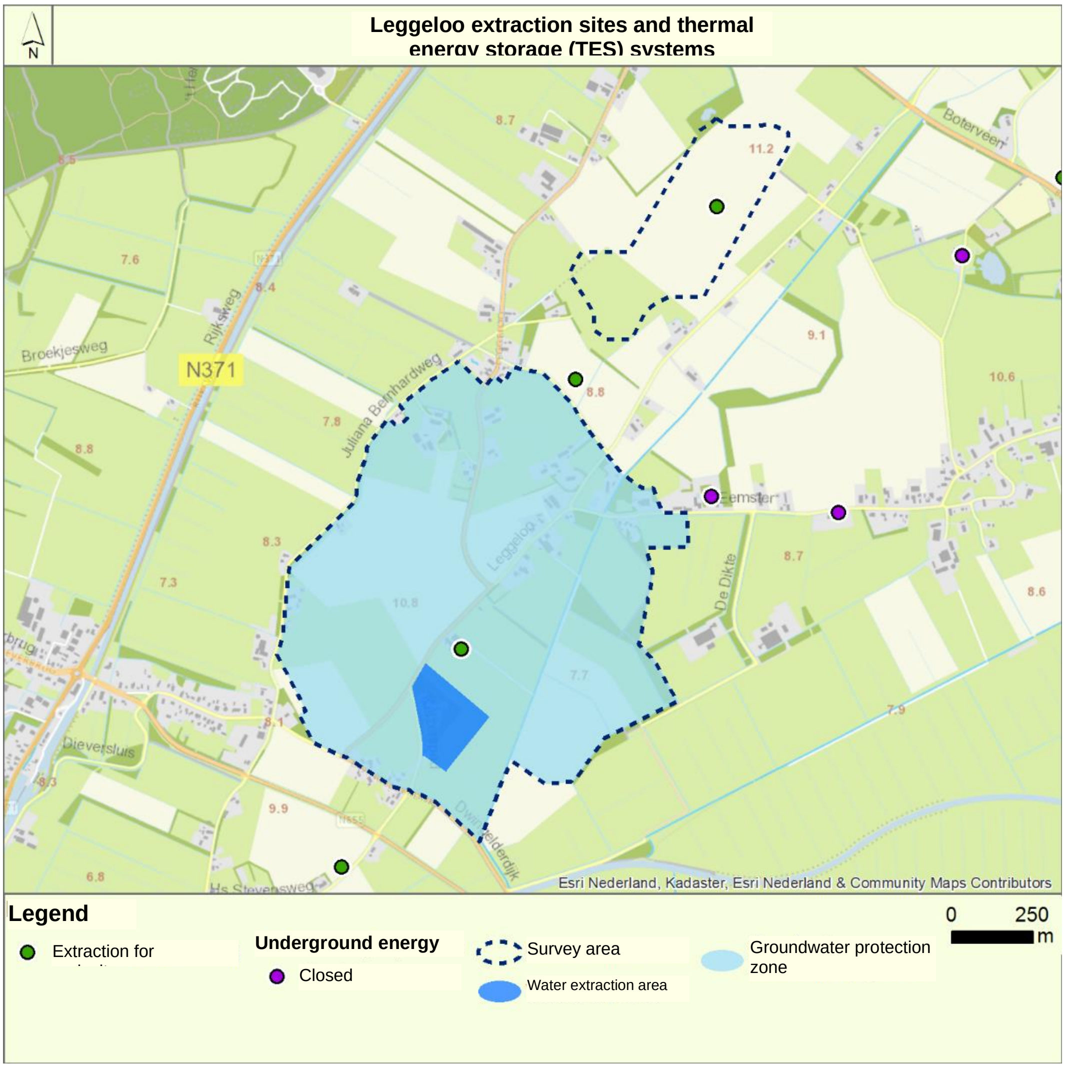


Figure 0-21 Other groundwater extraction sites and TES systems

[6] Authorisation for extracting groundwater was transferred from the provinces to the water boards when the Water Act went into force. An exception was made here for the licensing of certain categories of groundwater extraction and infiltration, namely groundwater for public drinking water supply, large industrial extraction sites greater than 150,000 m^3/year and open thermal energy storage (TES) systems. The provinces continue to be the licensing authority for these. Closed thermal energy storage systems fall within the competence of the municipality. The closed systems do not extract groundwater, but may certainly pose a hazard by boring through sealing layers of soil.

Table 0-2 Extraction sites in the vicinity of the groundwater protection zone

	Competent authority	Number	Depth (m-bs)	Same depth as extraction?	Flow rate
Agriculture	**Water Board**	**4**	**401**	**Yes**	**Unknown**
Closed TES	**Municipality**	**3**	**Unknown**	**Unknown**	**Unknown**

[1] the depth is not known for all systems

Sources of emissions

Indeterminate sources

The current land use in the groundwater protection zone has been surveyed in order to gauge the risks from the use functions for the groundwater quality. The CBS (Statistics Netherlands) land use map was used for the survey of the land use. Land use provides important information on the indeterminate stresses on the groundwater protection zone. Table 0-3 provides an overview of the land use. The potential risks from a particular type of land use are also shown.

Table 0-3 Land use in the groundwater protection zone and the survey area

Land use	% of total groundwater protection zone	% of total survey area	Risk for indeterminate stress
Nature	5%	4%	Nitrogen capture - atmospheric deposition. Possibility of dumping of waste, for example waste from drugs laboratories.
Agricultural - pasture	45%	39%	Crop protection chemicals - agricultural sector. Fertilisers and manures and the release of heavy metals from pyrite on denitrification. Veterinary medicines. Metals in animal feed and copper baths.
Agricultural - arable farming	39%	47%	Crop protection chemicals - agricultural sector. Fertilisers and manures and the release of heavy metals from pyrite on denitrification. Metals in animal feed and copper baths.
Residential	8%	7%	Use of herbicides and pesticides by private individuals. Contamination from sanitation and sewerage.

Land use	% of total groundwater protection zone	% of total survey area	Risk for indeterminate stress
			Contamination from do-it-yourself and hobbies. Leaching from building materials (zinc gutters, copper mainly from timber). Contamination from vehicles (oil leaks, carwash, tyre residue, etc.).
Infrastructure	3%	3%	Contamination with PAH and heavy metals, such as zinc and copper. Herbicides and pesticides, for example along railway lines and verges.

Line sources
The most important line sources in the vicinity of the groundwater extraction site have been mapped on the basis of the risk map (http://risicokaart.nl/) and the topographical map. A distinction is made here between roads/motorways, railway lines, sanitation and sewerage, surface water and other line sources. The line sources listed are shown in Figure 0-22.

Figure 0-22 Line sources

> Locations are shown on the Drenthe Province Risk Map where there is a risk of an incident occurring at this point, the extent of which could be so great that it necessitates the coordinated deployment of the emergency services. A road along which transports of hazardous substances regularly travel is shown on the map (Basic Network), for example. The risk map thus does not focus on risks to the drinking water quality, but if a (line) source is noted on the map, this may well be an indication of how high-risk it could be.
>
> A line source not shown on the map may still pose a risk to the groundwater quality.

The most important line sources in the vicinity of the groundwater extraction site are:

Roads
Motorways and regional main roads in particular pose a risk if an accident occurs where vehicle fuel or a hazardous load being transported ends up in the soil. There are the following roads in the groundwater protection zone:

The Leggeloo, the Dwingelderdijk and the Keizerspad.

Railway lines

Railway lines may pose a risk to the quality of the groundwater, because herbicides and pesticides are used for the operation & maintenance of the railways. In addition, for goods railway lines, there is the risk of an accident with the transport of hazardous substances. There are no railway lines in the groundwater protection zone or in the buffer zone of 2 km around the groundwater protection zone.

Surface water

The groundwater protection zone contains one main waterway as surface water (see *Figure 0-23*) Dwingelderstroom runs south of the groundwater protection zone.

Discharges from the sewer to the surface water may impact the quality of the surface water. There are no sewerage purification plants, sewerage overflows, individual wastewater treatment plants or helophyte filters within the groundwater protection zone. There is a sewerage purification plant (RWZI) a few kilometres to the west of the survey area.

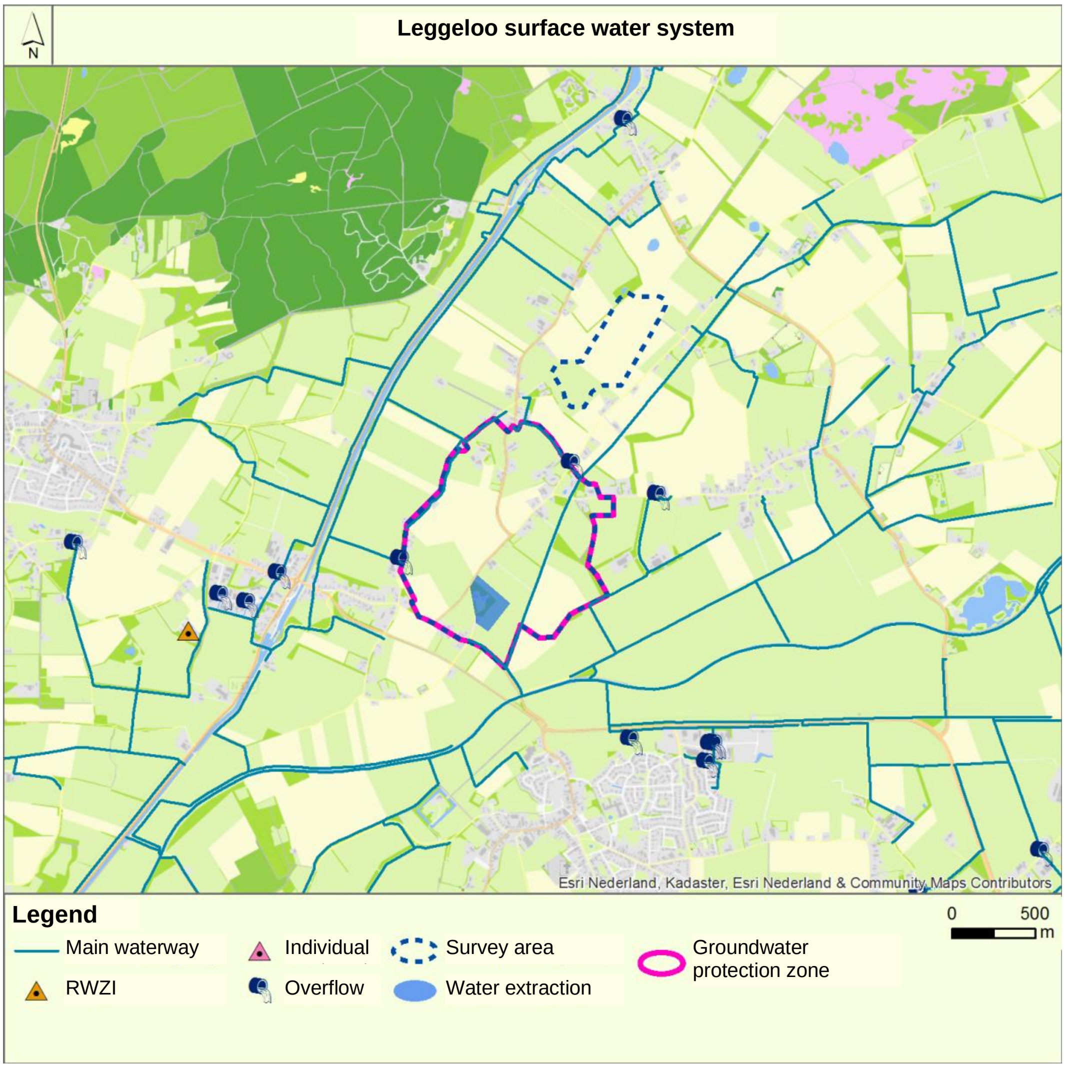


Figure 0-23 Leggeloo surface water system

Other line sources

There is one Gasunie pipeline in the groundwater protection zone and a buffer zone of 2 km outside of it. In the event of an accident with a gas main, there may be an indirect risk to the groundwater from damage resulting from an explosion.

Sanitation and sewerage

There are four ways in which the groundwater could be contaminated with domestic wastewater or contaminated rain water:

- Exfiltration from sanitation and sewerage as a result of leakage in the system.
- Infiltration of contaminated rain water.
- Overflows.
- Individual wastewater treatment.

In order to map the sanitation and sewerage, the municipality was asked to indicate where which type of sewer lies and what the condition of the sewer is. Figure 0-24 is a map containing an overview of the sanitation and sewerage at the groundwater extraction site. This map shows the pipes of the Westerveld municipality and the Drents Overijsselse Delta water board. Two overflows can be seen on the boundary of the groundwater protection zone. The Westerveld municipality has indicated that one of the two overflows flows indirectly into the area. The other flows away from it.

Table 0-4 contains an overview of the types of sewer systems in the area. Apart from the sewer systems of the municipality and the water board, there are probably also private sewer systems, for example sewerage in the recreational areas. In addition, residents in the groundwater protection zone are often unaware of the rules that apply in a groundwater protection zone. This is a general point affecting not only the sanitation and sewerage.

Table 0-4 Sewer systems in the survey area

Municipality	Name	Type	Year of construction	Condition[1]
Westerveld	Eemster	Mixed	Around 1980	Satisfactory
	Leggeloo	Mixed	1982	Good

[1] The state of repair is an assessment by the Westerveld municipality.

Figure 0-24 Sanitation and sewerage location

- **Point sources**

Soil contamination

The locations and assessment of soil contamination and landfill dumps have been mapped on the basis of information from Drenthe Province. There are various instances of soil contamination in and around the groundwater protection zone where past activity is known. The landfill dump present has been properly inspected.

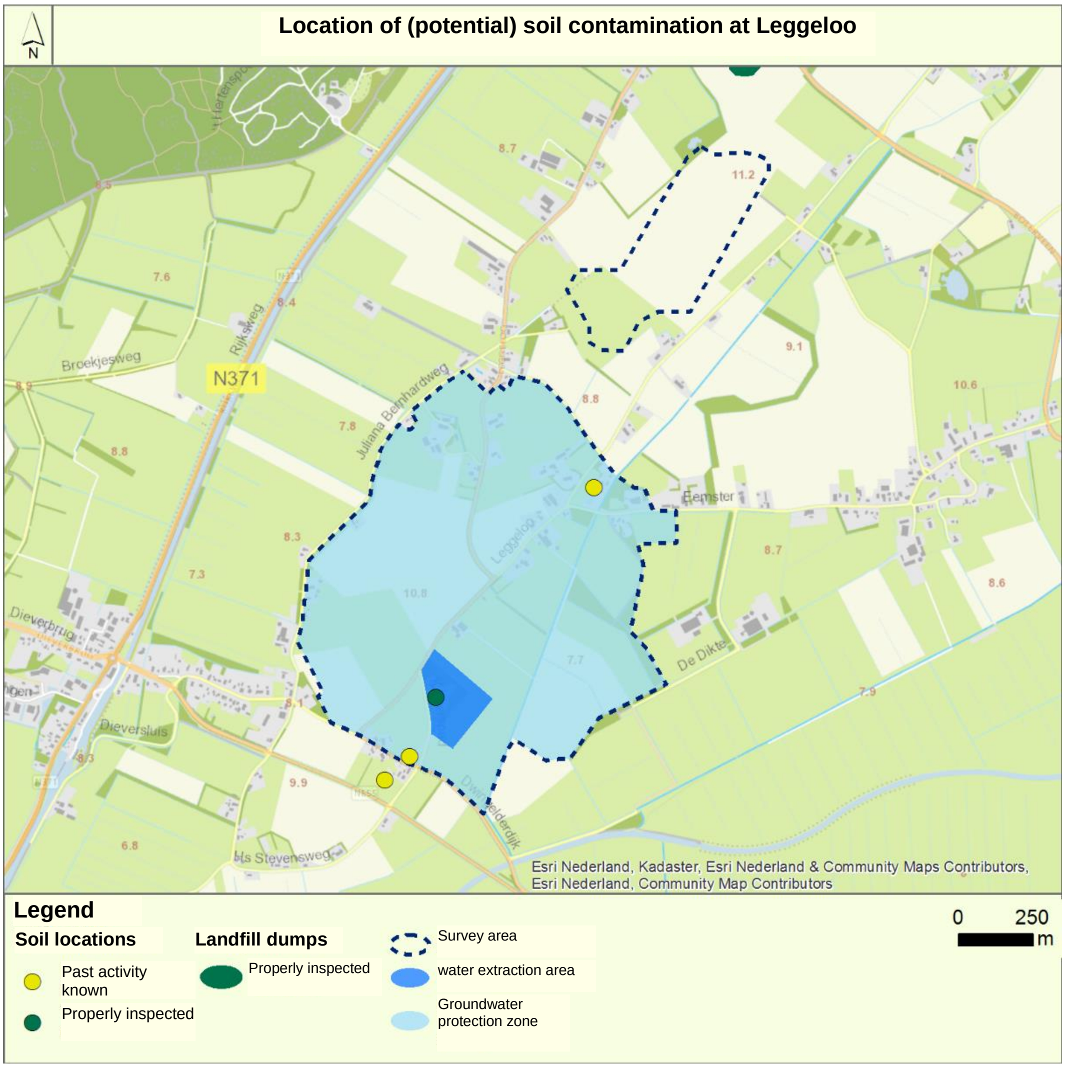


Figure 0-25 Soil contamination

Parking places

Parking places may be a source of contamination. Rules for parking places have been included in the environmental regulations. Figure 0-26 shows the location of the parking places in the groundwater protection zone and the survey area. There are no parking places inside the area.

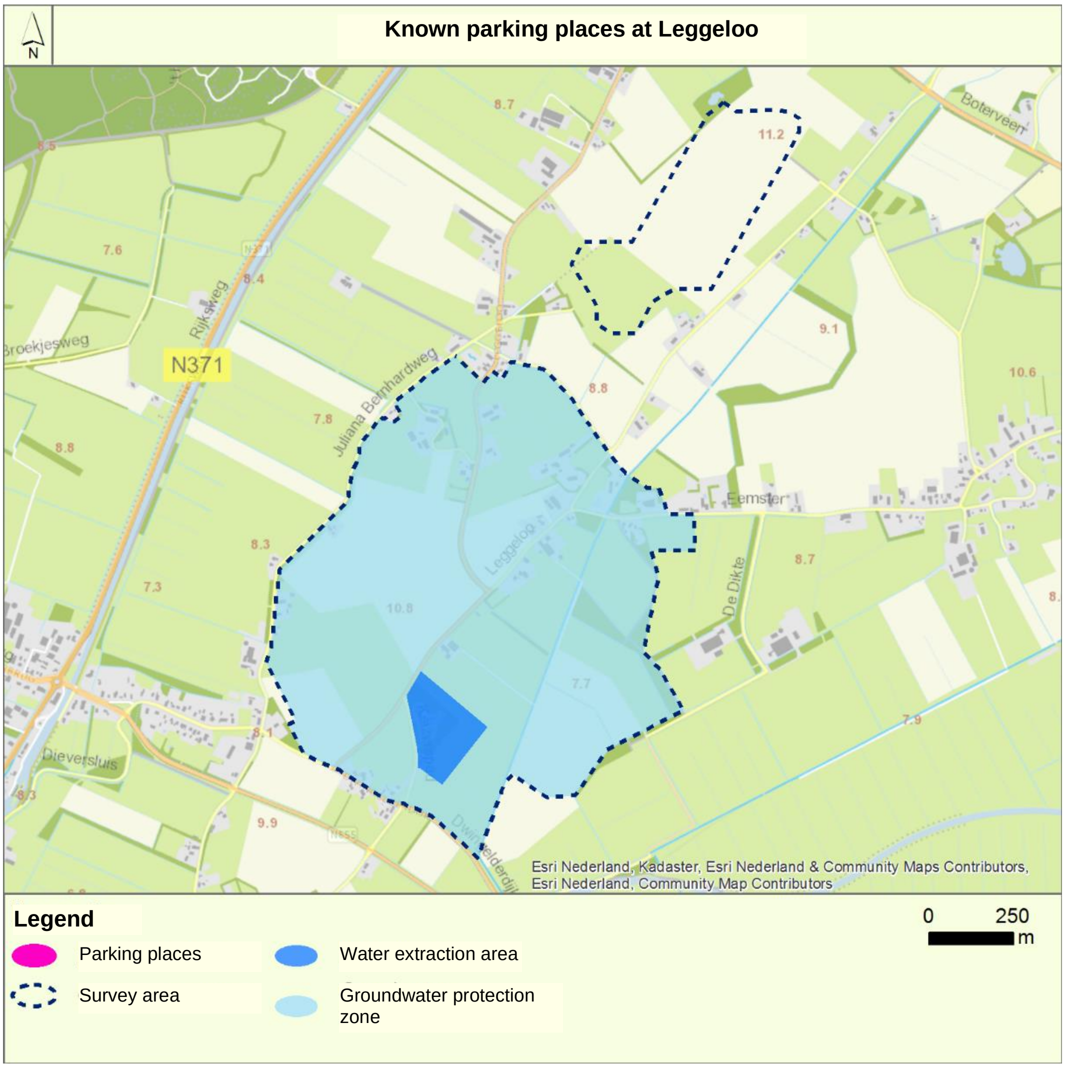


Figure 0-26 Parking places

Relevant developments

Spatial developments taking place in the groundwater protection zone may in future impact the quality of the groundwater. These developments may generate bottlenecks, but also opportunities. Section 3.2 sets out the policy applicable to spatial developments.

Development 1

Over recent years, lilies have been grown more frequently on varying plots abutting the water extraction area. WMD and Westerveld municipality are aware of this. Talks are taking place between stakeholders and growers about lily growing and protecting the groundwater. A new outlying area zoning plan is in preparation. Westerveld municipality has included the contours of the protection zones and reference from the POV (provincial environmental regulations) in the plan.

Development 2

In the context of the Sixth nitrate programme of action, Drenthe Province is to approach all farmers and growers in four groundwater protection zones in Drenthe where the nitrate levels have been exceeded, with the aim of reducing nitrate pollution. They are: Havelterberg, Leggeloo, Gasselte and Noordbargeres/Valtherbos.

Summary of risks from spatial functions

The Leggeloo groundwater extraction site has been classified as vulnerable. Land use is largely agricultural with a number of woodland areas. A limited number of line sources run through the groundwater protection zone, such as a gas main and local roads. There are no instances of soil contamination inside the groundwater protection zone where follow-up action is needed, or sites for thermal energy storage systems. There is one extraction site for agriculture inside the groundwater protection zone. The risk to the groundwater quality from spatial functions resulting from the above-mentioned aspects and the vulnerability of the extraction is assessed as limited. The (greater) oxidation of peat and marshy soils is a point for attention for the vulnerability of the extraction.

Chapter 7 Remaining tasks for the extraction

Introduction

This chapter charts the (remaining) tasks for the extraction. This is done by detailing the following aspects:

A. Extent to which targets have not (yet) been achieved (*problems*), or will possibly not be achieved (*risks*).

B. Causes behind the problems identified and risks on the basis of more detailed analysis.

C. Extent to which measures have already been taken to tackle the problems and risks identified or to cover them.

These (remaining) tasks serve as the basis for agreements yet to be made on (additional) measures to be taken that will be laid down in the Implementation programme.

When determining the (remaining) tasks of the extraction, a check has been conducted in each case on whether the monitoring is properly equipped. By determining, for example, whether parameters are lacking that should in fact be monitored on the basis of the activities/emissions identified. This may also concern the issue of whether 'early warning' is adequate to identify/monitor risks during extraction.

Drinking water protection file objective

The objective of an drinking water protection file is securing the groundwater extraction for the long term. This occurs if the WFD targets for groundwater extraction sites (Article 7) are met, and the drinking water supply is not at risk from problems of quantity.

WFD targets

The WFD has formulated quality targets, against which the water quality of the extraction sites must be tested. This concerns:

- No decline in water quality (obligation of result).
- Striving for improvement in water quality with a view to reducing purification work (best-efforts obligation).

Target values for substances or substance groups have been stipulated in order to test the WFD targets. These are the threshold levels shown in the Protocol for monitoring and testing drinking water sources WFD (BKMW) September 2015. The threshold levels in the WFD Protocol are derived from the standards for drinking water in the Drinking Water Decree (2011). Assessment of the raw water quality against the threshold levels in the WFD is conducted only for the combined raw water (in accordance with the Drinking Water Decree). A qualitative description and assessment has been conducted for an assessment of the individual extraction wells on the basis of the analysis of the raw water by Watermaatschappij Drenthe (Drenthe Water Company). The WFD also has stipulations with respect to the time/period over which the quality objectives have to be achieved:

- WFD targets have to be achieved by 2027 at the latest.
- Reasons for phasing to the third and last WFD planning period must comply with Article 4 of the WFD.

Securing quantity
The groundwater extraction may not face a risk on account of problems with quantity:

For groundwater extraction sites, a test must be conducted for this on whether the permitted quantity of groundwater to be extracted can be used.

In the case of surface water extraction sites, the fact must be taken into account that the quality of the water may decline sharply in the event of reduced quantitative availability owing to an increase in the concentrations of substances.

Problems and risks charted
Water quality and water quantity

A summary of the monitoring results is provided in *Table 0-5*on the basis of the analysis of the water quality and water quantity as set out in Chapter 5. A distinction is made here between problems and risks.

- Problems: extent to which targets have not (yet) been achieved (see 7.2).
- Risks: whenever there is a risk that the set targets will not be met (in order to secure groundwater extraction in a sustainable way):
- Negligible risk: No contamination present in the raw water / groundwater extracted.
- Limited risk: Contamination found in the raw water / groundwater extracted, but below the threshold level.
- Current risk: Contamination found in the raw water / groundwater extracted above the threshold level.

Table 0-5 Results of testing water quality (WFD targets) and water quantity

Problems/risks	**Assessment**	**Reasons**
Water quantity risks		
Are there developments/risks related to inability to make full use of the permitted capacity?	No risk	There are no developments or risks that will mean that the permitted flow rate cannot be extracted in full.
Water quality problems		
WFD target: any decline in the water quality?	Current risk	Herbicides and pesticides, metabolites of herbicides and pesticides, substances related to herbicides and pesticides and nitrate are found in the extraction wells and the observation wells.
WFD target: Improvement in water quality (with a view to reducing purification)?	Limited risk	Purification is relatively simple and aimed at operational parameters. Aeration is carried out more intensively to remove 1,2-dichloropropane.
Risks		

Problems/risks	Assessment	Reasons
Individual extraction wells.	Limited risk	Finding nitrate in pumping wells in concentrations below 75% of the threshold level.
	Current risk	Finding 1,2-dichloropropane in 2 extraction wells in concentrations above the threshold level.
	Current risk	Finding BAM in 1 extraction well above the threshold level.
	Limited risk	Finding MCPP systemically in 1 extraction well in concentrations lower than 75% of the threshold level.
Monitoring network.	Current risk	Finding 1,2-dichloropropane in 1 observation well in concentrations above the threshold level.
	Current risk	Finding BAM in 1 observation well in concentrations above the threshold level.
	Current risk	Finding nitrate in 1 observation well in concentrations well above the threshold level.

Risk analysis for spatial functions / developments

An analysis has been carried out in Chapter 6 of spatial and underground use in the groundwater protection zone (incl. buffer zone), along with the relevant developments. In this regard, an investigation was conducted into whether there are aspects/developments that could threaten the drinking water sources qualitatively or quantitatively, and as a result create an obstacle to achieving the set targets. The results of this analysis are summarised in Table 0-6 below, where the risks have been assessed qualitatively for the degree to which the targets are threatened as follows:

- Negligible risk.
- Limited risk:
- Current risk.

Table 0-6 Results risk analysis for spatial functions / developments

Problems/risks	Assessment	Reasons
Risks		
Surface water supply	Current risk	Water supply is possible during dry periods. The precise origin is not clear. The extent to which this water infiltrates into the groundwater is not known.
Soil contamination	Current risk	There are various instances of soil contamination in and around the groundwater protection zone where past

Problems/risks	Assessment	Reasons
		activity is known. The landfill dump present has been properly inspected.
Emergencies/incidents	Limited risk	Roads run through the groundwater protection zone. No railway lines or roads that are part of the Basic Network for the transport of hazardous substances run through the groundwater protection zone.
Developments underground (energy)	Limited risk	There are no thermal energy storage systems in the groundwater protection zone. In the event that thermal energy storage systems (open or closed) are installed, risks to the subsoil will arise. This is because the protective soil layer may be bored through and a short-circuit waterflow to the deeper groundwater may arise via the borehole.
Developments underground (extraction)	Current risk	There are various extraction sites in and around the groundwater protection zone. In the event that extraction sites, such as wells for watering animals or sprinkling/irrigation, are installed, risks to the subsoil will arise. This is because the protective soil layer may be bored through and a short-circuit waterflow to the deeper groundwater may arise via the borehole.
Developments underground (sanitation and sewerage)	Limited risk	In the event of an incident or leak, municipal (pressure) sewers may pose a risk to the quality of the groundwater. There are sanitation and sewerage and 2 overflows within the groundwater protection zone.
Preventive groundwater protection policy	Limited risk	In practice, the Westerveld municipality has included in its zoning plan the contours and the reference to the rules in the provincial environmental regulations for the protection zones for groundwater. The groundwater protection zones are to be found at ruimtelijkeplannen.nl.
Spatial use/developments	Current risk	Agricultural area: The groundwater protection zone consists largely (approx 85%) of agricultural area. This results in an increased risk from the use of herbicides and pesticides, leaching of manure/fertilisers, the release of heavy metals from pyrite on denitrification, use of veterinary medicines and the possible presence of manure pits. Over recent years, lilies have grown more frequently on plots abutting the water extraction area.
Spatial use/developments	Limited risk	Built-up area: There are a few buildings in the groundwater protection zone with an increased risk of the use of herbicides and pesticides, contamination from sanitation and sewerage and sewerage overflows, and leaching from building materials.

Problems/risks	Assessment	Reasons
Spatial use/developments	Limited risk	Infrastructure in the groundwater protection zone. There are various roads and a pressure pipe for wastewater in the groundwater protection zone.

Causes charted

In this section, a more detailed analysis has been conducted into the causes that (could) lie behind the problems and risks identified. In order to determine this, a relationship has been mapped between the threats at ground level (indeterminate sources, line sources and point sources) and the (potential) problems with the water extracted. Various causes have already been identified (from the local history of Watermaatschappij Drenthe and partners) and set out in the 1st generation of drinking water protection files. However, certain problems and risks are as yet not properly linked to the threats. This is linked to the complexity of the distribution of contaminants (transport behaviour) and the unambiguous interpretation of monitoring results. *Table 0-7*shows the results of this analysis, whereby use is made of both the insights from the 1st generation dossiers and the new insights contained in this dossier.

Table 0-7 Causes of problems and risks identified

Problems/risks	Causes
Risks	
Finding 1,2-dichloropropane above the threshold level in 2 extraction wells Finding 1,2-dichloropropane above the threshold level in 1 observation well	1,2-dichloropropane is a pollutant arising from the soil fumigant DD (active substance 1,3-dichloropropene) that was used in potato growing in the past. This soil fumigant has been banned in groundwater protection zones since 1985. As the chemical is prohibited, there is no longer any risk at ground level from its use, but this substance still poses a risk to the water quality of the groundwater extraction site.
Finding BAM in 1 extraction well above the threshold level Finding BAM in 1 observation well above the threshold level	BAM is a metabolite of the herbicide dichlobenil and the fungicide fluopicolide. These chemicals are used primarily professionally, so private use is unlikely. Detection is related to arable farming in the area
Finding MCPP systemically in 1 extraction well at less than 75% of the threshold level	MCPP (mecoprop) is a herbicide used primarily on pastures, golf courses, lawns and turfs, and in grain farming to combat perennial and annual weeds. It is still currently permitted only for grain farming. Given the land use in the surroundings of the drinking water extraction site, this is the most probable origin in the first instance.

Problems/risks	Causes
Finding nitrate in 1 observation well far above the threshold level	The elevated nitrate levels are to be linked to the use of manure/fertiliser in the agricultural area, in combination with extremely vulnerable subsoil.

Remaining tasks

Various measures have already been taken in response to the 1st generation of drinking water protection files. In addition, various measures are currently being implemented. An overview of them is summarised below.

Overview of regional measures already taken

A complete overview of all the regional measures is contained in the memo Drinking Water Extraction Implementation Programme Current Status (Drenthe Province, 17 October 2017). There has been no evaluation of the different projects as yet, because some of the projects have only just started, or are still being implemented.

Various projects in the context of the implementation programme have been launched in response to the drinking water protection files from 2012. An overview of all the projects is shown in *Table 0-8*. The projects are described in detail for each extraction site in the 'Groundwater Protection Zones in Drenthe Implementation Programme'. Four of these projects are explained in greater detail below. These are two agricultural projects, one project focussed on town and country planning controls and a project focussed on enforcement.

The first agriculture project (Measure 9 in Table 0-8) is the project 'Bezem door de middelenkast' (Clear-out of the Chemicals Cabinet). This project was carried out in 2008 and in 2016. Its aim is safe disposal of the residues of crop protection chemicals. Alongside raising awareness of the need to cut the use of chemicals and to prevent emissions (on the basis of so-called suggestion cards), as much as 11,000 kg of chemicals were collected and safely disposed of - in close consultation with the municipalities, RUD (Regional Implementing Agency), NVWA (Netherlands Food and Consumer Product Safety Authority), LTO-noord (Northern Netherlands Agricultural and Horticultural Organisation) and agricultural consultants. As a result, these chemicals no longer pose a risk to the environment.

The second agricultural project is the project 'Grondig boeren voor Water' (Water-Conscious Farming) (Measure 4b). This project was launched in 2015 and ran up to 2019. It is being implemented in the 11 vulnerable groundwater protection zones in Drenthe. The intention is to improve groundwater quality and the farmer's yield via '*mutual gain*'. This approach is aimed at optimising management of nutrients and any crop protection in the business system and thus at making a contribution to improving soil and groundwater quality.

The project that focusses on town and country planning controls for groundwater extraction is focussed on the municipal zoning plan (town and country planning controls, Measure 13). Attention has been requested via the official consultation of VDG (Association of Drenthe Municipalities) spatial development for town and country planning controls on the public drinking water supply when updating the municipal zoning plans.

Drenthe Province has arranged a workshop for the project focussed on enforcement (Measure 10). There was a workshop on World Water Day in 2018 for enforcement officials involved in supervision and enforcement in and around groundwater protection zones. The workshop had three aims. The first aim was getting to know each other (who does what and why?). The second aim was to investigate how work around groundwater protection zones can be optimised (including business/farm inspections on the basis of environmental legislation). The third aim was identifying any bottlenecks in enforcement.

Table 0-8 Implementation Programme Status (2014-2017)

no.	Measure	Leggeloo
1	**Point sources approach**	x
	Pilot MTBE/ETBE filling stations	
2	**Exploring area-specific groundwater management**	
3	**Sewer system risks**	
4	**Agricultural projects**	
	a Veldleeuwerik Foundation (arable farming)	x
	b Grondig boeren voor water (dairy farming)	x
5	**Municipal policy on crop protection chemicals**	(x)
6	**Reducing herbicide and pesticide use along the railway line**	
7	**Area process**	x
8	**Raising awareness and information**	x
9	**Bezem door de middelenkast** (Clear-out of the Chemicals Cabinet)	x
10	**Tackling improved Licensing, Supervision and Enforcement**	x
11	**Erect 'Goundwater protection zone' signs along the railway line**	
12	**Consider groundwater concerns in projects in the context of refurbishment of Emmen centre**	
13	**Town and country planning protection**	x
14	**Test of groundwater quality**	x
15	**Monitoring groundwater quality**	x
16	**Updating drinking water protection file**	x

x applicable measure for extraction

(x) measure not required to remove or reduce extraction risks. Parties in the groundwater protection zone extraction site value joining up with provincial initiative.

x	In accordance with planning / carried out / continuing process
x	Project/process launched
x	Postponed and tackled in the second period
	Project/measure not applicable to relevant groundwater extraction

Overview of national measures already taken on herbicides and pesticides

Use of herbicides and pesticides is a risk that comes up regularly. This concerns use by both the agricultural sector and other users (public greenery, private individuals). Apart from agriculture and horticulture, there are good alternatives to the use of herbicides and pesticides, such as burning, hot air and hot water. For this reason, the government has set up the following measures (https://www.rijksoverheid.nl/onderwerpen/bestrijdingsmiddelen/inhoud/gewasbeschermingsmiddelen):

- Ban on heavy-duty use on paved surfaces (March 2016).
- Ban on heavy-duty use on unpaved sites (November 2017).

Sports fields and leisure businesses are exempt from this ban. The ban also does not apply to private use of crop protection chemicals.

The government aims to assist the target groups above to resolve bottlenecks in converting to sustainable management via so-called Green Deals. The aim is to reduce the use of chemicals and the resultant risks, and to ensure by 2020 at the latest that crop protection chemicals are used only in situations where other means and methods are ineffective. Three Green Deals have now been concluded.

Green Deal Recreation; a collaboration between the sector organisations Recron and HISWA, and the national government (Ministry of Infrastructure and Environment and Ministry of Economic Affairs).

Green Deal Sports Fields; a collaboration between the NOC*NSF, various sports clubs, sector organisations, drinking water companies, nature and environmental federations and the national government (Ministry of Infrastructure and Environment and Ministry of Economic Affairs).

Green Deal Horticultural Sector; a collaboration between Tuinbranche Nederland, the Nefyto Foundation, Dutch Retail Council and the national government (Ministry of Infrastructure and Environment and Ministry of Economic Affairs).

Table extraction site-specific and Table generic below identify whether measures have been taken or a task remains for the problems/risks indicated.

Table 0-9 Remaining tasks for Leggeloo extraction site

Problems/risks	**Remaining tasks**
Water quantity	
Are there developments/risks related to inability to make full use of the permitted capacity?	No risk and so no remaining tasks.
Risks to water quality	
Determination of herbicides and pesticides, metabolites of herbicides and pesticides, and substances related to herbicides and pesticides in the extraction wells and the observation wells.	Use of herbicides and pesticides by private individuals remains a risk. One measure to counter this is continuing to rely on communication and awareness.
	Use of herbicides and pesticides in agriculture remains a risk. Measures to reduce this risk include: Relying on raising awareness, relying on a personal approach and via study groups. Request central government attention for the consequences of greater restrictions on the chemical agents package in groundwater protection zones (risk of resistance, etc).
Determination of nitrate in extraction wells and observation wells	Finding nitrate remains a risk. The measure for reducing this risk follows from the 6th nitrate programme of action, which seeks cooperation with farmers on reducing the nitrate load. This will also result in reduced leaching of nitrate to the groundwater (see also Chapter 6.4).
Surface water supply	The influence of water supply on the groundwater is unknown. Firstly, it is unknown how often use is made of the option of supplying water, secondly the origin of the water is unknown, and thirdly the risk to the extraction is unknown. One measure for reducing the risk to the groundwater extraction is to carry out a study.
Soil contamination	The severity and risk to groundwater extraction of all potential soil contaminants is not yet known for the groundwater extraction site. One measure for determining the risk from these potential contaminants is to investigate these sites.
Emergencies	Emergencies may happen at any time, such as accidents on roads and railway lines, or contamination of the surface water, or sanitation and sewerage (infiltration facilities). One measure for diminishing as far as possible the impact of an emergency on the groundwater extraction is to ensure that the emergency personnel in the safety region, the municipality, the water board and the province are aware of the significance of the groundwater. This can be done through consultation or including the significance of drinking water in the emergency plans.

Problems/risks	Remaining tasks
Manure pits	Manure pits are not registered. One measure for assessing this risk is first to chart details of sites and scope.
Extraction sites	Extraction sites (such as for sprinkling/irrigation) are a risk, because separating layers can be bored through and wells are not properly covered. In the event of extraction sites requiring an exemption (extraction within the groundwater protection zone) or a permit (more than 10 m^3/hour outside the groundwater protection zone, but within the recharge area), it must be stipulated in the regulations that a 'tidy' borehole must be made, with a full borehole description submitted, and that the well can be properly closed off. Requirements cannot currently be imposed beforehand on extraction sites where notification is required, or even where no notification needs to be made. The province and water board are to investigate the options that the Environment and Planning Act offers in this regard. Another measure is to chart all the extraction sites in the protection zone.
Sanitation and sewerage	The number of overflows and the frequency of overflow is a point for attention. Certainly if they lie in a vulnerable section of the recharge area. The condition and location of the sewerage is well known at the municipality. An additional measure is to enter into talks with municipalities in order to chart overflows (better) and to monitor frequencies. The age of the sanitation and sewerage and its condition form a possible risk. Disconnected rain water drainage and faulty connections also pose a risk. A measure to deal with this is to enter into talks with the policy officers in the field of sewerage at the municipalities. This may be linked with the cycle of drafting the Basic Sewerage Plans.
Peat oxidation and oxidation of organic matter	At the extraction sites with peat in the subsoil or extraction sites with a soil type with high organic matter content, the disappearance of peat and/or organic matter through oxidation leads to a rise in vulnerability. One way of determining this risk is a study with different angles of approach: What is the impact of the (decomposed) peat on the water quality? To what extent is there still (residual) peat above the lowest average groundwater level (GLG)? Was is the organic material content of the topsoil? To what extent does residual peat above the GLG run a risk of further attack? If this residual (decomposed) peat disappears, what are the real risks this holds for drinking water extraction?

Problems/risks	Remaining tasks
	The perspectives for action will be investigated on the basis of these angles of approach.
TES systems	There are no thermal energy storage systems in the groundwater protection zone. Notifications and applications for a permit for thermal energy storage systems are received by the province, water board and municipality. This results in fragmentation of supervision and enforcement. One measure to decrease the chance that a thermal energy storage system is installed in the protection zone after all is to boost awareness at the province and municipality through consultation between municipality, province and WMD.

Table 0-10 Remaining generic tasks

Problems/risks	Remaining tasks
Risks to water quality	
Geo-hydraulics	Updating of geohydrological description and cross section.
Introduction of Environment and Planning Act	The new Environment and Planning Act is a development that demands close attention to what the responsibilities of the province, municipality and environmental services are. Knowledge about protecting groundwater is becoming fragmented. The measure for the protection of groundwater extraction is relying on structural communication between these parties.
Climate change	Climate change generates possible risks to groundwater extraction. The impact on groundwater extraction is currently not clear. A measure in this regard is conducting a study into the impact on extraction. Consideration may be given in this regard to charting additional overflows from the sanitation and sewerage, further peat oxidation, supplying additional water in dry periods, etc.
Spatial planning	Including zoning of the groundwater protection zones in the municipal plans remains a point for attention. The measure for drawing the municipality's attention to zoning for groundwater protection is a tour of the province and the water companies through the municipalities in order to provide guidance to the municipalities. This is something that should be repeated regularly. The planning cycle of the authorities is a point for attention here.
Water test	Groundwater and groundwater protection are not part of the water test. This is a risk in recharge areas and groundwater protection zones. The measure for reducing this risk is to call for

Problems/risks	Remaining tasks
	extra attention to be paid to it in the communication between province and water board, via the water testing meetings, for example.
Solar farms	The risk from solar farms to groundwater extraction is not clear. A measure for determining this risk is to investigate whether there are solar farms in the groundwater protection zones; applications for this have already been sent to the municipalities and water boards (water testing).

Water quality monitoring

When determining the (remaining) tasks of the extraction, a check has been conducted in each case on whether the monitoring is properly equipped. Both the question whether 'early warning' at the extraction site is adequate for identifying/monitoring the risks and the question whether parameters that should be monitored on account of the activities/emissions identified are lacking were looked into.

Early warning monitoring

In order to identify up at an early stage whether a particular activity at ground level could negatively impact the water quality, an additional monitoring network will be set up around vulnerable extraction sites alongside the existing observation wells of the water companies.

There is a national agreement to set up this early warning monitoring in consultation between the provinces and the water supply companies. Drenthe and Groningen provinces are engaged, along with WMD and Groningen Water Company, in conducting an initial monitoring round (pilot) for a limited number of extraction sites, with a view to rolling out monitoring on the other vulnerable extraction sites in 2019 on the basis of the observations. In Drenthe, the first monitoring round will be conducted at the Gasselte and Leggeloo extraction sites. The monitoring wells are currently being installed around these extraction sites.

Monitoring programme

There is no reason to make a recommendation on the monitoring programme to WMD on the basis of the activities/emissions identified. WMD has an intensive monitoring programme (for new substances as well) for the combined raw water, and an intensive monitoring programme on a regular basis is being set up for the individual extraction wells.

ANNEX 2: EXAMPLE WATER SAFETY PLAN – SMALL SUPPLY

General information and objective

The following page shows a factsheet illustrating a quick-scan of a small water supply in the Netherlands. This type of factsheets are drawn up for every small-scale abstraction site of the province of Drenthe, which are registered in the National Groundwater Register (Landelijk Grondwater Register).

The factsheet is made for “small-scale abstraction sites”, which includes water supplies for drinking water consumption other than those for public drinking water supply. These are mainly privately owned groundwater abstractions used by third parties as drinking water (e.g. campsites and holiday parks) as well as industrial sites, that abstract groundwater for food production.

The factsheet visualizes the potential risk for small-scale abstraction sites and contains information regarding vulnerability and potential threats. Furthermore, the current water quality has been assessed and is shown on the factsheet.

Size and scale of the evaluation area

An abstraction is vulnerable to activities that affect the groundwater quality of the abstraction site, the so-called catchment area. The catchment area of public drinking water abstraction sites is determined by geohydrological (model) calculations. No geohydrological calculations are available for small-scale abstraction sites. Additionally, small-scale abstraction sites are not protected by groundwater protection areas. In order to include the risks on the maps in the fact sheet, the scale of the map has been chosen so that it includes at least the abstraction area. The scale is calculated by means of an indicative calculation based on the abstraction flow rate and the regional geohydrological characteristics.

For the scale of the map, two indicative calculations have been made, one for the small-scale abstraction volumes up to 10,000 m^3/year and one for the abstraction volumes of 250,000 m^3/year.

The indicative calculation is based on a "worst case" scenario meaning all potential threats are included in the map. The parameter values used for the for the calculation are chosen so that the worst case is calculated. The scale of the map is calculated by assuming a permanent source in a uniform groundwater flow (see formula below).

$$v = \frac{1}{pD}\left(q + \frac{Q}{2\pi x}\right)$$

v – velocity to the extraction at distance x from the extraction (m/d)
p – porosity
D – thickness of aquifer (m)
q - a parous flow in the aquifer (m^2/d)
Q -abstraction rate (m^3/d)
In excel the length of the 50-year zone of the abstraction aquifer is calculated iteratively. The length is the distance from the abstraction point to the edge of the map. For abstractions < 10,000 m3/year

the distance used is 1 km. For large-scale abstractions (250,000 m3/year) the distance is also 1 km. This is due to the difference in thickness of the aquifer.

Structure and content of the fact sheet

The factsheets include basic information, an analysis and an assessment. The basic information is visualized on the left site of the factsheet. This contains information on topography and the location of the abstraction site, the soil type and geology as well as information of the land use and possible soil contamination.

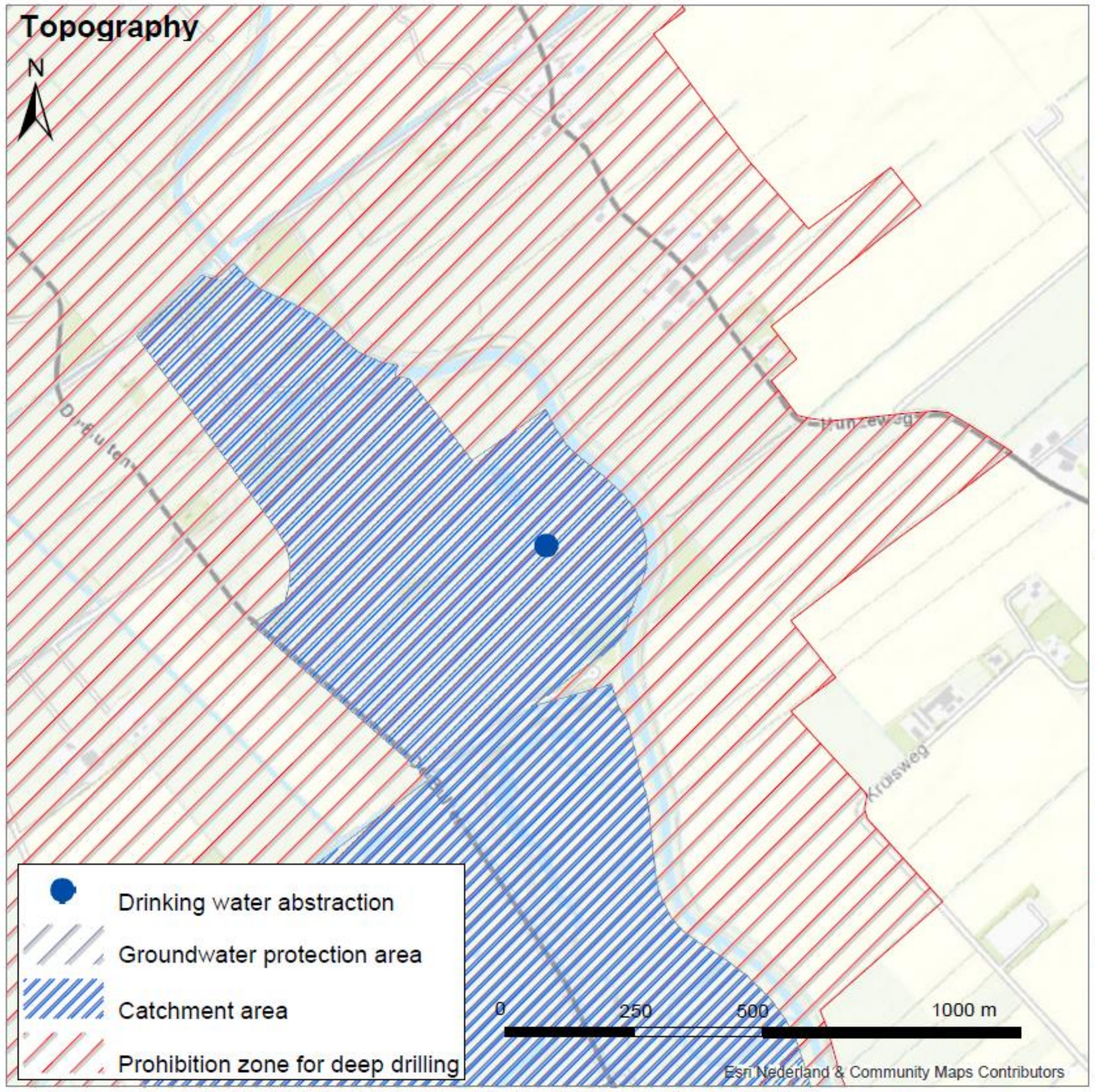
On the right site of the factsheet the analyses and the assessment can be found. It consists of an overview of the characteristics of the abstraction, the vulnerability and risks of the abstraction and an analysis of the protection capacity of the natural barrier.
The characteristics include information on the permitted abstraction rate recorded in the National Groundwater Register (LGR) and the filter depth. It also indicates the responsible organizations and authorities.

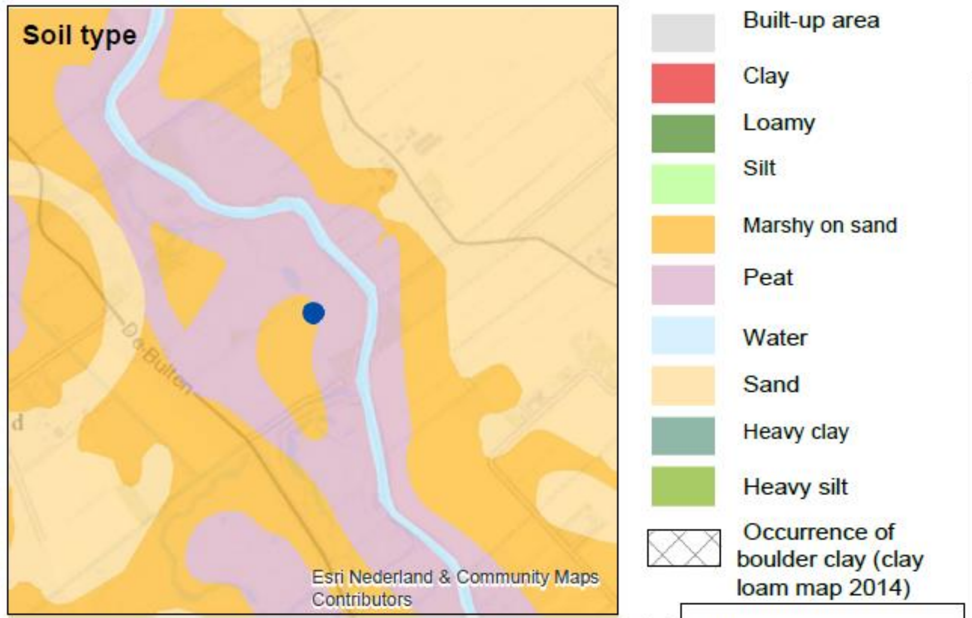
The vulnerability is influenced by geological- and soil properties, the natural protection of the abstraction site. On the one hand the natural protection of the abstraction site is influenced by the absence or presence of an impermeable layer/ aquiclude and on the other hand by the soil reactivity. The higher the reactivity of the soil, the better pollutants can be bound on the soil material. This can prevent leaching into deeper layers. Clayey and peaty soils have a greater reactivity than sandy soils.

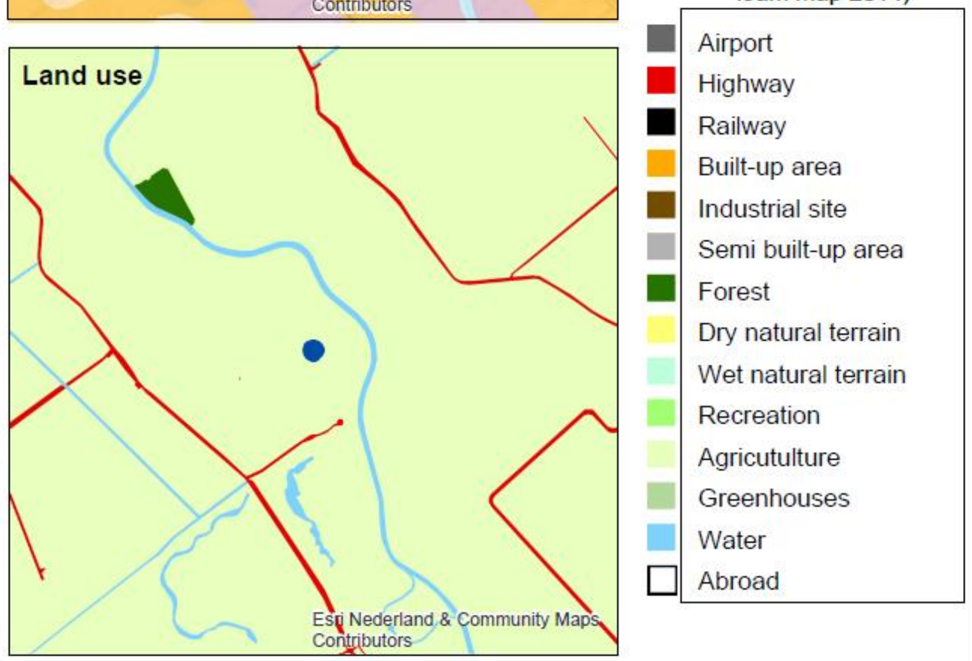
The analysis also includes information of the activities at ground level that pose a potential threat to the abstraction site. These activities are divided in three categories. Firstly, the land use, this information can be found on the topographic and the land use map. Secondly, the soil contamination, this information is based on the soil contamination map. And finally, the line sources, which can be found on the topographic map. Line sources are generally roads, highways, and canals that may release pollutants and pose a threat to the abstraction site.

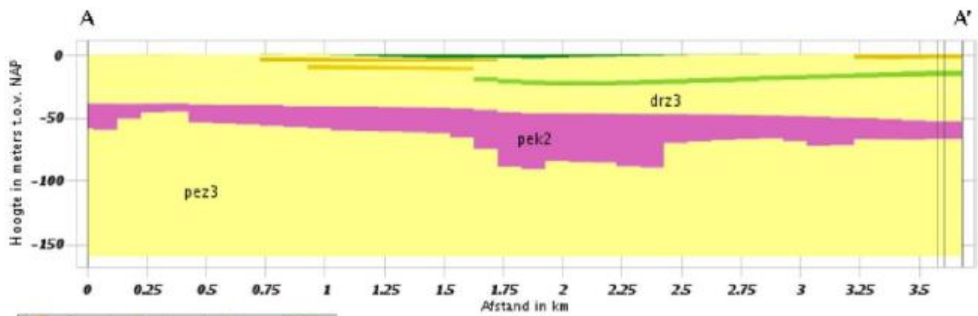
Substances and/ or activities at ground level that could have negative impacts on the abstraction site are listed in the section *threats to abstraction*: the assessment of the abstraction site based on the risk to the abstraction and the actual water quality.

The combination of the vulnerability of -and the threats to the abstraction together constitute the risk to the abstraction site. A low vulnerability and few threats give a low risk and a high vulnerability, and many threatening activities give a high ris.



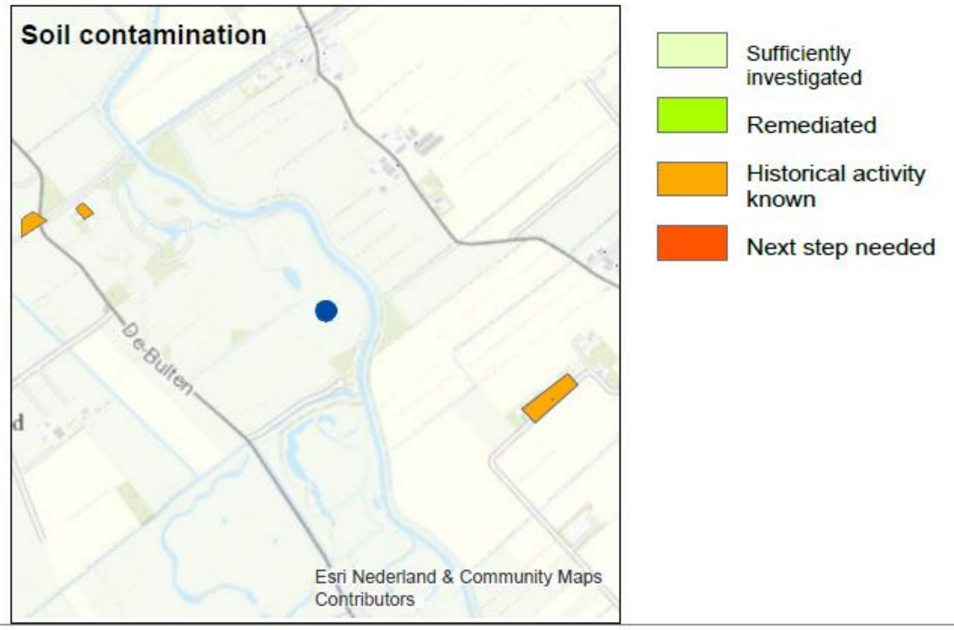






Hydrogeologie
- Holocene afzetting
- Formatie van Boxtel (klei)
- Eemformatie
- Formatie van Peelo (klei)
- Zand

Bron: REGIS II v2.1



Drinking water abstraction

Characteristics

Permitted abstractionrate: 12000m³/year
Filter depth: 96 - 108
Abstraction from 2nd aquifer
Abstractionrate: 4100 m³/year (2003-2004)
Name LGR:
NV Waterleidingmaatschappij Drenthe
Abstraction is known by: LGR and NVWA

Natural protection
Soil structure
Sandy soil with a thick cover layer above the filters.
Soil type
Peat and (marshy) sand

Vulnerability of the abstraction
Low vulnerability due to the peaty soil and the presence of a cover layer above filters.

Ground level activities
Land use
Agricultural area (grassland) partly in a water catchment area and in a prohibition zone for deep drilling of Annen-Breevenen drinking water abstraction.
Soil contamiantion
Potential pollutions requiring historical or exploratory research.
Line sources
Highways, roads and the river Hunze

Threats to abstraction
Pesticide and nutrient use in agriculture and potential soil contamination.

Risk to abstraction
The low vulnerability of the abstraction combined with activities at ground level ensure a low risk for the drinking water abstraction.

Water-quality
Abstraction is approved by the NVWA

Titel
Overview information

Project
Gebiedsdossier kleine winningen

Opdrachtgever
Provincie Drenthe

Datum 11/10/2016

Royal HaskoningDHV
Enhancing Society Together

ANNEX 3: LEARNING MODULE

1.1 INTRODUCTION

With this document the FAIRWAY team strives to stimulate the improvement of drinking water safety across the European Union by sharing context, best practices and lessons learned on Water Safety Planning for both small and large water supplies. It aims to raise awareness on the benefits of water safety planning and to build capacity for successful WSP implementation. Chapter 3 has provided a theoretical background on water safety planning.

This annex contains a learning module for WSPs. This learning module guides the reader through the specific steps of Water Safety Planning related to system assessment. These specific steps of the WSP approach relate to the availability, use and interpretation of data. This learning module aims to guide the reader through the process of assessing vulnerability, hazards and risks, and identifying mitigation measures. Annex 1 provides an example WSP which was written for a Dutch drinkingwater abstraction site called Leggeloo. Annex 2 shows an example of a WSP for a small supply.

The target audience of this learning module is the responsible authority (for example the regional water manager). The responsible authority developing a Water Safety Plan, could walk through the different steps and be guided through the process of setting up a WSP. The responsible authority who has outsourced this task, could use the learning module as a way to review the Water Safety Plan, and be involved in the different steps.

It is the challenges for WSP implementation that set small systems distinctly apart from large supplies, and thus define them in this context, rather than quantity supplied or population served. This learning module offers guidance for water safety planning for both contexts. However, different from previous manuals and guides, both contexts are integrated within one document. The reader can use elements of both in order to set up a WSP with the data and expertise available. The following typfication of large and small water supplies has informed the learning module:

- Large water supplies: organized, managed by a water utility, financial resources, high availability of data, high number of personnel/experts.
- Small water supplies: no existing organization, low availability of data, low number of personnel/experts.

The learning module does not distinguish between urban and rural areas, although these are very different contexts. Through this, it aims to prevent that hazards are excluded beforehand, and are not taken into consideration.

The learning module combines existing information from manuals and guides on water safety planning.

This learning module covers four elements of the Water Safety Plan:

- Assessment of vulnerability (paragraph 1.2).
- Identification of hazards (paragraph 1.3).
- Assessment of risks (paragraph 1.4).
- Development of measures (paragraph 1.5).

1.2 ASSESSMENT OF VULNERABILITY

The assessment of vulnerability is the first step in the system assessment. The goal of this step is to determine whether the quality of the water delivered will consistently meet the health-based targets. Through this step the nature of the raw, interim and finished water quality, and the steps within the system to produce water, are documented. In this way, risks can be adequately assessed.

The assessment of vulnerability has two elements:

- Theoretical vulnerability: Characteristics of the water supply.
  The WSP team describes thoroughly the water supply system. The system description should cover the whole system "from source to consumer".
- Proven vulnerability: Assessment of current water quality.

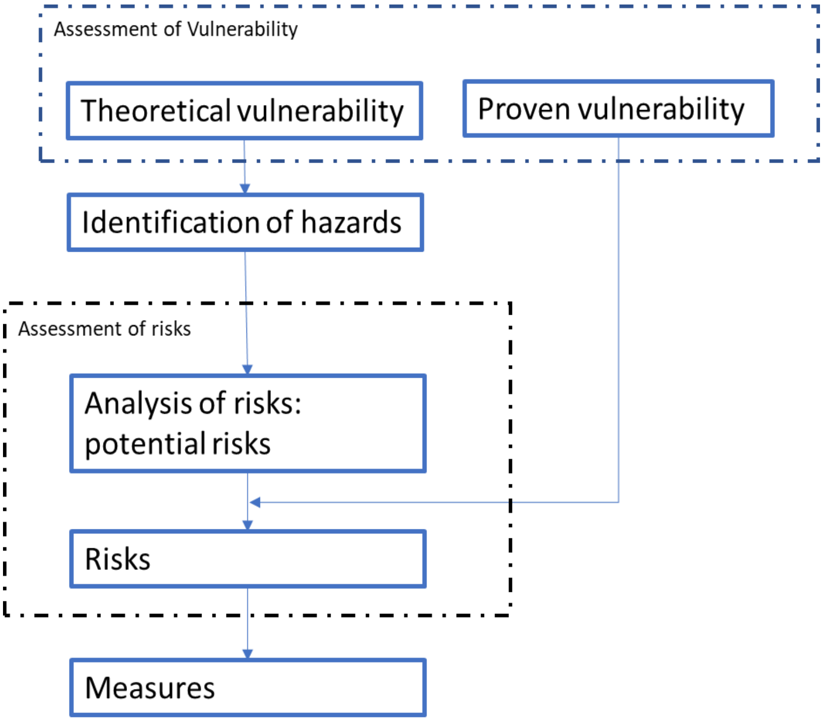


Figure 1: Assessment of vulnerability, risks and measures

1.2.1 Large Water Supplies

Theoretical vulnerability:

Textual description of characteristics water supply:

Surface water:

- Location.
- Geology and hydrology.
- Description of water body type (e.g. river, reservoir, dam).
- Physical characteristics such as size, depth, thermal stratification, altitude.
- Flow and reliability of source water.
- Retention times.
- Protection.
- Abstraction quantities.

- Distribution area.
- History of water supply.

Groundwater:
- Location.
- Aquifer hydrogeology.
- Physical characteristics such as size, depth, thermal stratification, altitude.
- Confined or unconfined aquifer.
- Flow rate and direction.
- Dilution characteristics.
- Recharge area.
- Well-head protection.
- Depth of casing.
- Distribution area.
- Abstraction quantities.
- Protection.
- History of water supply.

Treatment:
- Treatment processes.
- Equipment design.
- Monitoring equipment and automation.
- Water treatment chemicals used.
- Treatment efficiencies.
- Disinfection removals of pathogens.
- Disinfection residual / contact period time.

Service reservoirs and distribution systems:
- Reservoir design.
- Retention times.
- Seasonal variations.
- Protection.
- Distribution system design.
- Hydraulic conditions.
- Backflow protection.
- Disinfectant residuals.

<u>Flow diagram:</u>
- Conceptualize the water supply system through a flow diagram. Treatment steps from source to consumer.

<u>Cross sections:</u>
- Geohydrologic profile .

<u>Maps:</u>
- Location abstraction site (and if applicable protection zones based on flow rate).
- Distribution system.
- Soil types.

- Vulnerability (REFLECT method[7]) (vulnerability of the ground water abstraction: pressure (land use), vulnerabilty (soil type, protective layer, retention times) -> risk index).

Graphs:
- Abstraction quantities per year.
- Response curve (hydrologic vulnerability).

Proven vulnerability:

Assessment of current water quality in the smallest abstraction unit possible (f.i. individual abstraction wells) to be able to detect potential risks as soon as possible: monitoring results of raw and treated water for:
- Macroparameters.
- Organic micro pollutants.
- Indicators for agricultural effects.

1.2.2 Small Water Supplies

Theoretical vulnerability:

- Description of catchment/abstraction characteristics (including maps, graphs, figures), among which:
    - Catchment:
        - Where are the catchment and recharge areas?
    - Abstraction:
        - Where is the abstraction point located, and how does it operate?
        - What is the abstraction infrastructure made of, and how old is it?
        - What is the capacity/flow of abstraction?

- Description of the treatment characteristics (including, flow diagrams, maps, graphs, figures), among which:
    - What water treatment processes are in place, and how are they configured?
    - What chemicals and materials are used for treatment? What are the availability and quality of the chemicals? How are they stored?
    - Is the water disinfected? If so, what methods and disinfectants are used? Is there sufficient disinfectant (e.g. chlorine) contact time for proper disinfection?
    - Is water quality monitored? How? How often? Where?
    - Are treatment plant operators trained? Are there minimum competency standards, and do operators meet such standards?

- Description of storage and distribution characteristics, among which:
    - How is the water stored?

[7] REFLECT (BTO, 1999) is a method that has been developed in order to assess the risks from spatial functions to groundwater extraction based on the characteristics of these functions and the vulnerability of the subsoil. REFLECT calculates the vulnerability of the extraction based on scores for soil type, thickness of the covering layer and the travel time from ground level to the extraction point

  - Where are the storage tanks located?
  - What construction materials are used in the infrastructure, and how old is the infrastructure?
  - Are the storage tanks protected? (e.g. rainproof with gutters).
  - Is there adequate protection/security on storage tanks with locked gates and hatches?
  - Are there screens on ventilations and overflows to prevent vermin and animal entry?
  - Are there separate inlets and outlets at varying heights on opposite sides of tanks to promote good mixing?
  - Does the distribution operate constantly or intermittently?
  - Is there secondary disinfection, and, if so, are chlorine residuals in critical points in the system monitored and recorded?
  - What is the average pressure in the system, and does it vary? What is the flow rate at the tank inlet and tap points in the system?
  - Is water quality monitored? How? How often? Where?

- Description of installations' characteristics, among which:
  - What are the current water uses (identify the different uses and users, e.g. drinking, food preparation, domestic livestock, vegetable farming, market) and future needs (quantity and quality)?
  - What are the numbers and type of users, including commercial users (e.g. homes, hotels, guesthouses, institutions, workshops, small industry)?
  - Do households treat and store water? By what means?
  - How is water collected and transported?
  - Are stand posts and house connections inspected, and is water quality tested? How? How often?
  - Is water quality monitored at stand posts and at households? How? How often?
  - Is there backflow prevention?
  - What material is used for domestic pipe work, and how old is it?

- Textual description and maps:
  - Soil type:
    If no national dataset is available:
    - https://esdac.jrc.ec.europa.eu/content/european-soil-database-derived-data
    - http://www.europe-geology.eu/soil/soil-map/soil-regions/
  - Hydrogeology: protective layer.
  - Travel times.

Outputs:

- Maps/drawings of the water supply (catchment, abstraction, treatment, storage, distribution and the consumer).
- Flow diagram of the water supply system.
- Description of catchment/abstraction, treatment, storage & distribution and installations characteristics.
- Identification of uses and users.
- Maps of soil type, hydrogeology, travel times.

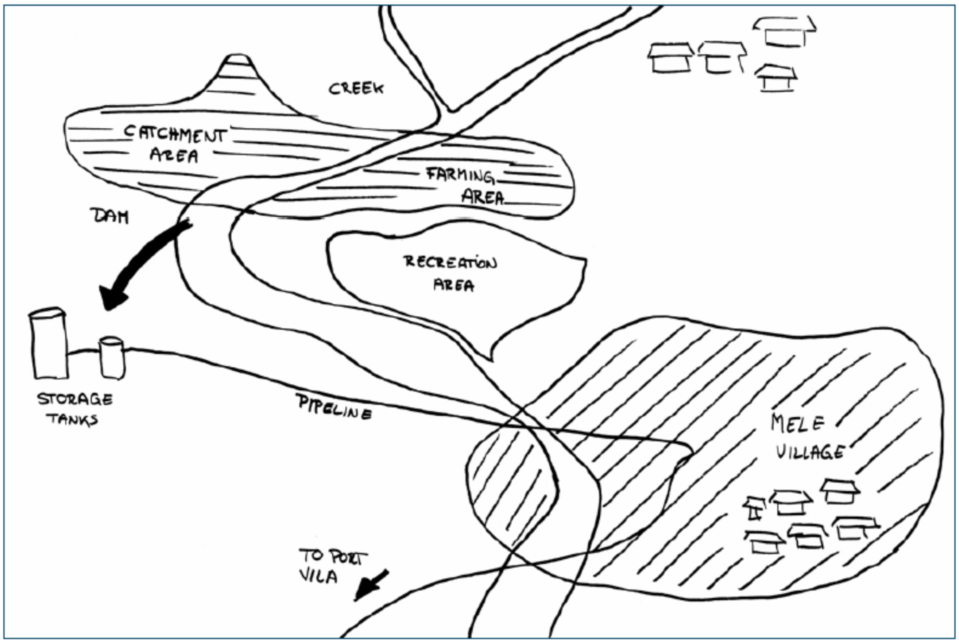


Figure 2 Example map/drawing of the water supply (WHO, 2011)

Proven vulnerability:

- Monitoring results of water quality.
- Indicators for agricultural effects.

1.3 IDENTIFICATION OF HAZARDS

The next step is to identify hazards: sources of diffuse and point pollution. All phases “from catchment to consumer” are assessed for potential hazards.

1.3.1 Large Water Supplies

The WHO manual outlines examples of typical hazards. The team can walk through this list, extract the hazards that are relevant and describe these and provide maps/figures etc.

Catchment: typical hazards

Table 1 Typical hazards catchment (Bartram, 2009)

Hazardous event (source of hazard)	**Associated hazards (and issues to consider)**
Meteorology and weather patterns	Flooding, rapid changes in source water quality
Seasonal varations	Changes in source water quality
Geology	Arsenic, fluoride, lead, uranium, radon Swallow holes (surface water ingress)
Agriculture	Microbial contamination, pesticides, nitrate Slurry and dung spreading Disposal of dead animals

Hazardous event (source of hazard)	Associated hazards (and issues to consider)
Forestry	Pesticides, PAHs -polyaromic hydrocarbons (fires)
Industry (including abandoned and former industrial sites)	Chemical and microbial contamination Potential loss of source water due to contamination
Mining (including abandoned mines)	Chemical contamination
Transport – roads	Pesticides, chemicals (road traffic accidents)
Transport – railways	Pesticides
Transport – airports (including abandoned airfields)	Organic chemicals
Development	Run-off
Housing – septic tanks	Microbial contamination
Abattoirs	Organic and microbial contamination
Wildlife	Microbial contamination
Recreational use	Microbial contamination
Competing water uses	Sufficiency
Raw water storage	Algal blooms and toxins Stratification
Unconfined aquifer	Water quality subject to unexpected change
Well / borehole headworks not watertight	Surface water intrusion
Borehole casing corroded or incomplete	Surface water intrusion
Flooding	Quality and sufficiency of raw water

<u>Treatment: typical hazards</u>

Table 2 Typical hazards treatment (Bartram, 2009)

Hazardous event (source of hazard)	Associated hazards (and issues to consider)
Any hazards not controlled/mitigated within the catchment	As identified in catchment
Power supplies	Interrupted treatment/loss of disinfection
Capacity of treatment works	Overloading treatment
Disinfection	Reliability Disinfection by-proucts
By-pass facility	Inadequate treatment
Unapproved treatment chemicals and materials	Contamination of water supply
Contaminated treatment chemicals	Contamination of water supply
Blocked filters	Inadequate particle removal
Inadequate filter media depth	Inadequate particle removal
Security/vandalism	Contamination/loss of supply
Instrumentation failure	Loss of control
Telemetry	Communication failure
Flooding	Loss or restriction of treatment works
Fire / explosion	Loss or restriction of treatment works

<u>Distribution: typical hazards</u>

Table 3 Typical hazards distribution (Bartram, 2009)

Hazardous event (source of hazard)	Associated hazards (and issues to consider)
Any hazards not controlled/mitigated within treatment	As identified in treatment
Mains burst	Ingress of contamination
Pressure fluctuations	Ingress of contamination
Intermittent supply	Ingress of contamination
Opening / closing valves	Reversed or changed flow disturbing deposits Introduction of stale water
Use of unapproved materials	Contamination of water supply
Third party access to hydrants	Contamination by backflow Increased flow disturbing deposits
Unauthorized connections	Contamination by backflow
Open service reservoir	Contamination by wildlife
Leaking service reservoir	Ingress of contamination
Unprotected service reservoir access	Contamination
Security / vandalism	Contamination
Contaminated land	Contamination of water supply through wrong pipe type

Consumer: typical hazards

Table 4 Typical hazards consumer (Bartram, 2009)

Hazardous event (source of hazard)	Associated hazards (and issues to consider)
Any hazard not controlled/mitigated within distribution	As identified in distribution
Unauthorized connections	Contamination by backflow
Lead pipes	Lead contamination
Plastic service pipes	Contamination from oil or solvent spillage

Outputs:

- Description of hazards.
- Land use map: national dataset, or https://land.copernicus.eu/pan-european/corine-land-cover/clc2018
- Point pollution map.
- Diffuse pollution map.
- Maps for specific hazards.

1.3.2 Small Water Supplies

The team can walk through the list below of typical hazards, as developed by Bartram, 2009 for WHO, extract the hazards that are relevant and describe these and provide maps/figures etc.

Catchment/abstraction:

Acute health risk due to disease-causing microorganisms in drinking-water:

- Rainstorm events and heavy rainfall causing high pollution load (due to runoff).
- Septic tanks in catchment and raw sewage causing faecal matter to enter water source.
- Swimming, boating, fishing or other human activities possibly introducing faecal material.
- Wastewater or urban stormwater discharge/local flooding.
- Intensive animal farming around shallow groundwater wells.
- Cracked spring box, well or borehole infrastructures, allowing ingress of faecally contaminated runoff or leachate.
- Direct access of animals to abstraction infrastructures.
- Latrines nearby water abstraction, introducing contamination.

Acute health risk due to short-term exposure to hazardous chemicals in drinking-water:

- Excessive or inappropriate use or inappropriate disposal of pesticides, insecticides, herbicies, etc. In agriculture.
- Wastewater discharges containing high concentrations of industrial chemicals (e.g. dyanide spilt to sewer).
- Chemical spills or industrial accidents.
- Algal blooms in reservoir (toxins).

Chronic health risk due to medium- or long-term exposure to hazardous chemicals in drinking-water:

- Naturally occuring lfuoride or arsenic in groundwater.
- Pesticide and fertilizer use (e.g. in plantations, agriculture and horticulture).
- Leaching from waste upstream of community water sources (e.g. solid wastes, mining wastes, contaminated landfills).
- Frequent urban stormwater discharge (runoff of high concentrations of heavy metals and hydrocarbons).
- Leakage/waste of hydrocarbons and other chemicals from commercial sites or fuel stations.
- Improper disposal of chlorinated solvents used for degreasing, resulting in hihg concentrations in groundwater.

Aesthetic issues:

- Soil erosion and runoff (high turbidity).
- Stratification, overturning of reservoirs (high iron, manganese levels).
- Heavy rainfall or thaw (high turbidity, colour).
- Excessive use of tubewell during drought (high turbidity).

Treatment:

Acute health risk due to disease-causing microorganisms in drinking-water:

- Microbial pathogen loading exceeds treatment removal capacity.
- Failure of disinfection system.
- Short-circuiting within tanks (e.g. some water to be treated passess too quickly through the treatent tank as a result of flaws in tank design, such as to the inlet/outlet).

Acute helath risk due to short-term exposure to hazardous chemicals in drinking-water:

- Overdosing and contamination with chemcials.
- No treatment for specific chemicals or toxins, or exceeding the treatment limit.

Chronic health risk due to medium- or long-term exposure to hazardous chemicals in drinking-water:

- Overdosing and contamination with chemicals (e.g. fluoride, chlorate from poorly stored hypochlorite).

Aesthetic issues:

- Treatment malfunctions (e.g. high chlorine, alum levels) (taste, odour, colour, high turbidity).

<u>Storage and distribution:</u>

Acute health risk due to disease-causing microorganisms in drinking-water:

- Access to service reservoir by humans or animals, including insects and birds (e.g. lack of screen at air vents).
- Ingress of contaminated runoff through service reservoir inspection covers.
- Inflow of contaminated roof drainage to service reservoir.
- Poor cleaning of pipes and tanks.
- Contamination of collected water because of the use of containers or jerry cans without a screw cap and poor hygienic practices associated with containers.
- Pipe breakage due to old pipes or road crossing.
- Contamination from broken sewerage pipes or road crossing.
- Contamination from broken sewerage pipes.
- Low pressure or intermittent operation causing influx of contaminants.
- Insufficient residual chlorine.

Acute health risk due to short-term exposure to hazardous chemicals in drinking-water:

- Cross-connections from chemical storage.

Chronic health risk due to medium- or long-term exposure to hazardous chemicals in drinking-water:

- Corrosion of materials used (copper, lead).

<u>User installations</u>

Acute health risk due to disease-causing microorganisms in drinking-water:

- Contamination of domestic water because of poor hygienic practices associated with storage containers (e.g. storage in wide-mouthed uncovered containers or hand clipping of cups).
- Rainwater system without functioning first-flush discharge device or filter.
- No place to hang the bucket to keep it clean when using an open well.
- Cross-connections with non-drinking-water systems in the whole.
- Insufficient residual chlorine.

Acute helath risk due to short-term exposure to hazardous chemicals in drinking-water:

- Backflow from a household or institution (hospital, workshop, garage or small factory including chemical storage).

Chronic health risk due to medium- or long-term exposure to hazardous chemicals in drinking-water:

- Corrosion of materials used in domestic plumbing (copper, lead).
- Continued use of a domestic filter, when the filter medium is exhausted (arsenic, fluoride).
- Cross-connections with non-drinking-water systems in the home.

Aesthetic issues:

- Material corrosion on internal galvanized pipe work (high iron levels).
- Stagnant water in internal system.

Outputs:

- Description of applicable hazards.
- Maps/drawings with applicable hazards.

1.4 ASSESSMENT OF RISKS

When the vulnerability of the system is assessed and the hazards are identified, the WSP team can make a risk assessment.

1.4.1 Large Water Supplies

This learning module identifies two methods (varying in complexity) to assess the risks.

Calculation of risks using a risk matrix:

The WHO manual describes the semi-quantitative risk matrix approach (from Deere et al., 2001). The risk matrix below can be used:

Table 5 Semi-quantitative risk matrix approach (Bartram, 2009, p. 32)

		Severity or Consequence				
		Insignificant or no impact - Rating: 1	Minor compliance impact - Rating: 2	Moderate aesthetic impact - Rating: 3	Major regulatory impact - Rating: 4	Catastrophic public health impact - Rating: 5
Likelihood or frequency	Almost certain / Once a day - Rating: 5	5	10	15	20	25
	Likely / Once a week - Rating: 4	4	8	12	16	20
	Moderate / Once a month - Rating: 3	3	6	9	12	15
	Unlikely / Once a year - Rating: 2	2	4	6	8	10
	Rare / Once every 5 years - Rating: 1	1	2	3	4	5

Risk score	<6	6-9	10-15	>15
Risk rating	Low	Medium	High	Very high

For every applicable hazard, the risk is calculated on severity and the likelihood of the event. The output is a table defining the hazard, the likelihood, severity, the risk score and the basis of the decision to act. An example can be found below:

Table 6 Example Output of risk assessment (Bartram, 2009, p. 33)

Process step	Hazardous event (source of hazard)	Hazard type	Likeli-hood	Severity	Score	Risk rating (before consideration of controls)	Basis
Source (groundwater)	Cattle defecation in vicinity of unfenced wellhead causing source of potential pathogen ingress in wet weather	Microbial	3	5	15	High	Potential illness from pathogens from cattle, such as *Cryptosporidium*
Source	Cocktail of pesticides from agricultural uses	Chemical	2	4	8	Medium	Potential introduction of toxic chemicals which could lead to concentrations in finished water above national standards and WHO Guideline values
Source	Potential for informal solid waste disposal	Microbial and chemical	1	1	1	Low	Potential for hazardous waste plus rainfall event causing contamination to water supply is low
Storage tank	Unroofed reservoir allows birds to congregate and defecate in treated water	Microbial	2	5	10	High	Potential illness from pathogens such as *Salmonella* and *Campylobacter*
Treatment	No back-up power supply	Microbial and chemical	2	5	10	High	Potential loss of treatment and pumps/pressure
Distribution	Leaks on trunk main and distribution system	Microbial	5	3	15	High	Leaks are a potential source of microbial pathogens and contribute to high % of unaccounted for water

Risk assessment on the basis of expert judgement, using descriptors:

A more simple way to carry out the risk assessment is expert judgement by the WSP team. The WSP team adds descriptors to the applicable hazards:

- Significant: The risk is a priority, and should be considered further to determine whether additional control measures are required. Also, control measures already in place need to be validated.
- Uncertain: It is unsure if the event is a significant risk. Further studies are needed.
- Insignificant: It is not a priority.

1.4.2 Small Water Supplies

This learning module identifies two methods (varying in complexity) to assess the risks.

Descriptive risk assessment:
In this approach the hazards are prioritized on the basis of the judgement of the WSP team. Based on the significance of each risk the team can describe the risk for each hazards as significant, medium, insignificant or uncertain. The significance of each risk is based on the likelihood of the event to happen and how serious this may be.

- Significant:The risk is a priority. Actions need to be taken, and existing control measures need to be validated.
- Medium: It has currently no impact on drinking water safety, but it requires attention for the medium- and long-term.
- Insignificant: No action is needed at this time.
- Uncertain: It is unsure if the event is a significant risk. Further studies are needed.

Risk ranking:
Risk ranking is based on the same principles as the descriptive risk assessment, but uses a two-step approach. The WSP team scores the hazard on the basis of likelihood and severity/consequence:

Likelihood:

- Likely.
- Possible.
- Unlikely.

Severity/consequence:

- Major impact.
- Moderate impact.
- No/minor impact.

First the WSP team defines these different descriptors. Consequently the team, ranks all hazards on likelihood and severity/consequence.

The WHO guide for small supplies (WHO, 2012, p. 25) offers an example:

Table 7 Example matrix for risk ranking (WHO, 2012, p. 25)

		Severity/consequences		
		No/minor impact	*Moderate impact*	*Major impact*
Likelihood	*Likely*	Medium	High	High
	Possible	Low	Medium	High
	Unlikely	Low	Low	Medium

1.5 DEVELOPMENT OF MEASURES

The vulnerability of the system is assessed, hazards are defined and the risks are scored. The next step is to determine whether additional control measures are needed. The step 'development of measures' thus consists of two parts: identifying the exising control measures and validating their effectiveness; and develop additional control measures.

1.5.1 Large Water Supplies

- Identify the existing control measures.
- Validate the existing control measures.
- Develop table: risk, risk rating, existing control measure, efficacy of control measure.
- In light of the above, re-prioritize the risks.

Example of re-assessment and re-prioritization from WHO manual (Bartram, 2009, p. 47):

Table 8 Re-assessment and re-prioritization (Bartram, 2009, p 47)

Hazard	Hazardous event (source of hazard)	Likelihood	Severity	Score	Risk rating (see table 3.6)	Example control measure	Validation of control measure	Reassessment of risk post-control
Microbial	Low chlorine residual in distribution and reticulation systems	4	4	16	Very high	Set point designed to achieve established target chlorine residual to achieve microbial standards at consumer premises linked to alarms.	Alarms effective and demonstration of consistent removal of indicator organisms under range of operating conditions.	Low with appropriate operational monitoring.
Microbial	Power failure to disinfection plant	2	5	10	High	Dual power source.	Supplies confirmed to come from different generating sources. Automatic switching shown to be triggered under a range of operating conditions.	Low with appropriate operational monitoring.
Physical, chemical, microbial	Contamination of dosing chemicals or wrong chemical supplied and dosed	2	4	8	Medium	On-line monitoring controls. Laboratory analysis certificate from supplier.	Intensive audit of suppliers. Alarms triggered under a range of operating conditions.	Low with appropriate operational monitoring.
Chemical	Over or under dosing from fluoridation plants	3	3	9	Medium	Plants have alarms on high and low levels with dosing cut-offs on high levels.	Alarms triggered under a range of operating conditions.	Low with appropriate operational monitoring.
Chemical, physical	Over or under dosing of lime for pH correction	3	3	9	Medium	Plants have alarms on high and low pH with dosing cut-offs on high pH.	Alarms triggered under a range of operating conditions.	Low with appropriate operational monitoring.
Physical	Failure of pumps	4	3	12	High	Pressure measurement triggering back-up pumps. (Not in place.)	No controls in place.	High - priority for mitigation.
Chemical	Nitrate exceeds compliance standards	3	2	6	Medium	Blending with low-nitrate source from another water supply. (Alternative source itself has rising levels of nitrate and is subject to other demands.)	Unreliable long-term control.	Medium - keep trend under regular review and propose alternative mitigation scheme.

1.5.2 Small Water Supplies

- Identify the existing control measures.
- Validate the existing control measures.
- Develop table: risk, risk rating, existing control measure, efficacy of control measure.
- In light of the above, re-prioritize the risks.

The output can be a table of the possible hazards, the existing control measures, the likelihood and consequence, risk ranking and priority for action.

Consequently, the WSP team can define and review options to control the identified risks.

Example of risk assessment and prioritization from WHO manual for small supplies (WHO, 2012, p. 28):

Table 9 Risk assessment and prioritization (WHO, 2012, p. 28)

Drinking-water system component	Possible hazard	Hazardous event	Control measures	Likelihood	Consequence	Risk ranking	Priority for action
Catchment/ abstraction	Microbial pathogens	Cattle and sheep can access the well and the immediate area around it, which could result in animal faecal matter entering the water supply.	Unprotected well: no control measures in place (e.g. no fence, no wellhead protection works).	**Likely** *Justification:* Access of cattle and sheep frequently observed by community members; animal faeces are visible and can easily be washed into well after heavy rainfall.	**Major** *Justification:* Cattle and sheep faeces may contain a variety of pathogens, which may cause illness in the community.	**High**	**High priority** *Justification:* Hazardous event is likely to occur and has major consequences, and no control measures are in place. Short- and long-term measures are required.
Treatment	Microbial pathogens	Gravity-fed water supply continues to flow through the treatment works during power failures, but will not be disinfected.	Failsafe device fitted to the inlet of the treatment plant, which diverts the water if there is a power failure.	**Unlikely** *Justification:* Device confirmed to be effective during power failure, tested quarterly to ensure effectiveness.	**Major** *Justification:* Untreated source water is known to contain a variety of pathogens that may cause illness in the community.	**Medium**	**Attention required; low risk with appropriate operational monitoring** *Justification:* Exposure to microbial pathogens from the water supply is a major concern. Therefore, special attention should be given to maintaining the control measure with appropriate operational monitoring to ensure that the likelihood remains low.
Treatment	Chlorine overdose	Chlorine dosing can result in chlorine overdose if control is lost at the treatment plant.	Chlorine dosing is flow-paced to ensure consistent dosing; online chlorine analysers.	**Unlikely** *Justification:* Disinfection unit and online analyser confirmed to be effective.	**Moderate** *Justification:* Chlorine overdose can cause taste and odour problems.	**Low**	**No further action is needed; low risk with appropriate operational monitoring** *Justification:* Hazardous event is unlikely to occur and has moderate consequences, and existing control measures are adequate.
Storage and distribution	Microbial pathogens	Access to water storage tank could result in bird or other animal waste entering treated water.	Cover on water storage tank and vermin screening over vent piping, although cover has gaps.	**Likely** *Justification:* Birds and other small animals have been previously found in the storage tank; animal faeces are visible around the storage tank cover.	**Major** *Justification:* Bird and other animal faeces may contain a variety of pathogens that may cause illness in the community.	**High**	**High priority** *Justification:* Hazardous event is likely to occur and has major consequences, and existing control measure (cover) is inadequate.

1.6 THE WSP AS MANAGEMENT INSTRUMENT

The learning module offers guidance on how to develop a WSP and helps to review a WSP. Next to being a systematic approach for ensuring water safety, the WSP can be an instrument for the management of the water supply in the broadest sense.

The WSP assesses the risks and formulates control measures to manage these risks. An outcome of the WSP process could also be that the measure is to leave the abstraction site. The WSP thus helps in the deliberation and substantiation of the decision to either take measures at the source, to dilute or purify the water, or to leave the abstraction site. Furthermore, when leaving the abstraction site, the line of reasoning of a WSP could aid in finding a new location for abstraction.

Furthermore, a WSP has the potential to promote continuation and long-term vision. Through the Water Safety Plan risks and improvement needs are prioritized, and measures are identified for the short-, medium- and long-term. Furthermore, if a WSP is embedded in the day-to-day practice and integrated as a holistic management plan into routine systems operations, the WSP enhances the long-term vision for the water supply. Often the primary focus is on system assessment and improvement planning. However, to promote continuation attention to operational monitoring, verification, management procedures, supporting programmes and review is fundamental (WHO, 2017).

Having a Water Safety Plan in place for the water supply can help to leverage funds. The systematic process of assessing risks and identifying improvement needs makes that WSPs can help to substantiate requests for financial support. Investment needs are prioritized. The WSP approach shows good water supply practice and could show that funds are utilized effectively (WHO, 2017).

Related to the above is the potential of a WSP and the WSP approach to build trust among the public, stakeholders and government agencies that the water supplied is safe. The WSP could be used to show to the public how the quality of the water is managed and maintained. Furthermore, a WSP can lead to improved record keeping and data collection, which can as well enhance the public's trust. Also, the WSP approach requires collaboration within water supplies, which can enhance the communication and collaboration of stakeholders within a water supply and in this way contribute to trust.

1.7 EVALUATION LEARNING MODULE

The case study leaders have been asked to fill in a questionnaire asking whether a Water Safety Plan (or equivalent) is in place for their particular case (see chapter 2.2.). It was found that there was no water safety plan in place for the Greek case study.

Consequently, the learning module as displayed in Chapters 1.1 – 1.6, was carried out with the Greek case study leader on January 13, 2020. During this session the editors of this report and the Greek case study leader were present. The different steps of the learning module and the reality in Greece were discussed.

Following this exercise, the Greek case study leader, with involvement of relevant actors within the case study, evaluated this exercise and the learning module. The following paragraph displays the review by Greece of participating in this learning module. The lessons learned have been integrated in the learning module.

General comments on WSP learning module from the viewpoint of the Greek case study

A learning module on the main aspects of a WSP, incorporating a description of its goals, main characteristics and basic steps towards its design, is necessary and useful, especially for stakeholders (water authorities, consumers, farmers, academia and citizen groups) of agricultural areas. These areas in Greece, tend to exhibit the lowest population density, along with the most frequent and critical water hazards, while they also tend to reflect a society of greater citizen participation and local environmental awareness, as opposed to urban areas.

Based on the experience from our case study area and the special issues and problems faced by the local reality, we will try to comment on the learning module in a constructive way. The contents of the learning module and the line of thought are concise and easy to understand, while the main objectives and basic parts of a WSP necessary for its implementation are clear.

A first comment is on the selection of the current size of the water supply. This seems to be a subjective matter, which is left to the decision of the trainee/student and the water authority/area they serve. Most of the times the size of the water supply is signified by the water flow or by the number of people served in the area. Also it could be related to the entire area of the catchment. This could be a subjective issue, left to the decision of the trainee, since the learning module describes water supply systems of both sizes, big and small.

Another comment is that the module is created in a way that it is useful for all target groups related to the possible stakeholders. It could serve as an operating procedure for a water authority manager or for a member of the local water works facility, even for a citizen association. The terms are clear and easy to understand and it leaves the freedom to build on each of its main characteristics. The terms are not fairly technical so it could also serve as a dissemination tool for a water facility.

One of the thoughts coming to mind is that, although the module educates all kinds of stakeholders, implementation of a WSP, selection of measures, and final application is not always a matter of all stakeholders. In our case implementation is done by the regional water management authority and the ministry of environment. Therefore, only a small part of the WSP and its creation is actually related to all stakeholders.

A possible advantage of creating a WSP in our case study could be that, there is a general lack of trust from people and consumers to the state which provides the water. People are always anxious about the quality of their water and about the actions of the management authority towards maintaining its quality. Therefore, even at times of great financial insecurity, people have been pushing towards monitoring of the quality and finally getting water of good quality. Citizen participation in our case is vital an important since people voluntarily are a part of the process, including sometimes financing the water quality monitoring.

Another reality is that most of the times there is a quality problem, authorities tend to find another viable clean source or dilute the water with clean water. This is a fast solution, as long as there are clean water sources available nearby. The option of treating water and processing pollutants is far behind in the priorities. Therefore, in the part of control measures and water treatment, it could be a good idea to incorporate options including a) ways to find viable new sources, b) accepted maximum dilution ratios, c) a way to continue monitoring the old source and either provide a treatment solution in middle term or to provide financing options and links to funding sources for the regional authorities to pursue. This way we address the problem of “continuation” of actions in Greece, which is the major problem of implementation. We tend to easily forget long-term problems when an easy and cheap solution emerges. In long-term this costs more in the state budget. Also this is not sustainable since we are going to run out of clean water sources. An operating procedure for abandoned sources of water and their possible way to treat are an important part of a WSP.

Also in the risk assessment of vulnerabilities, we could provide three levels of urgency, all related to the level of pollutants in the source. Immediate for those surpassing the MAC of the legislation, middle term for those that are in levels that bring unrest and need to be addressed soon (treatment, or change of source) and long-term (old sources with pollutants and their possible clean-up with treatment options that need time and funding).

From the point of view of a student of the learning module (e.g. water consumer and participant in the local board and farmer) I would say that the module regarding the small water systems is clear and easy to understand. I would certainly use most of its parts, except for the technical ones regarding the description of the geology and hydrology of the area, or the exact amount and age of abstraction facilities. Also I could not be able to prioritize the risks in order of urgency, without the education necessary for that. Other than that, it could be useful for me to understand all the problems faced by my regional water catchment area and it would help me to adjust my farming techniques and overall awareness, since I would be now part of the WSP and the holistic scheme of the water that I drink.

From the point of view of the regional water officer, this learning module is extremely useful and easy to understand. The only problems would be that in Greece most of the water facilities have already assigned outside consulting agencies to form WSPs and I am not sure of the real participation of water management employees in the WSP creating process. Nevertheless, this could be an opportunity for them to understand the whole WSP idea and to provide better information to the agencies. Another problem could be that WSPs are not following a certain template although implementation and legislation follows a very strict procedure. So again the assignment of certain quantification to risks in each case is subjective and it could lead to problems in implementation between different areas. It could be nice to have a standard operating procedure to assign quantifiable risks to all areas in Greece.

ANNEX 4: QUESTIONNAIRE

Please distinguish between large, small and very small supplies if different processes exist.

1. Case study.

2. Could you describe the water supplies in your case study area (size, type, year of establishment, capacity, location, organization, large/small etc.).

Register of water supplies:

3. Is a register of the water supplies (location, type, ownership every water supply) kept and maintained?

4. How is the information gathered for the register? Who are involved?

5. Are small and very small supplies registered?

6. What kind of records are kept in the register? Does this differ whether the supply is large or small?

Risk Assessment/Management and Water Safety Plan:

7. Is risk assessment and management for drinking water supplies embedded in national legislation? If yes, how? Does this apply to large, small and very small water supplies?

8. Is there an agreed methodology for the task of risk assessment and reporting the outcomes?

- If yes, could you share with us what it entails?
- What form does it have (e.g. national guidance document, electronic tool, technical standard)?
- Who is responsible for this methodology?
- Who are the stakeholders for whom this is meant?
- How is this disseminated to the stakeholders?
- How is this adapted to the local context?

9. How are operators of (very) small supplies capacitated? (e.g. training programs, guidance materials, regional/national support centers, regional and national networks for cooperation, communication platforms…).

10. Is the vulnerability of very small supplies known? Do the users of these very small supplies have information on the vulnerability of their supply?

11. What is the goal of RA/RM in your case study? (e.g. ensuring long-term protection, informing when to leave an abstraction site and move to another, informing where to start an abstraction site etc.)

12. Do the water supplies in your case study area have a Water Safety Plan or similar RA / RM plan?

If not:

13. What are the considerations for not having a Water Safety Plan?

If yes:

14. What are the elements that make up the WSP? (if possible, could you share with us a translated version of the content page?) .

15. In some cases the WSP elements are divided over multiple plans. Please note for the following WSP activities if it is carried out, and in what plans and processes it is embedded:

- Describe the water supply system.
- Assess the vulnerability of the water supply.
- Identify hazards and hazardous events.
- Assess the risks.
- Determine and validate control measures, reassess and prioritize the risks.

16. What method and information is used to assess the vulnerability of abstractions?

17. What method and information is used to identify the hazards?

18. What method is used to assess the risks from the identified hazards and vulnerability?

19. In what way are the measures determined?

20. How does the WSP (process) contribute to the goal of RA/RM as mentioned in question 11.

Roles and responsibilities

21. Who is responsible to keep and maintain a register of the water supplies (location, type, ownership every water supply regardless of size)?

22. Who is responsible for risk assessing a water supply?

23. Who is responsible for developing a Water Safety Plan?

24. Are there supplies without professional management (such as those owned by household, landowner, collective)? If yes, who is responsible for risk assessing the water supply?

25. Are stakeholders involved in RA/RM or the WSP process? If yes, who are the stakeholders? And how are they involved? What is their role?

26. Are local communities involved in RA/RM or the WSP process? If yes, how? And what is their role?

27. Could you give an overview of the actors involved in RA/RM / Water Safety Planning? Please indicate their roles and responsibilities.

Communication and Awareness

28. What is being done in the field of communication and awareness on groundwater quality?

29. Who is responsible for communication and awareness raising on groundwater quality?

30. To whom is this communication and awareness raising directed?

Evaluating the used approach:

31. In what way is the WSP adapted to the local context?

32. What were/are the barriers to successful WSP development and implementation?

33. What were/are the enablers for successful WSP development and implementation?

34. What are the strengths of the WSP and the used approach?

35. What are the weaknesses of the WSP and the used approach?

36. What are the lessons learned?