Theme 1: River and Flood Plain Science and Engineering

**BAE 5513 - Watershed Engineering**  
(3.0 cr; Prereq-3023, upper div IT; fall, every year)  
Application of engineering principles to managing surface runoff from agricultural, range, and urban watersheds. Design of facilities and selection of land use practices for controlling surface runoff to mitigate problems of flooding and degradation of surface-water quality.

**BAE 8513 - Hydrologic Modeling of Small Watersheds**  
(3.0 cr; Prereq-CE 3502, hydrology course)  
Study and representation of hydrologic processes by mathematical models: stochastic meteorological variables, infiltration, overland flow, return flow, evapotranspiration, and channel flows. Approaches for model calibration and evaluation.

**CE 4511 - Hydraulic Structures**  
(4.0 cr; Prereq-4501; A-F or Aud)  
Hydraulic design procedures for culverts, dams, spillways, outlet works, and river control works. Drop structures, water intakes, bridge crossings. Offered alt yrs.

**CE 4512 - Open Channel Hydraulics**  
(4.0 cr; Prereq-IT or grad, 3502 or #; A-F or Aud, fall, spring)  
Theories of flow in open channels, including gradually varied and rapidly varied flows, steady and unsteady flows. Computational methods for unsteady open channel flows, applications to flood routing. Introduction to moveable bed mechanics.

**CE 4501 - Hydrologic Design**  
(4.0 cr; Prereq-3502; A-F or Aud, fall, spring, every year)  

**CE 8511 - Mechanics of Sediment Transport**  
(3.0 cr; Prereq-3502 and 4501 or #; A-F or Aud)  

**FR 5114 - Hydrology and Watershed Management**  
(3.0 cr; =FR 3114; Prereq-Grad student or #; fall, every year)  

**FR 5153 - Forest and Wetland Hydrology**  
(3.0 cr; Prereq-[Basic hydrology course, [upper div or grad student]] or #; spring, every year)  
Current topics, methods/models in forest/wetland hydrology. Hydrologic role of forests, wetlands, riparian systems in snowfall/rainfall regimes. How activities such as deforestation, wetland drainage, and stream channel alterations, affect hydrologic response of watersheds. Runoff/streamflow response from undisturbed/ altered forest/wetland watersheds. Problem-solving exercises.

**GEO 4701 - Geomorphology**  
(3.0 - 4.0 cr [max 4.0 cr]; Prereq-1001, Math 1031 or #)  
Origin, development, and continuing evolution of landforms in various environments. Environmental implications. Weathering, slope and shore processes, fluvial erosion and deposition, arid region processes, glacial processes
Theme 2: River & Floodplain Ecology:

CE 8508 - Ecofluid Dynamics
(4.0 cr; Prereq-3502 or equiv; A-F or Aud)
Theoretical principles underlying environmental fluid dynamics of biochemical processes in lakes, rivers, wetlands, coastal ocean. Emphasizes small-scale fluid motion, dominant flux path, growth kinetics, thin layers, microstructure measurements

EEB 5?? - Stream and Watershed Ecology (currently under development by J. Finlay, EEB and NCED PI)
This graduate course will review dominant paradigms influencing current research and focus on areas of recent conceptual and empirical development in river ecosystems and their interactions with upstream and adjacent environments. We will explore topics that including geomorphic and hydrologic controls of ecological processes in river channels; rivers and global biogeochemical cycles; longitudinal connections in hydrologic, nutrient and organic matter cycles; ecology of food webs at the land-water interface; dynamics of longitudinally organized populations and communities; interactions between lakes and rivers; climate change and land-water interactions; scaling ecological phenomena in rivers. The format of this course will be a combination of lectures, discussion, field trips, and class project aimed at synthesis o primary literature. This course will be relevant for students with interests in aquatic ecology, environmental and water resources science, and conservation biology.

EEB 5xxx Limnology (currently under development by J. Finlay, EEB and NCED PI)
A new course to better serve the ca. 20-30 grad students per year who currently take the old version of Limnology (ie. EEB 4601) and advanced undergraduates. This course will serve as an advanced introduction to the interaction of physical, chemical, and biological variables that shape the ecology of freshwater ecosystems. The emphasis will be on lakes, and on quantitative components and primary literature. It will be offered simultaneously (spring) with a lab (5xxx Lab). Prerequisites: graduate standing in EEB, GEOL or WRS; alternatively chemistry plus one ecology course, or consent of instructor.

FW 8465 - Fish Habitats and Restoration
(3.0 cr; Prereq-Intro ecology course or #)
Mechanisms underlying physiology/behavior that shape fish community structure in specific north temperate habitats. Techniques and planning procedures for restoring lakes/streams

FW 8459 - Stream and River Ecology
(3.0 cr; Prereq-Limnology course or #)
Structure/dynamics of running waters from ecosystem perspective. Historical perspective, basic hydrology/fluvial geomorphology, terrestrial-aquatic interactions, detrital dynamics, metabolism, drift, trophic relations, biotic/abiotic interactions, ecosystem experiments and natural alterations, stability/succession, ecosystem dynamics in a watershed.

HORT 5071 - Restoration and Reclamation Ecology (ENVT)
(3.0 cr; Prereq-Biol 2022 or Biol 3002, Biol 1001 or Biol 3407 or equiv or #; fall, every year)
Ecological and physiological concepts as a basis for revegetation of grasslands, wetlands, forests, and other landscapes. Plant selection, stand establishment, evaluating revegetation success. State and federal programs that administer restoration and reclamation programs. Field trips within Minnesota.
Theme 3: Water Quality

**CE 5541 - Environmental Water Chemistry**
(3.0 cr [max 4.0 cr]; Prereq-3501, Chem 1021, Chem 1022; A-F or Aud, fall, every year)
Introduction to water chemistry. Physical chemical principles, geochemical processes controlling chemical composition of waters, behavior of contaminants that affect the suitability of water for beneficial uses.

**CE 8541 - Aquatic Chemistry**
(3.0 cr; Prereq-4541 or #; A-F or Aud, spring)
Advanced course on water chemistry; physical chemical principles and geochemical processes controlling the chemical composition of natural waters, soil- and sediment-water interactions. Emphasizes behavior of inorganic contaminants in natural waters and engineered systems and dissolved natural organic matter.

**CE 8561 - Analysis and Modeling of Aquatic Environments I**
(3.0 cr; Prereq-One sem grad work or #; A-F or Aud, spring, every year)

**CE 8562 - Analysis and Modeling of Aquatic Environments II**
(3.0 cr [max 6.0 cr]; Prereq-One sem grad work or #)
Models for transport/transformation of pollutants, nutrients, particulates, ecosystems, etc., from recently completed theses, articles, or research in progress. Students review assigned recent papers, make presentations, and analyze a topic of their choice.

**ENR 5111 - Hydrology and Water Quality Field Methods**
(3.0 cr; = [ENR 3111]; Prereq-Grad student or #; A-F or Aud)

**GEO 5701 - General Hydrogeology**
(3.0 cr [max 4.0 cr]; Prereq-Chem 1022, Math 1271, Phys 1201, Geo majors-core curriculum through 2402 or #; fall, every year)
Theme 4: Water Policy & Management:

**ENR 4295W - GIS in Environmental Science and Management (WI)**
(4.0 cr; =ENR 5295; Prereq-FR 3131 or #; A-F or Aud, fall, spring, every year)
Application of spatial data inventory/analysis in complex environmental planning problems. Spatial data collection, database development methods including GPS, DLG, TIGER, NWI data, spatial analysis. Topics identified by non-University partners.

**ENR 5202 - Environmental Conflict Management, Leadership, and Planning**
(3.0 cr; =ENR 3202W; Prereq-Grad or #; A-F or Aud, spring, every year)
Negotiation of natural resource management issues. Use of collaborative planning. Case study approach to conflict management, strategic planning, and building leadership qualities. Emphasizes analytical concepts, techniques, and skills.

**ENR 5061 - Water Quality and Natural Resources**
(3.0 cr; =ENR 4061W; Prereq-Grad student or #; fall, spring, every year)

**ENR 5703 - Agroforestry in Watershed Management**
(3.0 cr; =ENR 3703; Prereq-Grad student or #; spring, every year)
Biological, physical, and environmental attributes of agroforestry as pertains to watershed management. Coupling production with watershed protection benefits. Implications for policy, economics, and human dimensions in sustainable development. Examples/case studies from North America and developing countries.

**WRS 5101 - Water Resources: Individuals and Institutions (see CE 5581)**
(3.0 cr; A-F or Aud, fall, spring)
Control of water resources by natural system functions, user actions, and influence of social, economic, and political institutions. Water resource policy in the United States. Case studies (e.g., flood/drought management).