GeoERA

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

Deliverable

Definition of prioritized Information Products for the GeoERA Information Platform

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SUMMARY

This report describes the definition of prioritized Information Products for the GeoERA Information Platform for the RESOURCE project. The deliverable clarifies what data will be produced in the RESOURCE project in order to facilitate the interaction between RESOURCE and the GeoERA Information Platform (GIP) project. The report describes the prioritized information products of RESOURCE and the corresponding data requirements are specified as input for the EGDI (The European Geological Data Infrastructure / the Information Platform for the GeoERA projects). This deliverable is meant to ensure the communication with the GIP Project. Detailed information about the Information Products of RESOURCE can be found in the technical deliverables of the RESOURCE project itself.

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EXECUTIVE SUMMARY

The present document is deliverable D2.2 “Definition of prioritized Information Products for the GeoERA Information Platform” of the RESOURCE project: “RESOURCEs of groundwater, harmonized at Cross-Border and Pan-European Scale” developed for the specific research topic: Groundwater – GW3 Harmonization of groundwater resources information at cross-border to Pan-European scale.

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 will be 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 provides 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 the GeoERA Information Platform / The European Geological Data Infrastructure (EGDI).

The report describes the prioritized information products of RESOURCE and the corresponding data requirements are specified as input for the EGDI (The Information Platform for the GeoERA projects). This deliverable is meant to ensure the communication with the GIP Project. Detailed information about the Information Products of RESOURCE is to be found in the technical deliverables of the RESOURCE project itself.

0 INTRODUCTION

The overall aim of the RESOURCE project is to demonstrate the potentials of the harmonization of information about Europe's groundwater resources through cross-border demonstrations projects. This will be demonstrated 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 Pan-EU mapping approach and the cross-border demonstration projects under RESOURCE will lead to example products of a harmonized pan- European assessment of the 3D structure of aquifers, the volumes of water involved and its quality.

Main results from the RESOURCE project will be integrated in the European Geological Data Infrastructure (EGDI), through the GeoERA Information Platform project. The GeoERA project continues developing EGDI, as the most comprehensive information platform for dissemination of upto-date, comprehensive, reliable and harmonised subsurface data for Europe within and beyond GeoERA. The requirements from the RESOURCE project to the GIP-P project regarding the contents and functionality of the GeoERA Information Platform / European Geological Data Infrastructure (EGDI) have to be clearly defined in order to develop a common understanding of the information products delivered from RESOURCE to EGDI and further to all relevant stakeholders. The main results data requirements are described in the technical deliverables of the RESOURCE project, specifically for the Pan-EU map of WP6. This deliverable gives a summary of the requirements, updated to the submission data of the current deliverable, but readers are also expected to also access the technical deliverables of RESOURCE WP6 themselves and contact the WP coordinators for additional information.

1 DATA TYPES FOR EGDI FROM AND POTENTIALLY RELEVANT FOR ALL RESOURCE WORK PACKAGES EXCEPT WP 6

1.1 Description of the product

Title and description		Nº1-Pilot sites locations	Nº-2Pilot study reports	Nº3-Factsheet locations	Nº4-Factsheets
Product Type	**Structured Data** (Vector, raster, etc)	X (vector)		X vector)	
	Unstructured data		X		X
Data sources			Report contribution from partners & deliverables		Factsheets for features such as springs (WP 5CHAKA)
Spatial dimension		Polygon		Point	
Temporal dimension	**static**	Yes		Yes	
	dynamic: real time (yes/no)	No		No	
Scale		varying	varying	varying	varying
Coverage		Local/regional to pan European	Local/regional to pan European	Local/regional to pan European	Local/regional to pan European
Projection system.		EPSG:3035 and EPSG:3034.		EPSG:3035 and EPSG:3034.	
Delivery Format to EGDI	**OGC web services** (WMS, WFS, WCS, etc.)				
	Uploading GIS files (ESRI shapfiles or GeoPackage.)	Shape files		Shape files	
	Unstructured data (PDF, JPG; TXT, etc.)		PDF & url-link to local or national database or visualization tools where appropriate		PDF & url-link to local or national database or visualization tools where appropriate
Metadata:	**Metadata provider** (IGME, GBA etc .)	All WP partners		All WP partners	
	Metadata collection (Harvesting/direct editing)	Direct editing	Direct editing, title, author , keywords	Direct editing	Direct editing, title, author , keywords

1.2 Description of attributes for each product.

1.2.1 Nº1-Pilot site locations

Name of the attribute	Description	Unit	Data type
ID	Identification number		No.
Shape	Polygon of the study area		Polygon
Name	Name of the study area		text
Link to documents	Link to documents		text
Link to url	Link to url		text

1.2.2 Nº3- Factsheet locations of special interest

Name of the attribute	Description	Unit	Data type
ID	Identification number		No.
Shape	Polygon of the study area		Polygon
Name	Name of the study area		text
Link to documents	Link to documents		text
Link to url	Link to url		text

1.3 Use cases and requirements associated to each product

1.3.1 Use cases

1.3.1.1 Nº1-Pilot sites location

The ESRI shape file point to the location of the pilot studies and it includes the polygons, one each pilot site.

1.3.1.2 Nº2-Study reports

This includes the formal deliverables and reports the project evaluates to be relevant for stakeholders and the general public. The reports should be georeferenced, findable and downloadable, preferably from the EGDI repository as this will enable free text searches within the documents.

1.3.1.3 Nº3- Factsheet locations

Points of special interest as ESRI shape file.

1.3.1.4 Nº4-Factsheets

Factsheets are meant to summarize and visualize important findings and will be georeferenced to places of special interest, such as a karst spring (WP5 CHAKA) or a borehole etc.

1.3.2 Requirements:

Product title	Nr	Requirement	Description
Nº1-Pilot sites	7	Web page with all services	
	5	Enhanced interface to upload and thematize Shapefiles	
	12	Overview panel	
	13	Legend with tree view/hierarchical on/off switching	
	10	Identify and follow link	To pdf report
	10	Identify and follow link	To national database, repository or visualization product at regional or national level
Nº2-Pilot studies reports	9	Download (no access control)	
Nº3-Factsheet locations	7	Web page with all services	
	5	Enhanced interface to upload and thematize Shapefiles	
	12	Overview panel	
	13	Legend with tree view/hierarchical on/off switching	
	10	Identify and follow link	To pdf report
	10	Identify and follow link	To national database, repository or visualization product at regional or national level
Nº4-Factsheets	9	Download (no access control)	

2 DATA FOR EGDI FROM WP6

2.1 Description of the products

Title and description		Nº 5-Pan European map of groundwater resources	Description
Product Type	**Structured Data** (Vector, raster etc.)	X (Vector)	Polygons with extensive attribute table The grid is fixed and distributed to all partners
	Unstructured data	X	
Data sources		.xlsx table which contains the information from all partners	It is anticipated that the GIP project will set up a database that uses the xlsx files as input and is effective for the visualisation in EGDI
Spatial dimension		Polygon	
Temporal dimension	**static**	x	
	dynamic: real time (yes/no)		
Scale		1:200.000 to 1:2.500.000	
Coverage		Pan-EU but also able to zoom to more local scale	
Projection system.		EPSG:3035	This is important as this is an equal are projection and we are dealing with volumes
Delivery Format to EGDI	**OGC web services** (WMS, WFS, WCS, etc.)		
	Uploading GIS files (ESRI shapfiles or GeoPackage.)	Shapefile from a 10x10km INSPIRE grid	The grid is compatible with a known INSPIRE projection
	Unstructured data (PDF, JPG; TXT, etc.)	We will deliver a xlsx file, where the ID's are the cell ID's from the 10x10km inspire grid	
Metadata:	**Metadata provider** (IGME, GBA etc .)	All RESOURCE WP9 partners	
	Metadata collection (Harvesting/direct editing)	Harvesting: Metadata will be provided in the form of pdfs for each participating country describing the approach that is used to fill the grid and the justification for the folwoed approach	

2.2 Description of attributes

The Pan-EU map of groundwater resources is a multi-layered product. The attributes of each layer and collection of data is specified precisely in RESOURCE Deliverable 6.1. This deliverable is added as Appendix C of this report. During the RESOURCE WP6 workshop in Zagreb (Nov. 20t/21st, 2019) a number of changes to the template of D6.1 were agreed upon among the WP6 partners, that will be accounted for in a new version of the template to be distributed early 2020 at the latest. A summary of the agreed changes is given in Appendix A of this current Deliverable 2.2. The description of Use Cases and Requirements in section 2.3 of the current document was made with these changes in mind, but the reader should be aware that the Information Product to be developed in EGDI should be based on the final template that will be developed in the RESOURCE project.

2.3 Use case and associated requirements

2.3.1 Use cases

The Pan-EU map is based on a EPSG:3035 INSPIRE grid. Details are to be found in Deliverable D6.1 of RESOURCE. The idea is that different views can be made:

- map views of the grid, showing specific preselected, predefined features that are in the grid data
- view of the "Chronostratigraphic Groundwater Resource Column" in a single, selected grid cell, which is kind of a special form of a "borehole" but representative of a 10x 10 m grid cell (CGRC's)
- cross-sections through the grid, showing a large number of adjacent Chronostratigraphic Groundwater Resource Columns (CGRC-sections).

The legend of the resulting maps, CGRC's and CGRC-sections will follow the IHME1500 - International Hydrogeological Map of Europe 1:1,500,000 legend. The visualisation of the data in maps and cross-sections will be further defined in the coming 12 months; First ideas for the visualisation as developed in the Zagreb workshops can be found in Appendix B to this report. The maps and cross-section below give an idea of the visualisation anticipated. Examples on some of the desired functionalities, such a clicking information on and off, can be found in https://dev.grondwatertools.nl/gwatlas. Face to face interaction with GIP-P WP6 will be step up to refine functionalities, especially those related to the display of virtual boreholes (CGRC's) and cross-sections (CGRC-sections).

2.3.1.1 Maps of the grid

Using the attributes in the database, specific features of the map can be visualized, such as total volume of fresh groundwater, total thickness of layers with fresh groundwater, total transmissivity of the aquifers and total hydraulic resistance of the aquitards. The calculations will be made using the attributes of the grid using predefined calculation methods. Users will be able to visualize not only the attributes of the database, or part of them, but also the maps generated by the predefined calculations. A disclaimer explaining the purpose and use of the map should be available to end users to ensure that the map is used correctly and to avoid responsibility of GeoERA partners when misinterpretations are done. This disclaimer should be available through a link or a tab in the viewer.

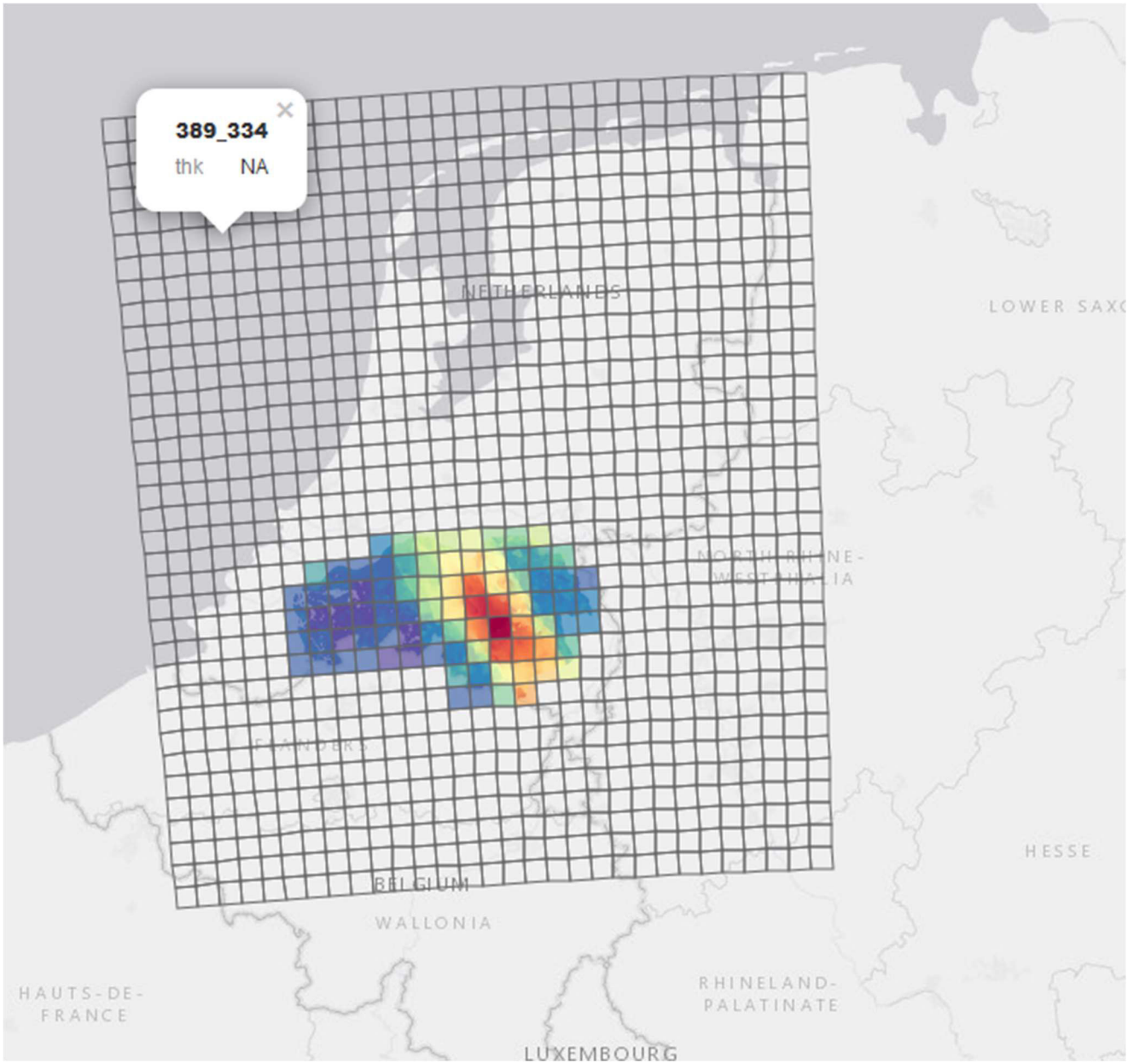

Figure 1: Example of a grid representation in a map: total thickness of first layer in the grid for a part of the Netherlands

2.3.1.2 Virtual boreholes: CGRC's

By selecting one of the grid cells in the grid, the user can display a chronostratigraphic groundwater resource column (CGRC), which summarizes the thicknesses of all layers in the grid and uses predefined colors and symbols for attributes of the layers based on the IHME1500 - International Hydrogeological Map of Europe 1:1,500,000 (see first example in Figure 2). Once the default CGRC is on display, the user can make some predefined choices to highlight specific features of the columns, for example choosing to highlight the total volumes within the layers or the transmissivity. Ideas about visualization are found in Appendix B of this report.
Additionally, the used can access a pdf with metadata provided by the individual WP6 partner that created the contents of the selected CGRC, which describes the procedures followed and

the assumptions made within the specific country or region to which the cell belongs, thus providing a justification of the result and guidance for proper use.

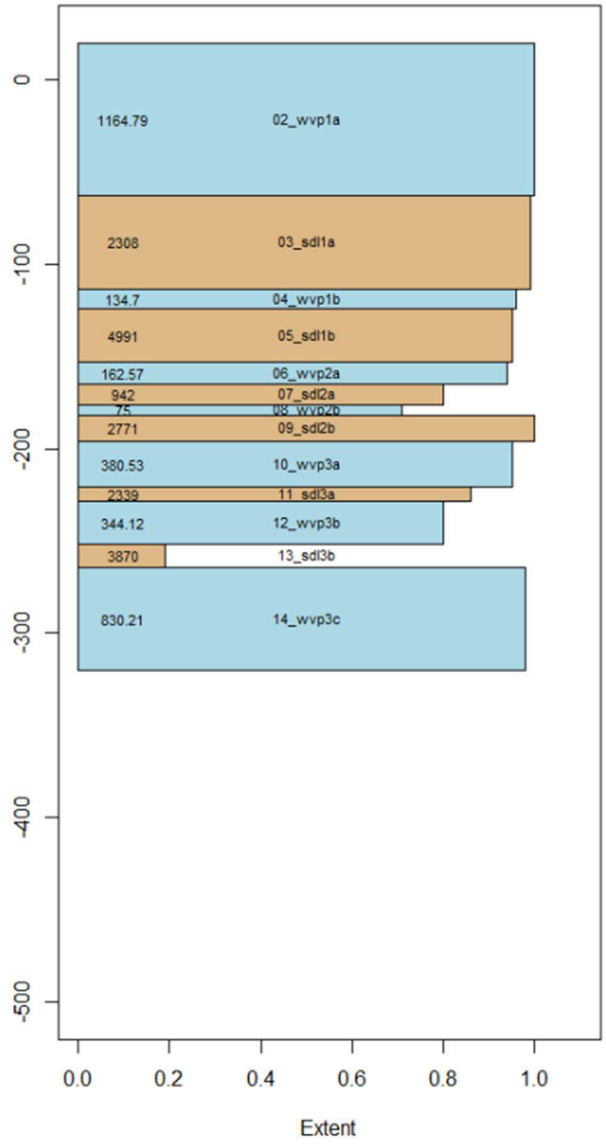

Figure 3: Example of a CGRC, a kind of virtual borehole at the 10x10 km grid cell scale. Colors refer to the colors of the IHME1500 - International Hydrogeological Map of Europe 1:1,500,000, which intergranular aquifers in blue and strata with essentially no groundwater resources in brown (aquitards in this case). Numbers represent transmissivities (aquifers) and hydraulic resistance (aquitards), and names of the layers. The user can choose which numbers to show in the columns (transmissivities, volumes and some other predefined characteristics). The idea is to further refine the legend for these columns; first ideas are described in Appendix B.

2.3.1.3 CGRC sections

Based on the grid, the user can define a line on the map to create a virtual cross-section, a CRGRC-section) through all layers. The section comprises of an array of columns that bears resemblance to a geological cross-section but is different because the layers are not necessarily mutually connected. However, the CRGC-sections provide the user with an overview of the volume and depth of groundwater resources in cross-sectional view. The section of chronostratigraphic groundwater resource columns together summarize the thicknesses of all layers in the grid and uses predefined colors and symbols for attributes of the layers based on the IHME1500 - International Hydrogeological Map of Europe 1:1,500,000 (see first example in Figure 3). Once the default CGRC is on display, the user can make some predefined choices to highlight specific features of all the columns, for example choosing to highlight the total volumes within the layers or the transmissivity. Ideas about visualization are found in Appendix B of this report.

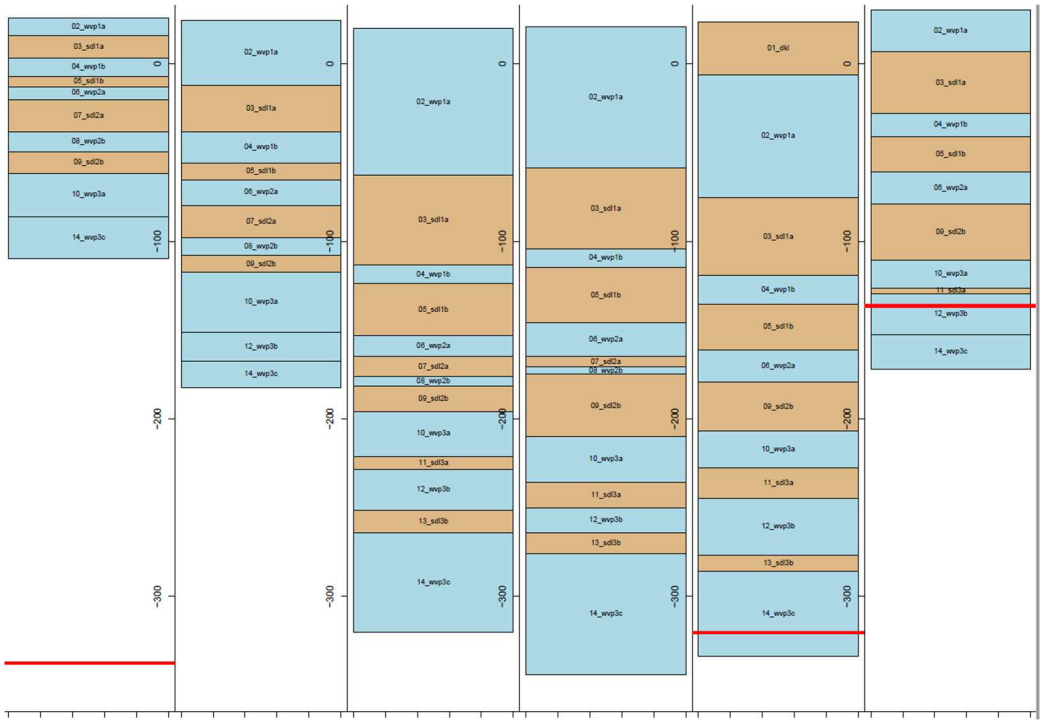

Figure 3: Example of a CGRC-section, a kind of virtual cross-section over the 10x10 km grid cells. Colors refer to the colors of the IHME1500 - International Hydrogeological Map of Europe 1:1,500,000, which intergranular aquifers in blue and strata with essentially no groundwater resources in brown (aquitards in this case). Numbers represent transmissivities (aquifers) and hydraulic resistance (aquitards), and names of the layers. The layers are not necessarily connected, which will be explained in a pdf or pop-up menu that justifies the approach and the assumptions. The user can choose which numbers to show in all the CRGC-columns within the section (such as transmissivities, volumes and some other predefined characteristics). The idea is to further refine the legend for these columns; first ideas are described in Appendix B.

2.3.2 Requirements:

Product title	Nr	Requirement	Description
2 D Map	3	Searching for maps	
	7	Web page with all services	Showing the 10x10 km grid all the time
	5	Enhanced interface to upload and thematize Shapefiles	
	10	Identify and follow link	Clicking on cell gives option to: 1-display virtual borehole (CRGC) 2-display a PDF where information about the definitions and making of the maps (could be made country specific. is described. 3-list a predefined selection of attributes which are included in the database
	11	Specific projection	EPSG:3035 This is important as this is a equal are projection and we are dealing with volumes
	12	Overview panel	
	13	Legend with tree view/ hierarchical on/off switching	
	14	Export map	
	20	Display virtual logs	Clicking on a cell a virtual borehole (CGRC) as shown in Figure 2 is displayed. The development of this functionality has to be agreed together with GIP-P WP6
	22	Create virtual cross-section 2.5D layers from a user defined geometry.	From a line draw by user a cross-section (CGRC-section) through all layers is displayed (See Figure 3). Cross-sections are built by displaying virtual boreholes next to each other
	26	Create simple queries and filters	Queries will be predefined but should work on the database created from the xlsx files. Queries to be defined in cooperation between GIP WP6 and RESOURCE WP6
2.5 D cross-section	12	Overview panel	

Product title	Nr	Requirement	Description
	13	Legend with tree view/ hierarchical on/off switching	Next to the cross –section a legend of the cross-section should be display. If one of the element of the legend is turn off, the cross-section displaying must reflect the change
	14	Export map	user could be able to export the Virtual Cross section to a PDF/JPG format
	26	Create simple queries and filters	User should be able to make queries on the layers displayed in the cross-section. Queries will be predefined but should work on the database created from the xlsx files. Queries to be defined in cooperation between GIP WP6 and RESOURCE
Virtual borehole	10	Identify and follow link	Clicking on the window of the virtual borehole a PDF is displayed where information about the definitions and making of the maps (could be made country specific). is described
	13	Legend with tree view/ hierarchical on/off switching	Next to the borehole a legend of the cross-section should be display. If one of the elements of the legend is turned off, the borehole displaying must reflect the change
	12	Overview panel	
	26	Create simple queries and filters	User should be able to make queries on the layers displayed in the boreholes. Queries will be predefined but should work on the database created from the xlsx files. Queries to be defined in cooperation between GIP WP6 and RESOURCE

APPENDIX A AGREED CHANGES TO THE TEMPLATE FOR THE PAN-EU GROUNDWATER RESOURCES MAP

Introduction

The production of the WP6 product Pan-EU map is based on a template for the pan-European grid. This template was described in the final version of RESOURCE Deliverable 6.1, which is added to this document as **Appendix C**. As RESOURCE WP6 partners we are now working to fill the grid and we anticipate a number of changes to the template, which have been discussed recently at the WP6 workshop in Zagreb November 20/21st 2019). The changes that we have agreed upon are listed in this Appendix A. These changes will appear in the newest version of the template which will be introduced by early 2020.

Additionally, Appendix B will give the current ideas of visualizations of the maps, CGRC's and CGRC sections, which will be further developed in the coming months.

Changes agreed on the template

Aquitard/aquifer distinction

The original template requires input for each layer to be aquitard or aquifer. In order to enable upscaling of thick sequences of mixed nature, we now introduce a third element "mixed aquifer/aquitard", which need a different calculation of the effective horizontal and vertical conductivities.

Hydraulic Parameters and types of aquifers:

In the original template, the following information was required in the template for each layer:

1. Porosity
2. Hydraulic Conductivity k_h
3. Hydraulic Conductivity, k_v
4. Artesian: Confined/unconfined/semi-confined/artesian.

These inputs were required for both aquifers and aquitards. As we change the subdivision in aquifers and aquitards and want to enable upscaling, we will change the requirements as follows:

Aquitards:

- Only porosity and k_v required, where k_v upscaled effective vertical conductivity representative of the whole grid cell and layer thickness

Aquifers:

- Porosity and k_h required, where k_h upscaled effective horizontal conductivity, representative of the whole grid cell and layer thickness
- Anisotropy factor for the layer as a whole, defined as effective k_h/k_v.
- New column: aquifer type, with options
    - Unconfined
    - Confined
    - Semi-confined

  These aquifer type characteristics apply to the layer as a whole over the extent of the grid cell that is occupied by the layer

Mixed aquifers/aquitards

- Porosity and k_h and k_v required, where k_h and k_v represent upscaled effective horizontal and vertical conductivity, representative of the whole grid cell and layer thickness. The next version of the template will include guidance how to calculate these effective conductivities with some examples
- New column: aquifer type, with options
    - Unconfined
    - Confined
    - Semi-confined

  These characteristics apply to the layer as a whole over the extent of the grid cell that is occupied by the layer

Artesian

The original template contained a field Artesian, that also covered typologies of aquifer types such as semi-confined and unconfined. These aquifer types are now in a separate column, and the column artesian now has another meaning and only two options: Y or N.
An aquifer has a Y for artesian once there is existing knowledge that at least part of the aquifer has artesian water, which means a groundwater head higher than the surface elevation at the location of the monitoring point where this is known. This column only appears Y when expert judgement indicates that this artesian situation is still present. Aquifers that were known to be artesian once, but now lost artesian status because of groundwater depletion are not marked as Y. Indication for groundwater depletion are given in the "Label_Dynamic" column, type P.

Thermal

The meaning of the Y in the column L#_Thermal has changed. We give Y as we know that the groundwater in part of the grid cell is thermal. Thus, it is not required that all the water in the layer is thermal. Temperature ranges are only given for cells that receive the label Y in the L#_Thermal column.

Paleo

The meaning of the Y n the column L#_Paleo has changed. We give Y as we know that the groundwater in part of the grid cell is paleowater. Thus, it is not required that all the water in the layer is paleowater.

Lithology

It was agreed that lithology is not the correct heading for this column. Therefore, the column is deleted and replaced by two new columns: Hydrogeofacies and Geologic Age.

Hydrogeofacies

For each layer in the grid we will now characterize the hydrogeofacies. The typology used is in line with the HME1500 - International Hydrogeological Map of Europe 1:1,500,000. The RESOURCE WP6 assembly agreed on the following list of hydrogeofacies, which is subdivided using the methodology of the IHME1500 legend:

Unconsolidated sedimentary hydrogeofacies
Unweathered marine clay
Clay, clayey loam, mud, silt, marls
Clayey-loamy alteration products
Loess
Coarse sand
Medium sand
Fine sand
Gravel
Eskjer deposits and moraines
Glacial till
Peat and raised bogs
Lignite
Pyroclastic, ash and tuff
Made ground

Fissured sedimentary hydrogeofacies
Karstified limestone
Dual-porosity fissured limestone and dolomite
Fissured Limestone and dolomite
Karstified Chalk
Fissured Sandstone
Fissured marlstone, flysch
Fissured mudstone, siltstone, shale, slate
Fissured alternation of sedimentary lithologies

Compact sedimentary hydrogeofacies
Mudstone, shale, slate, clay
Sandstone
Conglomerate
Chalk
Limestone
Dolomite
Travertine
Flysch
Rock salt
Anhydrite/gypsum
Siltstone, marlstone
alternation of silicastic lithologies

Compact igneous and methamorpic hydrogeofacie
Compact Basalt
Compact igneous and metamorphic rock
Lava

Fissured Crystalline Hydrogeofacies
Fissured igneous and metamorphic rock
Weathered granite
Weathered gabbro
Fissured basalt

Figure 4: Distinguished hydrogeofacies for the Pan-EU groundwater resources map

Geologic age

A new column will be added to the template that gives a rough indication of the age of the hydrogeofacies that is determined for each layer. The following options are available for the labels within this column. Intentionally, the list gives two levels of hierarchy, because upscaling at 10 x 10 km requires some flexibility, enabling to make predefined selections in a later stage.

Quarternary	Cretaceous
Tertiary Undistinguished	Jura
Mesozoic undistinguished	Triassic
Paleozoic undistinguished	Paleozoic undistinguished
Tertiary Neogene	Permian
Tertiary Paleogene	Carboniferous
	Devonian
	Silurian
	Ordovician
	Cambrian
	Precambrian

APPENDIX B: IDEAS FOR THEE VISUALISATION OF THE GRID FOR THE PAN-EU GROUNDWATER RESOURCES MAP

Following the discussion at the Zagreb workshop of Nov. 20/21th 2019, the following visualization options are foreseen. We distinguish three main views:

1. Map plane view
2. CGRC view: virtual borehole view
3. CGRC-sections: virtual cross-sections view

Map plane view

- Total volume over complete depth (default when map starts)
- Total thickness of fresh aquifers
- Total Transmissivity of the aquifers
- Total depth of fresh groundwater (based on the main worksheet in the template)
- Map of European principal aquifers
    - This will be made in a later stage after generalizing the main result of the work

Predefined selections:

Show:

- Total volume of fresh water
- Thickness of fresh aquifers
- Transmissivity of the aquifers

For the following selections:

- specific aquifer age (drop list: Quaternary to Precambrian, based on Geologic Age column)
- Specific hydrogeofacies (droplist: e.g. all karstified limestone)
- Overall groups such unconsolidated sedimentary hydrogeofacies, fissured sedimentary rocks etc.
- Aquifer type: Confined/unconfined/Semiconfined

Show:

- Presence of:
    - Artesian aquifers
    - Thermal water resources
        - Predefined temperature range
    - Paleowater
- Metadata for the grid or the grid cells (pop-up)
    - Pdf describing approach followed of individual countries
    - Pop up click on cell: pdfs about metadata and general approach

CGRC view: virtual borehole

After clicking a grid cell in map view the default is to show a Chronostratigraphic Groundwater Resource Column (CGRC)

The CGRC view shows:

- Thickness and extent of all the layers in the grid cell
- Hydrogeological IHME1500 legend colors for each of the layers
    - E.g. highly productive (dark blue) , locally productive (light blue) etc.
    - Follows directly for grid data for each of the layers
        - always on
- Hydrogeofacies using symbols that overly the colors for each of the layers
    - Symbols in accordance with IHME1500 legend
        - Default on, but on/off option
- Total depth of active fresh groundwater
    - as a thick horizontal line, data available in spreadsheets
        - always on
- Transmissivity ranges
    - Classification of transmissivities in range has to be made beforehand
        - On/off option
- (Hydraulic resistance ranges)
    - Idem
        - On/off option
- Geologic age
    - As a label juts outside of the column
        - On/off option
- Thermal, paleowater, artesian
    - Colors in contrasting color within the layer
        - On/off option
- Aquifers with a dynamic water level due to pumping
    - Colors in contrasting color within the layer
        - On/off option
- Help button
    - Pdf of the specific country as help
        - (metadata including assumptions, approach etc
        - Pdf with the general idea and applicability)

CGRC-section view: virtual cross-section

Most of the views are similar to the CRGC-view, but some options (on/off/defaults) are different in order to more easily see the main structures of the groundwater resources

The CGRC-section view shows

- Thickness and extent of all the layers in all adjacent columns that together make up the cross-section
- Hydrogeological IHME1500 legend colors for each of the layers
    - E.g. highly productive (dark blue) , locally productive (light blue) etc.
    - Follows directly for grid data for each of the layers
        - always on
- Hydrogeofacies using symbols that overly the colors for each of the layers
    - Symbols in accordance with IHME1500 legend
        - Default *off*, on/off option
- Total depth of active fresh groundwater
    - as a thick horizontal line, data available in spreadsheets
        - always on
- Transmissivity ranges
    - Classification of transmissivities in range has to be made beforehand
        - On/off option
- (Hydraulic resistance ranges)
    - Idem
        - On/off option
- Geologic age
    - As a label juts outside of the column
        - On/off option
- Thermal, paleowater, artesian
    - Colors in contrasting color within the layer
        - On/off option
- Aquifers with a dynamic water level due to pumping
    - Colors in contrasting color within the layer
        - On/off option
- Help button
    - Pdf of the specific country as help
        - (metadata including assumptions, approach etc
        - Pdf with the general idea and applicability)

APPENDIX C: DELIVERABLE 6.1 OF RESOURCE DESCRIBING THE TEMPLATE FOR THE WP6 PAN-EU MAP

GeoERA RESOURCE GROUNDWATER

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

Deliverable 6.1

Template that can be used by all participating surveys to collect the required data

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Work package	WP6, Pan-EU Groundwater Resources Map	
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Deliverable status		
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Verified (WP leader)	28/06/2019	Tano Kivits
Approved (Coordinator)	28/06/2019	Hans Peter Broers

INTRODUCTION

Although EU member states generally have a comprehensive overview of the groundwater resources in their homeland, a coherent overview of all fresh groundwater over Europe is not available for policy development and evaluation. The aim of the RESOURCE project and workpackage 6 (Pan-EU Groundwater Resources Map) is to produce a first information product at pan-European scale (for the participants, see figure 1) where available data is compiled and integrated to produce a map of the fresh groundwater resources of Europe. Workpackage 6 is divided in several tasks so that this goal can be achieved:

- Task 6.1: Criteria for harmonization across Europe;
- Task 6.2: Collection of data on depths and volumes;
- Task 6.3: Compilation of the map;
- Task 6.4: First estimate of water balance of EU's principal groundwater resources;
- Task 6.5: Data exchange with the Information Platform.

This document is the deliverable for task 6.1 of work package 6. It describes the template that will be used by all participating surveys for collection of required data on the average depths of aquifers and aquitards and the depth of the active fresh water groundwater system at a 10x10 km resolution. This template is used for task 6.2 where each participating survey collects the required data so that the map can be compiled under task 6.3.

In chapter 1, the general idea behind the template is explained. In chapter 2 the thought of some of the choices that were made based on the RESOURCE meeting in Vienna on 11-10-2018 are explained. The same is done in chapter 3 for the RESOURCE meeting in Budapest on 20 & 21-02-2019. In chapter 4, the template is described in more detail as to what information is asked and how this should be filled in.

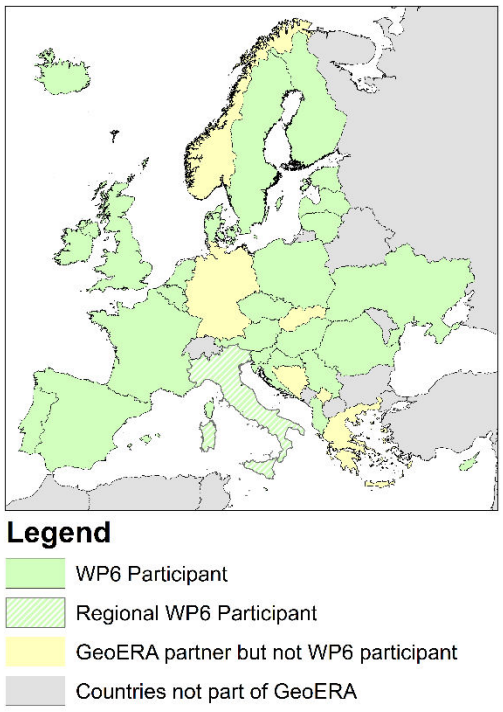

Figure 1 RESOURCE WP6 participants

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1 GENERAL IDEA

The general idea behind the RECOURCE WP6 project is to provide a map with the depths and volumes of fresh groundwater at a spatial scale that is feasible and useful for identifying the main patterns of groundwater availability, interpreting recharge and abstractions to and from the resource, providing base characterization for European and global scale models, and getting insight in the presence of paleo resources and its use as strategic reserves. To be able to get this information from all RESOURCE WP6 partners a template has been developed and discussed during the WP6 meetings in Vienna and Budapest. This deliverable describes the content of the template and how this should be filled in.

The spatial scale at which the data is gathered is very important. When filling in the template, please keep the European scale in mind. This means that not every detail which is included in the national data/models needs to be in the template. We suggest keeping the maximum amount of layers to at most 10, so that not every small layer that is most likely not significant of an European scale is included in the map.

The template is a xlsx file where each row indicates a grid cell. The cell-id's correspond with an existing 10x10 km INSPIRE shapefile grid over Europe (see figure 2 and https://www.eea.europa.eu/data-and-maps/data/eea-reference-grids-2). The coordinate system of this grid is ETRS89, with the Lambert Azimuthal Equal Area projection (LAEA) Each participant receives their own template (excel file, see figure 6) and grid (shapefile,

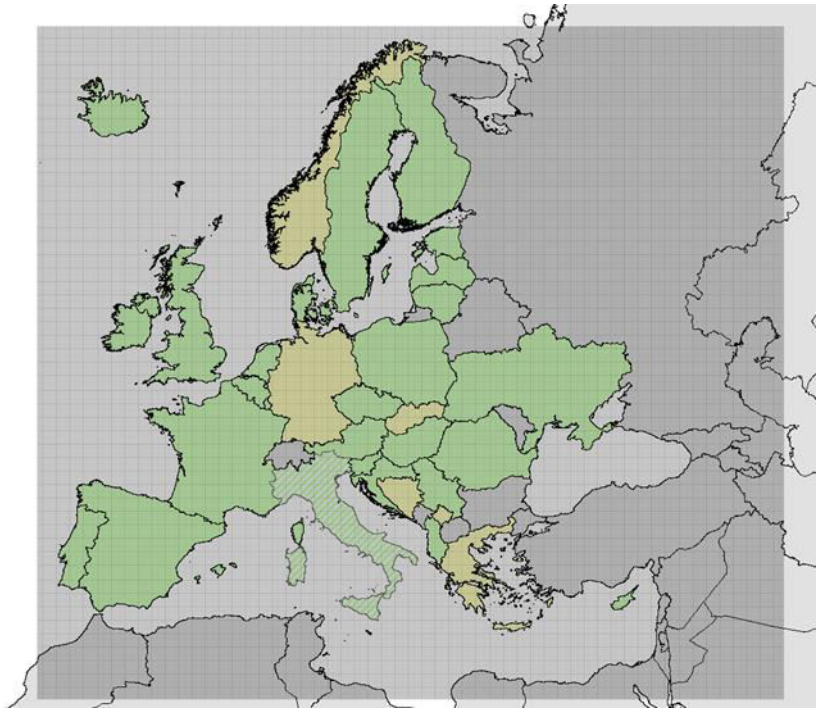


Figure 2 10x10 km INSPIRE grid

see figure 3) which covers their country, which will be joined later to cover Europe. The grid for each participating survey is distributed along with this deliverable. These county grids extend beyond the borders, each participant logically only fills in cells which are within their border. Cells that cover multiple countries are filled in by each nation in their own template, any large differences can be compared later.

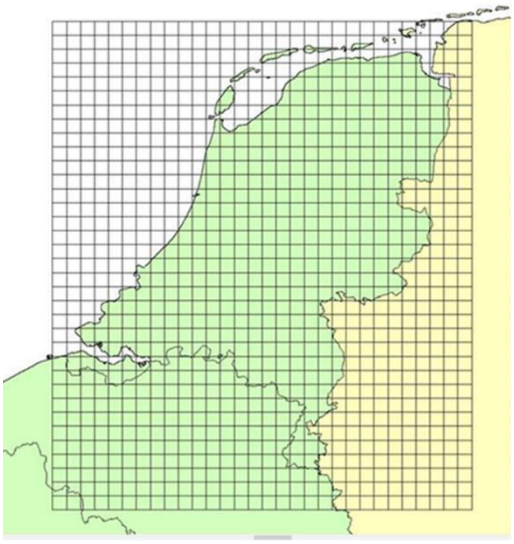


Figure 3 Country grid of the Netherlands

2 DECISIONS AFTER THE VIENNA MEETING

During the meeting in Vienna (11-10-2018) it was discussed what should be in the template and how the information should be filled in. Based on these discussions, we present the way we took the work forward as a first step in the development of the EU map. Some decisions might need further elaboration; that is why we ask you to work with the delivered template and share your experiences during our February 2019 meeting.

Grid type

- ETRS89; Official EU grid INSPIRE
- Projection: LAEA (Lambert Azimuthal Equal Area)
- Will be delivered to you with the template!
- Fixed ID's

Grid size

One point of discussion was the size of the grid cells. Originally, the plan was to have grid cells of 20x20 km. It was concluded that a resolution of 20x20 km is too coarse, so we should aim for a 10x10 km resolution. If 10x10 km is not feasible due to lack of information, 4 cells can be grouped to create a 20x20 km grid.

- Decision: scale = 10 x 10 km
- Countries that can easily deliver at higher resolution test 1 x 1, 2 x 2 and 5 x 5 km grids
- Countries that have difficulty at 10 x 10 km deliver 20 x 20 km, but on a grid that fitst the 10 x 10 to make it fit with the rest
- All data is averaged for the grid cell
    - But option to indicate if aquifer extends over only a % of the grid = extension
        - % of grid cell occupied by the aquifer

Main features of the grids

- Top and bottom of the most important aquifers and aquitards
    - Multiple layers
- Up to the **lower boundary of the active fresh groundwater flow system**
- Water level depth (stationary for agreed period, see later)

The definition of the lowermost boundary of the fresh groundwater system is broader that previously thought, because different surveys use different thresholds and parameters to delineate that boundary. It is accepted to use a hydrogeological boundary (a low permeability aquitard at some depth) or a salinity based threshold (the fresh-saline boundary). See next item.

Criteria for the delineation of the active fresh groundwater flow system

Another question was at which depth we stop defining layers. Since the general goal of the RESOURCE WP 6 project is to provide a map with the volumes and depths of fresh groundwater, we stop at the depth that is relevant for the total amount of available flowing fresh groundwater. This could either be the fresh-salt water interface or the top of a layer with very low conductivity that prevents further downward flow and effectively creates a

boundary for the fresh groundwater flow system. We decided to let you choose what is best for your country.
Point of discussion was how we should deal with different thresholds across different countries, for instance for the fresh-salt interface. For the fresh-salt interface it became apparent that each country has their own threshold, which could be generally be divided in three groups: 1. based on chloride concentrations, 2. based on Total Dissolved Solids (TDS), and 3. based on Electrical conductivity (EC). For chloride, the threshold concentration was set at 1000 mg/l, for TDS a concentration of 1500 mg/l is generally used, and for EC the boundary between fresh and salt is 2500 µS/cm. We suggest that each participating survey picks one of these three thresholds based on which best fits their current data. This choice must be indicated in the supporting information tab in the excel file.

We now offer four options in the template, which you may indicate using a symbol

- Hydrogeological boundary, depth of aquitard (H)
- Salinity boundary
  - Based on chloride (1000 mg/l chloride) (C)
  - Based on TDS (1500 mg/l TDS, still useful for irrigation) (T)
  - Based on EC (2500 µS/cm, EU drinking water standard) (E)

We provide an example in appendix 1, using figure 10 to delineate the active fresh groundwater system in a cross-section within the Netherlands (Note, the version of the template used in the appendix is an old version, see chapter 4 for the updated description). In this figure, the red vertical lines show the fresh-salt interface, the black vertical lines show the top of clay layers with a high vertical resistance (thus the hydrogeological base). In this example, the fresh-salt interface determines the depth of the total fresh water domain.

<u>Water level depth</u>

- Stationary for a fixed period (average over 2000-2010)
  - Minimal water level as measure for **Kars**t
- But with label: water table dynamically changing (Y/N)
  - Reason indicated with symbol
    - S = almost stationary
    - R= recovery after mining
    - P = pumping increase
    - After Budapest meeting: more labels needed (see next chapter)
- Unsaturated zone depth = Altitude minus water level depth
  - Indicate lithology of unsaturated zone

<u>Hydraulic Parameters:</u>

- Porosity
- Conductivity, very rough k_h, K_v for each layer
- Confined/unconfined

Paleowater

- Label of each layer based Expert judgement
  - Definition >10.000 year
    - Result of tracer studies
    - 18O, noble gas temperature, 14C dead
  - Models that indicate these time scales
  - Identify grid cells where it occurs

Criterium for delineating an aquitard that is significant at EU scale, new proposal:

- Criterium based on vertical hydraulical resistance = thickness of the aquitard divided by the vertical hydraulic conductivity (in days)
  - C = Thickness / estimated K_v (in days)
- If C > 10000 days: take this aquitard into account as separate layer
  - Example clay layer with K_v = 0.001 m/day and thickness 10 m yields this 10.000 days

Thermal water

The presence of thermal aquifers can be indicated in the template. Similar to the fresh-salt interface, there are different thresholds for each participant (e.g. Hungary = 30 °C, Romania = 20 °C, UK 15 °C). This will be indicated by temperature ranges (see next chapter).

3 DECISIONS AFTER THE BUDAPEST MEETING

During the RESOURCE WP6 meeting in Budapest (20 & 21 February 2019) there were further discussions on the content of the template after each participant had tested the first version for a couple of cells. Below the decisions that were made during and after the meeting are described.

Implementation of EVRF

In Vienna it was decided that we should use a common height reference system. There are different ways to implement this, but the easiest solution is to add or subtract the numbers from Figure 4 from the national height systems. This is not very precise, but the regional differences are only a few centimetres which, on a European scale, are not of any large influence on the calculation for the total volume of fresh groundwater.

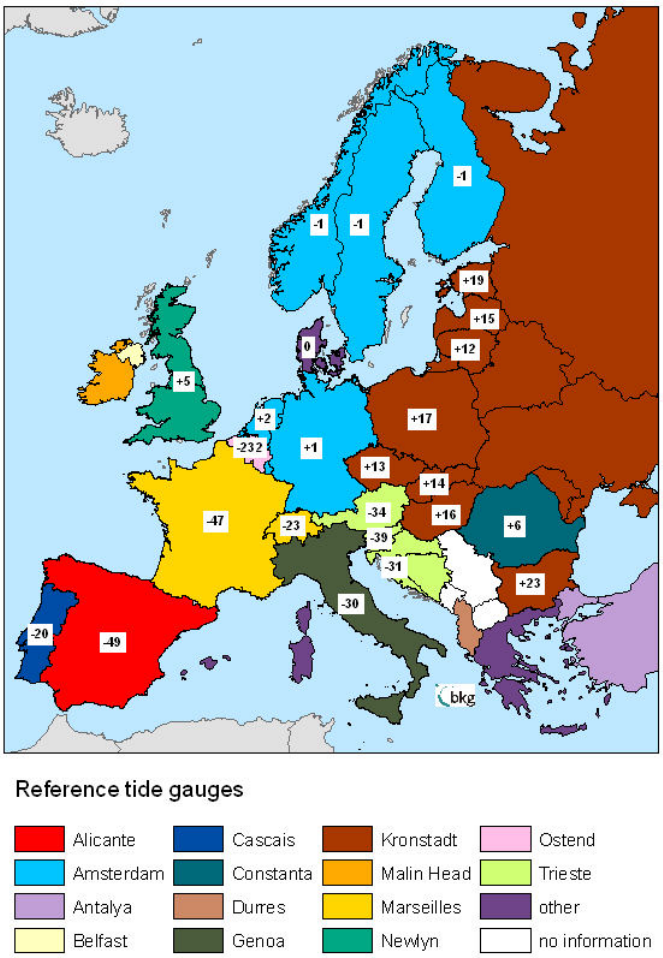


Figure 4 Difference between the European national height systems and EVRF2007 in cm

Border cells

Cells which are on the border between 2 countries are filled by the country which occupies more than 50% of that cell

Layer numbers
Layer numbers are not the same across multiple cells. This means that layer 1 is always the top layer in every cell

Layer grouping
Individual geological layers as mapped by each survey can be grouped to form one layer based on similar hydraulic parameters. When there are large differences in these hydraulic parameters the layers can be split. Also, when layers are covered by a label (e.g. paleo/thermal etc.) they are to be added as a separate layer.

Unsaturated zone
The information on the unsaturated zones is moved in the template from the main information tab to each layer, as more than the first layer can have unsaturated zones. This means that columns D,E, and F from the main information tab are moved to the layer information tabs.

Karst active zone
The active zone in Karst systems can be indicated by the extent of the fractured zone, and not necessarily by a change in lithology. This will now be indicated in the main information tab under column I.

Lithology list
We will use a standard list of lithologies so that we don't have to come up with our own names. The list that will be used is the INSPIRE list of lithologies (see http://inspire.ec.europa.eu/codelist/LithologyValue).

Semi-confined aquifers
Semi-confined aquifers are added as one of the possible aquifer types with a separate labels.

Naturally fluctuating water levels
Groundwater levels are mostly naturally fluctuating on a seasonal basis, but these can be considered static on a European scale. The label static (S) is changed to naturally fluctuating (N). This label doesn't include karst systems with very large seasonal fluctuations, these are covered by their own label (K).

Thermal water
It was decided that we will give temperature ranges for the groundwater in the layers instead of deciding on one temperature boundary for thermal layers. Each country with thermal groundwater has their own threshold, and these often don't match. Therefore, it is easier to give the temperature ranges in the layers, and a label if the groundwater is seen as thermal by the country.

Porosity

For the value of porosity, the effective porosity is given since this is most often known and used. We are mainly interested in the volume of groundwater that is available for groundwater flow, which is best represented by the effective porosity..

Standards for hydraulic parameters

By default, data will be entered as hydraulic horizontal conductivities in m/day, and vertical conductivities will be based on an anticipated ratio between k_h and k_v. For many layers the exact hydraulic parameters (porosity, horizontal/vertical conductivity) are not exactly known. Therefore, it was decided that it would be useful to have list of standard hydraulic parameters for the different lithologies in regions where no measurements are available. This list is not made yet, but will be discussed under the second task of the work package 6.

Multiple layers next to each other

One of the main topics of discussion was how to schematize the layers in cells with mountainous regions or subsurface tunnel valleys. The main issue in these regions was that there can be multiple layers next to each other in one grid cell, which is difficult to fill in the first version of the template.

After the meeting a discussion took place between the surveys where these problems were the most imminent (BRGM, GEUS, HGI-CGS, ICGC, IGME, AGS, GBA). The most feasible solution was, as suggested by the BRGM, to order the layers by chronostratigraphy first, and then determine the average thickness of both the saturated and unsaturated zone and the % extent of the layer in each cell. An example of how this would work is shown in Figure 5. The top left image shows a hypothetical cross section of a 10x10 km cell with a mountain (layer B), an underground tunnel valley (layer C) and several other layers in between. The unsaturated zones are indicated by the vertically striped layers. The top right image of Figure 4 shows the layers separated and ordered from top to bottom by chronostratigraphy. The same layers are schematized and converted to a 10x10 km scale on the bottom left image. Here, the black bars next to the layers indicate the extent of that layer. The final visualization will look like the image on the bottom right, where all layers are put beneath each other on chronostratigraphic order. In the Figure, the horizontal axis denotes the extent of the layer in the 10 x 10 km grid, where 100% extent is visualized as a fully filled horizontal axis.

The advantage of the approach chosen is that the final map will give a good representation of the volumes and thicknesses of the groundwater resource, at a scale which is useful at the Pan-EU level. The schematized cross-section has some shortcomings and cannot be used for many other purposes that one could think of. For one, it does not represent the actual depths that the layers are in real life. For example, in the “real” cross-section of the top left, the bottom of the last layer (G) is at -1400 meters, while in the schematized cross section it falls below that. This means that the schematized cross-sections that we will produce for the groundwater map are not a real representation of the geology, and it will be important that we stress that when presenting our final results.

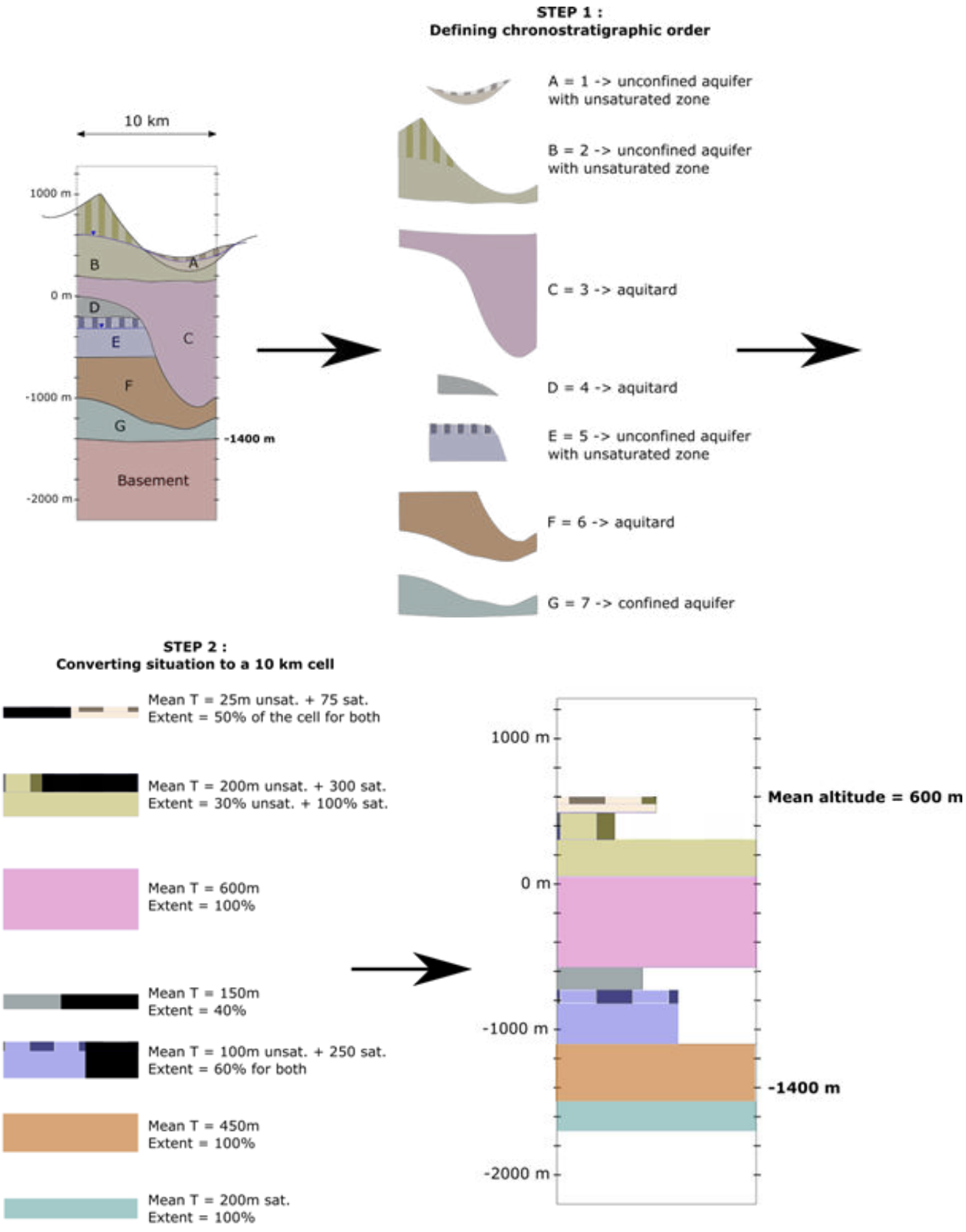


Figure 5 Approach for schematizing areas where there are multiple layers next to each other. First, the layers are ordered based on chronostratigraphy and then converted to a 10x10 km scale. T= thickness

4 DESCRIPTION OF THE TEMPLATE AND COMMON CRITERIA

This chapter contains descriptions for each of the columns in the template of what should be filled in and how this should be done. The template is an excel file consisting of multiple tabs (see Figure 6). These tabs are labelled as followed:

- Template instructions (this tab contains the same information as this chapter)
- Main information;
- Layer 1 to layer 10;
- Supporting info;

Below, for each of these tabs is a description of what information is required.

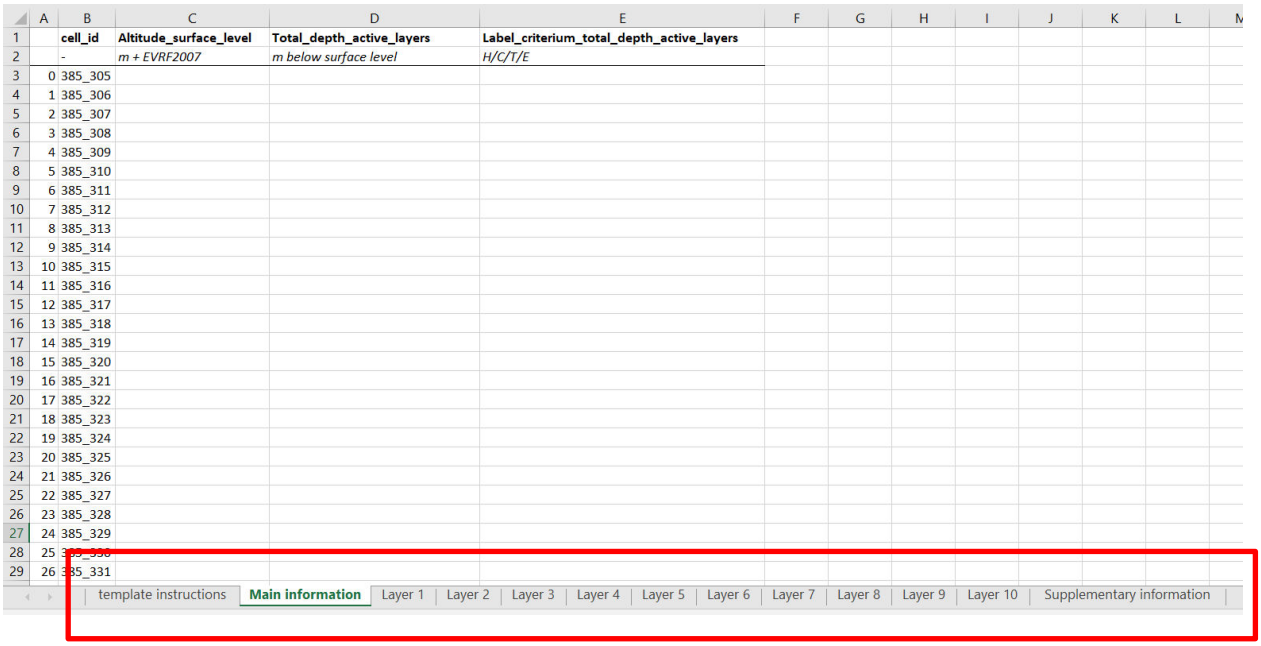


Figure 6 Template example with tabs indicated

4.1 Main information

The first tab includes information that is of importance to the entire 10x10 km grid cell (see figure 6). The columns are explained below.

B. cell-id

Unique identifier for each grid cell. The id's are labelled as col_row with column numbers increasing from south to north and row numbers increasing from west to east. Please do not change anything in this column, these will be used to link the individual county grids to the Europe-wide grid.

C. Altitude_surface_level

This column contains the average altitude over the grid cell in meters relative to the EU height reference level EVRF2007 (European Vertical Reference Frame). All other depths in the template are relative to surface level. The reference level can be obtained by adding/substracting from the national reference frames as seen in figure 4.

D. Total_depth_active_layers

This indicates the maximum depth of the layers that are defined are of importance considering the fresh water volume. This could either be the top of layer with a very high vertical resistance (hydrogeological base) or the interface between fresh and saline groundwater if this falls above the hydrogeological base. The boundary that is used can be indicated in the next column.

E. Label_maximum_depth_active_layers

In this column you can indicate what is used as a label for the maximum depth of the active layers. This can be indicated by the following letters:

- H = hydrogeological boundary (e.g. depth of aquitard, extent of fractured zone in karst systems)
- C = based on chloride concentration (1000 mg/l Cl)
- T = Based on TDS concentration (1500 mg/l TDS)
- E = Based on EC (2500 µS/cm, EU drinking water standard)

4.2 Layer 1 – Layer 10

Below is an explanation for each of the columns in the layer tabs in the template. The layers are numbered one to ten. In the template there is space for 10 layers, please try to not use any more layers. However, if you do need more it can easily been done by creating a new tab and copy-pasting one of the previous layers (be sure to change the layer numbers and to add the cell id's from column B).

As discussed in chapter 3, the order of the layers should be on chronostratigraphic order (for reference see figure 7 on the next page). This makes it possible to include layers which are beside each other vertically. It also means that each layer can have an unsaturated zone, so the information on the unsaturated zone (thickness, extent and level amplitude) in now in the layer information tabs instead of in the main information tab. In the example of figure 7, both layers 1, 2 and 5 have an unsaturated zone so for these layers, columns C, D, E, F, and G under the layer tabs will be filled in (along with the other columns on the saturated zone). The other layers do not have an unsaturated zone, so the columns C to G will remain empty for these layers.

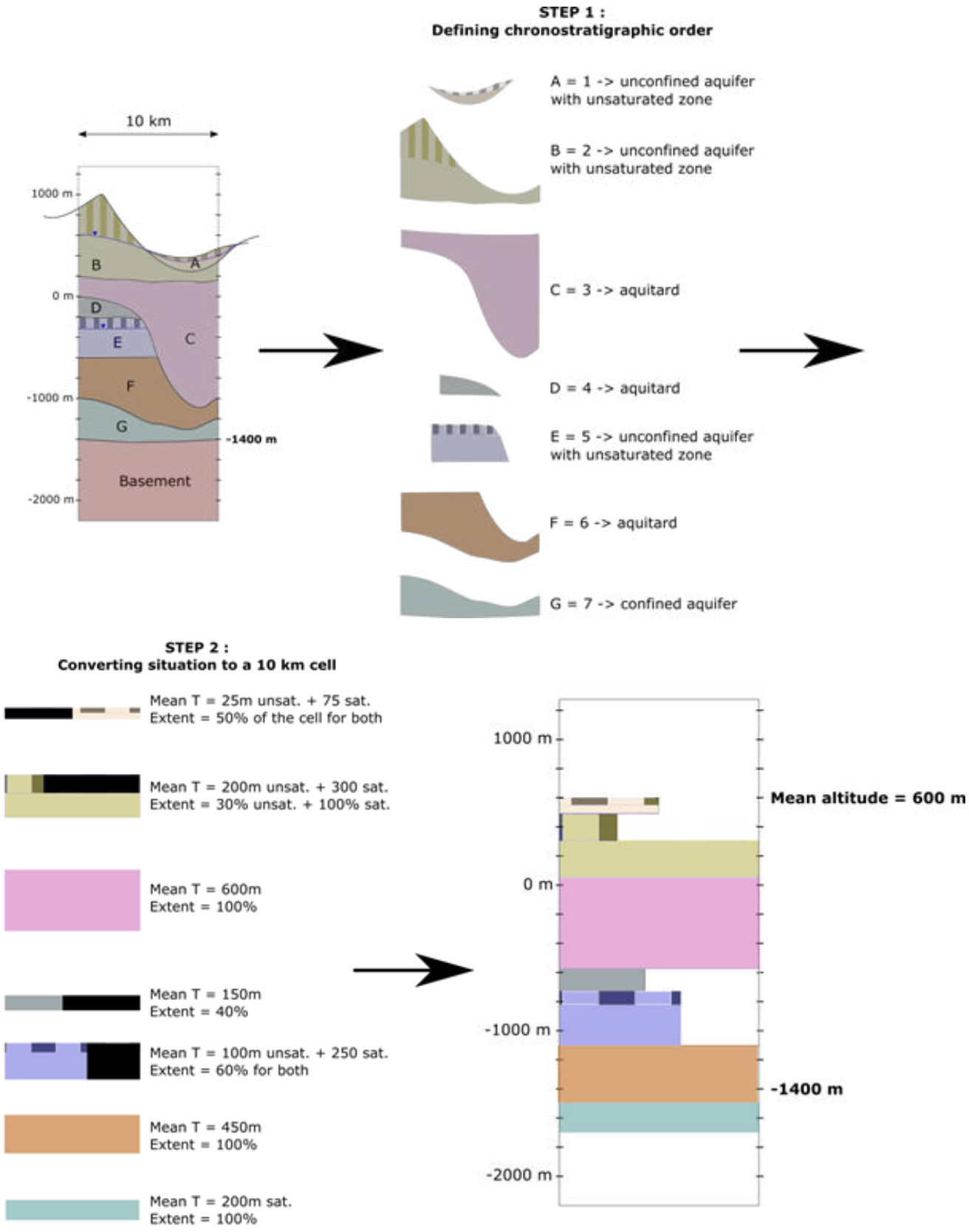
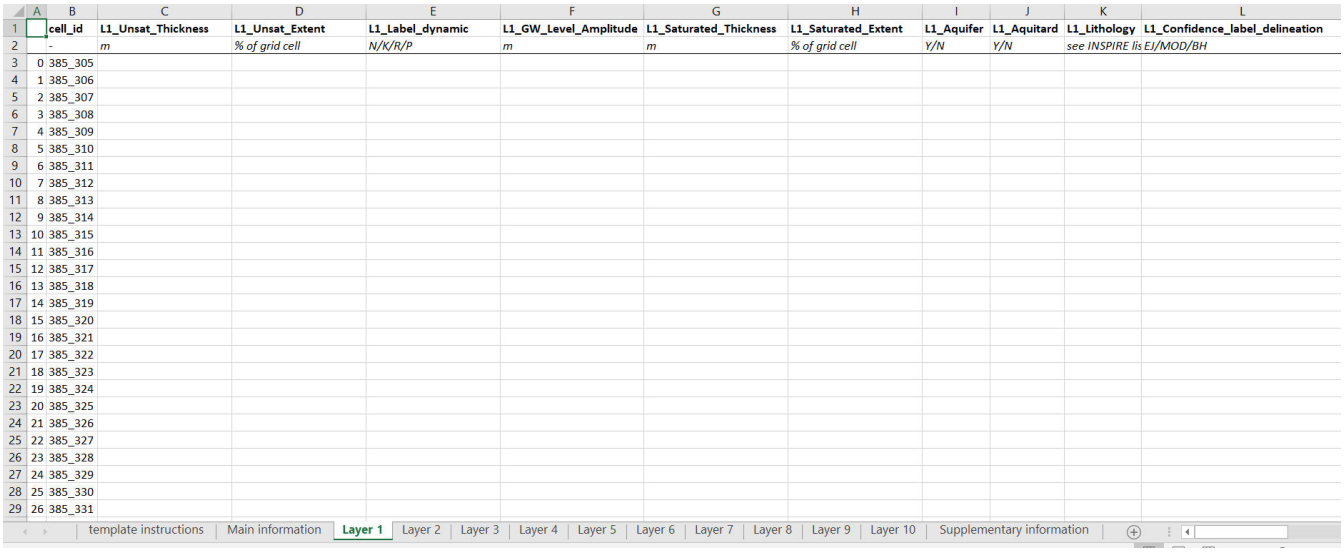


Figure 7 Approach for schematizing areas based on chronostratigraphic order



	A	B	C	D	E	F	G	H	I	J	K	L
1		cell_id	L1_Unsat_Thickness	L1_Unsat_Extent	L1_Label_dynamic	L1_GW_Level_Amplitude	L1_Saturated_Thickness	L1_Saturated_Extent	L1_Aquifer	L1_Aquitard	L1_Lithology	L1_Confidence_label_delineation
2		-	*m*	*% of grid cell*	*N/K/R/P*	*m*	*m*	*% of grid cell*	*Y/N*	*Y/N*	*see INSPIRE lis*	*E1/MOD/BH*
3	0	385_305										
4	1	385_306										
5	2	385_307										
6	3	385_308										
7	4	385_309										
8	5	385_310										
9	6	385_311										
10	7	385_312										
11	8	385_313										
12	9	385_314										
13	10	385_315										
14	11	385_316										
15	12	385_317										
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22	19	385_324										
23	20	385_325										
24	21	385_326										
25	22	385_327										
26	23	385_328										
27	24	385_329										
28	25	385_330										
29	26	385_331										

template instructions | Main information | **Layer 1** | Layer 2 | Layer 3 | Layer 4 | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 | Layer 10 | Supplementary information

Figure 8 Layer 1 - Layer 10 tabs example, columns A-L

C. L1_Unsat Thickness
The average thickness of the unsaturated zone of this layer in meters. If the layer has no unsaturated zone this can be left empty.

D. L1_Unsat_Extent
The average extent of the unsaturated zone in percent of the grid cell.

E. L1_Label_dynamic
Label which describes the dynamics of the groundwater level. There are several options which can be indicated by the following letters:

- N = Naturally seasonal variability;
- K = Karst systems with seasonal groundwater level fluctuation;
- R = Recovery after mining;
- P = Groundwater depletion by pumping.

F. L1_GW_level_amplitude

If the groundwater level is dynamic, the amplitude can be given here. This is indicated by the difference between average lowest groundwater level and average highest groundwater level over a 10 year period.

G. L1_Saturated_thickness
The average thickness of the saturated zone within this layer in meters. Please note that each layer may have its own value defined here, so unsaturated zone can exist in all layers.

H. L1_Saturated_Extent
The average extent of the saturated zone in percent of the grid cell.

I & J. L1_aquifer & L1_aquitard

Labels indicating if the layer is an aquifer or aquitard, indicated by Y (yes) or N (no).

K. L1_lithology

Description of the lithology of the layer, following the INSPIRE list of lithologies (see http://inspire.ec.europa.eu/codelist/LithologyValue).

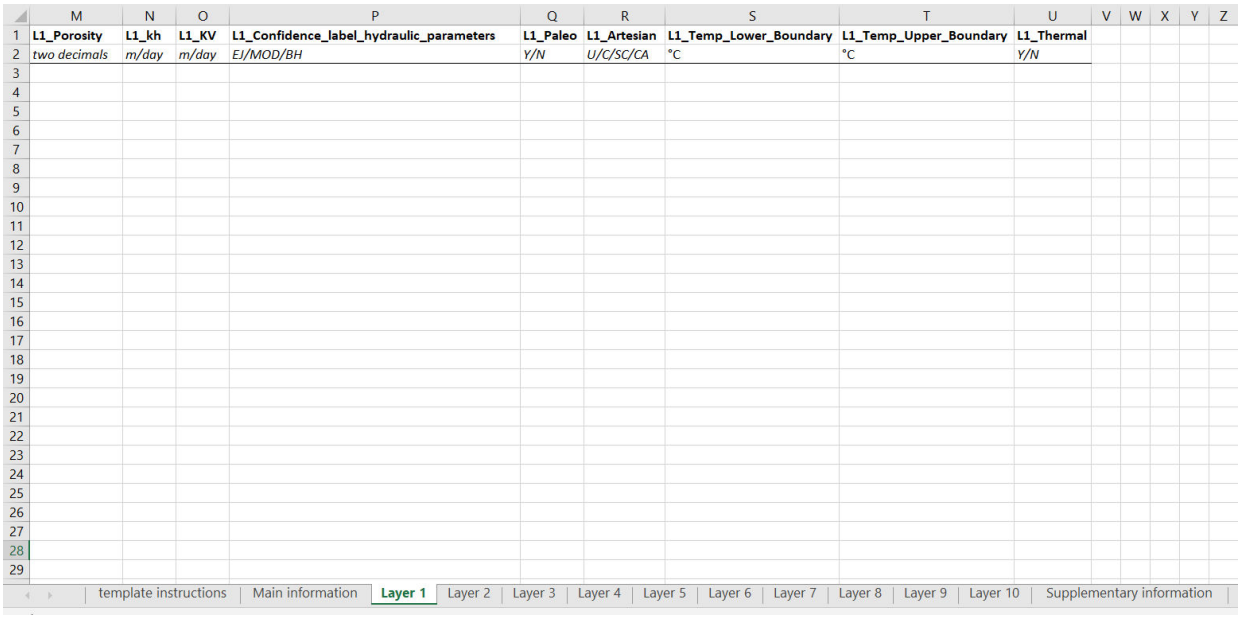
If a layer consist of multiple types of lithologies and it is not split in separate layers, the lowest common denominator for that group from the Inspire list should be noted in the template. For example, a complex of carbonate rocks including limestone, marls and gaizes, would be calcareous carbonate sedimentary rock (http://inspire.ec.europa.eu/codelist/LithologyValue/calcareousCarbonateSedimentaryRock). Limestone is in the Inspire list (see http://inspire.ec.europa.eu/codelist/LithologyValue/limestone), but marls and gaizes are not. The parent group of limestone is calcareous carbonate sedimentary rock, which is also the correct group for marls and gaizes.

Another example is Flysch (complex of sandstone, mudstone, shale etc.) which is by itself not in the INSPIRE list but would fit best under the label clastic sedimentary rock. Shale is in the list, with mudstone as a parent group (see http://inspire.ec.europa.eu/codelist/LithologyValue/shale). The parent group of mudstone and sandstone is clastic sedimentary rock, so this label is the best fit for flysch.

L. L1_Confidence_label_delineation

Label which describes the confidence level of which the above information about layer depths and extent is based on.

- EJ = Expert Judgement
- MOD = Based on subsurface model
- BH = Based on boreholes



	M	N	O	P	Q	R	S	T	U
1	**L1_Porosity**	**L1_kh**	**L1_KV**	**L1_Confidence_label_hydraulic_parameters**	**L1_Paleo**	**L1_Artesian**	**L1_Temp_Lower_Boundary**	**L1_Temp_Upper_Boundary**	**L1_Thermal**
2	*two decimals*	*m/day*	*m/day*	*EJ/MOD/BH*	*Y/N*	*U/C/SC/CA*	°C	°C	*Y/N*

template instructions | Main information | Layer 1 | Layer 2 | Layer 3 | Layer 4 | Layer 5 | Layer 6 | Layer 7 | Layer 8 | Layer 9 | Layer 10 | Supplementary information

Figure 9 Layer 1 - Layer 10 tabs example, columns M-U

M. L1_Porosity

Porosity indicated with two decimals

N. L1_kh

Horizontal conductivity in m/d (1 decimal)

O. L1_KV

Vertical conductivity in m/d (multiple decimals)

P. L1_Confidence label_hydraulic_parameters
Label which indicates the confidence level of which the hydraulic parameters are based on.

- EJ = Expert Judgement
- MOD = Based on subsurface model
- BH = Based on boreholes

Q. L1_Paleo

Label indicating if the groundwater in the layer is Paleogenic (older than 10.000 years) or not (Y or N).

R. L1_Artesian

Label indicating if the aquifer is confined/unconfined/semi confined/Confined artesian (C, U, SC, CA).

S. L1_Temp_Lower_Boundary

Here you can indicate the lower temperature boundary of the groundwater in the layer

T. L1_Temp_Upper_Boundary

Here you can indicate the upper temperature boundary of the groundwater in the layer

U. L1_Thermal

Label indicating if the groundwater, based on the temperature ranges given in the previous two columns, is considered thermal in your country (Y/N). There are no set temperature boundaries as thermal waters are defined differently for each country. Therefore each country decides for themselves if the given temperature ranges are considered thermal or not. This label allows to easily select all thermal aquifers when all the data is gathered.

4.3 Supplementary information

This worksheet can be used to add extra information that is not yet part of the template, but you think is important for good use of the data (free format per grid cell).

APPENDIX I TESTING PHASE EXAMPLE

This example was used after the Vienna meeting to give some guidance on the process. Based on the draft template and this examples, the individual surveys have tested this first version of the template. Chapter 3 describes the results of this testing and the changes discussed during the Budapest meeting.

As discussed during the meeting in Vienna, the idea is that each partner tests the template before the next RESOURCE meeting (end of February 2019). During the testing phase, all participants will fill in 5 to 10 grid cells to see if they are able to fill in the template, and if anything needs to be changed or if more information should be given. The feedback on this testing will be used to improve the template so that each participant is able to fill it in completely. It is therefore very important that each participant tests the template.

Below, an example is given for several grid cells within the Netherlands. Figure 10 shows a vertical cross-section of several 10x10 km grid cells within the Netherlands. In this figure, the colours of the layers indicate different stratigraphic units. Colour differences within each layer indicate the presence of clay layers (e.g. the difference between dark blue and light blue in the layer at -250 to -400 m depth, the dark colour indicates clay). This is used to distinguish aquitards from aquifers (see cells E, F, G, and H, indicated by a striped layer).

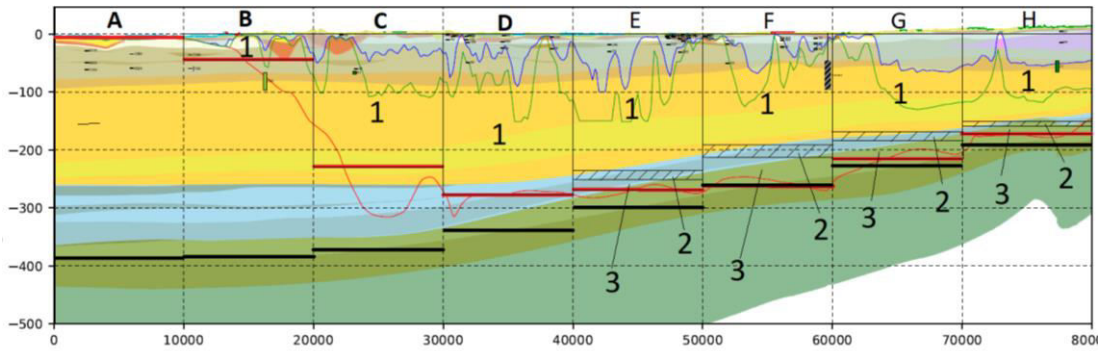


Figure 10 Cross-section of several grid cells in the Netherlands

As mentioned in chapter 1, the vertical red lines indicate an approximation of the fresh-salt interface (which is shown as the smaller fluent red line, our threshold was 1000 mg/l chloride) and the vertical black lines indicate the top of the layers with very low vertical conductivity (and corresponding high vertical hydraulical resistance. We use these layers to define our hydrogeological boundary. Effectively, in our case, we define our total depth

	A	B	C	D	E	F	G	H	I
1		cell_id	Altitude_surface_level	Unsaturated zone depth	Label_dynamic	GW_level_amplitude	Unsat_lithology	Total_depth_active_layers	Label_criterium_total_depth_active_layers
2		-	*m + EVRF2007*	*m below surface level*	*S/K/R/P*	*m*	*choice from a list*	*m below surface level*	*H/C/T/E*
3	1	A							
4	2	B	1	0.2	S		Unconsolidated sand	45	C
5	3	C	0	0.3	S		Unconsolidated sand	225	C
6	4	D	0	0.5	S		Unconsolidated sand	285	C
7	5	E	0	0.5	S		Unconsolidated sand	280	C
8	6	F	1	0.5	S		Unconsolidated sand	275	H
9	7	G	2	0.6	S		Unconsolidated sand	220	C

Figure 11 Example – Main information tab (note: this is the old template version)

of fresh groundwater by the fresh-salt interface, as the hydrogeological base is typically below that interface. In cell 1 the salt-fresh interface is on the same level as the surface level (this cell covers sea), so no layers are defined. For cell B to D, only 1 layer is defined since there are no aquitards of any importance (as far as relevant for the EU scale product). In cell E to H there is an aquitard above the fresh-salt interface so here there are multiple layers. The figures below show the filled in template for this example (note: this is very indicative and not precise).

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		cell_id	L1_Top	L1_Bottom	L1_Aquifer	L1_Aquitard	L1_Lithology	L1_Extent	L1_Confidence_label_delineation	L1_Porosity	L1_kh	L1_KV	L1_Confidence_label_hydraulic_parameters	L1_Paleo	L1_Artesian	L1_Thermal
2		-	*m below surface level*	*m below surface level*	*Y/N*	*Y/N*	*see table*	*% of grid cell*	*EI/MOD/BH*	*two decimals*	*m/day*	*m/day*	*EI/MOD/BH*	*Y/N*	*U/C/CA*	*Y/N*
3	1	A														
4	2	B	0.2	45	Y	N	Sand	100	MOD	0.32	15		BH	N	U	N
5	3	C	0.3	225	Y	N	Sand	100	MOD	0.32	75		BH	N	U	N
6	4	D	0.5	285	Y	N	Sand	100	MOD	0.32	75		BH	N	U	N
7	5	E	0.5	230	Y	N	Sand	100	MOD	0.32	75		BH	N	U	N
8	6	F	0.5	195	Y	N	Sand	100	MOD	0.32	75		BH	N	U	N
9	7	G	0.6	175	Y	N	Sand	100	MOD	0.32	75		BH	N	U	N
10	8	H	1	150	Y	N	Sand	100	MOD	0.32	75		BH	N	U	N
11																

Figure 12 Example – Layer 1 tab (note: this is the old template version)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		cell_id	L2_Top	L2_Bottom	L2_Aquifer	L2_Aquitard	L2_Lithology	L2_Extent	L2_Confidence_label_delineation	L2_Porosity	L2_kh	L2_KV	L2_Confidence_label_hydraulic_parameters	L2_Paleo	L2_Artesian	L2_Thermal
2		-	*m below surface level*	*m below surface level*	*Y/N*	*Y/N*	*see table*	*% of grid cell*	*EI/MOD/BH*	*two decimals*	*m/day*	*m/day*	*EI/MOD/BH*	*Y/N*	*U/C/CA*	*Y/N*
3	1	A														
4	2	B														
5	3	C														
6	4	D														
7	5	E	230	245	N	Y	Clay	100	MOD			0.025	BH			
8	6	F	195	210	N	Y	Clay	100	MOD			0.025	BH			
9	7	G	175	185	N	Y	Clay	100	MOD			0.025	BH			
10	8	H	150	155	N	Y	Clay	100	MOD			0.025	BH			

Figure 13 Example - Layer 2 tab (note: this is the old template version)

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1		cell_id	L3_Top	L3_Bottom	L3_Aquifer	L3_Aquitard	L3_Lithology	L3_Extent	L3_Confidence_label_delineation	L3_Porosity	L3_kh	L3_KV	L3_Confidence_label_hydraulic_parameters	L3_Paleo	L3_Artesian	L3_Thermal
2		-	*m below surface level*	*m below surface level*	*Y/N*	*Y/N*	*see table*	*% of grid cell*	*EI/MOD/BH*	*two decimals*	*m/day*	*m/day*	*EI/MOD/BH*	*Y/N*	*U/C/CA*	*Y/N*
3	1	A														
4	2	B														
5	3	C														
6	4	D														
7	5	E	245	280	Y	N	Sand	100	MOD	0.32	7.5		BH	N	C	N
8	6	F	210	275	Y	N	Sand	100	MOD	0.32	7.5		BH	N	C	N
9	7	G	185	220	Y	N	Sand	100	MOD	0.32	7.5		BH	N	C	N
10	8	H	155	175	Y	N	Sand	100	MOD	0.32	7.5		BH	N	C	N

Figure 14 Example - Layer 3 tab (note: this is the old template version)