Thematic area WATER AND ENVIRONMENTAL ENGINEERING (WEE)

for the final graduation examination in the Master's degree study programme
Water and Environmental Engineering

Topics of the COMMON part of the thematic area WEE:

Hydraulics:

- Principles of mathematical modelling: conservation of momentum and mass (Navier-Stokes equations, continuity equation), models of turbulence.
- Principles of physical modelling: model similitude, dimensional analysis, dimensionless numbers, types of physical models.
- Processes and phenomena: turbulence, boundary layer, unsteady flow, flow interaction with solid bodies, non-Newtonian flow.

Hydrology:

- Atmospheric water, surface energy balance, transport processes in the atmospheric boundary layer.
- Subsurface water, flow in porous media, infiltration, plant transpiration.
- Surface runoff, rainfall-runoff modelling, hydrological extremes.

Water Quality:

- Freshwaters eutrophication - causes, impacts, protection measures.
- Freshwaters acidification - causes, impacts, protection measures.
- Self-purification of streams and rivers - processes, where do they occur, what does effect them, typical longitudinal profile of water quality parameters below a sewage outlet.

Reservoirs Design and Management:

- Basic purposes of reservoirs and division of a reservoir storage capacity.
- Storage function of reservoirs. Data, reliability of water supply, the active storage determination.
- Flood control function of reservoirs – data, flood routing, reservoir with controlled (gated) spillway, reservoir with uncontrolled (ungated) spillway.

Ground Water Hydraulics and Modelling:

- Basic terms and principles in groundwater, physical properties of saturated zone, Darcy's law
- Laplace and Boussinesq equations, balance of flow, hydraulic approach simplification, Dupuit assumptions
- Flow in confined and unconfined aquifers. Linear flow through earth dam. Radial flow in wells.

Risk Analysis:

- Natural flood risk – governing ideas for risk analysis, linking consequences to flood events, probability of occurrence of natural floods, local flood characteristics and quantification of consequences, damages and casualties (population at risk vs expected casualties), flood risk vs flood hazard (categories), CBA input.
- Geotechnical risks – definition, risk sources, basic concepts in risk analysis, consequences in standards, factors of safety vs reliability-based design, LRFD, uncertainty (variability, lack of knowledge, site investigation vs construction cost increase)
- General risk analysis – definition of the risk, steps in risk analysis, acceptable risks, perceived risks, probability distributions used for risk analysis applications.

Topics of the TRACK-specific part of the thematic area WEE for the track
WATER MANAGEMENT:

Water Resources Management and Watershed Modelling:

- Runoff and erosion associated risks, soil erosion process in time and space (rain kinetic energy, splash, runoff, deposition), soil erosion forms (sheet erosion, rill erosion, gully erosion), empirical soil erosion modelling principles (Universal Soil Loss Equation).
- Off-site erosion effects, sediment transport modelling, reservoir's siltation, transport of contaminants by runoff and erosion. Basin scales versus model complexity.
- Landscape evolution and watershed management, soil protection measures and strategies (land organization, soil cover, agricultural strategies, technical measures against runoff and erosion).

Urban Drainage:

- Surface runoff processes in urbanized areas.
- Monitoring and modelling of urban drainage systems.
- Sustainable stormwater management in urbanized areas.

Drinking Water Engineering:

- Water demand (principles of calculating water demand (Q_{maxd}, Q_{maxh}), required water pressure (min. / max.) in private water connection given in the Czech Republic by Regulation no. 428/2001).
- Mathematical modelling of water distribution network system (basic types of water distribution networks according to their shape, advantages and disadvantages of different types of networks, parameters required to build geometry of network mathematical model in EPANET).
- Water supply system (diagram of water supply system, basic functions of water tanks, pipe materials of water supply system).

Water and Wastewater Treatment:

- Mechanical part of wastewater treatment plant (WWTP)
- Biological part of WWTP (including nitrogen and phosphorus removal)
- Sludge management

Topics of the TRACK-specific part of the thematic area WEE for the track
ENVIRONMENTAL ENGINERING AND SCIENCE:

Vadose Zone Hydrology:

- Water flow in variably saturated porous media: governing equations, boundary conditions and initial conditions
- Solute transport in porous media: advection, dispersion, conservative transport, reactive transport
- Hydraulic properties of porous media, heterogeneity of porous media, preferential flow

Environmental Monitoring and Data Assimilation Methods:

- Sensors and techniques for hydrometeorological monitoring
- Monitoring of environmental tracers, water quality, and ecological characteristics
- Data acquisition techniques, data analysis, and uncertainty analysis

Sustainable Landscape and Water Management:

- Positive and negative effects of globalization on landscape
- Basic principles of WFD (Water Framework Directive) and their impact on catchment development
- Sustainable development of human society – basic principles and its relation to landscape development and management

Subsurface Contamination & Remediation Technologies:

- Contaminants and their impact on humans. Site characterization for remediation.
- Soil remediation technologies in situ
- Soil remediation technologies ex situ