

Hydrogeological Map of Poland 1 : 50,000 — present state and development of computer data base

Piotr Herbich*



Abstract. The present stage of work on the numerical multisheet Hydrogeological Map of Poland 1 : 50,000 (HMP) is presented. In 2004, the first edition of 1069 sheets of the HMP has been completed. The HMP began to fulfill the role of the main database of hydrogeological information on occurrence conditions and properties of usable aquifers. The directions of further development of the GIS database of the HMP were formulated in the Instruction: HMP — Providing access to, verification, updating and development (2004). Polish Geological Institute began the first, 30-month stage of implementing the Instruction.

Key words: ground water, hydrogeological cartography, GIS in Hydrogeology

In 2004, the first edition of multisheet *Hydrogeological Map of Poland in 1 : 50,000 scale (HMP)* has been completed. Producing the 1069 sheets covering the whole area of the country was a formidable scientific and logistic task, that could have been achieved in such a short time (8 years) thanks to involvement of hydrogeologists from all the important Polish scientific centers and relevant companies. Richly documented, multi-layer synthesis of the occurrences, reservoir conditions and properties of useful aquifers, together with a huge GIS database, the *HMP* is a fine example of current digital cartography, which can be regarded as the greatest scientific achievement of Polish hydrogeology of the turn of the centuries.

The *HMP* has been commissioned by the Ministry Environment and funded by the National Fund of Environmental Protection and Water Management. The work was divided into four two-year stages (Fig. 1): in Stage 1 (completed in 1998), 341 sheets of *HMP* were produced, in Stage 2 (by the year 2000) — 230 sheets, in Stage 3 (by 2002) — 278 sheets, and in Stage 4 (by 2004) — 220 sheets. The General Contractor of the *HMP* was the Polish Geological Institute, where 472 sheets of *HMP* were compiled, and which coordinated the production of 597 sheets of the *HMP* made by 18 geological companies and 47 sheets of the *HMP* made by five scientific institutions/universities. As many as 382 hydrogeologists from geological companies, universities and research institutes participated in preparation of the *HMP* (authorship, editing and review of the sheets).

The topical content, cartographic visualisation, database software and logistic scheme for work on the *HMP* originated in the Department of Hydrogeology and Engineering Geology, Polish Geological Institute. The organization, control and supervision of the work and approval of the sheets were the responsibility of the Chief Coordinator of the *HMP* and his team, established in the Department of Hydrogeology and Engineering Geology, PGI, Warsaw. The work on the *HMP* commenced with a *Framework Instruction* (Paczyński et al., 1996) and continued till 1998 based on the *Instruction for producing the Hydrogeological Map of Poland in 1 : 50,000 scale* (Instrukcja, 1996). Sheets of the *HMP* completed in stages 2, 3 and 4 (1998–2004) were done according to the *Instruction for producing and computer-editing of the Hydrogeological Map of Poland in 1 : 50,000 scale* (Instrukcja, 1999).

Already during the production of the *HMP*, particular sheets were published and so the map began to fulfill the role of the main database of hydrogeological information on occurrence conditions and properties of usable aquifers. Thus, the users of the first edition of the *HMP* gathered experience and could comment on the information coverage of the map. At the same time, after 2001, due to implementation of the EU Water Framework Directive into the national legislation of Poland (the Act of 18th July 2001, *The Water Law*), the expectations and standards for hydrogeological information systems were substantially expanded. This necessitated further development of the GIS database for the *HMP*, including especially continuous updating, verification and reinterpreting the information layers of the map, adjusting the *HMP* to the existing or newly introduced national and UE standards, expanding the *HMP* database with new information layers and modernizing the *HMP* software to increase its usability and online access.

Current state and availability of the multisheet edition of the Hydrogeological Map of Poland

Hydrogeological Map of Poland in 1 : 50,000 scale in multisheet edition is a serial topical digital map, constructed on the 1942 topographic projection. The map contains information on hydrogeological conditions of occurrence of ordinary groundwaters, with a broader interpretation of the Major Useful Aquifer (MUA), being the main source of potable water. For each sheet of the *HMP*, a digital record in the Intergraph GIS technology and a printout was made of the main sheet, documentation map, explanatory text with database tables, topical maps, cross-sections and diagrams.

The main information layers of the *HMP* show the following characteristics of a MUA: its extent and depth of occurrence, thickness and transmissivity, groundwater quality as source of water for the population, the degree of hazard to the groundwaters due to surface pollution, potential discharge of water well, present position of the groundwater level and flow directions of groundwaters, renewable and manageable groundwater resources, as well as location and parameters of groundwater intakes and location and characterization of objects posing hazard to the groundwaters.

The printed cartographic edition of the *HMP* includes the main sheet, presenting most information layers for the MUA (Figs. 2–4). The explanatory text to each sheets of the *HMP* include a synopsis of geological, geomorphologic

*Polish Geological Institute, Rakowiecka 4, 00-975 Warszawa, Poland; piotr.herbich@pgi.gov.pl

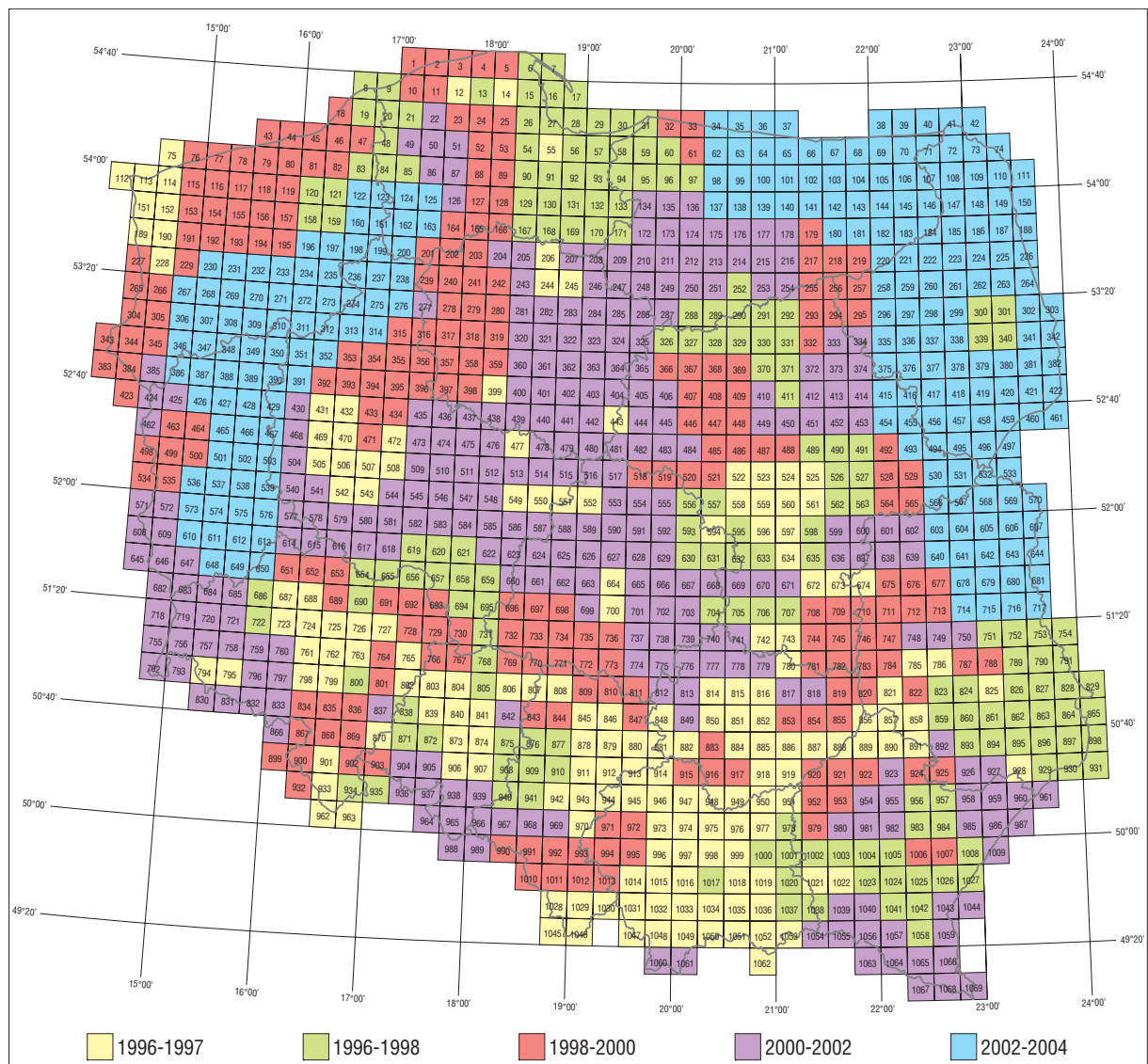


Fig. 1. Hydrogeological Map of Poland 1 : 50,000 — the present state

and hydrogeological conditions, usage of groundwaters, hydrochemistry and hazards to the quality of groundwaters, resulting from the land management. The text is appended with tables with information on wells, water reserves, intake and quality, on environmentally hazardous objects and hydrogeological sections, plus a documentation map and topical maps in 1 : 100,000 scale of: transmissivity, thickness and depth of occurrence of the MUA.

The GIS INTERGRAPH software system, used in production of the *HMP*, enables creating and editing maps with various information content (selected elements, merging with other maps), constantly updated, verified and enriched in new information, editable in selectable space format (currently within sheets of the topographic base map, but after unification of the GIS database of the *HMP* in a freely chosen area, e.g., province, county, commune, water catchment, protected area, hydrogeological region, etc.).

The main users of the *HMP* are government administration structures and local self-government units, regional water management boards, hydrogeological companies, architectural studios, spatial planning bureaus, as well as universities, research institutes, pro-environmental organizations and investors/developers. The application of the *HMP* includes areas and tasks such as: designing and docu-

menting groundwater intake and their protective zone, making groundwater inventories yielding water for the population, planning and conducting regional and local hydrogeological research and works, issuing water usage licenses, specifying the terms of water usage for hydrogeological regions or river catchments, planning water management investments, spatial planning (directions for land management) and environmental protection, issuing decisions on locating investments with adverse impact on environment.

The *Hydrogeological Map of Poland* is available at the Central Geological Archive of the Polish Geological Institute, within the scope arranged individually with the customer. The plotted version of the *HMP* sheets (printout of the main sheet, documentation map, explanatory text with database tables, topical maps, cross-sections and diagrams) and in electronic version (files exported in various formats). The map can be perused at the Central Geological Archive of the Polish Geological Institute (CGA PGI) or ordered there online (www.pgi.gov.pl).

By mid-2005, more than 2000 sheets of the *HMP* have been accessed by more than 300 customers: central and self-government administration units, geological companies, universities, organizations and individual researchers.

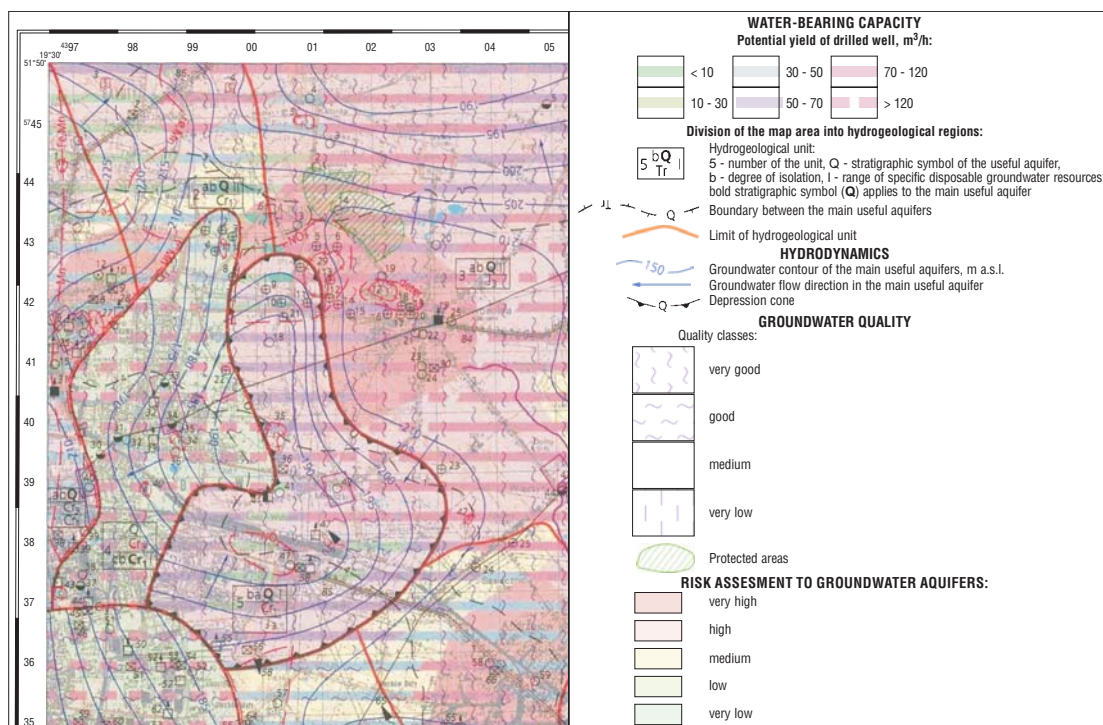


Fig. 2. HMP Sheet Łódź (627) — East part: Urbanized-industrial agglomeration. Intense groundwater intake from multi-aquifer system. Map sheet also contains the location of points sources of pollution, ranking of risk to groundwater aquifers and depression cones arising from groundwater development

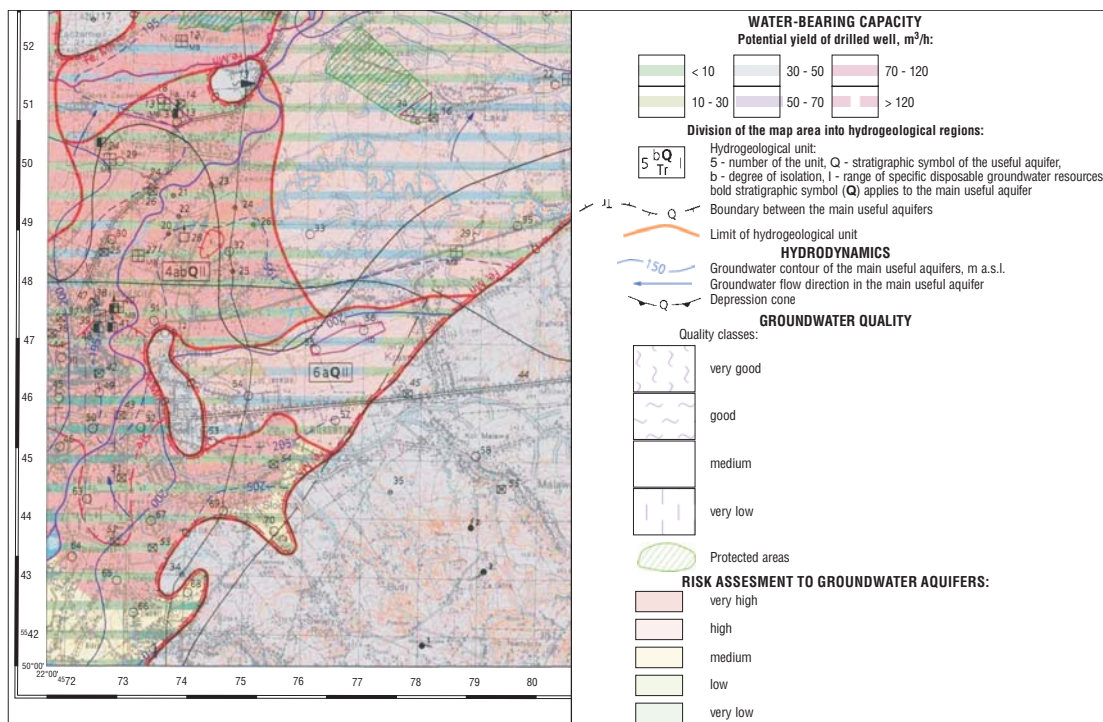


Fig. 3. HMP Sheet Rzeszów (982) — SW part: Urbanized-industrial agglomeration. One useful aquifer (UA). Areas without UA. Intense groundwater intake (collective intakes, depression cones). Objects adversely affecting the environment, local groundwater pollution, high risk level to UA

Main directions of further development of the GIS database of the HMP

The directions of further development of the GIS database of the HMP, after completing the multisheet edition of the HMP, were preliminarily formulated in 2002 (Herbich & Sadurski, 2002), and then developed during the ongoing

project of the HMP development. Eventually, the activities led to a study prepared by the team of the Chief Coordinator of the HMP, *Providing access to, verification, updating and development of the HMP: Instruction* (Mapa..., 2004). The instruction has been approved by the Minister of Environment on 24th of August, 2004 and thus entered into

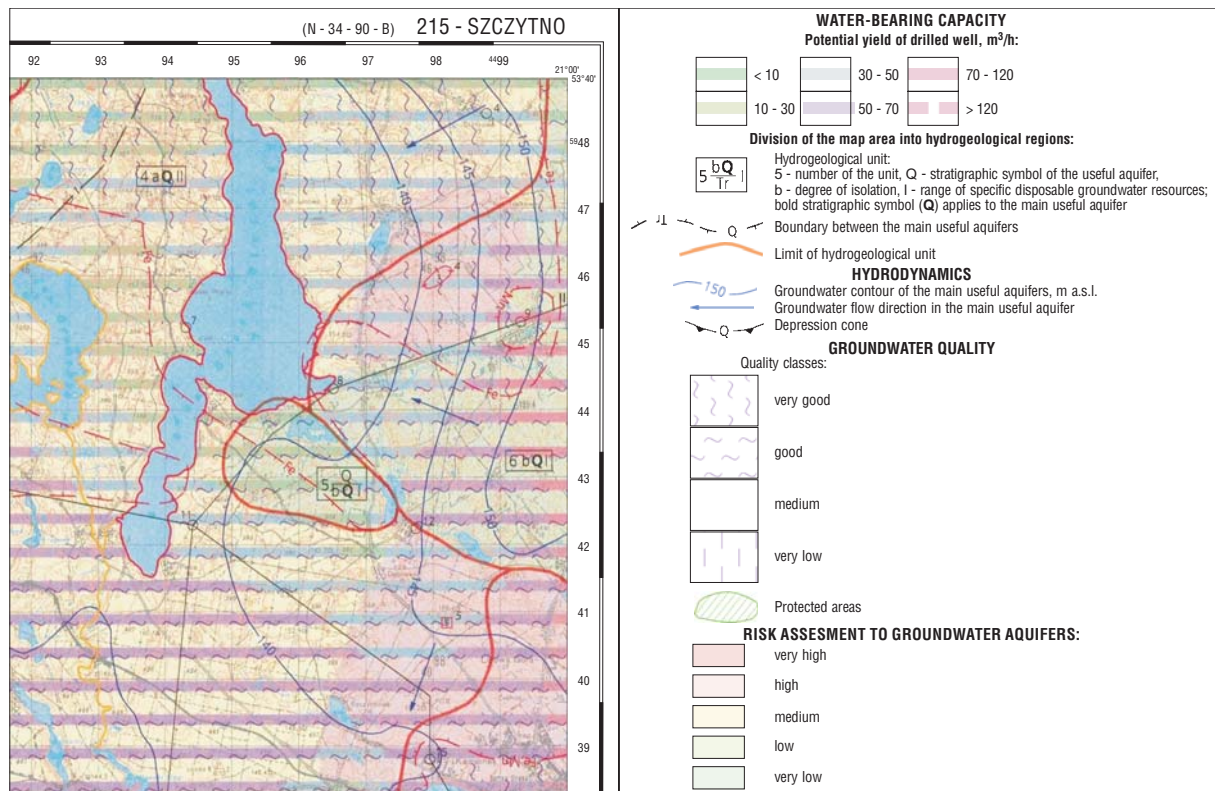


Fig. 4. HMP Sheet Szczytno (215) — NE part: Forested-agricultural area. Two-layered Quaternary aquifer. Very good and good groundwater quality, few objects adversely affecting the environment; low to average resistance of the major aquifer, low intake

force. Following an agreement with the Minister of Environment signed in December 2004, the Polish Geological Institute began the first, 30-month stage of implementing the *Instruction*.

The *Instruction* covers the following main tasks:

- Creating a spatially continuous GIS database of the *HMP*, feeding it with databases of 1069 sheets of the *HMP* and formal and factual verification of the information layers;
- Author's and computer-aided processing of the information layer "first aquifer — extent and hydrodynamics" of the GIS database of the *HMP*;
- Replacing those information layers of the GIS database of the *HMP*, for which new national and EU standards were introduced (surface waters and water divides, according to the Map of Hydrographic Division of Poland made by the Institute of Meteorology and Water Management [IMI GW], evaluation of the chemical state of the groundwaters — according to the EU Water Framework Directive and the Enactment of the Minister of Environment currently in preparation);
- Updating information layers of the GIS database of the *HMP* for areas where substantial changes in quality or dynamics of groundwaters has been observed;
- Reinterpreting information layers of the GIS database of the *HMP* for areas needing revision of the cartographic model as a result of advances in geological and hydrogeological survey;
- Archiving and providing access to the hydrogeological information, contained in the GIS database of the *HMP*, including periodic reambulation of sheets of the *HMP* stored and made available at the CGA PGI;
- Developing the GIS database of the *HMP* by introducing new information layers, currently those pertaining to

the first usable aquifer (in the first stage — on conditions of occurrence and hydrodynamics, in the second stage — on vulnerability and quality), and later by adding boundaries of water-economic regions and uniform parts of groundwaters.

Creation and verification of an integrated GIS database of the *HMP*

Creating a system of integrated GIS database of the *HMP* involves to following actions: creating a numerical structure for a spatially continuous GIS database of the *HMP* (countrywide), establishing a GIS metabase of the *HMP* (metainformation bank), controlling the formal correctness of the databases for the 1069 sheets of the *HMP* and transferring their contents into the integrated GIS database of the *HMP*, and a comprehensive verification of the information layers transferred to the integrated GIS database of the *HMP*.

The GIS database software for the *HMP* is appended with procedures for connecting and exchanging information layers with other GIS databases, with software modules assisting in updating and verifying the information layers and in managing the GIS database of the *HMP*, with procedures for data analysis in the GIS database of the *HMP*, and in modules assisting in data distributing and reporting.

The information layers of the integrated GIS database of the *HMP* are verified using the list of factually supported inconsistencies between interpretations of hydrogeological conditions in adjacent sheets, produced in different time, with varied quality of knowledge on such boundary water-bearing structures or with anthropogenously modified quality and hydrodynamics of groundwaters.

Fast progress in digital cartography during the work on the multisheet edition of the *HMP* provided software tools,

enabling comprehensive verification of the coherence of the GIS database system. The verification includes control of correlation between genetically dependent information layers characterizing the major useful aquifer (transmissivity, thickness and depth versus potential discharge of a well; degree of isolation, forest complexes and pollution centers versus risk degree; hydroisohypses and flow directions versus transmissivity), and then properly oriented correction of the compatible layers.

The PGI remains the general contractor, while upgrade of the software in GeoMedia technology is done in cooperation with the IT company (Intergraph).

Work on the information layers of the GIS database of the HMP “first aquifer — extent and hydrodynamics”

Work on 13 information layers of the GIS database of the HMP “first usable aquifer — extent and hydrodynamics”, including: hydroisohypses, depth to water table, occurrence conditions of the first aquifer (6 types discerned), substantial lowering or elevation of the water table, connections with the surface waters, springs and swamps (Fig. 5) commenced in 2005.

The first aquifer — as defined by the *Instruction* (Mapa..., 2004) — is the first aquifer (or set of hydraulically connected aquifers) below the ground, with transmissivity $T = 6 \text{ m}^2/24 \text{ h}$ and total thickness $M = 2 \text{ m}$ (in average retention conditions) occurring continuously usually over an area of $A > 20 \text{ km}^2$ while in especially well surveyed areas with strongly variable hydrogeological conditions, over an area $A > 2 \text{ km}^2$. In specific cases — if the aquifers are more than 5 m thick, the transmissivity exceeds $50 \text{ m}^2/24 \text{ h}$ and the potential discharge of a well is more than $5 \text{ m}^3/\text{h}$ — the first aquifer is also a useful aquifer, and if, additionally, it is the main source of groundwater, with predominant extent and resources — it is also the major useful aquifer shown in the main sheet of the HMP.

Instruction (Mapa..., 2004) predicts completing the project nationwide by 2011. The PGI is the main contractor, producing part of the sheets, as well as editing and coordinating sheets produced by geological companies. By the end of 2006, the authors should complete 414 sheets of the map in 1 : 50,000. The sheets cover areas with a heavy urban-industrial or mining pressure, areas at risk due to agricultural pollution with nitrogen compounds, protected swamps in national parks, as well as areas along the western and southern border of the country.

Update of the information layers of the GIS database of the HMP

Update of the information layers of the GIS database of the HMP adjusts the information in the spatial database and in descriptions to current data. Namely, the information on groundwater quality and dynamics is updated according to the current results of groundwater monitoring, while the information on the impact of objects and actions on the abundance and chemistry of groundwaters reflects the changing impacts of the objects and operations causing environmental nuisance. Currently undertaken update pertains to the characteristics of the major useful aquifer, and will cover also the first aquifer.

The update of the information layers of the GIS database of the HMP depends on the topical group, with variable frequency of update, its form, and extent and type of work involved. There are: systematic updates — annual (intake and resources of groundwaters), periodic — every 3 to 6 years (assessment of groundwater chemistry); special — made for an institution commissioning a set of selected information layers for particular area for a project requiring analysis of the current state of information; diagnostic — produced for the needs of the national hydrogeological survey (related to producing hydrogeological studies, analyses, reports and forecasts); operational — made at the request of the Chief Coordinator of the HMP after detecting an important change in groundwater conditions or their conditions of occurrence in large area (urging to update information layers of the GIS database of the HMP to study the phenomenon in detail); reactive — made at the request of the Chief Coordinator of the HMP because of the opportunity to directly apply available results and materials (hydrogeological documentations, special research).

The updating of the information layers of the GIS database of the HMP is performed by the Polish Geological Institute in cooperation with hydrogeological companies, research and development units, and universities. It is done according to the Guidelines for update of the information layers of the GIS database of the HMP, including usage of archival materials or at the basis of a program of updating the information layers of the GIS database of the HMP involving fieldwork and laboratory analyses.

Reinterpreting the information layers of the GIS database of the HMP is aimed at systematic adjusting of the cartographic scheme of the hydrogeological conditions and properties presented in the HMP to the ongoing survey of geological structure, extent and development of aquifers. The reinterpretation is done at the request of the Chief Coordinator of the HMP, upon finding an important discrepancy between the scheme of occurrence conditions and parameters of the aquifers, represented by the information layers of the GIS database of the HMP and a scheme established as a result of current hydrogeological, geological and geophysical survey, postdating the completion of work on a given information layer. Such reinterpretation enables the GIS database of the HMP to play a role of a tool facilitating administrative and economic decisions, planning, analyses and assessments concerning groundwaters. Issuing the reinterpretation request is mostly based on analysis of results of works done according to the regulations of the Geological and Mining Law of Poland (hydrogeological documentations, geological documentation of mineral resources, other geological documentations and topical maps in 1 : 50,000 scale or greater).

Reambulation of the HMP involves creating a new digital template for a given sheet of the *Hydrogeological Map of Poland in 1 : 50,000 scale*, containing updated and reinterpreted information layers of the GIS database of the HMP, and then printing the resulting main sheet, supplementary maps and other material accompanying the sheet (depending on the scope of changes compared to the original version of the HMP sheet). A sheet reambulated in this way is then archived in the CGA PGI as an Annex to the relevant sheet produced within the first edition of the HMP.

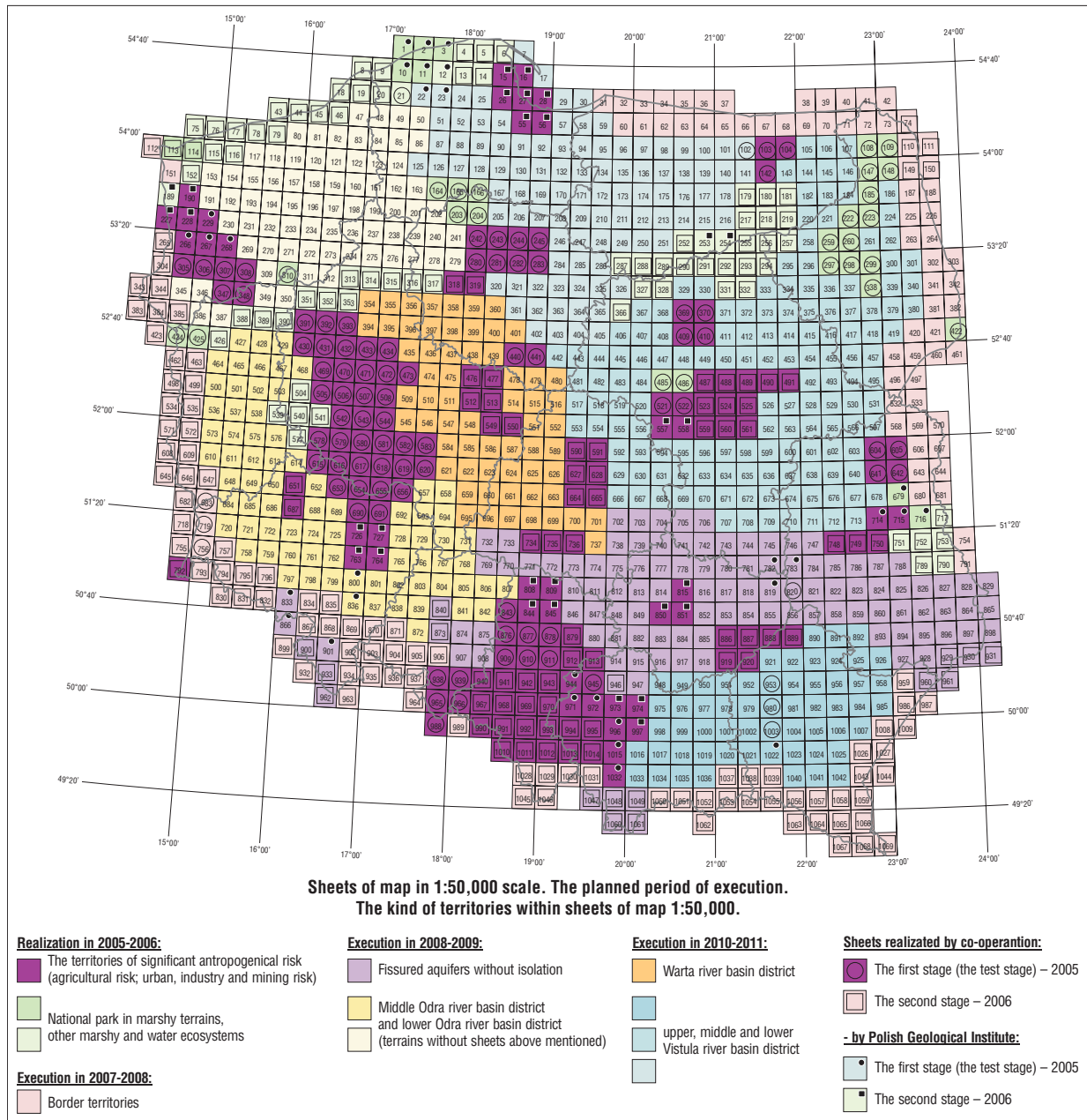


Fig. 5. Framework program of work out the computer data basis GIS *Hydrogeological Map of Poland* — unconfined aquifers (first from the surface) — occurrence and hydrodynamics. Sheets of map in 1 : 50,000 scale. The planned period of execution. The kind of territories within sheets of map 1 : 50,000

Conclusions

Current work to implement the EU Directives, involving the survey of groundwater conditions, identifying their relations with surface waters and terrestrial ecosystems, establishing programs of monitoring, protection and cleaning of groundwaters, demonstrated the necessity of using a digital hydrogeological map, together with its GIS database. This fully confirmed the importance of the quick production of the multisheet edition of the *Hydrogeological Map of Poland in 1 : 50,000 scale* including the characteristics of the Majur Useful Aquifer and accentuated the need of immediate work on integrated and verified GIS database of the *HMP*, its systematic update and expanding it by adding new information layers pertaining to the first aquifer.

References

Instrukcja opracowania Mapy hydrogeologicznej Polski w skali 1 : 50 000. Min. Och. Środ., Zas. Nat. i Leś., Państw. Inst. Geol., Warszawa 1996.

Instrukcja opracowania i komputerowej edycji Mapy hydrogeologicznej Polski w skali 1 : 50 000. Min. Och. Środ., Zas. Nat. i Leś., Państw. Inst. Geol.: Cz. I — opracowanie autorskie 1–93, Cz. II — Edycja komputerowa 1–66, Warszawa 1999.

HERBICH P. & SADURSKI A. 2002 — Mapa hydrogeologiczna polski 1 : 50 000 — stan aktualny, perspektywy rozwoju, możliwości zastosowania. [W:] Współczesne problemy hydrogeologii. T. XI, część 1: 77–86. Politechnika Gdańska.

Mapa hydrogeologiczna Polski w skali 1 : 50 000. Udostępnianie, weryfikacja, aktualizacja i rozwój. Instrukcja. Min. Środ., Państw. Inst. Geol., Warszawa 2004.

PACZYŃSKI B., PŁOCHNIEWSKI Z., SKRZYPCZYK L. & WITKOWSKA B. 1996 — Ramowa instrukcja sporządzania Mapy hydrogeologicznej Polski w skali 1 : 50 000. Min. Och. Środ., Zas. Nat. i Leś.