Co-funded by the
Erasmus+ Programme
of the European Union

REPORT ON MASTER CURRICULA RELATED TO WRM IN EU AND WB PARTNER COUNTRIES

This project has been funded with support from the European Commission. This publication reflects the views only of the author, and the Commission cannot be held responsible for any use which may be made of the information contained therein.

University of Nis

PROJECT INFO

Project title	Strengthening of master curricula in water resources management for the Western Balkans HEIs and stakeholders
Project acronym	SWARM
Project reference number	597888-EPP-1-2018-1-RS-EPPKA2-CBHE-JP
Funding scheme	Erasmus+ Capacity building in the field of higher education
Web address	www.swarm.ni.ac.rs
Coordination institution	University of Nis
Project duration	15 November 2018 – 14 November 2021

DOCUMENT CONTROL SHEET

Work package	WP1 Analysis of water resources management in the Western Balkan region
Ref. no and title of activity	WP1.3 Report on master curricula related to WRM in EU and WB partner countries
Title of deliverable	Report on master curricula related to WRM in EU and WB partner countries
Lead institution	BOKU
Author(s)	Kurt Glock, Michael Tritthart, Daniel Wildt, Petar Filkov, Irirna Ribarova, Vladimir Kukurin, Emil Tsanov, Barbara Karleuša, Nevena Dragičević, Elpida Kolokytha, Maria Manuela Portela, Luis Tavares Ribeiro, Rodrigo Proenca de Oliveira, Zakhar Maletskyi, Milan Gocić, Slaviša Trajković, Petar Mitković, Evica Petrović, Mladen Milanović, Nemanja Stanisavljević, Slobodan Kolaković, Srđan Kolaković, Igor Peško, Emina Hadžić, Suvada Jusić, Hata Milišić, Suada Džebo, Naida Ademović, Ammar Šarić, Suad Špago, Merima Šahinagić-Isović, Marko Ćećez, Mili Selimotić, Nebojša Arsić, Ljiljana Anđelković, Đurica Marković, Jelena Đokić, Marjan Mitić, Aleksandra Petrović, Predrag Stanojević, Jelena Rajović, Gordana Lešević, Dejan Živković, Nenad Marković, Goran Sekulić, Milan Radulović, Biljana Šćepanović
Document status	Final
Document version and date	V.03 08.10.2020
Dissemination level	National, Regional, International

VERSIONING AND CONTRIBUTION HISTORY

Version	Date	Revision description	Partner responsible
v.01	27.03.2019	Document created	BOKU
v.02	14.05.2019	Document revised	BOKU
v.03	08.10.2020	Missing skills and knowledge	BOKU

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1 Introduction

Water resources management requires well-developed professionals with appropriate knowledge. It is the responsibility of national institutions including universities to educate the mentioned specialists. In some European states special master curricula dealing with water resources management have been established. Other member states in turn have included appropriate courses in existing master curricula. Information about the education of well-developed professionals in EU as well as WB partner countries and a list of relevant curricula or courses are outlined.

2 Analysis of master curricula in EU

Information about existing master curricula in EU are a useful basis for developing and strengthening master curricula for water resource management in Western Balkan regions. In work package 1.3 (WP 1.3) a collaboration between BOKU and all EU partners (including Norway) is foreseen to close the knowledge gap concerning master curricula. In the following chapters several existing master curricula are documented.

2.1 Austria

2.1.1 Overview

In Austria a few master's degree programmes related to water resource management are available at different universities (Table 1).

Table 1: Relevant master´s programs in Austria

Master´s programme	Academic degree	University
Civil Engineering and Water Management	MSc	University of Natural Resources and Life Sciences, Vienna
Alpine Natural Dangers / Watershed Regulation	MSc	University of Natural Resources and Life Sciences, Vienna
Geotechnical and Hydraulic Engineering	MSc	Graz University of Technology
Civil Engineering	MSc	Vienna University of Technology
Environmental Engineering	MSc	University of Innsbruck

2.1.2 Civil Engineering and Water Management (CEWM), University of Natural Resources and Life Sciences, Vienna (BOKU)

The master's degree programme "Civil Engineering and Water Management" of the University of Natural Resources and Life Sciences, Vienna (BOKU, 2016) leads the students into the knowledge and working methods of applied natural sciences and their engineering applications. Graduates have a well-founded basic knowledge and a comprehensive understanding of sustainable use of natural resources. In addition, the ability of networked thinking in designing, planning, building and maintaining processes will be supported.

Occupational fields

Graduates of the master's degree programme "Civil Engineering and Water Management" are prepared for employment in the following fields of activities:

- Water management
- Land management, construction engineering and management
- Traffic and infrastructure management
- Waste management
- Geoinformation
- Risk management

3-pillar-principle

The characteristic of each master's degree programme at the University of Natural Resources and Life Sciences is the "3-pillar-principle", which ensures a minimum percentage of 15% of courses in each of the following scientific areas:

- Engineering sciences
- Natural sciences
- Economic, social and legal sciences

Scope and classification

In the scope of this master's degree programme courses in the extent of 120 ECTS have to be taken. The courses are subdivided into the following classification:

- Compulsory courses: 29 ECTS
- Master thesis: 30 ECTS
- Elective courses: 48 ECTS
- Free elective courses: 13 ECTS

Within the scope of elective courses four to six out of 13 subjects (Traffic and Transport planning, Geo Data Management, Land Management and Spatial Development, Risk Management and Resource Protection, Hydrology and Water Management, Hydraulic Engineering and River Management, Structural Design and Construction Industry, Structural Safety and Reliability Assessment, Aquatic Ecology, Sanitary and Industrial Water Management, Soil Water Management, Geotechnics and Applied Geology, Waste Management) have to be selected with at least 8 ECTS each. The subjects of Geo Data Management, Land Management and Spatial Development, Risk Management and Resource Protection, Hydrology and Water Management, Hydraulic Engineering and River Management, Aquatic Ecology, Sanitary and Industrial Water Management, Soil Water Management and Geotechnics and Applied Geology including courses related to water resources management, and all essential compulsory courses are listed in Table 2.

Table 2: Courses of the master's degree programme "Civil Engineering and Water Management"

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Complusory courses					
Construction and plane load-bearing structures	L	CEWM	Bergmeister K (Felderer C), Schwenn M (Lanik S), Stierschneider E (Mitterlehner S), Strieder E, Zeman O	Institute of Structural Engineering (IKI)	4
Applied geotechnical engineering	L	CEWM	Wu W (Brandmaier M), Acharya M	Institute of Geotechnical Engineering (IGT)	4
Hydromechanics	L	CEWM	Tritthart M (Brandmaier M), Nolz R (Wildt D)	Institute of Hydraulics and Rural Water Management (IHLW)	4
Special administrative law for civil engineering	SE	CEWM	Mittermüller B (Fürmann M), Werinos-Sydow S	Institute of Law	4
Strategic planning, desicion support, and mediation	SE	CEWM	Hössinger R (Wiesmann T), Aschauer F	Institute for Transport Studies (IVe)	3
Natural hazards	L	CEWM	Kaitna R	Institute of Mountain Risk Engineering (IAN)	2
Construction project (optional interdisciplinary)	P	CEWM	Cepuder P, Ertl T, Fürst J, Langergraber G, Mader H, Mayr E, Perfler R, Weihs P, Weissenbacher N, Seher W, etc.	Department of Water - Atmosphere - Environment (WAU), Department of Landscape, Spatial and Infrastructure Sciences, Department of Civil Engineering and Natural Hazards	6
Master´s thesis seminar	SE	CEWM			2

Elective courses (selected)					
Subject **Geo Data Management**					
Geo-data management	L	CEWM	Atzberger C, Vuolo F	Institute of Surveying, Remote Sensing and Land Information (IVFL)	3
Satellite-based positioning and navigation (GPS)	L	CEWM	Heine E (Sterlich P)	Institute of Surveying, Remote Sensing and Land Information (IVFL)	3
Remote sensing and image processing	L	CEWM	Vuolo F, Ng W	Institute of Surveying, Remote Sensing and Land Information (IVFL)	6
Computers in surveying	L	CEWM	Grillmayer E	Institute of Surveying, Remote Sensing and Land Information (IVFL)	3
Applied photogrammetry	L	CEWM	Mansberger R (Karel S), Lindner G (Kessler M)	Institute of Surveying, Remote Sensing and Land Information (IVFL)	4.5
Spatial modeling and simulation	L	CEWM	Suppan F	Institute of Surveying, Remote Sensing and Land Information (IVFL)	3
Geodata for GIS-application in Austria	L	CEWM	Janeschitz E	Institute of Surveying, Remote Sensing and Land Information (IVFL)	3
Web-GIS-technologies	L	CEWM	Grillmayer R, Vuolo F	Institute of Surveying, Remote Sensing and Land Information (IVFL)	3
Mathematical methods in geoinformatics	L	CEWM	Suppan F	Institute of Surveying, Remote Sensing and Land Information (IVFL)	1.5
Legal bases of the acquisition and management of geo-data	L	CEWM	Twaroch C	Institute of Surveying, Remote Sensing and Land Information (IVFL)	1
Application of GIS in hydrology and water management	L	CEWM	Fürst J	Intitute of Hydrology and Watermanagement (HyWa)	3
Subject **Land Management and Spatial Development**					
Land consolidation project	P	CEWM	Pelikan W, Seher W	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	3
Land administration	L	CEWM	Ernst J	Institute of Surveying, Remote Sensing and Land Information (IVFL)	2
Spatial planning: legal and planning instruments	L	CEWM	Stöglehner G, Seher W, Fischer T	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	2
Land management	L	CEWM	Seher W, Grossauer F	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	2
Spatial planning in alpine areas	L	CEWM	Seher W, Weiß G	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	2

Spatial impact assessment	SE	CEWM	Stöglehner G	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	3
International land management	SE	CEWM	Mansberger R, Seher W	Institute of Surveying, Remote Sensing and Land Information (IVFL)	1.5
Spatial research in rural areas	L	CEWM	Fischer T	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	2
Sustainable spatial development	SE	CEWM	Seher W, Stöglehner G	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	5
Politics of spatial and regional planning	L	CEWM	Maxian M	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	3
Integrated spatial and energy planning	SE	CEWM	Stöglehner G	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	3
Development innovation	SE	CEWM	Probst L	Department of Centre for Development Research	3
Subject **Risk Management and Resource Protection**					
Integrated flood risk management	L	CEWM	Holzmann H, Habersack H, Schober B	Intitute of Hydraulic Engineering and River Research (IWA)	3
Sustainability, Protection of Resources and Natural Hazards (compulsory in the module)	L	CEWM	Fiebig M	Institute of Applied Geology (IAG)	3
Protection and mitigation measures against natural hazards	L	CEWM	Hübl J (Mögele C)	Institute of Mountain Risk Engineering (IAN)	3
Risk management and vulnerability assessment	SE	CEWM	Papathoma-Köhle M, Thaler T	Institute of Mountain Risk Engineering (IAN)	3
Landslide hazards	SE	CEWM	Mergili M, Straka W, Zangerl C	Institute of Applied Geology (IAG)	3
Environmental risks - introduction to risk analysis	L	CEWM	Gazsó A	Insitute of Safety and Risk Sciences	2
Technology assessment	SE	CEWM	Liebert W, Drapalik M, Gufler K	Insitute of Safety and Risk Sciences	3
Environmental statistics	L	CEWM	Laaha G (Schlögl M)	Institute of Applied Statistics and Computing (IASC)	3
Soil water protection	L	CEWM	Cepuder P	Institute of Hydraulics and Rural Water Management (IHLW)	2
Soil protection	L	CEWM	Wenzel W	Institute of Soil Research (IBF)	3
Development and application of water erosion models	L	CEWM	Klik A	Institute of Hydraulics and Rural Water Management (IHLW)	2
Subject **Hydrology and Water Management**					
Hydrology and water management II	L	CEWM	Schulz K	Intitute of Hydrology and Watermanagement (HyWa)	3

Practical course in hydrology and sater management II	P	CEWM	Herrnegger M	Intitute of Hydrology and Watermanagement (HyWa)	1.5
Hydrology of Austria	L	CEWM	Fürst J	Intitute of Hydrology and Watermanagement (HyWa)	2
Seminar in groundwater management	SE	CEWM	Fürst J	Intitute of Hydrology and Watermanagement (HyWa)	3
Possible impacts of climate change on water resources	L	CEWM	Schulz K, Holzmann H	Intitute of Hydrology and Watermanagement (HyWa)	3
Seminar in surface hydrology	SE	CEWM	Holzmann H	Intitute of Hydrology and Watermanagement (HyWa)	3
Hydro-electric energy and electricity market	L	CEWM	Pirker O	Intitute of Hydrology and Watermanagement (HyWa)	2
Solution of conflicts between ecological integrity and engineering of rivers	L	CEWM	Mader H	Intitute of Hydraulic Engineering and River Research (IWA)	2
Hydrogeology	L	CEWM	Fiebig M, Häuselmann P, Zangerl C	Institute of Applied Geology (IAG)	3
Hydrogeological excursion	P	CEWM	Fiebig M, Zangerl C	Institute of Applied Geology (IAG)	1
Hydrometric and river engineering field exercises	P	CEWM	Bernhardt M (Hamedinger T), Herrnegger M (Balasch A), Schulz K	Intitute of Hydrology and Watermanagement (HyWa)	4.5
Subject Hydraulic Engineering and River Management					
Hydraulic engineering and river basin management	L	CEWM	Habersack H	Intitute of Hydraulic Engineering and River Research (IWA)	3
Planning and design of hydraulic structures (river engineering & small hydro power)	P	CEWM	Pelikan B (Battlogg S), Mader H (Egger M), Tritthart M (Krapesch M), Liedermann M, Gmeiner P	Intitute of Hydraulic Engineering and River Research (IWA)	3
Project management for hydraulic engineering	L	CEWM	Hanisch P, Haider S	Intitute of Hydraulic Engineering and River Research (IWA)	2
Environmental impact assessment for small hydropower plants	L	CEWM	Pelikan B	Intitute of Hydraulic Engineering and River Research (IWA)	1
Planning and design of small hydro power plants	L	CEWM	Pelikan B, Mader H	Intitute of Hydraulic Engineering and River Research (IWA)	2
Hydraulic scale models	L	CEWM	Sindelar C (Schur D)	Intitute of Hydraulic Engineering and River Research (IWA)	3
River maintenance and design	L	CEWM	Pelikan B	Intitute of Hydraulic Engineering and River Research (IWA)	2

Sediment regime and river morphology	L	CEWM	Habersack H	Intitute of Hydraulic Engineering and River Research (IWA)	3
Monitoring in river engineering	L	CEWM	Habersack H, Haimann M, Klösch M, Liedermann M	Intitute of Hydraulic Engineering and River Research (IWA)	2
River basin planning and management	L	CEWM	Habersack H, Schober B	Intitute of Hydraulic Engineering and River Research (IWA)	2
Computer based river modelling	L	CEWM	Tritthart M (Dörler S), Habersack H, Glock K	Intitute of Hydraulic Engineering and River Research (IWA)	3
Hydraulic Design and Water Right Law - Case Studies	SE	CEWM	Mader H	Intitute of Hydraulic Engineering and River Research (IWA)	3
Subject **Geotechnics and Applied Geology**					
Geotechnical engineering I	L	CEWM	Lin J (Friedl C)	Institute of Geotechnical Engineering (IGT)	3
Engineering geology - introduction (compulsory in the module)	L	CEWM	Zangerl C (Steiner G)	Institute of Applied Geology (IAG)	2
Geotechnical engineering II	P	CEWM	Acharya M (Wildt D)	Institute of Geotechnical Engineering (IGT)	3
Slope engineering	L	CEWM	Acharya M	Institute of Applied Geology (IAG)	2
Special ground construction I	L	CEWM	Preindl P	Institute of Geotechnical Engineering (IGT)	1
Special ground construction II	L	CEWM	Preindl P	Institute of Geotechnical Engineering (IGT)	1
Numerical methods in geotechnics and applied geology	L	CEWM	Lin J	Institute of Geotechnical Engineering (IGT)	3
Geotechnical engineering in waste management	L	CEWM	Zorzi M	Institute of Geotechnical Engineering (IGT)	2
Laboratory practices in geotechnical engineering	P	CEWM	Wu W (Reisinger F), Acharya M, Lin J	Institute of Geotechnical Engineering (IGT)	3
Rock mechanics	L	CEWM	Zangerl C	Institute of Applied Geology (IAG)	4.5
Applied geology - field practice	P	CEWM	Fiebig M (Hafenscherer S), Lüthgens C, Stur M, Zangerl C	Institute of Applied Geology (IAG)	3
Geotechnical methods in mapping and field tests	P	CEWM	Zangerl C (Auinger G, Mayrhofer S)	Institute of Applied Geology (IAG)	3
Applied geophysics for engineers	L	CEWM	Arndt R	Institute of Applied Geology (IAG)	3
Laboratory exercises	L	CEWM	Wriessnig K, Ottner F	Institute of Applied Geology (IAG)	3
Environmental geology	L	CEWM	Lüthgens C	Institute of Applied Geology (IAG)	3
Quaternary geology	L	CEWM	Lüthgens C	Institute of Applied Geology (IAG)	2
Groundwater prospection, drillingtechnology and well completion	L	CEWM	Bacher R	Institute of Hydraulics and Rural Water Management (IHLW)	3

Subject **Aquatic Ecology**					
Hydrobiology II (compulsory in the module)	L	CEWM	Graf W, Hein T, Hohensinner S, Schmutz S	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	2
Aquatic biomonitoring and -assessment	L	CEWM	Schmutz S, Schwarzinger I	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	2
Human impacts in riverine landscapes	L	CEWM	Schmutz S, Hayes D, Schinegger R, Schwarzinger I	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	2
Benthic invertebrate status assessment	L	CEWM	Graf W (Waberer M), Leitner P, Schwarzinger I	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	3
Benthic invertebrate sampling and monitoring	L	CEWM	Graf W (Waberer M), Huber T, Leitner P	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	3
Selected chapters in ecology of aquatic environments	L	CEWM	Waidbacher H	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	3
Applications in river landscape management	L	CEWM	Muhar S (Gruber G), Unfer G	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	2
Ecological river landscape management	L	CEWM	Muhar S, Unfer G	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	2
Ecology of aquatic plants	L	CEWM	Bernhardt K (Thornton M)	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	2
Ecology of fishes	L	CEWM	Unfer G, Friedrich T, Meulenbroek P, Waidbacher H	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	3
Ecohydromorphological mapping	L	CEWM	Muhar S (Pfeiffer M), Hohensinner S	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	2
Fish passes and continuity	L	CEWM	Schmutz S (Sonten L), Zeiringer B	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	2
Aquatic habitat modeling	L	CEWM	Zeiringer B, Melcher A (Sonten L)	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	2
Subject **Sanitary and Industrial Water Management**					
Projekt work on sanitary engineering and water pollution control (compulsory in the module)	P	CEWM	Ertl T (Grunert M), Kretschmer F, Neunteufel R	Institute of Sanitary Engineering and Water Pollution Control (SIG)	6
Technologies in sanitary engineering	L	CEWM	Ertl T, Kretschmer F, Langergraber G, Simperler L	Institute of Sanitary Engineering and Water Pollution Control (SIG)	3
Technologies in water pollution control	L	CEWM	Mayr E, Perfler R	Institute of Sanitary Engineering and Water Pollution Control (SIG)	3
Seminar of practice in sanitary engineering, industrial water management and water pollution control	SE	CEWM	Ertl T, Langergraber G, Perfler R	Institute of Sanitary Engineering and Water Pollution Control (SIG)	4.5

Modeling in sanitary engineering (sewer, treatment plant and receiver)	L	CEWM	Ertl T, Telegdy T, Langergraber G	Institute of Sanitary Engineering and Water Pollution Control (SIG)	4.5
Water quality assessment	L	CEWM	Fürhacker M, Allabashi R (Omarova L), Fiedler C	Institute of Sanitary Engineering and Water Pollution Control (SIG)	4.5
Strategic planning and operational optimisation in sanitary engineering	L	CEWM	Mayr E, Neunteufel R, Perfler R	Institute of Sanitary Engineering and Water Pollution Control (SIG)	4.5
Construction and rehabilitation of pipes, sewer operation and maintenance	L	CEWM	Ertl T, Kretschmer F	Institute of Sanitary Engineering and Water Pollution Control (SIG)	2
Water quality monitoring, sensor and control technology	L	CEWM	Perfler R, Allabashi R, Pressl A, Langergraber G	Institute of Sanitary Engineering and Water Pollution Control (SIG)	2
Industrial water management	L	CEWM	Ertl T, Allabashi R	Institute of Sanitary Engineering and Water Pollution Control (SIG)	3
Water quality management for municipal and industrial water use	L	CEWM	Perfler R	Institute of Sanitary Engineering and Water Pollution Control (SIG)	2
On site solutions for water supply and sanitation	L	CEWM	Jung H, Langergraber G	Institute of Sanitary Engineering and Water Pollution Control (SIG)	3
Risk assessment in the aquatic environment	L	CEWM	Fürhacker M (Grunert M), Moog O	Institute of Sanitary Engineering and Water Pollution Control (SIG)	3
Water resources management in developing cooperation	L	CEWM	Jung H, Eder G	Institute of Sanitary Engineering and Water Pollution Control (SIG)	3
Subject **Soil Water Management**					
Soil water management	L	CEWM	Klik A, Nolz R	Institute of Hydraulics and Rural Water Management (IHLW)	3
Soil conservation and soil protection	L	CEWM	Klik A (Söllradl S)	Institute of Hydraulics and Rural Water Management (IHLW)	3
Soil water management	L	CEWM	Kammerer G	Institute of Hydraulics and Rural Water Management (IHLW)	3
Migration processes in the soil and groundwater zone	L	CEWM	Bilek F	Institute of Hydraulics and Rural Water Management (IHLW)	3
Simulation in vadose zone environment	L	CEWM	Brunetti G	Institute of Hydraulics and Rural Water Management (IHLW)	3
Irrigation management	L	CEWM	Cepuder P (Ziesel G)	Institute of Hydraulics and Rural Water Management (IHLW)	3

Physical and selected chemical methods of soil analysis	P	CEWM	Cepuder P (Faulhammer M), Kammerer G (Fuchs A), Klik A (Haigner K), Johannsen L, Stockinger M (Locher D, Madrigal Sanchez A)	Institute of Hydraulics and Rural Water Management (IHLW)	4.5
Wetlands and small bodies of water	L	CEWM	Nolz R	Institute of Hydraulics and Rural Water Management (IHLW)	2
Soil physics (continued)	L	CEWM	Kammerer G	Institute of Hydraulics and Rural Water Management (IHLW)	3
Agricultural hydrology	L	CEWM	Nolz R	Institute of Hydraulics and Rural Water Management (IHLW)	2
Using water erosion models	P	CEWM	Klik A	Institute of Hydraulics and Rural Water Management (IHLW)	3
Applied methods of rural water management in subtropical and tropical regions	SE	CEWM	Loiskandl W, Ruffeis D, Strauss-Sieberth A	Institute of Hydraulics and Rural Water Management (IHLW)	4.5

2.1.3 Alpine Natural Dangers / Watershed Regulation (AND), University of Natural Resources and Life Sciences, Vienna (BOKU)

In the master's degree programme "Alpine Natural Dangers / Watershed Regulation" of the University of Natural Resources and Life Sciences Vienna (BOKU, 2015) the students acquire the necessary knowledge and skills for a responsible handling of hazards in alpine regions. In order to achieve the educational objectives, the program is oriented towards the cycle of "integral risk management" including sustainable coping, rebuilding and prevention measures. In addition to scientific and technical courses, questions of natural hazard legislation, spatial planning, disaster prevention and management are an essential part of the study program.

Occupational fields

Graduates of the master's degree programme "Alpine Natural Dangers / Watershed Regulation" are prepared for employments in the following fields of activities:

- Evaluation and analysis of hazards and mass movements in alpine regions
- Prevention of alpine natural hazards
- Integrated river basin management
- Risk prevention
- Disaster management

3-pillar-principle

The characteristic of each master's degree programme at the University of Natural Resources and Life Sciences is the "3-pillar-principle", which ensures a minimum percentage of 15% of courses in each of the following scientific areas:

- Engineering sciences
- Natural sciences
- Economic, social and legal sciences

Scope and classification

In the scope of this master's degree programme courses in the extent of 120 ECTS have to be taken. The courses are subdivided into the following classification:

- Compulsory courses: 22 ECTS
- Master thesis: 30 ECTS
- Elective courses: 50 ECTS
- Free elective courses: 18 ECTS

Due to the fact that the entire master's degree programme is dealing with water related issues, all potential courses are listed in Table 3.

Table 3: Courses of the master's degree programme "Alpine Natural Dangers / Watershed Regulation"

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Compulsory courses					
Hydrological hazards - analysis and assessment	SE	AND	Hübl J, Bernhardt M, Kaitna R	Institute of Mountain Risk Engineering (IAN)	3
Hydrological hazards - mitigation measures	L	AND	Hübl J, Habersack H, Schober B	Institute of Mountain Risk Engineering (IAN)	3
Runoff formation in torrential headwater basins	SE	AND	Holzmann H, Hübl J	Institute of Hydraulic Engineering and River Research (IWA)	2
Snow and avalanche hazards - analysis and evaluation	L	AND	Reiweger I (Heil K), Fischer J (Eberl A)	Institute of Mountain Risk Engineering (IAN)	3
Technical protection measures: avalanches	L	AND	Sauermoser S	Institute of Mountain Risk Engineering (IAN)	3
Landslide hazards	SE	AND	Mergili M, Straka W, Zangerl C	Institute of Applied Geology (IAG)	3
Hazards due to mass movements - rockfall	L	AND	Brauner M	Institute of Applied Geology (IAG)	3
Master's thesis seminar	SE	AND	Bergmeister K, Drexel A, Fiebig M, Florineth F, Fuchs S, Hübl J, Kaitna R, etc.	Institute of Mountain Risk Engineering (IAN)	2
				Sum	22
Elective courses					
Silviculture and forest protection	L	AND	Lexer M, Vacik H, Netherer S	Institute of Silviculture (WALDBAU)	5
Mountain forest ecosystems	SE	AND	Katzensteiner K	Institute of Forest Ecology (IFE)	3
Design of protection works	L	AND	Suda J	Institute of Structural Engineering (IKI)	4
Fundamentals of geotechnical engineering	L	AND	Wu W	Institute of Geotechnical Engineering (IGT)	4
Environmental aspects in the flood protection	L	AND	Merwald I	Institute of Mountain Risk Engineering (IAN)	3
Aquatic ecology and river morphology	L	AND	Hauer C, Seliger C	Institute of Hydrobiology and Aquatic Ecosystem Management (IHG)	3
Construction methods and management for barrier structures	SE	AND	Wehrmann H	Institute of Structural Engineering (IKI)	2
Structural maintenaince and monitoring	L	AND	Strauss A, Suda J	Institute of Structural Engineering (IKI)	2
Structural and objective based protection measures	L	AND	Hübl J, Strauss A	Institute of Structural Engineering (IKI)	4
Afforestation and forest protection near the timberline	L	AND	Halmschlager E, Klumpp R	Institute of Forest Entomology, Forest Pathology and Forest Protection (IFFF)	3
Soil bioengineering techniques	L	AND	Rauch J	Institute of Soil Bioengineering and Landscape Construction (IBLB)	2
Management of protective forests	L	AND	Hasenauer H, Seidl R	Institute of Silviculture (WALDBAU)	3
Wildlife ecology in protective and in selectively harvested forest stands	L	AND	Reimoser F	Institute of Wildlife Biology and Game Management (IWJ)	1.5

Spatial planning in alpine areas	L	AND	Seher W, Weiß G	Institute of Spatial Planning, Environmental Planning and Land Rearrangement (IRUB)	2
Natural danger law	L	AND	Wagner E	Institute of Law	2
Vulnerability and risk management	SE	AND	Fuchs S	Institute of Mountain Risk Engineering (IAN)	2.5
Introduction to natural hazard management	L	AND	Rudolf-Miklau F	Institute of Mountain Risk Engineering (IAN)	1.5
Civil protection	L	AND	Kaiser P	Institute of Mountain Risk Engineering (IAN)	1.5
Communicaton, information and participation	L	AND	Volgger S	Institute of Mountain Risk Engineering (IAN)	3
Forecasting and warning systems	L	AND	Hübl J	Institute of Mountain Risk Engineering (IAN)	1.5
Event documentation and damage analysis	L	AND	Hübl J	Institute of Mountain Risk Engineering (IAN)	1.5
Disaster management and emergency services	L	AND	Kreuzer S (Mayr B)	Institute of Mountain Risk Engineering (IAN)	1.5
Politics of natural hazards and risk governance	SE	AND	Rudolf-Miklau F	Institute of Mountain Risk Engineering (IAN)	1.5
Damage adjustment	L	AND	Holub M	Institute of Mountain Risk Engineering (IAN)	1.5
Watershed management	P	AND	Hübl J (Nagl G), Neumann M	Institute of Mountain Risk Engineering (IAN)	6
Dynamics of geophysical flows	SE	AND	Kaitna R	Institute of Mountain Risk Engineering (IAN)	3
Scenario development and analysis	L	AND	Mazzorana B	Institute of Mountain Risk Engineering (IAN)	2
Simulation models in natural hazards analysis	P	AND	Braito S, Hübl J, Scheidl C	Institute of Mountain Risk Engineering (IAN)	3
Road network planning	SE	AND	Pertlik E (Holzfeind T, Santner C), Holzleitner F, Kühmaier M	Institute of Forest Engineering (FT)	5
Harvesting systems	SE	AND	Holzleitner F (Gruber P), Kanzian C	Institute of Forest Engineering (FT)	3

EX...Excursion; L...Lecture; LU... Laboratory Exercises; P/PE...Practical Exercises; SE...Seminar;

2.1.4 Geotechnical and Hydraulic Engineering (GHE), Graz University of Technology (TU Graz)

The master's degree programme in "Geotechnical and Hydraulic Engineering" established at TU Graz provides students with an in-depth education in engineering, focussing on the field of civil engineering and its application and, through the three separate specialisation subjects offered, Soil Mechanics, Rock Mechanics and Hydraulic Engineering, is oriented towards the current international development of engineering sub-disciplines. The degree programme reflects the principle of research-led teaching. In addition to providing detailed specialist, theoretical knowledge, particular focus is laid on providing practical, social and media competencies. In extended exercises in laboratories and outdoors as well as on excursions, students learn to independently develop concepts and to put them into practice (TU Graz, 2015).

Occupational fields

Graduates of the master's degree programme "Geotechnical and Hydraulic Engineering" are prepared for employments in the following fields of activities:

- Geotechnics
- Soil mechanics
- Foundation engineering
- Rock mechanics
- Tunnelling
- Hydraulics
- Hydraulic engineering
- Urban water management

Scope and classification

In the scope of this master's degree programme courses in the extent of 120 ECTS have to be taken. The courses are subdivided into the following classification:

- Compulsory courses: 27.5 ECTS
- Master thesis: 30 ECTS
- Elective courses: 50.5 ECTS
- Elective courses (soft skills): 6 ECTS
- Free elective courses: 6 ECTS

Within the scope of elective courses two out of three subjects (Soil Mechanics, Rock Mechanics and Hydraulic Engineering) have to be selected. The subject Hydraulic Engineering, including courses related to water resource management, and all essential compulsory courses are listed in Table 4.

Table 4: Courses of the master's degree programme "Civil Engineering and Water Management"

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Compulsory courses					
Engineering Geological Investigation	L	GHE	Bitenc M, Harer G, Kieffer D	Institute of Applied Geosciences	3
Finite Element Method	L	GHE	Fries T, Steidl J	Institute of Structural Analysis	3
Geotechnical Monitoring	L	GHE	Ehrhart M, Lienhart W	Institute of Engineering Geodesy and Measurement Systems	4
Hydraulic Engineering	L	GHE	Zenz G, Shahriari S	Institute of Hydraulic Engineering and Water Resources Management	4
Hydraulics 1	L	GHE	Zenz G	Institute of Hydraulic Engineering and Water Resources Management	1.5
Hydraulics 1	SE	GHE	Knoblauch H	Institute of Hydraulic Engineering and Water Resources Management	1.5
Petrology	PE	GHE	Hippler D, Klammer D	Institute of Applied Geosciences	1
Petrology	L	GHE	Hippler D, Klammer D	Institute of Applied Geosciences	1.5
Rock Mechanics and Tunnelling	L	GHE	Pötsch M, Schubert W	Institute of Rock Mechanics and Tunnelling	4
Soil Mechanics and Foundation Engineeering	L	GHE	Ausweger G, Marte R, Pichler P, Schweiger H	Institute of Soil Mechanics and Foundation Engineering	4
Elective courses (selected)					
Hydraulic Engineering					
Field Excursion Hydraulic Engineering	P	GHE	Schneider J, Hammer A, Shahriari S, Staudacher E	Institute of Hydraulic Engineering and Water Resources Management	1.5
Fundamentals of Grouting	L	GHE	Kieffer D, Marte R	Institute of Applied Geosciences	3
Geotechnical Earthquake Engineering	L	GHE	Kieffer D, Lee H	Institute of Applied Geosciences	3
Hydraulics 2	L	GHE	Zenz G, Knoblauch H	Institute of Hydraulic Engineering and Water Resources Management	6
Hydrology	L	GHE	Muschalla D, Krall E	Institute of Urban Water Management and Landscape Water Engineering	3
Management of Risks and Disasters	L	GHE	Hammer A	Institute of Hydraulic Engineering and Water Resources Management	4
Master Project Hydraulic Engineering	SE	GHE	Knoblauch H, Schneider J, Hammer A, Shahriari S, Staudacher E	Institute of Hydraulic Engineering and Water Resources Management	5
Project Planning and Supervision of Hydraulic Structures	L	GHE	Zenz G, Hammer A	Institute of Hydraulic Engineering and Water Resources Management	5

River and Sediment Hydraulics	L	GHE	Knoblauch H, Schneider J	Institute of Hydraulic Engineering and Water Resources Management	3
Seismic Evaluation of Water Retention Structures	L	GHE	Zenz G, Shahriari S	Institute of Hydraulic Engineering and Water Resources Management	3
Testing Technology and Laboratory Tutorial in Hydraulics	P	GHE	Schneider J, Shahriari S	Institute of Hydraulic Engineering and Water Resources Management	4
Advanced Hydraulics	L	GHE	Zenz G	Institute of Hydraulic Engineering and Water Resources Management	3
Design and Construction of Headrace Tunnels	L	GHE	Vigl A	Institute of Hydraulic Engineering and Water Resources Management	3
Design of Hydraulic Steel Structures	L	GHE	Lechner A	Institute of Hydraulic Engineering and Water Resources Management	3
Field Excursion Geotechnics and Hydraulic Engineering	P	GHE	Buyer A, Marcher T, Marte R, Oberhollenzer S, Pikl F, Zenz G	Institute of Hydraulic Engineering and Water Resources Management	2
Hydrochemistry	L	GHE	Dietzel M	Institute of Hydraulic Engineering and Water Resources Management	3
Landscaping in Hydraulic Engineering	L	GHE	Schneider J	Institute of Hydraulic Engineering and Water Resources Management	4.5
Landscaping in Hydraulic Engineering	L	GHE	Hornich R, Schneider J	Institute of Hydraulic Engineering and Water Resources Management	3
Numerics in Hydraulic Engineering	L	GHE	Dorfmann C, Shahriari S	Institute of Hydraulic Engineering and Water Resources Management	3
Water Resources Management	L	GHE	Hammer A	Institute of Hydraulic Engineering and Water Resources Management	4

EX...Excursion; L...Lecture; LU... Laboratory Exercises; P/PE...Practical Exercises; SE...Seminar;

2.1.5 Civil Engineering (CE), Vienna University of Technology (TU Wien)

The master's degree programme in “Civil Engineering” of Vienna University of Technology (TU Wien, 2013) provides students with an in-depth education in engineering, focussing on the field of civil engineering and its application. The degree programme reflects the principle of research-led teaching. In the scope of the master's degree programme attention is given to an interdisciplinary education supporting technical engineering, cognitive and practical as well as social and innovative competencies.

Occupational fields

Graduates of the master’s degree programme “Civil Engineering” are prepared for employments in the following fields of activities:

- Structural engineering
- Geotechnics
- Construction management
- Traffic and mobility
- Water & resources

Scope and classification

In the scope of this master’s degree programme courses in the extent of 120 ECTS have to be taken. The courses are subdivided into the following classification:

- Compulsory courses: 52 ECTS
- Master thesis: 30 ECTS
- Elective courses: 21 ECTS
- Project: 8 ECTS
- Free elective courses (+soft skills): 9 ECTS

Within the scope of compulsory courses two out of six subjects (Structural Engineering I, Structural Engineering II, Geotechnics, Soil Mechanics, Construction Management, Traffic and Mobility, Water and Resources) have to be selected. The subject of Geotechnics, including courses related to water resource management, is depicted in Table 5.

Table 5: Courses of the master's degree programme "Civil Engineering"

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Compulsory courses (selected)					
Water and Resources					
Engineering Hydrology 2	L	CE	Blöschl G, Viglione A, Parajka J	Institute of Hydraulic Engineering and Water Resources Management	2.5
Water and River basin management	L	CE	Blaschke A, Zessner-Spitzenberg M	Institute of Water Quality and Resource Management	3
Wastewater Treatment	L	CE	Krampe J, Svardal K	Institute of Hydraulic Engineering and Water Resources Management	2.5
Resource Management	L	CE	Rechberger H, Fellner J, Cencic O, Roithner C	Institute of Water Quality and Resource Management	2
Waste Management and waste disposal systems	L	CE	Rechberger H, Fellner J, Scharff C, Ableidinger M, Dworak S	Institute of Water Quality and Resource Management	2
Hydraulic engineering 2	L	CE	Prenner R	Institute of Hydraulic Engineering and Water Resources Management	4

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Elective courses (selected)					
Hydraulic engineering 3	L	CE	Krouzecky N	Institute of Hydraulic Engineering and Water Resources Management	3.5
Dams	L	CE	Linsbauer H	Institute of Hydraulic Engineering and Water Resources Management	2
Hydraulic steelworks	L	CE	Prenner R	Institute of Hydraulic Engineering and Water Resources Management	2
River transport engineering	L	CE	Krouzecky N	Institute of Hydraulic Engineering and Water Resources Management	2
Scale models in hydraulic engineering	L	CE	Krouzecky N, Huber B	Institute of Hydraulic Engineering and Water Resources Management	2
Groundwater resources and modelling	L	CE	Blaschke A, Derx J	Institute of Hydraulic Engineering and Water Resources Management	4
Water and River basin management	LU	CE	Blaschke A, Zessner-Spitzenberg M	Institute of Water Quality and Resource Management	3

Hydrometry	L	CE	Parajka J, Komma J	Institute of Hydraulic Engineering and Water Resources Management	2
Biology and Chemistry of Water Quality Management	L	CE	Kreuzinger N, Sardal K	Institute of Water Quality and Resource Management	3
Laboratory Tutorial Wastewater Treatment	LU	CE	Krampe J, Svardal K, Saracevic E, Fuiko R, Winkelbauer A	Institute of Water Quality and Resource Management	2.5
Storm Water Treatment and Pollution Simulation	L	CE	Lehmann T	Institute of Water Quality and Resource Management	2.5
Drinking Water Treatment	L	CE	Kreuzinger N, Werderitsch M	Institute of Water Quality and Resource Management	2
Environmental Assessment	L	CE	Rechberger H, Cencic O, Döberl G, Spacek S	Institute of Water Quality and Resource Management	3
Project Work Water and Resources - Hydraulic Engineering	P	CE	Blanckaert K, Krouzecky N, Huber B	Institute of Hydraulic Engineering and Water Resources Management	6
Project Work Water and Resources - Water Quality Management	P	CE	Krampe J, Zessner-Spitzenberg M, Svardal K, Kreuzinger N	Institute of Water Quality and Resource Management	6

EX...Excursion; L...Lecture; LU... Laboratory Exercises; P/PE...Practical Exercises; SE...Seminar;

2.1.6 Environmental Engineering (EE), University of Innsbruck (UIBK)

The master's degree programme in "Environmental Engineering" established at University of Innsbruck provides students with an in-depth education in engineering, focusing on the field of civil engineering including residential water management, resource management, waste and disposal technology, spatial and environmental planning, traffic planning, traffic technology and traffic route engineering, geoinformatics and remote sensing, technical equipment in buildings, hydrology and hydraulic engineering, energy and ecoinformatics, environmental and process engineering. As a result, graduates are able to correctly apply their highly specialized knowledge, drawing on the latest findings from various areas of environmental engineering, to develop and implement innovative solutions and to engage in discourse with colleagues. Graduates possess the competence and critical awareness to independently realize socially and environmentally sustainable projects (UIBK, 2019).

Occupational fields

Graduates of the master's degree programme "Environmental Engineering" are prepared for employments in the following fields of activities:

- Water management
- Resource and waste management
- Traffic and mobility
- Geoinformatics
- Environmental and process engineering

Scope and classification

In the scope of this master's degree programme courses in the extent of 120 ECTS have to be taken. The courses are subdivided into the following classification:

- Compulsory courses: 10 ECTS
- Master thesis: 27.5 ECTS
- Elective courses: 82.5 ECTS

Within the scope of elective courses one out of three subjects (EEG – Energy-Efficient Buildings, GVW – Geotechnics, Survey and Hydraulic Engineering, UVW – Environmental Engineering and Traps) has to be selected. The subject of Geotechnics, Survey and Hydraulic Engineering, including courses related to water resources management, is depicted in Table 6.

Table 6: Courses of the master's degree programme "Environmental Engineering"

Title	Type	Master curriculum	Lecturer	Organisation	ECTS credits
Elective courses (selected)					
Geotechnical Earthquake Engineering					
Digital Terrain Models and Remote Sensing Data	L	EE	Hanke K	Institute for Basic Sciences in Engineering Science	2.5
Geoinformation Systems	L	EE	Weinold T	Institute for Basic Sciences in Engineering Science	2.5
Computational Fluid Dynamics	L	EE	Klar R	Institute for Infrastructure	2.5
Dynamic Hydraulics	L	EE	Achleitner S	Institute for Infrastructure	2.5
Dams	L	EE	Aufleger M, Lopez Reyes D C	Institute for Infrastructure	2.5
Rock and Tunnel Mechanics	L	EE	Cordes T	Institute for Infrastructure	2.5
Satellite-Based Positioning	L	EE	Weinold T	Institute for Basic Sciences in Engineering Science	2.5
Surface Detection with Terrestrial Laser Scanners	L	EE	Weinold T	Institute for Basic Sciences in Engineering Science	2.5
Sediment Transport in Rivers	L	EE	Gems B	Institute for Infrastructure	2.5
Engineering Hydrology	L	EE	Achleitner S	Institute for Infrastructure	2.5
Deformation Monitoring and Measurement	L	EE	Gamse S	Institute for Basic Sciences in Engineering Science	2.5
Surveying for Tunneling	L	EE	Gamse S	Institute for Basic Sciences in Engineering Science	2.5
Hydro Power Plants	L	EE	Aufleger M, Tutzer R	Institute for Infrastructure	2.5
Planning Law and Case Studies in Hydraulic Engineering	L	EE	Achleitner S, Egenbauer J, Reindl R	Institute for Infrastructure	2.5
River Engineering and Dams	L	EE	Aufleger M, Lindermuth A	Institute for Infrastructure	2.5
Torrent Science and Protection Technology in the Alpine Region	L	EE	Gems B, Gebhard W	Institute for Infrastructure	2.5
Ice, Snow and Avalanche Mechanics	L	EE	Fellin W	Institute for Infrastructure	2.5
Geotechnical Engineering and Natural Hazards	L	EE	Hofmann R	Institute for Infrastructure	2.5
Sediment Management	L	EE	Achleitner S	Institute for Infrastructure	2.5

EX...Excursion; L...Lecture; LU... Laboratory Exercises; P/PE...Practical Exercises; SE...Seminar;

2.2 Bulgaria

2.2.1 Overview

Bulgaria has more than 70 year tradition of education in master programmes in the field of Water Engineering. The University of Architecture, Civil Engineering and Geodesy (UACEG) was the only HEI in Bulgaria offering such programmes from 1942 until 2001. There are three traditional integrated master programmes (duration of 5 years) – "Irrigation and Drainage Engineering" (IDE), "Hydraulic Engineering" (HE) and "Water Supply and Sewerage" (WSS). These three study programmes are focused on four major branches of the Water sector in Bulgaria, namely *Irrigation*, *Protection against Harmful Effects of Water*, *Hydropower production* and *Water Supply and Sewerage*. Due to different reasons in 2018 the 5-years master study programmes in IDE and HE were joined in one programme – Water Engineering, which has two elective modules after the 2nd year – IDE and HE. Practically all specialists in WRM in Bulgaria were graduated either in IDE or HE. However, some of WRM professionals in the country were graduated in WSS study programme, but their knowledge in WRM was obtained mainly during PhD study, and the number of such specialists is limited.

The traditional for Bulgaria master programmes related to Water sector (and WRM) deal with research, design, maintenance and operation of the systems and structures in respective branches. Water resources management (WRM) as a subject is related to research and operation. It is present as a separate course in the curricula only for IDE programme, while it is part of the specific courses for other two programmes.

Since 2006 in UACEG are offered short (2-year long) master programmes in above mentioned three traditional specialities, as well as a short master programme in "Water Resources Management". In 2001 Varna Free University "Chernorizets Hrabar" launched an education in a short (2-year) master programme WSS. It is offered both as a full time and as a part-time study and it is upgrade to a bachelor degree programme with the same name.

Aside from engineering programmes, a short (1.5 years-long) master programme in "Climate Change and Water Management" (CCWM) is offered by Sofia University "St. Kliment Ohridski". It is also relatively new programme, launched after 2000. The main focus is on non-engineering subjects.

The short cycle master degree programmes related to water resource management available in Bulgarian universities are summarized in Table 7.

Table 7: Relevant master´s programs in Bulgaria

Master´s programme	Academic degree	University
Water Resources Management (WRM)	MSc	University of Architecture, Civil Engineering and Geodesy, Sofia
Irrigation and Drainage Engineering (IDE)	MSc	University of Architecture, Civil Engineering and Geodesy, Sofia
Hydraulic Engineering (HE)	MSc	University of Architecture, Civil Engineering and Geodesy, Sofia
Water Supply and Sewerage (WSS)	MSc	University of Architecture, Civil Engineering and Geodesy, Sofia
Water Supply and Sewerage (WSS)	MSc	Varna Free University "Chernorizets Hrabar"
Climate Change and Water Management	MSc	Sofia University "St. Kliment Ohridski"

ECTS converted for Bulgaria provides 1 credit to be assigned for each 25 to 30 hours of total student occupation/engagement. The total engagement includes classes in auditorium (lectures, exercises, laboratory exercises, development of course projects) and self-preparation work (work at home for solving tasks, project development, writing reports, studying, preparation for exam or defence of a course project). The auditorium engagements should not exceed time for self-preparation. Practices and Field trainings are considered as self-preparation work; the same is valid for development of the diploma thesis.

Different universities adopted different approach. All courses in UACEG have almost equal shares of student occupation as lectures/exercises and as self-preparation. In Varna Free University the self-preparation time is twice bigger than time for lectures/exercises. The approach for credit allocation/assignment of Sofia University is very similar to those of Varna Free University, considering compulsory courses. Considering the elective courses, the approach is like those used by UACEG – equal shares of self-preparation work and time for lectures/exercises.

It has to be noted that in Bulgaria exist State requirements for education in regulated profession "Engineer in the Investment Design". The requirements set minimum academic hours of lectures and exercises/project development for a list of subjects (courses) related to different specialities. In the area of Water engineering, related with WRM, these specialities are: "Irrigation and Drainage Engineering", "Hydraulic Engineering" and "Water Supply and Sewerage". If a student graduates in one of these master programmes and they fulfil the requirements, the graduate can apply for membership in a *Chamber of Engineers in the Investment Design*, thus he or she can obtain "limited designer's rights" immediately and later on to be granted with "full designer's rights". It will allow the engineer to develop independently design projects in the specified area – the same as the one pointed in his/her diploma. The above-mentioned State requirements imply quite "rigid" curriculum for the traditional master programmes in UACEG. It is important to note also that requirements deal with *academic hours*, not with ECTS.

2.2.2 Water Resources Management (WRM) at UACEG

This short (2-year) master programme aims to provide knowledge in all four branches of Water sector in Bulgaria - *Water Supply and Sewerage*, *Irrigation*, *Hydropower production* and *Protection against Harmful Effects of Water*. The structure, function and operation of different systems is well presented. The water treatment technologies, together with more profound knowledge on chemistry of water and hydrobiology are included. Graduates have reach information on almost all aspects of engineering systems, structures and facilities related to water, which is a base for adequate planning and managing of the water resources.

The prerequisite for enrolling a student in that speciality (study programme) is the candidate to have BSc or MSc degree in the field of Technical Sciences. The last amendment of the study programme in 2018 came together with a change of enrolment prerequisites – now it is also acceptable if the candidate has BSc or MSc degree in the field of Economics and Earth Sciences.

The study program is paid, i.e. the student cannot use standard state funding. According to Bulgarian *Higher Education Act* it is not allowed to demand state funding for students in a short master degree programme if there is no bachelor degree programme in the same speciality.

Occupational fields

The master degree programme has the main aim to prepare professionals for Bulgarian River Basin Management Directorates, but the graduates can be employed in Ministry of Environment and Water, as well as in operating companies such as regional "Water Supply and Sewerage" utilities, "Dams and Cascades" JSC, and "Irrigation Systems" JSC.

Graduates of the master degree programme "Water Resources Management" are prepared for employment in the following fields of activities:

- Water management
- Waste management
- Risk management

Guiding Principle

The main guiding principle is the same as the one used in BOKU, Austria, namely "3-pillar-principle". Almost the same scientific areas are concerned:

- Engineering sciences
- Natural sciences
- Economic and legal sciences

Emphasis is placed on engineering sciences, which have share of approx. 70% (incl. diploma thesis credits). This is mainly because of the accredited professional field of education of UACEG – 5. Technical Sciences; 5.7. Architecture, Civil Engineering and Geodesy. In contrast to other master programmes in UACEG, the share of natural sciences is relatively high – 26% (estimated taking into account the credits for diploma thesis).

Using different criteria, the subjects included can be separated into following groups:

1. Basic Subjects: Engineering Hydrology; Hydraulics; Chemistry of Water; Organic Chemistry, Biochemistry and Water Microbiology; Hydrobiology;
2. Special Water Engineering Subjects: Hydraulic Structures; Irrigation and Drainage Systems and Structures; Water Supply Systems and Structures; Sewerage Networks and Facilities, Coastal engineering; Practical Training: Introduction to Water Engineering Systems
3. Water Resources Subjects: Water Resources Management, Water Resources Planning,
4. Modelling: Hydroinformatics, Water distribution modelling, Hydrological Modelling, Practical Training in "Computational Methods in Hydraulics"
5. Environment Protection Subjects: Soil - specifics and regeneration; Water Treatment; Ecology and Environment Protection;
6. Legal and Economic Subjects: Legal and Regulatory Framework in Water Engineering, Economics of Water Sector.

Scope and classification

The academic curriculum of WRM study program includes 3 semesters with lectures, seminars and projects development and 1 semester for development of a diploma thesis. According to *Higher*

Education Act and related by-laws there are 120 ECTS gained from all subjects in the curriculum. The courses are subdivided into the following classification:

- Compulsory courses: 90 ECTS
- Master thesis: 30 ECTS
- Elective courses: N/A
- Free elective courses: 7 ECTS

Detailed list of the courses included in the curriculum is given in Table 8.

Table 8: Courses of the master degree programme "Water Resources Management"

Title	Type	ECTS	Organisation
Compulsory Courses			
Engineering Hydrology	L + PA	4 + 3	Faculty of Hydraulic Engineering (FHE)
Chemistry of Water	L	3	FHE
Hydraulics	L + PA	4 + 3	FHE
Organic Chemistry, Biochemistry and Water Microbiology	L + LE	3	FHE
Legal and Regulatory Framework in Water Engineering	L	2	FHE
Soils - specifics and restoration	L + PA	2 + 2	FHE
Hydrobiology	L + SE	3	Guest Lecturer - Sofia University, Faculty of Biology
Water and Wastewater Treatment	L + PA	4 + 3	FHE
Hydraulic Systems and Structures	L + PA	4 + 2	FHE
Irrigation and Drainage Systems and Structures	L + PA	4 + 2	FHE
Water Supply Systems and Structures	L + PA	3 + 2	FHE
Sewerage Networks and Facilities	L + PA	3 + 2	FHE
Water Resources Planning	L + PA	2 + 2	FHE
Ecology and Environment Protection	L + SE	3	FHE
Hydroinformatics	L + SE	3	FHE
Water distribution modelling	L + PA	2 + 2	FHE
Economics of Water Sector	L + SE	3	Faculty of Structural Engineering
Water Resources Management	L + PA	2 + 2	FHE
Hidrological Modeling	L + SE	3	FHE
Coastal engineering	L + SE	3	FHE
PRACTICES			
Practical Training: Introduction to Water Engineering Systems	P	1	FHE
Practical Training in "Computational Methods in Hydraulics"	P	1	FHE
Field Training	P	1	FHE
Pre-Diploma Field Training	P	2	FHE
Free Elective Courses			

Finite Element Method	L	1	Faculty of Structural Engineering
Mathematical Statistics	L	1	Faculty of Transportation Engineering
Management and Multipurpose Use of Water Resources	L	1	FHE
GIS using Open Source Software	SE	1	Faculty of Geodesy
Artificial Neural Networks in Construction	L	1	FHE
Applied Informatics in Water Sector	L + SE	2	FHE

Legend: L – Lectures; LE – Laboratory Exercises; SE – Seminars; PA – Project Assignment; P - Practice

Currently changes in curriculum contents and length of study are discussed. It is planned to shorten the study duration from 4 to 3 semesters. The diploma thesis will be developed in 3rd semester and some of the courses will be reduced as contents and ECTS assigned.

2.2.3 Irrigation and Drainage Engineering (IDE) at UACEG

This short (2-year) master programme is dedicated for students already having BSc or MSc degree in the field of Technical Sciences. The emphasis is on two of the branches of Water Sector – *Irrigation* and *Protection against Harmful Effects of Water* (field drainage, local drainages, flood protection, river training, and soil reclamation). The programme curriculum includes also courses related to WSS and Hydropower generation branches. Graduates have profound knowledge on research, planning, design, operation and maintenance of irrigation systems and schemes, as well as on flood protection systems and structures.

The prerequisites for enrolling a student in that speciality (study programme) are the candidate to have BSc or MSc degree in the field of Technical Sciences. The study program is paid, i.e. the student cannot use standard state funding, because there is no bachelor degree programme for this speciality. There was an integrated master programme (5-years duration) at UACEG till 2017, which was joined with Hydraulic Engineering in 2018.

Occupational fields

Graduates of the master degree programme "Irrigation and Drainage Engineering" are prepared for employment in the following fields of activities:

- Research, design, operation and maintenance of irrigation systems, schemes and structures, incl. embankment dams
- Research, design, operation and maintenance of drainage systems and structures, incl. river trainings
- Water management
- Risk management
- Soil protection and reclamation, anti-erosion measures

Guiding Principle

The main guiding principle is the same as the one used in BOKU, Austria, namely "3-pillar-principle". Almost the same scientific areas are concerned:

- Engineering sciences
- Natural sciences
- Economic and legal sciences

Emphasis is placed on engineering sciences, which have share of approx. 83% (incl. diploma thesis). This is related with the requirements of the Bulgarian state (and the Chamber of Engineers in Investment Planning) for the authorized designers in the field of irrigation and drainage engineering. The huge difference between WRM study programme and the rest of master programmes offered by UACEG, incl. IDE, is that the share of Economic and Legal sciences for other programmes is very small (just above 2%). Since the IDE programme is dedicated to students which already have BSc or MSc in other technical science speciality it is supposed that a general knowledge in Economic and Legal sciences is already obtained.

Scope and classification

The academic curriculum of IDE study program includes 3 semesters with lectures, seminars and projects development and 1 semester for development of a diploma thesis. According to *Higher Education Act* and related by-laws there are 120 ECTS gained from all subjects in the curriculum. The courses are subdivided into the following classification:

- Compulsory courses: 81 ECTS
- Master thesis: 30 ECTS
- Elective courses: as modules 9 ECTS
- Free elective courses: 13 ECTS

The courses included in curriculum and their academic hours are coherent with the requirements of the Bulgarian state set for "Engineer in the Investment Design".

The study programme has two modules – Irrigation Systems and Drainage Systems. The modules are elective, but the courses included in each module come together as a package. Once the module is selected, all provided courses in that module become compulsory.

Water resources planning is included as a separate course. There are topics dedicated to that matter and WRM in courses "Water Power Use" and "Exploitation of I&D Systems…", as well as in "Optimization of Irrigation Systems".

Detailed list of the courses included in the curriculum is given in Table 9.

Table 9: Courses of the master degree programme "Irrigation and Drainage Engineering"

Title	Type	ECTS	Organisation
Compulsory Courses			
Engineering Hydrology	L + PA	3 + 2	Faculty of Hydraulic Engineering (FHE)
Meliorative Soil Science	L + SE	5	FHE
Hydraulics	L + PA	3 + 2	FHE
Economics of Irrigation and Drainage Construction	L + SE	2	Faculty of Structural Engineering

Water Resources Planning	L + SE	3	FHE
Irrigation Systems and Structures	L + PA	5 + 4	FHE
Hydraulic Structures	L + PA	4 + 3	FHE
Landscape Irrigation and Drainage	L + PA	1+1	FHE
Agromelioration	L + SE	2	FHE
Drainage Systems and Structures, River Trainings	L + PA	3 + 2	FHE
Pumping Stations for Irrigation and Drainage Systems	L + PA	3 + 2	FHE
Exploitation of Irrigation and Drainage Systems and Environment Protection	L + PA	5 + 4	FHE
Organization and Management of Irrigation and Drainage Construction	L + PA	3 + 3	Faculty of Structural Engineering
Water Power Use	L + PA	2 + 1	FHE
Water Supply and Sewerage	L + PA	2 + 1	FHE
Hydroinformatics	L + SE	2	FHE
Module: Irrigation Systems			
Automation and Modernization of Irrigation and Drainage Systems	L + SE	3	FHE
Optimization of Irrigation Systems	L + SE	3	FHE
Embankment Dams	L + SE	3	FHE
Module: Drainage Systems			
Drainage Systems and River Corrections Special Issues	L + PA	4 + 3	FHE
Optimization of Drainage Systems	L + SE	2	FHE
PRACTICES			
Practical Training in Meliorative Soil Science	P	1	FHE
Practical Training: Introduction to I&D Systems	P	1	FHE
Practical Training in "Computational Methods in Hydraulics"	P	1	FHE
Field Training	P	2	FHE
Pre-Diploma Field Training	P	3	
Free Elective Courses			
Finite Element Method	L	1	Faculty of Structural Engineering
Mathematical Statistics	L	1	Faculty of Transportation Engineering (FTE)
Management and Multipurpose Use of Water Resources	L	1	FHE
GIS using Open Source Software	SE	1	Faculty of Geodesy
Artificial Neural Networks in Construction	L	1	FHE
Geoinformatics	L + SE	2	FTE
Computer Technologies in Geotechnical Design	L	1	FTE
Real Estate Valuation	L + SE	2	Faculty of Geodesy
Free elective practical training in Real Estate Valuation	P	1	Faculty of Geodesy
Applied Informatics in Water Sector	L + SE	2	FHE

Legend: L – Lectures; LE – Laboratory Exercises; SE – Seminars; PA – Project Assignment; P - Practice

2.2.4 Hydraulic Engineering (HE) at UACEG

This short (2-year) master programme is dedicated for students already having BSc or MSc degree in the field of Technical Sciences. The emphasis is on two of the branches of Water Sector – *Hydropower production* and *Protection against Harmful Effects of Water* (coast-protective structures, river training, and soil reclamation). The programme curriculum includes also courses related to IDE and WSS branches. Graduates have profound knowledge on research, planning, design, operation and maintenance of hydropower systems and structures, especially construction of dams, as well as on flood protection systems and structures.

The prerequisites for enrolling a student in that speciality (study programme) are the same as for IDE. The study program is also paid. There was an integrated master programme (5-years duration) at UACEG till 2017, which was joined with Irrigation and Drainage Engineering in 2018.

Occupational fields

Graduates of the master degree programme "Hydraulic Engineering" are prepared for employment in the following fields of activities:

- Research, design, operation and maintenance of hydropower production systems and structures, incl. underground construction (tunnels), Hydroelectric Power Plants, etc.
- Research, design and maintenance of hydraulic structures, especially all kinds of dams, port and cost protective structures and river trainings
- Research, design, maintenance and operation of industrial waste (tailing dams and slag dumps).
- Water management
- Risk management

Guiding Principle

The main guiding principle is the same as the one used for IDE master programme. The curriculum is in accordance with the requirements of the Bulgarian state for the education of authorized designers in the field of hydraulic engineering. The engineering sciences have share of approx. 86% (incl. diploma thesis credits).

Scope and classification

The academic curriculum includes 3 semesters with lectures, seminars and projects development and 1 semester for development of a diploma thesis. There are 120 ECTS gained from all subjects in the curriculum. The courses are subdivided into the following classification:

- Compulsory courses: 79 ECTS
- Master thesis: 30 ECTS
- Elective courses: as modules 11 ECTS
- Free elective courses: 13 ECTS

The courses included in curriculum and their academic hours are coherent with the requirements of the Bulgarian state set for "Engineer in the Investment Design".

The study programme has two modules – Hydropower Systems and Structures and Hydraulic Structures. The modules are elective, but the courses included in each module come together as a package. Once the module is selected, all provided courses in that module become compulsory. Water resources planning is included as several topics in the course "Hydropower Systems and Facilities", as well as in "Irrigation and Drainage Systems and Pumping Stations".

Detailed list of the courses included in the curriculum is given in Table 10.

Table 10: Courses of the master degree programme "Hydraulic Engineering"

Title	Type	ECTS	Organisation
Compulsory Courses			
Engineering Hydrology	L + SE	6	Faculty of Hydraulic Engineering (FHE)
Hydraulics	L + PA	4 + 2	FHE
Fundamentals of Fluid Mechanics	L + SE	2	FHE
Marine Hydrodynamics	L + SE	2	FHE
Irrigation and Drainage Systems and Pumping Stations	L + PA	2 + 1	FHE
River Morphology and River Training works	L + PA	2 + 1	FHE
Water Supply and Sewerage	L + PA	2 + 1	FHE
Economics of Hydrotechnical Construction	L + SE	2	Faculty of Structural Engineering
Ports and Coast-Protective Structures	L + PA	2 + 2	FHE
Hydropower Systems and Facilities	L + PA	6 + 4	FHE
Hydraulic Structures	L + PA	6 + 4	FHE
Hydraulic Tunnels	L + PA	4 + 2	FHE
Organization and Management of Hydrotechnical Construction	L + PA	3 + 2	Faculty of Structural Engineering
Hydroinformatics in Hydraulic Construction	L + SE	3	FHE
Ecology and Environment Protection	L + PA	2 + 1	FHE
Exploitation of Hydraulic Engineering Structures	L + PA	3 + 1	FHE
Module: Hydropower Systems and Structures			
Hydropower Plants and Pumped-Storage Power Plants	L + PA	4 + 1	FHE
Underground Hydraulic Construction	L + PA	2 + 2	FHE
Hydraulic pumps and motors	L + SE	2	FHE
Module: Hydraulic Structures			
Tailings Dams, Slag Dumps and Hydraulic Transport	L + PA	2 + 2	FHE
High Dams	L + PA	4 + 1	FHE
Dynamics and Stability of Hydraulic Structures	L + SE	2	Faculty of Structural Engineering
PRACTICES			
Practical Training in Meliorative Soil Science	P	1	FHE
Practical Training: Introduction to I&D Systems	P	1	FHE
Practical Training in "Computational Methods in Hydraulics"	P	1	FHE
Field Training	P	2	FHE

Pre-Diploma Field Training	P	3	FHE
Free Elective Courses			
Finite Element Method	L	1	Faculty of Structural Engineering
Mathematical Statistics	L	1	Faculty of Transportation Engineering (FTE)
Management and Multipurpose Use of Water Resources	L	1	FHE
GIS using Open Source Software	SE	1	Faculty of Geodesy
Artificial Neural Networks in Construction	L	1	FHE
Geoinformatics	L + SE	2	FTE
Computer Technologies in Geotechnical Design	L	1	FTE
Real Estate Valuation	L + SE	2	Faculty of Geodesy
Free elective practical training in Real Estate Valuation	P	1	Faculty of Geodesy
Applied Informatics in Water Sector	L + SE	2	FHE

Legend: L – Lectures; LE – Laboratory Exercises; SE – Seminars; PA – Project Assignment; P - Practice

2.2.5 Water Supply and Sewerage (WSS) at UACEG

This short (2-year) master programme is dedicated for students already having BSc or MSc degree in the field of Technical Sciences. The emphasis is on main branch of Water Sector and includes not only technical courses, but a lot of "technological" ones – Water and Wastewater Treatment, Solid Waste Treatment. The programme curriculum includes only one course related to other branches of Water Sector. Graduates have profound knowledge on research, planning, design, operation and maintenance of water supply and sewerage systems and structures, as well as on various water and wastewater treatment technologies, structures, etc.

The prerequisites for enrolling a student in that speciality (study programme) are the same as for IDE and HE. The study program is also paid. There was an integrated master programme (5-years duration) at UACEG.

Occupational fields

Graduates of the master degree programme "Water Supply and Sewerage" are prepared for employment in the following fields of activities:

- Research, design, operation and maintenance of water supply and sewerage systems and structures, including fire-fighting networks.
- Research, design, operation and maintenance of water and wastewater treatment plants
- Research, design, maintenance and operation of natural gas supply systems
- Research, design, maintenance and operation of solid waste sites
- Water management (with some reservations/limitations)

The aim of this study programme is to prepare highly qualified specialists for design companies, as well as for WSS utilities, for Municipalities and Ministry of Environment and Water.

Guiding Principle

The main guiding principle is the same as the one used for IDE and HE master programmes in UACEG. The curriculum is in accordance with the requirements of the Bulgarian state for the education of authorized designers in the field of WSS engineering.

Scope and classification

The academic curriculum includes 3 semesters with lectures, seminars and projects development and 1 semester for development of a diploma thesis. There are 120 ECTS gained from all subjects in the curriculum. The courses are subdivided into the following classification:

- Compulsory courses: 43 ECTS
- Master thesis: 30 ECTS
- Elective courses: as modules 47 ECTS
- Free elective courses: 15 ECTS

The study programme has two modules – *WSS Networks and Facilities* and *Water and Wastewater Treatment*. The modules are elective, but the courses included in each module come together as a package. Once the module is selected, all provided courses in that module become compulsory.

The courses included in curriculum and their academic hours are coherent with the requirements of the Bulgarian state set for "Engineers in the Investment Design".

In the module *WSS Networks and Facilities* the shares of engineering and natural sciences are approx. 82% and 11% respectively (estimated as diploma thesis is included as course in engineering sciences). For the module *Water and Wastewater Treatment* these shares are 72% and 21% respectively. Relatively bigger share of natural sciences in "*Treatment*" module is easily explained. The difference in two modules implies the need students to be enrolled in one of the modules right from the 1st semester.

Detailed list of the courses included in the curriculum is given in Table 11.

Table 11: Courses of the master degree programme "Water Supply and Sewerage" at UACEG

Title	Type	ECTS	Organisation
Compulsory Courses			
Engineering Hydrology	L + SE	6	Faculty of Hydraulic Engineering (FHE)
Hydraulics	L + PA	4 + 3	FHE
Organization and Management of Water Supply and Sewerage Construction	L + PA	4 + 2	Faculty of Structural Engineering
Economics of Water Supply and Sewerage Construction	L + SE	2	Faculty of Structural Engineering
Hydroinformatics in Water Supply and Sewerage Systems	L + SE	2	FHE

Pumps and Pump Stations	L + PA	3 + 2	FHE
Water Supply and Sewerage of Buildings (Plumbing)	L + PA	4 + 4	FHE
Automation and Exploitation of Water Supply and Sewerage Systems	L	3	FHE
Module: Water Supply Networks and Structures			
Chemistry of Water	L + LE	3	FHE
Ecology and Environment Protection	L	1	FHE
Streets	L + SE	2	Faculty of Transportation Engineering
Natural Water Treatment	L + PA	5 + 2	FHE
Wastewater Treatment	L + PA	5 + 2	FHE
Water Engineering	L + PA	2 + 2	FHE
Water Supply Systems and Structures	L + PA	5 + 5	FHE
Sewerage Networks and Facilities	L + PA	5 + 5	FHE
Gas Supply	L + PA	2 + 1	FHE
Module: Water Treatment			
Chemistry of Water	L + LE	4	FHE
Ecology and Environment Protection	L	3	FHE
Organic Chemistry, Biochemistry and Water Microbiology	L + LE	6	FHE
Solid Waste Treatment	L + PA	2 + 1	FHE
Natural Water Treatment	L + PA	6 + 5	FHE
Municipal and Industrial Waste Water Treatment	L + PA	6 + 5	FHE
Water Supply Systems and Structures	L + PA	2 + 3	FHE
Sewerage Networks and Facilities	L + PA	2 + 2	FHE
PRACTICES			
Practical Training in Introduction to Water Supply and Sewerage Systems	P	1	FHE
Practical Training in "Computational Methods in Hydraulics"	P	1	FHE
Field Training	P	1	FHE
Pre-Diploma Field Training	P	1	FHE
Free Elective Courses			
Finite Element Method	L	1	Faculty of Structural Engineering
Mathematical Statistics	L	1	Faculty of Transportation Engineering
Management and Multipurpose Use of Water Resources	L	1	FHE
GIS using Open Source Software	SE	1	FHE
Artificial Neural Networks in Construction	L	1	FHE
Geoinformatics	L + SE	2	Faculty of Transportation Engineering
Computer Technologies in Geotechnical Design	L	1	Faculty of Transportation Engineering
Real Estate Valuation	L + SE	2	Faculty of Geodesy

Free elective practical training in Real Estate Valuation	P	1	Faculty of Geodesy
Applied Informatics in Water Sector	L + SE	2	FHE
Computer Modelling of Sewerage Networks	SE	1	FHE
Installations in Buildings, Sustainability and Integrated Approach in Design	L + SE	1	FHE

Legend: L – Lectures; LE – Laboratory Exercises; SE – Seminars; PA – Project Assignment; P – Practice

2.2.6 Water Supply and Sewerage (WSS) at Varna Free University "Chernorizets Hrabar"

This master programme has duration of 1.5 years (3 semesters) and it is an upgrade to a bachelor degree programme "Structural Engineering, profile WSS" in Varna Free University.

Occupational fields

Graduates of the master degree programme "Water Supply and Sewerage" are prepared for employment in almost the same areas as the graduates of WSS at UACEG:

- Research, design, operation and maintenance of water supply and sewerage systems and structures, incl. fire-fighting networks.
- Research, design, operation and maintenance of water and wastewater treatment plants
- Water management (with serious reservations/limitations)

Scope and classification

The academic curriculum includes 3 semesters with lectures, seminars and projects development, taking into account that during the 3rd semester a diploma thesis is also developed. There are 90 ECTS gained from all subjects in the curriculum. The courses are subdivided into the following classification:

- Compulsory courses: 61.5 ECTS
- Master thesis: 15 ECTS
- Elective courses: 13.5 ECTS
- Free elective courses: N/A*

* Although stated as *Free Elective Courses*, actually the listed in the next table courses are *Elective*, because students must choose one out of two courses during 2nd semester in order to gain necessary 30 credits for that semester.

The study programme corresponds to module – *WSS Networks and Facilities* of master programme WSS offered by UACEG.

Practices are not included as separate courses/topics in curriculum. In the web site (https://www.vfu.bg/ects-guide/WSS-BG) is stated that "…some courses include practices as part of their study plan", but it is not specified which courses how many hours/ECTS provide for practical training. It is also doubtful if the graduated person can apply for membership in Chamber of Engineers in the Investment Design, because the academic hours and/or group of subjects stated in the deliberated Ordinance *State requirements for higher education in Master degree in regulated profession "Engineer in the Investment Design"* about WSS seem not fulfilled. This is valid also for

required minimum duration of Field Training and Pre-diploma Field Training, which are not listed in the curriculum.

The shares of engineering and natural sciences vary in accordance with the elective courses chosen. The share of engineering sciences can be between 84% and 95%, while the share of Economic and Legal Sciences can vary between 10% and 0 (zero). The share of natural sciences is 5%. It has to be mentioned that Hydrology is not included in any form in the curriculum. Also, no special dedicated courses on modelling, optimization and/or WRM are included.

Detailed list of the courses included in the curriculum is given in Table 12.

Table 12: Courses of the master degree programme "Water Supply and Sewerage" at Varna Free University

Title	Type	ECTS	Total ECTS
Compulsory Courses			
Hydraulics - Special Chapters	L + SE	4,5 + 1,5	6
Pumps and Pump Stations	L + PA	3 + 3	6
Natural Water Treatment	L + SE	4,5 + 1,5	6
Water Supply and Sewerage of Buildings (Plumbing)	L + PA	4,5 + 3	7,5
Water Supply Systems	L + PA	4,5 + 3	7,5
Wastewater Treatment	L + PA	3 + 3	6
Sewerage Systems	L + PA	4,5 + 3	7,5
Water Engineering	L + PA	4,5 + 3	7,5
Exploitation of Water Supply and Sewerage Networks and Structures	L	3	3
Technology and Organization of Water Supply and Sewerage Construction	L + SE	3 + 1,5	4,5
Elective Courses			
Module 1st semester			
Ecology and Environment Protection	L	4,5	4,5
Physicochemistry of Water	L	4,5	
Module 2nd semester			
Electricity supply of Water Supply and Sewerage Facilities	L	4,5	4,5
Project management	L	4,5	4,5
Module F 2nd semester			
Design Software for Water Supply and Sewerage Systems	L	4,5	4,5
Economics of Water Supply and Sewerage Construction	L	4,5	4,5

Legend: L – Lectures; LE – Laboratory Exercises; SE – Seminars; PA – Project Assignment; P – Practice

2.2.7 Climate Change and Water Management (CCWM) at Sofia University "St. Kliment Ohridski"

This master programme has duration of either 1 year or 1.5 years (3 semesters) depending on the preparation of the enrolled student. If he/she has BSc in Earth Sciences (Geography, Geology), Natural Sciences (Geography and Biology, Ecology and Environment Protection) or Social Sciences (Biomanagement and Sustainable Development, Regional Development and Policy, and History and Geography) the student studies in a short (1-year) programme. If the candidate has BSc in a different programme than these mentioned above, he/she goes the "long road" – 3 semesters.

Occupational fields

Graduates of the master degree programme "Climate Change and Water Management" are prepared for employment as:

- Climate change policy experts (development of national strategies, plans and projects, regulations, etc.),
- Environmental protection specialists (air and water quality control),
- Water management specialists (with some limitations),
- Specialists in Use of renewable and environment-friendly resources.

It has to be noted that the graduates do not obtain title "engineer", thus the specialists can only take part in activities different than engineering design. It is also not expected graduates in Climate Change and Water Management to perform works related with operation and maintenance of water engineering systems – e.g. irrigation, water supply, etc.

Scope and classification

Here the 3-semester study programme is presented. The academic curriculum includes lectures and seminars in 3 semesters, taking into account that during the 3rd semester a diploma thesis of 15 ECTS has to be developed. There are 90 ECTS gained from all subjects in the curriculum. The courses are subdivided into the following classification:

- Compulsory courses: 60 ECTS
- Master thesis: 15 ECTS*
- Elective courses: 15 ECTS
- Free elective courses: 6**

*There is possibility to pass State exams instead of developing the diploma thesis. The State exams have to bring at least 15 ECTS.

** There are free elective courses of total 18 ECTS. It is explicitly mentioned that no more than 2 courses (6 ECTS) can be chosen during the study period.

The curriculum contains courses from four types of sciences: engineering, natural, economic & legal and social sciences. The share of different types depends on the chosen elective and free elective courses. The approximate distribution between 4 types of sciences represented through the courses is as follows: Engineering sciences - 12%, Natural Sciences – 73%, Economic & Legal – 12%

and Social – 5%. It should be noted that course "Water Management" is considered as representative of engineering sciences, although the scope of the course it is not known. The same is the case with the course "Hydrology of Cities and Urban Territories", because it requires knowledge in sewerage (urban drainage) and river trainings.

The curriculum does not specify the number, title and ECTS of practices (field trainings). It is questionable if these practices are compulsory or not.

Detailed list of the courses included in the curriculum is given in Table 13.

Table 13: Courses of the master degree programme "Climate Change and Water Management" at Sofia University

Title	Type	ECTS
Compulsory Courses		
General Climatology and Climate of Bulgaria	L + SE	5
General Hydrology and Hydrology of Bulgaria	L + SE	5
General Geomorphology and Geomorphology of Bulgaria	L + SE	5
Geography of the Population and Settlements	L + SE	5
Geography of the World Economy	L + SE	5
Socio-economic Geography of Bulgaria	L + SE	5
Water Management	L + SE	5
Climate Change	L + SE	5
Dangerous and Adverse Meteorological and Hydrological Phenomena	L + SE	5
Hydro-climatic Resources of Bulgaria	L + SE	5
Climate Research Methods	L + SE	5
Methods for River Runoff Research	L + SE	5
Elective Courses		
Global and Regional Water Problems	L + SE	3
Hydrology of Cities and Urban Territories	L + SE	3
Models and Scenarios for Climate Change	L + SE	3
Climate and Economy	L + SE	3
Renewable Energy Resources	L + SE	3
Air and Water Monitoring	L + SE	3
Black Sea	L + SE	3
Hydro-ecological Assessments and Expertises	L + SE	3
Synoptic Analysis and Meteorological Climatology	L + SE	3
Climate Change Policies	L + SE	3
GIS in Hydro-Climate Research	L + SE	3
Free Elective Courses		
Fundamentals of Scientific Research	L + SE	3
Applied Climatology	L + SE	3
Applied Hydrology	L + SE	3
Wetlands Hydrology	L + SE	3

Legal Framework for Air and Water Protection	L + SE	3
Cross-border Waters	L + SE	3

Legend: L – Lectures; SE – Seminars

2.3 Croatia

2.3.1 Overview

In Croatia a few master's degree programmes related to water resource management are available at different HEI that deliver studies of civil engineering (Table 14).

Before enrolment in master level programmes students have to graduate at undergraduate university or vocational studies in civil engineering of 180 ECTS. In case of enrolment of students that graduated at the undergraduate vocational studies some differential courses (one year of courses) is obligatory in order to be permitted to enrol in the university master study programme.

The scheme adopted according to education cycles for university studies in civil engineering is «3+2+3», namely:

3 Three-year Undergraduate Programme
4 Two-year Graduate (Master) Programme
5 Three-year Postgraduate Programme

The scheme adopted according to education cycles for vocational studies in civil engineering is «3+2», namely:

6 Three-year Undergraduate Programme
7 Two-year Specialisation Graduate Programme

All study programmes in civil engineering (with emphasis on water management) on master level (both university and vocational studies) in Croatia are presented in Table 14, but only the university master programmes are explained more in detail in the following chapters.

Table 14: Relevant master´s programs in Croatia

HEI	Master´s programme	Type of programme	Occupational fields/branch/ specialization	Academic degree	Vocational degree	Study Programmes (in English language)	Study Programmes (in Croatian language)
University of Rijeka, Faculty of Civil Engineering	Civil Engineering	University	- **Hydraulic Engineering** - **Urban Engineering** - Transportation engineering - Geotechnical Engineering - Structures - Engineering Modelling of Structures	MSc in CEng	n/a	http://www.gradri.uniri.hr/files/studiji/Academic_Graduate_2018-May.pdf	http://www.gradri.uniri.hr/files/studiji/Diplomski_sveucilisni_2018_studeni.pdf
	Civil Engineering	Specialisation vocational	- **Building in Coastal Region and Infrastructural Engineering**	n/a	Specialist in CEng	n/a Only the old study programme is available in English	http://www.gradri.uniri.hr/files/studiji/Specijalisticki_diplomski_strucni_2018_studeni.pdf
University of Zagreb, Faculty of Civil Engineering	Civil Engineering	University	- **Hydraulic Engineering** - Geotechnical Engineering - Structural Engineering - Construction Materials - Construction Management - Transportation engineering - Theory and Modelling of Structures	MSc in CEng	n/a	http://www.grad.unizg.hr/images/50012216/HANDBOOK2014-english.pdf https://www.grad.unizg.hr/images/50012217/UNIZG_FCE_Course_Catalogue_Master%20Programme.pdf	https://www.grad.unizg.hr/images/50012373/handbook5_18velj.pdf
University of Split, Faculty of Civil Engineering, Architecture and Geodesy	Civil Engineering	University	- **General** - **Hydraulic Engineering** - Modelling of Structures - Structures	MSc in CEng	n/a	http://gradst.unist.hr/Portals/10/docs/Referada/Studies/Opis%20studija%20DSSG.pdf	http://gradst.unist.hr/LinkClick.aspx?fileticket=OvZcJQgS_JM%3d&tabid=789&portalid=9&mid=6685

HEI	Master´s programme	Type of programme	Occupational fields/branch/ specialization	Academic degree	Vocational degree	Study Programmes (in English language)	Study Programmes (in Croatian language)
Josip Juraj Strossmayer University in Osijek, Faculty of Civil Engineering and Architecture	Civil Engineering	University	- **Hydraulic Engineering** - Supporting structures - Construction Management and technology	MSc in CEng	n/a	http://www.gfos.unios.hr/app/storage/protected/studijski-program-diplomski-studij-hidrotehnika-en.pdf (old programme from 2005)	http://www.gfos.unios.hr/app/storage/protected/studijski-program-diplomski-studij-hidrotehnika-hr.pdf
	Civil Engineering	Specialisation vocational	- Construction management, supervision and maintenance of structures (the programme includes courses on construction and maintenance of hydraulic structures)	n/a	Specialist in CEng	http://www.gfos.unios.hr/app/storage/protected/specialist-profesional-graduate-study.pdf	http://www.gfos.unios.hr/app/storage/protected/specijalisticki-diploski-strucni-studij-studijski-program.pdf
Zagreb University of applied sciences – Civil Engineering department	Civil Engineering	Specialisation vocational	- **Civil and Environmental Engineering** - Engineering Management and Entrepreneurship - Civil and Construction Engineering - Civil Engineering & Building Construction	n/a	Specialist in CEng	http://bartolomeo.tvz.hr/mojtvz/razno/specgra11819eng_npp.pdf	http://bartolomeo.tvz.hr/mojtvz/razno/specgra11819hrv_npp.pdf

7.1.1 Civil Engineering - University of Rijeka, Faculty of Civil Engineering

The Faculty of Civil Engineering of the University of Rijeka offers two study programmes on master level:

1 University master study programme (also called Academic graduate programme) in civil engineering (120 ECTS), that is explained in detail in the following text,
2 Specialisation vocational graduate study programme in civil engineering (120 ECTS), that will not be explained in detail.

In the University master study programme in civil engineering students can enrol in one of 5 different branches / **occupational fields**:

3 **Hydraulic Engineering**
4 **Urban Engineering**
5 Transportation engineering
6 Geotechnical Engineering
7 Structures
8 Engineering Modelling of Structures

Competences acquired by the student with completion of the study programme:

With completion of the University Master Programme (also called *Academic Graduate Programme*) in Civil Engineering the student acquires the basic competences to understand the general phenomena and problems connected with civil engineering and particularly with a specific branch of civil engineering (Geotechnical Engineering, Hydraulic Engineering, Engineering Modelling, Structures, Transportation Engineering and the interdisciplinary area of Urban Engineering).

He is able to apply general knowledge, acquire new knowledge and ideas, and draw conclusions based on science and his profession as well as to develop his scientific and applied scientific-research competences.

He is qualified for the design, construction and maintenance of civil engineering structures and systems in terms of bearing capacity, stability, safety, environmental protection and cost.

With completion of the Graduate Programme, the student is specially qualified for understanding and solving problems in a specific branch of Civil Engineering.

During his studies, the student learns how to prepare and formulate complex civil engineering solutions in written and oral form. At the same time, he develops the ability to communicate his own ideas, analyses and conclusions, connected with specific civil engineering problems, to the professional and non-professional public.

He is able to manage a group of people preparing and executing complex civil engineering projects.

The academic title or degree acquired on completion of the University Master Programme is *Master in Civil Engineering*.

Structure of the study programme (by semesters):

The Master study curriculum consists of compulsory and elective part. The student creates the study program by selecting the modules from a specific civil engineering field. By selecting the modules from the same or two different civil engineering fields the student selects course of studies – the specialization within the civil engineering branch.

In the 1st semester the student enrols into four (4) compulsory courses and two (2) elective ones. The selection of the courses is determined by the selected modules.

The courses organized through modules are attended by the student during the 2nd and the 3rd semester while the 4th semester is dedicated to writing the graduation thesis and, if required, practical teaching classes (Table 15).

Students have to acquire a minimum of 30 ECTS credits per semester.

Table 15: Structure (by semesters) of the University master study programme in civil engineering at the University of Rijeka, Faculty of Civil Engineering

I Semester	II Semester	III Semester	IV Semester
Common graduate study programme: 4 (four) compulsory courses 2 (two) elective courses depending from enrolled module - branch	COMPULSORY COURSES 1. MODUL (Geotechnical Engineering, Hydraulic Engineering, Engineering Modelling of Structures, Structures, Transportation Engineering, Urban Engineering)	COMPULSORY AND ELECTIVE COURSES 2. MODUL (Geotechnical Engineering, Hydraulic Engineering, Engineering Modelling of Structures, Structures, Transportation Engineering, Urban Engineering)	FINAL YEAR PROJECT (15-30 ECTS) FIELD WORK – practical teaching (0-15 ECTS)
30 ECTS	30 ECTS	30 ECTS	30 ECTS

Common part of the study programme (1st SEMESTER, 1st YEAR):

By enrolling into a branch of study the student has to enrol into the elective courses as follows (Table 16):

1 **Hydraulic Engineering:** Computational Hydraulics, Engineering Rock Mechanics
2 **Urban Engineering:** Road Design, Computational Hydraulics or Theoretical Soil Mechanics – depending on the courses that they plan to enrol in the 2nd and 3rd semester
3 Structures / Engineering Modelling of Structures: Concrete and Masonry Structures, Theory of Elasticity
4 Geotechnical Engineering: Theoretical Soil Mechanics, Engineering Rock Mechanics
5 Transportation Engineering: Road Design, Engineering Rock Mechanics

Table 16: Common part of the University master study programme in civil engineering at the University of Rijeka, Faculty of Civil Engineering – 1st SEMESTER, 1st YEAR (L-lessons, E-exercises, S-Seminars)

	Compulsory courses	*Hours of active classes (L+E+S)*	*ECTS*
1.	Probability Theory and Statistics	30+30+0	4
2.	Theory and Technology of Concrete	30+15+15	5
3.	Project Management	30+15+15	5
Elective courses of group I - Student selects one of the following two courses			
4.	Numerical Modelling	30+30+0	6
	Programming in Modelling	30+30+0	6
	Elective courses	*Hours of active classes (L+E+S)*	*ECTS*

1.	Computational Hydraulics	45+15+0	5
2.	Engineering Rock Mechanics	30+30+	5
3.	Road Intersections and Crossroads	20+15+15	5
4.	Concrete and Masonry Structures 1	45+30+0	6
5.	Theory of Elasticity	35+0+10	4
6.	Theoretical Soil Mechanics	40+15+20	6

Course structure by modules (2nd SEMESTER, 1st YEAR and 3rd SEMESTER, 2nd YEAR):

In Table 17 only the course structure by modules for 2nd and 3rd semester for Hydraulic engineering and Urban Engineering branches is presented.

Table 17: Course structure by modules for the University master study programme in civil engineering at the University of Rijeka, Faculty of Civil Engineering – 2nd (Module 1) and 3rd (Module 2) semester, Hydraulic engineering and Urban Engineering branches (L-lessons, E-exercises, S-Seminars)

MODULE – BRANCH: HYDRAULIC ENGINEERING

Hydraulic Engineering Module 1:

	COMPULSORY COURSES	*(L+E+S)*	ECTS
1.	Water Supply and Drinking Water	30+30+0	6
2.	Drainage and Wastewater Treatment	30+30+0	6
3.	Hydraulic Structures	30+30+0	6
	ELECTIVE COURSES		12
	TOTAL		**30**

	ELECTIVE COURSES	*(L+E+S)*	ECTS
1.	Experimental Hydraulics	30+30+0	4
2.	Water Resources Management	30+0+30	4
3.	Karst Hydrosystems	30+0+30	4
4.	Waste Management	30+10+5	4
5.	*Operations Research and Linear Programming **	*30+0+30*	*6*

**Elective courses of other fields (modules)*

Hydraulic Engineering Module 2:

	COMPULSORY COURSES	*(L+E+S)*	ECTS
1.	Engineering Hydrology	30+30+0	6
2.	Hydraulic Regulations and Meliorations	30+30+0	6
3.	Coastal Engineering	30+15+15	6
	ELECTIVE COURSES		12
	TOTAL		**30**

	ELECTIVE COURSES	*(L+E+S)*	ECTS
1.	Hydraulic Modelling	30+30+0	4
2.	Computational Hydrodynamics	30+30+0	4
3.	Water Power Development	30+30+0	4
4.	*Seepage and Consolidation of Soil**	*30+15+15*	*4*
5.	*Underground Structures and Tunnels**	*30+30+0*	*6*
6.	*Slope Stability**	*30+30+0*	*6*
7.	*Geohazards**	*20+10+15*	*4*
8.	*Civil Engineering Regulations**	*30+0+0*	*4*

MODULE – BRANCH: URBAN ENGINEERING – Interdisciplinary module

Urban Engineering Module 1:

	COMPULSORY COURSES	*(L+E+S)*	ECTS
1.	Spatial Planning	40+10+10	5
2.	*Waste Management**	*30+10+5*	4
3.	*Urban Traffic**	*30+30+0*	6
	ELECTIVE COURSES		15
	TOTAL		**30**

Urban Engineering Module 2:

	COMPULSORY COURSES	*(L+E+S)*	ECTS
1.	GIS in Municipal Infrastructure Planning	30+15+15	6
2.	Public Buildings and Spaces	30+0+30	6
3.	Urban Water Systems	30+15+15	6
	ELECTIVE COURSES		12
	TOTAL		**30**

	ELECTIVE COURSES	*(L+E+S)*	ECTS
1.	Management in Civil Engineering	30+0+15	3
2.	Investment Policy	30+15+0	3
3.	*Foundation Engineering***	*30+15+15*	*6*
4.	*Traffic Engineering***	*30+15+15*	*5*
5.	*Traffic Buildings***	*30+30+0*	*5*
6.	*Traffic, Space and Environment ***	*30+0+15*	*3*
7.	*Road Design***	*20+20+10*	*5*
8.	*Water Supply and Drinking Water Treatment***	*30+30+0*	*6*
9.	*Water Resources Management***	*30+0+30*	*4*
10.	*Operations Research and Linear Programming***	*30+0+30*	*6*
11.	*Drainage and Wastewater Treatment***	*30+30+0*	*6*

	ELECTIVE COURSES	*(L+E+S)*	ECTS
1.	Civil Engineering Regulations	30+0+0	4
2.	Building Maintenance	30+15+0	4
3.	*Geotechnical Structures**	30+30+5	6
4.	*Underground Structures and*	*30+30+0*	*6*
5.	*Geohazards***	*20+10+15*	*4*
6.	*Engineering Hydrology**	*30+30+0*	*6*
7.	*Hydraulic Regulations and Meliorations**	*30+30+0*	*6*
8.	*Maintenance and Repair of Roads **	*30+15+05*	*3*
9.	*Flexible Pavement Structures **	*30+30+0*	*6*
10.	*Coastal Engineering*	30+15+15	6

** Compulsory courses of other fields (modules)*

*** Elective courses of other fields (modules)*

Course structure (4th SEMESTER, 2nd YEAR):

In the final (4th) semester students prepare the Final Year Project (Master Thesis), Table 18.

Table 18: : Final Year Project / Master Thesis for University master study programme in civil engineering at the University of Rijeka, Faculty of Civil Engineering

	COURSE	ECTS
1.	FIELD WORK – practical teaching	0-15
2.	**FINAL YEAR PROJECT / MASTER THESIS**	15-30

Students write their master thesis during the semester with the individual cooperation with the mentor. Student load is up 30 ECTS.

Field work - practical teaching can be planned as a part of creating the graduation thesis – final year project. It consists of students collaborating (besides the mentor) with professionals in firms, agencies, laboratories, etc. on topics related to their master thesis. Student load with field work - practical teaching can be up to 15 ECTS credits. In this case the student load in writing their master thesis during the semester with the individual cooperation with the mentor has a load from 15 to 30 ECTS.

5.1.1 Civil Engineering - University of Zagreb, Faculty of Civil Engineering

The Faculty of Civil Engineering of the University of Zagreb offers University master study programme (also called Graduate Programme) in civil engineering (120 ECTS), that is explained in detail in the following text and in Table 19,

In the University master study programme in civil engineering students can enrol in one of 7 different branches / **occupational fields**:

1 Hydraulic Engineering
2 Geotechnical Engineering
3 Structural Engineering
4 Construction Materials
5 Construction Management
6 Transportation engineering
7 Theory and Modelling of Structures

Competences acquired by the student with completion of the study programme:

- Comprehensively understand general phenomena and problems in civil engineering, particularly in their area of specialisation
- Demonstrate a high level of professional knowledge and conduct in civil engineering
- Apply the obtained knowledge and skills to planning, design, construction, supervision and maintenance of complex building structures, interventions and systems in their specialised area with regard to the issues of stability, safety, occupancy, environment protection and costs
- Apply the obtained skills and necessary knowledge in recognizing, formulating and analysing problems and in finding one or more acceptable solutions in their specialized area
- Have an analytic approach to work, based on wider knowledge of science
- Plan, supervise and perform professional, developmental and scientific projects
- Interpret the social aspect as well as the social context of construction projects they are working on
- Manage companies and research institutions and contribute to innovations
- Develop the civil engineering area of his/her specialization, respecting the development of other scientific disciplines
- Explain their ideas and projects to associates
- Find solutions to technical and personal problems in working environment
- Creatively apply obtained knowledge to decision making at high levels
- Work on an international level, taking into account cultural, linguistic, social and economic influences
- Constantly follow innovations and improve their profession
- Accept responsibility for their decisions
- Accept requirements of other professions and be ready to participate in interdisciplinary activities

Structure of the study programme (by semesters) – Hydraulic engineering branch:

Table 19: Structure (by semesters) of the University master study programme in civil engineering at the University of Zagreb, Faculty of Civil Engineering

1st YEAR, 1st SEMESTER

Course			Hours per week		ECTS
			Lectures	*Practice*	
1.	ELECTIVE subjects	Mathematics 3	3	2	7,5
		Stochastic Processes			
2.	Research Methods		1	0	1,5
3.	Hydraulics 1		3	2	7,5
4.	Hydrology 2		2	2	6
5.	River Regulation		3	2	7,5
		TOTAL	**12**	**8**	**30**

1st YEAR, 2nd SEMESTER

Course			Hours per week		ECTS
			Lectures	*Practice*	
1.	ELECTIVE subjects	Water Supply and Sewerage1	2	1	4
		Water Protection			
2.	Ports and Waterways		3	3	9
3.	Drainage and Irrigation 1		3	2	8
4.	Structures		2	2	6
5.	ELECTIVE subjects	Applied Geology	2	0	3
		Environmental Protection			
		TOTAL	**12**	**8**	**30**

2nd YEAR, 3rd SEMESTER

Course			Hours per week		ECTS
			Lectures	*Practice*	
1.	Water Power Use		2	2	6
2.	Water Supply and Drainage 2		2	2	6
3.-6.	ELECTIVE subjects (students have to select 3)	Urban hydrology	2	2	6
		Potable and Waste Water Treatment	2	2	6
		Modelling in Hydraulic Engineering	2	2	6
		Drainage and Irrigation 2	2	2	6
		Flood Protection	2	2	6
		Hydraulics 2	2	2	6
		Earth fill and Retaining Structures	2	2	6
		Hydrogeology and Engineering Geology	2	0	6
		Hydrotechnical Concrete	2	2	6
		Courses of other programmes or electives of other studies			
		TOTAL	**12**	**8**	**30**

2nd YEAR, 4th SEMESTER

Course			Hours per week		ECTS
			Lectures	*Practice*	
1.	Water Resources Engineering		3	1	6
2.	ELECTIVE subject	Design in Hydraulic Engineering	0	4	6
		Vegetative Water Facilities	2	2	6
		Special Water Power Projects	2	2	6
		Maritime Structures	2	2	6
		Courses of other programmes or electives of other studies			
3.	Final Year Project /Master thesis		0	18	18
		TOTAL	**12**	**8**	**30**

The preparation of the Final Year Project / Master Thesis during the semester with the individual cooperation with the mentor is 18 ECTS.

5.1.2 Civil Engineering - University of Split, Faculty of Civil Engineering, Architecture and Geodesy

The Faculty of Civil Engineering, Architecture and Geodesy of the University of Split offers one study programme on master level:

University master study programme (also called Academic graduate programme) in civil engineering (120 ECTS), that is explained in detail in the following text.

In the University master study programme in civil engineering students can enrol in one of 4 different branches / **occupational fields**:

1 **General** (Table 20 and Table 22)
2 **Hydraulic Engineering** (Table 21 and Table 22)
3 Modelling of Structures
4 Structures

Competences acquired by the student with completion of the study programme:

- To formulate equations of mathematical physics for engineering problems, and to solve them analytically or with numerical methods
- To integrate knowledge and handle complexity, and to formulate judgments with incomplete information, that include reflection on social and ethical responsibilities
- To apply knowledge and problem solving abilities in new environment within multidisciplinary contexts related to the field of study
- To clearly communicate own conclusions and develop learning skills for lifelong learning
- To design and perform calculation for the geotechnical structures using the ability to assess information and parameters on the properties of soil or rock mass
- To design hydraulic structures, sewage systems, stormwater sewage systems as well as hydropower and coastal structures
- To plan, analyse and manage hydraulic and hydropower object and systems
- To structure mathematical models in hydrology and hydraulics for the analysis of catchment's processes, as well as hydraulics characteristics of open channel flow and pressurised systems
- To interpret the processes in the catchment area and to model water resources systems, as well as to apply basic elements of water resources management to the catchment scale in line with EU Water Framework Directive
- To design reinforced concrete, metal, timber, masonry and geotechnical structures (buildings, bridges, tunnels, silos, hydraulic structures, dams, etc.) which are composed of different structural load bearing systems.
- To analyse processes, structures and systems in particular fields of civil engineering by applying numerical modelling
- To analyse and solve problems related to the durability, stability and reliability of structures
- To participate in the construction of different types of structures and supervise design and construction work
- To determine capacity and level of service of transportation and to make decisions on conceptual solutions in transportation engineering
- To model and perform calculation for structures exposed to seismic load using linear and non-linear models

- To assess the behaviour of structure during earthquake and to design seismic resilient structures using numerical models
- To apply techniques of the system analysis and operation research in civil engineering
- To evaluate production using standard indicators, make judgement on companies based on their balance sheets and assess investments
- To demonstrate knowledge and understanding that is founded upon and extends and/or enhances preceding qualification's level, and that provides a basis or opportunity for originality in developing and/or applying ideas, often within a research context

Structure of the study programme (by semesters) – General branch:

Table 20: Structure (by semesters) of the University General master study programme in civil engineering at the University of Split, Faculty of Civil Engineering, Architecture and Geodesy

1st YEAR, 1st SEMESTER

Course		Hours of active classes (L+E)		ECTS
		Lectures	*Practice*	
1.	Applied Mathematics	30	30	5,0
2.	Concrete Structures I	30	30	5,0
3.	Dynamics of Structures and Earthquake Engineering	30	15	4,0
4.	Geotechnical Engineering	30	30	5,0
5.	Hydraulics	45	30	6,0
6.	Pavement Structures	30	30	5,0
	TOTAL	**195**	**165**	**30**

1st YEAR, 2nd SEMESTER

Course		Hours of active classes (L+E)		ECTS
		Lectures	*Practice*	
1.	Hydraulic Systems	30	30	5,0
2.	Engineering Hydrology	30	30	5,0
3.	Coastal Engineering	30	30	5,0
4.	Traffic Engineering	30	30	5,0
5.	Rock Mechanics	30	30	5,0
6.	Operational Research in Civil Engineering	30	30	5,0
	TOTAL	**180**	**180**	**30**

2st YEAR, 3rd SEMESTER

Course			Hours of active classes (L+E)		ECTS
			Lectures	*Practice*	
1.	ELECTIVE subjects	In agreement with the mentor			15.0
		By free choice			5.0
2.	Hydropower Engineering		30	30	5,0
3.	Business and Investments in Civil Engineering		30	30	5,0
	TOTAL				**30**

2nd YEAR, 4th SEMESTER

	Course	Hours of active classes (L+E)		ECTS
		Lectures	*Practice*	
1.	Final Year Project /Master thesis	0	15	30
	TOTAL	**0**	**15**	**30**

Structure of the study programme (by semesters) – Hydraulic Engineering branch:

Table 21: Structure (by semesters) of the University Hydraulic Engineering master study programme in civil engineering at the University of Split, Faculty of Civil Engineering, Architecture and Geodesy

1st YEAR, 1st SEMESTER

	Course	Hours of active classes (L+E)		ECTS
		Lectures	*Practice*	
1.	Applied Mathematics	30	30	5,0
2.	Concrete Structures I	30	30	5,0
3.	Hydrogeology	30	15	4,0
4.	Hydraulics	45	30	5,0
5.	Geotechnical Engineering	30	30	6,0
6.	Elective Courses			Min 4,0
	TOTAL			**30**

1st YEAR, 2nd SEMESTER

	Course	Hours of active classes (L+E)		ECTS
		Lectures	*Practice*	
1.	Irrigation and Drainage	30	15	4,0
2.	Engineering Hydrology	30	30	5,0
3.	Coastal Engineering	30	30	5,0
4.	Steam Regulation	30	30	6,0
5.	Municipal Wastewater and Stormwater Treatment	30	30	5,0
6.	Integrated Water Resources Management	30	30	5,0
	TOTAL	**180**	**165**	**30**

2st YEAR, 3rd SEMESTER

	Course		Hours of active classes (L+E)		ECTS
			Lectures	*Practice*	
1.	ELECTIVE subjects	In agreement with the mentor			15.0
		By free choice			5.0
2.	Hydropower Engineering		30	30	5,0
3.	Groundwater Flow ad Solute Transport Modelling		30	30	5,0
	TOTAL				**30**

2nd YEAR, 4th SEMESTER

Course		Hours of active classes (L+E)		ECTS
		Lectures	*Practice*	
1.	Final Year Project /Master thesis	0	15	30
	TOTAL	**0**	**15**	**30**

The preparation of the Final Year Project / Master Thesis during the semester with the individual cooperation with the mentor is 30 ECTS.

Elective courses for both Hydraulic Engineering and General branch:

Table 22: Elective courses for both Hydraulic Engineering and General branch of the University master study programmes in civil engineering at the University of Split, Faculty of Civil Engineering, Architecture and Geodesy

Course		Hours of active classes (L+E)		ECTS
		Lectures	*Practice*	
1.	Hydraulic Structures	30	15	5,0
2.	Applied Stochastic Methods	30	30	5,0
3.	Ports and Marine Structures	30	30	5,0
4.	Complex Foundations	30	30	5,0
5.	Composite Structures	30	30	5,0
6.	Building Materials II	30	30	5,0
7.	Road Interchanges	30	30	5,0
8.	English Language	30	30	5,0
9.	Building Physics	30	30	5,0
10.	Urban Traffic Areas	30	30	5,0
11.	Karst Hydrology	45	30	5,5
12.	Construction of Engineering Structures	30	30	5,0
13.	Construction of Historical Buildings	30	30	5,0
14.	Housing Installations	30	30	5,0
15.	Management in Civil Engineering	45	15	5,0
16.	Surface Water-Quality Modelling	30	30	5,0
17.	Advanced Timber Structures	30	30	5,0
18.	Application of GIS in Water Resources Management	30	30	5,0
19.	Design of Structures by Computer	30	30	5,0
20.	Decision Systems in Civil Engineering	45	15	5,0
21.	Durability of Structures	30	30	5,0
22.	Tunnels and Underground Structures	30	30	5,0
23.	Project Management	45	15	5,0
24.	Urban Management	30	30	5,0
25.	Urban Hydrology	30	30	5,0
26.	Earthworks	30	30	5,0
27.	Municipal Solid Waste Management	30	30	4,5

5.1.3 Civil Engineering - University of Osijek, Faculty of Civil Engineering and Architecture

The Faculty of Civil Engineering and Architecture of the Josip Juraj Strossmayer University in Osijek offers two study programmes on master level:

- University master study programme (also called Academic graduate programme) in civil engineering (120 ECTS), that is explained in detail in the following text and in Table 23,
- Specialisation vocational graduate study programme in civil engineering (120 ECTS), that will not be explained in detail.

In the University master study programme in civil engineering students can enrol in one of 3 different branches / **occupational fields**:

1 **Hydraulic Engineering**
2 Construction Management and Technology
3 Supporting structures

Competences acquired by the student with completion of the study programme:

- ability of designing and dimensioning in particular field of specialization
- understanding of legal and professional practice connected with construction industry
- understanding of construction processes, conveying of knowledge, methods, materials, systems, machines, planning, safety, analysis and expenses control
- understanding fundamentals of economy, business, law, statistics, professional ethics, management, optimization, process analysis, engineering economy and developing of decision making skills
- understanding of general phenomena and problems in civil engineering context along with knowledge of boundary conditions and through interaction with other areas of science
- design, realisation and maintenance of civil engineering structures and systems in terms of bearing capacity, stability, safety, environmental protection and prices
- After graduating and on-the-job training one will be able to assume responsibility in the field he/she graduated in. He/she will use acquired knowledge and develop abilities in problem formulation and problem solving and to gain an ability to apply such skills to solve real problems and to find an optimal solution. He/she is qualified to obtain new knowledge in the development and methods of scientific and applied-scientific research.

Master of Civil Engineering is trained for:

- project design and design of necessary technical documents for construction and reconstruction of buildings and civil engineering works of all kinds
- independent management of a building site
- design of structures, design of stability of structures, dimensioning of elements
- design of water supply, land reclamation, sewers and other hydraulic engineering structures
- design of roads, railways, airports, ports, maritime and river waterways and other similar structures
- coordination of complex technical documentation for civil engineering projects, construction management and technology, environmental protection
- production and management of various geotechnical projects, including the planning and control of geotechnical investigation works
- design, testing and control of the quality of civil engineering works and materials

- preparation of feasibility study; investments in construction of buildings
- scientific research work in civil engineering
- education of civil engineers

Structure of the study programme (by semesters) – Hydraulic Engineering branch:

Table 23: Structure (by semesters) of the University master study programme in civil engineering - Hydraulic Engineering branch at the University of Osijek, Faculty of Civil Engineering and Architecture

1st YEAR, 1st SEMESTER

Course		Hours per week		ECTS
		Lectures	*Practice*	
1.	Probability Theory and Statistics	2,0	2,0	4,0
2.	Structural Dynamics	2,0	2,0	4,0
3.	Bridges 1	3,0	2,0	6,5
4.	Concrete Structures 2	2,0	2,0	4,0
5.	Hydraulic Structures	3,0	2,0	6,5
6.	Hydrology 2	2,0	2,0	5,0
	TOTAL	**14**,0	**12**,0	**30,0**

1st YEAR, 2nd SEMESTER

Course			Hours per week		ECTS
			Lectures	*Practice*	
1.	ELECTIVE subjects	Min. 2 courses	6,0	6,0	15,0
2.	Hydraulic Systems		2,0	2,0	5,0
3.	River Regulation		2,0	2,0	5,0
4.	Meliorations 1		2,0	2,0	5,0
	TOTAL		**12,0**	**12,0**	**30,0**

Elective Courses		Hours per week		ECTS
		Lectures	*Practice*	
1.	Hydrogeology	2,0	2,0	5,0
2.	Modelling of groundwater flow and pollution transport	2,0	2,0	5,0
3.	Architecture of Industrial Buildings	2,0	2,0	5,0
5.	Bridges 2	2,0	2,0	5,0
6.	Structure modelling	2,0	2,0	5,0
7.	Construction maintenance	2,0	2,0	5,0
8.	Water conditioning	2,0	2,0	5,0
9.	Analysis of structure stress and load-bearing capacity	2,0	2,0	5,0
10.	Total Quality Management	2,0	2,0	5,0
11.	GIS and Road Engineering Geodesy	2,0	2,0	5,0
12.	Airports	2,0	2,0	5,0
13.	Road modelling	1,0	2,0	5,0
14.	Spatial concrete application	2,0	2,0	5,0

2st YEAR, 3rd SEMESTER

Course			Hours per week		ECTS
			Lectures	*Practice*	
1.	ELECTIVE subjects	Min. 2 courses	6,0	6,0	15.0
2.	Hydraulic Modelling		1,0	3,0	5,0
3.	Water Protection and Purification		2,0	2,0	5,0
4.	Water supply and Sewage 2		2,0	2,0	5,0
	TOTAL				**30**

Elective Courses		Hours per week		ECTS
		Lectures	*Practice*	
1.	Utilisation of Water Power	2,0	2,0	5,0
2.	Masonry structures 1	2,0	2,0	5,0
3.	Marketing	2,0	2,0	5,0
4.	GIS in Hydraulic Engineering	2,0	2,0	5,0
5.	Financial Management	2,0	2,0	5,0
6.	Application of Geosintetics	2,0	2,0	5,0
7.	Characteristics of the top layer of road pavement	2,0	1,0	5,0
8.	Traffic simulation in public road networks	1,0	2,0	5,0
9.	Integrated project designs	2,0	2,0	5,0
10.	Energy Efficient buildings	2,0	2,0	5,0
11.	Meliorations 2	1,0	2,0	5,0
12.	Hydrometry	0,0	2,0	5,0
13.	Earthquake risk	2,0	2,0	5,0
14.	Basics of nonlinear structural analysis	2,0	2,0	5,0

2nd YEAR, 4th SEMESTER

Course		Hours of active classes (L+E)		ECTS
		Lectures	*Practice*	
1.	Essentials of Scientific Work	1,0	1,0	0,00
2.	Final Year Project /Master thesis	0		30,0
	TOTAL			**30,0**

5.2 Greece

5.2.1 Overview

In Greece a few master's degree programs related to water resource management are available at different universities (Table 24).

Table 24: Relevant master´s programs in Greece

Master´s programme	Academic degree	University
Interdisciplinary program "Water resources science and technology"	MSc	National Technical University of Athens Dept. of Civil Engineering
Hydraulic Engineering and Environment	MSc	University of Thrace, Dept. of Civil Engineering
Management of Water Resources in the Mediterranean	MSc	Department of Forestry and Natural Environment Management, Eastern Macedonia and Thrace Institute of Technology (EMATECH)
Postgraduate program in "Environmental Engineering"	MSc	Technical University of Crete, School of Environmental Engineering
Protection of the environment and sustainable development	MSc	Aristotle university of Thessaloniki, School of Civil Engineering

5.2.2 "Water resources Science and technology" from the National Technical University of Athens, Dept. of Civil Engineering (90 ECTS)

The interdisciplinary program grants a Postgraduate Diploma (MD) in the area of Water Resources Science and Technology after successful completion of the relevant study program, with the following specializations:

Specialization A: Hydrology and Environmental Management of Water Resources.

Specialization B: Water Quality and Environmental Technology.

Specialization C: Coastal Zone and Port Management.

The curriculum includes two (2) semesters of courses and one (1) semester of thesis.

The minimum duration of studies is 3 academic semesters and the maximum duration of study is 2 years, including the preparation of the thesis. Extension of the maximum duration of studies is

generally only allowed in special cases. During the course of study in the present master program, no other postgraduate program is allowed to follow.

Admission

Graduates of Polytechnic schools or graduates of all academic departments and faculties of a relevant field of study, holders of a 5-year or 4-year certificate in HEIs.

Criteria of admission

The applications of the students are evaluated in relation to their graduate diploma degree, relevance of cognitive background, relevant professional experience and employment, related publications & other Master Degrees obtained letters of recommendation and personal Interview.

Infrastructure

The MSc Program operates on the premises of the Department of Civil Engineering with the existing infrastructure which includes high-tech equipment and explicit laboratories.

Master Thesis

The Master Thesis is supported in an open by the public procedure facing a three-member examination committee appointed by the Department of Civil Engineering.

Total: 30 ECTS

Analysis of courses

SPECIALIZATION A: Hydrology and Environmental Management of Water Resources

First semester (winter semester)

1.	Water resources management	6 ECTS
2.	Hydrometeorology	6 ECTS
3.	Hydrogeology	6 ECTS
4.	Water Resources- Stochastic modeling	6 ECTS
5.	Simulation of River Hydraulics	6 ECTS

SPECIALIZATION B: Water Quality and Environmental Technology

1.	Sewage and Sludge Management	6 ECTS
2.	Biochemical Processes in the Aquatic Environment	6 ECTS
3.	Solid Waste Management	6 ECTS
4.	Mathematical Simulation of Pollutant Transfer and Surface Water Quality	6 ECTS
5.	Basic Principles of Aquatic Environment Management	6 ECTS

SPECIALIZATION C: Coastal Zone and Port Management

1.	The harbor system	6 ECTS
2.	Marine Hydrodynamics	6 ECTS
3.	Coastal Processes	6 ECTS
4.	Coastal Projects	6 ECTS
5.	Finance of Ports	6 ECTS
6.	Environmental Management of Coastal Zone and Ports	6 ECTS

Elective courses

1	Economics of water resources	6 ECTS
2	GIS on water resources	6 ECTS
3	Laboratory Methods of Sanitary Technology	6 ECTS
4	Special Topics in Water Chemistry	6 ECTS
5	Restoration of polluted areas	6 ECTS
6	Ports	6 ECTS
7	Corrosion, Transport and Deposition of Materials	6 ECTS

Second semester (spring semester)

SPECIALIZATION A: Hydrology and Environmental Management of Water Resources

1	Advanced Hydrology and Simulation	6 ECTS
2	Optimization of Hydraulic Systems - Hydroinformatics	6 ECTS
3	Floods- Flood protection works	6 ECTS
4	Advanced issues of water resources management	6 ECTS
5	Hydroelectric Projects and Renewable Energy Sources	6 ECTS

SPECIALIZATION B: Water Quality and Environmental Technology

1	Advanced Waste Treatment Methods	6 ECTS
2	Production of Drinking Water	6 ECTS
3	Exploitation, management and protection of groundwater aquifers	6 ECTS
4	Decentralized Waste Management and Small Scale Processing Systems	6 ECTS
5	Management of Hazardous Waste	6 ECTS

SPECIALIZATION C: Coastal Zone and Port Management

1	Integrated Coastal Zone Management	6 ECTS
2	Mathematical Models of Pollution in the Marine Environment	6 ECTS
3	Port Management	6 ECTS
4	Mathematical Models in the Coastal Zone	6 ECTS
5	Shipping and Maritime Transport	6 ECTS
6	Port Policy, Law and Development Strategies	6 ECTS

Elective courses

1	Underwater Excavation Pipelines	6 ECTS
2	Securing ports	6 ECTS
3	Urban hydrology	6 ECTS
4	Integrated Mathematical Groundwater Simulation	6 ECTS
5	Environmental impacts of hydraulic projects	6 ECTS
6	Optimization of Installation Networks	6 ECTS
7	Advanced Environmental Hydraulics	6 ECTS

5.2.3 MSc in Hydraulic Engineering and Environment from the University of Thrace, Dept. of Civil Engineering (ECTS75)

Website: www.civil.duth.gr

Objective

The objective of the program is the high level of postgraduate education, research, practical application, training and specialization of scientists so that they become capable of producing new knowledge in modern fields of civil engineering science, oriented to the latest developments in the wider field of Hydraulic Engineering and Environmental Engineering.

It includes three specializations, which are:

• Hydraulic Works and Environment

• Water Resources Management and Natural Disasters

• Maritime Projects and the Environment

Courses are taught mainly in Greek, but it is possible to have some courses taught also in English. Course attendance is mandatory. They are accepted up to 30 students each year.

Duration of MSc

For the award of the master degree two (2) academic semesters and the summer period (intensive program) are required.

Each postgraduate student is required to successfully attend ten (10) courses in total, of which four (4) are compulsory. The remaining six (6) are selected by one of the three specializations.

Type of postgraduate degree awarded

The program leads to a Postgraduate Diploma in Hydraulic Engineering and Environment.

Admission

Candidates who are not Civil Engineers are required to successfully attend a number of undergraduate courses, which are specified by the Coordinating Committee, as the most appropriate, and approved by the Department of Civil Engineering.

Master Thesis

Graduates of Polytechnic schools or graduates of all academic departments and faculties of a relevant field of study, holders of a 5-year or 4-year certificate in HEIs.

Postgraduate students are required to undertake postgraduate diploma thesis, which corresponds to fifteen (15) ECTS. The writing language of the postgraduate diploma thesis is Greek and, in special cases, English.

Infrastructure

The educational process of the program is carried out in its biggest part in an exclusively allocated room in the wing of the Civil Engineering Department. The specific room has been suitably put into shape and equipped with modern audiovisual means.

Cost

Students are enrolled with a registration fee of € 600 per semester.

Analysis of courses

SPECIALIZATION A: Hydraulic Works and Environment

First semester (winter semester)

1	Fluid Mechanical Hydraulic Works	6 ECTS
2	Physical, Chemical and Biochemical Processes of Water Systems	6 ECTS
3	Design of Drainage Works	6 ECTS
4	Elective courses Water Resources Management and Rehabilitation of Water Systems	6 ECTS
5	Restoration of polluted Soils and Groundwater resources	6 ECTS
6	Stability of Geotechnical Structures and Natural Environment	
7	Management of Hydrometeorological Disasters	

Second semester (spring semester)

1	Environmental Fluid Mechanics	6 ECTS
2	Elective courses Design of Potable Water Treatment Plant	6 ECTS
3	Sanitary Engineering and Wastewater Engineering	6 ECTS
4	Advanced Urban and Industrial Wastewater Treatment and Sludge	6 ECTS
5	Numerical Methods of Fluid Mechanics	6 ECTS
6	Hybrid Models (Statistical and Fuzzy) in Hydraulic Engineering	6 ECTS

7	Mild Energy Forms: Exploiting Hydrodynamic, Wind and Marine Energy	6 ECTS
8	Hydrogeoinformatics	6 ECTS
9	Geosynthetic Materials in Hydraulic and Environmental Projects	6 ECTS

SPECIALIZATION B: Water Resources Management and Natural Disasters

First semester (winter semester)

1	Advanced Technical Hydrology - Floodplain Works	6 ECTS
2	Transfer of Feeding Materials	6 ECTS
3	Management of Hydro-meteorological Disasters	6 ECTS
4	Elective courses Geothermal energy. Research - Exploitation	6 ECTS
5	Fluid Mechanical Hydraulic Works	6 ECTS
6	Physical, Chemical and Biochemical Processes of Water Systems	6 ECTS
7	Integrated Water Resources Management	6 ECTS

Second semester (spring semester)

1	Special Issues of Exploitation and Management of Groundwater resources	6 ECTS
2	Elective courses Mild Energy Forms: Exploiting Hydrodynamic, Wind and Marine Energy	6 ECTS
3	Hydro-geo-informatics	6 ECTS
4	Hybrid Models (Statistical and Fuzzy) in Hydraulic Engineering	6 ECTS
5	Numerical Methods of Fluid Mechanics	6 ECTS
6	Dynamic Phenomena in River Estuaries	6 ECTS
7	Stochastic Models in Hydrology	6 ECTS

SPECIALIZATION C: Maritime Projects and the Environment

First semester (winter semester)

1	Coastal Physical Processes	6 ECTS
2	Numerical Methods	6 ECTS
3	Research Methodology and Symbolic Languages	6 ECTS
4	Elective courses Building Materials in Marine Constructions	6 ECTS
5	Offshore Engineering	6 ECTS
6	Marine Ecosystem and Environment	6 ECTS

Second semester (spring semester)

1	Special Issues in the management of Ports	6 ECTS
2	Elective courses Coastal Protection and Coastal Zone Management	6 ECTS
3	Physical Oceanography	6 ECTS

4	Static and Dynamic Analysis of Marine Constructions	6 ECTS
5	Environmental Fluid Mechanics	6 ECTS
6	Mild Energy Forms: Exploiting Hydrodynamic, Wind and Marine Energy	6 ECTS
7	Geotechnical applications in coastal and port works	6 ECTS
8	Geosynthetic Materials in Hydraulic and Environmental Projects	6 ECTS
9	Management and Configuration of Terrestrial Area of Ports and Marinas	6 ECTS
10	Dynamic Phenomena in River Estuaries	6 ECTS

5.2.4 MSc in Water Resources of the Mediterranean - Postgraduate Diploma in Management of Water Resources in the Mediterranean" from the Department of Forestry and Natural Environment Management, Eastern Macedonia and Thrace Institute of Technology (EMATECH) (90 ECTS)

Website: www.medwatermsc.gr

Objective

The aim of this MSc (Postgraduate Studies) is the management and policies of Water Resources in the Mediterranean under Conditions of Water Scarcity. The main objective of the MSc is to provide education and knowledge on issues such as: Water Conservation, Quality Control of Water, Water Law and Policy, Sustainability in Urban and Suburban Areas in conditions of Water Scarcity, etc.

Type of postgraduate degree awarded

The program leads to a Master (MSc) in Management of Water Resources in the Mediterranean (Water Resources of the Mediterranean).

Admission

Undergraduates from programs of the Department of Forestry and Environmental Management of EMATTECH are aimed primarily, but not exclusively, postgraduate Universities of Geotechnical and Environmental Sciences and generally undergraduates from Universities of Science, Engineering, Economics and related disciplines Universities domestic and / or recognized equivalent institutions abroad.

The duration first the MSc

The duration for the award of the M.Sc. in this particular program is three (3) semesters, each one of 30 ECTS, of which the third is for the preparation of the Master thesis.

Teaching and Research Employment of Postgraduate Students

Graduate students may, after graduation, following a decision of the Special General Assembly of the Department and of the Steering Committee, assist teachers of the Department in tutorials and workshops of the curriculum, and participate in research projects and programs on the scientific the object.

It is also expected to be high demand for the graduates of this Program from companies and organizations from all Mediterranean countries of Europe, Asia and Africa, especially in countries of the Middle East where water scarcity conditions exist.

Practical Exercises

During the MSc, beside the theoretical lectures, practical and laboratory exercises with research technology equipment, presentations and visits to related workspaces are made.

The number of students enrolled each academic year in the postgraduate program is specified up to a maximum of thirty five (35) students.

Furthermore, apart from the number of students admitted each academic year, the MSc program also award scholarships holders.

Infrastructure

The MSc Program operates on the premises of the Department of Forestry and Environmental Management of the EMATECH with the existing infrastructure which includes high-tech equipment and explicit laboratories.

Analysis of the courses

The total number of courses in the Postgraduate program that a student must attend is ten (10), of which all ten are compulsory subjects. Each course is six (6) credits, taught four (4) hours per week. Also, the student should write/construct and present a Master Thesis, which will be under the supervision of specific MSc Professors. Courses are taught in English.

First Semester (winter semester)

1.	GIS and Remote Sensing in Water Resources	6 ECTS
2.	Ecohydrology and Protected Areas	6 ECTS
3.	Water Policy, Planning and Economics	6 ECTS
4.	Adapted Watershed Management	6 ECTS
5.	Statistics in Water Resources	6 ECTS

Total: 30 ECTS

Second Semester (spring semester)

1.	Urban Sprawl and Sustainable Water Management	6 ECTS
2.	Flood and Drought Cycles: Implications in Water Management	6 ECTS
3.	Hydrologic Modeling and Geoinformatics	6 ECTS

4.	Climate Change and Green Technologies	6 ECTS
5.	Water Quality and Water Scarcity Conditions	6 ECTS

Total: 30 ECTS

Third Semester

Master Thesis

The Master Thesis is supported in an open by the public procedure facing a three-member examination committee appointed by the Department of Forestry and Natural Environment of the MSc in which the students Supervisor and two (2) other Professors are present.

Total: 30 ECTS

Cost

The total cost of the Postgraduate Program is 3.200 € for EU residents and 5.000€ for Non EU residents, payable in four equal payments over a period of 16 months, with the first payment being paid simultaneously with the registration.

5.2.5 Postgraduate program in Environmental Engineering from the Technical University of Crete (TUC), School of Environmental Engineering, (90 ECTS)

Website: https://www.enveng.tuc.gr/en/studies/postgraduate/masters-programme/

The Postgraduate Studies Program awards the degree of Master of Science (M.Sc.) [Diploma of Postgraduate Studies] in Environmental Engineering (second cycle of university studies) and is offered by the School of Environmental Engineering. The Program offers science and engineering graduates the opportunity to specialize in one of the following areas:

Water and Wastewater Management (A)

Environmental Management, Sustainable Energy and Climate Change (B)

The duration for the MSc

The minimum duration of studies is three (3) academic semesters and includes the time needed to complete the Master's Thesis.

Courses for the Master's degree may be taught in Greek or in English. The Master's thesis may be written in Greek or in English.

The minimum number of courses, research and every other educational and research activities required to earn the Master's degree, are as stated below:

Six (6) courses (54 ECTS in total) and two (2) research lectures (6 ECTS in total) contribute 60 ECTS

Master Thesis

The Master Thesis is supported in an open by the public procedure facing a three-member examination committee appointed by the Department of Civil Engineering.

Total: 30 ECTS

SPECIALIZATION AREA A: Water and Wastewater Management

First semester (winter semester)

Analysis of the Courses

1.	*Required courses* Advanced topics in Environmental Chemistry	9 ECTS
2.	Integrated Water Resources Management	9 ECTS
3.	Research Lectures	3 ECTS
4.	*Elective courses* Environment and Public Health	9 ECTS
5.	Environmental Impact Assessment	9 ECTS

Total: 30 ECTS

Second semester (spring semester)

1.	*Required courses* Fate and transport of Contaminants in the subsurface	9 ECTS
2.	Advanced Oxidation Processes in Water and Wastewater Treatment	9 ECTS
3.	Research Lectures	3 ECTS
4.	*Elective courses* Environmental Law and Sustainable Development	9 ECTS
5.	Computational dynamics with emphasis on earthquake engineering	9 ECTS

Total: 30 ECTS

Third Semester

Master Thesis

The postgraduate diploma thesis is assessed by a three-membered committee composed of the supervisor and two other faculty members. The student must submit an application for the approval of the three-member committee composition the application form is available on the School's website).

When all research work is concluded and the writing of the Master thesis is completed, the date, time and venue of the open oral presentation/defense of the student's work is determined. The

candidate provides the School's Secretariat with a thesis summary for publication on the University's Academic Announcements website (template available on the website).

The candidate defends his/her thesis publicly before the three examination committee members, who assess and evaluate the quality of research, the scientific methodology adopted for obtaining the stated results, the presentation of the literature review and the significance of results. It is noted that both the thesis manuscript and the oral presentation are evaluated.

Total: 30 ECTS

Cost

Registration fees apply for any post-graduate student of Greek nationality who is not entitled to a fee waiver. The entire fee is 1500 Euro for the three semesters. An extra charge of 100 euro per semester applies to post-graduate students who wish to extend their studies.

SPECIALIZATION AREA B: Environmental Management, Sustainable Energy and Climate Change

First semester (winter semester)

1.	*Required courses* Design of Sustainable Energy and Mobility Systems	(9 ECTS)
2.	Solid and Toxic Waste Management	(9 ECTS)
3.	Hydrometeorology and Climate Change	9 ECTS
4.	Research Lectures	3 ECTS
5.	*Elective courses* Special topics of Catalytic Surfaces and Catalytic Processes for Environmental Applications	9 ECTS
6.	Environment and Public Health	9 ECTS
7.	Environmental Impact Assessment	9 ECTS

Total: 30 ECTS

Second semester (spring semester)

1	*Required courses* Advanced Studies on Energy Efficiency and Environmental Quality in the Built Environment	9 ECTS
2	Advanced Catalytic and Electrocatalytic Energy Processes	9 ECTS
3	Environmental Economics & Policy	9 ECTS
4	Research Lectures	3 ECTS
5	*Elective courses* Environmental Law and Sustainable Development	9 ECTS
6	Computational dynamics with emphasis on earthquake engineering	9 ECTS

Total: 30 ECTS

5.2.6 "Environmental Protection and Sustainable Development", Civil and Environmental Engineering (CE), Aristotle University of Thessaloniki (AUTh) (90 ECTS)

Website: www.ppva.civil.auth.gr

The master's degree programme in "Civil and Environmental Engineering" of Aristotle University of Thessaloniki (AUth) provides students with an in-depth education in engineering, focussing on the field of civil engineering and its application. It is not purely a water resources oriented postgraduate program but has strong implication with water oriented issues. The degree programme reflects the principle of research-led teaching. In the scope of the master's degree programme attention is given to an interdisciplinary education supporting technical engineering, cognitive and practical as well as social and innovative competencies.

Objective

The main objectives of the program are:

- The promotion of interdisciplinary knowledge and research in the field of environment and sustainable development.
- The provision of a high-quality postgraduate education and the promotion of a positive attitude and behavior regarding the sensitive issues of environmental protection and sustainable development.
- The training of new graduates and professionals aiming at the upgrade of the human potential of the country in the context of a dynamic economic and technological development policy.
- The intensive specialization in the relevant vital issues aiming at the formation of well-equipped graduates from the program and providing them with suitable means for professional careers in the public or private sector or for the continuation of their postgraduate studies at the doctorate level.

Analysis of Courses

First semester (winter semester)

1.	*Compulsory courses* Environmental Assessment and Management	6 ECTS
2.	Natural Resource and Environmental Economics	6 ECTS
3.	Decision and Risk Analysis	6 ECTS
4.	Acquisition, Processing and Management of Environmental Data: Geographic Information Systems (a)	6 ECTS
5.	Acquisition, Processing and Management of Environmental Data:	6 ECTS

	Photogrametry, Remote Sensing and Geoinformation Methods and Systems (b)	
6.	Acquisition, Processing and Management of Environmental Data: Statistical Methods and Techniques	6 ECTS

Second semester (spring semester)

1.	*Compulsory courses* Introduction to Research Methodology	6 ECTS
2.	*Elective courses* Sustainable Management of Water Resources	6 ECTS
3.	Protection and Restoration of Groundwater	6 ECTS
4.	Systems and Technologies for Waste Management	6 ECTS
5.	Transportation - Transport Policy and the Environment	6 ECTS
6.	Environmental aspects of spatial planning	6ECTS
7.	Integrated coastal zone management	6 ECTS
8.	Environmental impacts of coastal and marine works	6 ECTS
9.	Management of Natural Hazards	6 ECTS
	Environmental Geotechnology	6 ECTS

Every postgraduate student has to attend five courses of his choice during the spring semester. Introduction to Research methodology is the sole compulsory course in the spring semester. This specific course is of a seminar character and is not contributing to any grade.

The postgraduate students, whose first academic degree varies from, that of a civil engineer, have to attend the following four additional homogenization courses for the completion of their essential knowledge.

1. Elements of Environmental Chemistry
2. Elements of Water Resources
3. Elements of Oceanography and Coastal Mechanics
4. Elements of Geology and Geo-mechanics

The traits of the up to present graduates of the program can be summarized such as follows:

- The vast majority of the graduates of the program are new scientists who have completed their undergraduate studies in the last three years before entering the program. However, the number of real professionals or executives from the private and public sector should not be undervalued.
- The graduates of the program are at 2/3 civil engineers and at 1/3 graduates of other schools.
- The entry and the subsequent graduation of women from the program is especially high and rates at an average of over 60%.This fact is of great importance if we consider that the demand and participation of the two sexes in the undergraduate studies of the Department of Civil Engineering is the exact opposite in quantity.

Infrastructure

The educational process of the program is carried out in its biggest part in an exclusively allocated room in the wing of the Civil Engineering Department of A.U.Th. The specific room has been suitably put into shape and equipped with modern audiovisual means.

The postgraduate students of the program are allowed to use the central computer lab which operates in the Civil Engineering wing, which comprises a complete and modern network of computers directly connected with the central network of A.U.Th. Other special computer labs of the department are alternatively used, depending on the individual needs of the program courses. Each computer post in all labs has a direct access to a rich collection of electronic journals as well as to a plethora of other scientific resources connected to the A.U.Th.

The practice of postgraduate students in specialized courses is also carried out in the modern installations of the nine laboratories of the Civil Engineering Department, the staff of which is directly involved in the educational process of the program.

Finally, regarding the use of the libraries, the postgraduate students of the program have direct access to:

(a) The Central Library of A.U.Th.

(b) The departmental libraries operating by the individual departments of A.U.Th

(c) The library of the Civil Engineering Department

an extensive part of which is especially dedicated to the support of the program “Environmental Protection and Sustainable Development ”.

Cost

Students are enrolled with a registration fee of € 500 per year.

5.3 Norway

Today there are 10 universities in Norway, 6 high schools and 5 research colleges publicly funded. For the purpose of this report we have screened curricula of Norwegian universities.

University	WRM in curricula
Norges teknisk-naturvitenskapelige universitet (NTNU) Universitetsadm., 7491 Trondheim Norwegian University of Science and Technology Tlf: 73 59 80 00 http://www.ntnu.no	There are 3 main study programs, related with WRM: 2 x Civil & Environmental Engineering and Environmental Engineering. The most relevant course is "Water resources and sanitation".
Norges miljø- og biovitenskapelige universitet (NMBU) Pb. 5003, 1432 Ås Norwegian University of Life Sciences Tlf: 64 96 50 00 http://www.nmbu.no	There are 3 courses relevant to this report: "Water Resources and Water Supply", "Water Resources Management and Treatment Technologies", "Water management in cold climate".
Universitetet i Bergen Pb. 7800, 5020 Bergen University of Bergen Tlf: 55 58 00 00 http://www.uib.no	There is no water-related specialisation. There is one most relevant course "Hydrology, Ground Water and Geohazards"
Universitetet i Oslo Pb. 1072 Blindern, 0316 Oslo University of Oslo Tlf: 22 85 50 50 http://www.uio.no	There is no water-related specialisation. There is one most relevant course "Water and food in a global health perspective".
Universitetet i Stavanger 4036 Stavanger University of Stavanger Tlf. 51 83 10 00 http://www.uis.no	There is one relevant study program "Water Science and Technology" and one most relevant course "Natural Water System".
Universitetet i Tromsø Norges arktiske universitet 9019 Tromsø University of Tromsø The Arctic University of Norway Tlf: 77 64 40 00 http://www.uit.no	There is no dedicated specialisation or course. WRM elements are integrated in general courses like Process Technology; Energy, Climate and Envrionment.
Universitetet i Agder Pb. 422, 4604 Kristiansand University of Agder Tlf: 38 14 10 00 http://www.uia.no	There is no dedicated specialisation or course. WRM elements are integrated in Water & Wastewater Treatment course.
Nord universitet 8049 Bodø Nord University Tlf: 75 51 70 00 http://www.nord.no/no	No relevant issues.

OsloMet – storbyuniversitetet Postboks 4, St. Olavs plass 0130 Oslo. OsloMet – Oslo Metropolitan University. Tlf: 67 23 50 00 http://www.hioa.no	No relevant issues.
Universitetet i Sørøst-Norge Pb. 235, 3603 Kongsberg University of South-Eastern Norway Tlf: 31 00 80 00 www.usn.no	There is no water specialization, WRM issues are spread between various environmental courses.

5.3.1 Norwegian University of Science and Technology

Study program

Civil and Environmental Engineering - Advanced Engineering (MSc) 2 years

This master's programme is a two-year long supplementary study which builds on a three year engineering degree. The programme provides students the opportunity to specialize, and reach a deeper understanding of important topics in civil and environmental engineering. It is also possible to take additional courses which are not a part of the obligatory curriculum.

Students join their peers in the 5-year programme — for the 4th year of the popular Civil and Environmental Engineering Programme — and may choose between the following fields of study:

- Construction and Building (Trondheim)
- Structures (Trondheim)
- Roads, Transportation and Geomatics (Trondheim)
- Water and the Environment (Trondheim)
- Digital Building Processes (Gjøvik)

The most relevant to this report part is Water and the Environment:

This field deals with the exploitation of water and water resources; drinking water, waste water, water for power production, flood control, etc. One of the other topics is environmentally friendly purification and waste disposal.

In addition, we offer specialization in geomatics, arctic technology, project management, and industrial ecology. As part of NTNU we also offer several courses in the social sciences/economy that are of interest for civil engineers.

All ordinary courses in the civil engineering programme each awards 7.5 ECTS credits. Thus, during the 4th year you will take 4 courses each semester, primarily technology courses that strengthen your knowledge from your college education.

The 5th year at NTNU is devoted to specialization within a chosen field. In the autumn semester, you will work on a written project and take courses related to this project. The entire spring semester is devoted to the master's thesis which has a stipulated duration of 20 weeks. The project and the thesis are often related to ongoing research projects and problems within industry.

Course

*Water resources and sanitation – **10 ECTS***

Course content

- Water supply: Drinking water sources, treatment technologies, distribution systems
- Water treatment: Different types of waste water, sources, collection systems, treatment of municipal wastewater (mechanical, chemical, biological), recipients, sludge (production, treatment and disposal)
- Solid waste: Collection, treatment, disposal
- Laws and regulations within the field (national and international)

Learning outcome

General aim: The students get an overview of the field, making them able to keep a professional communication on the topics and to make simple assessments.

Upon fulfilling the course, the student:

- Can make a rectified choice between available drinking water sources and describe the main components in a drinking water supply system
- Can define waste water and storm water run-off, can describe the main components in a waste water system, and make basic calculations on sizes of a transport- and handling system
- Can describe known methods for handling and disposing of sludge
- Can describe the main components of a solid waste management system, and can describe alternative strategies for the treatment and disposal of solid waste
- Knows how to find and understand the regulations and laws within the field

Learning methods and activities:

- Excursions, Lectures, Group- and Project work
- Semester assignments in a group
- Two Excursion(s)

Further on evaluation: Re-sit of written exam in August.

Specific conditions

Exam registration requires that class registration is approved in the same semester. Compulsory activities from previous semester may be approved by the department.

Recommended previous knowledge: Mechanics

Required previous knowledge: Physics and chemistry.

5.3.2 Norwegian University of Life Sciences

*Water Resources and Water Supply –**5 ECTS***

Relation with study programs: Environment and Natural Resources, Water and Environmental Technique, Ecology and Management of Natural Resources (Water Resources).

Course contents

Lectures on the following topics: Water as a resource, protection of water resources, the influence of various types of pollution on the quality of the drinking water and methods for treating drinking water. The classification of environmental quality in freshwater and chemical and biological quality requirements for water to be used with emphasis on drinking water regulations will also be covered. In addition, evaluation of different water supply sources will be considered. Regulation and managements regarding water supplies/water management including the water directive. Group work: 3-4 students cooperate on a relevant topic that is presented in plenary for all the students taking the course. Excursion: 5-6 hour excursion.

Learning outcome:

The student is to understand the significance of water as a resource and be able to classify, protect and use different types of water for different purposes. Have knowledge of various sources that can be used for drinking water supply, the need for action in the drainage basin and water treatment according to the drinking water regulations. Have knowledge on reference condition in different water sources and the characteristics of different water types. Water quality and water pollution should be treated in a holistic perspective with the whole catchment as a unit according to the Water Framework Directive (WFD). Water is an important resource that must be managed correctly, all the time taking future generations into consideration.

Learning activities:

The lectures are used for covering central topics in the course. Guest lecturers are used for some lectures to give examples of how the knowledge gained in the course may be used and so make the subject more concrete. Central topics are discussed during the course. Group work is used for giving students a more active relationship with the material. The students select topics from a list that is set up. The completed result is presented in plenary. An excursion to a drinking water plant and a sewage treatment plant in the Oslo/Akershus region are arranged to see how these plants really work.

Teaching support: Discussions are arranged under supervision of the teacher. The course intends to establish a good dialogue between the students and the teacher.

Syllabus: Andersen E. (2016). Vannforsyning og helse Veiledning i drikkevannshygiene Vannrapport 127 Folkehelseinstituttet. Arne Tollan: Vannressurser (3 chapters). Relevant reports and articles can be loaded from Canvas.

Mandatory activity: Participation on excursion.

Assessment: Final written examination (2.5 hours): 80%. Presentations of group work in plenary: 20%. Both parts of the exam have to be passed. Continous exam, grading scale A-F.

Nominal workload: 150 hours.

Type of course: Lectures: 22 hours. Discussion: 6 hours. Group work: max 5 hours of supervision. Excursion: 6 hours.

*Water Resources Management and Treatment Technologies –**10 ECTS***

Course contents

Lectures on: Water resources management, Water treatment Wastewater treatment, Monitoring and control of water quality and treatment processes, Working with literature databases, Project report/scientific writing. Hands on practice: lab analysis and process simulation software Excursions: to water and wastewater treatment plants

Learning outcome

Knowledge: students should have an understanding of the basic principles in modern water resources management, European water legislations, theoretical understanding of the main treatment processes and, operational aspects a treatment plant. They should possess basic understanding of state-of-the-art techniques on process control and optimization they must have an understanding of the modern simulation and design tools available for treatment plants and their capabilities. Professional skills: students should be able design modern river basin structures using best practices and to understand the composition of a treatment plant and identify and improve general operational problems. They should be able to carry out basic water quality analysis and how to utilize the water quality data in WRM and operational improvement of treatment plants. They should be able to carry out a literature review using modern scientific databases and internet and to prepare a well-structured project report. General competence: students should have an understanding of the development trends in the European water legislation and practices, be able to identify the advantages/weaknesses in a WRM setup and to propose improvements based on modern practices. They should also have a general process optimization knowledge using lab- and full scale experiments and possibilities with simulation programs.

Learning activities

(1) Lectures (2) analytical work in small teams, (3) Tutorials with process simulation program STOAT, (4) excursion to treatment plant(s) to learn how the unit processes are integrated and their operational challenges, (5) instructions and hands-on practice in usage of scientific databases and reporting. Most of the presentations will be available in Canvas before the lectures

Recommended

- Handbook for IWRM in Basins by GWP/INBO, 2009
- EU's Water Directive and Urban Water Directive
- Wastewater Engineering: Treatment and Reuse, 5th Edition, by Metcalf and Eddy, Inc, 2013 (selected sections)
- Water Treatment: Principles and Design, 3rd Edition, MWH, 2012 (selected sections)

Prerequisites: Basic knowledge on water and wastewater treatment (similar to THT 271) is required.

Recommended prerequisites: Basic knowledge on water resources management

Mandatory activity: Compulsory participation in all activities during the first two weeks of intensive work + Project report

Assessment: (1) Multiple Choice Questions, at the end of the 2 weeks of lectures (2) Evaluation of project works Final mark will be based equally on the above.

Nominal workload: ca 80 hours of lectures, exercises, excursions within 2 intensive weeks, followed by 220 h project work during a 5 months period.

Type of course: Part-1: First two weeks of intensive, full-time work: 50 hours of lectures, 6-10 hours of analytical work, 6-10 hours of process simulation exercises, 20 hours of excursions. Part-II: Project work (can be carried out outside of NMBU). Part-III: submission of the project report

Note: The course is organised as an intensive/full-time 2-weeks course in June/July at NMBU and an independent project work carried out either from Norway or abroad in December.

*Water management in cold climate – **5 ECTS***

Course contents

Lectures on: Arctic conditions, Water resources management, Water treatment, Wastewater treatment and Cold Climates, Project report/scientific writing. Excursions: to water and wastewater treatment plants

Learning outcome:

Knowledge: students should have an understanding on arctic conditions, of the basic principles in modern water resources management, theoretical understanding of the main treatment processes and, operational aspects a treatment plant in cold climates.

Professional skills: students should be able design modern river basin structures relevant for cold climates using best practices and to understand the composition of a treatment plant and identify and improve general operational problems. They should be able to understand how to achieve

operational improvement of treatment plants. They should be able to carry out a literature review using modern scientific databases and internet and to prepare a well-structured project report.

General competence: students should have an understanding of the development trends in the cold climates, be able to identify the advantages/weaknesses in a WRM setup and to propose improvements based on modern practices.

Learning activities: (1) Lectures (2) analytical work in small teams, (3) excursion to treatment plant(s) to learn how the unit processes are integrated and their operational challenges, (4) instructions and hands-on practice in usage of scientific databases and reporting. Most of the presentations will be available in Canvas before the lectures

Recommended:

- Wastewater Engineering: Treatment and Reuse, 5th Edition, by Metcalf and Eddy, Inc, 2013 (selected sections)

- Water Treatment: Principles and Design, 3rd Edition, MWH, 2012 (selected sections)

Prerequisites: Basic knowledge on water and wastewater treatment (similar to THT 272) is required.

Recommended prerequisites: Basic knowledge on water resources management

Mandatory activity: Compulsory participation in all activities during the block course + Project report

Assessment: (1) Multiple Choice Questions, at the end of the 1 week of lectures (2) Evaluation of project works Final mark will be based equally on the above.

Nominal workload: ca 50 hours of lectures, exercises, excursions within one intensive week, and 100 h project work during a 3 months period.

Type of course: Part-1: One week of intensive, full-time work: 50 hours of lectures, 20 hours of excursions. Part-II: Project work (can be carried out outside of NMBU). Part-III: submission of the project report

Note: It is obligatory to participate in the lectures in the block course at UNIS, Longyerabyen on the specified week. Travel, board and lodging costs and other costs related to the sojourn in Longyerbyen has to be covered by candidates.

5.3.3 University of Bergen

*Hydrology, Ground Water and Geohazards –**10 ECTS***

Level of Study: Bachelor

Objectives and Content

This course introduces topics in physical geography related to the interaction between water, climate, landscape and society. It aims to provide the student with a better understanding of water as

a geomorphic agent, and how hydrological systems and catchments are influenced by human activity and climate change on different spatial and temporal scales. The course has a focus on the dynamic processes in nature related to runoff, and the objective is to increase the ability of participants to identify and reflect on the interaction between nature and society in hydrological processes.

The course also aims to disseminate an understanding of how water flows above and below the ground, and how human activity can influence the flow conditions. Students will gain experience with collecting, analysing and presenting hydrological data. Furthermore, the course will discuss triggering mechanisms of hydro-meteorological geohazards, and the impact on society by fluvial- and slope-related processes following predicted man-made climate changes with increased precipitation, higher sea level and extreme weather events. We will also discuss how planning and management can be used by the society to adapt to water-related problems. The course will have a focus on a Norwegian context.

Learning Outcomes

On completion of the course, the student should have the following learning outcomes defined in terms of knowledge, skills and general competence:

Knowledge

The student

- can explain important concepts, theories and processes in hydrogeology
- can outline and discuss how climate change and human activity influence on drainage above and below ground
- can explain the influence of climate change on geohazard risks and discuss the impact on society
- is familiar with research on geohazards and extreme weather events
- can update his/her knowledge about ground and surface water hydrology, and climate related geohazards

Skills

The student

- can assess how human activity, land use and climate change may influence catchment hydrology
- can apply knowledge to define a water related academic problem and find literature to elaborate on that topic
- has acquired skills in discharge gauging
- can use a precise professional language to describe and discuss processes and problems in hydrogeology, hydrology and geohazards

General knowledge

The student

- can communicate and write an academic text on current issues in hydrogeology, hydrology and geohazards, and relate it to scientific literature
- can exchange opinions with others having a background in the field, and provide constructive comments to their work
- can write a field report alone with adequate analysis and illustrations

Teaching Methods and Extent of Organized Teaching: 1-2 lectures/seminars á 2 hours pr. week

Total: 12-18 lectures/seminars.

2-4 days excursion/field course

Forms of Assessment: Portfolio assessment of three assignments: Assignment 1 (20%), assignment 2 (20 %), assignment 3 (60 %).

5.3.4 University of Oslo

*Water and food in a global health perspective – **5 ECTS***

Course content

The course provides basic knowledge on the global challenges related to water, sanitation, food availability and security, as well as waterborne and foodborne infections and intoxications. Through an interdisciplinary approach, combining essential scientific knowledge from fields of anthropology, clinical medicine, history, microbiology, public health and toxicology the course provides appropriate tools to understand and tackle challenges related to water, food and health. Focus will be given to the most vulnerable populations.

Learning outcome

Knowledge

- The risk of infectious diseases associated with water and food
- The diseases associated with chemicals in food and water (toxicology)
- The association between climate changes and risk for food production and malnutrition
- The effect of diet changes on human development and health
- How multiple disciplines bring unique perspectives to questions regarding health and society

Skills

- Water-and foodborne diseases are diagnosed and managed
- Outbreaks of water-and foodborne diseases are investigated
- These diseases can be controlled and prevented

General competence

- An understanding of methods used in the field environmental epidemiology
- An understanding of the societal forces driving health risks associated to food and water

5.3.5 University of Stavanger

*Study program Water Science and Technology - **2 years/4 semesters***

Study plan

Compulsory courses	
+ Water Chemistry	Year 1 / Semester 1
+ Natural Water Systems	Year 1 / Semester 1
+ Environmental Microbiology	Year 1 / Semester 1
+ Environmental Process Analysis	Year 1 / Semester 1
+ Interfacial Water Chemistry	Year 1 / Semester 2
+ Water Treatment and Membranes	Year 1 / Semester 2
+ Separation Technology	Year 1 / Semester 2
+ Master Thesis in Environmental Technology	Year 1 / Semester 2
+ Methods in Water Science and Technology	Year 2 / Semester 3

The specialisation in Water Science and Technology is offered to students who want to focus on aquatic chemistry and ecology, and technologies for water and wastewater treatment. Being more natural science and research based, the programme provides students with fundamental and advanced competences in aquatic chemistry, environmental biotechnology and water process engineering.

With an MSc in Environmental Engineering, graduates will be able to suggest, design and operate adequate environmental process technologies based on profound understanding of recipient aquatic system, in both offshore and onshore companies.

*Natural Water System –**10 ECTS***

Natural Water System gives an introduction to the main water systems on earth - surface waters and water systems in soil and atmosphere - salt- and fresh waters. Emphasis is put on geo-/physical and biogeochemical conditions, transport processes and ecological aspects. The course contributes to the knowledge base for aquatic environmental technology.

Learning outcome

The student shall acquire broad basic knowledge about ecology in natural water systems, hereunder physical and climatic basics and processes, systems ecology, biology and biogeochemistry.

Contents

- The Atmosphere (atmospheric processes, climate and weather, hydrological cycle)
- Freshwater systems (catchment hydrology, rivers and groundwaters, lakes and wetlands, glaciers and permafrost, particular focus on lake eutrophication and biogeochemical processes)
- Sea water systems (ocean basins, wind and ocean circulation, waves and tides, coasts)
- Particles in water, sedimentation and sediments (sea-, lake-, river sediments and soils)
- Organisms and ecology (fresh- and sea water fauna, habitats and ecology)

Coursework requirements

Report from field/laboratory exercises

Participation to field course.

Completion of mandatory lab assignments connected to the field course is to be made at the times and in the groups that are assigned and published on Canvas. Absence due to illness or for other reasons must be communicated to the laboratory personnel as soon as possible. One cannot expect that provisions for completion of the lab assignments at other times can be made, unless prior arrangements with the laboratory personnel have been agreed.

Failure to complete the assigned field and labs or not having them approved will result in non approval of the course.

Method of work: 4 hours lectures per week. Field- and laboratory courses coordinated with parallel 1st semester courses.

Supplementary literature is selected parts of:

- Holden. J., (2008) Introduction to Physical Geography and the Environment. Prentice-Hall.

- ISBN 0131753045.
- Pinet, P.R (2009) Invitation to Oceanography. Fifth edition. Jones and Bartlett Publishers.
- ISBN 978-0-7637-5993-3
- Cole G.A. & Weihe P.E. (2016) Textbook of Limnology, Fifth Edition. Waveland Press, Inc. ISBN 978-1-4786-2307-6

6 Analysis of master curricula in WB

It is from fundamental importance to gain knowledge about existing master curricula related to water resource management in WB for strengthening them. In work package 1.3 (WP 1.3) a collaboration between BOKU and all WB partners is foreseen to get a good overview about existing curricula and courses. In the following chapters several existing master curricula are documented.

6.1 Bosnia

6.1.1 "Džemal Bijedić" University of Mostar – Faculty of civil engineering

UNDERGRADUATE STUDY PROGRAMME: GENERAL

II year - third semester

No.	Subject	L	E	ECTS	Short description
1.	Hydromechanics	3	2	6	Aim of the course is to provide theoretical and practical knowledge of hydrostatic and kinematics of liquids, potential flow, dynamics of ideal and real fluids, hydrodynamics of leakage and flooding, flow in open corridors, groundwater flow and modeling of hydrodynamic processes.
2.	Water supply and wastewater disposal	3	2	6	Presentation of theoretical knowledge on all aspects of the management of water supply and sewage systems. Practical knowledge of hydraulic dimensioning of individual parts of water supply and sewerage systems as well as their design
3.	Hydrotechnical structures	2	0	3	The aim of the course is to introduce the properties of hydro engineering structures, dams and dam types, dam elements.

GRADUATE STUDY PROGRAMME: GENERAL

No.	Subject	L	E	ECTS	Short description
1.	Hydraulics	2	2	6	Introduction to hydraulic systems, open-flow hydraulics, basics of modelling of canal systems, etc. the candidate can independently or in the team solve standard problems related to the design and construction of hydraulic structures, water supply, sewerage, hydroelectric and other hydraulic systems
2.	Water protection	2	2	6	Introducing a student with the basics of pollution of water and environment, water and environmental protection, pollution control procedures.

GRADUATE STUDY PROGRAMME: ENVIRONMENTAL INFRASTRUCTURE MANAGEMENT

No.	Subject	L	E	ECTS	Short description
1.	Sustainable management of communal water supply enterprises	2	2	6	Introducing a student with basic concepts related to the management of utility water companies: - Areas of operational and financial management - Reliability of the water supply system - Loss detection - Multi-criteria decision-making in water supply systems etc.
2.	Sustainable water management in the local community				Development of knowledge about complexity and multidisciplinary of water management issues. Getting acquainted with the various aspects of water emergence in nature and built systems.
3.	Professional project	1	1	2	Realization of courses Professional project is based on interactive teaching and compulsory excursions in selected fields of study (wastewater disposal, water supply, landslides, waste landfills, roads, etc.). It offers students the opportunity to learn through a direct connection with practice and encourages their self-evident problems in different infrastructure systems and construction areas.
4.	Hydropower (MHE)	2	2	5	The aim of the course is to introduce students to hydro-energy use of water. Special emphasis will be given to the role of the MHE in EES in future strategic development at the local level. Hydropower plants for students will be explained through elements of such a hydrotechnical facility.
5.	Wastewater disposal	2	2	5	Presenting advanced knowledge on wastewater disposal of settlements and industry and its importance for ensuring hygiene conditions of life and protection of water from pollution
6.	Studio project	2	2	5	The Studio project is a comprehensive course that should represent the culmination of education through the practical application of knowledge and the introduction of a student into independent work (from research to design and presentation). It is realized through interactive teaching of more related subjects (building physics, instruments and tools of sustainable development, energy efficiency, sustainable energy sources, sustainable management of communal water supply companies, waste water disposal, geotechnical aspects of landfill, management and maintenance of roads).

6.1.2 University of Sarajevo – Faculty of Civil Engineering

Bachelor academic studies – Civil Engineering (3 years)

No.	Year/Semester	Course Title	M(andatory)/ E(lective)	Classes	ECTS
1	II/ 3rd	Hydromechanics	M	3+2	6
2	II/4th	Engineering hydrology	M	2+1	4
3	III/5th	Water Supply and Sewerage System	M	3+2	6
4	III/6th	Hydraulic Structures	M	2+1	4

Hydromechanics

The main goal is that the candidate is qualified for hydraulic engineering calculations: flow in pipe lines, canals and structure for capturing and draining groundwater.

Course content

Definition and classification of fluids, physical properties.
Fluid statics - Hydrostatics.
Fluid kinematics and fluid dynamics.
Euler's equations of fluid motion.
Bernoulli's equation.
The equation of change of momentum.
Leaking fluid through the holes.
Spillover / overflow and highlight below the weir.
Measuring the speed and flow.
Steady flow in pipes under pressure.
Free surface of the steady flow.
Hydraulic jump.

Engineering hydrology

The first main goal of studying Hydrology is to understand basic processes and principles in the framework of the hydrological cycle and the ability to measure and analyze hydrological phenomena. Based on this understanding, the other main objective is to apply the acquired knowledge and skills in solving practical problems. Quantitative description of hydrological processes is a necessary prerequisite for planning, design and operation of hydrotechnical facilities and systems.

Course content

The role of hydrology in planning, design and management of hydro-technical facilities.
Water (hydrological) cycle in nature.
Measurements of all the variables in the hydrological cycle (Hydrometry).
The climatic characteristics that affect the river flow (precipitation, evaporation, interception).
Water regime and flow characteristics (average water, low water, high water).
Statistical methods for analysis of hydrologic processes.
Water Balance.

Water Supply and Sewerage System

The acquisition of basic knowledge of water supply and wastewater sewage, with indications of the need for water processing (intended for drinking, wastewater)

Course content

Historical development. Components and classification of water supply systems. Fundamentals of planning: planning period, consumption and required water quality. Supply sources: water occurance in the nature, characteristics of sources and catchment areas. Capture buildings. Pumping plants: functions, types, pumping station. Tanks: function, volume, forms. Feeder pipelines and distribution network: the basics of sizing, pipe materials. Home/plumbing installation. The role of water treatment plant, as part of the water supply system.

Historical development. Sewerage systems. The types and quantities of waste water: used water - characteristics, calculation of quantity; storm water - characteristics relevant for precipitation, runoff coefficients; other waste waters. Home installation and urban stormwater drainage systems. Sewerage network of settlements (tracing, basics of dimensioning, pipe material and base construction). Facilities and equipment of sewerage system. The role of waste water treatment plant, as a fundamental part of the sewerage system.

Hydraulic Structures

The aim of the study subjects Hydraulic structures is to enable students to apply the knowledge, primarily from fluid mechanics and hydrology, planning, sizing and design of hydraulic structures. Special attention is paid to prepare the necessary groundwork and the planning and conduct of investigative activities.

Course content

Water Management. General information about water. Inconsistency of inflow and consumption. Water Supply Planning. The accumulation basins and flow regulation. The role of water accumulation. Types and basic parameters of the water accumulation. Problems of water accumulation. The characteristics and classification of hydraulic structures. Fundamentals and research work. Dams with the following objects: Dams, purpose and classification of the dams, the basic elements. The load on the dam, stability control. Causes of collapse. Regulatory structures: Buildings for flood protection. Structures for river flow.

Structures for water transport - intake: Channels. Selection of cross-section. Estimation of leakage. Erosion stability. Objects on the canals: aqueducts, siphons, culverts, bridge piers, cascades, fish ladders, measuring objects. Closed water intake with free water surface. Facilities for water abstraction. Facilities for the abstraction of surface water: water intakes on rivers. Water intakes on reservoirs, lakes. Flow in the underground, the physical properties and parameters of ground. Darcy's law. Investigating works. Underground structures - wells, galleries, drainage collectors. Aquifer with free water surface, feeding on the surface, defining the water table for different boundary conditions and environments. Defining yield. Test wells. Performing well.

Master academic studies – (2 year) – Water Resources and Environmental Engineering

No.	Year/Semester	Course Title	M(andatory)/ E(lective)	Classes	ECTS
1	I/ 1rd	Hidrology	M	3+2	6
2	I/ 1rd	Hydraulics	M	3+3	6
3	I/ 1rd	Water Supply Systems	M	3+2	6
4	I/ 1rd	Water Treatment	M	3+2	6
5	I/ 2rd	Sewerage Systems	M	2+3	6
6	I/ 2rd	Environmental Protection	M	2+2	6
7	I/ 2rd	Water Management Systems	M	2+2	6
8	I/ 2rd	Solid Waste Management I	E	3+2	6
9	I/ 2rd	Groundwater Hydrodynamics	E	3+2	6
10	I/ 2rd	Stochastic Hydrology	E	3+2	6
11	II/3rd	Hydropower	M	3+3	7
12	II/3rd	River Engineering	M	3+2	6
13	II/3rd	Water Protection I	M	3+2	6
14	II/3rd	Wastewater Treatment	M	3+2	6
15	II/3rd	Hydrotechnical Melioration	E	3+2	6
16	II/3rd	Numerical Hydraulics	E	3+2	6
17	II/4 rd	Master thesis			30

Hidrology

After mastering the basic knowledge on processes and applicable laws within the hydrological cycle and gaining the ability to measure and analyze hydrological phenomena within the subject of Engineering Hydrology, the goal of Hydrology course is: adopting the methods for defining spatial and temporal distribution of rainfall, average, small and high water levels on basin areas, i.e. defined areas, and hydrological methods for calculating the volume of artificial accumulation as selected structures for leveling of water in time. All this is seen as an indispensable prerequisite for planning, design and managing of hydrotechnical facilities and systems.

Course content

Surface Flux Analysis: Introductory (Hydrological System, Concept of Transformation Function, Origin and Flow Component); causal factors of flaw; rainfall (rainfall in a point, rainfall classification, ITP and PTP diagrams, seasonal and spatial variations of precipitation); drying periods and their importance for the small water regime. Flow Regime and flow characteristics: average flow (statistical distribution of monthly and annual values, seasonal variations, specific flow, flow coefficient, connection with precipitation); small water (daily, monthly, statistical characteristics and distribution, specific flow, recession line analysis); high water (importance in dimensioning waterworks facilities and systems, statistical methods for defining high water levels, parametric methods for defining high water levels,

determination of high water levels based on unit hydrograph, probably of maximum water levels-bases, regional analysis of high water levels, basic regarding transformation of high waters along the watercourse). Hydrological basic regarding accumulation design: purpose of accumulation and their significance in water management; calculation of the required volume of accumulated space/area; space for acceptance of water waves; transformation of the flood waves through accumulation.

Hydraulics

Hydraulics course aims is that the candidate acquires basic knowledge from: dimensional analysis and model similarities, hydraulics of short objects and stationary flow in pipe pressure systems, open channel flow in prismatic channels and flow through the porous media.

Course content

Dimensional analysis and hydrodynamic similarity: dimensional homogeneity and dimensional relations; Π theorem; similarity and modeling; Hydraulics of short objects (openings, overflows, wide thresholds and bridges opening); Steady flow in pipes under pressure; Unsteady flow in pipes under pressure: the mass fluctuations; water hammer; cavitations; Steady flow in open prismatic channels, Unsteady flow in open channels: Saint - Vennant equations, theory and analysis of spatial and temporal gradually varied flow; rapidly varied flow in prismatic and non prismatic channels; Basics of porosity flow - Application of the Darcy`s law to one-dimensional flows – filtration.

Water Supply System

Acquiring knowledge about water supply systems, drinking water capture, transportation and distribution of the required quantities of drinking water for settlements and industry, including all necessary elements of planning and hydraulic calculation of water supply systems.

Course content

Basics of water supply systems. Required quantities of water, water consumption, and quality of water intended for water supply, standards. Quantities for firefighting. Technical documentation. Selection of water supply system, water system facilities, distribution according to method of capture and distribution, regional systems. Drinking water intake. Protection of sources from pollution. Piping regimes in the pipelines, the hydraulic calculation of the inlet pipelines. Tanks: function and elements, division, calculation. Hydrocells. Pump Aggregates: Operation and calculation of pumps and similar plants, hydraulic impact and protection possibilities. Pipes and pipe material. Distribution network: division, hydraulic calculation of branched and ring net, pipeline facilities and network. Plumbing installation of water supply systems. System maintenance. Investment costs and maintenance costs, water prices.

Water Treatment

The objective is to familiarize students with the need of water treatment, hydraulic principles and mechanisms of various technologies and processes of treatment, depending on the quality of row water. Also, the objective is to introduce students to the principles of planning, design and

construction of facilities and installations all of the equipment in water treatment plants within the water supply system.

Course content

Overview of different technologies and processes of water treatment as a function of the quality of water sources. The significance of defining the physical, chemical and bacteriological characteristics of the water from the viewpoint of selection of processing technology - appropriate processes and facilities of water treatment plant. Introduction to relevant legislation (regulations) that considers issues of water protection, categorization of water sources, drinking water quality, laboratory testing ect. Water treatment plant - capacity, disposition of facilities, hydraulic analysis, site selection, measurement, regulation and management. Basic and additional operations and facilities - theoretical foundations, functions, constructions and types, mechanisms and running issues, design. Basics of water treatment modeling.

Sewerage Systems

Sewerage Systems: The acquirement of advanced knowledge about municipality and industry sewerage systems and its importance in providing hygienic living conditions and water pollution protection. Introduce the theoretical concepts and professional rules, related to the planning, design and construction of various systems of the sewerage system from urban areas.

Course content

Introduction. Waste water and stormwater sewerage systems – basics, types, schemes. The relevant quantities of waste water – expanded calculation. Design of the sewerage network and certain facilities - defining all relevant design parameters and their limitations; elevation and horizontal traction of the channel; crossing with other installations and obstacles; static analysis of the collectors; network dimensioning. Sewerage Collectors - types, installation, testing. The usual and special facilities and equipment on the canal network. Drainage of the roads. Basics of dimensioning of waste water outlets. Measuring, operation, maintenance and management of sewerage systems. Guidelines for wastewater treatment. Different project documentation of the sewerage system.

Environmental Protection

Acquisition of basic knowledge about the environment, the causes of contamination and pollution and the prevention of pollution of the environment, and rational use of natural resources. Introduction to basic ecological terms and changes in the biosphere. Consideration of the impact of construction on the environment, cities, landfills, roads and hydraulic structures and systems. Introduction to the concept of sustainable development, and in particular with, the principles of sustainable development in construction. Interpretation of basic measures and environmental practices.

Course content

Introduction to Environmental Protection. The basic ecological concepts; Habitat; Ecology. Biotop ecosystem; Biodiversity. Geochemical composition of the earth's crust: the hydrosphere and

atmosphere. The causes of contamination by the environmental pollution: natural, anthropogenic, of venom. The changes in the biosphere. Changes in the atmosphere. Pollution pedosphere. Pollution of hydrosphere. Pollution through energy discharge. Reduction of biodiversity. Climate changes. The impact of construction on the environment: The impact of cities; The impact of the landfill; The impact of roads; The impact of hydraulic engineering. Sustainable Development and Construction: Principles of sustainable development in construction.

Natural processes and hazards that affect the environment: volcanoes, earthquakes, floods, floods, processes on the slopes, landslides. Interaction between natural and anthropogenic factors and their influence on the formation process of the padinaam. The measures and procedures of defense against landslides, torrents and floods. Peneplain. Measures and environmental protection procedures: The political and sociological approach; Legal measures; Planning and environment management; Economic and financial measures; Scientific approach and technological measures; Institutional measures.

Water Management Systems

As a result of the clash of interests in the water domain, the problem of protection against harmful effects of water, the increase in the demand for water system efficiency, the increasing threats to man and its environment due to water pollution, the water management systems are becoming more complex configurations and complex structures, requiring a qualitatively new approach for their planning, design and management. Due to the fact that under these conditions the traditional water planning methods have become unenforceable, the aim of this course is to master the basic techniques and methods of applied science on water management systems, for planning, optimizing, simulation and managing water management systems.

Course content

General tendencies in water management: basic characteristics of water resources; available quantities and their inequality; water quality and trend of change; global indicators of water needs; water management areas and branches. Water management systems-basic postulates: definition and basic characteristics; development phase; system division; mathematics models of water management systems. Planning of water management systems: planning tasks; goals in water management planning; decision making; optimization and expert systems in the decision-making process. Optimization of water management systems: optimization tasks; systematization methods; goal and limit functions; most commonly used methods of system optimization. Simulation of water management systems: concept and tasks of simulation; forming a simulation model; model verification. Management of water management systems: basic principles and tasks of management; Criteria and Limitations in Management Tasks. Economic analysis of water management systems: the term investment; making investment decisions; methods for making investment decisions. Water management systems and the environment: environmental pollution issues; significant ecological terms; impacts of water management systems on the environment.

Solid Waste Management I

Introduction to students with the basics of waste management, types of waste, processing methods and final disposal, in accordance with the applicable legal frameworks in BiH and the EU. Clarify the

methodology for selecting the appropriate technical solution, the way of dimensioning and selection of equipment for waste recovery and disposal.

Course content

Basic on solid waste management, principles, legal framework in BiH and the EU. Types of waste and basic characteristics. Production and properties of solid waste. Collection and transport - location and dimensioning of transfer stations. Selection of technology and methods of municipal waste management. Waste reduction. Waste recycling: significance, processes, equipment, physical and mechanical processes, recycling of certain types of waste. Recycling and application of construction materials derived from waste. Biological waste treatment: aerobic and anaerobic treatment. Compost: dimensioning and guiding the process. Mechanical biological treatment (MBO) of waste. Thermal waste treatment. Sanitary landfills: definitions of basic concepts and size for the budget, methods of disposal, processes in landfills. Landfill gas. Landfill water. Selection of landfill sites, construction techniques, power plants and infrastructure, mechanization, landfill monitoring. Remediation of wild dumps. Hazardous waste.

Groundwater Hydrodynamics

The aim of the study dynamics of groundwater is that the candidates acquire the basic knowledge about: the formation of groundwater, porous media characteristics and the basic equations of groundwater flow. Candidates will be qualified for hydraulic engineering calculations of steady and unsteady flow of groundwater, both plane and radial flows. Based on data interpretation pumping test will be trained for the calculation of the basic hydrodynamic parameters of porous media.

Course content

Characteristics of porous media: the structure and texture of the porous media; the concept of continuity of the porous media; representative elementary volume and porosity; total and effective porosity; Basic equations of groundwater flow: Darcy's law; physical meaning of Darcy 's law; Limits the validity of Darcy 's law; Application Darcy 's law at the flow under pressure and free surface flow in stationary conditions by hypothesis Dipuia; Generalization of Darcy 's law: The use of potential flow at the flow in porous media; Laplace equation - derivation of the Navier - Stokes equations; Two dimensional - 2D unsteady flow of groundwater: Elementary differential equations - equations Boussinesq's; Methods of solving; Radial unsteady flow: Differential equations of radial flow; Theiss's solution the equation; Application Theiss's equation; Additional hydraulic losses in the well and filter's zone; Pumping test analysis - interpretation of data pumping test in the steady and unsteady regimes; Semi graphical data processing for test pumping; Pumping with variable flow; Application of computers in data processing of test pumping.

Stochastic Hydrology

The classical techniques of probability theory and statistics, studied in the course of hydrology and engineering hydrology, were sufficient in hydrological practice, until different complexities of multipurpose approaches for the use of water resources and complexity of the environment and water quality did not enter into the water management, which requires the introduction of stochastic techniques, e.g. spatial and time stochastic models for describing and analyzing the hydrologic

processes. In this course, students will master the basic techniques of stochastic modeling of hydrologic processes, which will serve as an important tool in the process of planning and managing water supply systems and facilities.

Course content

Terms and Definitions of Stochastic Processes. Classification of hydrological processes. Terms and definitions of stationarity and ergonomics. Linear-dependent stochastic processes. Stationary and ergonomic tests. Hydrologic time series (general characteristics of the series, hydrological series classification, autocorrelation and cross correlation with displacement). Linear Models (Basic Ideas and Mathematical Formulas of Linear Models, Yule-Walker Equations, Auto regression AR Models, Moving Average Models - MA Models, ARMA Models, Parameters of Linear Models). Decomposition of Hydrological Time Series (Periodic Component Series, Stochastic Component Series). Generation of synthetic hydrological series. Hydrologic series range analysis (span analysis as a method for hydrological processes, span analysis as a method for solving water accumulation problems).

Hydropower

The aim of studying Hydropower is to introduce students hydro power water use. Emphasis in the Hydropower shall be given small hydro power systems in and their development at the local level. Hydro power facilities will be explained in all the elements of such a complex hydraulic structure - from water supplies and lock chamber, through tunnel and penstock, through various types of machine building.

Course content

Physical fundamentals of Hydroelectric power, the energy of the water flow, the energy of fluid in hydraulic machines, losses in energy and transformation coefficients. All types of hydroelectric power plants and their classification. The hydropower potential and methodological aspects of the same gross and net potential of the river, specific aspects of presentation of hydropower. Economic characteristics of plants and methodological aspects of the evaluation and optimal dimensioning of HPP. Retentions and regulation of flow in them, geometric and operational characteristics of accumulation basins, determining losses from reservoirs, etc. Turbine HPP, bases, classification, development, cavitations turbine and its impact on the solution of HPP, cavitations coefficient and permissible sucking height. The choice of the parameters and turbine. Transient phenomena.

River Engineering

Acquisition of basic knowledge about the objectives and problems in regulatory work, as well as the approach and how to resolve certain problems. Special attention is paid to the study of the necessary maps, geological background, hydrologic and hydraulic analysis of the significance of river regulation. Application of the acquired theoretical knowledge in the field of mechanics, hydraulics and hydrology in the river hydro-engineering. Mastering new methods to solve practical engineering problems in the field of hydraulic engineering river.

Course content

The purpose, problems and tasks of regulation. The role of of waterways regulations in water management. Basic definitions and divisions. Morphological characteristics of the waterways: the purpose and character of the morphological analysis, the application of statistical and other methods. Catchment area. Types of forms watercourses. Meandering. The roughness of the riverbed. Basic characteristics of alluvial material. Hydrologic properties of natural watercourses, water regime, sediment regime, ice. Water regime. The impact of the regulation of the flow regime in the aquifer: the construction of reservoirs, retention basins and pressure relief channel. Interventions on the catchment area and the water regime, functioning. Hydraulic calculation of natural and artificial watercourses. Calculations of flow in open channels. Analysis, sediment. Trailed tension. Calculations stability of the riverbed. Training works at watercourse bed. The longitudinal structure, vertical buildings and structures for special purposes. Training facilities out of the riverbed. Flood protection, technical defense embankment. Embankments and stone deposits. Prokopi. Floods and Flood Risk Assessment. Making plans danger of flooding. Assessment of damage and mapping flood risk. Analysis of the elements of the system of flood protection. Work on the regulation of watercourses and their impact on the environment: Concepts solutions favorable to the environment. The procedures and measures of recovery of watercourses in the basin, the corridor around the river bed and the bed of the watercourse. Ecological engineering and when conventional engineering in the function recovery of watercourses

Water Protection I

Acquisition fundamental knowledge about the characteristics of natural water, changes of water quality and causes changes in water quality, and the activities, measures and plans for water protection. After completing the course, students will gain the ability to review the impact of pollutants on the environment, forecasting transport of contaminants, planning of measures and activities in the protection of water resources

Course content

The basic characteristics of water resources: water origin and development of scientific thinking about water. Distribution of the global amount of water on the planet. The hydrologic cycle. Water balance. The basic characteristics of water. The composition of natural waters. Water quality. The change in water quality. Water regime. The basic characteristics of water resources of Bosnia and Herzegovina. Pressures on water resources: Pollution and contamination of water-quality changes of water. Sources of water pollution. Distribution of sources of pollution to the spatial scope and manner of release. Active and potential sources of pollution. The dilution and self-purification. Re-pumping source. Access to water protection: Sustainable developmental concept, dimensions and character, differences and advantages over non-sustainable, sustainable development and water resources. Basic terms of water management, historical development. Integrated water resources management - IWRM: The concept of integrated water resources management, in term of integrated water resources management, natural system and human activities - System Manageability WR = relations, measures, actions, conflicts. The advantages, principles and implementation IWRM. The strategies and principles. Control mechanisms. The quality of the effluent. Receivers and protection of water ecosystems. Eco flow. Water Framework Directive and the valid EU and BH legislation in the field of water. Implementation of Water Management, Water Management Master Plan and plans. The measures and procedures for the protection of water. Methods of groundwater remediation. Planning of water protection: The basic principles of planning, control of pollution sources, the basics of systematic approach to protect water resources, essential elements to create a plan for water

protection. Mathematical models and their use in monitoring and forecasting of transport of contaminants in surface and ground waters, and solve the problem of water protection.

Wastewater Treatment

Introducing students with basics of wastewater treatment, as integral part of integrated water management. Students in this course acquire relevant knowledge related to the mechanical, chemical and biological processes of wastewater treatment depending on the composition and choice of the recipient as well as the designing of the structures in which these processes take place. Hydraulic plant calculations are included.

Course content

The origin of wastewater (WW), characteristic composition and quantity of WW. Project Criteria. Standard for WW treatment. Legal frameworks. Pretreatment. Mechanical Treatment Procedures (Primary Treatment). Secondary - biological treatment: the basis of the process, chemical processes, technical - technological processes of active sludge treatment (AS) in suspended growth. Sludge treatment procedures. Subsequent precipitation. MBR and SBR devices. Tertiary level of treatment. Programmable Dimension Software - Aqua designer. Unconventional wastewater treatment technologies (bio rotors, bio filters, lagoons). Hydraulic calculation of the plant. Plant monitoring. Costs related to plant, operation and maintenance

Hydrotechnical Melioration

Adoption of basic knowledge about water-air regime of soil and the laws of formation of waterways. Main task of land melioration is drainage or irrigation needed in order to achieve a higher form of modern intensive agricultural production and crop production in general, the aim of the course Hydrotechnical melioration is to adopt knowledge of various engineering measures and irrigation techniques which alter water properties of soil, increasing soil fertility, creating optimal conditions for food production to meet the necessary needs of population that are constantly increasing.

Course content

Introduction; concept and purpose of irrigation; current state and irrigation development in BiH; water in soil; relations plant-water-air; factors of plant growth and the impact of certain factors. Fundamentals of Soil science: genesis of the soil; physical and chemical properties; land classification; Soil irrigation: basic principles and criteria; designing the system and basic elements; required amount of water for irrigation (irrigation and soaking norm). Basic forms of irrigation and irrigation system elements: irrigation operation; norm, module, round, efficiency; irrigation techniques; conditions for determining irrigation methods; irrigation methods (overflow irrigation, irrigation by flooding, irrigation by infiltration, sprinkling irrigation, localized irrigation); planning and design of irrigation systems; basics of construction and maintenance of irrigation systems.

Numerical Hydraulics

Numerical Hydraulics course aims to: Introducing students with problems of unsteady flow of water in pipes, open flows and mathematical modeling of these cases. Acquiring practical knowledge of

physical and numerical modeling flow in open watercourses and pressure systems, gaining insight into the possibilities of application modern numerical models.

Course content

Introducing unsteady flow in pressure systems; Oscillations of fluids in pipes, execution of basic equations, numerical methods for solving equations; Hydraulic impact, the derivation of basic equations, numerical methods for solving equations, Facilities on pipelines and objects for protection against hydraulic shock, defining contour conditions, Numerical modeling of non-stationary phenomena in pressure systems - application of software; Non-stationary flow in natural and regulated aquifers, derivation of basic equations, Navier -Stokes and Saint Venant equations, equations of conservation of mass, the dynamic equation, Numerical solving of basic equations; Numerical modeling of non-stationary phenomena in open flows - application of software.

Link: http://www.gf.unsa.ba/studijski-program-brosura-2017.pdf

6.1.3 Missing skills and knowledge

Although the master programs include the most important aspects of water resources management and environmental protection, the curricula should be updated with respect to current developments. This includes both, development of technology as well as population increase and climate change. Additional knowledge which should be delivered in the master programs includes aspects of integrated water resources and urban water management. In addition students should get a holistic view to solve the cause of problems in the catchment area and to find cross sectorial solutions to problems.

Concrete examples of deficits are e. g.: While the design and construction of water supply and sewer systems are taught in detail, students learn only little about the management and maintenance of operational systems. Similarly, technical aspects of the treatment of portable water are covered by the master programs, but the students miss an overview of integrated approaches which also include the protection and analysis of water resources. Finally, students need to acquire competencies to solve problems of urban ecology by taking into account the overall hydrological cycle instead of only parts of it.

To acquire these skills and knowledge up-to-date laboratory equipment and software is needed. On top of that there is not enough teaching staff to adequately support all students.

6.2 Kosovo*

6.2.1 University of Pristina in Kosovska Mitrovica – Faculty of Technical Sciences

Undergraduate study program ECTS 240

ON	Course code	Course title	S	Status	Active teaching			OC	ECTS
					L	E	OFT		
FIRST YEAR									
1	1.1.6.OGZ	Mathematics 1	1	M	3	2	0	0	6
2	1.2.5.OGZ	Descriptive geometry	1	M	2	2	0	0	5
3	1.3.5.OGZ	Geodesy	1	M	2	2	0	0	5
4	1.4.3.OGZ	Engineering geology	1	M	2	1	0	0	3
5	1.5.5.OGZ	Engineering physics	1	M	2	1	1	0	5
6	Elective course 1								
	1.6.4.OGZ.1	Introduction to Computer Applications	1	E	1	3	0	0	4
	1.6.4.OGZ.2	Computer drawing in Civil Engineering	1	E	1	3	0	0	4
7	Elective course 2								
	1.7.2.OGZ.1	The English Language 1	1	E	0	2	0	0	2
	1.7.2.OGZ.2	The Russian Language 1	1	E	0	2	0	0	2
8	2.1.6.OGZ	Mathematics 2	2	M	3	2	0	0	6
9	2.2.8.OGZ	Engineering Mechanics 1	2	M	3	2	0	0	8
10	2.3.4.OGZ	Basics of Environmental Engineering	2	M	2	2	0	0	4
11	2.4.4.OGZ	Building materials 1	2	M	2	1	0	0	4
12	Elective course 3								
	2.5.4.OGZ.1	Advanced using computers	2	E	1	3	0	0	4
	2.5.4.OGZ.2	Application of spreadsheets for calculations	2	E	1	3	0	0	4
13	Elective course 4								
	2.6.2.OGZ.1	Business presentations and communications	2	E	2	0	0	0	2
	2.6.2.OGZ.2	Internet and e-business	2	E	2	0	0	0	2
14	Elective course 5								
	2.7.2.OGZ.1	The English Language 2	2	E	0	2	0	0	2
	2.7.2.OGZ.2	The Russian Language 2	2	E	0	2	0	0	2

ON	Course code	Course title	S	Status	Active teaching			OC	ECTS
					L	E	OFT		
SECOND YEAR									
1	3.1.5.OGZ	Mathematics 3	3	M	2	2	0	0	5
2	3.2.8.OGZ	Strength of materials 1	3	M	3	3	0	0	8
3	3.3.4.OGZ	Engineering mechanics 2	3	M	2	2	0	0	4
4	3.4.5.OGZ	Fluid mechanics	3	M	2	2	0	0	5
5	3.5.4.OGZ	Building materials 2	3	M	2	2	0	0	4
6	3.6.2.OGZ	Legal regulations in construction	3	M	2	0	0	0	2
7	3.7.2.OGZ	Engineering Economics in Construction	3	M	2	0	0	0	2
8	4.1.6.OGZ	Soil mechanics	4	M	2	2	0	0	6
9	4.2.4.OGZ	House construction	4	M	2	2	0	0	4
10	4.3.4.OGZ	Strength of materials 2	4	M	2	2	0	0	4
11	4.4.4.OGZ	Building physics	4	M	2	1	0	0	4
12	4.5.6.OGZ	Traffic infrastructure systems	4	M	3	2	0	0	6
13	4.6.6.OGZ	Hydro-technics	4	M	3	2	0	0	6

ON	Course code	Course title	S	Status	Active teaching			OC	ECTS
					L	E	OFT		
THIRD YEAR									
1	5.1.8.OGK	Theory of structures 1	5	M	4	3	0	0	8
2	5.2.6.OGK	Theory of concrete structures	5	M	3	2	0	0	6
3	5.3.5.OGK	Steel structures	5	M	2	2	0	0	5
4	5.4.6.OGK	Timber and masonry structures	5	M	3	2	0	0	6
5	Elective course 6								
	5.5.2.OGK.1	Concrete technology	5	E	1	1	0	0	2
	5.5.2.OGK.2	Contemporary materials in construction	5	E	1	1	0	0	2
6	Elective course 7								
	5.6.2.OGK.1	Finishing works and In-house installations	5	E	2	0	0	0	2
	5.6.2.OGK.2	Hydro-technical infrastructure systems	5	E	2	0	0	0	2
7	6.1.6.OGK	Theory of structures 2	6	M	3	3	0	0	6
8	6.2.6.OGK	Design and construction of concrete structures	6	M	2	3	0	0	6
9	6.3.5.OGK	Steel structures 2	6	M	2	2	0	0	5
10	6.4.5.OGK	Measurement and evaluation of works in construction	6	M	2	2	0	0	5
11	6.5.7.OGK	Foundations	6	M	3	3	0	0	7
12	6.6.2.OGK	Internship	6						2

ON	Course code	Course title	S	Status	Active teaching			OC	ECTS
					L	E	OFT		
FOURTH YEAR									
1	7.1.6.OGK	Dynamics of Structures and Earthquake Engineering	7	M	3	2	0	0	6
2	7.2.5.OGK	Planning methods in construction	7	M	2	2	0	0	5
3	7.3.4.OGK	The theory of slabs	7	M	2	2	0	0	4
4	7.4.4.OGK	Design and construction of concrete structures 2	7	M	2	2	0	0	4
5	7.5.4.OGK	Pre-stressed concrete	7	M	2	1	0	0	4
6	Elective course 8								
	7.6.2.OGK.1	The use of computers in the design of structures	7	E	2	0	0	0	2
	7.6.2.OGK.2	Elastoplastic analysis of line systems	7	E	2	0	0	0	2
7	Elective course 9								
	7.7.5.OGK.1	Stability of structures	7	E	2	2	0	0	5
	7.7.5.OGK.2	Basics of composite structures	7	E	2	2	0	0	5
8	8.1.5.OGK	Steel structures in Building Design	8	M	2	2	0	0	5
9	Elective course 10								
	8.2.4.OGK.1	Structural Testing and Fundamentals of Experimental Methods	8	E	2	2	0	0	4
	8.2.4.OGK.2	Special problems of foundation	8	E	2	2	0	0	4
	8.2.4.OGK.3	Finite element method	8	E	2	2	0	0	4
10	Elective course 11								
	8.3.3.OGK.1	Concrete structures construction technology	8	E	2	1	0	0	3
	8.3.3.OGK.2	Special steel structures	8	E	2	1	0	0	3
11	Elective course 12								
	8.4.3.OGK.1	Glued laminated wooden structures	8	E	2	1	0	0	3
	8.4.3.OGK.2	Production Technology of steel structures	8	E	2	1	0	0	3
12	Elective course 13								
	8.5.3.OGK.1	Project management in construction	8	E	2	0	0	0	3
	8.5.3.OGK.2	Composite Steel and Concrete Structures	8	E	2	0	0	0	3
13	8.6.12.OGK	Final year project	8						12

ON – Ordinary number; S – Semester; Status: M – Mandatory, E – Elective; L – Lectures; E – Exercises; OFT – Other forms of teaching; OC – Other classes;

Master study programme ECTS 60

ON	Course code	Course title		S	Status	Active teaching			OC	ECTS
						L	E	OFT		
1	1.1.5.DGK	Concrete bridges		1	M	3	2	0	0	5
2	1.2.5. DGK	Steel bridges		1	M	3	2	0	0	5
4	1.3.5. DGK	Design of Hydraulic Structures		1	M	2	1	0	0	5
5	1.4.5. DGK	Elective course 1		1						5
		1	Rehabilitation, reconstruction and maintenance of concrete structures in construction	1	E	2	2	0	0	5
		2	Rehabilitation, reconstruction and maintenance of masonry and wooden structures	1	E	2	2	0	0	5
		3	Light steel structures	1	E	2	2	0	0	5
6	1.5.5. DGK	Elective course 2		1						5
		1	Rock mechanics and underground construction	1	E	2	2	0	0	5
		2	Analysis of structures on dynamic loads	1	E	2	2	0	0	5
		3	Special types of concrete structures	1	E	2	2	0	0	5
7	2.1.5. DGK	Internship		2	M					5
8	2.2.10. DGK	Study research work on the preparation of the Master thesis		2	M				20	10
9	2.3.20. DGK	Master thesis		2	M					20

ON – Ordinary number; S – Semester; Status: M – Mandatory, E – Elective; L – Lectures; E – Exercises; OFT – Other forms of teaching; OC – Other classes

Course name		Concrete bridges	
ECTS	5	Course status (mandatory/elective)	elective
Pre-requisites			
Course objectives	Acquiring theoretical and practical knowledge for designing concrete bridges, using BAB'87 and Eurocodes, in order to follow modern methods and recommendations of FIP and ACI. Fundamentals of calculation, materials, durability and protective layer of concrete to reinforcement, structural analysis, load bearing limit states, limit states of usability, structural details of reinforcement and cables for pre-stress.		
Syllabus			
Lectures	1. Concrete bridges: Introduction, design principles construction of bridges, static system, foundation, hydraulic analysis of bridge openings, design and construction of bridges, testing of bridges for test load. 2. Concrete constructions: Introduction, pillar calculations, calculation of bending elements, T cross-section carriers, calculation to transferal forces - main tensile stresses.		
Practical teaching (excersises, OFT, study research work)	1. Concrete bridges: Preparation of a bridge conceptual design, monitoring of the construction phase of the bridge (construction site). 2. Concrete constructions: Practical teaching: Creating tasks (2) according to the chapter.		

Hours of Active Classes per Week				
Lectures	Exercises	OFT	Study research work	Other classes
3	2			
Teaching methods	Lectures and excersises.			

Assessment (max. 100 points)			
Pre-exam obligations	points	Exam	points
activity during lectures	10	written exam	50
practical teaching	10	oral exam	
colloquiums	20		
seminars	10		

Course name		Steel bridges	
ECTS	5	Course status (mandatory/elective)	elective
Pre-requisites			
Course objectives	To introduce students with the basics of bridge construction, or acquire basic knowledge in the field of steel bridges. Students are introduced to the basic elements of road and railroad bridges with a brief overview of other types of bridges such as pedestrian, industrial, mobile ... Modern design systems used in bridge construction are considered, such as composite bridges and bridges of the orthotropic plate system . Special attention is being paid to the general arrangement of the bridge.		
Syllabus			
Lectures	Introduction to metal bridges: general (definition, division, components, disposition) bridge position in the ground plan, bridge level, openings, bridge width, construction height, free profile, carriageway position, historical overview of the development of metal bridges. Railway bridges: main structural elements, free profile, bridge width, carriageway and pavement girders, joints and transverse stiffness, main girders - full and lattice. Road bridges: main elements of construction, traffic and free profile, bridge width, carriageway, drainage, fences and bumpers, supporting carriage construction, main girders - full and lattice, compound construction. Bridge bearings: function, division, layout, selection, setting, operation. Carriageway crossings: function, selection, operation. Structural systems: field of application and basic characteristics - beam bridges, supported frame bridges, bridges with sloping cables, hanging bridges. Assembly: choice of assembly technology, basic types - mounting on a scaffold, free assembly, installation by transverse or extended coating. View selected bridges made in Serbia. View the bridges in the world.		
Practical teaching (excersises, OFT, study research work)	Examples are provided that are following theoretical part.		

Hours of Active Classes per Week				
Lectures	Exercises	OFT	Study research work	Other classes
3	2			
Teaching methods	Lectures and excersises			

Assessment (max. 100 points)			
Pre-exam obligations	points	Exam	points
activity during lectures	5	written exam	35
practical teaching	5	oral exam	35
colloquiums			
seminars	20		

Course name		Design of Hydraulic Structures	
ECTS	5	Course status (mandatory/elective)	elective
Pre-requisites			
Course objectives	Training of participants to structural design of hydraulic structures (HS).		
Syllabus			
Lectures	Introduction to hydraulic structures (HS). HS features and design. Reservoirs: purpose, basic concepts. Characteristics and division of HS. Basics of HS design. Building materials. Damage and collapse of HS. Monitoring of HS. Dams and Appurtenant structures. Basic types and layouts. Spillways, outlet works and diversion structures. Concrete Gravity Dams (CGD): features and basics. Seepage in foundations. Concrete Gravity Dams: Load analysis and Load Combinations, overall stability. CGD: Computation of displacements. CGD: Structural design. Cracks. Impact of temperature. Construction of concrete dams. Roller Compacted Concrete Dams (RCC). Arch dam: characteristics, loads, structural analysis. Other types of concrete dams. Embankments Dams: characteristics, basics and loads, seepage. Stability of Embankment Dams. Earth Dams. Rockfill Dams. Construction of Earth Dams. Other hydraulic structures.		
Practical teaching (excersises, OFT, study research work)	Examples are provided that are following theoretical part.		

Hours of Active Classes per Week				
Lectures	Exercises	OFT	Study research work	Other classes
2	2			
Teaching methods	Lectures and excersises			

Assessment (max. 100 points)			
Pre-exam obligations	points	Exam	points
activity during lectures	5	written exam	30
practical teaching		oral exam	20
colloquiums	30		
seminars	15		

Course name			Rehabilitation, reconstruction and maintenance of concrete structures in construction	
ECTS	5		Course status (mandatory/elective)	elective
Pre-requisites				
Course objectives	Students are taught the main principles and guidelines for repair, reconstruction and maintenance of reinforced concrete (RC) structures.			
Syllabus				
Lectures	Reasons and processes which in turn lead to actions of repair/strenghtening of RC structures. Durability of RC structures. Service life design of reinforced concrete structures. Basic concept of durability and reliability. Design verification for basic deterioration mechanisms. Maintenance of infrastructure – importance and the main principles and guidelines. Condition rating assessment for bridges and buildings. Structure strenght evaluation – update of loadings, update of member properties. Semi probabilistic and probabilistic proofs – the main principles. Repair of damaged RC elements – use of adequate materials (repair mortars, carbon fiber reinforced polymers, steel plates/jackets). Strenghtening and repairs of RC beam elements subjected to bending and shear. Strenghtening and repair of RC plate elements. Strenghtening and repair of RC elements by reconstruction and use of pre-stressing. Planning of maintenance actions and management of infrastructure.			
Practical teaching (excersises, OFT, study research work)	Solving problems from practice which are related to the teaching contents.			
Hours of Active Classes per Week				
Lectures	Exercises	OFT	Study research work	Other classes
2	2			
Teaching methods	Lectures and excersises			
Assessment (max. 100 points)				
Pre-exam obligations		points	Exam	points
activity during lectures		5	written exam	30
practical teaching			oral exam	30
colloquiums		20		
seminars		15		

Course name			Rehabilitation, reconstruction and maintenance of masonry and wooden structures	
ECTS	5		Course status (mandatory/elective)	elective
Pre-requisites				
Course objectives	Introducing the audience to main causes of damages to masonry and timber structures, classification of damages. Methods, materials and techniques of rehabilitation and protection.			
Syllabus				
Lectures	Causes and classification of structural damages to timber and masonry structures. Examples of damaged structures, typical damages, evaluation of structure. Classification of damages and causes – fire, earthquake, explosion, overload, moisture, uneven subsidence, biological influences, chemical influences, mechanical influences etc. Methods and techniques of identification and quantification of damages. Methods, materials and techniques of rehabilitation and maintenance. Rehabilitation and protection of cultural heritage buildings.			
Practical teaching (excersises, OFT, study research work)	Students individually work on the project of rehabilitation and reconstruction for a given structure or the project for maintenance of a structure with timber or masonry elements.			
Hours of Active Classes per Week				
Lectures	Exercises	OFT	Study research work	Other classes
2	2			
Teaching methods	Lectures and excersises			
Assessment (max. 100 points)				
Pre-exam obligations		points	Exam	points
activity during lectures		10	written exam	40
practical teaching			oral exam	
colloquiums				
seminars		50		

Course name			Light steel structures	
ECTS	5		Course status (mandatory/elective)	elective
Pre-requisites				
Course objectives	Introduction to the basics of calculation and design of cold-formed steel structures and aluminum alloys structures.			
Syllabus				
Lectures	Introduce with the program and work organization on course. Application of cold formed profiles and sheets. Basic material properties. Production and pallet of cold-formed products. Influence of the cold forming at mechanical material properties. Steel grades for cold-formed products. The effective width of stiffened and unstiffened cross section parts (webs and flanges) of elements. Calculation of the geometric properties of the effective cross-section. Compressed members with open cross-section. Buckling (flexural, torsional and flexural-torsional buckling). Distorsional buckling. Bending members. Moment resistance. Shear resistance. Combined bending moment and shear force. Lateral torsional buckling. Purlins and girts made of cold-formed profiles (specificity of calculation and rules for design). Fasteners for cold-formed structural elements. Application of the structural elements of aluminium alloys in civil engineering. Production and pallet of products. Mechanical material properties of aluminium alloys. Specificity of the design and connection of aluminium structural elements. Axially loaded members (tension and compression). Buckling of compressed members. Failure of the cross-section caused by local buckling. Bending structural elements – beams. Eccentrically loaded structural elements (interaction of bending and axial compression force).			
Practical teaching (excersises, OFT, study research work)	Numerical examples which are processed on exercise completely follow the content of course.			

Hours of Active Classes per Week				
Lectures	Exercises	OFT	Study research work	Other classes
2	2			
Teaching methods	Lectures and excersises			

Assessment (max. 100 points)			
Pre-exam obligations	points	Exam	points
activity during lectures	20	written exam	15
practical teaching		oral exam	15
colloquiums	50		
seminars			

Course name			Rock mechanics and underground construction	
ECTS		5	Course status (mandatory/elective)	elective
Pre-requisites				
Course objectives	Introducing students of the basis of rock mechanics, designing of underground structures, stress analysis, methods of analysis of structures and their performance.			
Syllabus				
Lectures	Mechanical, physical and rheological properties of the rock as material that makes the environment in which are performed underground structures. Introduction of the methods of calculation and analysis of loads on underground structures. Display of modern construction technology of underground structures.			
Practical teaching (excersises, OFT, study research work)	Individual work of students in the form of project one traffic or hydrotechnical tunnel. Making two colloquiums.			
Hours of Active Classes per Week				
Lectures	Exercises	OFT	Study research work	Other classes
2	2			
Teaching methods	Lectures and excersises			
Assessment (max. 100 points)				
Pre-exam obligations		points	Exam	points
activity during lectures		10	written exam	30
practical teaching			oral exam	40
colloquiums		20		
seminars				

Course name			Analysis of structures on dynamic loads	
ECTS		5	Course status (mandatory/elective)	elective
Pre-requisites				
Course objectives	Acquiring knowledge from the analysis of structures exposed to the effects of vibration from traffic, impact, wind, etc.			
Syllabus				
Lectures	Vibration sources and vibration effects on structures. Dynamic analysis in time and frequency domain. Methods of analysis with distributed, consistent and concentrated mass. Fourier transform. Method of spectral elements. Interaction of soil and object. Application of computer programs: Matlab, SAP2000, SASSI			
Practical teaching (excersises, OFT, study research work)	Examples are provided that are following theoretical part.			
Hours of Active Classes per Week				
Lectures	Exercises	OFT	Study research work	Other classes
2	2			
Teaching methods	Lectures and excersises			
Assessment (max. 100 points)				
Pre-exam obligations		points	Exam	points
activity during lectures		10	written exam	40
practical teaching			oral exam	(50)
colloquiums		50		
seminars				

Course name			Special types of concrete structures	
ECTS		5	Course status (mandatory/elective)	elective
Pre-requisites				
Course objectives	Introduction to students with special types of concrete structures (design, calculation, dimensioning, execution): silos, hanging roof structures, halls for small sports, shelters, reservoirs, water tanks, chimneys, stadiums, high buildings, garages, pipes, power lines.			
Syllabus				
Lectures	Design, load, calculation, dimensioning and execution: silo, hanging roof constructions, small sports hall, shelters, reservoirs, water tanks, chimneys, stadiums, high buildings, garages, pipes, power lines.			
Practical teaching (excersises, OFT, study research work)	Development of the Conceptual Design of a Concrete Structure.			
Hours of Active Classes per Week				
Lectures	Exercises	OFT	Study research work	Other classes
2	2			
Teaching methods	Lectures and excersises			
Assessment (max. 100 points)				
Pre-exam obligations		points	Exam	points
activity during lectures			written exam	30
practical teaching			oral exam	20
colloquiums		20		
seminars		30		

Course name		Internship	
ECTS	5	Course status (mandatory/elective)	elective
Pre-requisites			
Course objectives	Development of the student's ability to apply practical knowledge gained from studies in the field of construction and to familiarize with the processes of planning, designing and building construction objects.		
Syllabus			
A four week professional practice involves student participation in concrete activities of realization of professional or scientific-research projects. It is performed either in enterprises or in appropriate institutes.			
Teaching methods	The student receives instructions for conducting professional practice from the student service. The student's attendance in the organization to which it is addressed is mandatory, with due respect for the work plan received from the staff responsible for the students in practice. Staff in charge of students follow the student's presence and ultimately gives an assessment of his engagement in practice. Upon completing the practice, a student writes a report and hands it over to a teacher in charge of the practice.		
Assessment (max. 100 points)			
The assessment of professional practice is descriptive and does not enter the average of studying.			

Course name		Study research work on the preparation of the Master thesis	
ECTS	10	Course status (mandatory/elective)	elective
Pre-requisites			
Course objectives	The aim of the study research work is to prepare the student for the Master thesis through the preparation of a seminar paper (essay) on the subject from the selected narrow field of construction from which the student should work thesis. The aim of this activity is to examine the situation in the selected narrow area and define the specific content of graduation work.		
Syllabus			
The student prepares a seminar paper (essay) on a selected topic containing a review of literature from the chosen field, identification of the problem being solved, description of the problem solving methods, conclusions and the content of the thesis. Depending on the topic, part of the study research work can be done on the field or in the laboratory.			
Hours of Active Classes per Week			
Lectures	Exercises	OFT	Study research work	Other classes
			20	
Teaching methods	Independent work of the student in the preparation of seminar work (essays), in consultation with the selected teacher (mentor for graduation work). The mentor gives instructions to the student, points him to specific literature and directs him in order to produce high-quality essays and graduation work. In addition to consulting with a mentor, the student can also conduct consultations with other teachers or experts from other institutions and companies dealing with issues related to the topic of work. Where necessary, field or laboratory research may be carried out. A completed essay student passes the teacher to the examination and grade. Upon successful completion of this course, the student will apply the thesis with the proposed topic.		
Assessment (max. 100 points)			
Pre-exam obligations	points	Exam	points
active consultation with mentor	15	positively evaluated essay	55
active consultation with experts	15		
assessment of the use of literature	15		

Course name		Master thesis	
ECTS	20	Course status (mandatory/elective)	elective
Pre-requisites			
Course objectives	The aim of development and defense of the Master thesis is training of students for individual solving of engineering tasks at the level of general or conceptual design, or for analysis of research topic that is directly related to the tasks for which the student is educated. Through the development of Master thesis students must demonstrate knowledge in different areas acquired during their studies, as well as to develop the ability for understanding the complex problems of civil engineering, analytical approach to solving them and apply the knowledge acquired during their studies. Through scientific research topics, students are introduced to the methods of scientific work.		
Outcome	Master thesis that represents a conceptual design of a particular geotechnical structure or design of foundations of engineering structure, or scientific work that uses previous and acquire new knowledge in the field of geotechnical engineering and apply it to solve practical engineering problems.		
Syllabus			
Master thesis that represents a conceptual design of a particular geotechnical structure or design of foundations of engineering structure, that contains the complete analysis of structural system with appropriate calculations and drawings, as well as required technical descriptions and specifications. Master task is a scientific student work that includes analysis of the original geotechnical engineering problem using commercial software solutions or by creating own programs and checking the validity of results of the examples from the literature.			
Teaching methods	Student prepares a Master thesis with consultation with mentors. Completed thesis is submitted to Student Services, and then defended before a committee of three teachers that are chosen by the Chair.		
Assessment (max. 100 points)			
Assessment of the work	60	Assessment of the defence of the work	40

6.2.2 Missing skills and knowledge

Water as a natural resource, environmental criterium and pollution recipient as well as pathway is widely studied in the master programs of Environmental engineering. Deficits in the master programs can be related to the goal of education of experts who have the necessary knowledge of general scientific disciplines to get a complete picture of the processes in nature and environment. Students are lacking the following knowledge, skills and competences which are necessary to reach this goal:

Missing knowledge:

- Modern technologies of water preparation and wastewater treatments
- Understanding of processes in aquatic medium
- Understanding of ground water systems - occurrences, processes
- Advanced physical, chemical and biological purification processes

Missing skills:

- Analyses of possible mechanisms of water management
- Application of advanced technologies in water treatment
- Implementation of protection measures
- Assessment of water quality and classification of water resources according to the national legislations and EU Directives
- Application of strategic documents for water management
- Adoption of advanced concepts in the field of water protection and environmental protection

Missing competencies:

- Selection of appropriate purification processes with respect to the water status
- Sustainable water resources management
- Development of integrated water management as a functional part of sustainable management of natural resources at the local, regional and national level
- Development of systems for water savings and water recycling
- Critical analysis of the functioning of water protection measures
- Application of the acquired theoretical knowledge in real world environments
- Apply theoretical knowledge when analyzing data

The missing knowledge, skills and competencies can be covered by the master programs in future by:

- Integration of basic technical, IT and communication skills in the syllabus
- Internships in water companies
- Focus on the ability of students to demonstrate theoretical and practical knowledge in solving complex problems in an unknown environment

6.3 Montenegro

6.3.1 University of Montenegro – Faculty of civil engineering

The Faculty of Civil Engineering is an organizational unit of University of Montenegro and it operates in accordance with the Statute of University of Montenegro.

It is the oldest and the only highly educated institution in Montenegro which educates quality and representative staff from the area of civil engineering and building construction.

Organization of the teaching courses is performed in accordance with the principles of Bologna declaration.

Starting with the study year 2017/18, the basic, master and doctoral studies are organized according to the system of studying 3+2+3.

Basic studies take three years, that is six semesters and they have 180 credits. At the basic studies, the Faculty has only one academic study program, Civil Engineering.

Master studies take two years, that is four semesters and they have 120 ECTS credits. At the master level, the Faculty has three academic study programs: Civil Engineering - Structures; Civil Engineering – Infrastructure; Management in Civil Engineering.

Doctoral studies take three years, that is six semesters and they have 180 ECTS credits. At the doctoral studies, the Faculty has one academic study program, Civil engineering.

Nowadays more than 1000 active students study at the Faculty of Civil Engineering.

Teaching courses at the Faculty is realized by the staff including: 7 full professors, 8 associate professors, 4 assistant professors and 18 assistants of whom 6 achieved doctoral degree. The teaching staff is representative, and there are the most recognizable names of Montenegrin civil engineering who enjoy great respect in the region and beyond.

At the Faculty the research work is continuous, intensive and rich. It is supported by the Laboratory for testing building materials and structures and it functions like sub-organizational unit of the Faculty.

MASTER STUDIES

The University organizes Postgraduate studies and entitles the right to obtain a degree of Master of Science and Arts in interdisciplinary and multidisciplinary scientific and artistic fields.

In Postgraduate studies, candidates acquire education based on scientific research or artistic creativity by taking part in organized scientific research activities or research-based artistic work.

Postgraduate studies are organized after the completion of Undergraduate or Specialist studies, and the scope of the Master's programme amounts to 120 ECTS credits.

The Board for Monitoring Master's studies which functions within the Centre for Studies and Quality Control gives its opinion on the application of the theme of each Master's thesis, from the point of view of the methodological principles of scientific research work.

Each Master's thesis, which amounts to a maximum of 30 ECTS credits, can be submitted only after a candidate has passed all their exams and has met all the other requirements envisaged by the study programme.

By defending their Master's thesis, a MA/MS candidate shows that he/she has mastered the curriculum of Master's studies, has acquired the necessary knowledge and has become qualified for its application.

1. SCHEMATIC REVIEW OF STUDY PROGRAMS AT FACULTY OF CIVIL ENGINEERING - PODGORICA

UNDERGRADUATE

STUDY PROGRAM CIVIL ENGINEERING	Module 1 CONSTRUCTION
	Module 2 INFRASTRUCTURE

MASTER STUDIES

Study program CIVIL ENGINEERING CONSTRUCTION	Module 1 CONCRETE AND MASONRY STRUCTURES
	Module 2 STEEL, COMPOSITE AND WOOD CONSTRUCTION
	Module 3 GEOTECHNICS
	Module 4 MODELING AND THEORY OF STRUCTURES
Study program CIVIL ENGINEERING INFRASTRUCTURE	Module 1 TRAFFICS ENGINEERING
	Module 2 WATER ENGINEERING

Study program - Interdisciplinary MANAGEMENT IN CIVIL ENGINEERING	

MASTER STUDIES– CIVIL ENGINEERING INFRASTRUCTURE –
MODULE 2 – WATER ENGINEERING

	Name of the subject	Sem.	The number of classes			No. ECTS
			L	E	LB	
FIRST YEAR						
I - COMMON SEMESTER						
1	ENGINEERING GEODESY	I	2	1	1	5
2	ENGINEERING GEOLOGY	I	2	1	1	5
3	PROJECT MANAGEMENT	I	2	1	1	5
4	ENGINEERING HYDRAULICS	I	2	1	1	5
5	HYDROLOGY	I	2	1	1	5
6	MANAGEMENT IN CIVIL ENGINEERING	I	3	1	1	5
Total of active teaching			13	6	6	
Total of ECTS credits						30
	MODULE 2 WATER ENGINEERING – II – SEMESTER					
1	ENGINEERING HYDROLOGY	II	2	1	1	5
2	HYDRAULIC STRUCTURES	II	2	1	1	5
3	MUNICIPAL HYDROTECHNICS	II	3	1	1	5
4	WATER PROTECTION AND QUALITY	II	2	1	1	5
5	RIVER REGULATION	II	2	1	1	5
6	MODELING IN HYDRAULIC ENGINEERING	II	1	0	3	5
Total of active teaching			12	5	8	
Total of ECTS credits						30
SECOND YEAR						
	MODULE 2 WATER ENGINEERING – III – SEMESTER					
1	WATER TREATMENT	III	2	1	1	5
2	MEASUREMENTS IN HYDROTHETICS	III	2	1	1	5
3	USE OF WATER POWER	III	3	1	1	6
4	DRAINAGE AND IRRIGATION	III	2	1	1	5
5	PORTS AND HARBORS	III	2	1	0	4
6	HYDRAULIC OF GROUNDWATERS	III	2	1	1	5
7	MASTER'S THESIS	IV	13	6	6	30.0
Total of active teaching			26	12	11	
Total of ECTS credits						60

SHORT COURSES DESCRIPTION – SUBJECTS OF WATER ENGINEERING

	Name of the subject	Short courses description
FIRST YEAR		
I - COMMON SEMESTER		
1	ENGINEERING GEODESY	
2	ENGINEERING GEOLOGY	
3	PROJECT MANAGEMENT	
4	ENGINEERING HYDRAULICS	Mechanical and kinematic characteristics of the fluid. Flow and continuity equation. Hydrostatics: inaction fluid equation. The effect of pressure on flat and curved surfaces - the pressure force. Hydrodynamics: fluid movement which is limited with solid border, the equation of friction, friction in the pipes - dimensional analysis. Tangential tension. Experimental tests of friction resistance, Nikuradse's experiments. Colebrook´s formula and Manning´s formula. Steady flow in open channels with the prismatic cross-section. Local losses: extension, entrance to the reservoir, narrowing, entrance to the pipe, plumbing fittings, circular curve. Hydraulic short objects. Overflows as structures for the evacuation of water and as flow meters. Broadcreasted weir, Shaft weir, side weir, spillway. Leakage through holes, short pipes, vertical pipes. Overflows as structures for the evacuation of water and as flow meters.
5	HYDROLOGY	Hydrologic cycle. Water balance; hydrological data. Weather Service. Hydrometeorology: atmospheric processes; climate and weather; measurement and analysis of meteorological variables: temperature, humidity, pressure, wind, evaporation. Precipitation, origin, measurement and analysis. Hydrological systems and processes: hydrological systems and subsystems; basin as a system; physical parameters. Process parameters. Hydrometry, surveillance networks; measurement / observation of basic hydrological parameters. The basic data processing, hydrograph, hydrograph, flow curves; fault frequency and duration. Runoff Modelling: component hydrograph; Types of hydrological models. Large and small water. Regional analysis. Probably the maximum precipitation and runoff.
6	MANAGEMENT IN CIVIL ENGINEERING	

	MODULE 2 WATER ENGINEERING – II – SEMESTER	
1	ENGINEERING HYDROLOGY	The course serves as an introduction to the field of engineering hydrology. It covers fundamentals such as the hydrological cycle, catchment, losses, hydrographs and hyetographs. Design topics covered will be selected from: flood frequency analysis, determination of design rainfall intensity and hyetographs, peak flow estimation, design hydrograph estimation, groundwater process and modelling, and drought risk analysis/yield hydrology.
2	HYDRAULIC STRUCTURES	Hydraulic structures for water resources projects. Embankment Dams. Gravity Dams. Forces acting on failure of a gravity dam, stress analysis, elementary profile, design of gravity dam, other functional features of a gravity dam. Types of outlet structures. Basic principles of hydraulic modelling, dimensional analysis, modelling free-surface flows, design of physical models
3	MUNICIPAL HYDROTECHNICS	Processes and methods for design and operation of treatment systems for water and wastewater, drinking water distribution systems and waste water collection systems, including stormwater. The components of distribution and collection systems, water needs, composition of wastewater, drinking water quality, disinfection, effluent water quality, quality and environmental hygiene, process theory for water and wastewater, and selected methods for treatment of drinking water and wastewater.
4	WATER PROTECTION AND QUALITY	Components of water quality. Calculate concentration of ions in water and express them in proper units. Eutrophication process. Transport process of contaminants in water. Develop vulnerability maps, hazard and risk maps of groundwater contamination; Determine limits of sanitary protection zones around water sources. Calculation guaranteed ecological flow of water flow Classification of environmental impacts of hydrotechnical reservoirs.
5	RIVER REGULATION	Hydrological characteristics of natural rivers. River morphology. Hydraulic analysis of natural rivers. Numerical methods for solving equations line steady and unsteady flow in complex riverbed. River sediment. The beginning and the mechanic of movement river sediment Forms of river sediment at the bottom of the river and their influence on hydraulic resistance. Basic theories for suspended river sediment on the basis of turbulent diffusion and basis on energy relations. Physical models waterways. Works on developing the natural rivers. Dimensioning of regulation construction. Building materials and construction methods.
6	MODELING IN HYDRAULIC ENGINEERING	The basic of software to simulate the hydraulic phenomena (flow in pipe, channel, natural channel) Basics facts about software to simulate the hydrological processes in nature. The basic of software to simulate the water supply networks (EPANET, WATER CAD) The basic of software to simulate sewer networks (EPASWMM, SEWER). The basic of software to simulate flow in open watercourses and canals (HEC-RAS). GIS

SECOND YEAR		
	MODULE 2 WATER ENGINEERING – III – SEMESTER	
1	WATER TREATMENT	Water in nature, hydrological cycle of water, natural water resources, usable water cycle, water consumption, types and quantities of waste water. Fundamentals of aquatic ecology. Basics of sanitary microbiology. Physical, chemical, biological and radiological parameters of the quality of natural and waste waters. Self-cleaning of receiving waters, the balance of oxygen in the polluted water, oxygen curve, the budget required level of wastewater treatment. Primary processing: grids, screeners, removal of inert material, sedimentation, filtration, flotation. Secondary treatment: physio-chemical processes (coagulation and flocculation, aeration, adsorption, chemical precipitation, neutralization, oxidation processes, ion exchange, membrane separation processes, disinfection) and biological processes (biological filtration, activated sludge, aerated lagoons, anaerobic processes). Tertiary treatment: removal of nitrogen and phosphorus. Physio-chemical processing of municipal wastewater.
2	MEASUREMENTS IN HYDROTHETICS	Management of hydraulic structures. Basic concepts, about system management. Analysis of errors. Errors and indetermination, statistical analysis of random uncertainty, distribution of random errors Basic characteristics of physical values: classification of metered data's, deterministic values, stochastic values. Dynamic characteristics of physical system. Transducers hydraulic size. Types of converters and distribution, sensors for pressure and differential pressure, depth, speed, flow, sacrificing parameters, position. Measurement in systems under pressure. Measurement in systems with open flow. Characteristics, flow metered with overflow. Diagnostic measurements, components, types, organization, examples. Measurements in hydrometeorology, characteristics, organization, data collecting, home works. Telemetry detection in hydraulic, basic concepts. Data acquisition systems, telemetry, data bases. Management of hydraulic structures, basic concepts, controllers and control.
3	USE OF WATER POWER	Physical basis's in use of water power, classification of hydro power plants and their role in the electric power system. Complex systems of hydro power plant. Characteristics of the electric power system, diagram of load, way coverage, reserves. Energy value of hydro power plant. Regulation of water flow in accumulations, the role accumulations in complex system. Hydro power plants on the small head. Turbines of hydro power plants. Characteristics of individual object of hydro power plant, valves and valve space, intake structures .Objects for derivation, the forces acting on objects, stability problems. Unsteady phenomena's in the derivation. Powerhouses of hydro power plants. Special features of small hydro power plants, special features of hydro power plants on small head, pump accumulation hydro power plants. Construction aspects of use renewable resource. Further tendencies in field of complex energy and role of construction techniques in these processes.

4	DRAINAGE AND IRRIGATION	Water management problems of irrigation and drainage. Balance equation. Hydro physics of soil, water and air in soil. Forms of water in the soil and forming humidity in it. Basic lows of movement humidity in soil. Water quality for irrigation. Irrigation norm and for watering. Determining the water flow for system dimensioning. Distribution water for irrigation. Elements of system for irrigation. Gravitational methods for irrigation. Delivery and distribution network. Structures on channels and pipelines. Water intakes. Pumping stations. Drainage and influence on soil and plants. Norms of drainage. Elements of system for drainage. Collecting regulatory networks Drainage of soil with open channels. Calculation for drainage. Protective filters and their calculation. Drainage and protective networks. Water recipient.
5	PORTS AND HARBORS	General characteristics of internal and maritime water transport. Natural and artificial waterways. Regulated and channeled rivers and rivers with altered hydrological regime. Channel as part of a dam. Dimensioning. Hydraulic systems for charging and discharging. Mechanical and electromechanical equipment. Access channels. Ports and docks. Classification and basic elements of ports and docks. Planning, project, building. Influence of hydrological meteorological parameters to select the type of ports and docks. Wave analysis. Warehouses. Equipment for transshipment. Terrestrial roads. Hydrotechnical facilities of ports and dock. Material for construction. Basic methods for dimensioning structures and construction technology. Selection of optimal combination coastal structure-reloading equipment.
6	HYDRAULIC OF GROUNDWATERS	Definition of ground water, role of ground water in hydrological cycle, ground water bearing formations, classification of aquifers, flow and storage characteristics of aquifers, Darcy's law, anisotropy and heterogeneity. Governing Equations for Ground water Flow. Wells and Well Hydraulics. Ground water Conservation. Ground water Quality. General problem of contamination of ground water, sources, remedial and preventive measures, seawater intrusion in coastal aquifers. Ground water Flow Modeling. Role of ground water flow models, reference to hydraulic, introduction to numerical modeling. Planning of Ground water Development.
7	MASTER'S THESIS	

6.3.2 Missing skills and knowledge

The main shortcoming of the master curricula at the Faculty of Civil Engineering, University of Montenegro is the lack of practical experience. When graduates start working as civil engineers, they miss practical knowledge which should be gained already during their studies. Although practical teaching classes are envisaged by the accreditation of the Faculty, their realization has been lacking so far. The modules still include very little practical work and thus also do not cover the problems related to practice. This problem is further exacerbated by an insufficient number of hours of laboratory exercises during studies. This is a consequence of the lack of adequately equipped laboratories. The problem is particularly evident for students working on master's or PhD projects. Due to the missing resources, their work is usually based on theoretical research or cooperation with the business sector, which is not always smooth.

Missing access to licensed software prevents students to get experience with tools used in industry. Although the master programs require students to create a large number of graphics and seminar papers during studies, their IT skills should still be improved. Many student papers are still prepared using classical, manual calculation methods, without the use of software. As a consequence, students are unprepared and have to receive additional training when they start their first jobs.

The economic situation in the country has conditioned that the planned student mobility is very small. Only a very small number of students had the opportunity to study at or at least visit some other faculties outside Montenegro. This has a negative impact on the knowledge of foreign languages of students. The number of foreign language classes has been drastically reduced so that it cannot be enough for students to acquire knowledge during their studies. This is despite the fact that knowledge on foreign languages is already essential during the studies e. g. when scientific literature has to be read.

6.4 Serbia

6.4.1 University of Nis – Faculty of Civil Engineering and Architecture

Bachelor academic studies – Civil Engineering (4 years)

No.	Year/Semester	Course Title	M(andatory) /E(lective)	Classes	ECTS
1	II/ 3rd	Fluid mechanics	M	2+2	5
2	II/4th	Hydraulics	E (module Hydraulic Engineering)	3+3	6
3	II/4th	Introduction to hydrology	E (module Hydraulic Engineering)	2+2	5
4	III/5th	Engineering hydrology	M	2+2	5
5	III/5th	Fundamentals of water resources usage	M	2+2	5
6	III/5th	Water supply and sewage systems in buildings	M	2+2	5
7	III/6th	Settlement water supply and sewage systems I	M	3+2	5
8	III/6th	Structures in hydraulic engineering I	M	3+2	5
9	III/6th	Water course training I	M	3+3	6
10	III/6th	Irrigation and drainage I	M	2+2	5
11	IV/7th	Settlement water supply and sewage systems II	M	3+3	7
12	IV/7th	Structures in hydraulic engineering II	M	3+3	7
13	IV/7th	Irrigation and drainage II	M	3+3	6
14	IV/7th	Water course training II	M	2+2	5
15	IV/8th	Dams and reservoirs	M	3+3	5
16	IV/8th	Ground waters	E	2+2	5
17	IV/8th	Applied Hydrology	E	2+2	5
18	IV/8th	Simulation models in hydraulic engineering	E	2+2	5

Fluid mechanics

Providing students necessary knowledge about the laws of static fluid and fluid in motion, required for calculations and design in civil engineering, and especially in hydraulic engineering.

Theory classes

Fluid properties (General description, Density, Specific gravity, Compressibility, Viscosity) (2)
Hydrostatics (Pressure, Pressure measuring, Pressure force, Buoyancy) (4)
Hydrokinematics (Velocity, Discharge rate, Continuity equation, Deformations) (2)

Steady flow energy (Kinetic and potential energy, Bernoulli's equation) (2)
Real fluid behavior (Laminar and turbulent flow, Cavitation, Boundary layer) (2)
Analysis of steady flow in pressurized pipes (Hydraulic radius, General friction equation, Friction induced loss of energy, Friction factor, Local energy loss) (4)
Pipe line design (Basic equations, Serial and parallel connected pipes, Siphons, Pumps, Variable boundary conditions, hydraulic analysis of water supply network) (6)
Steady flow in open channels (Chezy-Manning equations, Uniform flow, Normal depth, Specific energy, Critical depth, Still and turbulent regime) (6)

Hydraulics

Acquiring knowledge which allows solving of practical tasks and hydraulic designing of hydraulic engineering structures and systems.
Possession of knowledge required for understanding of liquid flow, solving of various practical tasks and hydraulic designing of hydraulic engineering structures and systems.

Theory classes

Non-uniform flow in open channel watercourses (hydraulic jump, flow on transitions between regimes, determination of the shape of open channel water) (9)
Dimensional analysis and laws of similarity (consideration of dimensions, p-theorem, theory of mechanical similarity, hydraulic models) (3)
Resistance of bodies to fluid flow (friction resistance, shape resistance, cavitation) (3)
Hydraulics of hydraulic engineering structures and systems (evacuation of high waters from dam lakes, overflows, cascades, downstream spillway, stepped spillway, river divergence, diversion gallery and outflows) (12)
Unsteady flow in pressurized systems (basic equations, surge tank, pressure tank, hydraulic shock, phases of hydraulic shock, prevention of hydraulic shock) (9)
Unsteady flow in the open channel flows (introduction, gradually variable flow, abruptly variable flow, steep waves) (9)

Practical classes

Exercises, other forms of classes

Unsteady flow in the open channel flows – calculation Exercises (4), laboratory (2)
Dimensional analysis and similarity laws – calculation Exercises (2)
Resistance of bodies to fluid flow – calculation Exercises (2)
Hydraulics of hydraulic engineering structures and systems – calculation Exercises (5), laboratory (3)
Unsteady flow in pressurized systems – calculation Exercises (6)
Unsteady flow in the open channel flows – calculation Exercises (6)

Introduction to hydrology

Definition of hydrometeorological parameters and hydrologic events. Linking of hydrometeoroligcal parameters. Mastering of fundamental hydrological concepts.
Students are capable of independently collecting and processing of basic hydrometeorological data. Students understand causal relations of hydrologic processes. Students have capacity to perform basic hydrological calculations.

Theory classes (2+0)

Subject matter, tasks and historical development of hydrology;
Circulation of water in nature; Rivers and river basins;
Hydrometry (measuring of water table, water table drop, depth of water, creation of longitudinal and transversal water course profiles);
Hydrometry (measuring of water course velocity, discharge rate, monitoring of ice on rivers);
Hydrometry (discharge curve);
Atmospheric processes and their effects of on river runoff (solar radiation, temperature, air pressure and humidity, cloud cover, duration of daylight, wind);
Atmospheric processes and their effects of on river runoff (evaporation);
Atmospheric processes and their effects of on river runoff (precipitation);
Underground processes and their effects of on river runoff (soil humidity, infiltration, underground water);
Surface processes (fundamental characteristics of river runoff, hydrograms of discharge);
Precipitation Models –runoff (effective rain and direct runoff, unit hydrogram);
Precipitation models –runoff (rational method, synthetic unit hydrogram);
Water balance;
Application of hydrology in planning and designing of structures.

Practical classes

Exercises (0+2):
1) Data, information and activities of the Republic hydrometeorological service of Serbia (RHMSS);
2) Morphometric characteristics of a basin and watercourse and derived parameters;
3) Morphological and hydraulic parameters of the riverbed;
4) Processing of hydrometric measuring;
5) Discharge curve;
6) Processing of climatological data;
7) Evaporation;
8) Precipitation: local and in the basin;
9) Infiltration curves;
10) Basic characteristics of the river runoff;
11) Unit hydrogram;
12) Rational method;
13) Water Balance;
14) Compensation time.
Other forms of classes (4)
Field classes (visits to the regional station Niš RHMZS and hydrometric measuring).

Engineering hydrology

Definition of calculation hydrological parameters, applying the method of mathematical statistics and probability theory. Classification of calculation parameters into indicators of hydrological regimes. Production of a hydrological analysis at the level of the river basin profile. Making decisions on the meaning of the obtained indicators of hydrological regimes.

Students are capable to recognize the type of scope of input data required for assessment of hydrological parameters according to the obtained engineering task and to evaluate indicators of hydrological regime of average, low and high waters at the level of the river basin profile. The student is capable of explaining the obtained results and summarize the most important ones.

Theory classes (2+0):

Introduction to probability and mathematical statistics. Fundamental elements of the probability theory;
Important distributions of probabilities in hydrology;
Numerical characteristics of random variables;
Fundamental elements of mathematical statistics. Marking distribution parameters;
Testing of statistic hypotheses;
Correlation. Regression of two variables;
Regression of multiple variables;
Hydrologic regimes. Calculation discharges, relevant discharges.
Design rainfalls (heights and intensities, rainfall duration curves – height (intensity) - return period, design histograms);
High water regime (studied river basins);
High water regime (partially studied and unstudied basins);
Average water regimes (studied and unstudied river basins);
Low water regime (studied and unstudied river basins);
Hydrological time series; Error evaluation – agreement of observed and design parameters;
Recapitulation and discussion.

Practical classes

Exercises (0+2):
1) instructions and work data;
2) Distributions of hydrological variables;
3) Application of f-th distribution -1;
4) Application of f-th distribution -2;
5) Testing of hydrologic al Series;
6) Correlation;
7) Regression;
8) Preparation of data about discharges and precipitation;
9) Design rainfall;
10) Evaluation of high waters using yearly maximum method;
11) Evaluation of high waters on an unstudied river basin;
12) Evaluation of average discharges and definite duration discharges on a studied and unstudied river basin;
13) Evaluation of low waters on a studied and unstudied river basin;
14) Evaluation of errors – agreement of observed and design parameters;
15) Compensation time.

Fundamentals of water resources usage

Mastering of fundamental principles of water resource usage.
Acquired knowledge in the field of water resource usage principles.

Theory classes (2+0)

Diagrams of water resource usage; River courses characteristics (6 classes)
River course discharge regulations; Design of annual and perennial regulation (9 classes)
Facility power; Daily regulation of water quantity (5 classes)
Energy – economical indicators; Power plant installed power selection; Operation of the power plant

within a power supply system (2 classes)
Hidraulic energy accumulation (2 classess)
Universal characteristics of turbines, Application of universal characteristics; choice of power plant turbines (2 classes)

Practical classes

Exercises (0+2)
Design and calculation exercises in fields of theory classes.

Water supply and sewage systems in buildings

Expected acquisition of necessary knowledge for independent solving of professional problems in the area of water supply and sewage systems.

Acquired necessary knowledge for independent solving of professional problems in the area of water supply and sewage systems.

Theory classes

Introduction. Water demand and consumers. Basic concepts of the water supply and sewage system. Relevant discharges (2)
Water supply sources and recipients of waters from facilities (2)
Drinking water quality (2)
Physical, chemical and bacteriological properties of drinking water (2)
Disinfection of water and water supply facilities (2)
Waste water quality (2)
Materials for construction of water supply and sewage network of buildings. Pipes, fittings and armatures (2)
Sanitary devices and water supply and sewage services (2)
Water supply of buildings. Elements of water supply network of a building. Designing and calculation of building water supply network (2)
Construction of building water supply network. Constructed water supply network control and commission to service (2)
Special cases and issues (2)
Building sewage network. Elements of building sewage network. Designing and calculation of building sewage network (2)
Construction of building sewage network. Constructed sewage network control and commission to service (2)
Special cases and issues (2)
Regulations, norm and standards in the area of water supply and sewage of buildings (2)

Practical classes

Exercises, other forms of classes
Water demand and consumers. Basic concepts of the water supply and sewage system. Relevant discharges (2), - calculation exercises. Water supply sources and recipients of waters from facilities – Calculation exercises (2), Drinking water quality – Laboratory exercises (2), Physical and chemical properties of drinking water - Laboratory exercises (2), Bacteriological properties - Laboratory

exercises (2), Physical, chemical and bacteriological properties of drinking water - Calculation exercises (2)
Water supply network of buildings – Production of partial tasks (2), Sewage systems of buildings - Production of partial tasks (2), Production of design of water supply and sewage network for a minor housing building (6 x 2), Reception and defense of analysis. Final consultations and preparation of the students to pass the examination (2)

Settlement water supply and sewage systems I

Acquisition of necessary knowledge in the field of settlement water supply and sewage systems for independent solving of professional problems.

Theory classes

Introduction (6)
Water supply and sewage systems as a branch of water resources, Water supply situation in our country. General diagrams of settlement water supply systems, Urban water supply network water consumption. Water sources (6)
Atmospheric waters. Surface waters (running and stagnant waters), Ground waters (natural and artificially replenished aquifers). Sanitary protection of water supply sources. Pumping of water (6)
Pump types and usage, water well pumping, Pumping stations. Joint operation of pumps. Transport of water to and within a settlement (9)
Basic forms of distribution network in settlements, Design of distribution network in settlements. Hidraulic design and dimensions of network and network structures. Construction of water supply network and structures (6)
Construction materials, fitting. Network structures. Surge tanks. Testing and commission of constructed networks. Tanks (6)
Classification of tanks, Capacity of tanks, Closing gate and auxiliary facilities. Maintenance and management of settlement water supply system (3)

Practical classes

Exercises
Water demand. Relevant discharge–Calculation exercises (4)
Water sources. Water intake and sanitary protection – Calculation exercises (4)
Pumping of water – Calculation exercises (4)
Production of small settlement water supply design (14)
Reception and defence of an analysis. Closing consultations and preparation of students for examination (2)

Structures in hydraulic engineering I

Acquisition of knowledge required for design of hydraulic structures, by combining of previously acquired new knowledge
Building capacity for design, technical control of documents and/or management of construction works.

Theory classes

In general about the hydraulic structures. Prospecting works. Design data. Technical documents.
Water intakes. Classification. River water intakes.

Surface intakes. Water intakes with regulated water level. Inlet structures. Grills and sieves.
Settling tanks with periodical flushing. Settling tanks with continuous flushing.
Weirs– weir slab.
Diaphragms. Grout curtains.
Gates. Classification. Sluice gate – structural properties.
Sluice gates – design characteristics.
Canals.
Tanks. Classification. Role in the system. Hygienical-technical conditions. Operation control.
Circular layout tanks– structural properties.
Circular layout tanks – design characteristics.
Rectangular layout tanks– structural properties.
Rectangular layout tanks – design characteristics.

Practical classes

Exercises, Other forms of classes, Study research work
Field work.

Water course training I

Students training for field work in collecting data for training natural watercourses and channels design works, not uniform steady flow and sediment transport determination in natural watercourses.
Motives and objectives of natural watercourses planning.
Basic hydrological, topographical and morphological characteristics of natural watercourses. Genesis and systematization of natural watercourses.
Hydrographical network topology, the forms of natural streams, characteristics of alluvial and torrential watercourses.
Field investigations on natural watercourses. Display mode of watercourse view, transverse and longitudinal profiles.
The morphology of natural watercourses, the objectives and methods of morphological analysis.
Field investigations (bed load and suspended sediment in natural water courses)
Steady flow determination in natural streams. The equations of the linear steady flow, hydraulic head loss. Water level determination in terms of uniform and not uniform steady flow in a subcritical and supercritical flow regime. The simulation models.
Torrential watercourses.
Sediment transport mechanics. MPM equations for determination of bed load transport.

Irrigation and drainage

Acquiring of fundamental knowledge in the area of irrigation and drainage.
Independent designing of a drainage system.

Theory classes

Introduction to irrigation and drainage.
Designing and construction of irrigation and drainage systems.
Water-physical properties of soil.
Drainage system elements.
Drainage canal network.
Forms of underground drainage.

Structures on the canal network.
Drainage systems maintenance.
Water balance equation elements.
Evapotranspiration calculation.

Practical classes

Exercises
Production of a graphical project in the field of drainage. Field classes. Tests and calculation tasks on exercises.

Settlement water supply and sewage systems II

Acquisition of necessary knowledge in the field of settlement water supply and sewage systems for independent solving of professional problems.

Theory classes

Introduction (3)
Development of the settlement sewage systems, Sewage system status in our country
Fundamental characteristics of waters requiring evacuation (3)
Sewage waters of settlements and industry; Atmospheric and ground waters
Settlement sewage systems (6)
Potential types and forms systems, choice of sewage system
Designing of settlement sewage system
Hydraulic design of a sewage system (9)
Definition of fundamental parameters for design of a sewage system
Hydraulic fundamentals for design of sewage network and facilities
Design of sewage network and facilities
Construction of sewage network and facilities (9)
Excavation and protection of ditches, construction of sewage network and facilities
Testing of a constructed sewage network and facilities and commission to operation
Maintenance and control of operation of sewage network and facilities (6)
Design of as-is condition of the settlement sewage network; Cadastre of settlement sewage network
Cleaning and maintenance of sewage network and facilities
Standards, regulations and measurements on the sewage network (3)
Analysis of impact of the sewage contents on the receptor (3)

Practical classes

Exercises, Study research work
Relevant discharges of settlement waters which require evacuation– Calculation exercises (3)
Fundamental characteristics of settlement waters which require evacuation– Laboratory exercises (3)
Production of small settlement sewage system design (30)
Analysis of impact of sewage contents on a receptor (3)
Reception and defense of the design. Closing consultations and preparation of students for taking the examination (3)

Structures in hydraulic engineering II

Acquisition of knowledge required for design of hydraulic engineering structures, by combining previous and newly acquired knowledge.
Building capacity for designing, technical control of documents and/or management of construction works.

Theory classes

In general about hydraulic structures. Designing, construction and operation experience.
Rock mechanics fundamentals. Physical and structural properties of rock masses. Ground pressures and stress states.
Deformability or rock masses and mechanical resistance.
Geotechnical measures. Anchoring, shotcreting, drainage.
Pipelines of hydraulic power facilities.
Aaqueducts.
Hydraulic engineering tunnels and pressurized shafts. Basic concepts development, prospecting works. Tunnel alignment, optimization.
Timbering of hydraulic engineering tunnels. Construction methods. Tunnel linings, Grouting works.
Stress states, secundary, tertiary, impacts of temperature and overlays.
Hydraulic engineering equipment of pipelines.
Gates and valves on hydraulic power facilities. Definitions, classifications, disposition.
Bulkhead gates. Structural designs. Supporting, guiding, sealing.
Bulkhead design.
Segmental gates. Flaps.

Practical classes

Exercises, Other forms of classes, Study research work
Field classes.

Irrigation and drainage II

Acquiring knowledge in the field of irrigation and draining - irrigation.
Independent designing of a drainage system.

Theory classes

Importance of irrigation.
Quality of irrigation water.
Irrigation regime.
Determination of water flow rate for designing irrigation systems.
Irrigation system elements.
Irrigation methods.
Supply and distribution network.
Water intake and pumping stations.

Practical classes

Study research work

Calculation exercises and production of a graphical project in the field of irrigation and drainage (conceptual irrigation design).

Water course training II

Students training for field work in collecting data for training natural watercourses and channels design works, not uniform steady flow and sediment transport determination in natural watercourses.

Dams and reservoirs

Mastering of fundamental knowledge in the area of calculation and design of dams and reservoirs.

Theory classes (3+0)

Hydrographic basing; Principal hydrological elements of the river course regime (2 classes)
Dam lakes; Water users; Water balance (6 classes)
Reservoir designing; Usage of reservoirs in high water management (6 classes)
Introduction to dams; Gravity dams load (2 classes)
Gravity dams; Arch dams (8 classes)
Buttress dams; Masonry dams (8 classes)
Earth dams (7 classes)
Evacuators (6 classes)

Practical classes

Exercises.0+3
Calculation and design exercises in fields of theory classes.

Ground waters

Providing students with the necessary knowledge on the water flow through porous media.
Possesion of knowledge allowing solving of various practical data in field of steady water flow through the underground porous media.

Theory classes

Introduction, Darcy's filtration law– (introduction , validity limit, generalization , application) (2)
Application of theory of potential flow and function of complex variables to flow in the porous medium (potential and flow functions, flow image) (6)
Unidimensional flow (uniform flow, non-uniform flow, special cases, filtration flow) (2)
Radial flow– flow towards wells, group of wells operation (flow towards a solitary well with open surface and under pressure, flow towards a group of wells) (6)
In-plane mathematical models of steady flow (discretization of mathematical equations, calculation methods, numerical modles) (4)
Fill dams flow (flow through the dam body, filtration control) (2)
Flow under the dam and vertical sheet pile cut-off (flow image, thrust, thrust force) (4)
Analogous models (electro and viscoanalogy) (4)

Practical classes

Exercises
Introduction, Darcy's filtration law (2)
Application of theory of potential flow and function of complex variables, simple examples– calculation exercises (2), numerical modeling (4)
Unidimensional flow (2)
Radial flow– flow towards wells, group of wells operation (6)
In-plane mathematical models of steady flow – numerical modeling (6)
Fill dams flow (2)
Flow under the dam and vertical sheet pile cut-off – laboratory, numerical modeling (4)
Analogous models– laboratory, numerical modeling (4)

Applied Hydrology

Presentation of the modes of combining various hydrological concepts and methods of design in planning, designing, construction and management of hydraulic engineering structures and water resource systems.
Students build capacity to choose the suitable concept and implement met5hdos for solving of hydrological problem relating to a hydraulic engineering structure and/or region. It is capable of solving the problem, make an explanation in a written form and orally defend the solution.

Theory classes (2+0)

Application of hydrology in planning, designing, construction and management of hydraulic structures and water resource systems.
Propagation and transformation of flood surges (theoretical fundamentals, classification, hydrologic methods);
Urban hydrology (impact of urbanization on hydrometerological parameters and runoff process);
Urban hydrology (calculation methods and models);
Urban hydrology (rainfall management concepts in urban environments, measures and structures);
Hydrologic models (purpose, classification, examples);
Stochastic models;
Regional hydrology (hydrologic analogy, homogeneous regions);
Drought (definition, importance, indicators);
Flood (historical data, exceptions, flood risk maps);
Climate changes (definition, causes, recognition, scenario, adaptation);
Hydrologic forecast (basics, classification and method evaluation);
Short term, long term and super long term forecast;
Term paper defense;
Recapitulation and discussion.

Practical classes

Exercises (0+2):
1) Instructions and data for operation; 2) Propagation of flood surge along the watercourse and transformation of the water surge through a reservoir; 3) Work on the model – input data; 4) Work on the model – calculations; 5) Work on the model – presentation and interpretations of data.

Simulation models in hydraulic engineering

Building student capacity for independent solving of professional problems in the field of hydraulic engineering by implementing simulation and optimization models.

Theory classes

Introduction to subject matter (4)
Definition and system types. Simulation and optimization models. Necessary hardware and software support. Development of simulation and optimization models (4)
Principles and phases of development of simulation and optimization models. Acquisition, processing and storing of data necessary for model development. Sources of errors during development and implementation of the model. Detection, analysis and removal of errors. Model accuracy. Calibration, validation and verification of the model. Interpretation of the results of simulation and optimizacion models.
Implementation of simulation models in hydraulic engineering (4)
Role and importance of information technologies in design, control and management of hydraulic engineering structures and systems. Principles of solving of hydraulic engineering problems by using simulation and optimization models.
Modeling of hydraulic engineering problems (12)
Modeling of hydraulic problems using general (spreadsheet, graphics, database), object-oriented simulation, mathematical and statistical software packages. Modeling of the rainfall/runoff process in the river basin. Modeling of ground waters. Modeliang of hydraulics of surface waters. Modeling of the reservoir/watercourse system. Modeling of the quality of water in rivers and reservoirs. Modeling of water distribution system. Modeling of atmospheric and waste water disposition systems. Optimization models.
Computer control of hydraulic structures and systems (4)
Control models. Information systems. Decision support systems.

Practical classes

Study research work.
Analysis and solving of partial tasks and production of term papers for solving of concrete tasks from the certain filds of hydraulic engineering using simulation and optimization models

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Master academic studies – Civil Engineering (1 year) - Module Hydraulic Engineering

No.	Year/Semester	Course Title	M(andatory) /E(lective)	Classes	ECTS
1	I/ 1st	Water resources	M	2+2	5
2	I/ 1st	Control and management of water treatment plants	M	2+2	5
3	I/ 1st	Application of GIS in hydraulic engineering	M	2+2	5
4	I/ 1st	River hydraulics	E	2+2	5
5	I/ 1st	Drinking water treatment	E	2+2	5
6	I/ 1st	Waste water treatment	E	2+2	5
7	I/ 1st	Flood control	E	2+2	5
8	I/ 1st	Water course and river sediment training	E	2+2	5
9	I/ 1st	Locks and gates	E	2+2	5
10	I/ 1st	Hydropower plant structures	E	2+2	5
11	I/ 1st	Hydroinformatics	E	2+2	5
12	I/ 1st	Water regulations	E	2+2	5

Water resources

The course aim is focused on mastering basic knowledge in the field of water management and water management planning and introduction to the Water Framework Directive.
Students can gain basic knowledge on Water Management Planning and the issue of water use, protection of water and flood protection in present and future, as well as to learn about the key aims of the European Framework Directive.

Theory classes

Global indicators of available water, water consumption and water needs. Water regimes indicators of spatial and temporal unevenness of available and required water resources in the basin.
The importance of planning in the field of water management.
Water Framework Directive.
Water resources management authorities, branches and division. Water resources management principles.
Water resources management systems, description and stages of their development. Single-purpose and multi-purpose water management systems. Water resources management systems features.
Water systems planning and management tasks defining. Water resources management objectives, criteria and restrictions.
Mathematical modelling in tasks of management of water supply systems.
Basic principles and tasks of the application of simulation models in the field of water resources management planning.
Water supply systems management simulation models.
Systematization of optimization methods for solving planning and management problems of water systems.
Water management master plan, structure and content of the information systems within the water management system.
Socio - economic relations and water management legislative framework.

Control and management of water treatment plants

Building student capacity for independent solving of professional problems in the field of control of the water treatment plant.
Building student capacity to implement the acquired knowledge in solving engineering tasks in the area of control and management of the water treatment plant.

Theory classes

Introduction (6)
Legal aspects of usage, protection and management of waters (Serbia, EU)
Parameters for quality control of waters, waste waters and receptors of waste waters
Water polluters cadastre.
Analysis of requirements for treatment of water in facilities.
Control of performance of a water treatment plant and treatment of communal waste waters (8)
The choice of parametes for water quality control.
Choice of measuring pints for measuring of capacity and performance of a facility operation.
Defining of the program of the facility operation control
Facility operaiton paperwork
Measuring methods and equipment (4)
Modeling of the water treatment system (4)
Operative management and control of water treatment facility performance (2)
Measures of working and living environment at a water treatment facility (4)

Practical classes

Exercises
Production of partial tasks and conecptual design of control and management of a waste water treatment plant.

Application of GIS in hydraulic engineering:

Acquainting with the fundamental postulates and potentials for application of geographic information systems (GIS). Mastering of work with the package ArcGIS for data analysis, situation assessment and production of hydraulic or water resources design.
Students are able to develop and head less complex projects in the field of hydraulic engineering or water resources using GIS software.

Theory classes (2+0)

Information systems. Geographic information systems (GIS) (defining, components, emergence and development).
Spatial data (types, structures, collection, input and sources)
Spatial data (system for global positioning GPS, remote sensing).
Data bases.
Standards in GIS. Basic functions.
Planning of data in GIS;
Compiling of data base;
Preparation of data for analysis;
Analysis in GIS;

Presentation of results;
Examples of implementation of GIS in hydraulic engineering;
Water resources information system of Serbia;
Current situation worldwide and in Serbia – cooperation in the areas of data collection, processing, analysis and dissemination of important information via GIS;
Defense of term papers;
Recapitulation and discussion.

Practical classes

Exercises (0+2):
ArcGIS – presentation of basic concepts, tools, work with ArcCatalog and ArcMap, work with spatial data and data bases models; 6) -10) Supervised work on a computer in an individual or group project;
Study research work:
Production of an individual or group design (depending on the size of the group), presentation of result in the form of a term paper. Preparation of presentation and defense of a term paper.

River hydraulics

Mastering of specific chapters of open courses hydraulics.
Independent production of hydraulic analysis and designs of steady and variable flow in open courses.

Theory classes

Variable flow in open courses. Numerical methods for solving of fundamental equations of variable flow. Simulation models for solving of variable flow.
Calculation of backwater due to bridge structures.

Practical classes

Exercises
Usage of simulation models for calculation of variable flow in open water courses.

Drinking water treatment

Building student capacity for independent solving of professional problems in the field of drinking water treatment.
Buildings student capacity to implement the acquired knowledge in solving of engineering problems in the domain of drinking water treatment.

Theory classes

Introduction (4)
Indicator of quantities and quality of natural waters for water supply purpose
Norms and standards of drinking water quality, needs for drinking water treatment
Procedures of drinking water treatment (2)
Basic groups of procedures of drinking water treatment. Schemes of procedures of water treatment,
Settling (4)

Theory basis of settling, types of settling devices, design parameters
Efficiency of settling
Coagulation and flocculation (4)
Theoretical foundations of coagulation and flocculation processes
Types of coagulants and flocculants, preparation and dosage of chemicals
Facilities for coagulation and flocculation, Efficiency of coagulation and flocculation processes
Filtering (6)
Theoretical foundations of filtration, Slow filters, Rapid filters, Microfilters
Filter backwashing, Filter operation and method of control, Filter efficiency,
Disinfection (2)
Methodes of disinfection, Preparation and dosage of disinfectants, Facilities and devices for disinfection
Special methods and processes (4)
Aeration, Flotation, Oxidation, Sorption, Iron, manganese, ammonium, reduction, softening
Processing of sludge from the drinking water treatment facilities
Drinking water treatment facilities (2)
Management and control of a drinking water treatment plant operation

Practical classes

Exercises
Inidcators of quantity and quality of natural waters for water supply needs– Calculation exercises (2)
Norms and standards of drinking water quality. Need for drinking water treatment. Preparation and dosage of chemicals– Laboratory exercises (6)
Design of water treatment facility of small settlements (16)
Acceptance and defence of the analysis. Final consultations and preparation of students for taking the examination (2)

Waste water treatment

Training students to independently solve professional problems in the field of wastewater treatment. Ability of the student to use acquired knowledge in solving engineering problems in the field of wastewater treatment.

Theory classes

Introduction (2)
Water pollutants and sources of pollution, Quantity and quality of wastewater of settlements and industry
Water pollution protection, Conditions for discharging waste water into receivers
Waste water treatment (2)
Basic methods and processes for purification of waste water, Degree of wastewater treatment
Mechanical purification (6)
Gratings, sieves, sandblasting, oil and grease separators, primary sediment
Biological purification (6)
Biological processes, Biological filters, Bioacervation basins, Lagoons
Supplementary - tertiary purification (4)
Chemical, Physical-chemical procedures, Disinfection
Treatment and disposition of sludge (4)

Qualitative and quantitative characteristics of sludge, Sludge processing processes
Sludge damping, Sludge stabilization, Reduction of water content in sludge
Disposition of sludge
Waste water treatment plants (4)
Variants of wastewater treatment technology, Management and control of the operation of wastewater treatment plants

Practical classes

Exercises
Types, quantities and quality of wastewater of settlements and industry - Laboratory exercises (4)
Wastewater treatment. Required degree of purification - Computational exercises (4)
Development of a project for a wastewater treatment plant for a smaller settlement (18)
Receiving and defending the study. Final consultations and preparation of students for taking the exam (2)

Flood control

Mastering modern methods of planning and organizing flood protection by using active and passive measures. New materials and equipment for flood protection design.
Students learn to work on the torrential and alluvial watercourses flood protection using modern methods, materials and equipment.

Theory classes

Torrential and alluvial watercourses floods.
The risk and flood damage assessment.
Understanding active and passive flood proofing options.
The impacts of exclusion wet and dry floodplains on flood waves.
The levees design, the cost-benefit analysis.
Flood protection based on retention ponds along the river and lakes.
Simulation model for determining the impact of reservoirs in the upper catchment areas on flood waves.
The flood control.
Materials and equipment for flood protection.

Water course and river sediment training

Estimation of suspended and bed load sediment in natural streams, assessing riverbed deformation in zones of river structures and reservoir siltation.

Theory classes

Origination and physical properties of sediment.
Suspended sediment. Basic characteristics of two-phase turbulent flow.
The sediment concentration.
Suspended sediment transport. Energy approach to the analysis of suspended sediment.
Bed load sediment. Problems in the study of bed load. Conditions for bed load moving.
Transport capacity of a watercourse.

Bed load transport estimation methods.
Stochastic approach to bed load transport estimation.
The riverbed deformation determination.
The local deformation of the riverbed around the bridge piers, river structures and downstream of the transverse structures and cascades.
The problems of reservoir siltation.
Riverbed physical models. Models with movable-bed and fixed bottom. The problems of using the models.

Locks and gates

Acquiring of necessary knowledge for design of these structures, by combining the previous and new knowledge.
Capacity to design, control technical documents and manage construction works.

Theory classes

Gates and locks on hydraulic structures. Definitions, classifications, dispositions.
Flashboards. Structural designs made of full steel profiles.
Flashboards with lattice structure.
Design of flashboards made of full steel profiles.
Design of flashboards with lattice structure.
Support, guiding and sealing of flashboards.
Manipulation of flashboards. Friction forces. Calculation of force required for opening the gate.
Immovable parts of equipment in recesses. Portal structures and devices for gate manipulation.
Segmental locks and gates. Structural and disposition design.
Load of segmentnih locks and gates. Calculation of forces in supports.
Details of support, guiding and sealing of segmental gates.
Manipulation of segmental gates.
Design of segmental gates.
Stationary equipment in pillars. Equipment for prevention of negative action of ice and frost.

Practical classes

Exercises, other forms of classes, study research work
Field classes.

Hydropower plant structures:

Preparation of students for design and calculation of dams with locks.
Preparation of students for employment in companies and continuation of the studies.

Theory classes

Introduction.
Hydro power parameters. Dam lake.
Drop. Power and energy of hydro-power designs (HER).
Regulation of flow. Variation of energy consumption.
Energo-economic factors. Water intake.

Water transport structures. Water chambers.
Surge tank. Machinery building.

Practical classes

Exercises
Calculation exercises in the field of the theory classes.

Hydroinformatics

Introduction to techniques and methods of hydroinformatics and its practical application in the field of hydrotechnics. Acquired methods and techniques in the field of hydroinformatics and the ability of students to apply them in other cases in the field of hydraulic engineering and later in engineering practice.

Theory classes

1. Introduction to Hydroinformatics. 2. Hydrological metadata: problems, standardization, markup languages. 3. Hidrological data models: concept, structure and purpose. 4. Models for the storage and collection of data. 5. Data formats. 6. XML. 7. Transfer of data using web services. 8. Data processing and analysis. 9. Presentation of data. 10. Data integration. 11. Extracting information. 12. Soft computing. 13. Artificial neural networks. 14. Genetic Algorithms. 15. Fuzzy logic.

Practical classes

1. Hidrological metadata. 2. ArcHydro model data. 3. The collection, use and storage of data. 4. Data formats: netCDF, SDTS. 5. XML. 6. Web services. 7. Sources of data. 8. Presentation of data. 9. Integration of data and extract information. 10. Regression methods. 11. Analysis of the cluster. 12. An example of the generation of time series of annual flow based on neural networks. 13. Genetic Algorithms. 14. Fuzzy logic. 15. The practical examination.

Water regulations

Acquainting students, future civil engineers - hydraulic engineers, with the EU directives concerning management, usage and protection of waters.
Buildings students' capacity for independent work, according to EU standards in the domain of waters.

Theory classes

EU policy in waters.
Frame directive on waters (Directive 2000/60/EC about establishing framework for the Union action in the field of water policy).
Directive 98/83/EC on quality of water for human usage.
Directive 75/440/EEC relating to the required quality of surface water to be treated for drinking in member states.
Directive 79/869/EEC relating to the measuring methods and frequency of sampling and analysis of surface water to be treated for drinking in member states.
Directive 76/160 on the quality of bathing water.

Directive 91/271/EEC relating to the treatment of communal waste waters.
Directive 91/676/EEC relating to protection of waters from pollution caused by nitrites from the agricultural sources.
Directive 96/61/EC relating to integrated prevention and pollution control measures.

Practical classes

Study research work.
Case study analysis. Production of semestral papers.

Link: www.gaf.ni.ac.rs menu STUDIJE

6.4.2 University of Belgrade – Faculty of Civil Engineering

Bachelor academic studies – Hydraulic and Environmental Engineering (4 years)

No.	Year/Semester	Course Title	M(andatory) /E(lective)	Classes	ECTS
1	II/ 4th	Hydrology	M	4+1	7
2	III/5th	Engineering Hydrology	M	2+2	5
3	III/5th	Hydraulics 1	M	3+3	7
4	III/5th	Water Quality	M	2+3	5
5	III/6th	Drainage Systems	M	2+2	5
6	III/6th	Hydraulics 2	M	3+3	7
7	III/6th	Hydraulic Structures 1	M	3+2	6
8	III/6th	Municipal Hydraulic Engineering 1	M	3+3	7
9	IV/7th	Irrigation	M	2+2	4
10	IV/7th	Municipal Hydraulic Engineering 2	M	2+2	5
11	IV/7th	Design and Construction of Hydraulic Engineering Infrastructure	O	2+2	5
12	IV/7th	Engineering Limnology	O	2+2	5
13	IV/7th	Solid Waste Management	O	3+2	5
14	IV/8th	River Engineering	M	3+3	7
15	IV/8th	Water Resources Systems Management	M	3+2	6
16	IV/8th	Geoinformation Systems	O	2+2	5
17	IV/8th	Urban Hydrology	O	2+2	5

Hydrology

Aim: Introducing students to hydrologic cycle and Hydrology as a fundamental discipline for hydraulic engineering and water resources management. Introduction to hydrometeorology, hydrometry, deterministic and stochastic hydrology. Proficiency in methods of measurement and processing of hydrologic data, water balance studies and statistical analysis for hydraulic engineering applications.

Outcome: Students capable for individual work on collecting and processing hydrologic data, preparation of hydrologic studies as a basis for planning, design, construction and management of hydraulic engineering facilities and water resources systems.

Contents: Introduction to hydrology (definition and subject; hydrologic sub-disciplines; role of hydrology in hydraulic engineering and water resources management; hydrologic cycle; hydrologic data and hydrologic information systems; water balance; characteristics of water regime). Hydrometeorology (definition, role, atmosphere, solar radiation, temperature of air, soil and water, air humidity, air pressure, wind, evaporation, precipitation, global and local climate changes). Hydrometry (observation networks, watershed characteristics, measurement and data processing of water depth, stage, level, slope, velocity, flow rate; hydrologic data presentation, charts and maps of water balance components). Statistical hydrology (definition and types of stochastic processes; empirical and theoretical methods; hydrologic data series and their properties; probability

distributions for discrete and continuous random variables – parameter estimation, hypothesis testing, probability papers; confidence intervals; hydrometeorologic applications for low flows, mean flows and flood flows; multivariate and regional analysis; analysis of global and local changes in hydrologic regime).

Tutorials: Individual numerical problems related to lectures.

Engineering Hydrology

Aim: Introduction to hydrologic analyses and modelling and its application in the applied water engineering disciplines.

Outcome: Students capable for individual work hydrologic analysis for as a basis for planning, design, construction and management of hydraulic engineering facilities and water resources systems.

Contents: Introduction. Hydrologic assessments in hydraulic engineering and water resources management. Hydrologic models: types, purposes. Definitions of the design precipitation and design flows. Design storms (IDF relationships, design storm hyetographs). Runoff volume (precipitation loss methods). Unit hydrograph. Synthetic unit hydrograph. Rational method. Examples of complex hydrologic models. Water balance assessment for various water management sectors. Urban hydrology. Flood flow analysis. Low flow analysis. Hydrologic studies and water master plans (river basin management plans). Examples from engineering practice.

Tutorials: 10 tasks with computational problems related to lectures.

Hydraulics 1

Aim: Introduction to the basic principles and laws of hydraulics. Introduction to measurement, measuring techniques and processing results through laboratory practice

Outcome: Proficiency of students in independent hydraulic computations and analysis, which are needed for planning and design of hydraulic structures and water resources systems.

Contents:
Lectures:
Basic principles in hydraulics. Flow in pipes. Friction and local losses. Pumpes and turbines. Cavitation. Open channel flow. Uniform flow. Gradually varied flow in channels. Gradually varied flow in rivers. Rapidly varied flow. Hydraulic jump. Flow under a vertical sluice gate. Flow over: broad-crested weir, rectangular weir and round-crested weir. Stilling basin. Shaft spillway, side spillway, ski-jump spillway and stepped spillway. Flow in porous media. Darcy law. Application of Darcy law in one-dimensional flow. Filtration through the earth dam. Suffosion and fluidisation.

Exercises:
Exercises consist of solving ten homework and measurements in the hydraulic laboratory.

Water Quality

Aim: The scope of the course is to get knowledge on the chemical principles that are used for the characterization and water quality control.

Outcome: After the attended course, from the experimental part and theoretical units, students should be able to make water quality assessment, as well as comparison of the analyzed water with legislation according to the regulations from EU and Republic of Serbia.

Contents: Theoretical units and calculations
Introduction based on unique characteristics of water as a compound and a solvent. Water, physico-chemical characteristics. Chemical calculations. Chemical equilibrium. Solutions of strong acids. Solutions of weak acids and bases. Buffer solutions. Solubility products.
Heterogeneous reactions. The precipitation and dissolving of ions from water.
pH and chemical reactions. Lewis theory of acids and bases.
Chemical thermodynamics. Definitions and concepts. The first law of thermodynamics. Enthalpy. The second law of thermodynamics. Entropy. Free energy. Effect of temperature on the equilibrium constant.
Oxidation-reduction equations. The Nernst equation. Design of electric cells. Applications. Exercises.
Chemical kinetics. Reaction rate and the rate constant. Kinetics and reaction mechanism.
Organic compounds, organic matter in water and waste water.
Microbiological aspects of water quality. Indicator organisms for water quality. Coliform group and tests.
Water quality legislation (EU and Republic of Serbia).
Chemical water analysis-experimental exercises
Color and turbidity.
pH and conductivity
Acid-base titration; indicators.
Water hardness
Iron and manganese removal and determination of chloride and iron ions in water.
Sulphate, nitrate and ammonia (nitrogen compounds) determination.
Sum of ions, calculating equivalent concentrations.
Colloids and coagulation
Organic compounds (Biological Oxygen demand and Chemical Oxygen demand)
Desinfection of water (chlorine determination).
Visit to the laboratory of water quality with certification.

Drainage Systems

Aim: Introduction with types, elements and applicability of different types of drainage systems and application of calculation methods in design and operation.

Outcome: Students capable to apply acquired knowledge in designing, building and operation of drainage systems.

Contents: General types of drainage systems (surface, subsurface). Physical and mechanical characteristics of soil. Basic equations of soil water dynamics. Methods for calculating soil infiltration. Applicability of different methods of drainage. Horizontal pipe drainage systems, classification, criteria for design, methods of hydraulic calculation. Criteria for design of protection filters. Vertical drainage systems (vertical drains, deep wells, relief wells), elements, design criteria, methods of hydraulic

calculation for stationary and non stationary conditions. Laboratory and in situ methods for calculating soil conductivity (slug test, seepage test, pump test analysis). Dewatering during construction. Subsidence due to lowering groundwater level.

Tutorials: Design of drainage system. Hydrological analysis. Determining soil characteristics based on laboratory and in situ data. Design and hydraulic calculation of drainage system. Each student works on his own individual project.

Hydraulics 1

Aim: Advanced Course in Hydraulics: To develop understanding and confidence of students to analyse and apply acquired knowledge to solve practical problems of unsteady flow in pipes, open channels, by an appropriate mathematical/numerical method.

Outcome: Developed competency and knowledge in solving hydraulic engineering problems of steady and unsteady flows in pipe networks and open channel networks.

Contents: Introduction – Mathematical and Numerical Models. Steady state flow in pipes; Systems of equations, special elements of pipe networks, Mathematical Simulation of continuous operation of pipe networks. Transport processes in pipes. Mathematical models of water oscillations in pipes and connected reservoirs, Surge tanks, types, basic equations based on rigid column, Numerical models, design principles and recommendations. Hydraulic transients (Water Hammer), basic equations. Method of characteristics, basic boundary conditions. Hydraulic transients control: by surge tanks, air chambers, air valves, surge relief valves etc. Hydraulic transients caused by pumps and turbines. Control characteristics of valves, dynamic monitoring of pipe networks.
Unsteady flow in open channels – basic concepts and assumptions. Hydraulic jump – stable and moving, elementary disturbance wave celerity, Riemann invariants. St Venant equations: mass balance equation and momentum conservation equation – dynamic equation, possible simplifications. Kinematic wave model, Cunge-Muskingum method, Diffusion wave model. Method of characteristics, initial and boundary conditions (gates, weirs, sills etc). Dynamic wave models, Explicit methods, operator splitting method, Implicit methods: Preissmann scheme. Unsteady flow in open channel networks. Students are taking their assignments individually according to the schedule of teaching.

Hydraulic Structures 1:

Aim: Training of participants to design hydraulic structures (HS).

Outcome: Proficiencies for design of hydraulic structures.

Contents: Introduction to hydraulic structures (HS). Reservoirs. Characteristics and divisions of HS. Data for design of HS. Dams and Appurtenant Structures. Concrete Gravity Dams: characteristics and loads, foundation seepage, overall stability, sizing and shaping. Construction of Concrete Gravity Dams. Arch dams. Other types of concrete dams. Embankments Dams: characteristics, basics and loads, seepage. Earth Dams. Rockfill Dams. Construction of Earth Dams. Other hydraulic structures.

Exercise: Computational exercises based on class lectures.

Municipal Hydraulic Engineering 1

Aim: Introduction to basic principles of water supply and design of water supply structures. Introduction to basic principles of potable water treatment and facilities.

Outcome: Students trained for independent application of theoretical knowledge for planning, designing and building of water supply structures and drinking water treatment facilities

Contents: Lectures: Water supply as a part of water resources management. Water demand. Water supply systems. Sources of potable water (atmospheric water, rivers, lakes, groundwater). Water intakes: types and design. Pumps and pumping stations. Pressure relief structures. Water supply distribution networks. Water supply installations in buildings. Reservoirs: design and equipment. Hydraulic computations of water supply network. Pipe materials. Construction and maintenance of water supply systems. Drinking water quality standards: chemical, physical and biological characteristics of water. sampling of water for analyses. Sanitary protection of drinking water sources. Unit operations in drinking water treatment. Design of drinking water treatment plant: design of structures, plant layout, waste treatment and disposal, facilities and equipment. Technological and hydraulic computations of drinking water treatment plant, plant hydraulic profile. Automatic control and regulation in water supply systems. Water supply in irregular conditions (war, earthquakes, etc.)

Tutorials: Individual work: water supply system calculations for a settlement (~15000 PI) incl. water intake facilities, drinking water treatment plant, distribution network, reservoir and pumping station.

Irrigation

Aim: Introduction with types, elements and applicability of different types of irrigation systems and application of calculation methods in design and operation.

Outcome: Students capable to apply acquired knowledge in designing, building and operation of irrigation systems.

Contents: Types of irrigation systems. Elements of vertical water balance. Methods for calculation of evapotranspiration and vertical infiltration. Basic terms: irrigation hydromodul, irrigation norm, turnus and calculation methods. Different models of water distribution in irrigation systems (rotational and „on demand“ distribution) and criteria for designing irrigation system. Different irrigation methods (sprinkler, drip), basic elements of irrigation system, design criteria, hydraulic calculation. Design criteria and hydraulic calculation pressure distribution networks. Design of pump stations. Elements of economic analysis and feasibility study.

Tutorials: Design of irrigation system. Irrigation water demand. Water resources analysis to determine availability of water and calculate reservoir volume. Calculating soil vertical infiltration curve. Selection and design of sprinkler and drip laterals. Design and hydraulic calculation of irrigation system (water distribution network and pump station. Each student works on his own individual project.

Municipal Hydraulic Engineering 2

Aim: Introduction to basic principles of wastewater network and structures computation and design.

Outcome: Students trained for independent application of theoretical knowledge for planning, designing and building of urban drainage structures and facilities.

Contents: Wastewater engineering as a part of water resources management. Types of sewerage systems. Final selection of sewerage system and final recipient. Origin and quantities of wastewater. Indoor sewer installations. Urban drainage. Pipe layout. Types of pipe cross-sections and its application. Sewerage structures and hydraulic calculation. Hydraulic-hydrologic calculation of sewerage network. Mathematical flow models in sewers. Sewer system layout. Building materials for sewerage pipes and structures. Construction and maintenance of sewerage. Automatic control and regulation in sewer systems.

Tutorials: Individual work: sewerage system calculations for a settlement (~15000 PI)

Design and Construction of Hydraulic Engineering Infrastructure

Aim: Introduction into complete procedures of undertaking of preparation, planning and project for a construction of the hydraulic infrastructure systems and structures.

Outcome: An introduction needed for students as a preparatory phases for taking part into project design procedures and construction phases for hydraulic systems and structures.
Contents: A detailed review of the phases of preparation for design projects, such as: planning, design, issuing condition and terms for design projects. Approvals and confirmation of projects. Numerous works, such as preparatory, construction site protection, and protection of neighboring , historical and cultural structures, as well protection of workers and passengers, from works, and water surface and ground. Terms of reference, hydraulic and static calculations, methods of statements, bill of quantity for hydraulic works. Technical approvals and testing work and terms. License for structures and works. Project of the works executed. Maintenance and operation of hydraulic structures.

Exercises: Study work in small groups including presentations and essays.

Engineering Limnology

Aim: Introduction to the basics of physical, chemical and biological processes within the natural and artificial water bodies. Introduction to methods of numerical modeling of these processes. Introduction to anthropological effects on the physical, chemical and biological processes in water bodies. Introduction to methods for restoration and improvement of water quality in lakes.

Outcome: Qualifying students that, in terms of hydro-technical engineers, make contributions in multidisciplinary teams working on these issues.

Contents: Introduction - the origin and classification of water bodies. Physical, chemical and biological characteristics of water bodies (water quality and sediment). Definition of terms of reaction dynamics and chemical reactors. The influence of hydrodynamics on the spatial distribution and concentrations of water quality parameters. Mathematical modeling of the balance of oxygen, nutrients and toxicants. Analysis of phytoplankton, zooplankton, and macrophytes. Connection of meteorological factors (wind, insulation, temperature ...) with hydrodynamics and water quality parameters. Impact of seasonal temperature variations and occurrence of thermal stratification in lakes and its consequences.

Anthropogenic activities and their impact on water quality, lake ecosystem and the dynamics of eutrophication.

Exercises: Creating computational exercises.

Solid Waste Management

Aim: Introduction to municipal, industrial and hazardous solid waste management and disposal. Focus on environmental protection issues, impacts of landfills on water and air pollution and land degradation.

Outcome: Student competence to independently solve solid waste management problems including the design and operation of sanitary landfills.

Contents: Synthesis of existing knowledge on solid waste landfills, with a focus on landfill gas and leachate management problems and implementing environmentally sound operating procedures. Basics of solid waste decomposition. The choice of location, landfill design and operation. Analysis of social, economic and technical factors important for landfill development and operation. Current domestic and international trends in waste management. Waste characterization and production. Waste collection, reuse and recycling. Thermal treatment methods with energy production. Biological treatment of waste. Waste in oceans. Construction and demolition waste. Optimal design of transport, separation and disposal of waste in sanitary landfills. Landfill site selection and preparation. Basics of landfill design, geotechnical aspects, drainage, leachate and gas treatment systems for the protection of ground and surface water, air and soil. Closure methods and landfill reclamation. Industrial fly ash waste landfills and tailings.

River Engineering

Aim: Mastering the principles of river engineering, river training and the design of river training structures.

Outcome: Upon completion of the course the student is capable of preparing river engineering studies and designing river training structures

Contents: Introduction to river geomorphology. Basics of boundary layer theory. Flow resistance in rivers. 1D unsteady and steady non-uniform flow modelling. Secondary flows. Sediment origin and properties. Incipient motion. Bed load transport capacity; bed load transport relations; bed load measurement. River flow as a two phase flow. Suspended load. Vertical distribution of suspended sediment concentration. Suspended load transport capacity. Total sediment load. Suspended sediment measurement. River bed aggradation and degradation. Erosion around bridge piers, abutments and river training structures. River models. River training works: motives, background data, design parameters, river channel alignment. River training structures: types, position, structural elements, construction. Passive and active flood control measures. River re-naturalisation. Design documentation.

Water Resources Systems Management

Aim: Introduce students to the basic types and characteristics of hydropower plants and their role in the electric power system. Understanding the types of turbines and their characteristics. Consideration of the basic elements of intake structures, powerhouses and diversion systems. Examining the role of the electric power system, and the types of pumped-storage hydroelectricity.

Outcome: Students learn to apply the knowledge of the design of diversion and dammed hydropower systems in engineering practice.

Contents: **Theoretical Work**
Hydropower in the electric power systems. The physical basis of utilization of water power. Types of hydropower plants (HPP). Evaluation and optimal design of HPP. Types of turbines and elements of turbine block. Hydrogenerators. Valves on intake structures: surface gates and deep valves. The intake structures. Diversion canals. Diversion tunnels. Penstocks. Special facilities in HPPs (settling basin, facilities for fish). Powerhouses - dispositions and structural solutions. Basic facilities in powerhouse. Pumped-storage hydropower plant.

Practical training (Exercises):
Students are doing conceptual (preliminary) design of diversion hydropower plant with reservoir, with all necesary hydrological analysis. They receive individual task which work independently on the base of auditory methodical explanations and consultation with the teacher.

Geoinformation Systems

Aim: To introduce students the basic concepts related to spatial databases and technologies of gathering, modeling and analysis of geospatial data.

Outcome: To train students to apply modern methods and tools for collecting, processing and analyzing geospatial data in solving engineering problems. During the course, students will learn the basics of using Geographic Information Systems software (ArcGIS).

Contents: **Theoretical Studies**: Definitions of GIS and geospatial data, GIS components; conceptual models in GIS, geographic data model-vector and raster data models, GIS-functions input and output data, data retrieval, query and transformation; interpolation methods; digital terrain models, the application of global positioning system (GPS) in GIS, spatial data acquisition methods, remote sensing, GIS product quality; database cadastre, cadastre database.

Practical lessons: Laboratory exercises in order to familiarize with the software ArcGIS environment and its basic functions; Working on personal project in ArcGIS software environment; demonstration practices in the application of GPS and GIS in digital photogrammetry and ortophotoproduction.

Urban Hydrology

Aim: Introduction to the urban hydrologic cycle and effects of storm water runoff in urban areas. Emphasizing the necessity for protection of urban areas from storm runoff and main principles of integrated urban water management. Knowledge on methods for storm runoff assessment and for design of systems for storm water quantity and quality control.

Outcome: Students capable of performing individually collection, processing and analysis of hydrometeorological data, urban storm runoff calculations, design of urban storm drainage systems and urban water quality control.

Contents: Introduction. Hydrologic cycle in urban environment, changes in natural water balance and regime. Principles of drainage of urban areas, roads, motorways, railways stations and airports and interaction of a storm drainage system with other infrastructure systems and urban watercourses. Measurements of precipitation and runoff in urban areas, short-duration rainfall analysis. Runoff assessment, hydrologic models, rational method. Hydraulics of drainage systems. Design storms and design runoff. Elements of groundwater regime and groundwater quality control. Aspects of treatment of storm runoff from pavements. Facilities for water supply, drainage, treatment and flood control in urban areas.

Tutorials: 8 computational problems in accordance with lectures.

Link: http://www.grf.bg.ac.rs/studije/mo/e?mid=17&sem=4

Master academic studies – Hydraulic and Environmental Engineering (1 year)

No.	Year/Semester	Course Title	M(andatory) /E(lective)	Classes	ECTS
1	I/ 1st	Groundwater Management	M	2+2	5
2	I/ 1st	Water Resources Systems	M	3+2	6
3	I/ 1st	Waterways and Ports	M	2+2	5
4	I/ 1st	Embankments and Stability of Slopes	O	2+2	5
5	I/ 1st	Geoenvironmental Engineering	O	2+2	4
6	I/ 1st	Hydraulic Structures 2	O	2+2	5
7	I/ 1st	Hydroinformatics	O	2+2	5
8	I/ 1st	Municipal Hydraulic Engineering 3	O	2+2	5
9	I/ 1st	Protection from Floods	O	2+2	5
10	I/ 1st	Stochastic Hydrology	O	2+2	5
11	I/ 2nd	Measurements in Hydraulic Engineering	M	2+2	5
12	I/ 2nd	Numerical Methods in Hydraulic Engineering	M	2+2	5

Groundwater Management

Aim: The aim is students to learn the basic concepts of groundwater hydraulics and pollutant transport in subsurface. Also, students are aimed to learn numerical methods for solution of flow and transport equations, with application of available software solutions. In addition, the students will learn the practical aspects of well construction and groundwater management.

Outcome: Knowledge in groundwater and well hydraulics applicable for long term groundwater management.

Contents: Introduction. Porous media. Groundwater hydraulics. Transport of dissolved matter by groundwater. Experimental techniques for determination of aquifer parameters. Well hydraulics. Numerical simulations: methods and application. Groundwater management. Examples from the engineering practice.

Practical tasks: 10 practical tasks in accordance with lectures. Tasks are continually reviewed and evaluated. This includes practical tasks on the physical model of groundwater flow which includes measurements of hydraulic variables, as well as additional weekly advising related to task execution.

Water Resources Systems

Aim: Introduction of students with ways of defining water management systems, defining their objectives, criteria and constraints (restrictions). Models for the optimization and management of these systems. Introduction to the basic aspects of reliability, water resources system planning and legislation and legal documents regulating the discussed issues. Analysis of the impact of water management on ecological and social environment.

Outcome: Training students to apply acquired knowledge about sizing the reservoirs, system decomposition, determining reliability and optimal management of water resources systems in engineering practice.

Contents: **Theoretical Work**
Stages of development of water resources systems (WRS). Main characteristics of WRS. The formalization of water resources systems and planning objectives. Functional description of WRS. Objectives structure. Criteria for management and planning of WRS. Constraints. Conflicting objectives. Mathematical formulation of management tasks. Management of complex WRS. Entropy as a measure of system uncertainty. Mathematical modeling for management of WRS. The simulation models for system control. Optimization. Decision making in water resources planning and management. Reliability of complex WRS. Legislation in the area of water resources planning and management. WRS and ecological environment. WRS and social environment.Practical training

Exercises: Examples of calculating total and active storage capacity. Mathematical modeling of complex water resources systems. Decomposition of the system of reservoirs. Determing of the optimal value using linear and dynamic programming. Examples for claculation of entropy and reliability of complex systems. Two numerical tests.

Waterways and Ports

Aim: Gaining a broad overview of the inland waterway infrastructure. Application of river engineering principles in the design and maintenance of navigable waterways. Mastering the hydraulics and the design of hydraulic structures on inland waterways as well as the hydraulic aspects of the design of inland ports and terminals. Acquirement of basics in service systems theory

Outcome: After completing this course the student will be able to: 1) design inland waterways and approach channels, 2) design navigation locks, 3) address issues related to relevant hydraulic aspects

for the layout of river ports and waterways and 4) discuss with experts about issues related to the function of ports and waterways in the transportation of goods and port capacity planning.

Contents: Characteristics of waterway traffic on inland waterways. Classification of inland waterways. Inland waterway alignment and design parameters of inland waterway cross-section. Ship's resistance. Navigable canal size and alignment. Navigation locks. Classification of navigation locks. Design of lock chamber. Classification of hydraulic systems for navigation lock chamber filling/emptying. Hydraulic design of through the head systems and through longitudinal culverts systems. Navigation lock capacity. Natural waterways. Inland navigation channel training works (river training structures, navigation dams). Maintenance of navigation channels and waterway marking. River ports. Planning and design of water areas and port terminals. Terminal dimensions. Terminal capacity. Introduction to queuing theory

Embankments and Stability of Slopes

Aim: To introduce students to the methods of slope stability analysis and remedial measures for slope stabilization. Introduction to the basics of design and construction of embankments.

Outcome: On completion of the course, students will be able to:`
based on the results of geotechnical investigations adopt input parameters of slope stability analysis (such as soil strength and pour water pressures) and to apply appropriate method to assess the stability of slopes, design remedial measures where necessary, apply the acquired knowledge in design and construction of embankments.

Contents: Modes and causes of slope failure: natural slopes, embankments, cuts, landfills. Geotechnical field investigations and laboratory tests. Soil strength. Methods of analyzing soil slope stability: limit equilibrium methods of stability analysis – planar, circular and noncircular slip surface. Finite element method (FEM) analysis. Stability of slopes under short-term and long-term conditions. Typical cases of slope instability. Remedial measures for slope stabilization. Embankments: embankments for roads and railways, embankment dams, landfills.

Geoenvironmental Engineering

Aim: To introduce students to the concepts of geoenvironmental engineering. Introduction to basic principles of groundwater flow and contaminant transport. To introduce students to contaminated site remediation methods and geotechnical aspects of landfill design.

Outcome: On completion of the course, students should be able to understand and solve basic problems of geoenvironmental engineering, to understand the geotechnical aspects of landfill design, to apply the acquired knowledge in design of landfills and to apply geosynthetic materials. Identify the types, advantages, and disadvantages of different methods of contaminated site remediation.

Contents: Introduction to geoenvironmental engineering. Soil properties. The basic principles of groundwater flow and contaminant transport. Multiphase flow in porous media. Numerical models. Characterization of waste and contaminants. Geotechnical aspects of landfill design. Solid waste landfills. Fly ash and bottom ash landfills. Geosynthetics and their application in geoenvironmental engineering. Contaminated site characterization, risk assessment of contaminated site, remediation methods. Case Studies.

Hydraulic Structures 2

Aim: Training of participants to design hydraulic structures (HC).

Outcome: Proficiencies for design of hydraulic structures.

Contents: Spillways: Basic concepts. Data requirements. Rating curve computation. Design flow. Risk management and risk analysis. The most common types of spillways. Overflow dams: purpose and characteristics. Gated and free spillways, hydraulic design, the discharge coefficient. Chute for overflow dams: hydraulic computation and design, self-aeration, cavitation and aeration.
Energy dissipation. Stilling basins. Downstream rip-rap protection. Sky jump, plunge pull. Chute spillway and Side spillway: the usage, characteristics, hydraulic design. The shaft spillway: the usage, characteristics, hydraulic design. Stepped spillway. Auxiliary spillways. Other types of spillways. Diversion works. Diversion tunnel. Hydraulic gates: purpose, division, rating curve, sealing. Surface intake structures: characteristics, location, hydraulic design, layout and basic types. Lateral intake, bottom intake (Tyrolean intake). Reservoir intakes: characteristics, hydraulic design, the most common mistakes in design and construction, layout and types. Water supply and drainage facilities, channels (lined and unlined), tunnels and penstocks. Structures for crossing watercourses: division, characteristics, fundamentals of hydraulic design. Cascades and fish ladders.
Other small hydraulic structures: types and uses, characteristics.

Hydroinformatics

Aim: Introduction to basic principles and required knowledge in domain of Hydroinformatics.

Outcome: Students capable to apply acquired knowledge in design and usage of Hydroinformatic systems.

Contents: Introduction to relational database. Basics of SQL. Spatial data models. Basics of GIS. Introduction to graph theory. Basic graph algorithms and application in hydro-networks. Algorithms of computational geometry and application in hydrotechnics. Different approaches to modeling in hydrotechnical engineering. Model calibration.

Tutorials: Each student works on his own individual hydrotechnical project from the field of: water distribution, sewage, irrigation or drainage system. Design of database for managing data for hydraulic modeling. Forming a network and applying algorithms for graph search, ring detection, topological sorting etc. Hydraulic modeling and analyzing results.

Municipal Hydraulic Engineering 3

Aim: Introduction to basic principles of wastewater engineering, treatment and reuse. Introduction to wastewater treatment plant structures and facilities.

Outcome: Students trained for independent application of theoretical knowledge for planning, designing and building of wastewater treatment facilities in cooperation with other engineering profiles (process, chemical, electrical, etc.)

Contents: Wastewater characteristics. Health and environmental concerns in wastewater management. Mathematical modeling of oxygen depletion processes in natural recipients. Water

pollution control regulations. Constituents of wastewater. Unit operations in municipal wastewater treatment. Wastewater treatment and residuals management. Municipal wastewater treatment plant: calculations of structures and facilities, sludge treatment and disposal, auxiliary structures, plant layout. Plant hydraulic profile. Automatic regulation and control in wastewater treatment plants.

Tutorials: Individual work: wastewater treatment plant calculations for a settlement (~15000 PE)

Stochastic Hydrology

Aim: Students capable of performing individually statistical and stochastic analysis within the hydrologic studies for planning, design and management of hydraulic engineering facilities and water resources systems.

Outcome: Students capable of performing individually statistical and stochastic analysis within the hydrologic studies for planning, design and management of hydraulic engineering facilities and water resources systems.

Contents: Introduction: deterministic, probabilistic and stochastic models; continuous and discrete random variables; independent events and time series of dependent data; univariate and multivariate probability distributions. Advanced statistical analysis of independent events: parameter estimation, criteria for selecting theoretical distributions; annual extremes method; confidence intervals; testing statistical hypotheses. Analysis of extreme values by point processes: peaks over threshold method; seasonal peak occurrence and compound peaks over threshold method; high-intensity storms analysis; low flows analysis; flood flows analysis. Time series analysis: statistical and stochastic characteristics of dependent hydrologic series (covariance, autocorrelation function); series decomposition into deterministic and stochastic component (trend, periodic component, outliers, stochastic component); linear and stationary models; autoregressive models, moving average models, mixed models. Simulation of hydrologic series. Regional hydrologic analysis: multivariate hydrologic problems; correlation matrix, multiple linear regression; regional hydrologic models; testing spatial homogeneity of the statistics and information transfer.

Tutorials: Individual computational tasks.

Measurements in Hydraulic Engineering

Aim: Introduction of basic work principles of contemporary sensors and measuring techniques for various hydrostatic and hydrodynamic quantities (water level, pressure, velocity, flow, concentration of different materials, etc.). Explanation of measuring method's application in different fileds of usage (measuring in pressurized systems, measuring in open channel flow, remote detection, measurement for control, etc.). Measuring error, quantification and handling errors, error propagation, optimization of measuring equipment for selected site.

Outcome: Students capable of performing individually measurements and data processing of basic hydraulic quantities, and capable for design and operation of measuring site.

Contents: Introduction. Place and role of measurement. Error analysis, error propagation, sources of errors, error handling. Basic characteristics of physical systems. Dynamic characteristics of physical systems. Measuring transducers for hydraulic quantities, types, principles of conversion, measuring bridge, error class. Pressure transducers. Level transducers. Velocity transducers (velocity vector in a

single point, averaged velocity along one line, velocity field). Flow transducers. Transducers for water quality and position. Application of transducers in pressurized systems. Measuring in open channels including sewer systems. Diagnostic measurements. Hydrometeorologic measurements. Remote detection for hydro cience. SCADA systems.

Practical work: Group semestral work (3 or 4 students) with public progress presentation and WEB site.

Numerical Methods in Hydraulic Engineering

Aim: Introduction to numerical methods in Hydraulic Engineering

Outcome: Proficiency of a student in application of numerical methods and usage of commercial software for solving practical problems in hydraulic engineering.

Contents: **Lectures**:
Errors in numerical problem solving. Interpolation and approximation. Numerical integration and differentiation. Solution of nonlinear equations. Matrices and related topics. Systems of linear equations. Systems of nonlinear equations. Numerical solution of ordinary differential equations. Numerical solution of partial differential equations. Finite differences method. Finite volume method. Finite element method.

Exercises: Exercises consist of fourteen homework problems

Link: http://www.grf.bg.ac.rs/studije/mo/e?mid=17&sem=1

6.4.3 University of Novi Sad – Faculty of technical sciences

At the Faculty of Technical Sciences, from its establishment until now, more than 17.000 students obtained Bachelor and Master degrees in engineering and more than 600 candidates obtained a PhD in engineering.

Based on recommendations of the University (initiated by the Faculty of Technical Sciences), the Rules on completion of the studies and acquisition of a title were adopted by the Law on Higher Education. According to that, the students were allowed to move into a new system of studies. They need to achieve 270 credits and then they can finish their studies after the defense of a Master thesis (30 credits). Therefore, in the end, the student achieves a total of 300 ECTS credits. The Faculty of Technical Sciences was the first faculty in Serbia to enable students to replace their degree with the ''new'' Master degree, according to the Law on Higher Education. So far, around 1,000 diplomas have been substituted at the Faculty. On the 23rd May 2008, the Faculty of Technical Sciences received the Decision on the accreditation of the Faculty as a higher education institution.

The Faculty of Technical Sciences originates from the Faculty of Mechanical Engineering, which was established by the Decree of the National Assembly of People's Republic of Serbia on 18th May 1960 as the Faculty of Mechanical Engineering in Novi Sad. At the beginning, it was a constituent part of the University of Belgrade. Then, after the founding of the University of Novi Sad on 28th June 1960, the Faculty of Mechanical Engineering as well as other six previously established faculties in Vojvodina became part of the University of Novi Sad.

In the first period of its development the Faculty of Mechanical Engineering provided educational activities for three different profiles of mechanical engineering. In 1971, electrical and civil engineering studies were also founded. The establishment of the Department of Electrical Engineering as well as of the Department of Civil Engineering brought - on 22nd April 1974 - to the change of the name into Faculty of Technical Sciences. In the academic year 1979/80, the studies in the area of traffic engineering started, and in 1996/97 the first generation of students of architectural engineering was enrolled. In the academic year 1999/2000 several different studies for the new professional profile were introduced: Industrial Engineering and Engineering Management, Graphic Engineering and Design, Environmental Engineering. Curricula for Postal Services and Telecommunications were introduced at the Department for Traffic Engineering in 1999/2000. Interdisciplinary studies of Mechatronics were established in the academic year 2002/03. In the academic year 2006/07, the first generation of students of specialist academic studies was enrolled at the Faculty (according to the Law on Higher Education). The studies of Geodesy and Geomatics engineering were introduced into the educational activities of the Faculty in the academic year 2007/08. Furthermore, in 2009/2010, the studies of Occupational Safety and Health were established at the Department of Environmental Engineering, as well as the undergraduate professional programme at the Department of Power Engineering – Renewable Energy Sources. In the academic year 2013/2014 the following curricula are established: Biomedical Engineering, Measurement and Control, Clean Energy Technologies, Stage Architecture, Engineering and Design, Electric Power Software Engineering, Software Engineering and Information Technology and undergraduate professional studies within the curriculum of Electronics and Telecommunication. Beside Treatment and Water Protection program, master studies are organized also at: Mathematics in Engineering; Energy Management; Logistic Engineering, Digital Technology, Design and Production of Architecture and Urban Planning, Industrial Engineering - Advanced Engineering Technology, Industrial Engineering – Development and Product Lifecycle Management, Planning and Management of Regional

Development as well as. The Faculty of Technical Sciences offers a very prominent educational profile for prospective engineers, which ranks it among the most developed institutions in the field of technology in Serbia. The Faculty of Technical Sciences is organized as a unique complex institution comprising smaller organizational units such as departments, chairs, research centers, registrar offices, etc. for appropriate scientific fields and laboratories.

CURRICULUM IN WATER TREATMENT AND PROTECTION ENGINEERING

The name of the curriculum is Water Treatment and Protection Engineering. It is a Master academic study at the Department of Environmental Engineering and Occupational Safety and Health, Faculty of Technical Sciences, University of Novi Sad. The acquired academic degree is Master in Water Treatment and Protection (M.Sc.). A student has to complete the undergraduate studies with a minimum of 180 ECTS and to pass an entrance examination in order to be enrolled in the curriculum.

This document has been developed based on the Serbian accreditation document of the University of Novi Sad: DOKUMENTACIJA ZA AKREDITACIJU STUDIJSKOG PROGRAMA: "INŽENJERSTVO TRETMANA I ZAŠTITE VODA" MASTER AKADEMSKE STUDIJE.

The framework of the document is structured according to the EUR-ACE guidelines and to the following documents:

- EUR-ACE Framework Standards for the Accreditation of Engineering Programmes (as approved by the ENAEE Administrative Council on 5 November 2008).
- Modello CRUI/EUR-ACE per la Certificazione della Qualità e l'Accreditamento EUR-ACE dei Corsi di Laurea e dei Corsi di Laurea Magistrale in Ingegneria, Agenzia per la Certificazione della Qualità e l'Accreditamento EUR-ACE dei Corsi di Studio in Ingegneria - QUACING (2011).
- Rapporto di Autovalutazione a.a. 2012/2013, Università degli Studi di Firenze, Facoltà di Ingegneria, Corso di Laurea Magistrale in Ingegneria per la Tutela dell'Ambiente e del Territorio.
- Caporali E., Catelani M., Manfrida G., Valdiserri J., Accreditation of Environmental Engineering Education at the School of Engineering, University of Firenze (Italy), ENAEE Annual Conference (2013).

Needs, Objectives and Outcomes

The Master Program "Water Treatment and Protection Engineering" enables the students to concretize and expand their knowledge concerning waste water treatment. It allows understanding the basic principles of engineering in various fields of environment protection, acquiring additional expertise for the implementation of modern technical systems, gaining ability for knowledge integration to be applied in any particular case, ensuring them to be engaged in independent research and creative work during realization of the curriculum.

As matter of fact, developing countries often have to face uneven economic growth and need for sustainable development. It imperatively requires trained professionals, who will be prepared and trained for commercial and industrial systems, public enterprises and state institutions. They have to deal with all the complex problems accumulated in the field of environmental engineering and especially water treatment and protection.

In fact, the interdisciplinary nature of the curriculum Water Treatment and Protection Engineering, being a result of technical and engineering skills, specifically educates engineers in the field of environmental protection and enables them to solve the accumulated problems in the system of environmental and water protection, as well as in other industrial and commercial systems.

Evaluation

The curriculum Water Treatment and Protection Engineering is developed in response to the needs of the industry, business and institutions, which have to face environmental problems and ask for engineers with interdisciplinary expertise in the field of environmental engineering and water treatment and protection. This requirement is fulfilled because the curriculum was specifically designed on the basis of an extensive needs analysis and surveys of labor market needs. It ensures consistency and practical relevance of the academic program in the area of environmental protection at national and international level.

Program Educational Objectives

The aim of the curriculum is to achieve competence and academic skills in the field of Water Treatment and Protection Engineering. Being continued to undergraduate studies and including additional fundamental scientific disciplines as well as some vocational courses, such a master study enables students to develop creative skills and ability to consider issues with critical independent thinking, develop capacity for teamwork, cooperation and mastery of specific theoretical and applicative skills. The aim of the study is to educate a professional engineer who possesses the necessary knowledge in basic scientific disciplines, able to depict a realistic picture of the processes that occur in industrial systems and environment. In this regard, classic as well as special engineering disciplines are addressed. They are related to the fields of mechanical engineering, electrical engineering, programming and applied professional disciplines concerning water management and hazardous materials, environmental projects, management and risk reduction in environment.

One of the specific objectives, consistent with educational goals of experts from the Faculty of Technical Sciences, focuses on the development of knowledge and awareness among students about the need for permanent education (life-long learning 3L), and in particular on sustainable development and environmental protection.

Furthermore, the Faculty of Technical Sciences defined graduate master tasks and objectives for the purpose of education of highly competent staff in the field of industry, business, profession, science and engineering disciplines. The purpose of the curriculum in Water Treatment and Protection Engineering is fully consistent with these graduate master tasks and goals of the Faculty of Technical Sciences. The realization of such a curriculum results in education of Master engineers in Water Treatment and Protection Engineering that have competence, comparability and competitiveness in European and world levels. The final aim of the curriculum is to educate a master capable of teamwork, who can reveal the scientific results to experts and public and also able to be engaged in research.

Evaluation

The program educational objectives are consistent with the objectives pursed by the higher education institution, as well as with the needs of the labor market.

Program Outcomes

The purpose of the curriculum is to educate students for the profession of Master in Water Treatment and Protection Engineering, in accordance with the basic needs of society. The curriculum Water Treatment and Protection Engineering is designed to provide acquisition of competence and skills that are socially justified and useful.

Graduate Master Students of Water Treatment and Protection Engineering are competent and qualified to solve complex multidisciplinary problems, both from the theoretical and practical point of view. Competencies include, above all, developing skills of critical and independent thinking, skills of problem analysis, solution synthesis, prediction and behavior of selected budget solutions with a clear idea of good and bad sides of the chosen solution.

Qualifications and competences for the completion of the graduate academic studies are gained by the students, who:

- demonstrated theoretical knowledge and understanding in the field of environmental engineering, also increased by the knowledge gained at undergraduate studies. It is the basis to develop critical and independent thinking;
- are able to apply knowledge for solving complex problems in the new or unknown environment;
- who have the ability to integrate knowledge, solve complex engineering problems and to reason on the basis of information available, including considerations and responsibilities;
- are able to clearly and unambiguously transfer the knowledge and way of reasoning to professionals and general public;
- possess the ability to continue their studies in individual way.

Regarding specific abilities, it is worth mentioning that through a graduate academic curriculum, a student acquires basic knowledge and understanding of all disciplines of the selected study group and ability to solve specific problems using scientific methods and procedures.

A student with a Master degree in Water Treatment and Protection Engineering is capable to adequately define and present the results by intensive use of information and communication technologies. A student with a Master degree has an additional competency, compared to students in undergraduate studies, for application of knowledge in practice, monitoring and implementation of innovations in the profession. An important educational outcome is to train the students to independently apply the previously acquired knowledge, that was gained in the different fields previously studied. This allows to review the structure of the given problem and its system analysis and to draw conclusions on possible directions for its resolution. By reading literature, the students

expand their knowledge in the selected field and study various methods and papers relating to similar problems. In this way, the students develop the ability to conduct analyses and identify problems within the given topic.

Students are especially trained to design, organize and manage environmental protection. During education, a student acquires the ability to independently plan and conduct experiments with statistical data processing and to formulate and make the appropriate conclusions. Furthermore, a student with a Master degree in Water Treatment and Protection Engineering acquires special competence to sustainably use and protect the natural resources of the Republic of Serbia in accordance with the principles of sustainable development.

Evaluation

The program outcomes are consistent with the educational objectives and the market needs. In the future, it would be advisable to compare the outcomes of these curricula with those of other similar programs in other universities.

EDUCATIONAL PROCESS

Admission requirements

Every year a certain number of students is enrolled at the Faculty of Technical Sciences, depending on the social needs and the infrastructure resources, either through budget financing or self-financing. This is annually defined by special decisions of Scientific Educational Council of the Faculty of Technical Sciences. Students from other academic programs as well as persons who have completed other studies can apply for enrollment in the curriculum Water Treatment and Protection Engineering. In this respect, the evaluation committee (comprising heads of all departments involved in the realization of the curriculum) evaluates all the passed activities of candidates for enrollment. The evaluation is based on the recognized number of points determined by the year of study in which a student needs to be enrolled. The passed activities can be recognized in full, in part (Commission may require the proper supplement) or they cannot be recognized at all.

Evaluation

The criteria for enrollment are clearly defined by the recognized number of points determined by the year of study that the student applies for. It would be advisable, in the future, to develop some agreements with the other curriculums in order to facilitate the enrollment of students without educational debts.

Planning

The curriculum of graduate academic studies in Water Treatment and Protection Engineering is designed for the purpose of achieving defined goals and competencies. The structure of the curriculum includes elective courses with at least 30% points. Through elective courses, students meet their affinities profiled during undergraduate academic studies. The fundamental scientific disciplines, which are studied at this level, define the research character of the program and enable even better understanding of the complex processes in the environment. They also lie the

foundations for further scientific research at academic level. All courses last one semester and carry a certain number of points (one point corresponds to about 30 hours of student activities).

The study program includes the description of each course containing the name, the type of article, the year and the semester, the number of ECTS credits, the name of the teacher, the aims of the course and the expected outcomes, the knowledge and the competencies, the prerequisites for attending the course, the course content, the recommended literature, the methods of teaching, the way of testing and assessment knowledge. The study program is consistent with European standards in terms of conditions of enrolment, duration of study, conditions of transition to the next year, graduation, and modes of study.

Table 1. Study program and distribution of courses per semester - first year (S-semester; T-Teaching; E-Exercises; SR – Study Research; OFC - Other forms of teaching, O – obligatory; E – elective; EC – Elective choice)

Table 1. Study program and distribution of courses per semester - first year (S-semester; T-Teaching; E-Exercises; SR – Study Research; OFC - Other forms of teaching, O – obligatory; E – elective; EC – Elective choice)

FIRST YEAR												
No.	Course code	Course title		S	Type	Status	Active classes				Other classes	ECTS
							T	E	SR	OFT		
1	MPK001	Statistical and numerical methods		1	AGE	O	3	1	0	1	2	9
2	MRKI	Elective Course 1 (choose 1 of 2)		1		EC	2	2	0	0	0	5
		MPK004	Fundamentals in hydrotechnics and hydromechanics	1	SE	E	2	2	0	0	0	5
		MPK021	Sources and pollution of the environment	1	SE	E	2	2	0	0	0	5
3	MPKI2	Elective Course 2 (choose 1 of 2)		1		EC	2	2	0	0	0	5
		MPK022	Hydrometry	1	TM	E	2	2	0	0	0	5
		MPK023	Basics of biological principles of the environmental protection	1	TM	E	2	2	0	0	0	5
4	MPKI3	Elective Course 3 (choose 1 of 2)		1		EC	2	2	0	1	0	6
		MPK005	Analysis of the system of environmental protection	1	PA	E	2	2	0	1	0	6
		MPK028	Hydrotechnical objects and systems	1	PA	E	2	2	0	1	0	6
5	MPK026	Technological processes of water quality control		1	SE	O	3	2	0	0	0	7
6	MPK027	Management of envirnmental protection systems		2	TM	O	2	3	0	0	0	5
7	MPK009	Hazards and the environment		2	PA	O	3	3	0	0	2	9
8	MPK015	Technologies of renewable energy sources		2	SE	O	2	2	0	0	0	6
9	MPK029	Groundwater hydraulics		2	PA	O	3	2	0	1	0	8
Total number of active classes:							44					
Total number of ETCS credits: 60												

Types of courses:

AGE - Academic general education,

SE - Scientific-Expert,

TM - Theoretical and methodological,

PA - Professional and applicative

Table 2. Study program and distribution of courses per semester - second year (S – semester; T – Teaching ; E – Exercises; SR – Study Research; OFC - Other forms of teaching; O – obligatory; E – elective; EC – Elective choice)

SECOND YEAR													
No.	Course code	Course title		S	Type	Status	Active classes				Other classes	ECTS
							T	E	SR	OFT		
10	MPKI21	Elective Course 1 (choose 1 of 3)		3		IB	2	2	0	0	0	4
		MPK003	Advanced sanitary engineering	3	PA	I	2	2	0	0	0	4
		MPK012	Solid waste management	3	TM	I	2	2	0	0	0	4
		MPK014	Monitoring and system management	3	SE	I	2	2	0	0	0	4
11	MPK025	Design of drinking water treatment processes		3	PA	O	3	2	0	0	1	5
12	MPK024	Design of wastewater treatment processes		3	PA	O	3	2	0	0	1	5
13	MPK018	River basin management		3	PA	O	3	2	0	0	1	5
14	MPKI22	Elective Course 2 (choose 1 of 2)		3		IB	2	2	0	0	0	4
		MPK017	Fundamentals in geotechnics	3	SE	I	2	2	0	0	0	4
		MPK019	Risk management	3	PA	I	2	2	0	0	0	4
15	MPK020	Management of environmental impact assessment		4	PA	O	2	3	0	0	0	4
16	MPK0SP	Internship		4	PA	O	0	0	0	0	3	3
17	MPKSIM	Research work on theoretical aspects of master thesis		4	PA	O	0	0	15	0	0	15
18	MPK0ZR	Preparation and defence of master thesis		4	PA	O	0	0	0	0	10	15
Total number of active classes							43					
Total number of ETCS credits: 60												

Types of courses:

AGE - Academic general education,

SE - Scientific-Expert,

TM - Theoretical and methodological,

PA - Professional and applicative

An integrated part of the curriculum in Water Treatment and Protection Engineering is constituted by professional practice and practical work, for a total amount of 80 hours. This can be implemented in the relevant scientific research institutions, in organizations for innovation activities, in organizations which provide infrastructural support to innovation activities, in enterprises and public institutions. The educational goal of professional practice is to gain a direct knowledge about the working principles and the organization of those companies and institutions dealing with matters for which the student is getting qualifications and where he/she has the possibility of applying the acquired knowledge into practice. The students learn how to apply the previously acquired theoretical and professional knowledge to solve specific practical engineering problems in the selected companies or institutions.

The issue of professional practice is to introduce the students into the activities of the selected companies or institutions, their ways of doing business and management. Performing professional practice is done in agreement with the management of companies or institutions, and in accordance with the needs of the profession for which the student is qualified.

The student completes his/her studies by the elaboration of a master thesis. It involves theoretical and methodological preparation for in-depth understanding of the chosen field of study. Prior to the defense of the thesis, the candidate has to give proof of his/her theoretical and methodological competences in front of a Commission. The final assessment of the master thesis is performed on the basis of the theoretical and methodological preparation, on the evaluation of the contents of the thesis and on its defense. The final thesis is defended in front of a committee consisting of at least three professors, of whom one member has to be from another Department or Faculty. The educational goal of the master thesis is the application of theoretical, methodological, scientific, technical and professional knowledge, as well as the application of methods to solve specific problems within the selected area of study. By studying literature, students are introduced to the methods that are designed for solving similar tasks in engineering practice. In this way, the student acquires the necessary experience to solve complex problems and tasks and explores the possibilities to apply the previously acquired knowledge in practice. Then, in the second part of the master thesis, the candidate studies the problem and the complexity of its structure and draws conclusions on the possible ways of solving it.

The Master Thesis is formed in accordance with the individual needs. At first, the student studies the literature and learns about other projects that deal with similar topics. Then, he makes analyses of possible solutions to the specific task of the master thesis. Part of the work is conducted through independent research. It includes active monitoring of the current state of knowledge, organization and conduction of experiments, numerical simulations and statistical analysis of data. The Mentor compiles and submits to the student the tasks of the master thesis. The student is required to work within the given framework to the development of a given topic, which is defined task of master thesis work, by using literature from the proposed mentor. During the preparation of the master thesis, a mentor can give students additional guidance and references to specific literature. In the research study, the student consults the supervisor, if necessary, and also other teachers who are dealing with related topics. In case of need, the student performs measurements, tests, counts, surveys and other research on statistical data.

Evaluation

The planning of the curriculum is consistent with the educational objectives and outcomes. Particular relevance is given to the internships - which allow a practical application of the previously

acquired knowledge - and to the outline of the master thesis, in accordance with the individual needs and interests.

Delivery and Learning Assessment

Classes are taught through lectures and exercises. In the teaching process, special stress is put on the independent student research as well as on increasing his personal involvement in the educational process.

Lectures are supposed to explain the teaching material, through the use of appropriate didactical means. On this occasion, the students are also informed about research trends in the respective areas. During the exercises, which follow the lectures, specific tasks are presented and examples that further illustrate the material are exposed. In addition, exercises are supposed to provide additional information to the teaching material explained during the lectures. Exercises can be auditory, laboratory, computing or calculating. The part of the exercises can be performed in factories or other institutions. Student's obligations regarding exercises can include the elaboration of seminar papers and homework, project assignments or graphic works. Each student's activity during the teaching process is monitored and evaluated according to the rules adopted at the department level. Each course carries a certain number of ECTS. The entire study is considered completed when the student fulfils all the obligations under the study program and thereby gains a minimum of 60 ECTS.

Teaching methods are expressed through lectures, exercises and consultations. Examinations may be taken in the form of two colloquiums, each one presenting a chapter of the teaching material. Both colloquiums are taken in a written form. Colloquiums are held during the semester of instruction. Students who do not pass through colloquiums are obliged to take the entire exam at the final examination session. The final grade for each course of the curriculum is formed by continuous monitoring of students work and results during the academic year and the final exam. A student fulfill the study program by taking exams and acquiring a certain number of points. Each individual course in the program carries a certain number of points, which is achieved when a student successfully pass the exam. The number of points per each course is defined by a unified methodology of the Faculty of Technical Sciences for all curricula. It reflects how the student is burdened with obligations, on the basis of student's workload. The student success in mastering a particular course is continuously monitored during the teaching, and is expressed in points. The maximum number of points a student can achieve on the course is 100.

A student obtains the points of the course through involvement in the teaching process and fulfillment of pre-examination obligations. Each course of the curriculum has a clear way of gaining points. The way of gaining points during the teaching process includes a number of points that a student can obtain on the basis of a particular type of activities during the teaching process or through performing the pre-examination obligations and taking exams. The minimum number of points which a student can obtain by fulfilling the pre-examination obligations during the teaching process is 30 and the maximum number is 70.

The final success of the student for a given course is expressed by grades from 5 (failed) to 10 (excellent). Assessment of students is based on the total number of points obtained by their fulfillment of obligations and taking exams, including the quality of acquired knowledge and skills.

Table 3. List of points achievable during the different courses (O – Obligatory; E – Elective)

No.	Course title	Status	Lecture Attendance	Prerequisites	Final examination
1	Statistical and numerical methods	O	5.00	45.00	50.00
2	Fundamentals in hydrotechnics and hydromechanics	E	5.00	45.00	50.00
3	Sources and pollution of the environment	E	10.00	40.00	50.00
4	Hydrometry	E	10.00	40.00	50.00
5	Basics of biological principles of the environmental protection	E	10.00	40.00	50.00
6	Analysis of the system of environmental protection	E	10.00	20.00	70.00
7	Hydrotechnical objects and systems	E	10.00	40.00	50.00
8	Technological processes of water quality	O	10.00	20.00	70.00
9	Management of enviornmental protection systems	O	10.00	20.00	70.00
10	Hazards and the environment	O	10.00	20.00	70.00
11	Technologies of renewable energy sources	O	10.00	20.00	70.00
12	Groundwater hydraulics	O	10.00	20.00	70.00
13	Advanced sanitary engineering	E	10.00	20.00	70.00
14	Solid waste management	E	10.00	20.00	70.00
15	Monitoring and system management	E	10.00	20.00	70.00
16	Design of drinking water treatment processes	O	10.00	20.00	70.00
17	Design of wastewater treatment processes	O	10.00	20.00	70.00
18	River basin management	O	10.00	40.00	50.00
19	Fundamentals in geotechnics	E	10.00	20.00	70.00
20	Risk management	E	10.00	40.00	50.00
21	Management of environmental impact assessment	O	10.00	40.00	50.00
22	Internship	O	0.00	50.00	50.00
23	Research work on theoretical aspects of master thesis	O	0.00	0.00	100.00
24	Preparation and defence of master thesis	O	0.00	0.00	100.00

The Faculty also has a Student Web Service. Application for examinations through web service started at the Faculty of Technical Sciences in the academic year 2005/06. Since then, it is possible to apply for examinations from home or any other location, without coming to the registrar office and waiting in a queue.

In order to use the web service, a student has to be enrolled for that school year. At enrolment a student opens a web account, gets a personal identification number with a password and a number for making payments to the Faculty. They have to complete the so-called SV20 form, with all their personal data and information about their parents. This is then sent to the Provincial Bureau of Statistics. Higher year students are required to periodically update their personal data.

A student can make or cancel an exam application up to two days ahead of the examination date. When the application is completed, the list of applicants is sent electronically to the teacher of the course, who will electronically return the file to the registrar office once the exam is completed. The introduction of student's web service has also enabled students to electronically register for the courses, view the list of the courses they have already done, together with the grades and the state of their financial card.

Evaluation

The teaching is delivered according to planning and the examinations demonstrate the achievement of the learning outcomes. Questionnaires to the students (see Appendix) prove the quality of teaching and quantify the amount of workload, as perceived by the students.

Curriculum specification of selected courses in the field of water management

Table 4. Specification of course: Technological processes of water quality control

Course:					
Course code	MPK026	Technological processes of water quality control			
ECTS credits:	8				
Lecturers:		PhD Marina Šćiban, Full Professor; PhD Milutin Darko, assistant professor			
Course status:		O			
Number of classes (per week)					
Lectures:	Practice:	Other forms of classes:	Academic research:	Other:	
3	2	0	0	0	
Prerequisite courses:	None				
1. Educational objectives: Acquiring the necessary knowledge about the production processes that are used in the preparation (treatment) of the drinking water and the purification (treatment) of waste water.					
2. Educational outcomes (acquired knowledge): Student should master the basic knowledge of: · chemical reactions and reaction kinetics. · nuclear engineering · biological processes. · processes used in water treatment and wastewater treatment.					

3. Course content/structure:
Theoretical teaching: Basics of chemical reactions and reaction kinetics. Analysis of the reactor. Separation processes and mass transfer. Chemical oxidation and reduction. Coagulation and flocculation. The gravitational sedimentation. Flotation. Filtration through a granular medium. Membrane separation. Aeration and stripping gas. Adsorption. Ion exchange. Dry deposition. Disinfection. Basis of biological treatment (micro-organisms, microbial growth kinetics, suspended and immobilized by the growth of microorganisms, aerobic and anaerobic metabolism, biological nitrification and denitrification, the biological removal of phosphorus). Biological treatment processes. Practical classes: Computing practice (quantification process).

4. Teaching methods:
Classes are realized in the form of lectures, calculation exercises. There are two tests and two term papers, each of which contains a logical whole curriculum. In addition to lectures and exercises consultation are held regularly. Both, term papers and tests are taken in written form. Tests and term papers are held during the semester. Students who did not pass the perm papers must take the tests over the entire final exam.

Knowledge evaluation (maximum number of points 100)

Prerequisites	Compulsory	Points	Final examination	Compulsory	Points
Exercise attendance	Yes	5	Written exam	Yes	40
Lectures attendance	Yes	5	Oral exam	Yes	30
Test 1	Yes	10			
Test 2	Yes	10			
Colloquium exam I	No	20			
Colloquium exam II	No	20			

Literature

No.	Author	Title	Publisher	Year
1.	Spellman, F.R	Hadbook of Water and Wastewater Treatment Plant	SRC Press	2009
2.	J.C. Crittenden et all.,	Water Treatment: Principles and Design, 3rd Edition	John Wiley & Sons, Inc., Hoboken, New Jersey, USA	2012
3.	Metcalf & Eddy, Inc.	Wastewater Engineering: Treatment and Reuse, 4th Edition	McGraw-Hill, Inc.	2003

Table 5. Specification of course: Hydrometry

Course:		Hydrometry			
Course code	MPK022				
ECTS credits:	5				
Lecturers:		PhD Milutin Darko, assistant professor			
Course status:		E			
Number of classes (per week)					
Lectures:	Practice:	Other forms of classes:	Academic research:	Other:	
2	2	0	0	0	
Prerequisite courses:	None				

1. Educational objectives: Enabling students in fundamental areas for the acquisition of professional knowledge and practical application.
2. Educational outcomes (acquired knowledge): Acquired knowledge is used as a basis for further development in professional courses
3. Course content/structure: Hydrological cycle, precipitation, evaporation and transpiration, infiltration, runoff, small river water, high river water, propagation of flood waves, water reservoirs, thermal regime of the river. Measuring water levels, falling water surface, depth of water, the rate of water flow, dissemination of sediment. Dependencies between the water level and flow, dissemination and sediment flow. Data processing.
4. Teaching methods: Teaching is done interactively through lectures, auditory and computer exercises. In lectures theoretical part is presented with characteristic examples for better understanding. For auditory exercises typical tasks are done which deepens on the exposed material. Lectures and exercises are regularly held. Part of the material, which makes a logical unit can be taken during the teaching process through colloquiums. Colloquia are written and in the form of the test. The final grade is based on: attendance at lectures and exercises (auditory and computer), success in examinations and written exam (combined tasks and theory).

Knowledge evaluation (maximum number of points 100)

Prerequisites	Compulsory	Points	Final examination	Compulsory	Points
Exercise attendance	Yes	5	Written exam	Yes	50
Lectures attendance	Yes	5			
Graphical paperwork	Yes	20			
Test 1	Yes	10			
Test 2	Yes	10			

Literature

No.	Author	Title	Publisher	Year
1.	Zelenović Emir	Engineering Hydrology	Scientific Book Belgrade	1991
2.	Jovanović Slavoljub	Hydrometry	Faculty of Civil Engineering Belgrade	1980

Table 6. Specification of course: Fundamentals in hydrotechnics and hydromechanics

Course:					
Course code	MPK004	Fundamentals in hydrotechnics and hydromechanics			
ECTS credits:	5				
Lecturers:		PhD Đurić Duško, associate professor; PhD Milutin Darko, assistant professor			
Course status:		E			
Number of classes (per week)					
Lectures:	Practice:	Other forms of classes:	Academic research:	Other:	
2	2	0	0	0	
Prerequisite courses:	None				
1. Educational objectives:					

Enabling students in fundamental areas for the acquisition of professional knowledge and practical application.
2. Educational outcomes (acquired knowledge): Acquired knowledge is used as a basis for further development in professional courses
3. Course content/structure: Fundamentals of hydrology and hydrometry. Physical and chemical properties of liquids. Hydrostatics, monitoring well, gauge, absolute, atmospheric and hydrostatic pressure. The compressive force on the flat and the complex surface, the pressure of the fluid in the pipe and reservoir. Hydrokinetics, flow rate, flow, continuity equation, equation of steady flow of ideal and real fluids. Application of the Bernoulli equation to examples. Flow in water-pipes, line and local losses of mechanical energy. Steady flow in conductors with a free surface. Uniform flow with free surface, Reach-Manning equation, types of flow quiet, turbulent and critical regime. Non-uniform flow with free surface, transitional regimes. Short objects, dressings, highlighting and narrowing the bridge. Basic settings of groundwater flow. Darcy equation for speed.
4. Teaching methods: Teaching is done interactively through lectures. At lectures theoretical part is presented with characteristic examples for better understanding. In addition to lectures regular consultations are held. Presentations from the lectures are available in electronic form for students. Part of the material, which makes a logical unit, can be taken during the teaching process through colloquiums. Colloquia are written in the form of the test

Knowledge evaluation (maximum number of points 100)

Prerequisites	Compulsory	Points	Final examination	Compulsory	Points
Homework	Yes	5	Written exam	Yes	50
Homework	Yes	5			
Homework	Yes	5			
Homework	Yes	5			
Computational test	Yes	5			
Lectures attendance	Yes	5			
Test 1	Yes	10			
Test 2	Yes	10			

Literature

No.	Author	Title	Publisher	Year
1.	Georgije Hajdin	Basic Hydraulics	Faculty of Civil Engineering Belgrade	2002
2.	Batinić R., Radojković M.	Stationary flow in open channels with prismatic cross section	Faculty of Civil Engineering Belgrade	1973

Table 6. Specification of course: Groundwater hydraulics

Course:		
Course code	MPK029	Groundwater hydraulics
ECTS credits:	8	
Lecturers:		PhD Srđan Kolaković, Full professor; PhD Đurić Duško, associate professor
Course status:		E
Number of classes (per week)		

Lectures:	Practice:	Other forms of classes:	Academic research:	Other:
3	2	1	0	0

Prerequisite courses: None

1. Educational objectives:
Enabling students in fundamental areas for the acquisition of professional knowledge and practical application.

2. Educational outcomes (acquired knowledge):
Acquired knowledge is used as a basis for further development in professional courses

3. Course content/structure:
Flow underneath buildings, square grid. Hydraulic instability of porous media. Unsteady flow towards a single well. Specific yield of aquifers. Operating range of the well. The impact of the limits and conditions on the borders of the effects of water abstraction. Data processing for pumping test. Problems of designing and exploitation wells. Phenomena and processes that reduce the generosity of wells. The choice of filter characteristics and the filling openings of the filter. Lowering of groundwater for the purpose of construction of buildings (construction pit). Problems with the construction of facilities in groundwater.

4. Teaching methods:
Teaching is done interactively through lectures, auditory, laboratory and computer exercises. Theoretical part is presented with characteristic examples for better understanding. Auditory exercises are done with typical tasks which depend on the exposed material. In addition to lectures and exercises consultation are regularly held. Part of the material, which makes a logical unit, can be taken during the teaching process through colloquiums. Colloquia are written and in the form of the test. The final grade is based on: attendance at lectures and exercises (auditory and computer), success in examinations and written exam (combined tasks and theory).

Knowledge evaluation (maximum number of points 100)

Prerequisites	Compulsory	Points	Final examination	Compulsory	Points
Graphical work	Yes	20	Written exam	Yes	70
Lectures attendance	Yes	5			
Exercise attendance	Yes	5			

Literature

No.	Author	Title	Publisher	Year
1.	Georgije Hajdin	Selected topics in groundwater hydraulic	Faculty of Civil Engineering Belgrade	2008
2.	Vuković M., Soro A.	Groundwater dynamics	Institute of Water Management "Jaroslav Černi"	1984

Table 7. Specification of course: Hydrotechnical objects and systems

Course:					
Course code	MPK028	Hydrotechnical objects and systems			
ECTS credits:	6				
Lecturers:		PhD Srđan Kolaković, Full professor; PhD Stipić Matija, associate professor			
Course status:		O			
Number of classes (per week)					
Lectures:	Practice:	Other forms of classes:	Academic research:	Other:	
2	2	1	0	0	
Prerequisite courses:	None				

1. Educational objectives:

Introducing students to the practical problems and the acquisition of professional knowledge for practical application in the field of planning and water management.

2. Educational outcomes (acquired knowledge):

Acquired knowledge is directly applicable in engineering practice, as well as for upgrading knowledge and understanding of other engineering subjects.

3. Course content/structure:

Hydraulic structures, division and specificity, activity of water in hydraulic structures. Materials for the construction, static and dynamic water pressure and seismic action, waves, ice operation, safety slip, rummage, resurfacing.

Instability of the object due to distortion of the structure of land under the building, lift, measures to reduce buoyancy. Actions on objects in the zone of surface water and groundwater. Hydro system, their specificity and manage them.

4. Teaching methods:

Teaching is done interactively through lectures, auditory, laboratory and computer exercises. Theoretical part is presented with characteristic examples for better understanding. Auditory exercises are done with typical tasks which depend on the exposed material. In addition to lectures and exercises consultation are regularly held. Part of the material, which makes a logical unit can be taken during the teaching process through colloquiums. Colloquia are written and in the form of the test. The final grade is based on: attendance at lectures and exercises (auditory and computer), success in examinations and written exam (combined tasks and theory).

Knowledge evaluation (maximum number of points 100)

Prerequisites	Compulsory	Points	Final examination	Compulsory	Points
Graphical work	Yes	20	Written exam	Yes	50
Lectures attendance	Yes	5			
Exercise attendance	Yes	5			
Test 1	Yes	10			
Test 2	Yes	10			

Literature

No.	Author	Title	Publisher	Year
1.	Kolaković Srđan	Hydrotechnical objects and systems	Faculty of Technical Sciences Novi Sad	2006
2.	Savić Ljubomir	Introduction to hydraulic structures	Faculty of Civil Engineering Belgrade	2003

Table 8. Specification of course: Design of drinking water treatment processes

Course:					
Course code	MPK028	Design of drinking water treatment processes			
ECTS credits:	6				
Lecturers:		PhD Klašnja Mile, Full professor; PhD Milan Dimkić, Full professor			
Course status:		O			
Number of classes (per week)					
Lectures:	Practice:	Other forms of classes:	Academic research:	Other:	
3	2	0	0	0	
Prerequisite courses:	None				

1. Educational objectives:
Acquiring the necessary skills and knowledge to resolve the problems of design of the preparation process (treatment) of drinking water, and the plant for preparation of drinking water (industrial water).

2. Educational outcomes (acquired knowledge):
Understanding the importance and role of obtaining hygienic and quality of drinking water in the context of the overall problem of water supply. Understanding and knowledge of the process of drinking water treatment, and ways to design an appropriate process water treatment plants and water treatment plants achieve the required quality of drinking water.

3. Course content/structure:
Theoretical teaching: Characteristics and water quality standards for drinking water quality. Selection of unit preparation process water, alternative process line (technology) water treatment. Conceptual design of the preparation process and plant for preparation of drinking water. Elements of the project processes and systems. The design phase of the process of preparing water: aeration and stripping with air; stirring, the coagulation and flocculation; clarification; filtration (filter with a granular infill); membrane separation; oxidation and disinfection; lime softening; ion exchange; processes on activated carbon; handling of chemicals; instrumentation and process control. The aspect of environmental protection: the waste streams of the process of preparation, their processing and disposal. Operator training and the start of operation of the plant. Safe operation of the plant. Practical exercises: Demonstration of the process of design: design of process water treatment; conceptual design process line (technology) and water treatment plants for treatment of water; technological development project plants for water treatment.

4. Teaching methods:
Lectures and exercises (interactive work in the simulation process design process and treatment plant for preparation of drinking water).

Knowledge evaluation (maximum number of points 100)

Prerequisites	Compulsory	Points	Final examination	Compulsory	Points
Lectures attendance	Yes	5	Colloquium	No	20
Exercise attendance	Yes	5	Colloquium	No	20
Test 1	Yes	10	Written exam	Yes	40
Test 2	Yes	10	Oral exam	Yes	30

Literature

No.	Author	Title	Publisher	Year
1.	J.C. Crittenden et all.,	Water Treatment: Principles and Design, 3rd Edition	Faculty of Technical Sciences Novi Sad	2012

2.	AWWA, ASCE	Water Treatment Plant Design. 6th Edition	McGraw-Hill. Inc.	2012

Table 9. Specification of course: River basin management

Course:					
Course code	MPK018	River basin management			
ECTS credits:	5				
Lecturers:		PhD Milan Dimkić, Full professor; PhD Duško Đurić, Associate professor;			
Course status:		O			
Number of classes (per week)					
Lectures:	Practice:	Other forms of classes:	Academic research:	Other:	
3	2	0	0	0	
Prerequisite courses:	None				

1. Educational objectives:
Introduction to the basic elements of natural, socio - economic and legal environment and the way they impact on the
mechanisms of river basin management.

2. Educational outcomes (acquired knowledge):
After completing the course content student should have developed the ability to solve scientific, research and professional tasks and problems in the field of river basins management.

3. Course content/structure:
Pressures on water quality. Legislation in the field of water quality and aquatic sediment quality. Theoretical basis and methods for water quality analysis and immobilization of organic and inorganic components. The application of techniques and methods for monitoring of water quality. Status of surface water, groundwater. Monitoring of water quality and aquatic sediment. Methods for sediment remediation. Measures and actions for improvement of water quality. Analysis of the main activities and objectives of water quality management plans and studies of sediment remediation.

4. Teaching methods:
Classes will be realized in the form of lectures, exercises and seminar work. In addition to lectures and exercises consultation are held regularly. Term papers are made by groups designated by the subject teacher, while research papers are auditory in terms of exercise. Each term paper consists of a theoretical and computational work that can be put down in writing during the semester. Students who did not pass both term papers must take the tests over the entire final exam. The oral exam is taken after passing the written exam and all examination prerequisites realized.

Knowledge evaluation (maximum number of points 100)

Prerequisites	Compulsory	Points	Final examination	Compulsory	Points
Lectures attendance	Yes	5	Colloquium	No	20
Exercise attendance	Yes	5	Colloquium	No	20
Seminar work	Yes	20	Written exam	Yes	40
Test 1	Yes	10	Oral exam	Yes	10
Test 2	Yes	10			

Literature

No.	Author	Title	Publisher	Year
1.	Dimkic A.Milan., Brauch	Groundwater Management in Large	IWA	2008

	Heinz-Jürgen, Kavanaugh Michael	River Basins	Publishing,London	
2.	Dante A., Caponera, Marcella Nanni	Principles of Water Law and Administration	Taylor & Frances	2007
3.	Daniel P. Loucks, Eelco van Beek	Water Resources Systems Planning and Management - an introduction to methods, models and applications	UNESCO Publishing	2005

Table 10. Specification of course: Advanced sanitary engineering

Course:				
Course code	MPK003	Advanced sanitary engineering		
ECTS credits:	4			
Lecturers:		PhD Stipić Matija, Assistant professor;		
Course status:		E		
Number of classes (per week)				
Lectures:	Practice:	Other forms of classes:	Academic research:	Other:
2	2	0	0	0
Prerequisite courses:	None			
1. Educational objectives: Education objective is to familiarize students with advanced techniques that are applied in the field of sanitary engineering primarily with techniques of designing water supply and sewage systems for settlements and cities as well as mastering for independent work in application given techniques using modern standards and methods.				
2. Educational outcomes (acquired knowledge): After mastering lectures and exercises, students gain the ability to work independently in the application of advanced techniques for water supply and sewerage of settlements as necessary for the needs of environmental protection in the framework of which they acquire education.				
3. Course content/structure: Detailed description and illustration of solutions in the field of water, sewage and environmental protection. Waterworks design refers to the needs and requirements for water, for various purposes of human life, water sources that are distributes, quantity and quality of water, treatment and distribution of water and others. The design of sewage systems is related on the quality and quantity of municipal wastewater, construction and design of sewage systems, treatment methods, and more. A typical design of a treatment plant for municipal wastewater treatment using active sludge and SBR technology.				
4. Teaching methods: Teaching will be performed by lectures, using appropriate presentation techniques, presentation current issues in the European environment and the country, preparation and development of exercises in which students will master the presented lecture and auditory exercises.				
Knowledge evaluation (maximum number of points 100)				

Prerequisites	Compulsory	Points	Final examination	Compulsory	Points
Lectures attendance	Yes	5	Written exam	Yes	40
Exercise attendance	Yes	5	Oral exam	Yes	30
Seminar work	Yes	20			

Literature

No.	Author	Title	Publisher	Year
1.	Dimkic A.Milan., Brauch Heinz-Jürgen, Kavanaugh Michael	Groundwater Management in Large River Basins	IWA Publishing,London	2008
2.	Dante A., Caponera, Marcella Nanni	Principles of Water Law and Administration	Taylor & Frances	2007
3.	Daniel P. Loucks, Eelco van Beek	Water Resources Systems Planning and Management - an introduction to methods, models and applications	UNESCO Publishing	2005

Table 11. Specification of course: River basin management

Course:					
Course code	MPK018	Design of wastewater treatment processes			
ECTS credits:	5				
Lecturers:		PhD Dalmacija Božo, Full professor; PhD Budinski Ljubomir, Associate professor;			
Course status:		O			
Number of classes (per week)					
Lectures:	Practice:	Other forms of classes:	Academic research:	Other:	
3	2	0	0	0	
Prerequisite courses:	None				

1. Educational objectives:
Acquiring the necessary knowledge and skills in the problems of designing the process of purification (treatment) of wastewater and wastewater treatment plants (refiners).

2. Educational outcomes (acquired knowledge):
Knowing the characteristics of wastewater. Understanding and knowledge of wastewater treatment processes, and ways to by designing an appropriate wastewater treatment and purification plant, the required level purification (emission standard) of wastewater.

3. Course content/structure:
Theoretical teaching: Origin of wastewater. Characterization of wastewater. Emission standards for wastewater. analysis and selection of wastewater flow and load elements. Selection of unit wastewater treatment processes, alternative process lines (technologies) for wastewater treatment. Conceptual solution of the purification process and plant for wastewater treatment. Designing stages of the wastewater treatment process: mechanical purification procedures; chemical purification processes; biological purification (processes with suspended micro flora; processes with immobilized micro flora; anaerobic processes); improved purification processes; disinfection. Waste Process Flows

wastewater treatment, treatment and disposal. Aspects of operation of the plant (control and management of the process; control smell; energetic efficiency). Practical classes Demonstration of the design process: designing the purification process wastewater; development of the conceptual solution of the process line (technology) of wastewater treatment and plant for wastewater treatment; development of a technological project for a wastewater treatment plant.

4. Teaching methods:
Lectures and exercises (interactive work in the simulation of the process design process and analysis for the treatment of waste water).

Knowledge evaluation (maximum number of points 100)

Prerequisites	Compulsory	Points	Final examination	Compulsory	Points
Lectures attendance	Yes	5	Colloquium	No	20
Exercise attendance	Yes	5	Colloquium	No	20
Test 1	Yes	10	Written exam	Yes	40
Test 2	Yes	10	Oral exam	Yes	30

Literature

No.	Author	Title	Publisher	Year
1.	Metcalf & Eddy, Inc.	Wastewater Engineering: Treatment and Reuse, 4th Edition	McGraw-Hill, Inc.	2003
2.	Eckenfelder, W.W. Jr., Ford, D.L., Englande, A.J. Jr.	Industrial Water Quality, 4th Edition	McGraw-Hill, Inc.	2009

RESOURCES AND FACILITES

Teaching staff with necessary professional and academic qualifications is appointed for the realization of the curriculum of Water Treatment and Protection Engineering. The number of teachers engaged in the realization of the curriculum meets the requirements of the study program itself and depends on the number of courses and on the number of hours of these courses. The total number of teachers is sufficient to cover the total number of hours of the study program, so that a teacher realizes about 180 hours per year (lectures, consultations, exercises, practical work, ...) or 6 times a week. Out of the total number of necessary teachers, one teacher is employed for 5% of working time, five teachers are from other faculties within the University of Novi Sad, one teacher from master and doctoral studies has been retired. Other teachers are full-time employed.

The number of collaborators meets the requirements of the study program. The total number of collaborators on the study program is sufficient to cover the total number of hours on exercises. The collaborators perform an average of 300 hours of exercises per year, or 10 hours per week. Scientific and professional qualifications of the teaching staff match the educational and scientific field and the level of their assignments. Each teacher has at least five references in specific scientific or technical fields, which are related to his teaching activities.

The group size for the lectures is up to 180 students, the group for exercises up to 60 students and groups for labs up to 20 students.

Registrar's office with twenty employees is located in the newly adapted space at the ground floor of the Educational block. It continuously manages students' academic activities during their studies and occasionally even later. The office is organized around twelve separate counters with employees working with students from different curricula. In addition to this, there is a front desk in

the entrance hall which is open all day to provide the necessary information, certificates and documentation to the students. The organization depends on the level of study. Some employees handle the first and second cycles, other are in charge of the third cycle. Registrar's office can be contacted through the Faculty web site: http://ftn.uns.ac.rs/. Registrar's office is available to students at any time and makes every effort to minimize the time required by the students to complete the administrative procedures. For that purpose it also introduced Students' Web Service.

Adequate, technical and technological libraries and other resources suitable to the features of the curriculum are available, according to the predicted student number and such that at least 2 m2 of space are provided per student. Lectures are held in amphitheatres, classrooms, computer rooms or measurement laboratories.

The library has more than 150 bibliographic units which are relevant for this curriculum Water Treatment and Protection Engineering. All the courses within the curriculum of Water Treatment and Protection Engineering are accompanied by adequate textbook literature, software licenses, multimedia presentations and other modern tools that are available in sufficient amount for the teaching process.

The Laboratory of Applied Chemistry consists of a cabinet equipped with computers (16 m2 surface) and experimental part (34 m2 surface), where a complete laboratory equipment is located. It includes utensils, chemicals and apparatus used for internships during several courses.

During laboratory exercises, students usually perform the following activities: synthesis and analysis of various disperse systems and the real solution, determination of the degree of purity of chemical substances, formation of colloidal systems and analysis of physical-chemical characteristics of the given systems, synthesis of compounds with different chemical bonds; conduction of different types of oxidation-reduction reactions and detection of visual changes in their progress, investigation of the effects of various catalysts on the dynamics of the chemical reactions; formation and dynamics of chemical equilibrium in homogeneous and heterogeneous systems, monitoring and analysis of corrosion processes, electrochemical processes, electroplating and metal deposition in electro-chemical mode, analysis and behavior of the strong and weak electrolytes in solutions, electrolysis, water hardness determination. Furthermore, the students do the following experimental determinations and practical exercises: neutralization method, determination pH values of solutions of acids and bases, cation exchange reactions -exhibited reaction; anion reaction – exhibited reaction; qualitative and quantitative chemical analysis - gravimetric determination; precipitate reactions; volumetric determination, establishment of complex compounds, determining the concentration of dissolved oxygen, conductivity and pH values of different types of drinking, municipal and industrial wastewater; effects of various exothermic and endothermic chemical reactions - the determination of heat; determination of the absorption curve of colored substance in solution and testing the applicability of Lambert - Beer law; spectrophotometric determination, sampling and analysis of waste water; water treatment, activated carbon, analysis and detection of air pollution by mobile gas chromatograph - Perkin-Elmer Photovac, Voyager.

During the laboratory exercises within the classes in the course Analysis of the System of Environmental Protection, the students do the following experimental activity: practical determination of Multi parameter Water Samplers - Multi 340i, determination of basic categories of data and necessary information for risk management against disasters, identification and analysis of equilibrium processes in heterogeneous systems, determination of thermal phase transitions, viscosity and vapor pressure of different systems, spectroscopic determination, qualitative and

quantitative analysis of the material system; chromatographic quantitative analysis, qualitative chromatographic analysis, analysis and detection of air pollution by mobile gas chromatograph - Perkin-Elmer Photovac, Voyager; operation of separation regarding heterogeneous systems - adsorption, coagulation and flocculation; demonstration, Jar test, adsorption determination of surfactants at the interface phase air / water, testing methods of benzene and paraffin diffusing on the surface of pure water.

The Centre for Computer Science at Faculty of Technical Sciences in Novi Sad was established in order to provide support to the process of modernization of the education activity and research work. The centre is located on the third floor of the teaching block in the Faculty building. It comprises seven laboratories:

L1 - General purpose computer laboratory (32 working positions)

L2 - Computer laboratory for design and computer graphics (16 working positions)

L3 - Special purpose computer laboratory (21 working positions)

L4 - Computer laboratory for construction and computer graphics (16 working positions)

L5 - Computer laboratory for design and computer graphics (21 working positions)

L6 - Multimedia laboratory (16 working positions)

L7 - Internet Laboratory (16 working positions).

In addition to the computer centre there are other 18 computer laboratories equipped to perform computer laboratory exercises. They provide between 12 to 32 places.

Since the academic year 2008/09, a computer classroom with 16 places, which is not used in regular teaching process, is available to students 24 hours. The Faculty of Technical Sciences has 79 state-of-the art equipped laboratories that are designed for: students education, research activity and providing services to third parties.

6.4.4 Missing skills and knowledge

Students need more practical exercises e. g. from internships with water-related companies. In addition, experience in using machine learning for data analysis is becoming more and more important in industry but hardly covered by water related study programmes. On top of that technical competency with domain-specific business knowledge that they acquire in practice is given too low emphasis.

In addition to technical skills students should also develop soft skills just as teamwork, listening, and, most important, empathy. This takes time and is only learned by experience. Graduates should possess not only theoretical and technical expertise, but also practical, domain-specific business expertise related to WRM.

The main bottleneck holding back further innovative WRM adoption is that company culture does not yet recognise the need for adoption of EU procedures. In addition, the lack of skilled people, and technical infrastructure challenges need to be addressed for the realisation of innovative WRM.

Some additional recommendations to better prepare students for their future work as engineers: students should improve their ability to use open source tools, libraries, tutorials and EU reports in the field of WRM. More student projects related to real world problems in water-related companies should be defined and provided to students. Professors should try to get international research projects in the field of WRM in order to involve students at the MSc and PhD level in preparing their final papers. Faculties and Universities should try to acquire additional finance in order to buy up-to-date laboratory equipment, software and library units.

7 Summary of missing skills and knowledge

The evaluation of master curricula showed several areas where improvement is possible. Activities for strengthening the master curricula in the western Balkan region should include both, investment in new hardware and laboratory equipment as well as changes in organisation and content of the courses. One country additionally mentions that more teaching staff is necessary to adequately support all students.

The following list should provide an overview of the most important missing skills and knowledge:

Missing technical knowledge:

- Modern technologies of water treatment
- Holistic understanding of water related processes
- Use of freely available tools such as open source software and libraries
- Use of other freely available resources such as EU reports
- Use of machine learning for data analysis

Missing technical skills:

- IT skills
- Turn theory into practice
- Analyse, assessment and implementation of integrated water management measures
- Working in a real world environment

Soft skills:

- Team work (listening, empathy)
- International experience
- Foreign languages
- Holistic view for problem solving, cross sectoral thinking

Missing resources:

- Laboratory equipment
- IT hardware
- software licenses
- libraries
- teaching staff

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BULGARIA

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UACEG, Curriculum of Short Master Programme in Water Supply and Sewerage; bilingual version: https://www.uacg.bg/filebank/ECTS-2018-2019/HIDRO/ViK_Mag1.pdf and https://www.uacg.bg/filebank/ECTS-2018-2019/HIDRO/ViK_Mag2.pdf

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CROATIA

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