Activity 10 Vocational educational and training of personnel which works in the field of hydrology and water management

In the last decade, both the purpose and professional opportunities of personnel in the field of hydrology diversified considerably. Currently, the basic course packages and professional competencies of personnel in the field of hydrology has to be defined.

The World Meteorological Organization recommends the classification of personnel involved in hydrological activities in two categories: technicians (secondary education) and hydrologists (personnel with college education or complete higher education)

In their turn, each category has three stages of qualification, depending on the training degree: junior, medium, senior.

In general, a person is qualified to take up a job if he/she has the required knowledge and skills to perform specified tasks belonging to that job. In seeking to fill a particular post, care should be taken to distinguish among:

- Knowledge and skills as outcomes of education and training;
- Competency for a given job, which not only relates to knowledge and skill but also to aptitude, attitude, behavior and perception. Besides this individual competency, team and organizational competency is also of utmost importance in dealing with changing environmental conditions;
- Ethical aspects of qualification and competency. These will generally increase in importance with career progression. Ethics deals with a moral framework for making good and right decisions.

These general notions have a particular interpretation for the personnel in the field of hydrology. It includes water quantity and quality, both in a hydrological cycle, and in the context of water management.

The activity undertaken in a certain field is regulated based on occupational standards. They are also at the base of the vocational educational and training standards.

For **technicians** in the field of hydrology there are to activity branches: instruments and measurement technologies.

The first branch is the classic one linked to the quantitative and qualitative survey of surface water and groundwater, including measurements, instrument maintenance, and determination of characteristic parameters for water systems, data processing and the analysis of all information.

The second branch refers to information and communication technologies. That is why, these activities imply technical and routine solutions for the processing of images, development, maintenance and operation with large databases, GIS applications, internet applications (web pages, internet searches, etc.

Personnel employed in **Hydrology and Water Resources Engineering** activities will necessarily be of different backgrounds in civil engineering, agricultural engineering, physical sciences, geophysics, geography, forestry, etc.

They may receive further education and training, which further supports preparation for the profession of Hydrologist, with typical responsibilities

Monitoring and forecasting influence planning, design, operation and maintenance and are essential for crisis management, design and construction, as well as operation and maintenance, influence management.

At the base of vocational education and training for the activity of hydrology and water resources engineering is the **Guidelines for the education and training of personnel in meteorology and hydrology, vol. II Hydrology, Fourth Edition WMO no 258/2003.** It presents training forms and programs recommended for the personnel which works in the operative activity of hydrology and water resources engineering.

For the activity of hydrology and water resources engineering, the WMO recommends the following training syllabus:

Topical units and subjects
1. Supporting science and technology 1.1 Statistics 1.2 Engineering mathematics 1.3 Computer operations 1.4 Technical report writing 1.5 Geology and geomorphology 1.6 Meteorology and climatology 1.7 Economics and finance Total 1 (hours) 240
2 General hydrology 2.1 Principles of hydrology 2.2 Catchment hydrology 2.3 Agricultural and forest hydrology 2.4 Urban hydrology 2.5 Hydrogeology and groundwater exploration 2.6 Groundwater Flow 2.7 River Hydraulics Total 2 (hours): 660
3. Data collection and processing
3.1 Data information systems 3.2 Earth observation systems 3.3 Hydrological statistics 3.4 Meteorological observations 3.5 Hydrometry 3.6 Hydrological network design Total 3 (hours): 360
4. Hydrological Modelling
4.1 Numerical methods 4.2 Hydrological modelling

4.3 Hydrological forecasting 4.4 Surface Water modelling 4.5 Groundwater flow modelling 4.6 Contaminant transport modelling Total 4 (hours): 420
5. Environment 5.1 Surface water chemistry and biology 5.2 Environmental Impact Assessment 5.3 Environmental policy 5.4 Groundwater chemistry 5.5 Water pollution Total 5 (hours): 240
6. Water resources management 6.1 Water resources management 6.2 Water resource system operation 6.3 Institutional arrangements 6.4 Water law Total 6 (hours): 180
7. Integrating activities 7.1 Team-building exercise 7.2 Fieldwork 7.3 Field excursions 7.4 Individual study Total 7 (hours): 480
Total hours: 2580

Next we will make a brief description of the mentioned subjects:

Engineering mathematics
Learning objectives: To provide participants with a refreshment of their undergraduate

Computer operations
Learning objectives: To assist participants to use the local computer network and the most commonly used software packages.

Technical report writing
Learning objectives: To assist participants in preparation of a structured technical report, including proper literature references and to perform a technical presentation.

Geology and geomorphology
Learning objectives: To introduce participants to the basic terminology and concepts of geology, and its relevance to the water environment. In particular, the participant should be able to read geological and geomorphological reports,

maps and cross-sections, and interpret these in terms of hydrological implications.

Meteorology and climatology

Learning objectives: To increase participants' understanding of the principles of atmospheric physics, general circulation patterns and weather systems and to evaluate the role of evaporation in the climatic system and in particular in atmosphere – land-surface interactions.

Economics and finance

Learning objectives: To introduce participants to the basic concepts of economic and financial administration and their use these within engineering projects and organizations.

General hydrology

Principles of hydrology

Learning objectives: To enhance participants' understanding of the basic principles of hydrology, the establishment of water balances and the estimation of its components, and the performance of hydrological data analysis.

Catchment hydrology

Learning objectives: To assist participants to master the more advanced applications and techniques for describing the relationship between rainfall and stream flow, use of remote sensing techniques at the catchment scale, flood routing in open channels and reservoirs, storage-yield relationships of reservoirs and the ungagged catchment problem.

Agricultural and forest Hydrology

Learning objectives: To enhance participants' understanding of the importance of physical and chemical soil properties on the availability and quality of soil water so that they are able to design a simple sub-surface drainage system and to compute crop and irrigation water requirements.

Urban hydrology

Learning objectives: To expose participants to the problems associated with the water cycle in urban and urbanizing areas.

Hydrogeology and groundwater exploration

Learning objectives: To familiarize the participants with the various concepts and techniques applied to the analysis of groundwater systems, the exploration for groundwater resources in a variety of natural conditions, and the investigation of the properties of aquifers and the construction of wells.

Groundwater flow

Learning objectives: To familiarize participants with steady and non-steady groundwater flow calculations, including flow towards wells in aquifers and

analytical solutions for evaluation of pumping tests and the principles of salt-water intrusion in coastal aquifers.

River hydraulics
Learning objectives: To familiarize participants with those aspects of hydraulics and the transport of sediments that are necessary in the analysis of fluvial systems.

Data collection, processing and interpretation

Data information systems
Learning objectives: To provide participant with a working understanding of hydrological data information systems. To introduce participants to the principles of geographical information data processing, storage and analysis so that they are able to use geographical information systems (GIS) as a tool for water resources applications.

Earth observation systems
Learning objectives: To introduce participants to the principles of stereoscopic photogrammetry, satellite imagery and radar detection of precipitation and to conduct a hydrological survey using these techniques.

Hydrological statistics
Learning objectives: To enhance participants' knowledge of quality assurance of data sets, frequency analysis and the regionalization of hydrological variables, and their awareness of the various techniques for the analysis and generation of hydrological time series.

Meteorological observations
Learning objectives: To enable participants to set up a climatological field station for hydrological purposes and to carry out observations and analyze the data.

Hydrometry
Learning objectives: After finishing, participants are able to select appropriate sites and techniques for measuring water levels, discharges and sediment transport.

Hydrological network design
Learning objectives: To provide participants with a clear appreciation of the importance of collecting hydrological data in a systematic and cost-effective manner and methods for designing a network of hydrological observations.

Modelling

Numerical methods
Learning objectives: After finishing, participant understand the most common numerical solution procedures and are aware of the constraints in model applications.
Hydrological modelling
Learning objectives: To provide the participants with a thorough background in the various aspects of modelling, model approaches and modelling studies.

Hydrological forecasting
Learning objectives: To expose participants to the techniques involved in flood forecasting, control and warning.

Surface water modelling
Learning objectives: To provide the participants with a working knowledge of hydrodynamic modelling.

Groundwater flow modelling
Learning objectives: To enable the participants to design and evaluate groundwater models.

Contaminant transport modelling
Learning objectives: To enhance participants' understanding of contaminant transport processes and their ability to use numerical models for contaminant transport simulation both in surface water and groundwater environments.

Environmental aspects

Water chemistry and biology
Learning objectives: To introduce the participants to the basic chemical and biological processes in aquatic systems.

Environmental Impact Assessment
Learning objectives: To provide participants with an overview of techniques of Environmental Impact Assessment.

Environmental policy
Learning objectives: To enhance participants' understanding of the technical background to policy formulation.

Groundwater chemistry
Learning objectives: To assist the participants in applying the principles of hydrochemistry in order to assess groundwater quality in a variety of situations and conditions.

Water pollution
Learning objectives: To enable participants to understand groundwater quality standards, the different sources of pollution, the most important processes affecting groundwater quality and measures to protect groundwater resources.

Water resources management
Learning objectives: To introduce participants to modern approaches to water resources planning and management, including the assessment of demands and tools for planning and management.

Water resources system operation
Learning objectives: To provide participants with a basic knowledge of approaches for the design and operation of water resources systems.

Course packages for the assimilation of basic knowledge for hydrological technicians

A Hydrological Technician generally holds a qualification such as a high-school diploma based on 12 or more years of formal education, specialized formal training in a technical field related to hydrology and relevant experience. The Hydrological Technician is expected to master increasingly sophisticated laboratory instruments and office equipment, deal with the increasing scientific character of daily problems and also take on the role of an instructor to more junior technicians

Instruction and training needs for Hydrological Technicians differ from those of Hydrologists in several respects. Perhaps the most important difference is that whereas Hydrologists tend to have relatively similar educational and experiential backgrounds, even at a global scale, the educational backgrounds and practical experience of Hydrological Technicians can be quite diverse, not only at the global scale but also at the national or regional scale. Despite this diversity of backgrounds, Hydrological Technicians are often expected to work as members of a team in support of initiatives and projects led by Hydrologists. In addition, Hydrological Technicians are often expected to provide continuous knowledge transfer and training to junior technicians through on-the-job training. The support activity provided by the Hydrological Technician is closely tied to rapidly changing technology, both in the office and in the field, which puts a premium on the ability for lifelong learning and continuing education. On the job training activities of junior technicians is conducted on a practical basis, in the field, and theoretical basis.

Matrix of topical units for the BIPs (contact hours)

Subjects	Technicians specialized in measurement instruments	Technicians specialized in information and telecommunications
1. Basic subjects (in hours)		
1.1 Introduction to hydrological processes	6	6
1.2 Mathematics	15	15
1.3 Statistics	20	20
1.4 Electrical principles for measuring techniques	6	6
1.5 Metrology and sensor technology	6	6
1.6 Computer operations	20	30
1.7 Surveying, map reading and photo interpretation	30	10
2. Hydrological subjects (in hours)		
2.1 Meteorology	20	20
2.2 Hydraulics	30	30
2.3 Hydrometry	40	20
2.4 Hydrogeology	40	20
2.5 Water quality	40	20
2.6 Analysis of hydrological data	50	50
2.7 Data storage and retrieval	10	40
2.8 Instruments maintenance	10	40

3.3 Description of thematic units from the course packages for the assimilation of basic knowledge for hydrological technicians

1. Basic subjects – objectives – To introduce participants to the basic concepts of hydrology, the establishment of water balances and the appropriate technical terminology.

Mathematics
Learning objectives: To provide participants with the necessary knowledge of the mathematical tools that will be used in other subjects.

Statistics
Learning objectives: To provide the participants with the necessary knowledge of the statistical tools that will be used in other subjects.

Electrical principles for measuring techniques
Learning objectives: To introduce participants to the basic concepts of electricity that govern some measuring methods and instruments.

Metrology and sensor technology
Learning objectives: To provide participants information on the science of measurements and sensor technology.

Computer operations
Learning objectives: To provide participants an introduction to the use of PCs and assist them to use some common software packages.

Surveying, map reading and photo interpretation
Learning objectives: To provide the participants with a working knowledge on surveys, maps and photos used in hydrology.

2. Hydrological subjects

Meteorology
Learning objectives: To familiarize participants with basic aspects of hydraulics and sediment transport that are necessary in hydrological activities

Hydrometry
Learning objectives: Participants should be able, after completing the subject, to cooperate in the selection of sites and techniques and to perform measurements of water levels, discharges and sediment transport under safe conditions.

Hydrogeology
Learning objectives: To familiarize participants with groundwater resources, and to provide them with basic knowledge of related topics.

Water quality
Learning objectives: To provide participants with basic knowledge in chemistry related to water quality and to familiarize them with the collection and the analysis of water samples

Analysis of hydrological data
Learning objectives: To provide participants with the theoretical background on hydrological data analysis and familiarize them with the most common hydrological analysis.

Data storage and retrieval
Learning objectives: To provide the participants with a working understanding of hydrological data storage and retrieval systems.

Instruments maintenance
Learning objectives: To familiarize participants with common practices on instruments maintenance.

Based on the above-mentioned, we propose the next intensive training program for staff working in operational hydrology:

Hydrological technicians

1. "Classic" and modern equipment for the measurement and collection of data - 80 hours (40 hours theory lectures and 40 hours practical work in the field)
   - Electrical principles of measurement techniques;
   - Methodology and Sensor Technology;
   - Constructive and functional description of modern equipment (including automatic stations) for the measurement of hydrometric parameters;
   - Maintenance of instruments;
   - Practical work in the field.

2. Hydrometric data processing: 80 hours
   - Types of observed and measured hydrometric data;
   - Methods to transfer field data on computers;
   - Primary processing and validation of data (manually and using PC);
   - Preparing annual hydrometric studies at gauging stations.

Hydrology and water resources engineering

1. Introduction in hydrology - 40 hours
   - hydrological network structures;
   - Fundamentals of meteorology and climatology;
   - Meteorological observations;
   - Hydrometric observations and measurements programs.
2. Methods of obtaining and processing hydrometric data - 80 hours
   - Types of hydrometric observations and measurements;
   - "Classic" and modern methods of obtaining, collecting and primary processing of hydrometric data;
   - Drafting annual hydrometric studies at gauging stations;
   - Writing technical reports.

3. The use of computer applications for processing and validation of hydrometric data - 80 hours (40 theory lectures and 40 practical applications)
   - Programming languages used to develop software for the processing of hydrometric data (general concepts);
   - algorithms used in developing computer applications;
   - Applications existent in Romania for processing and validation of hydrometric data (description and method of use)
4. Hydrological modeling - 80 hours
   - Numerical Methods;
   - Hydrological modeling;
   - Hydraulic Modeling;
   - Hydrological forecast;
   - Modeling of surface waters;
   - Groundwater Modeling.
5. Collection, processing and interpretation of hydrologic data: 80 hours (40 theory lectures and 40 practical applications)
   - hydrological data systems;
   - Modern methods and techniques (GIS) for the collection and processing of geographical information;
   - GIS applications in hydrology and water management.