Brief information about the project

Name of the project	AP19678157 «Development of a hardware and software complex for monitoring the state of the occupancy level of a reservoir» (0123PK00551)
Relevance	Algorithms, mathematical models, and hardware-software complexes (HSC) developed on their basis are proposed. The proposed HSC will provide the user with the necessary information about the hydraulic situation in the regions of Kazakhstan in real time. The math and software being developed will improve monitoring and prediction of dam breach threats and provide: - Operational management of emergency elimination. - Operational monitoring and visualization of the consequences of emergency situations. - Preliminary modeling of possible variants of emergency dynamics. - information necessary for making managerial decisions on emergency elimination. Application of the software and hardware complex and method of application will allow taking measures for evacuation of the population and other measures to reduce the consequences of a dam breach. Based on the results of the conducted research, preparation, and submission of a scientific article to the journals recommended by the Committee for Quality Assurance in the Sphere of Education of the Ministry of Education of the Republic of Kazakhstan and participation in the International Conferences were performed.
Purpose	The aim of the project is to develop algorithms, mathematical models and hardware-software complexes that provide real-time monitoring of water body occupancy.
Objectives	The following tasks are planned for the realization of the project: - Creation of a hydrotechnical database providing storage of various static data on water bodies. - Creation of a territorial database providing storage of information on the relief of the area nearest to the water body. - Development of climatic and hydrogeological sensors. - Development of a system for real-time transmission of climatic and hydrogeological information via the Internet or satellite communications. - Providing microcontrollers and sensors with autonomous low-power electricity (solar or battery). - Mathematical modeling of the process of monitoring the filling of hydraulic structures. - Mathematical modeling of forecasting the consequences of emergency (dam breach) occurrence. When solving the set tasks for setting up the mathematical model, the main problem will be to obtain reliable information about the hydraulic situation in the region. Theoretical research will be based on the application of mathematical modeling, three-dimensional machine graphics, computational mathematics, and applied programming methods. As a result of the first stage, a hardware-software part will be developed to obtain climatic and hydrotechnical information about the reservoir and transfer it to the server in real time.

	As a result of the second stage, a mathematical model for estimating the occupancy of a water body will be developed based on ordinary differential equations. For correct practical application of the results of mathematical modeling a few tasks will be solved: 1) conditions of existence and uniqueness of the solution of the system of nonlinear differential equations are obtained; 2) algorithms for parametric identification of the mathematical model were developed; 3) The controllability criteria of the mathematical model will be obtained in order to obtain an effective assessment of the hydraulic engineering situation. As a result of the third stage, a mathematical model for assessing the consequences of a dam breach will be developed based on difference-differential equations. For correct practical application of the results of mathematical modeling it will be necessary to solve the problems listed in the second stage as well. A hardware and software system for real-time monitoring and warning of dam breach threats will be developed. The theoretical basis for this will be the theoretical results of the previous steps. The proposed complex of monitoring of the threat of hydrostructures breakthrough consists of four blocks: 1) a unit for receiving and transmitting current information on water level, humidity, and temperature at the crest of the dam; 2) a unit for processing permanent and operational information about the threat of dam failure on the server; 3) Dam breach warning unit and 4) Dam failure consequence prediction unit. As a result of all stages, a hardware-software complex for real-time monitoring and forecasting of the hydraulic situation will be developed. The said complex will contribute to the improvement of environmental safety in the region.
Expected and achieved results	Several climate and hydrological sensors will be developed, for the transmission of information from which is provided through satellite communication. A centralized hydrologic database will be developed that will contain a variety of static reservoir data. Based on ordinary differential equations and optimization methods, a few mathematical models will be proposed to obtain estimates of reservoir occupancy in real time. The identification problem will be solved to adapt the constructed mathematical models to real water bodies to identify the selected models and to develop a constructive algorithm for solving the controllability problem (based on mathematical control theory and interval mathematics). The solution of the set tasks will allow to receive recommendations to stakeholders on the possibility of solving problems with available resources (management). Based on ordinary differential equations and optimization methods, several mathematical models will be proposed to assess the consequences of floods. A centralized territorial database will be developed, which is necessary for flood impact assessment and will contain information on the topography of the area closest to the water body. Based on all conducted research the hardware-software complex and methodology of its application will be developed. According to the

	requirements of the tender documentation, the results obtained will be published. 1. An autonomous microcomputer system of climate data transmission based on microprocessor technology and sensors was developed. 2. Technical means that measure water level has been developed, which can receive data from sensors at different intervals. 3. The tasks of developing a unified integrated approach to ensuring safe operation of hydraulic structures based on real-time monitoring and notification of stakeholders were solved. A series of computational experiments of breakthrough wave propagation and assessment of the ecological state of the nearby areas based on the developed program complex were carried out. The scientific novelty of this project lies in the development of new algorithms, mathematical models and hardware and software implementation. The solution of the set tasks will ensure operational monitoring and forecasting of emergency development about flooding of settlements. Mathematical modeling will provide prediction of dam failure consequences. The use of GIS-technology will provide visualization of the hydraulic engineering situation and thus facilitate management decision-making.
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List of publications with links to them	

Patents	-