Annex No. 5
to Ordinance No.
21/2019

COURSE/MODULE SYLLABUS FOR UNIVERSITY COURSES/PhD STUDIES

1.	Course/module name in Polish and English Groundwater Modelling/ Modelowanie przepływów wód podziemnych
2.	Discipline Earth and Environmental Science
3.	Language of instruction English
4.	Teaching unit Faculty of Earth Science and Environmental Management, Institute of Geological Sciences
5.	Course/module code USOS
6.	Type of course/module *(mandatory or optional)* optional
7.	Field of studies (major, if applicable) Geology
8.	Level of higher education *(undergraduate (I cycle), Master's (II cycle), 5 year uniform Master's studies)* Master's (II cycle)
9.	Year of studies (*if applicable*) I/II
10.	Semester *(winter or summer)* winter
11.	Form of classes and number of hours Lectures: 20 Lab classes: 36 Teaching methods: Multimedia lecture, presentation, discussion, practical exercises, individual work, group work, preparation of reports, work with computers.
12.	Name, title/degree of the teacher/instructor Coordinator: dr hab. Piotr Jacek Gurwin, prof. UWr Lecturer: dr hab. Piotr Jacek Gurwin, prof. UWr Classes instructor: dr hab. Piotr Jacek Gurwin, prof. UWr
13.	Course/module prerequisites, in terms of knowledge, skills, social competences Knowledge and skills in hydrogeology and groundwater dynamics.
14.	Course objectives

	Classes are a specializing training to enable the practical application of numerical models in hydrogeological practice. The lectures are aimed at understanding the theoretical basis for numerical solutions, adoption of new concepts in the field of groundwater filtration, and knowledge of the data and their processing for the model applications. Classes are conducted entirely in the computer lab - the aim is to provide programs for modeling filtration and practical implementation of simple models for the various hydrodynamic systems.
15.	Course content Lectures: The idea is to highlight the broad multidisciplinary research methodology for modelling of hydrogeological processes (groundwater dynamics, hydraulics, methods of pumping test, the protection of the aquatic environment, monitoring, geoinformation). The aim is to gain theoretical and practical basis for the use of modern numerical methods across the spectrum of groundwater flow in both as well the local as regional scale. The effect of education is to understand how the numerical representation of real hydrogeological conditions is created, including knowledge of the scope of the necessary information and environmental data for the preparation of groundwater numerical solution. Modeling as the primary method of modern hydrogeology. Definitions and basic concepts. Hydrogeological model, conceptual model and a numerical model. Outline of the history of modeling, including the method of electrohydrodynamic analogy (AEHD) and operation mesh integrators. Theoretical basis of numerical models of filtration. The objectives of the model simulation. The solution for steady state and transient conditions. Methods of solutions being used in the modeling (the difference between MRS and MES methods). The solution of mathematical equations describing the filtration. Iterative methods. Identification of the aquifer system on the model. Aquifer system and the types of hydrostructural systems restored on the model. Boundary surfaces. Circulation and vertical seepage of water within the aquifer system. Defining the boundary conditions. Procedure of schematization for the implementation of the model. Discretization and mesh types. Boundary conditions and initial conditions of the model. Schematization of hydrogeological conditions and simulation of the multi-aquifer structure on the model. Deterministic and stochastic models. Presentation of the examples and the role of the Internet. Lab classes: Implementation of the individual work in the computer lab. The aim is to introduce and teach the operation of most versatile and widely used modeling programs in hydrogeology. It is also important to master specialized terminology and operation interface. The primary effect of course is the possibility to prepare the necessary data and to develop a numerical model of filtration in simple hydrogeological conditions. The issue of preparation of model inputs. Input data, databases and digital maps. Application of GIS techniques. The problem of model scale. Specificity of the construction of models of regional aquifer systems. The problem of schematization of hydrogeological conditions. Geostatistical and geoinformatic tools in modeling. Numerical methods. 2-D and 3-D spatial models. The principle of operation and application of the leading programs in the FDM method of modeling. Construction of multilayer models. Simulation of the interactions with the surface water. Analysis of the quality of the model. Calibration and verification of the model. The types of errors that occur. The results of model. Analysis of the results of the model. Water balance calculations and groundwater resources in the model. Analysis of the pathlines and intake runoff area, recognition of protection zones on the model. MODFLOW. The MODFLOW and combined packages. Workflow and proper model documentation. Transient conditions. Implementation of stress periods and time steps. Analysis of time varied results. Basic problem of mass transport and migration of

	contaminants. Modeling of contaminant migration in porous media. Application of the MT3D. Examples of applications. Presentation of the results and the role of the Internet.	
16.	Intended learning outcomes	Symbols of learning outcomes for particular fields of studies:
	W_1 He has in-depth knowledge about the phenomena and processes in groundwater. He can see the existing relationships and dependencies in the aquifer. He has knowledge of the science related to fluid mechanics and hydraulics.	K2_W01, K2_W02
	W_2 He's able to critically analyze and make choices of hydrogeological model inputs.	K2_W03
	W_3 Consistently applies the strict principles, based on empirical data to interpret phenomena and processes at a flow rate of groundwater.	K2_W04
	W_4 He has expertise in the field of statistics (geostatistics) allows forecasting (modeling) phenomena and processes associated with groundwater filtration.	K2_W05
	W_5 He has in-depth knowledge of the terminology in the field of hydrogeology and geo-information.	K2_W09
	U_1 He's able to apply advanced techniques and research tools in the field of modeling filtration. He uses scientific literature in the field of modeling.	K2_U01, K2_U02
	U_2 He can use statistical methods and specialized techniques and tools for the description of phenomena and hydrogeological data analysis	K2_U05
	K_1 He understands the need for continuous learning and professional skills development. He's able to prioritize appropriately for implementation specified by himself or other tasks.	K2_K01, K2_K03
17.	Required and recommended reading *(sources, studies, manuals, etc.)* Required reading: Anderson M., Woessner W., 1992: Applied Groundwater Modeling, Academic Press, Inc., London. Bear J., Verruijt A., 1994: Modeling Groundwater Flow and Pollution. D. Reidel Publishing Co., Dordrecht. Dąbrowski S., Kapuściński J., Nowicki K., Przybyłek J., Szczepański A., 2011: Metodyka modelowania matematycznego w badaniach i obliczeniach hydrogeologicznych.Warszawa. Kulma R., Zdechlik R., 2009: Modelowanie procesów filtracji. Wyd. AGH, Kraków. Szymanko J., 1980: Koncepcje systemu wodonośnego i metod jego modelowania. Wyd. Geol., Warszawa.	

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<tr><td></td><td colspan="2">Wang H.F., Anderson M.P., 1982: Introduction to Groundwater Modeling. W.H. Freeman and Co., San Francisco.

Recommended reading

Bear J., Verruijt A., 1994: Modeling Groundwater Flow and Pollution. D. Reidel Publishing Co., Dordrecht.
Fetter C.W., 1994: Applied hydrogeology. MCPC, New York.
Gurwin J., 2010: Ocena odnawialności struktur wodonośnych bloku przedsudeckiego. Integracja danych monitoringowych i GIS/RS z numerycznymi modelami filtracji. HYDROGEOLOGIA Acta Univ. Wratisl. No 3258, Wyd. U.Wr., Wrocław
Gurwin J., Szczepiński J., Wąsik M., 1994: Opis programu MODFLOW wykorzystanego w regionalnych badaniach hydrogeologicznych. Mat. I Symp. Nauk.-Techn. Bilansowanie zasobów wodnych w dorzeczu Odry'. Zesz. Nauk. Wr.A.R. nr 248, Wrocław
Kresic Neven, 2006: Hydrogeology & groundwater modeling (2nd Ed.)
Macioszczyk T., Szestakow W.M., 1983: Dynamika wód podziemnych – metody obliczeń. Wyd. Geol. Warszawa.
Modelowanie przepływu wód podziemnych – wydania MPWP 1 (2004), MPWP 2 (2006), MPWP 3 (2008), MPWP 4 (2010), MPWP 5 (2012), MPWP (2014), MPWP (2016), MPWP (2018)
Pinder John, 2002: Groundwater Modeling, John Wiley & Sons. ISBN: 978-0-471-08498-3
USGS: Techniques of Water-Resources Investigations Reports (TWRI), USGS Publications.</td></tr>
<tr><td>18.</td><td colspan="2">Assessment methods for the intended learning outcomes:
- written examination: K2_W01, K2_W02, K2_W03, K2_W04, K2_W05, K2_W09.
- preparation and implementation of (individual) projects related to the issues of modeling groundwater filtration in various hydrogeological conditions: K2_W03, K2_W05, K2_U01, K2_U02, K2_U05, K2_K01, K2_K03</td></tr>
<tr><td>19.</td><td colspan="2">Credit requirements for individual components of the course/module:
- monitoring attendance and progress on the course subject matter,
- assessed paper (final),
- preparing and implementing a project (individual or possibly group),
- writing a class report,
- exam (written).</td></tr>
<tr><td rowspan="6">20.</td><td colspan="2">Total student effort</td></tr>
<tr><td>form of student activities</td><td>number of hours for the implementation of activities</td></tr>
<tr><td>classes (according to the plan of studies) with a teacher/instructor:
- lectures: 20
- lab classes: 36
- exam: 2
- consultations: 2</td><td>60</td></tr>
<tr><td>student's own work (including group-work) such as:
- being prepared for classes: 5
- reading the suggested literature: 10
- preparing papers/projects: 18
- writing a class report: 17
- preparing for tests and exam: 15</td><td>65</td></tr>
<tr><td>Total number of hours</td><td>125</td></tr>
<tr><td>Number of ECTS credits</td><td>5</td></tr>
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