

Call for 2011 - 2014 project proposals in Technological Development.

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Page 1 – General Data
Project number TR037009
Project name Monitoring and Modeling of Rivers and Reservoirs (MORE) - Physical, Chemical, Biological and Morphodynamic Parameters
Technology field in which research will be conducted Regulation, Protection and Utilisation of Water, Soil and Air
Page 2 – Description of Research
Abstract The aim of the project is to develop a harmonized methodology for the assessment of the status of major rivers, reservoirs, and lakes in Serbia, as well as for the assessment of the future status improvement measures. The methodology is based on the advanced monitoring and modeling of flow, physical, chemical, and morphodynamic parameters, complemented with an effective set of indicators of aquatic ecosystem degradation. The selected approach will provide reliable data for model preparation, calibration and verification. The development and correlation of 1D, 2D and 3D modeling of flow, physical, chemical, and morphodynamic parameters will allow simulations of historical events, as well as predictions of the effects of natural or man-induced changes. The study of relations between abiotic parameters (flow velocities, selected water quality parameters, physical and chemical sediment characteristics and morphological changes) and Biological Quality Elements (algae, macrophyte, macroinvertebrates and fish fauna), will result in the development of a set of effective status indicators for selected water bodies in Serbia. In addition, the effects of management measures on fisheries and aquatic ecosystems will be analyzed. A methodology for the design and maintenance of more effective hydraulic structures will be developed, contributing to the improvement of the status of selected reservoirs.
Keywords Water Status, Water Quality, Modeling, Hydrodynamics, River Sediments, Biological Quality Elements
Project Description The project is divided into six work-packages: WP1 Monitoring of hydrodynamic processes and water quality parameters; WP2 Numerical modeling of hydrodynamic processes and water quality parameters; WP3 Monitoring and numerical modeling of hydrodynamic and morphologic processes; WP4 Biological Quality Elements (BQE) in assessment of ecological water status; WP5 Ichthyofauna and water quality parameters – interactions, indicators, and influence of hydrotechnical constructions and fisheries management; WP6 Design and management methodology for hydraulic structures. The goal of WP1 is to develop a measuring methodology for water bodies and to procure reliable water status parameters. The measured parameters will be used for numerical model development for chosen reservoirs (Bovan, Zavoј and Palić). Temperature, dissolved oxygen, specific conductivity, nitrogen, phosphorus, organic matter, microbiological compounds and hydrodynamic profiles will be measured seasonally. Measurements will be performed in characteristic cross-sections along the reservoirs. WP1 will result in creating a permanent network of sensors for real-time water quality monitoring and the establishment of a center for water quality monitoring (in Sokobanja near Lake Bovan), which would also serve a research and educational center. Numerical models that simulate hydrodynamic quantities and water quality changes will be formulated and applied in WP2 for Lakes Bovan, Zavoј and Palić. Model development is divided into four phases: 1) spatial domain discretization based on recorded bathymetry; 2) development and calibration of the hydrodynamic component; 3) development and calibration of the water quality component; 4) model sensitivity analysis. Major reservoirs and rivers in Serbia (e.g. Iron Gates 1 and 2, the Danube River, etc.) have a long history of extensive sediment-flow monitoring, but the resulting data often lack time-space consistency. To remove these inconsistencies in the data, mathematical models will be added to current sediment-flow monitoring to form a new program within WP3. Field data will be used to formulate boundary

conditions for numerical simulations, and to calibrate and verify models. Historical data will be complemented with several new series of measurements. Initial applications, parallel to data analysis and new monitoring program formulation, will be based on existing models (CHARIMA, MOBED2, CH3D-SED). These models are capable of simulating unsteady flow, sediment transport, and bed evolution in natural watercourses with sediment mixtures. Further research will include improvements of 1D, 2D, and 3D models, as well as their connection into a chain of models. Model improvements will benefit from a series of laboratory experiments, each concentrating on a different aspect of sediment-flow interactions. Hydromorphological degradation is one of the most important stressors for aquatic ecosystems in Europe. Different biological indices have been tested mostly for detecting the relations of biota and hydromorphological degradation in smaller, wadable streams, while the issue of system development for the evaluation of the level of hydromorphological pressures based on BQE is still pending. Thus, the aim of biological investigations within this project is to define an effective scheme for the evaluation of hydromorphological pressures based on BQE that are obligatory according to the EU Water Framework Directive (2000/60/EC - WFD). Algae, aquatic macrophytes and macroinvertebrates will be taken into the consideration. The quality of the structure and functioning of aquatic ecosystems associated with surface waters will be evaluated based on selected BQE - taxa richness, abundance/biomass/density, functional relation in feeding groups, sensitive taxa indicators and the results will be used to define an appropriate multimetric index. Rivers, lakes and accumulations in Serbia and their ichthyofauna share the faith of European land water in view of the consequences of multipurpose exploitation of water resources. The aim of ichthyological research in WP5 is the research of the qualitative and quantitative structure of ichthyocenosis and parasite fauna, and interactions between fish settlements and habitats and their effects on water quality, as well as defining the adequate indicators of the state and status of aquatic ecosystems assessment. Special attention is given to aquatic invasive species (AIS) of fish. Based on the results, models and programs of sanitation, sustainable management and operation will be developed, along with adequate monitoring programs for fishery resources and fish faunas. A software application for hydraulic-structure-design will be developed in WP6 based on the results of physical and CFD models. Models of the fish ladder, double-sided spillway, diversion tunnel and bottom outlet with free surface flow will be developed, as well as the terminal structures (ski-jumps and stepped spillway stilling basins). The flow net and air concentration analysis will enable a reliable assessment of ecological conditions in the area downstream of the structures. For efficient design and repair of hydraulic structures during flood and ecological incidents, A thermal-stress numerical model will be developed for the efficient design and repair of hydraulic structures that alleviates the potential and danger of floods and ecological incidents.

Expected key results Projects results will include doctoral dissertations, journal publications, conference presentations, monographs and manuals. The result of WP1 is a methodology for water quality monitoring in reservoirs (biotic and abiotic parameters) to serve as input for simulating and predicting water regime changes effects on the environment. A set of permanent sensors for real-time water quality measurements will be put in place and a water quality monitoring center will be established. The result of WP2 are operational models for different reservoirs in Serbia, which will give insight into the possibilities of their use as a drinking water source and for recreational purposes in the long-term. The models will highlight the key parameters that are detrimental to the environment and allow for the formulation of recommendations of reservoir management strategies, in the pursuit of higher water quality standards. The first result in WP3 will be the proposal of a new monitoring program, linking data to the models. Processed historical data, complemented with new measurements, will be the basis for future modeling studies. The second result will be the formulation of 1D, 2D, and 3D models, establishing a new methodology for unsteady flow, sediment transport and bed evolution simulation and forecasting. The final result will be an improvement of the developed models, including not only numerical aspects, but also the physical understanding of complex sediment-flow interaction phenomena through

laboratory experiments. Investigations of aquatic ecosystems will provide the data needed to select effective biological parameters for describing the relation of biota-hydromorphological pressures in WP4. The results will be used to develop protocols for hydromorphological surveys. A set of manuals will be provided for the evaluation of hydromorphological pressures in large and very large rivers (Manual for hydromorphological surveys; Manual for using BQE; Manual for the Field Procedure in using BQE). Researching ichthyocenosis structures (WP5) and measuring and modeling abiotic parameters will enable better understanding of the interrelations between fish populations and their habitats and the effects of these relations on the water quality. Such an integral approach will give insight into the current problems in the exploitation of rivers/reservoirs as fishing waters. Applying appropriate indicators of the status assessment of the aquatic ecosystems (EFI – European Fish Index, EcoQ – Ecological Quality Status) will result in the development of models and programs of sustainable management and monitoring programs for the fishery resources. Results of WP6 research (software and procedures for hydraulic and thermal-stress computation) will enable efficient design and repair of hydraulic structures, as well as the assessment of hydrodynamic parameters, thus providing a realistic estimation of ecological conditions and alleviation of flood-damage and ecological incidents.

Page 3 – Research Relevance

Research Relevance There is a growing stress upon good quality fresh water demand in almost all fields of hydraulic engineering, such as water supply, irrigation, hydropower production, recreation etc. It is therefore important to preserve, or rather improve the quality of water in reservoirs. The proposed research will enable continuous water quality control in chosen reservoirs by installing a network of monitoring devices. The monitored parameters will allow for numerical model development for quantitative forecast of water status that will represent the basis for water resource management. Numerical simulations can predict different effects of water management policies prior to their implementation and help in the choice of optimal practical problem solutions. The simulations of possible accidents in the tested water bodies will result in a set of control action measures aimed at reducing the detrimental environmental effects. Morphological changes have significant influence on reservoirs (e.g. Iron Gates 1 and 2). For example, excessive deposition in the Iron Gates 1 reservoir produces the so-called additional backwater effect that influences the hydro power plant exploitation regimes and riparian land protection (floods, high groundwater levels). Excessive erosion immediately downstream from the Iron Gates 1 Dam is detrimental to the Dam structure. Unstable river bends, e.g. on the Danube River, are endangering river navigation, and increase the flood risk. Sediment transport and morphological changes are closely related to the river or reservoir biological diversity. Water quality in rivers and reservoirs is significantly affected by sediment-attached pollutants. Resolving any of aforementioned and similar problems requires proper understanding of sediment-flow interaction phenomena, reliable data, as well as superb simulation and forecasting modeling tools to be developed within this project. The proposed biological investigations will provide a tool for valorisation of hydromorphological protocols. A list of main activities related to hydromorphological degradation in Serbian waters will be provided. The proposed research will provide a better scientific understanding of the structure and function of fish fauna in aquatic ecosystems and the interrelations of ichthyocenoses, habitats and water quality. Criteria for the valuation and sustainable management of fishery resources will be defined, which represents a significant contribution from the aspect of long-term exploitation of the natural resources of Serbia. The development of application models and sanitation programs, sustainable management, and adequate monitoring programs presents an important contribution to practical protective and management measures, which the users of fishing waters in Serbia will be able to implement with the aim of improving the state of the fish population in fishing waters. The application of the model should reduce the existing conflicts between the different users of the potentials of water resources in Serbia. The project results will also provide a fast and efficient assessment of hydraulic structures hydrodynamic-conditions, for modeling and improvement of river and

reservoir water parameters. The proposed research of energy-dissipating structures and fishways, as well as the numerical modeling of thermal behavior of concrete structures, will support efficient structure repair and enhancement of ecological conditions.

Technoeconomical analysis An improvement in measurement methodology and hydromorphological process' modeling in rivers and reservoirs assures more reliable and therefore more efficient research of parameters that define water status: connections between hydromorphological changes and biodiversity, sediment particles pollution problems, etc. The same methodology provides more cost-effective solving of problems like reservoir sedimentation and its influence on banks (flood risk and high groundwater levels), erosion downstream of a dam, unstable river zones that endanger navigation and increase flood risk, etc. Defining efficient bio-monitoring methodology (development of a multimetric index for hydromorphological degradation) should provide a simple and financially acceptable water status estimation system. Project results are important for national (Republic Water Directorate, Environmental protection Agency, public water management companies etc.) and international organizations (ICPDR). Efficient status index development improves monitoring and helps in defining more acceptable measures for water ecosystems improvement. Improved monitoring concept does not guarantee reduction in currently employed resources, but may upgrade its usability. Biological and data on physical and chemical water characteristics may be incorporated in measurements conveyed by the Republic Hydrometeorological Service of Serbia. It can be estimated that project results in biological research are worth approximately 100,000 EUR on an annual basis. Collected biological material will provide data on invasive species detected in samples, which will diminish expenses of invasive species future research. Project results, like the set of research manuals (Manual for hydromorphological research, Manual for BQE use, Field procedures manual for BQE use), can be effectively used by public institutions for design of methodology for implementation of EU WFD and associated legislation. Project activities may contribute to income increase and expense reduction in domains of tourism, recreation, fishing and waterworks. Also, they may have significant contribution to the public health improvement. This research will increase competitiveness of Serbian scientists in participation in water management related projects. Ten member team can make a revenue of over 200,000 EUR. Additionally, the project employs existing human resources and coordinates activities between experts in various fields.

Page 4 – General Data on Researchers

Complete CV of the Project leader Dr. Zorana Naunovic's research work and interests lie in the area of water quality monitoring and modeling as well as the development of new technologies for drinking and wastewater treatment. Her doctorate work was funded by the National Aeronautics and Space Administration (NASA) and included the design of an ultraviolet disinfection reactor for a closed-loop water recycling system that is being considered for inclusion in the next generation of NASA space vehicles. As part of her doctoral studies curriculum, Dr. Naunovic successfully completed 16 graduate courses with top marks, including the following: Integrated water quality management, Hazardous chemicals in water systems, Wastewater and residual treatment processes, Advanced physical-chemical processes, Environmental fluid mechanics, Computational fluid dynamics, Applied finite element analysis, Environmental organic chemistry, Hazardous waste handling, Sustainable design. The title of her doctoral dissertation was "Modeling and Design of an Ultraviolet Water Disinfection System for Long-term Space Missions". During her postgraduate studies, Dr Naunovic worked in a multidisciplinary team environment that included 24 professors and 32 students from three Universities under the NASA Specialized Center of Research and Training (NSCORT) Advanced Life Support (ALS) umbrella. The research team goal was to create a self-sustainable space craft habitat that would support six astronauts uring their mission to Mars. Dr. Naunovic received both her Master of Science (in 2002) and Doctorate of Philosophy (in 2006) degrees from Purdue University, School of Civil Engineering, Department of Environmental Engineering, West Lafayette, Indiana, USA. She received her Bachelor of Science degree in 2000 from the University of Belgrade,

Faculty of Technology and Metallurgy, Department of Environmental Engineering. The results of Dr. Naunovic's research have been published in top international journals (Environmental Science and Technology, Water Research, Journal of Environmental Engineering) and presented at international conferences (Water Environment Federation Technical Exhibition and Conference (WEFTEC), the Water Quality and Technology Conference (WQTC)). She is the coauthor of patented method for measuring ultraviolet dose distribution delivery in photochemical reactors registered with the United States Patent and Trademark Office and the author of a copyrighted software application for estimating intensity field profiles around ultraviolet excimer lamps (the Surface Power Apportionment for Cylindrical Excimer Lamps (SPACE) model). Upon completion of her doctoral studies, Dr. Naunovic was employed as an environmental engineer (2006-2008) with a leading international environmental engineering consultancy company, Camp Dresser McKee (CDM, Inc.). Dr. Naunovic was employed at CDM's headquarters in Cambridge, Massachusetts, USA, where she worked with a team of world renowned experts on solving various engineering problems. She worked on developing comprehensive wastewater management plans and designing new wastewater treatment processes that could meet new nutrient (phosphorus and nitrogen) effluent discharge limits. During her graduate studies and while employed at CDM, Dr. Naunovic completed a number of project management courses (Applied Management Principles, Krannert Graduate School of Management, Purdue University, 2005; CDM's internal Project Management courses). She had the opportunity to manage a number of project tasks during her time at CDM, and gain valuable client relations experience. Dr. Naunovic also received the CDM Inc. Values in Action Award for an outstanding team contribution made to the firm in 2007. Dr. Naunovic currently holds an assistant professor position at Department of Hydraulic and Environmental Engineering, Faculty of Civil Engineering, University of Belgrade (since 2009). She teaches the following courses: "Introduction to Environmental Engineering" (undergraduate course), "Solid Waste Management" (Master's level course) and "Ecology, Chemistry and Microbiology" (the course is a part of the EDUCATE international postgraduate program in Water Resources and Environmental Management). She is also a coordinator for the EDUCATE program and a member of the academic board. Dr. Naunovic is a member of the Serbian Chamber of Engineers, the Water Environment Federation (WEF) and the Serbian Solid Waste Management Association (SeSWA).

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Number of Researchers on the project: 47

Total number of person-months on the project per year 233

Total number of person-months on the for the whole period 932

Number of PhDs on the project 21

Page 5 – Total cost of the project

Cost of researchers financed by the Ministry: 506950

Indirect costs financed by the Ministry: 229519

Direct material costs financed by the Ministry: 273967

Other sources of financing (in €): 113718