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

Deliverable 4.3

Harmonized hydrogeological dataset and model input

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1 INTRODUCTION

This document is the deliverable for task 4.3 of the TRANSFLUX 4 (WP4) work package which involved the “Unification and harmonization towards a hydrogeological dataset and the model parameters and layers for the multi-aquifer system”. The report presents the scope of data that was developed by participating parties in the form of GIS layers for groundwater hydrodynamic numerical model purposes. The groundwater model will cover the Polish-Lithuanian cross-border area. In order to eventually derive a harmonized hydrogeological dataset for transboundary use as deliverable 4.3 of the work package, in earlier tasks was developed a template, that can be used by the project partners for collecting the data and to prepare the harmonized dataset.

In this document the assumptions and scope of task 4.3 are explained, the format which was developed based on arrangements made during the WP4 TRANSFLUX Polish-Lithuanian working meeting, that was hosted in the headquarters of the Polish Geological Institute-National Research Institute in Warsaw on May 30th 2019, as well as ideas, that were considered during workshop of Groundwater RESOURCE project group of GeoERA, that took place in the headquarters of the Croatian Geological Survey in Zagreb on November 19th -21th 2019.

2 WORK FLOW

2.1 General idea and aims of the WP4 project

The general idea behind the work package 4 (WP4) Groundwater RESOURCE "*TRANSFLUX: Harmonization of data, monitoring and modelling in a transboundary setting*" is to develop a numerical hydrodynamic model for the Lithuanian-Polish cross-border area, that will cover the Quaternary multi-aquifer system for the selected parts of the transboundary river basins.

The project has two major research goals: the verification and determination of the transboundary groundwater flow directions in the cross-border area and the estimation of the volume of groundwater, that flows through the state border between Poland and Lithuania. The crucial part of the project, which focuses on the numerical model development was preceded by the comparison of the scope of data, that is available in each institution involved in the WP4 and can be used for hydrodynamic modelling purposes for cross-border areas. Task 4.1 of WP4 (*Comparison and unification of methods for groundwater modelling in Poland and Lithuania*) is linked to the task 4.2 and it was carried out between July 1th 2018 and the end of December 2018. The deliverable for task 4.1 covered the comparative tables of data review, that can be used for groundwater hydrodynamic numerical modelling purposes. The tables were developed and provided by all institutions participating in the WP4: Polish Geological Institute-National Research Institute (PIG-PIB), Lithuanian Geological Survey (LGT) and Geoinform of Ukraine. The comparative tables allowed to realize the similarities, as well as obstacles in a common works aimed at development of numerical hydrodynamic models, which will cover cross-border areas in this part of Europe. It turned out, that some materials needed further clarification in detail among involved cooperators, as well as some data needed to be standardized or adjust for the transboundary use.

2.2 Model choices and project tasks

The first workshop of the WP4, was hold at the Sidorówka hydrogeological station of the Polish Geological Institute-National Research Institute on October 16th 2018. In this meeting representatives of the Polish Geological Institute-National Research Institute (PIG-PIB) and the Lithuanian Geological Survey (LGT) attended. At the working meeting, a proposal for the GIS layers was presented with boundary conditions for the modelling area, covering the Polish-Lithuanian cross-border zone. Discussions also aimed at the issues related to the transboundary spatial extent of model layers. It was decided, that the numerical model will be developed in Groundwater Vistas software, operating in the Microsoft Windows environment. In terms of the organization of the calculation process, GW Vistas is an interface on the ModFlow group calculation modules. During the meeting in Sidorówka experiences referring to already existing numerical models, developed in Poland and in Lithuania were compared.

Task 4.2 of WP4 (*Integrated evaluation and harmonization of the hydrogeological data set for modelling purposes*) was conducted since January 2019. Participants of the project prepared and provided: geological, hydrogeological and other data useful for groundwater modelling purposes. In this stage of the project cooperating parties of the project made attempts aimed at adjusting data (that are partly available in analog form or in .pdf files) to the requirements of GIS environment. The raw data were processed to the common projection in the GIS environment. The jointly agreed geographic coordinate system used is PUWG-1992. System WGS-84 is used to share data between the cooperating parties. To carry out modelling investigations the study area was discretized, the model boundaries were defined, and the boundary conditions were determined.

Task 4.3 "Unification and harmonization towards a hydrogeological dataset and the model parameters and layers for the multi-aquifer system" aimed to collect the rest of necessary data and prepare the GIS layers for modelling purposes. Some layers were merged on the contact surface and gaps of data were filled with necessary information. As the result of this work, harmonized GIS data, that presented schematic hydrogeological conditions for studied cross-border area were obtained.

2.3 Unification and harmonization of data

The second workshop of the Groundwater RESOURCE WP 4 was held on May 30th 2019 in the headquarter of the Polish Geological Institute-National Research Institute in Warsaw. Participants of the workshop from the Polish Geological Institute-National Research Institute (PIG-PIB) and from the Lithuanian Geological Survey (LGT) discussed the issues related to the development of GIS layers (aquifers and aquitards). Important part of discussion was focused on GIS layer unification and harmonization, in order to develop hydrogeological conditions schematization.

Task 4.3 "Unification and harmonization towards a hydrogeological dataset and the model parameters and layers for the multi-aquifer system" included following activities:

- Determination of the number, occurrence and spatial extent of model layers, especially within the cross-border area,
- Development of model layers in GIS,
- Merging the model layers at the border, filling the gaps of data,
- Distribution of the hydrogeological parameters (layer thickness, hydraulic conductivity coefficient k, transmissivity T) in model layers.

Partners of the consortium from the Lithuanian Geological Survey and the Polish Geological Institute-National Research Institute prepared model layers in GIS environment in .shp files of ArcGIS software.

In the task 4.3, the hydrogeological dataset with data on thickness, depth of the top and the bottom of model layers of the multi-aquifer system and the hydraulic parameters of the layers were unified and harmonized Moreover, the spatial extent of each model layer was distinguished and determined. The geometry of transboundary watercourses and ordinates of the surface water table in rivers were unified in this approach..

The team of WP4 has been working to import of the prepared GIS layers into the modeling software (Groundwater Vistas). Developed and merged model layers allowed to obtain schematization of hydrogeological conditions for the transboundary area. Some gaps of data on the contact surface within the cross-border area between Poland and Lithuania were filled and GIS layers were merged in these parts.

2.4 Hydrometric measurements for model calibration purposes

In July and August 2019 were carried out hydrometric measurements of surface water discharge within the cross-border area in following rivers: Szeszupa (Šešupė), Szelmentka, Wigra, Marycha (Seina), Biała Hańcza (Baltoji Ančia), Hołnianka (Alna), Dziedziulka (Didžiulė), Potopka, Gazda, Kirsna, Raišupis, Uide, Zapse, Nieda, Šlaventėlė, Morkauas, Seira, Krūčius, Bilsinyčia, Igara, Mara and in their tributaries, using handheld electromagnetic water flow meter with automatic discharge calculation. The measurements were conducted by experts from the Lithuanian Geological Survey and from the Polish Geological Institute-National Research Institute. Hydrometric measurements were taken at low states of surface water in rivers, after a long-term period of lack of atmospheric precipitation, which allowed to consider flow of surface water in individual river basins as the equivalent of recharge, that originated from groundwater.

The results of hydrological measurements were calculated as the volume of river flow in the framework of the task 4.3 "*Unification and harmonization towards a hydrogeological dataset and the model parameters and layers for the multi-aquifer system"*. The results of hydrometric measurements will allow to verify and determine the hydrodynamic state of hydrogeological system within the modelling area.

3 DEVELOPING THE TEMPLATE

3.1 Data collection structure

A joint data set was developed in the GIS environment, using the ArcGIS software for the management of the archive hydrogeological data and results of field works. For modelling purposes the following raw data of the Polish Geological Institute-National Research Institute and the Lithuanian Geological Survey were collected:

- litho-stratigraphic profiles of hydrogeological objects (hydrogeological boreholes, piezometers and drilling wells),
- data related to hydrogeological parameters of aquifers (hydraulic conductivities *k* values from the pumping tests, accessible in the Central Hydrogeological Data Base of the PIG-PIB),
- layers of the Geological Map of Poland 1:50 000 (of Quaternary sediments),
- layers of the Hydrogeological Map of Poland 1:50 000,
- hydrometeorological data,
- Digital Model Terrain layers,
- various data essential for the project needs.

All the data mentioned above were processed, transformed and adopted to the GIS layers, which will be import in the modelling software during the task number 4.4 “Set-up of a hydrodynamic model for Polish-Lithuanian cross-border area”. The ArcGIS environment was used for the management of the field works data, as well as to archive geological and hydrogeological data. The structure of resulting data set is illustrated In the scheme of Fig. 1.

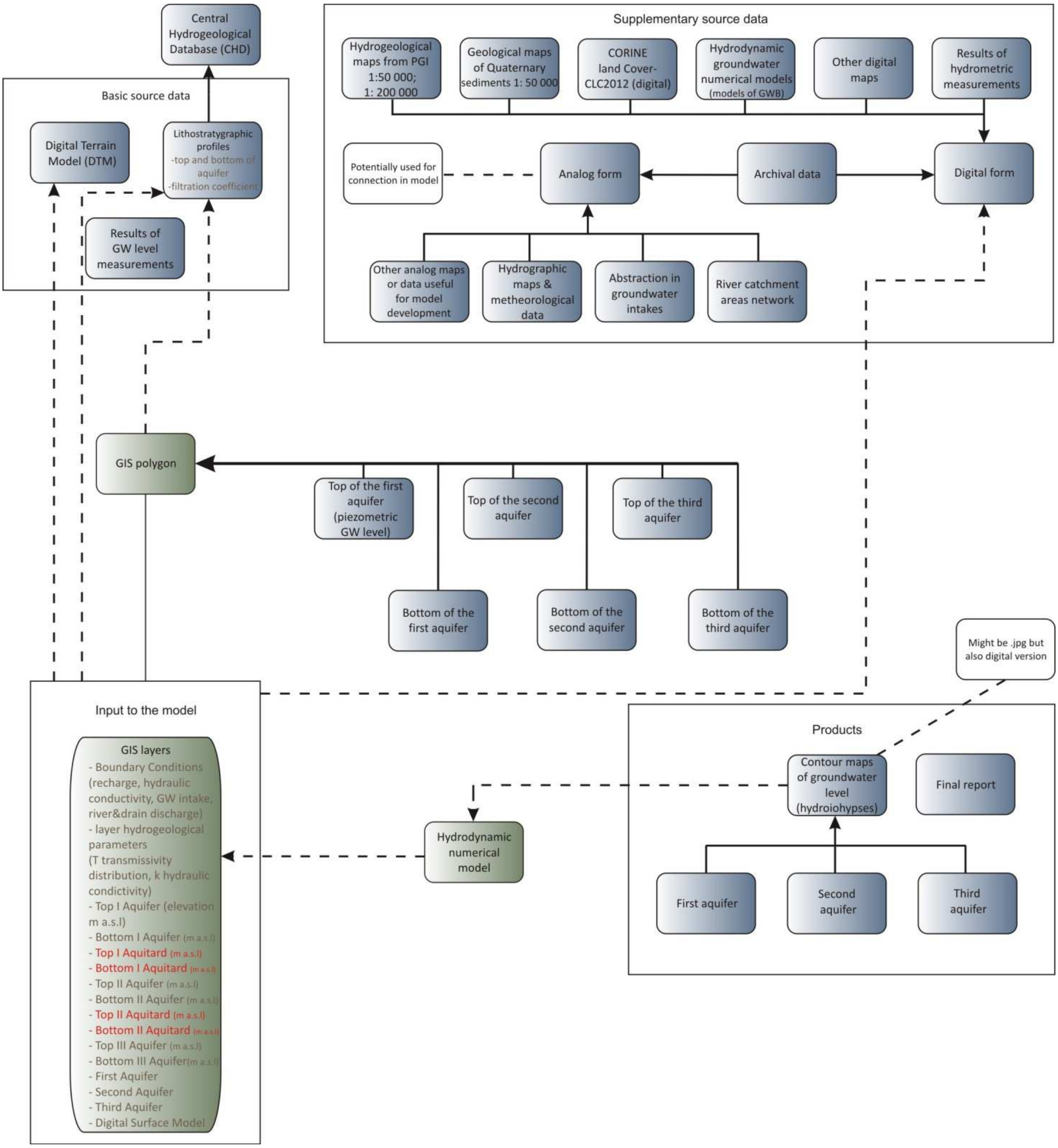

Fig. 1. Scheme of data set of the Polish Geological Institute – National Research Institute usable for numerical modelling within Polish-Lithuanian cross-border area (Lewandowski P., Gidziński T., 2019)

4 HARMONIZATION OF DATA TOWARDS MULTI-AQUIFER STRUCTURE

In the task 4.2 “Integrated evaluation and harmonization of the hydrogeological data set for modelling purposes” were mentioned different examples, that were identified in the contact surface of GIS layers, that were developed and provided by both parties of the project consortium form the Polish Geological Institute – National Research Institute (PIG-PIB) and from the Lithuanian Geological Survey (LGT). The data and GIS layers were unified, harmonized and merged in the task 4.3 “Unification and harmonization towards a hydrogeological dataset and the model parameters and layers for the multi-aquifer system”.

The first case was focused on GIS layers that corresponds to the aquifer from one side of the border line does not touch the GIS layer from the other side, within the territory of another country. Selected parts of GIS layers were analyzed in detail, in order to fill the gaps and individual layers were unified and merged. These activities required interpolation and aggregation of accessible data, taking into consideration reliable data and information, and eventually an expert interpretation. Beneficial in the process of preparation of cross-border GIS layers was access to the new hydrogeological data from the border territory of the riparian country.

The second example was connected with the GIS layers, that overlap each other. Thickness of individual layers, aquifer hydraulic properties and parameters of aquitards differ in some parts of study area. The cross-border zone within the numerical model area is low populated, thus number of drilled wells, investigative boreholes and piezometers is low. The GIS layers were unified and harmonized, using accessible, reliable data from profiles of existing geological boreholes, hydrogeological wells and piezometers.

In a case where we identified differences in the thickness of aquifers on the GIS layers contact surface, a decision was made to use average values of the thickness to merge the model layers.

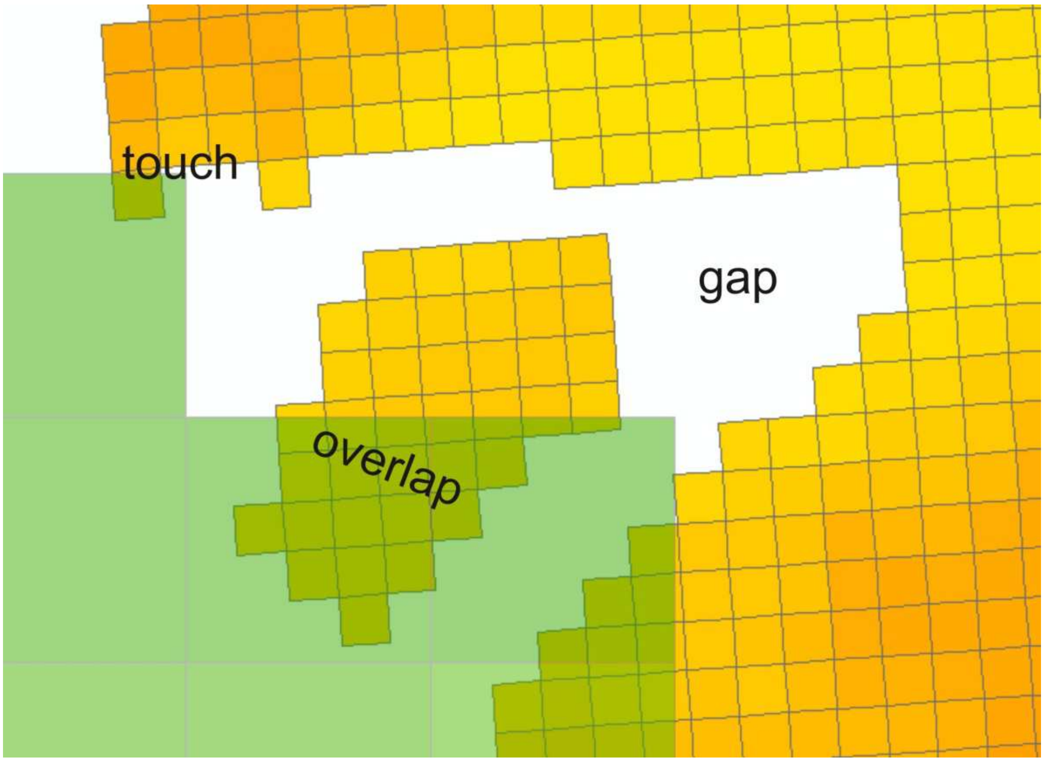

Fig. 2. Differences in GIS layers, that were developed by representatives from the Polish Geological Institute-National Research Institute (PIG-PIB) and Lithuanian Geological Survey (LGT). First aquifer

The last, third example listed in the task 4.2 referred to the on GIS layers, that touch on contact surface along border line, but there were distinguished differences in parameters of layers. The elevations of the top and the bottom of individual layers, occurred on different levels [m b.s.l]. Thickness of individual layer, aquifer hydraulic properties and parameters of aquitards change and differ in some parts of the modelling area. The GIS layers were harmonized and merged in the parts mentioned above, using reliable data from profiles of existing hydrogeological objects. Sharing data from the territory of another country was a unique opportunity to fill or verify hydrogeological information in the cross-border scale. Close to the border line, where accuracy of data provided by each party is not sufficient, data were reprocessed using GIS tools e.g. interpolation.

In June 2020, we measured groundwater tables in selected, representative piezometers and hydrogeological boreholes within the Polish part of the modelling area. Moreover, this includes data from automatic data loggers, that were installed in selected piezometers.

The principle calibration criterion in task 4.4 "*Set-up of a hydrodynamic model for Polish-Lithuanian cross-border area*" will be to minimize the difference between the groundwater table heads measured in the field and calculated in selected observation wells by the groundwater flow simulations.

An example of the first approach in merging of the top of the first aquifer in GIS layers (work versions) from the border territories, that were prepared by experts from the Lithuanian Geological Survey and from the Polish Geological Institute – National Research Institute is presented below.

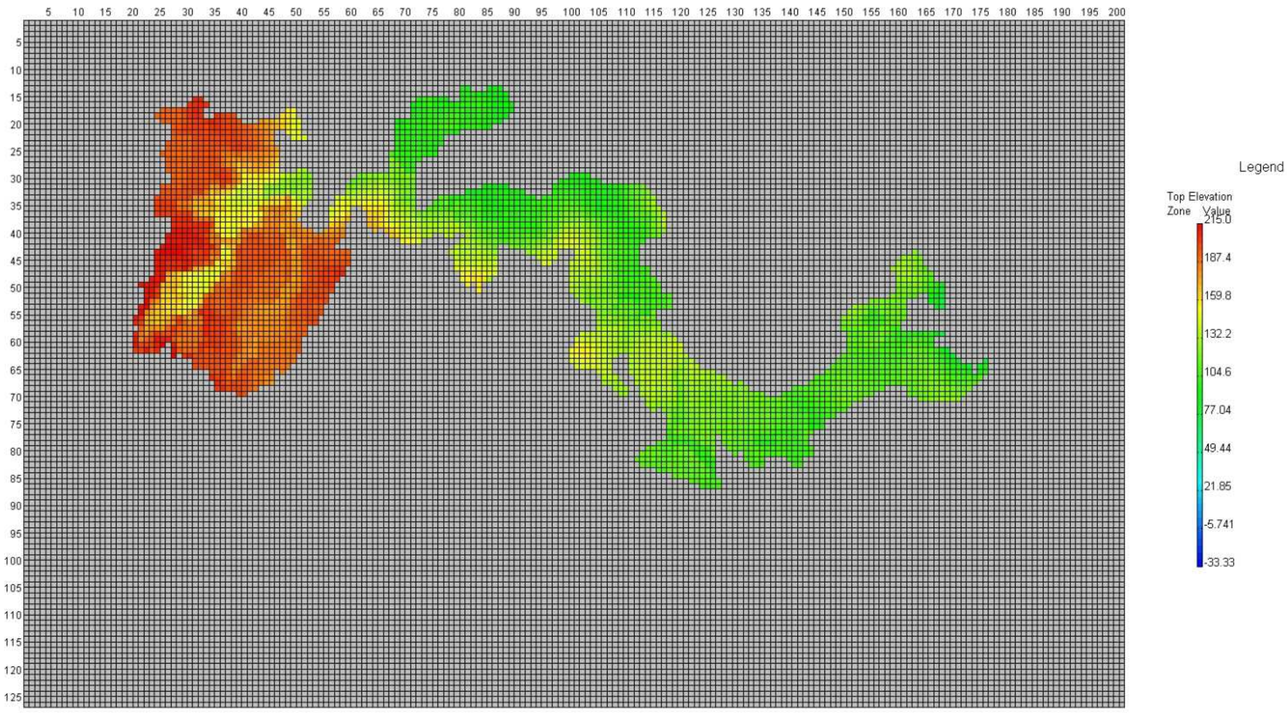

Fig. 3. Top of the first aquifer in the GIS layer within the modelling area (working version)

Some selected layers of the model or their parts will be finally transformed or modified based on simulation results (e.g. based on the solution of an inverse task).

The final hydrogeological dataset and model input can be made available at request, and will be delivered as the final outcome of the project in Month 36 of GeoERA, in accordance to the procedures, that are in force in the Polish Geological Institute-National Research Institute, as well as are abligatory in the Lithuanian Geological Survey.

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5 NEXT TASK

The next task 4.4 of the TRANSFLUX project is "*set-up of a hydrodynamic model for Polish-Lithuanian cross-border area*".

In the task 4.4 following activities were distinguished:

- Set-up of the cross-border numerical groundwater flow model,
- Calibration and verification of the numerical model, model simulations,
- Determination of the transboundary groundwater flow directions in the cross-border area,
- Groundwater level elevation contour (hydroizohypses) maps for model layers (aquifers),
- Assessment of the volume of groundwater that flows through the state border between Poland and Lithuania in each model layer (- in each, individual aquifer).

As the final result of numerical model simulations it is planned to obtain groundwater level contour maps for each aquifer, that were distinguished in the model structure.

Eventually, we will compare the results of TRANSFLUX WP4 with the results of the Pan-EU mpap of WP6. Obviously, the TRANSFLUX model is much more detailed that the 10 x 10 km grid scale of WP6, but we will upscale the volumes and depth of the detailed model to compare it with the WP6 grid data. It could be considered to use results, that will be obtained in WP4 TRANSFLUX (500x 500 m grid cells) as the more detailed case study for the selected part of the transboundary area, that are covered by the Pan-European Resource Map (10x10 km cells).

5.1 Model Calibration

Numerical model always constitutes the simplification of the real hydrogeological conditions. This is why model simulations results include certain error, which results from the never full knowledge of the investigated hydrogeological system and necessary simplification made during the construction of the model.

Factors limiting the model reliability:

- Small number of piezometers and observation wells with the possibility to measure water level in the investigated area,
- mosaic distribution of the permeability values,
- differences in archive hydrogeological data (parameters) provided by project partners,
- small number of reliable data from hydrogeological database in low populated cross-border areas.

The project will evaluate how these uncertainties effect the model outcomes in Task 4.4