

Resources of groundwater, harmonized at Cross-Border and Pan-European Scale

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#### **EXECUTIVE SUMMARY**

This deliverable describes the progress made towards the criteria for harmonisation over the Dutch-Flemish-German border in the work package H3O-PLUS. This particular work package of the project builds further on previous cross-border initiatives where the first step - 3D harmonization of the extension and depths of shallow and deep aquitards and aquifers – has already been accomplished. The work package takes the harmonization a step further, developing common standards to harmonize data on hydraulic properties, groundwater quality, groundwater age, hydraulic heads, groundwater fluxes and depletion patterns, This deliverable describes the outcomes of Task 3.1 s, which sets common criteria for this further harmonization, analyzing and re-interpreting tools and methods that have been applied previously on both sides of the bordering regions and countries.





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## **1 EXECUTIVE SUMMARY**

The present document is deliverable D3.1 " Report describing the criteria set for cross-border harmonisation of groundwater data" of the project RESOURCE: "RESOURCEs of groundwater, harmonized at Cross-Border and Pan-European Scale".



Figure 1 Overall structure of the RESOURCE project

The RESOURCE project aims at demonstrating the potentials of the harmonization of information about Europe's groundwater resources through cross-border demonstrations projects, through harmonized characterization approaches for Karst and Chalk aquifers and through a first information product at Pan-European scale where available data is compiled and integrated to produce a map of the fresh groundwater resources of Europe. The set of deliverables of the RESOURCE project will provide good practices in providing harmonized data and information across borders for assessments of the 3D structure of aquifers, the water volumes available, and the water fluxes and water quality of the resource. Harmonization of such hydrogeological information is a prerequisite for any transboundary groundwater management. A range of regional and national stakeholders are currently involved in the work in order to ensure both interaction with authorities that manage and protect groundwater resources and end-users. The RESOURCE project maximizes the dissemination of the results and provide stakeholders and end-users with easy-access tools through the cooperation with the GeoERA Information Platform Project, jointly prioritizing the information products that are most beneficial for society. The information products to be delivered will serve as a first prototype example of information to be accessible within a Geological Service for Europe.

This deliverable describes the progress made towards the criteria for harmonisation over the Ducth-Flemish-German border in the work package H3O-PLUS. This particular work package of the project builds further on previous cross-border initiatives where the first step - 3D harmonization of the extension and depths of shallow and deep aquitards and aquifers – has already been accomplished. The work package takes the harmonization a step further, developing common standards to harmonize data on hydraulic properties, groundwater quality, groundwater age, hydraulic heads, groundwater





fluxes and depletion patterns, This deliverable describes the outcomes of Task 3.1 s, which sets common criteria for this further harmonization, analyzing and re-interpreting tools and methods that have been applied previously on both sides of the bordering regions and countries.





## 2 INTRODUCTION

This document summarizes the results of 'Task 3.1-Harmonization criteria' of WP3 "H3O-PLUS" of the RESOURCE project. The overall motivation for the RESOURCE project is that only limited data on hydrogeology and groundwater are available at EU scale, besides the IHME maps (International Hydrogeological Map of Europe 1:1,500,000<sup>1</sup>), but these contain only limited information (e.g. only 2D) and do therefore not enable more complex hydrogeological assessments such as the calculation of water balances. The general rationale of the project is that the harmonization of (hydro)geological information and harmonized 3D characterization of aquifers and aquitards is a prerequisite for transboundary groundwater management.

The RESOURCE project is built around 4 technical work packages (Figure 1), two of them relating to cross-border demonstration projects (WP3 and 4), one consisting of a methodological demonstration project on Karst and Chalk aquifers (WP5) and one pan-EU mapping effort (WP6). One additional work package is directed to creating a strong link with the Information Platform Activity (GIP) under GeoERA and includes tasks for dissemination and communication of the project results (WP2). Coordination of the work is done in WP1.



Figure 1: Overall structure of the resource project

The two cross-border demonstration projects may set a new standard for harmonization across borders, not only for hydrostratigraphy but also for hydrological data such as groundwater heads and groundwater quality. The intention is to find similarities and differences of approaches tested and needed in the two areas and to use the mutual inspiration for harmonizing the project deliverables and to use it as learning material for further harmonization at the larger EU scale and intermediate supra-national scales.

The H3O-PLUS work package (WP3) aims to be an advanced demonstration of a transboundary assessment of groundwater resources. It is 'advanced' in the sense that it builds on and extends previous work, trying to make it more useful for groundwater policy and management and for

<sup>1</sup> 

https://www.bgr.bund.de/EN/Themen/Wasser/Projekte/laufend/Beratung/Ihme1500/ihme1500\_projektbesch r\_en.html





subsurface spatial planning. A 3D hydrogeological model has been developed in a series of so called 'H3O' projects in the transboundary region around the Roer Valley Graben, comprising parts of Germany, the Netherlands and Belgium. The model contains 3D maps of the top, base and thickness of aquifers and aquitards (*Figure 2*). H3O-PLUS aims to add attribute data to these maps to facilitate the use of the maps in decision making processes. Note that the project does not aim to produce new maps or spatial delineations. The objective is to characterize units on existing maps and hence support the interpretation and use of those existing maps.



Figure 2: Example of an existing 3D geological model in the H3O-PLUS project area

This document is the first step towards this aim. It should be considered as a methodological document. It describes the 'harmonization criteria' that will guide future work in tasks 3.2 (hydraulic properties of aquifers and aquitards), 3.3 (groundwater quality and age distributions), 3.4 (volumes, water balances, recharge, discharge) and 3.5 (groundwater depletion patterns). The objective is to set common criteria for the cross-border harmonization of these attribute data. The harmonization will not start from scratch but will build on existing experience and practice by analyzing and reinterpreting tools and methods that have been applied previously in the study area.

This document discusses some methodological issues that are relevant for all considered tasks (3.2, 3.3, 3.4 and 3.5) and specifies the scope, expected outcome and approach ('harmonization criteria': what the harmonization entails and how it will be attained) for each of those tasks. It thus contains the starting points for the methodology sections in later task reports of tasks 3.2 to 3.5. Parts of that text may be repeated and/or reworked in those reports. This documents ends with a preliminary outline of the way project results can be interpreted and disclosed for real-world applications in groundwater protection and management in the transboundary region.

Figure 3 gives an overview of the planning of the project.





				2	018								20	19											20	20								20	21		
		Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun
	Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36
3.1	Harmonisation criteria			ws	\$			PR						PR																							
2.2	Harmonisation of hydraulic properties																																				
3.2	of aquifers and aquitards													ws				PR								PR											
2.2	Harmonisation of groundwater quality																																				
3.3	and age distributions													ws				PR								PR											
24	Harmonisation of volumes, water																																				
3.4	balances and re- and discharge fluxes													ws				PR								PR											
2.5	Cross-border patterns of groundwater																																				
3.5	depletion													ws				PR								PR											
2.0	Cross-border protection and																																				
3.0	management strategies																																				

Duration of task Prelimenary activities	WS = workshop PR = progress report
Deliverables:	
Report	
Database	
Database and 3D visualization	
Database and 3D maps	

Figure 3: Planning of tasks and deliverables in the H3O-PLUS project





# **3 GENERAL METHODOLOGICAL ISSUES AND CONCERNS**

## **3.1** Delineation of the study area

The overall study area coincides with the study areas of previous H3O projects (*Figure 4*). For most topics, the entire study area will be covered. For others, the analysis might be limited to part(s) of the overall study area because of practical concerns. In the last case the extent of the study area and the motivation for choosing that area will be explained in the methodology section of that topic.



Figure 4: Study areas of previous H3O projects (note the label "Roerdalslenk" can be translated to "Roer Valley Graben")

#### 3.2 Vertical delineation

Vertically, the study is limited to the clastic (hydro)geological layers of Cenozoic age or younger. This coincides with the vertical scope of the recently developed transboundary 3D





(hydro)geological models of the H3O projects. The base of the models is thus located at the top of the Chalk aquifer (Formation of Houthem or Maastricht) or the top of the Carboniferous deposits.

Appendices 1, 2 and 3 show the correlation tables that have been made in earlier H3O projects to establish a relation between existing hydrogeological units in different countries. The units mentioned in these tables will form the basic units for the data that will be gathered in the RESOURCE project: all attribute data that will be inventoried will relate to one or a group of units of these tables.

#### 3.3 Coordinate system

Because there is only point data involved, transformation between coordinate systems is relatively easy to carry out. It seems therefore logical to add coordinates from the system used in all partner countries: the Netherlands (RD), Belgium (Lambert) and Germany (UTM). However, the GIP uses another coordinate system. The question is whether it is better (1) to store the data in the EU coordinate system used by the GIP and then transfer to local systems or (2) to use local coordinates and later transfer these to the ones used in the GIP. The advantage of using local systems is that these are the ones that our stakeholders use. The advantage of using the EU system is that only one system is used in the entire transboundary area.

The only coordinate system that is used in all H3O projects is that from the Netherlands (RD). Therefore, it is logical to use this as a common system during the H3O-PLUS project. Another reason for choosing RD is that the visualization tool for water quality data of TNO works with RD. Water quality data of other regions will be built in in this tool during H3O-PLUS.

The Dutch partner, TNO, is responsible for transforming coordinates in WP3 to RD of all data that are shared by the project partners. All shared GIS data should thus at least contain RD coordinates. The final result should be published in UTM coordinates. Transformation to UTM coordinates will be carried out at the end of the project.

The reference level for elevation will also be based on the system that is used in the Netherlands (NAP). Belgian data will be provided to TNO in m TAW and TNO is responsible for converting this to NAP level. For exchange with Germany, no conversion is required as the offset with the Netherlands is only one centimeter (Figure 5).







Figure 5: Datum offsets (cm) between national vertical reference frames and EVRF2007 (after http://www.euref.eu/documentation/Tutorial2015/t-04-01-Liebsch.pdf).





## 4 TASK-SPECIFIC ANALYSIS

## 4.1 Harmonization of hydraulic properties

The second task of WP3 (3.2) aims to add information on hydraulic properties to the H3O model. The format of the 'database' is an excel sheet.

The <u>procedure for data collection</u> of hydraulic properties is as follows: a first round of data gathering based on an initial template developed by one project partner (TNO) was completed before the WP3 meeting in February 2019. It was discussed during that meeting, focusing on the structure of the data sheet (Which fields are useful? Which are less useful? Which data are lacking?) rather than on the collected data content. The discussion lead to several modifications of the sheet. A second round of data gathering - with an adjusted sheet – will be performed mid 2019. As soon as all data are collected, the range of values for the same hydrogeological unit and parameter (but provided by different partners) will be analyzed. If the parameters are within the same order of magnitude, they can be used directly in H3O-PLUS. If there are important differences for a given hydrogeological unit, the data should be interpreted in more detail to assess the reason for the difference and the way it should be dealt with in H3O-PLUS.

Regarding the <u>faults</u>, there is a link with the GeoERA project HIKE, which aims to make a generic database of faults (e.g. not 3D) based on the input from project partners. HIKE will not store data about hydraulic properties of faults directly, but might include links to literature about that topic. So HIKE will not provide data to RESOURCE, but data from RESOURCE might be imported in HIKE. Furthermore, there is also a link with the GeoERA project VoGERA, in which two pilot studies are addressing the hydraulic functioning of Roer Valley Graben faults (Rauw Fault and Peel Boundary Fault) (down to 600m). At the stakeholder workshop, the drinking water sector expressed specific interest in hydraulic properties of faults.

The <u>entire study area</u> will be considered in terms of hydraulic properties, including all H3O project areas.

Which <u>hydrogeological units</u> should be considered? In any case, it is not the intention to go deeper than the units that were modelled in 3D within the H3O projects. Units can also be grouped vertically. This will be decided while making the inventory.

Concerning the <u>considered parameters</u>: hydraulic conductivity is the most important, but transmissivity, resistance and porosity might also be considered. However transmissivity and resistance can be deducted from hydraulic conductivity and (saturated) thickness of the units. Also important to consider is the way the parameters are derived (cores, regional estimates, ...), the number of measurements/data points and the scale at which they can be used.

We intend to produce a table mentioning (ranges of) parameter values for each (group of) hydrogeological unit(s) that is (are) distinguished in the H3O models. That table can provide information about regional differences and trends in parameter values which could be used for making maps, but it is explicitly NOT the objective of H3O-PLUS to produce such maps. Instead, the goal is to gather data from different regions and explain cross-border differences in inventoried parameter value ranges should they occur.





How can the <u>spatial variation</u> in parameter values be recorded in the database in a more simple way without making new maps? One option is to distinguish between values for different H3O subregions. This is a practical way to deal with spatial variation. It would also solve the problem with the lack of unique correspondence for the Kieseloolite Formation between the H3O units and the hydrogeological code of Flanders (HCOV) (which is unique within a H3O subregion). Which boundaries should be taken for the subregions? There is some overlap between H3O subregions: between ROSE and Roer Valley Graben (here we take the Meuse as boundary) and between De Kempen and Roer Valley Graben. However, the overlap is small. If the overlapping region would contain parameter values, then these will be used for both regions.

A field 'known spatial trends' will be added to the excel where we keep descriptive information about spatial variations in parameter values within the region.

We discussed whether <u>metadata should be included</u> in the excel table: literature source, method (type of test, type of interpretation, ...), ... This seems to be difficult, because one parameter range can be derived from different literature sources. A comment field is included in the excel table where arguments (and literature sources) can be inserted for setting the range to certain values (see further).

A distinction is made between the 'absolute' min-max <u>range</u> that includes the extremes (at the stakeholder workshop, some people argued against throwing away 'extreme' data) that can be found in literature and the 'likely' range that a modeler or other expert would use. Here, we add a 'representative' value that we would recommend to use. A field will be added to the excel table to write a <u>motivation</u> for using certain parameter values as a 'likely' or 'extreme' range or as representative. This might become lengthy and difficult to handle, so later on we might change the way we keep that info depending on how it works out in practice.

Furthermore, should a distinction be made between the uncertainty on properties of aquifers (usually smaller uncertainty) and aquitards (usually larger uncertainty) and the way we deal with that in setting the range? It could be argued that it does not make sense to mention 'representative values' for aquitards with very uncertain characteristics. In that case, one should leave the 'representative value' column blank.

Information about <u>thickness of layers</u> can be derived from the H3O models, so it is not really necessary to include this in the excel file. It might however be insightful to include a histogram of thickness values, eventually a separate graph per H3O subregion. If feasible, the histograms will be included in a (digital) appendix to the report of 3.2.

The <u>'Lithofacies'</u> column is often difficult to complete because lithology shows a significant spatial variation. It is possible to include info about the spatial variation in that column (text field). However, partners are requested not to extend too much on this topic, because it is at the limit of the scope of our project.

The excel table with the completed list of attribute data is the output of task 3.2 of our project and this will be provided to the GeoERA GIP. The H3O models are needed to use these data but it is not our task to deliver this to the GIP.

In the proposal for Task 3.2, it was also proposed to assess the resistance of aquitards based on the analysis of the correlations between groundwater head series above and below clay layers. This is methodological research that will be handled in a later phase of the project (detail of the analysis depends on available time).





## 4.2 Groundwater quality and groundwater age

A Dutch groundwater quality tool is under construction where transects of groundwater quality data can be visualized. It is also possible to select a formation and make plots of water quality (e.g. boxplot, frequency plots) per formation. The objective is to feed this system with Flemish and German data. In this way, a tool will be set up to visualize cross-border variation in groundwater quality.

The visualization tool offers a 'static' view on groundwater quality, showing average concentrations. Time series and trends are not considered, only average properties. That implies that exchange of data via webservices to get the most actual data is not required. We need to export the validated water quality data from German and Flemish databases and import these into the tool. There is no continuous update of data needed.

The considered <u>study area</u> is the entire H3O project area. In vertical direction all H3O model units will be considered.

The <u>considered parameters</u> encompass macro-chemistry but trace metals might also be included. Derived information e.g. water type and redox class could also be considered. TNO will make a list of mandatory and optional parameters. In case of problems with (differences in) definitions of parameters by different partners arise when collecting and merging the data these issues will be solved ad hoc.

There are some automatic <u>data quality checks</u> in the tool: ion balance, pH versus Al, pH vs Zn, pH vs Cd, pH vs Cu, pH vs Ni, pH vs As and Fe vs NO3 (to be incorporated). These checks are at the level of the individual sample. Users of the tool will be able to choose whether or not the less reliable data are shown.

When reading each dataset, a number of automatic checks are performed by the tool:

- Check on mandatory metadata (coordinates, well name, screen number, screen depths, sampling date)
- consistency checks (coordinates, surface level, screen depths)
- screen depths checks (screen depths below surface levels, top screen above bottom screen)
- duplicates (same well-screen-date)

These checks are also performed when merging datasets from different stakeholders.

Besides, each project partners has its own data validation procedure. A comparison of these procedures will be made later on in the project.

Concerning <u>data availability</u> by the project partners:

- In Germany, a water quality database is available, but this is not managed by GD NRW. The owner of the data does not allow the publication of raw data but, it is possible to include the data in the tool and show processed (averaged) info.
- In Flanders, all data collected by VMM are publicly available and downloadable at dov.vlaanderen.be, even the raw data can be found there.
- Groundwater quality data provided by SCK can be disclosed as averaged data in the tool, but the underlying raw data should not be accessible for end-users.
- At the stakeholder workshop, the Flemish drinking water comparny agreed to provide groundwater quality data if the raw data are not disclosed.
- In the Netherlands, groundwater data are publicly available and downloadable at dinoloket.nl. More recent data are available at the provinces.





Concerning <u>groundwater age</u>, data from isotope analysis are available at TNO and some local measurements are also available at SCK. The question is whether ages determined by flowpath modelling can be useful here. We will make an inventory of the approaches used for age determination by the project partners and summarize the results of these analyses. In task 3.6, we can then analyze how these data are used in the regions for policy support.

The topic of groundwater age is also part of the GeoERA 'HOVER' project. In that project, groundwater age data of several GeoERA partners will be collected. It is not clear yet how in the HOVER project the data will be gathered. Therefore, we will start to think independently about our own approach and will adjust our method so that it fits with the HOVER methodology as soon as more info is available. Most probably, there will be differences in approach between HOVER and RESOURCE given the scale and problem setting: our transboundary study will most probably work with more detailed data than the EU scale assessment of HOVER.

#### 4.3 Volumes, fluxes, balances, trends

In this task, the entire H3O area is considered.

<u>Considered variables</u>: water fluxes and ages (how does age distribution change when pumping increases/decreases?).

Two approaches can be followed:

- Approach 1: Based on the H3O model, the total volume of water per aquifer and aquitard can be estimated, based on some assumptions of the hydraulic properties of these layers (porosity, eventually also groundwater level).
- Approach 2: There are several groundwater flow models available for the study region. We could use these models to estimate the volumes, fluxes and balances.

Assessing differences between these two approaches could be interesting.

Calculations should ideally be made with groundwater flow models (approach 2). Only existing models will be used. There is no model that covers the entire project area. So we will have to use multiple models. It is not feasible in the timeframe and budget of this project to make a new model. If multiple models are available, a pragmatic approach will be followed e.g. define units where you want to know balances and fluxes and then examine whether there are differences in calculated fluxes. If so, look for possible reasons. Theoretically, it would be better to first compare the model structure, but this is less likely to deliver useful results within the timeframe of the project.

At the stakeholder workshop, an inventory of large-scale models that overlap with the study region was made. Model owners will be asked to assess the fluxes/balances/ages that are envisaged in this task, e.g. fluxes through clay layers with their models. The selection of models and variables wstill has to be made. If this is completed, the spatial distribution of the modelled fluxes and ages will be assessed and an interpretation of their uniformity will be made. Groundwater volumes and extraction rates will also be calculated.

At the stakeholder workshop, a third approach was proposed: why not make a simple, conceptual model of the entire project area? This is not that much work, only a little more complex than approach 1 (calculations based on H3O model). It was also emphasized that fluxes are more (or at least as) important for practical questions than the volumes. Volumes are only a starting point. The H3O model is not well suited for assessing fluxes.





### 4.4 Depletion patterns

The term 'depletion' patterns in the project proposal is too limited. The study not only considers regions with declined heads, but aims to map trends in groundwater heads in a more general way. The trends can be downward or upward or absent.

The tools for analyzing groundwater head time series will be harmonized, for a consistent cross border determination of the trends. A first step towards this goal was the organization of an expert meeting, which was hosted by SCK·CEN in Mol on 16<sup>th</sup> May 2019. Experts from the involved regions presented the groundwater head data that are available in their region and the methods that are typically used for assessing trends.

A short report of the expert workshop can be found in appendix 4.

The second step will be the selection of groundwater head time series that represent the major dynamics of the groundwater system. Criteria will be established to select these series from the existing databases. At the expert meeting, some preliminary criteria and questions that still need to be answered were formulated:

- o Can we define a minimum measurement frequency ?
  - Twice a year may be enough for some areas (for example for areas without seasonal fluctuations)
- Can we define a minimum measurement period? (and then taking into account the whole time series)
- Only monitoring sites which are still active should be considered
- Screen-depth should not cross different H3O-units

For the selected series, trend assessments will be available from the methods used by the responsible organization. Where possible, these will be complemented by trend assessments with one or more methods used by the partners.

This will aid the comparison of trend assessment methods used in the Netherlands, Germany and Flanders. Based on this comparison, harmonized trends will be determined. Preliminary output will include maps (point-based) with the meteorological response and/or residuals, data about land use change and an interpretation of abstraction data. Also, the trends will be mapped.

#### 4.5 Link with groundwater policy and management

This analysis will be limited to themes not covered by HOVER: no discussion of threshold values and qualitative status and trend assessment, but focus on groundwater protection, link with drinking water policy and quantitative status.

Two groups of stakeholders can be distinguished:

- EU and other international institutions
- Local or regional organizations that are responsible for one or more water management aspects in different parts of the project area: water boards, drinking water companies, local authorities responsible for groundwater pumping licenses etc.





Whereas the first group is mainly interested in the general approach and methods used in H3O-PLUS, the second group is primarily interested in practical applications of the H3O-PLUS approach and the concrete results.

Stakeholder meetings that are part of WP3 are oriented towards the second group. The first stakeholder workshop is organized on the 17<sup>th</sup> of June 2019 in Maastricht.

The notes and discussions of the stakeholder meeting can be found in appendix 5.

At the stakeholder workshop in Maastricht, the following policy topics were put forward:

- Licensing of abstractons
- Licensing of geotermal projects
- Protection zones

The approaches of the partner regions to these policy topics will be assessed and compared.

#### Who must be involved in this comparison?

In <u>the Netherlands</u> the provinces are responsible for groundwater protection. The Ministry of Infrastructure and Waterworks (I&W) gives the national point of view. For some abstractions the Ministry of Econimics Affairs is responsible.

In <u>Gemany</u> the communities are responsible for the small abstractions. The 'Bezirksregierung' carry out the groundwater protection policy of the Ministry. For geothermal questions it depends on the depth. For deep the mining authority, otherwise the local authority must be involved.

In Flanders, VMM advise the province and the Ministry.

Also the <u>drinking water companies</u> must be involved: de Watergroep, WML, Brabant Water and , if possible, the german drinking water supply companies (many small companies). Although they don't make policies, we must also take their point of view into account.

VMM will compile a list of contact persons for each of the three identified topics (abstractions, geothermal, protection). Each of the contact persons will be asked to send information regarding the topic (how it is handled in their region) to VMM and VMM will compare and summarize that information. Based on that comparison and summary, a discussion will be organised with the contact persons of the themes. These meetings will either be organised per theme (if contact persons are different) or for a combination of themes (in case the contact persons are the same). We can start this process in autumn 2019 (gathering information), so that the meetings and discussions can be organised in 2020.

Next to the discussion of the three themes, this tasks also deals with how the results of other tasks can be used in policy and for other practical questions.

#### How to proceed?

In each case, there will be a stakeholder workshop at the end of the project (mid 2021). The stakeholders would like to have an additional mid-term meeting (June 2020).





# APPENDIX I : CENOZOIC CORRELATION CHART FOR PROJECT H30 – ROER VALLEY GRABEN (ROERDALSLENK)

Correlation table H3O-Roerdalslenk van de geologische en hydrogeologische modeleenheden (Deckers et al., 2014)

Nederlandse stratigrafische eenheld (formatie - laagpakket)	Nederlandse hydrogeologische eenheld (cf. REGIS II.2)	Viaamse stratigrafische eenheid (formatie - lid)			Viaamse hydrogeologische eenheid	(cf. HCOV kartering)	Resultaat: H3O Modeleenheid Geologisch model	Resultaat: H3O Modeleenheid Hydrogeologisch model
Antropogeen - opgebrachte grond	HL-c	(Antropogeen)		0110		Ophogingen	HL	HL-0
Bostel - Singraven		Singraven		0140	1	Allustale deklanen		
Bostal - Schimmart	BYSC-8-1			0140		Andreite Genergen		BYCC k.t
Dure - Strimmen	BX-z-2	Bouwel + Hechtel + Wildert			0151+0152	Zandige deklagen		BX-z-2
Boxtel - Liemode	BX-k-1 BXI M-k-1	Kinrool / Molenbeersel B		0150	0152+0153	Zand-lemige deklagen + Lemige deklagen	Boxtel	BX-k-1 BXI M-k-1
	BX-z-3	Dilsen			0151	Zandige deklagen	i i i i i i i i i i i i i i i i i i i	BX-z-3
Boxtel - Best	BX-8-2	Kinrool / Molenbeersel A	0100		0152+0153	Zand-lemige deklagen + Lemige deklagen		BX-8-2
Boxtel ongedifferentleerd	BX-z-4	herwerkt Maas-Rijn		-	0151	Zandige deklagen		BX-z-4
	HL-C	Leut (Hepppeneert + Mutern)		0140		Altimale deklagen	HL	HL-C
	86-2-1	Lankiaar / Stokkem + Geistingen		1	01/3	Arzetungen Maasvakte		BE-2-1
	DC-R-1	Kinrool / Molenbeersel B + A						BC-K-1
Beegden ongedifferentieerd	BE-z-2	Lanklaar / Maasmechelen + Elsden			0172	Afzettingen Tussenterrassen		BE-z-2
a constant of geometre intervo	BE-k-2						Beegden	BE-k-2
		Lanklaar / ouder grind		0170	0172	Afzettingen Tussenterrassen		
	BE-z-3	Zutendaal Zutendaal - Winterslag						BE-z-3
	ST-z-1	Sterksel - Lommel			0171	Afzettingen Hoofdterras		ST-z-1
Sterksel ongedifferentieerd	ST-8-1	Sterksel - Hamont					Sterksel	ST-k-1
	ST-z-2	Sterksel - Bocholt						ST-z-2
	SY-2-1							SY-2-1
	SY-K-1	Manufacture in the second				Teadles suchaid being de Demosion		SY-II-1
Stramproy ongedifferentleerd	SY-2-2	kiel)		0210	0211	Likiel	Stramproy	SY-z-2
	ST-8-2							ST-1-2 CV-3-3
	ST-2-5							SY-4-3
	SY-7-4							SY-7-4
	PZWA-z-1			<u> </u>		1		PZWA-z-1
	WA-k-1							WA-k-1
	PZWA-z-2							PZWA-z-2
Waaire ongedifferentieerd	WA-k-2						Waalre	WA-k-2
	PZWA-z-3							PZWA-z-3
	WA-k-3							WA-k-3
	PZWA-z-4	Kempen Groep		0220	0221-0223	Klei-zand-complex van de Kempen		PZWA-z-4
	MS-z-1							
	MS-IK-1							
Maassluis	MS-Z-2						Maassiuls	MS-z
	MS-C MS-k-2							
	MS-z-3		0200					
Klezeloöllet - onbenoemd	KI-z-1		t	<u> </u>		1		KI-z-1
	Ki-k-1	Klezeloöllet - Jagersborg (vanaf Reuver- klei)						K0-Ik-1
Viendefillet Revereive	KI-z-2							KI-z-2
Nezeooner - Brunssum	KI-k-2	Klezeloöllet - Brunssum I		0210	0212	Brunssum I-kiel	KlazaloAllat	KI-k-2
	KI-z-3	Klezeloöllet - Pey		0210	0213	Zand van Pey	Kiezeloollet	KI-z-3
	KI-k-3	Klezeloöllet - Brunssum II			0214	Brunssum II-kiel		KI-Ik-3
	KI-z-4	Klezeloöllet - Waubach						KI-z-4
Kiezeloöllet - Waubach	KI-k-4				0215	Zand van Waubach		KI- <b>k</b> -4
	KI-z-5		•	<u> </u>	I			KI-2-5
Oosterhout	00-2-1 + 00-2-2	zie bufferzone					Oosterhout	00-2-1 + 00-2-2
	00-c IE-z-1			0210/0230	0234/0215	Zand van Poederiee en/of zandige top van Kasteriee of Zand van Wardsch		00-c IE-z-1
Inden ongedifferentleerd	IE-k-1	the second second second second second				e	Inden	IE-k-1
	IE-z-2	Inden (+ herwerkt Breda) (nieuw)						IE-z-2
	IE-k-2							IE-k-2
	E-z-3							E-z-3





# APPENDIX II: CENOZOIC CORRELATION CHART FOR PROJECT H30 – DE KEMPEN

Correlatietabel H3O-De Kempen van de geologische en hydrogeologische modeleenheden (Vernes et al., 2018)

Nederlandse stratigrafische eenheld (formatie - laagpakket)	Nederlandse hydrogeologische eenheld (cf. REGIS II v2.2)	Vlaamse stratigrafische eenheid (formatie - lid)	Из	amee hydr	ogeologisci	he eenheid (cf. Meyus et al., 2000)	Resultaat: H3O Itthostratigrafie	Resultaat: H30 hydrogeologie
Antropogeen - opgebrachte grond	He	(Antropogeen)		D110	1.5	Ophogingen	Antropogeen - opgebrachte grond	HZ
Boxtel - Singraven		(Singraven)		0140	at a	Aluvale deklagen	Baxtel - Singraven	100
Boxtel - Kootwijk	8962	Hechtel - Kaimthout		3	0151	Zandige deklagen	Boxte - Kootwijk	814-1
Boxtei - Wierden / Boxtei - Delwijnen		Gent - Wildert		Ranov	0151	Zandige deklagen	Boxtel - Wierden / Boxtel - Delwijnen	ore.
Boxtel - Llempde	EXLMI:1	Gent - Sint-Lenaarts	0100	0150	0152 + 0153	Zand-ternige deklagen + Lernige deklagen	Boxte - Liempde	EXLMR1
Bautal - Baut	BALS BAD				1	4	Doutel - Dest	8723
Boutel - conscillatorilianti	EXec.	Complex up Meet / theraetit Mast - Dini		3	0151	Zandice deltanen	Boutei - montferentinenti	8/74
Conc. orgenneenseers	8721	position and access premerie made in the	-	0	0101	in the beneget	Conc. a geanerancera	8721
Stensel - orgedifferentieerd	STk1	Sterksel - ongedifferenteerd		0170	0171	Afzettingen Hoofdterras	Sterksel - ongedifferentieerd	STk1
and the state state of the	8Tz2	Alteres contractor and a second		100 C	230424	Sector States and Sector States		8Tz2
	SYz1			8 - X				8Yz1
Stramony - consel Securit seri	SYKI	Davais + Mai castin (Strangenti)		0720	0222	Zanduan Mai	Channess - constituent and	1378
Construction of generative construction	6124 GVF2	rance - nor period program (			000000		biblighty organizations	0144
	8Yz3			6 6	13			SYz3
	PZWAz1	- T		5 11 5	1. 2	1		PZWAz1
	WAL1	Weeide		0220	0221-0223	Kiel van Turnhout + 2and van Beerse + Kiel van Bilteromei		WAR1
1200 22 2 2	PZWAz2			0.000		The Maringhe Made		PZWAz2
Waare - ongediterenceerd	WAR2	Maie		to the second			Waare - orgeofferencieerd	WAR2
	P2WAz3	Metispias		0230	0231	Zanden van Brasschalat ervof Merksplas		PZWAz3
	WAK3		-			00		WAR3
	MR21			1	an Xi	100		Mart
1000000	MER1	F.		, X	$-\mathcal{E}$	<u>36</u>		MSk1
Maassiuls	MSz2	Markenian	1	"Sales"	0724	Tandan yas Brazarhant anist Madaging	Maas sluts	M8z2
and the first of the second	M8#2	Mexspas		0230	0231	tanon var brasschaat ever mensplas		MSk2
Manufallation and an article	M8z3	Lilio - ongeditierentieerd		2	0233/0234	Zandige top van Ulio / Zand van	Manager Mind	M8z3
Kiezelooilet - onbenoemo	521	<i>k k k k k k k k k k</i>		0 - M - 0	6.2		Nezelopilet - onbendemo	NZ1
Klezelodilet - Brunssum	Kip2	14.64	0200	6622565	0.00535	1000000000	Klezeloðiet - Brunssum	Kb2
	K82	Moi	0200	0230	0232	Zand van Mol		KR2
Klezeloöllet - Walibach	Kiz3						Klezeloðilet - Waubach	Kbz3
	0021	1		z = T = z	1.3	1		00z1
Oosterhout - Wouw	OOk1			0340	0241	Kielig dee van Lilo en/drvan de overgang Lilo-Kattendijk	2000 A00 A	OOk1
	00±2	Lilo - ongediferentieerd + Poedetee +		s - 5	( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( ) ( )	Zand van Katiendik en/of onderste	Oostemout	0022
Oostehout - orgedifferentieerd	OOc	Kattendijk + Kasteriee (zand)		0230 / 250	0234 / 251	zandiaag van Lilio / Zand van Poederiee		00:
	A CONTRACTOR OF			a - 3		en/of zandige top van Kasteriee		a second s
Breda - ongedifferentieerd	Net gedefinieerd	Kasterlee (kiel)		0240	0342	en of zandige top van Rasteriee Kelige overgang tussen de zanden van Kasteriee en Diest	Kastetee (kiel)	842
Breda - ongedifferentieerd	Net gedefinieerd	Kasteriee (kiel) Diest		0240	0242	Nelige overgang tussen de zanden van Kasterier en Diest Zand van Diest	Kasteree (kiel) Dest	842 852
Breda - ongedifferentieerd Breda - Vrijherentierg	Net gedefinieerd BRz2	Kasteriee (kiel) Dest Berchem / Bolderberg - Oenk		0.340	0242 0252	en d'izandige top van Kasteriee Koelge overgang tussen de zanden van Kasteriee en Diest Zand van Diest	Kasteriee (kiel) Dest Viljherenberg	8042 8052 0254
Breda - ongedifferentieerd Breda - Vrijherenberg Breda - Hetsenberg	Net gedefiniteend BRz2 BRz3	Kasteriec (kiel) Dest Berchem / Boldetkerg - Cenk Bolderberg - Cenk		0240	0242 0252 0253 + 0254	en of zandige top van Kasteree Kelige overgang tussen de zanden van Kasteriee en Diest Zand van Diest Zand van Bolderberg + Zanden van	Kasterice (kiel) Dest. Vitjhereberg Bolderberg - Cenk	0042 0052 0054 0053
Breda - ongedifferentikerri Breda - Vrijherenberg Breda - Hetsenberg Breda - Kakert	Net gedefinieerd BRz2 BRz3 BRz4	Kasterier (kiel) Diest Berchem / Bolderberg - Cenk Bolderberg - Cenk Berchem / Bolderberg - Houthalen		0.240	0242 0252 0253 + 0254	en of zanage top van Katoene Noelge overgang tussen de zanden van Katoene en Diest Zand van Beste Zand van Besterberg + Zanden van Berchem en/of Voort	Kasteneo (kiej) Dest Villjhersbog Boldeberg - Cenk Boldeberg - Houthalen	1042 0552 0354 0253 0253
Breds - ongedifferentieerd Breds - Vrijherenberg Breds - Hetsenberg Breds - Kakert Veidhoven - Someren	Net gedefinieerd BRz2 BRz3 BRz4 VEBOc	Kasterter (klet) Dett Berchern / Bolderberg - Cenk Bolderberg - Cenk Berchern / Bolderberg - Houthalen Voort - Somern		0340	0242 0252 0253 + 0254 0254	en of zanage top van Kaberee Neige overgang tussen ée zanden van Kaberee en Dest Zand van Bolesterg - Zanden van Berthem en of Voort Zanden van Berchem en of Voort	Kastetee (kie) Diest. Virijherenberg Bioldenberg - Cenk Bioldenberg - Houthalen Voort - Someren	0252 0254 0259 0253 0253 0253
Breda - ongedförentikend Breda - Vitjkremberg Breda - Hetashberg Breda - Hetashberg Breda - Kalvert Veldhoven - Kol van Vedhoven	Net gedefnicend BRz2 BRz3 BRz4 VESOC VEWIX1	Kasterbe (kier) Dest Berchem / Boldenbeg - Cenk Berchem / Boldenbeg - Cenk Berchem / Boldenberg - Houthalen Voor - Someren Voor - Venhoven		0340	0242 0252 0253 + 0254 0254 0255	en of zandge top van katterie Nelige vergang tassen de zanden van Katierie en Diest Zand van Dest Zand van Dest Berchem en of Vanden van Berchem en of Vanden Zanden van Berchem en of Vand Kiel van Veldioven	Kastener (kiel) Dest Vrijnernberg Bolderberg - Cerrk Bolderberg - Houthaen Voort - Vesthoem	002 0152 0254 0253 0253 0253 0255 0255
Brode - ongedifferntikend Brode - Vrijverntikend Brode - Hetsenberg Brode - Hetsenberg Vedinoen - Kol kan Vedinoen Vedinoen - Kol kan Vedinoen	Net gedefnieerd BRz2 BRz3 BRz4 VE80c VEWh1 VEV0c	Kasterter (klot) Dest Beschem / Bolderberg - Cenk Bolderberg - Cenk Beschem / Bolderberg - Houthalen Voor - Vesthoven Voor - Voort - Voort		0340	0342 0252 0253 + 0254 0254 0255 0254 0255	en of zandje top en Automet Neige overgand basen de zanden ven Kauterte en Diest Zand ven Diest Zand ven Boleteterg + Janden ven Berchem erviol Voort Zande ven Berchem erviol Voort Kiel ver Vedhoen Zander ven Berchem erviol Voort	Kasterier (kiej) Dest. Vitjerenberg Boldeberg - Clenk Boldeberg - Houthalen Voort - Velitionen Voort - Velitionen Voort - Voort	0042 0054 0054 0053 0053 0055 0055 0055
Breds - ongedifferentieerd Breds - Vitjherentierg Breds - Hetsenberg Breds - Kaket Veidhoven - Kole van Veidhoven Veidhoven - Kole van Veidhoven Veidhoven - Kole van Veidhoven Rugel - Steensel	Net gedefinitiend BRx2 BRx3 VESoc VEWIN1 VEV/oc Ru21	Kasterter (klet) Deat Berchem / Boldenberg - Genk Berchem / Boldenberg - Cenk Berchem / Boldenberg - Houthalen Voort - Soneen Voort - Soneen Voort - Voort Eigensten Boort - Boeretano		0340	0242 0252 0253 + 0254 0255 0254 0255 0256 0351	en of zandje tou en aktierte Neilige wenging latsen de zanden van Kantere en Dest Zand van Boderterg + Zanden van Berchem evid Voort Zanden van Berchem ervid Voort Nie van Veldroen Zanden van Berchem ervid Voort Zander van Berchem mit Voort Zander van Berchem mit Voort Zander van Berchem mit Voort	Kasterlee (kiel) Dest Vitjhersnberg Bolderberg - Clerk Bolderberg - Houthalen Voort - Vieldhoven Voort - Vieldhoven Voort - Vieldhoven Bond - Scentare	052 055 055 055 055 055 055 055 055 055
Ereda - orgedifferenticend     Ereda - Vrijherenberg     Ereda - Vrijherenberg     Ereda - Heitzenberg     Veldhoen - Somern     Veldhoen - Kol en Veldhoen     Veldhoen - Kol en     Veldhoen - Kol en     Veldhoen - Kol en	Net gedefnieerd BR22 BR23 BR24 VF8.0c VF9.0c VEW11 VEV0c RU21 BBCC	Kasterter (kiel) Drett Berchem / Soldetberg - Cank Berchem / Boldetberg - Houthalen Voort - Someren Voort - Vedhoven Voort - Vedhoven Voort - Vedhoven Boorn - Boretang Boorn - Boretang Boorn - Putte		0340	0242 0252 0253 + 0254 0255 0254 0255 0254 0256 0256 0301 0302	en of zandje too van Auderne Neilieg overgrand, basen de zanden van Kauterie en Diest. Zand van Diest. Zand van Botterberg + Zanden van Berchem en/of Voort Zander van Berchem en/of Voort Reg dee van Eigenblazen Neilig dee van Eigenblazen	Kastener (kiel) Dest Vitjherenker Boldetreg - Cerk Voor - Somern Voor - Veldhoen Voor - Veldhoen Boon - Somern Boon - Somerang Boon - Futte	0242 0252 0254 0253 0253 0255 0255 0255 0255 0255 0255
Binds - ongediffernitiend Binds - Vitjeenblorg Binds - Hetserberg Binds - Hetserberg Binds - Hatert Verdhoen - Kont Verdhoen - Kont Rupel - Sternet Rupel - Rupel kind	Net gedefnieerd BR23 BR23 BR24 VES02 VEWIR1 VEV02 RUE1 RUE081	Kasterter (klet) Dest Berchem / Bolderberg - Cenik Bolderberg - Cenik Berchem / Bolderberg - Houthafen Voort - Sonteen Voort - Sonteen Voort - Sonteen Boort - Floretage Boort - Floretagen	0300	0240	0242 0252 0253 + 0254 0255 0254 0256 0301 0301 0302 0303	en of zandje top en Autorne Keller overgang harsen de zanden van Kauterise en Diest Zand van Bolett Zand van Boletsteg + Janden van Berchem evid Voort Zanden van Berchem evid Voort Xiel van Veldioven Zanden van Berchem evid Voort Zande van Berchem evid Voort Zande van Berchem evid Voort Xiel van Eugenbizen Kiel van Betre Kiel van Betre	Kasterier (klaj) Detri Bokierberg - Genk Bokierberg - Houtvalen Voort - Vietkoven Voort - Vietkoven Voort - Vietkoven Boon - Flute Boon - Flute Boon - Flute Boon - Flute	025 025 025 025 025 025 025 025 025 025
Breda - orgedifferentieerd     Breda - Vrijherenberg     Breda - Vrijherenberg     Breda - Hestenberg     Breda - Hestenberg     Vedhoen - Sommen     Vedhoen - Koll an Vedhoen     Vedhoen - Koll an Vedhoen     Repel - Rupel Ned     Rupel - Rupel Ned     Breda - Rupel Ned	Net gedefnieerd BR22 BR23 BR24 VESOC VEWR1 VEVOC RUE1 RUBOK1	Kasterbe (kiel) Dest Berchem / Solderberg - Carik Beichem / Bolderberg - Carik Berchem / Bolderberg - Houthalen Voort - Nordhoven Voort - Vieldhoven Voort - Vieldhoven Soorn - Boretang Boorn - Putte Boorn - Petteg-Voar	0300	0240 0250 7	0242 0252 0253 + 0254 0255 0255 0255 0256 0301 0302 0303 0304 0303	en of zandje too en Actiente Netige overgreg hasen de zanden van Kauterte en Diest. Zand van Diest. Zand van Botterberg + Zanden van Berchem eriof Voort Zanden van Berchem eriof Voort Rie van Veldboern Zanden van Berchem eriof Voort Rie van Berchem eriof Voort Rie van Berchem eriof Voort Kei gede van Egenblaam Kei og Bester Net van Fertagen Kei van Fertagen	Kasteriere (kiel) Dest Vitjherenkong Bokierberg - Cerk Bokierberg - Heuthalen Voort - Songern Voort - Voort Boorn - Boerenkong Boorn - Betreger Boorn - Tenagen Boorn - Tenagen	0242 0252 0254 0253 0253 0255 0255 0255 0255 0256 0256 0201 0201 0200 0200 0200
Binda - ongedifferntikend     Binda - Vrijherntikend     Binda - Vrijherntikend     Binda - Hattanberg     Binda - Hattanberg     Binda - Katkert     Vedincen - Konrent     Vedincen - Konrent     Vedincen - Voort     Rupel - Sternet     Rupel - Rupel I kle     Rupel - Vessem	Net gedefnieerd BRz2 BRz3 BRz4 VESOc VEVOc VEVOC RUE1 RUECk 1 RUE2	Kasterter (kiel) Dest Berchern / Bolderberg - Cenk Bolderberg - Cenk Berchern / Bolderberg - Husthalen Voor - Voort Voor - Voort Voor - Voort Boon - Seretang Boon - Puite Boon - Puite Boon - Perlage Blaan - Berg Blaan - Berg Blaan - Berg	0300	0340 0250 / 0430	0342 0252 0253 + 0254 0255 0254 0255 0354 0355 0354 0301 0302 0303 0304 0304 0304	en of zandje top en Automete Nelige overgand basen de zanden van Kauteree en Diest. Zand van Diest Zand van Betritten en of Voort Zander van Betritten Nelige da Betriet Nelige Betriet Nei en Filler Nei en Betriet Nei en Tetragen Nei en Betriet Sand van Betriet Zander van Betriet Nei en Betriet	Kasteriere (kiej) Dest. Vitjhersnoeg Boldeberg - Clerk Boldeberg - Clerk Voor - Somern Voor - Viethoen Boon - Somern Boon - Somern Boon - Filde Boon - Filde	0042 0252 0254 0253 0253 0255 0255 0255 0255 0255 0255
Breds - ongedifferentieerd Breds - Vrijveenberg Breds - Vrijveenberg Breds - Katker Veidnoen - Katker Veidnoen - Voort Veidnoen - Voort Rupel - Steensel Rupel - Rupel I tiel Rupel - Rupel I tiel Rupel - Vessem Tongeren - Kilmmen	Net gedetnieerd BR22 BR23 BR24 VESOc VEVOC RUE1 RUECk 1 RUECk 1	Kasterie (kie) Dest Berchen / Bolderberg - Oenk Berchen / Bolderberg - Oenk Berchen / Bolderberg - Houthalen Voor - Noneen Voor - Voorboen Voor - Voorboen Voor - Voorboen Boon - Tenngen Boon - Tenngen Boon - Tenngen Boon - Tenngen Boon - Tenngen Boon - Tenngen Boon - Tenngen	0300	0240 0250 / 0430 0450	0342 0252 0253 + 0254 0254 0254 0255 0254 0255 0254 0255 0254 0254	en of zandje tou en Addente Neilje overgand tasen de zanden van Kasterke en Dest Zand van Bodetsey + Zanden van Berchem ervior Voort Zande van Berchem ervior Voort Xiel van Veldoven Zande van Berchem ervior Voort Zande van Berchem ervior Voort Zande van Berchem ervior Voort Neilig de van Eigenblaan Keil van Betsel-Vlaas Xoal van Besel-Vlaas Zand van Besel-Vlaas Zand van Besel-Vlaas	Kasteler (kiel) Dest Vitjherenorg Boisterberg - Cerrk Boisterberg - Houthalen Voort - Someren Voort - Vesthoen Voort - Vesthoen Boorn - Boerster Boorn - Boerster Boorn - Berster-Vaan Boorn - Berster-Vaan Boorn - Berster-Vaan Bilter - Berg Sint-Huiterscha-Hem - Neerspen Sint-Huiterscha-Hem -	0042 0052 0054 0053 0055 0054 0055 0055 0050 0050
Einda - ongedifferentieerd     Einda - Vrijherenberg     Einda - Vrijherenberg     Einda - Kakert     Veldhoen - Someren     Veldhoen - Kole en Veldhoen     Veldhoen - Kole en     Veldhoen - Kole en     Veldhoen - Kole en     Rupel - Rupel Niel     Rupel - Rupel Niel     Rupel - Rupel Niel     Rupel - Vessem     Tongeran - Kölmmen	Net gedefnieerd           BR23           BR24           VF8/00           VES/00           RUE/01           RUE/01           RUE/02           TOp2	Kasterber (klef) Dest Berchem / Soldetberg - Cark Berchem / Boldetberg - Houthalen Voort - Visidhoven Voort - Visidhoven Voort - Visidhoven Voort - Visidhoven Voort - Visidhoven Boom - Rotten Boom - Rotten Boom - Pattee Boom - Pattee Boom - Betsee Voors Blaten - Betsee Voors Blaten - Betsee Voors	0300	0340 0250 / 0430 0450	0342 0253 + 0254 0253 + 0254 0255 0255 0255 0255 0256 0301 0302 0303 0303 0303 0303 0303 0303	en of zandje too en Actiente Neilie overgreit hasen de zanden van Kauterte en Diest. Zand van Diest Zand van Betritem en/of Voort Zander van Betritem Neilig det van Eigenstizen Neilig det van Eigenstizen Neilig det van Eigenstizen Neilig det van Eigenstizen Neilig det van Eigenstizen Xand van Betrij Zand van Betrij Zand van Betrij Zand van Betrij	Kastener (kiel) Dest Vijherenorg Boldetrorg - Gerik Boldetrorg - Huchtaen Voort - Somern Voort - Veldhoen Voort - Veldhoen Boon - Somerang Boon - Flutte Boon - Somerang Boon - S	0042 0252 0254 0253 0253 0254 0255 0255 0255 0255 0255 0255 0255
Binds - ongediffernitiend     Binds - Vrijvernitiend     Binds - Vrijvernitieng     Binds - Kakert     Vedinoen - Kol en Vedinoen     Vedinoen - Vont     Rupel - Sternee     Rupel - Rupel hie     Rupel - Rupel hie     Rupel - Rupel - Rupel hie     Rupel - Rupel - Rupel hie     Rupel hie	Net gedefnieerd BR23 BR24 VE60c VEWh1 VEV0c RUE1 RUE1 RUE2 T0z2	Kasterter (kiel) Dest Berchem / Bolderberg - Cenk Beloeberg - Cenk Beloeberg - Cenk Berchem / Bolderberg - Houthalen Voor - Voortown Beloe - Voortown Beloe - State -	0300	0340 0250 / 0430 0450 0450	0342 0253 + 0254 0254 0254 0254 0254 0254 0254 0254	en of zandje tou en Akterne Neige overgan basen de zanden van Kauterse en Dest Zand van Otest Zand van Besterne ervlof Voort Zander van Besterne ervlof Voort Reis van Besterne Keis van Besterne Keis van Besterne Keis van Besterne Xander van Bester Zander van Bester Zander van Bester Zander van Bester Zander van Bester	Kasteriere (kiej) Dest. Vitjnersnerg Boldeberg - Clerk Boldeberg - Clerk Voort - Veldhoen Voort - Veldhoen Voort - Veldhoen Boorn - Fuller Boorn - Fuller Sint-Hultrecht - Hen Commercht - Fuller Boorn - Fuller Sint-Hultrecht - Hen Commerchen	0042 0252 0253 0253 0253 0255 0255 0255 025
Breda - ongedifferentieerd     Breda - Vrijherenberg     Breda - Vrijherenberg     Breda - Hetsenberg     Breda - Hetsenberg     Verdhoven - Sommern     Verdhoven - Koll an Verdhoven     Verdhoven - Koll an Verdhoven     Verdhoven - Koll an Verdhoven     Rupel - Rupel Net     Rupel - Rupel Net     Rupel - Rupel Net     Tongersn - Kölmmen     Tongersn - Kölmmen	Net gedefnieerd           BR22           BR23           BR24           VES0c           VEV0c           RUE0t           RUE0t           T0z3           T0z3	Kasterbe (kiel) Dest Berchem / Boldetberg - Carik Beichem / Boldetberg - Carik Berchem / Boldetberg - Houthalen Voort - Nordhoven Voort - Vieldhoven Voort - Vieldhoven Voort - Vieldhoven Boom - Berteg Boom - Berteg Boom - Betteg-Vielan Boom - Betteg-Vielan Bint-Hultercharken - Netmoen Bint-Hultercharken - Netmoen Bint-Hultercharken - Netmoen Bint-Hultercharken - Netmoen Bint-Hultercharken - States	0300	0240 0250 7 0450 0450 0450	0342 0253 + 0254 0254 0254 0254 0256 0301 0302 0303 0304 0303 0304 0452 0453	en of zandje too en Aktiente Vielige overgreg hasten de zanden van Kauterte en Diest Zand van Diest Zand van Betchem evid Voort Zander van Betchem evid Voort Keig des van Egenbizen Keig des van Egenbizen Keig des van Egenbizen Keig des van Egenbizen Keig des van Egenbizen Zand van Bette Vier van Tertagen Zand van Better Zand van Better Reig zanz van Betserekin Bettoor Augementdenen	Kasteriere (kiel) Dest Vitjkeenkoig Bokierberg - Gerik Bokierberg - Heuthalen Voort - Sonsren Voort - Velstoven Boorn - Boerstag Boorn - Bette Boorn - Fitte Boorn - Fitte	0242 0252 0254 0253 0253 0255 0255 0255 0255 0255 0255
Einste - ongestifferentiserd     Einste - Vrijherenberg     Einste - Vrijherenberg     Einste - Hextenberg     Einste - Kakert     Vetaflowen - Kommen     Vetaflowen - Koll win Vetaflowen     Vetaflowen - Voort     Rupel - Rupel - Rupel     Rupel - Rupel Inte     Rupel - Rupel Inte     Rupel - Rupel Inte     Rupel - Rupel - Rupel Inte     Rupel - Vessem     Tongeren - Rubenet     Tongeren - Assister - Basterdete     Dongen - Asse	Net gedefnieerd           BRx2           BRx3           BRx4           VE80x           VEV0x           RU21           RU21           RU22           T0x2           T0x3           DOX41	Kasterter (kiel) Dest Berchern / Solidetterg - Cank Belothern / Solidetterg - Cank Berchern / Boldetterg - Houfhalen Voor - Northourn Voor - Viethourn Voor - Viethourn Voor - Viethourn Boom - Bertagen Boom - Bertagen Boom - Bettere Voor Bitten - Bettere Voor	0300	0240 0250 7 0430 0450 0450 7	0342 0252 0253 + 0254 0255 0255 0255 0255 0255 0255 0255	en of zandje top van Akterne Neilige overgrund haard e zanden van Kauteree en Diest. Zand van Diest Zand van Boterberg + Zanden van Berchem evid Voort Zanden van Berchem evid Voort Zanden van Berchem Nei van Pertreen Nei van Pertreen Xei van Pertreen Zand van Berge Zand van Berge	Kasteriere (kiej) Dest. Vitjhersnöerg Boldstorg - Oenk Boldstorg - Neutraen Voor - Somern Voor - Viethoon Voor - Viethoon Boon - Soersan Boon - Seetaan Boon - Seetaan Boon - Seetaan Boon - Feltagen Boon - Feltagen Boon - Feltagen Boon - Feltagen Boon - Feltagen Boon - Feltagen Boon - Seetaan Bitter - Berg Sint-Huitsechts-Hem - Koempon Zeitste - Bastonoise Zeitste - Bastonoise	0042 0252 0254 0253 0253 0255 0255 0255 0255 0255 0255
Breda - ongedifferentieerd     Breda - Vrijherentieerg     Breda - Vrijherentierg     Breda - Kattert     Veldhoen - Sommen     Veldhoen - Kommen     Veldhoen - Kol an Vedhoen     Vedhoen - Kol an Vedhoen     Rupel - Rupel kiel     Rupel kie	Net gedetnizerd           BR2           BR23           BR24           VF8/00           VES/00           VEV00           RUEV0           RUE01           RUE01           T0x2           D0x1           D0x51	Kasterier (kier) Dest Berchem / Boldenberg - Cenk Berchem / Boldenberg - Cenk Berchem / Boldenberg - Houthalen Voor - Voorkoven Voor - Voorkoven Voor - Voorkoven Boorn - Boretang Boorn - Buite Boorn - Brite Boorn - Brite Bellaen - Serg Sint-Hulter-Citra - Nearopen Beiten - Serg Sint-Hulter-Citra - Nearopen Beiten - Serg Sint-Hulter-Citra - Nearopen Beiten - Serg Sint-Hulter-Citra - Nearopen Beiten - Serg Sint-Hulter-Citra - Nearopen Beiter - Serg Sint-Hulter-Citra - Searopen Beiter - Serg Sint-Hulter-Citra - Nearopen Beiter - Serg Sint-Hulter-Citra - Nearopen Beiter - Serg Sint-Hulter-Citra - Nearopen Beiter - Searopen	0300	0240 0250 7 0430 0450 0450 7 0450 7 0510	0342 0252 0253 + 0254 0254 0254 0254 0254 0254 0254 0254	en of zandje too en Actiente Vielige overgreg lasen de zanden van Kauterke en Diest. Zand van Diest. Zand van Botterberg + Zanden van Berchem evid Voort Zanden van Berchem evid Voort Kiel van Vieldboen Zanden van Berchem evid Voort Kiel goes van Eigenbizen Kiel goes van Eigenbizen Kiel goes van Eigenbizen Kiel van Tertagen Zand van Berchem evid Voort Kiel goes van Eigenbizen Kiel van Tertagen Zand van Berchemen Zand van Bietroek Eigenbizen Zand van Bietroek Eigenbizen Zand van Bietroek Eigenbizen Zand van Ritubroek Eistroon Anjatardispteen Vangezthereideed Zand van Veennet	Kasterier (kiel) Dest Vitjherenkong Bokierberg - Clerk Bokierberg - Heuthaden Voort - Sonneen Voort - Voors Boon - Boeren Boon - Boeren Boon - Beeren Boon - Temagen Boon -	0042 0252 0253 0253 0253 0254 0255 0255 0255 0255 0255 0255 0255
Einda - ongedifferentieerd     Einda - Vrijherenberg     Einda - Kakert     Veidheen - Somern     Veidheen - Somern     Veidheen - Kie en Veidhoen     Veidheen - Kie en Veidhoen     Veidheen - Kie en Veidhoen     Rupel - Rupel I.I.el     Rupel - Rupel I.I.el     Rupel - Rupel I.I.el     Rupel - Rupel I.I.el     Rupel - State - Balsonek     Tongersn - Asse	Net gedefnieerd           BR24           BR24           VF80c           VF80c           RU2           RU2           RU2           RU2           T0c2           T0c3           D0c41           D0c41	Kasterber (klief) Dest Berchern / Soldetberg - Carik Beichern / Soldetberg - Carik Berchern / Boldetberg - Houthalen Voort - Verdhoven Voort - Verdhoven Voort - Verdhoven Voort - Verdhoven Voort - Verdhoven Boom - Ruite Boom - Ruite Boom - Ruite Boom - Ruite Boom - Betsee Waas Bitteh - Betsee Waas Bitteh - Betsee Waas Bitteh - Betsee Waas Bitteh - Betsee Vaas Bitteh - Betsee Vaas Bitteh - Betsee Vaas Bitteh - Betsee Vaas	0300	0340 0250 / 0430 0450 0450 / 0450 / 0450	0342 0252 0253 + 0254 0254 0254 0255 0301 0302 0303 0303 0303 0303 0303 0303	en of zandje too van Akterne Neilje overgrad haard e zanden van Kastlerete en Diest. Zand van Diest Zand van Besthem en of Voort Zand van Besthem en of Voort Zand van Besthem en of Voort Zand van Besthem en of Voort Risker van Besthem en of Voort Zand van Besthem en of Voort Zand van Besthem en of Voort Risker van Besthem Nei van Fette Nei van Fette Nei van Fette Zand van Bester Zand van Bester Zand van Bester Zand van Bester Zand van Bester Betroen Aufwartstreen Jand van Kester Zand van Bester Betroen Aufwartstreen Jand van Vermie Zand van Vermie Zand van Vermie	Kasteriere (kiel) Dest Vitjherending Bokiesterg - Cenk Bokiesterg - Neutraen Voor - Velstvoen Voor - Velstvoen Voor - Velstvoen Boon - Boeren Boon - Fulge Boon - Sersee-Waas Bitter- Sing Sint-Huitzecks-Hen - Grinnertingen Zetaste - Ruisbrock Zetaste - Busseeride Makagen - Vermmel Lote	0042 0252 0254 0253 0255 0255 0255 0255 0255 0255 0255
Breds - orgedifferenticerd     Breds - Vrijherenticerg     Breds - Vrijherenticerg     Breds - Kalkert     Veldhoven - Sommern     Veldhoven - Sommern     Veldhoven - Vord     Rupel - Rupel kile     Dongent - Attabe - Rationek     Tongent - Attabe - Rationek     Dongen - Asse     Dongen - Snussel	Net gedetniserd           BR2           BR23           BR24           VES.0c           VEV0c           Rut1           RU22           T0c2           D0c45x1	Kasterie (kie) Dest Berchem / Boldenberg - Cenk Berchem / Boldenberg - Cenk Berchem / Boldenberg - Houthalen Voor - Northoven Voor - Voorthoven Voor - Voorthoven Voor - Voorthoven Boom - Bercerto Boom - Bercerto Bioth- Tempen Boom - Bercerto Bioth-Hulter, them - Neemsen Bint-Hulter, them - Neemsen Bint-Hulter, them - Neemsen Bint-Hulter, them - Orthmetingen Baster, Bistopole	0300	0240 0250 / 0430 0450 / 0450 / 0510 0552	0342 0253 + 0254 0253 + 0254 0256 0356 0356 0356 0356 0356 0356 0356 03	en of zandje too en Acklerie Vielige overgrund basen de zanden van Kauterke en Diest Zand van Dest Zand van Bestehen van Berchem word Voort Zanden van Berchem vorVoort Kiel van Vieldboen Zanden van Berchem vorVoort Kiel van Vieldboen Kiel van Berchem vorVoort Kiel van Digerbizen Kiel van Berchem vorVoort Kiel van Digerbizen Kiel van Berchem vorVoort Kiel van Digerbizen Kiel van Berchem vorVoort Kiel van Berchem vorVoort Kiel van Berchem Digerbizen Digerbizen Zand van Berchem Zand van Berchem Gragestreenbeed Zand van Berchem Zand van Berchem Zand van Berchem Zand van Berchem Zand van Berchem Zand van Kernenel Zand van Veenmel Zand van Veenmel	Kasterier (kiel) Dest Vitjherenorg Bolisterberg - Clerik Bolderberg - Kuthalen Voort - Someren Voort - Someren Voort - Vesthoven Boom - Bolen Boom - Berenevban Boom - Berenev	0042 0152 0154 0153 0153 0155 0155 0155 0155 0155 0155
Ereda - ongedifferentieerd     Breda - Vrijherenberg     Breda - Vrijherenberg     Breda - Kakert     Veldhoen - Sommern     Veldhoen - Kommern     Veldhoen - Kole an Veldhoen     Veldhoen - Kole an     Tongern - Rusei Niel     Tongern - Asse     Dongen - Asse     Dongen - Blussel	Net gedefnieerd           BR23           BR24           VES/0c           VES/0c           VEV/0c           RUE/0           RUE/0           RUE/0           TOE2           DOASK1           DOa2	Kasterber (klef) Dest Berchem / Boldetberg - Cark Berchem / Boldetberg - Cark Berchem / Boldetberg - Houthalen Voor - Northowen Voor - Vieldhowen Voor - Vieldhowen Voor - Vieldhowen Boom - Rottee Boom - Rottee Boom - Rottee Boom - Pittee Boom - Pittee Boom - Pittee Boom - Pittee Boom - Betsee-Voas Bitter - Betsee-Voas Bitter - Betsee-Voas Bitter - Geogetherstee Maddgem - Wiendel Boose Bitter - Basseel Bitter - Bitter - Boose	0300	0250 0250 / 0450 0450 / 0450 / 0510 0540	0242 0252 0253 + 0254 0254 0254 0254 0254 0254 0301 0303 0303 0304 0451 0453 0445 0453 0445 0453 0453 0453 0453	en of zandje too en Aktiente Keilge overgreit jasen de zanden van Kastierte en Diest. Zand van Diest. Zand van Botterberg + Zanden van Berchem eviof Voort Zander van Berchem eviof Voort Zander van Berchem Kei van Tertagen Kei van Tertagen Xeit van Tertagen Zand van Bestel Vlaas Zand van Bestel Zand van Be	Kasteriere (kiel) Dest Vitjherenkeg Bolderberg - Cerk i Bolderberg - Hukthalen Voort - Voort Voort - Veldhoven Voort - Veldhoven Boom - Storetang Boom - Filde Boom - Storetang Destate - Fildende Destate - Statework Metalgeen - Wermel Boosel Boosel Boosel Boosel Boosel Boosel Centonge-Vierscle	0242 0252 0254 0253 0253 0255 0255 0255 0255 0255 0255
Einste - ongestifferentikeerd      Einste - Vrijfwerenberg      Binste - Vrijfwerenberg      Binste - Kakkert      Vetafweren - Somment      Vetafweren - Koll war Verdahouen      Vetafwere - Voort      Rupel - Rupel Inte      Ruper - Sommen      Tongeren - Soltiene - Ruponet      Tongeren - Soltiene - Ruponet      Dongern - Asse      Dongen - Bussel	Net gedefnieerd BR22 BR23 BR24 VE80c VEV0c Ru21 Ru80k1 Ru22 T0x2 T0x2 D0x1 D0x3k1 D0x22	Kasterter (klot)  Dest Bechen / Solidetbeg - Cank Belother / Solidetbeg - Cank Belother / Solidetbeg - Cank Bechen / Boldetbeg - Cank Bechen / Boldetbeg - Huthalen Voor - Verthoven Voor - Verthoven Voor - Verthoven Boom - Putte Boom - Research Boom - Research Bood - Betroe-Waas Bitten - Serge Boom - Betroe-Waas Bitten - Serge Boom - Betroe-Waas Bitten - Serge Bood - Betroe-Waas Bitten - Serge Maldagen - ongeditterstleerd Maldagen - Versnel Lack Brussel Centbrugge-Vierzele Gentbrugge-Pitten	0300	0240 0250 7 0430 0450 0450 7 0510 0520 7	0342 0252 0253 + 0254 0254 0254 0254 0254 0254 0254 0254	en of zandje top en Aktiente Neilige overgrad, basen de zanden van Kauteree en Diest. Zand van Diest Zand van Boterberg + Zanden van Berchem ervid Voort Zanden van Berchem ervid Voort Zanden van Berchem Neilig van Patrie Nei van Tertagen Xei van Ferder Zand van Berge Zand van Gergen Zand van Berge Zand van Berge Zand van Gergen Zand van Gergen Zand van Bergen Zand van Gergen Zand van Bergen Zand van Gergen Zand van Bergen Zand van Bergen Zand van Bergen Zand van Bergen Zand van Gergen Zand van Bergen Zand van Bergen Zan	Kasteriere (kiej) Dest. Vitjhersnörg - Boldstorg - Olenk Boldstorsg - Neutralen Visor - Somstein Visor - Visitivoen Visor - Visitivoen Boon - Boerstein Boon - Boerstein Boon - Bettere - Boon - Bettere - Bettere - Onnwertingen Zeaate - Bastonole Naldegen - Wennel Lake Brussel Centbrugge-Vileracie Centbrugge-Vileracie	0042 0252 0254 0253 0253 0255 0255 0256 0256 0207 0207 0207 0207 0207 0207 0207 020
Breda - ongedifferentieerd     Breda - Vrijherentieerd     Breda - Vrijherentierg     Breda - Kastert     Veldhoen - Sommern     Veldhoen - Kole an Veldhoen     Veldhoen - Kole an Veldhoen     Vedhoen - Kole an Veldhoen     Rupel - Rupel kild     Rupel - Rupel kild     Rupel - Rupel kild     Rupel - Velden     Tongeren - Kölmmen     Tongeren - Kölmen     Tongeren - Kölmen     Dongen - Asse     Dongen - Brussel	Net gedefnieerd           BR23           BR24           VF8/00           VES/00           VEV00:           RUEV0:           RUEV1           RUE0:1           T023           D04581           D022	Kasterbe (kier) Dest Berchem / Boidenberg - Oank Berchem / Boidenberg - Oank Berchem / Boidenberg - Oank Berchem / Boidenberg - Houthalen Voort - Vorthoven Voort - Verthoven Voort - Verthoven Voort - Verthoven Voort - Verthoven Boom - Putte Common - Doom - Putte Boom - Putte Common - Doom - Putte Boom -	0300 0400 0500 0500	0250 0250 7 0450 0450 0450 7 0610 0520 0540 7	0342 0252 0253 + 0254 0254 0254 0254 0254 0301 0303 0303 0304 0431 0431 0451 0435 0435 0435 0435 0435 0435 0411 0611 0612 7 7	en of zandje too en Aktiente Keitge overgreg hasen de zanden van Kauterke en Diest Zand van Bestel Zand van Bestehen en/of Voort Zander van Bestehen Keig des van Egenbizen Keig des van Egenbizen Keig des van Egenbizen Keig aan Fette Nore van Tertagen Zander In Bestehen Zander In Bestehen Zander In Bestehen Zander In Bestehen Zander Bestehen Zander Bestehen Zander Vermie Zander Metmoel Zander Wemmel Zander Metmoel Zander Metmoel	Kastaner (kia) Dest Vitjkersnörg Bokistorg - Levik Bokistorg - Huthalen Voor - Sonsen Voor - Voor Bigersbare Boon - Soortang Boon - Soortang Boon - Soortang Boon - Stellagen Boon - Stellagen Sitter - Stellagen Dester - Bestellagen Stellagen - Vermel Late Brussel Centoruge - Viersole	0242 0252 0254 0253 0253 0255 0255 0255 0256 0301 0300 0304 0304 0451 0451 0451 0451 0451 0451 0451 04
Einste - ongedifferentieerd      Binds - Vrijherenberg      Binds - Kakert      Veidhoen - Sommen      Veidhoen - Kommen      Veidhoen - Kie en Veidhoen      Veidhoen - Kie en Veidhoen      Rupel - Rupel hie      Rupel - Rupel hie      Rupel - Rupel hie      Tongersn - Killsmeen      Tongersn - Killsmeen      Tongersn - Asse      Dongen - Brussel	Net positivent BR22 BR23 BR24 VE80c VEW11 VEV0c RUE2 RUE0k1 RUE2 T0c2 T0c2 T0c2 D0c41 D0c45k1	Kasterber (klief) Dest Berchern / Boldetberg - Cank Beichern / Boldetberg - Cank Berchern / Boldetberg - Houthalen Voort - Verdhoven Boom - Ruite Boom - R	0300 0400 0500 0500	0240 0250 7 0450 0450 0450 0450 7 0610 0525 0540 7 7	0342 0252 0253 + 0254 0254 0256 0356 0356 0356 0356 0350 0350 0350 03	en of zanaje too van Akterie Neilije overgrad basen de zanaden van Kastlerete en Diest. Zand van Diest Zand van Diester Zand van Bosterberg + Zanden van Berchem en of Voort Zander van Berchem nich Voort Zander van Berchem nich Voort Zand van Berchem nich Voort Zand van Berchem nich Voort Rie van Eigenstizen Neilig den van Eigenstizen Neilig aan Patte Nei van Eigenstizen Xei van Besterk/Mass Zand van Berg Zand van Bergen Zand van Bergen	Kasteriere (kiel) Dest Vitjherenking Bolderberg - Cenk Bolderberg - Neuthaen Voor - Voor - Voor - Veldhoen Voor - Veldhoen Boon - Boeren Boon - Boeren Boon - Fulge Boon - Betsee-Waa Bitter - Statu Bitter - Status Sint-Huitzecks-Hen - Genterunge - Vermine Lote Brussel Gentunge- Vitratie Gentunge - Vermie	0042 0252 0254 0253 0255 0255 0255 0255 0255 0255 0255
Breda - ongedifferentieerd     Breda - Vrijherentieerg     Breda - Vrijherentierg     Breda - Kattert     Veldhoen - Sommen     Veldhoen - Kol an Vechhoen     Vedhoen - Kol an Vechhoen     Vedhoen - Kol an Vechhoen     Rupel - Rupel Itie	Net pochtiend BR22 BR23 BR24 VESOC VEVIC RUEC RUEC TO22 TO23 DOX51 DOX581 DOX52	Kasterie (kier) Dest Berchem / Boldenbeg - Oank Berchem / Boldenbeg - Oank Berchem / Boldenbeg - Oank Berchem / Boldenberg - Houthalen Voor - Voorbowen Voor - Voorbowen Voor - Voorbowen Boom - Berchevitae Boom - Berchevitae Boom - Berchevitae Boom - Berchevitae Boom - Berchevitae Bisch-Hulten Bisch-Berg Staht-Hulten-Starten - Neemsen Beith-Hulten-Starten - Neemsen Berch-Hulten-Starten - Neemsen Berch-Hulten-Starten - Neemsen Berch-Hulten-Starten - Neemsen Berch-Hulten-Berg Berchevitae - Rubioses Berzel Madagem - Wennet Lote Britzel Gentinugge - Vierzie Gentinugge - Vierzie Gentinugge - Vierzie Titel - Egen	0300 0400 0500 0500	0340 0250 7 0430 0450 7 0450 7 0610 0610 0640 7 0640 7 0910	0342 0252 0253 + 0254 0254 0254 0256 0256 0256 0256 0256 0256 0256 0257 0256 0257 0256 0257 0256 0257 0257 0257 0257 0257 0257 0257 0257	en of zandje too en Actiente Netje overgreg hasen de zanden van Kauterke en Diest Zand van Best Zand van Besterken en viel Voort Zander van Berchen en viel Voort Zander van Berchen en viel Voort Zander van Berchen en viel Voort Kei van Viel dooen Zander van Berchen en viel Voort Kei goes van Eigenbizen Kei goes van Eigenbizen Kei van Teitige Net van Teitige Net van Teitige Zand van Berchen Zand van Berchen Berton Aufwerten Zand van Berchen Zand van Berchen Reis in Methoenen Kei van Methoenen	Kastaterier (kild) Dest Vitjherenden, Boisterberg - Gerik Boisterberg - Heuthalen Voort - Sommen Voort - Voort Boorn - Beergen Boorn - Beergen Boorn - Bergen Boorn - Bergen Bergen - Bergen Zetaate - Basseroele Nadagen - Wenmet Lote Brossel Gentonuge-Vierscie Gentonuge-Vierscie Gentonuge-Vierscie Gentonuge-Vierscie Gentonuge-Vierscie Gentonuge-Vierscie Brossel Gentonuge-Vierscie Gentonuge-Vierscie Gentonuge-Vierscie Brossel Gentonuge-Vierscie Gentonuge-Vierscie Brossel Gentonuge-Vierscie Gentonue	0442 0252 0254 0253 0253 0255 0255 0256 0256 0257 0257 0257 0257 0257 0257 0257 0257
Ereda - orgedifferenticerd     Ereda - Vrijherenticerd     Ereda - Vrijherenticerg     Ereda - Kakert     Veldhoen - Somern     Veldhoen - Komern     Veldhoen - Kole mit Veldhoen     Vedhoen - Kole mit     Rupel - Rupel I lei     Rupel - Rupel I lei     Rupel - Rupel I lei     Tongern - Rupel - Rubotek     Tongern - Koltmen     Tongern - Asse     Dongen - Asse     Dongen - Brussel     Dongen - Brussel	Net gedefnieerd           BR23           BR24           VF8/0c           VES/0c           VEV0c           RUE0t1           RUE0t1           T0c2           T0c3           D046k1           D0c21           D0c21	Kasterbe (kiel)  Dest Berchem / Boidetberg - Carik Beichem / Boidetberg - Carik Berchem / Boidetberg - Houthalen Voort - Voort-Someen Voort - Veldhoven Voort - Veldhoven Voort - Veldhoven Voort - Veldhoven Boom - Brutte Boom - Brutte Boom - Betse-twaas Bitsen - Setse-twaas Bitsen - Betse-twaas Bitsen - Setse-twaas Bitsen -	0300 0400 0500 0500 0500	0250 (0250 (0250 0430 0450 0450 0430 0510 0550 0640 () 1 0510 0540 () 0510 0540 () 0540 () 0540 () 0550 () 0	0342 0253 + 0254 0253 + 0254 0255 - 0254 0255 - 0255 0255 - 0255 0301 0302 0303 0303 0303 0303 0303 0303	en of zandje tou en Acklerie Neilige overgreg hasen de zanden van Kastlerde en Diest. Zand van Diest. Zand van Boletsterg + Zanden van Berchem erviof Voort Zand van Boletsterg + Zanden van Berchem erviof Voort Zand van Berchem erviof Voort Zand van Berchem erviof Voort Zand van Berchem erviof Voort Reig det van Eigenblazen Neilig det van Eigenblazen Zand van Besterkingen Zand van Retreen Zand van Retreen Zand van Retreen Zand van Retreen Zand van Retreen Zand van Retreen Keilig aan er Bassekloe Bestoon Austratig Voern voer Besterkingen Zand van Vermee Zand van Vermee Zand van Vermee Retreen het Deter Keilig van Vermee Keilig van Vermee Keilig van Vermee Keilig van Kaster Keilig van Kaster	Kastener (kiel) Dest Vijfversnorg Bolderberg - Oerk Bolderberg - Hkuthalen Voort - Soneren Voort - Veldhoven Voort - Veldhoven Voort - Veldhoven Boon - Boerstag Boon - Boerstag Boon - Boerstag Boon - Bette Boon - Beerstag Boon - Beerstag	0242 0252 0254 0253 0253 0255 0255 0255 0255 0255 0255
Breds - orgedifferenticerd Breds - Vrijherenticerg Breds - Vrijherenticerg Breds - Kalkert Veldhoen - Sommen Vedhoen - Kole an Vechoen Vedhoen - Kole an Vechoen Vedhoen - Kole an Vechoen Rupel - Rupel I ie Rupel - Rupel I ie Rupel - Rupel I ie Rupel - Rupel Kie Rupel - Rupel Kie Rupel - Rupel Kie Rupel - Asse Dongen - Asse Dongen - Brussel	Net gedefnieerd BR22 BR23 BR24 VESOC VEVIC Rue Rue TO22 TO23 DO45k1 DO45k1	Kasterie (kie) Dest Berchem / Bolderberg - Oank Beitchem / Bolderberg - Oank Berchem / Bolderberg - Oank Berchem / Bolderberg - Houthalen Voor - Voort- Voor - Voort Berchem / Voort Berchem / Voort Berchem / Voort Berchem / Voort Berchem / Terngen Boom - Berchem / Voort Bint+Litzerber - Neemgen Bint+Litzerber - Neemgen Bint+Litzerber - Neemgen Bint+Litzerber - Neemgen Bint+Litzerber - Neemgen Bintsteller - Berg Josef - Ostmager / Viersne Bintsteller - Ostmanet Bintsteller Bintstelle	0300 0500 0500 0500	1340 1250 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	0342 0253 + 0254 0253 + 0254 0255 - 0254 0302 0304 0304 0453 0453 0453 0453 0453 0453	en of zandje too en Aktiente Netige overgreg hasen de zanden van Kauterke en Diest Zand van Dest Zand van Bestehen vir Voort Zander van Berchen vir Voort Zander van Berchen vir Voort Kei van Vieldboen Keig van vieldboen Keig van de perbaan Keig van de perbaan Zand van Betrepen Zand van Keiterepen Zand van Keiterepen Keiteren Heterepen Keiteren Heterepen Keiteren Heterepen Keiteren Heterepen Keiteren Heterepen Keiteren Keiterepen Keiteren Heterepen Keiteren Keiterepen Keiteren Keite	Kastatere (kia) Desi Vitpersnong Boistorg - Gerik Boistorg - Serier Voor - Somern Voor - Vestoven Voor - Vestoven Boon - Boostang Boon - Boostang Boon - Beiser-Van Boon - Beiser-Van Boon - Beiser-Van Bister - Berg Sint-Hullanscha-Hem - Neemeen Sinter-Hullanscha-Hem - Neemeen Sinter-Hullanscha-Hem - Neemeen Sinter-Hullanscha-Hem Zetaste - Basbrock Zetaste - Basbrock Zetaste - Basbrock Centonuge - Viernie Gerstrunger-Viersnie Gerstrunger-Viersnie Tet - Spernkoel Tet - Spernkoel Tet - Spernkoel	0242 0252 0254 0253 0255 0255 0255 0255 0255 0255 0250 0200 000000
Ereda - orgedifferentieerd     Breda - Vrijherentieerd     Breda - Vrijherentierg     Breda - Kaket     Veldhoen - Sommern     Veldhoen - Kommern     Veldhoen - Kommern     Veldhoen - Kommern     Rupel - Rupel III     Rupel - Rupel IIII     Rupel - Rupel IIII     Rupel - Rupel IIII     Rupel - Vessem     Tongeren - Robite - Balahoek     Tongeren - Robite - Balahoek     Dongen - Balahoek     Dongen - Brussel     Dongen - Brussel	Net gedefnieerd BR22 BR23 BR24 VESOC VEVOC RUE0C RUE0C RUE2 TO23 TO23 DO21 DO21 DO21 DO21 DO22	Kasterler (klef) Dest Berchern / Bolderberg - Oark Berchern / Bolderberg - Oark Berchern / Bolderberg - Oark Berchern / Bolderberg - Hudhalen Voort - Vordhoven Voort - Veldhoven Voort - Veldhoven Voort - Veldhoven Boorn - Rufte Boorn - Ruft	0300 0400 0500 0500 0500 0500	0250 / 0250 / 0450 0450 0450 0450 0550 0550 0550 0550 0550 0550	0342 0253 + 0254 0253 + 0254 0255 - 0254 0255 - 0255 0256 - 0255 0301 0303 0303 0303 0304 0451 0452 0453 0453 0453 0451 0611 0611 0612 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	en of zandje tou en Aktiente Keilge overgreigt bese de zanden van Kauterte en Diest. Zand van Diest. Zand van Betchem evid Voort Zande van Betchem evid Voort Rei van Tertagen Keilg des van Eigenbizen Keilg des van Keinen Zand van Betregen Zand van Betregen Zand van Eiderbizen Keilg astettingen an net Croter- Pariseliaan Keilg van Koternank Keil van Atabete Keil van Abetee Keil van Koternank	Kasteriere (kiel)  Dest Vitjkeenkoig Bokinterg - Gerik Bokinterg - Heuthalen Voort - Sonsren Voort - Velstoven Voort - Velstoven Boon - Sonsten Boon - Sonsten Boon - Stelle Boon - Senservitae Boon - Stelle Boon - Vermel Boon - Stelle Boonsel Gentouge - Viersole Centouge - Viersole Tet - Kortenan Kortyk - Roubske Kortyk - Roubske	0242 0252 0253 0253 0253 0255 0255 0255 025
Einda - ongedifferentieerd     Binda - Vrijherentierd     Binda - Vrijherentierg     Binda - Kakert     Veldhoen - Sommen     Veldhoen - Sommen     Veldhoen - Kill en Veldhoen     Veldhoen - Kill en Veldhoen     Rupel - Rupel hild     Rupel - Rupel hild     Rupel - Rupel hild     Rupel - Rupel hild     Rupel - Asse     Dongen - Asse     Dongen - Brussel     Dongen - Brussel	Net gedetnieerd BR22 BR23 BR24 VESOc VEV00 RUE1 RUE0K1 RUE2 TO22 TO23 DO21 DO45K1 DO45K1	Katterie (kie) Dest Berchem / Boldenberg - Oank Beichem / Boldenberg - Oank Berchem / Boldenberg - Oank Berchem / Boldenberg - Houthalen Voor - Voort Voor - Voort Berchem / Voort Berchem / Voort Berchem / State Boom - Stringen Boom - Stringen Boom - Stringen Boom - Stringen Bioth-Libercha-Hein - Oarmertingen Brith-Libercha-Hein - Oarmertingen Zezate - Stateseko Zezate - Stateseko Berchunger-Vierzeie Gertitnugge-Vierzeie Gertitnugge-Vierzeie Gertitnugge-Vierzeie Tet - Egerin Tet - Egerin Tet - Egerin	0300 0500 0500 0500	0340 0250 7 7 8335 9450 9450 9450 9450 9450 9450 9450 945	0342 0252 0253 + 0254 0254 0254 0256 0301 0302 0303 0304 0452 0452 0452 0455 0452 0455 0452 0451 0611 0701 0701 0701 0701 0701 0701 070	en of zandje top van Akterie Neilige overgreit basen de zanden van Kauteree en Diest. Zand van Diest Zand van Dester Zand van Bosterberg + Zanden van Berchem ervid Voort Zand van Bosterberg + Zanden van Berchem ervid Voort Zand van Beschem ervid Voort Zand van Beschem vid Voort Rei van Eingerbizen Neilig des van Eigenbizen Neilig des van Eigenbizen Neilig am Fester Nei van Fester Nei van Fester Zand van Beschevlikas Zand van Beschevlikas Zand van Beschevlikas Bistoon Aujulanstysteem vongothersteed Zand van Vermiel Zand van Vermiel Zand van Vermiel Zand van Vermiel Zand van Peter Nei van Netwerkel Stans Notemank Nei van Netwerkel Zand van Reter Rei van Netwerkel Zand van Reter Rei van Netwerkel Zand van Reter Rei van Netwerkel Zand van Reter Nei van Netwerkel Rei van Netwerkel Rei van Netwerkel Rei van Netwerkel Rei van Netwerkele Rei van Sam-Alber Nei van Sam-Alber Nei van Sam-Alber	Kasteriere (kiel) Dest Vitjherending Bolderberg - Clerk Bolderberg - Clerk Voort - Somern Voort - Voort Boorn - Somern Woort - Vieldvoen Boorn - Boere Boorn - Fullag Boorn - Beisee-Waa Bitter - Sign Sint-Huitzecks-Hen - Commentingen Jesster - Bassonide Maldagen - Verminet Lobe Brusset Gentbrugge - Mitroel Brusset Brusset Centbrugge - Mitroel Tet - Sign Mad	0042 025 025 025 025 025 025 025 025 025 02
Breds - orgedifferentieerd     Breds - Vrijherentieerg     Breds - Vrijherentieerg     Breds - Kastert     Veldhoen - Sommern     Veldhoen - Koll an Veldhoen     Veldhoen - Koll an Veldhoen     Vedhoen - Koll an Veldhoen     Rupel - Rupel kild     Rupel - Rupel kild     Rupel - Vessem     Tongeren - Scalle - Balsbreide     Dongen - Asse     Dongen - Asse     Dongen - Brussel	Net pockhilend BR22 BR23 BR24 VESOC VEVIC RUE2 RUECK1 RUE2 T023 D021 D045K1 D022 D021	Kasterie (kier) Dest Berchem / Boldenberg - Cenk Berchem / Boldenberg - Cenk Berchem / Boldenberg - Houthalen Voor - Voortween Voor - Voortween Boorn - Boretan Boorn - Correction Boretan Bor	0300 0400 0500 0500 0500	0250 / 0250 / 0450 0450 0450 0450 0450 0450 0450 0450 1 0510 0520 0520	0342 0253 + 0254 0253 + 0254 0253 + 0254 0361 0362 0364 0364 0364 0364 0364 0364 0364 0364	en of zandje too en Aktiente Netige overgreg hasen de zanden van Kauterke en Diest. Zand van Bestel Zand van Bestelen vir Voort Zander van Bestelen vir Voort Zander van Bestelen vir Voort Zander van Bestelen vir Voort Zander van Bestelen vir Voort Rei van Bestelen vir Voort Rei van Bestelen vir Voort Kei van Ferdagen Kei van Ferdagen Kei van Ferdagen Zand van Bestelen Zand van Bestelen Rei van Ferdagen Zand van Bestelen Zand van Bestelen Danktel van Gimmetingen Zand van Bestelen Reisen Bistannet Reisen Bistannet Reisen Reisenet Reisen Reisenet Reisen Reisen Reisen Reisenet Reisen Reisenet Reisen Reisen Reisen Reisen Reisenet Reisen Reisen Reisen Reisen Reisenet Reisen Reisen Reisen Reisen Reisenet Reisen Reisen Reisen Reisen Reisen Reisenet Reisen Reis	Kasterier (kiel) Dest Vitjkerstelog Bokisterg - Cerk Bokisterg - Heuthalen Voort - Sonsen Voort - Voort Boon - Boerstan Boon - Boerstan Boon - Beerstan Boon - Wennet Lade Bousel Centoruge - Merstelet Rotrijk - Abelete Rotrijk - Rotelet Rotrijk - Abelete Rotrijk - Abeletem Rotrijk - Roteletem Rotrijk -	044 025 0254 0253 0253 0255 0255 0255 0255 0255 0255
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# APPENDIX III:CENOZOIC CORRELATION CHART FOR PROJECT H30 – ROSE (DRAFT)







#### Cenozoic Correlation chart H<sub>3</sub>O Rose NRW – NL

(MARTIN SALAMON, BERND LINDER, ARMIN MERKOVIC, NORA WITMANS, DRK MUNSTERMAN, MARTIN HISS)





stratigraphic range uncertain





# APPENDIX IV: REPORT OF THE H3O-PLUS EXPERT MEETING ON TREND ASSESSMENT OF GROUNDWATER HEADS

Thu. 16 May, 10-14h, Mol

Jelle Buma (TNO-GSN), Willem Jan Zaadnoordijk(TNO-GSN), Renate Jaritz (Erftverband), Jasper Claus (IMDC), Bart Rogiers (SCK•CEN), Koen Beerten (SCK•CEN), Bob Peeters (VMM), Griet Heuvelmans (VMM), Cis Slenter (VMM)

#### Purpose of the meeting

The meeting was organized for the GeoERA groundwater project RESOURCE, and specifically for task 3.5 (cross-border patterns of groundwater trends) within work package 3 (H3O-PLUS concerning groundwater in the Roer Valley Graben and adjacent areas). The purpose of this meeting is (1) to inform each other about how we monitor groundwater heads and which methods each country uses for trend calculations, and (2) to prepare input for the H3O-PLUS stakeholder meeting in Maastricht (June 17<sup>th</sup> 2019).

#### Resource WP3: H3O-PLUS

VMM gives a short presentation about the content of H3O-PLUS. The presentation is attached to these minutes (Annex 1).

#### Task 3.5: cross-border patterns of groundwater trends

TNO gives a short presentation about the content of task 3.5. The presentation is attached to these minutes (Annex 2). Three aspects were discussed specifically, terminology, deliverables and relation to the EU Water Framework Directive (WFD):

- Terminology

Proposal: replace depletion by trends. This term covers more the load.

The term depletion has been used in the project proposal. But the proposal makes sense. Depletion points to a problem, but the groundwater heads may also rise again.  $\rightarrow$  Agreement: in an official document we will still use depletion in the title, but in the texts we will use trends.

- Deliverables

According to the DoW: Database and 3D maps of cross-border patterns of groundwater depletion and recharge. To be delivered in Month 32 of the project (= February 2021). The required methods of analysis and visualisation are to be elaborated by the Task partners.

- Relation to WFD

RESOURCE Task 3.5 wil consider trends in time and in space (laterally, especially across faults, and vertically). We will not limit ourselves to the methods used in the WFD, but will make use of the WFD information where appropriate (monitoring, preliminary work, etc.).

#### Stakeholder meeting 17<sup>th</sup> of June Maastricht

The GeoERA projects are designed to "the development of knowledge and services aimed at European, national and regional policy makers, industry and other stakeholders". Therefore, we think it is important to have guidance from stakeholders in shaping and developing the project. The stakeholders of RESOURCE are no trend specialists, but they can tell us what they want/need and in which way they want it.





#### **Country presentations**

Germany: Erftverband (+input from LANUV)

- Erftverband is responsible for the regional water management, including groundwater.
- The brown coal mining sites are within the study area.
- 17000 wells/screens in an area of approximately 100 \* 150 km.
- Owners of the screens vary, but the data is collected in one database.
- 1 measurement per month.
- Many old measurement series from the 1950s.

Four different methods are available for trend calculation. The statistical test and notably the Multichannel Wiener-filter analysis are preferred nowadays. The latter is further outlined below:

- Three time series without anthropogenic influence are compared with the time series that you want to investigate
  - Difference between what it is now and what it should be like:
    - The direction of the trend may be good, but perhaps not increasing enough.
    - The effect of compensation measures becomes visible.
    - The last drought period (more drought than ever) has been calculated fairly well.
- 12 reference points (nearby, but not too close)
  - The influence of the brown coal mining is everywhere.
  - In the north the influence is less, but the reference points must be a bit spread out over the study area.
  - These point have long time series, from the 1950s.
- A lot of expert knowledge about the study area is needed (a bit trial and error is needed for the calibration)
  - The influence of the mining has slowly shifted to the West since the 1980s.
  - Infiltration facilities have been implemented as compensation measures; sometimes, these added too much water.
  - There is a difference in groundwater heads inside and outside wetland areas.
- → The time series are partly public and can be consulted at ELWASWEB (https://www.elwasweb.nrw.de/elwas-web/index.jsf)
- → Erftverband / LANUV would like to exchange groundwater data with The Netherlands.

#### Flanders: VMM and SCK•CEN

VMM

- VMM is responsible for the groundwater management in the study area
- phreatic groundwater network
  - o 174 wells, 493 screen in the study area
  - Monitoring frequency: 2 times a year
- primary groundwater network
  - o 53 wells, 122 screens
  - Monitoring frequency: monthly, by hand
- There are some longer times series, but most start from the late 1980s, early 1990s



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Trends in the groundwater heads:

- For the phreatic layers:
  - SWAP model
  - o trendanalist on the residu





MILIEUMAATSCHAPPIJ

- For the confined layers:
  - o statistic approach
  - preprocessing for filling gaps and removing outliers
  - o trend assessment

→ Data is public and can be found at <a href="https://dov.vlaanderen.be">https://dov.vlaanderen.be</a> .

#### SCK•CEN

- Monitoring:
  - regional network (deep aquifer model)
  - subregional network (neogene aquifer model)
  - local network (local model)
- Methods used for time-series analysis
  - Impulse-response function modelling
    - More basic than SWAP-model, but looks like it
    - Errors: research on human impact
  - $\circ$  Time series decomposition
  - Break detection

#### The Netherlands: TNO-GSN





- GSN does not monitor groundwater heads, only provides monitoring data in public national database (https://www.dinoloket.nl/ondergrondgegevens)
  - Typical frequency twice per month for manual measurments, daily for automatic 0 pressure transducers with data loggers
  - Some long series (starting in 1950s or even before)
- Time series models on https://www.grondwatertools.nl/grondwatertools-viewer
  - Transfer noise models with Impulse response functions for: 0
    - Precipitation
      - Evapotranspiration
  - daily update: a program detects whether there are new measurements, if so, it 0 recalculates the time series model for the last 8 years of data
  - 5 calibrated parameters in time series model (3 for precipitation impulse response 0 function, 1 for evapotranspiration response relative to precipitation, 1 decay parameter in noise model)
- Since the 1950s general downward trend +/- 30cm in The Netherlands
- Around 2000 a programme started to restore the original higher groundwater heads in nature preserves.

Following the expert meeting, TNO has made an overview of the methods:

GeoERA - RESOURCE



# Methods for gw trend analysis (selection)

#### Discussion: necessities and perspectives for harmonization of groundwater trend assessment





- Deliverables: we all have a lot of time series, but we also want to produce maps. How are we going to do this?
  - Due to time and money, we cannot work in great detail For example: global/regional maps
  - Point maps, the stakeholder may use the point data to make interpolations by herself (which is a lot of work, see the maps shown in the PPT of the Netherlands)
- Which data can be used for cross-border relations?
- What is the impact of using different networks&installations (for example screen length), monitoring, methods on the results?
- How are we going to harmonize the data?
  - What are the criteria?
  - Phreatic and confined?
  - $\circ$   $\;$  Should we take wetland data into account or not? They influence the image of the regional pattern
- Which aquifers should be taken into account?
  - Which hydrogeological units from H3O are we taking into account?
    - H3O-Rose: probably delivered end of 2019
- Which are the minimum requirements to use groundwater head data? We still have to define the criteria for this, for example:
  - Can we define a minimum measurement frequency ?
    - Twice a year may be enough for some areas
      - (for example for areas without seasonal fluctuations)
  - Can we define a minimum measurement period? (and then taking into account the whole time series)
  - Only monitoring sites which are still active
  - Screen-depth should not cross different H3O-units
- → Agreement to create a dataset of selected time series from all three countries for use in the project.
- → Not feasible to apply all methods to all of these selected time series so work out different ways of detecting systematic differences in results.
- → Use the H3O-Rose model to assign piezometers to hydrogeological units.

#### Actions

- Jelle and Willem are going to make a template table "network&installation, monitoring, methods".
  - To clearly compare the differences and similarities between the different countries.
  - They will send it to the other partners, and they will complete the schedule a week later.
- TNO will make a short presentation for the stakeholder meeting about task 3.5 summarizing the results of this workshop, others will provide feedback:
  - Differences and similarities between countries;
  - $\circ$  Proposed approach for task.
- Create dataset of selected time series
  - $\circ$   $\;$  TNO will send around a proposal for selection criteria and a template table in June
  - Finalize criteria in July (all)
  - October 2019: complete dataset (all)









# APPENDIX V: NOTES AND CONCLUSIONS RESOURCE STAKEHOLDER MEETING MAASTRICHT 17TH JUNE 2019

#### Introduction

- Welcome (Eric Castenmiller, Provincie Limburg, Nederland)
- Introduction to the GeoERA initiative, RESOURCE and H3O-PLUS (Griet Heuvelmans, VMM)
- Role of the stakeholders, todays program, tour de table (Cis Slenter, VMM)

#### Task 2: Hydraulic properties

Presentation: Ronald Vernes (TNO) Notes: Koen Beerten (SCK)

- Simon Six (De Watergroep) asks if the median value is the representative - and how to honour spatial variation. This is done through tackling the separate H30 areas (ROSE, De Kempen...)

- Willem Jan Zaadnoordijk (TNO) says that spatial trends need to be analyzed between the subproject areas (4), whether due to analysis method or real spatial trend?

- From what source are the data coming from? This is done through a comment field (type of data, number of points)

- Willem Jan Zaadnoordijk (TNO) advises against throwing away extreme data. From min-max, to likely range (expert judgement) to 'most representative value'

- Ksat is horizontal (aquifers) and vertical (aquitards), Ksat of faults is not very well known. All information is welcome. First focus is Kiezeloöliet because it is present in three countries. Simon Six (De Watergroep) is very interested in hydraulic properties of faults. There will be information from VoGERA project on properties of faults. Down to 600 m.

- Are you going to use information from groundwater calibrations? In any case it is not included for the test case (Kiezeloöliet). But Ronald Vernes (TNO) would include it because it might give additional information.

#### Task 3: Groundwater quality and age

Presentation: Mariëlle van Vliet (TNO) Notes: Koen Beerten (SCK)

- GW quality tool: work plan (see presentation Marielle van Vliet)

- interface will be translated into English, it will be an open database, not a project database

- how many groundwater age data is available in Belgium and Germany? not for Germany in any case, for Belgium only through modelling of De Watergroep (10x10 km), some data at SCK

- GW tool has two time periods: before 1980 and after 1980, it operates through depth (not layer)

- which parameters does Marielle van Vliet needs for the tool? Anything, any information is important, but most important is nutrients and metals. Best case is a total analyses to be able to calculate the charge balance.

- also data from De Watergroep will be incorporated - it's closed data but they can deliver what we need.

- It will be possible to include data that will not be disclosed but ARE used in the spatial and temporal analyses





## Task 4: Harmonization of volumes, balances and fluxes

Presentation: Ronald Vernes (TNO) Notes: Griet Heuvelmans (VMM)

Approach 1: Based on the H3O model, the total volume of water per aquifer and aquitard can be estimated, based on some assumptions of the hydraulic properties of these layers (porosity, eventually also groundwater level).

Approach 2: There are several groundwater flow models available for the study region. We could use these models to estimate the volumes, fluxes and balances.

Assessing differences between these two approaches could be interesting.

Questions:

- Do you agree with the general approach?
- Which groundwater flow models to consider? How can we cooperate with the owners of the models?
  - See slide with model areas. There is no model that covers the entire project area. So we will have to use multiple models. It is not feasible in the timeframe and budget of this project to make a new model.
  - Pragmatic approach if multiple models are available: define units where you want to know balances and fluxes and then examine whether there are differences in calculated fluxes. If so, look for possible reasons. Theoretically, it would be better to first compare the model structure, but this is less likely to deliver useful results within the timeframe of the project.
  - Why not make a simple, conceptual model of the entire project area? This is not that much work, only a little more complex than approach 1 (calculations based on H3O model).
  - Contact persons for NL known by TNO, for Germany: LANUV, for Flanders: VMM and/or SCK
- Which administrative and hydrological boundaries to consider?
  - Examples: flux across fault, fluxes from and to rivers (especially Meuse)

Remarks:

- Fluxes are more (or at least as) important for practical questions than the volumes. Volumes are only a starting point.

#### Task 5: Trends and groundwater depletion patterns.

Presentation: Willem Jan Zaadnoordijk (TNO) Notes: Matej Gedeon (SCK)

- A lot of data on groundwater levels available in project countries
- Different purposes and already trend assessment according to EU requirements;
- Various method to link heads to prec. and evap. (B: SWAP model, NL: transfer noise, DE: statistical tools using a reference piezometer);
- Different visualization tools to present (areal coverage (interpolation) or piezometer level)
- Plan:
  - Stakeholder involvement;
  - Criteria for selecting the public data for analyses;





- Database building;
- Various methods to analyse the trends (including other driving forces than atmospheric input);
- Visualisation;
- Recommendations to Task 6 -> management strategies

#### Discussion:

- What about the data only public DB or there are more sources?
  - In NL -> Dino loket
  - o DOV Vlaanderen
  - Industry data? Are there some other interesting data? Maybe there are some data on extractions. Probably important data are delivered to Dino loket? Not sure. We need to check.
  - Other input series as precipitation and evaporation?
    - Extractions, river discharge, mining re-watering
    - It can be very tedious to clean the data up
    - Depends if applicable
    - Limburg province can provide data for abstractions (after 1990)
  - What are the recommendations for methodology of the trend analysis?
    - Need for a comparison and insight onto the used methods;
  - What is the timeframe?
    - Not yet decided, looking at various scales and period lengths.
    - It is about the long-term trend analysis
    - Looking at the trends in deep system
  - Are other stakeholders prepared to deliver abstraction data?
    - Brabant has data from approx. 70ies
    - Complete datasets are only available from 90ies, agricultural data from 2000
    - For agriculture indirect calculation according to the water shortage
    - German part: big abstractions available from 1975, small abstractions from after 1990 on, but is not public.
    - VMM DOV has values for abstractions, including big agricultural abstractions
    - Watergroup has detailed data on a yearly bases in DOV, monthly data available.
    - Statistical modelling does not really take into account the distance between piezometers and pumping, but the correlation is stronger if the abstraction is close. The approach should start with only precipitation and add abstractions if the oscillations are not explained.

#### **Task 6: Groundwater policy**

Presentation: Griet Heuvelmans (VMM) Notes: Mariëlle van Vliet (TNO)

Main questions for the session of today:

- 1) Which policy/management topics do we need to consider in task 6
- 2) How do we proceed :
  - a. Who must be involved?
  - b. How will we organize information exchange?





The important topics to consider are:

- Licensing of abstractons (the idea of licensing of abstractions is the same, but pratical it is different)
- Licensing of geotermal
- Protection zones

Who must be involved?

In the Netherlands the provinces are responsible for groundwater protection. The Ministry of Infrastructure and Waterworks (I&W) gives the national point of view. For abstractions >500 m the Ministry of Econimics Affairs is responsible.

In Gemany the communities are responsible for the small abstractions. The 'Bezirksregierung' carry out the groundwater protection policy of the Ministry. For geothermal questions it depends on the depth. For deep the mining authority, otherwise the local authority must be involved.

In Flanders, VMM advise the province and the Ministry.

Also the drinking water companies must be involved: de Watergroep, WML, Brabant Water and , if possible, the german drinking water supply companies (many small companies). Although they don't make policies, we must also take their point of view into account.

VMM will compile a list of contact persons for each of the three identified topics (abstractions, geothermal, protection). Each of the contact persons will be asked to send information regarding the topic (how it is handled in their region) to VMM and VMM will compare and summarize that information. Based on that comparison and summary, a discussion will be organised with the contact persons of the themes. These meetings will either be organised per theme (if contact persons are different) or for a combination of themes (in case the contact persons are the same). We can start this process in autumn 2019 (gathering information), so that the meetings and discussions can be organised in 2020.

Next to the discussion of the three themes, this tasks also deals with how the results of other tasks can be used in policy and for other practical questions.

In this task we should also think about the way that we want to collect and harmonise the data (which data, how should we come to a continued harmonisation and data exchange after the project?) and about a monitoring strategy (what are the differences in monitoring set-up between the regions?).

How to proceed with the project: In each case, there will be a stakeholder workshop at the end of the project (mid 2021). The stakeholders would like to have an additional mid-term workshop e.g. in a year we will organise another meeting to discuss the project results (June 2020).