

## Undergraduate Water-Related Courses

### AAEC 3314 Environmental Law

Principles of law involved in environmental issues, survey of environmental litigation, legislation and administrative rulings. Law topics include natural resources, water pollution, private land use, air pollution, toxic substance, food, drug, pesticides, and biotechnology.

### AAEC 3324 Environment and Sustainable Development Economics

Sustainable development through an exploration of hard and soft green schools of thought. Hard Green Strategies reliance on markets, technology, property rights, human ingenuity to increase production efficiency versus Soft Green Strategies-adoption of simpler lifestyles, government subsidies, natural design of buildings (biomimicry), and urban infrastructure to locate public transportation hubs nearest to densely populated neighborhoods to decrease consumption of natural resources. Connecting the influence of place in personal and group identity. Interdisciplinary examination of environmental justice among poor and minority U.S. communities. Social equity distribution of the economic costs and benefits of natural resources management policies. Roles of property rights, economic incentives, religious values, and political power in determining local communities' capacity to control their environmental destiny.

### ALS/WATR 4614 Watershed Assessment, Management, and Policy

Multidisciplinary perspectives of assessment, management and policy issues for protecting and improving watershed ecosystems. Topics include: monitoring and modeling approaches for assessment, risk-based watershed assessment geographic information systems for watershed analysis, decision support systems and computerized decision tools for watershed management, policy alternatives for watershed protection, urban watersheds, and current issues in watershed management.

### BIOL 4004 Freshwater Ecology

Interactions of physical, chemical, and biological properties of freshwater ecosystems.

### BIOL/ENT 4354 Aquatic Entomology

Biology and taxonomy of insects and other macroinvertebrates most commonly encountered in freshwater environments. Selected aspects of biology, such as habitat, feeding, locomotion, and life history. Identification of individual taxa, mostly at family and genus level. Significance of these organisms in aquatic ecology, pollution monitoring, and natural resource management.

### BSE 3324 Small Watershed Hydrology

Precipitation, soil physics, infiltration, evapotranspiration, groundwater hydrology, overland flow, open channel flow, flow routing, hydraulic analysis.

#### BSE 3334 Nonpoint Source Assessment & Control

Erosion prediction and control; transport and fate of sediment, nutrients, and microorganisms; design of nutrient management plans, wetlands, detention facilities and other management practices for rural and urban nonpoint source pollution control.

#### BSE 4224 Field Methods in Hydrology

Site characterization: surveying, channel and floodplain mapping, land use, electronic data acquisition. Techniques for measuring surface and subsurface hydrologic processes: water flow, hydrologic conductivity, precipitation, evaporation. Sampling techniques: surface water, groundwater, and soil pore water sampling. In-situ monitoring: automatic samplers, dataloggers, water quality sondes. Laboratory analyses: good laboratory practices, selection of analytical method, calibration, quality assurance/quality control.

#### BSE 4304: Introduction to Watershed Modeling

Fundamental modeling principles used to quantify watershed hydrology, energy budgets, and associated ecosystem functions, such as plant dynamics and biogeochemical processes, at scales ranging from soil pores to watersheds. Code development and model integration to simulate watershed hydrology and nutrient and sediment transport. Model calibration and performance assessment. Data discovery, acquisition, and processing of data relevant to hydrologic/watershed modeling.

#### BSE 4394 Water Supply & Sanitation in Developing Countries

Social, economic and engineering principles of water supply and sanitation in developing countries as affected by climate, cultural and sociological factors, and material and financial resources.

#### CEE 3104 Introduction to Environmental Engineering

Overall view of environmental engineering with emphasis on hazardous waste management, water treatment, wastewater treatment, air pollution and its control, solid waste management, groundwater pollution and environmental regulations.

#### CEE 3304 Fluid Mechanics for Civil and Environmental Engineering

Introductory course in fluid mechanics. Includes concepts and measurements of fluid properties; computing hydrostatic and hydrodynamic forces on hydraulic structures; computing fluid pressures, discharges, and velocities; and determining energy losses in pipe flows. Course includes conducting hydraulic laboratory experiments and demonstrations, analyzing and interpreting collected data, and preparing technical laboratory reports. Emphasizes the fundamentals of effective interpersonal, written, and visual communication skills for technical civil engineering reports.

#### CEE 3314 Water Resources Engineering

Open channel flow; hydrology; hydraulic modeling; hydraulic machinery and structures; laboratory experiments and demonstrations.

#### CEE 4104 Water & Wastewater Treatment Design

Design of municipal water and wastewater treatment plants. Emphasis on characterization of water and wastewater and physical, chemical, and biological treatment methods. Sludge processing advanced treatment methods and treatment plant hydraulics are considered.

#### CEE 4264 Sustainable Land Development

An introduction to the modern techniques for developing land while maintaining a focus on long-term sustainability. Topics include site layout, stormwater impacts, air quality and microclimate, living resources, LEED and EarthCraft development standards.

#### CEE 4304 Hydrology

Precipitation, evaporation, consumptive use, infiltration; stream flow, flood routing; statistical analysis of hydrologic data, flood and drought forecasting, risk analysis, subsurface flow, well hydraulics, introduction to urban drainage design.

#### CEE 4314 Groundwater Resources

Fundamentals of groundwater hydrology; flow through porous media, both saturated and unsaturated; flow to wells in both confined and unconfined aquifers; seepage of groundwater to canals and field drains; analysis of aquifer test data to quantify flow and storage parameters; contaminants in groundwater, basic introduction to groundwater modeling.

#### CEE 4324 Open Channel Flow

Mechanics of open channel flow, including uniform flow, gradually varied flow, channel transitions, and unsteady flow.

#### CEE 4334 Hydraulic Structures

Hydraulic analysis and design of engineering structures for water control, including reservoirs, dams, spillways, spilling basins, drainage structures, and hydraulic models.

#### CEE 4344 Water Resources Planning

Analysis of the water resources planning process and the institutional framework for water resources management. Criteria and procedures for evaluating management alternatives are examined, with emphasis on assessment of economic and environmental impacts.

#### CEE 4354: Environmental Hydrology

Overall view of pollutants movements in surface waters, with emphasis on the role of various hydrologic processes. Natural and constructed wetlands and their use for water quality control. Fundamentals of river hydraulics. Design of flood control channels. Environmental consequences of various types of hydraulic systems. Mitigation, enhancement, and restoration techniques.

#### CSES/GEOG/GEOS 3304 Geomorphology

Examines the variety of landforms that exist at the earth's surface. Detailed investigation of major processes operating at the earth's surface including: tectonic, weathering, fluvial, coastal, eolian, and glacial processes. Field excursion.

#### CSES/ENSC 3614 Soil Physical & Hydrological Properties

Soil physical and mechanical properties and the physical processes controlling soil water retention and flow in agronomic and natural settings. Grain size distribution, weight-volume relationships, specific surface, electrical charge density, consistency, stress, compaction, rainfall runoff, water retention, steady/non-steady water flow in saturated/unsaturated soil, infiltration, bare soil evaporation, and soil water balance.

#### CSES/ENSC 3634 Physics of Pollution

Physical processes that control the fate of pollutants in our land, air, and water resources. Types and sources of pollutants, physical processes in the soil-water-atmosphere continuum controlling the dispersion and deposition of pollutants, the movement of pollutants, including radionuclides, by surface and subsurface water flow in soils, and physics of disturbed soils.

#### CSES/BIOL/ENSC 4164 Environmental Microbiology

Ecology, physiology, and diversity of soil and aquatic microorganisms; incorporates the significance of these topics within the context of environmental applications such as bioremediation, wastewater treatment, control of plant-pathogens in agriculture, and pollution abatement in natural systems. The laboratory portion of the course will stress methodology development, isolation and characterization of microorganisms from natural and engineered systems, and examination of the roles of microorganisms in biogeochemical cycling.

#### CSES/ENSC 4854 Wetland Soils and Mitigation

Wetland soils as components of natural landscapes: biogeochemistry, hydrology, geomorphology, hydric soil indicators, and wetlands functions under various land uses. Soil and hydrologic factors important to wetland delineation and jurisdictional determination. Mitigation of wetland impacts with emphasis on restoration and creation. Outdoor lectures at local wetlands and a two-day long field trip to observe and identify wetland soils are mandatory.

#### ENSC 3604 Fundamentals of Environmental Science

Interrelationships between human activities and the environment; provides national and global perspective; emphasis is on the physical, chemical, and biological principles and processes that are essential to an understanding of human-environment interactions; the role of energy in human and natural systems; environmental legislation and human behavior.

#### ENSC/CSES 4314 Water Quality

Provide comprehensive information on the physical, chemical, biological, and anthropogenic factors affecting water quality, fate and transport of contaminants in water, water quality assessment and management, and current water quality policies.

#### ENSC/CSES 4324 Water Quality Lab

Teach students a variety of laboratory chemical and biological techniques for water quality analysis. Complementary to ENSC/CSES 4314.

#### ENSC 4414 Monitoring and Analysis of the Environment

Provides comprehensive hands-on-laboratory-and field-based experience and information on the principles and methods for field monitoring and sampling, as well the physical, chemical, and biological analysis of soil, surface water, groundwater, and solid wastes within the context of regulatory compliance. Optional 40-hour Hazards Materials (HAZMAT) training will be available.

#### ENT/BIOL/FIW 4484 Freshwater Biomonitoring

Concepts and practices of using macroinvertebrates and fish to monitor the environmental health of freshwater ecosystems. Effects of different types of pollution and environmental stress on assemblages of organisms and underlying ecological principles. Role of biological studies in environmental regulation. Study design, field and laboratory methods, data analysis and interpretation, verbal and written presentation of results.

#### ESM 3024 Introduction to Fluid Mechanics

Fluid properties and hydrostatics. Derivation and application of the continuity, momentum, and energy equation (Bernoulli's equation) for ideal and real fluid flow (laminar or turbulent). Dimensional analysis and similitude. Introduction to boundary layers, lift and drag.

#### ESM 3034 Fluid Mechanics Laboratory

Introduction to experimental fluid mechanics. Dimensional analysis. Experiments on fluid properties, flow measurements, and flow visualization, including manometry, determining hydrostatic forces on submerged surfaces, applications of the impulse-momentum principle, velocity measurements, measuring drag forces, quantifying flow in channels. Modern data acquisition techniques.

#### FREC 2124 Forests, Society & Climate

Role of forest ecosystems on the global carbon cycle, climate, biodiversity and economies. Anthropogenic impacts on forest ecosystems and their ecological function in the face of changing climate. Regional and cultural implications for the state of the forests and deforestation-related policy. Climate-related threats to global forests, including loss of biodiversity, deforestation, forest fires, and invasive species. Sustainable forest management for anticipated future scenarios.

#### FREC/NR/LAR 2554 Leadership for Global Sustainability

Leadership principles and humanities perspectives that help examine and engage global sustainable development challenges such as climate change, food-water-energy nexus, rising middle class, circular economy, and environmental justice. Topics include collaboration, stories, conflict resolution, self-awareness, bias, equity, religion, hubris, globalism, and moral naturalism. Examine trade-offs among economic, environmental, and social dimensions of sustainable development. Integration and application of disciplinary topics including ethics, ecology, evolution, anthropology, economics, religion, aesthetics, and risk management.

#### FREC/SBIO 2784 Global Forest Sustainability

A socio-economic approach to examining the management and use of the world's forests, enhance knowledge of global forest resources and products, and understand the roles and relationships of key stakeholders.

#### FREC/WATR 3104 Principles of Watershed Hydrology

Study of hydrology in watersheds. Qualitative and quantitative principles of physical hydrological processes governing the movement, storage, and transformation of water on the Earth's surface as influenced by watershed characteristics, including human modifications.

#### FREC 3604 Climate Science

Physical and biological principles that govern Earth's climate with applications to natural resource management. Mechanisms explaining the causes of past and future climate change. Concepts of system dynamics as applied to the analysis of the climate system. Current and future effects of climate on ecosystem functioning and the associated provision of natural resources.

#### FREC/WATR 3754 Watersheds and Water Quality Monitoring

Delivery of water quality constituents from watersheds to water bodies (streams, lakes, and estuaries). Field monitoring methods to assess watershed drivers and how they affect water quality and aquatic ecosystem condition. Linkages among water quality, watershed characteristics, land use and management, and climate. Design of watershed monitoring programs to guide watershed management for protecting water quality and ecological condition of aquatic systems.

#### FREC/NR 4014 Natural Resources Economics

Examination of domestic and international natural resource use, exploitation, and degradation problems, with special focus on use of economics to understand why potential overuse of natural resources exists, and what policy options are available to correct these problems and ensure sustainable natural resource use over time. Water, forests, fisheries, land and exhaustible resources.

#### FREC 4354 Forest Soil and Watershed Management

Properties and processes of soil and water in forests. Emphasis on management for the delivery of ecosystem services at local to global scales. Includes analysis and interpretation in field and laboratory.

#### FREC 4374 Forested Wetlands

Classifications, jurisdictional delineation, and management options of forested wetlands. Relationship of hydrology, soils, and vegetation to ecosystem processes, societal values, and management with regard to environmental and legal considerations and best management practices. Emphasis is on forested wetlands in the southern U.S., but national and international wetlands are included.

#### FREC/WATR 4464 Water Resources Policy & Economics

Economic concepts to understand public and private decisions about water use. Current water policies and law. Analytical tools to evaluate policies and address management challenges. Water markets, climate change, and environmental flows.

#### FREC 4784 Wetland Hydrology and Biogeochemistry

Water flows creating wetland hydrologic regime. Hydrologic controls on wetland processes. Linkages between hydrology and biogeochemical cycles. Carbon, nitrogen, phosphorus, and other element cycles within and across wetland boundaries. Field methods to assess hydrologic regime and biogeochemical cycles. Ecosystems services from hydrologic and biogeochemical processes. Applications of wetland hydrology and biogeochemistry in wetland restoration, delineation, and creation.

#### FIW 2114: Principles of Fish and Wildlife Conservation

Basic principles, key people, agencies and laws guiding the science-based conservation and management of fish and terrestrial animals. Conservation and management of organisms, habitats, and human users examined in terms of biological, physical, ecological, ethical and sociological theories and practices. Local to global illustration from both recreational and commercial resources

#### FIW 2234 Fish, Fishing, and Conservation

Sensory perception, behavior, and consciousness in fish. Principles, as related to fish and why they matter, fish conservation ethics, food security, recreational fishing, and responsible fishing practices. Ethical reasoning applied to the contemporary issues of conservation and use of fish, such as subsistence fishing, fish farming, marine protected areas, highly migratory fishes, sharks tourism, and ornamental fishes.

#### FIW 3514 Fisheries Techniques

Application of field and laboratory methods in fisheries management and research. Experience with fisheries equipment and techniques.

#### FIW 4424 Ichthyology

Morphology and physiology, systematics, zoogeography, and identification of fishes.

#### FIW 4534 Ecology & Management of Wetland Systems

Introduction to the variety of wetland systems found in North America, though emphasis will focus on eastern and mid-Atlantic wetland systems. Origin and processes of formation of wetlands, functions and values of wetlands, wetland delineation, wetland classification, regulatory processes affecting wetlands. Objectives of and management techniques used to protect and/or manipulate wetland systems for wildlife and other human needs.

#### FIW 4614 Fish Ecology

Interactions of fish with the physical and biological environment. Adaptations of organisms, populations, and communities. Impacts of human activities on major aquatic ecosystems and important fishes. Ecological principles for management of important sport, commercial, and prey fishes.

#### FIW 4624 Marine Ecology

History, theory, and practice of fisheries management. Emphasis on basic strategies used in effective management and setting management objectives. Synthesis of fish population dynamics and manipulation, habitat improvement, and human management to achieve objectives. Case studies of major fisheries.

#### FIW 4714 Fisheries Management

History, theory, and practice of fisheries management. Emphasis on basic strategies used in effective management and setting management objectives. Synthesis of fish population dynamics and manipulation, habitat improvement, and human management to achieve objectives. Case studies of major fisheries.

#### GEOG/WATR 2004 Water, Environment, and Society

Introduction to the hydrologic cycle, water resources, and related environmental issues. Emphasis on ethics and relationships between human needs for and effects upon water including: water quality, water treatment, and wastewater treatment; water for health, energy, and food; water management, laws, economics, and conflict; hydrometeorological hazards and climate change; and potential solutions for these and other critical water issues.

#### GEOG 3104 Environmental Problems, Population, & Development

Environmental problems in their social, spatial, and global contexts. Impacts of globalization, neoliberalism, and population growth on the environment. Examination of effects of developed and developing countries on the environment. Focus on conceptualizing development, population dynamics, environmental justice, factory farming, energy and renewable energy, global health, disasters, and intercultural and global awareness.



#### GEOG/GEOS 4134 Interdisciplinary Issues and Ethics in Water Resources

Analysis of issues and ethics related to water resources, water as a hazard upon human (infrastructure, economy) and ecological (rivers, groundwater) systems, water and vector borne disease, climate change, dams, and eutrophication. Development of proficiency in demonstrating the multidimensionality of water resources.

#### GEOG 4204 Geography of Resources

Physical and cultural systems that influence the spatial distribution of resources and resource use. Emphasis on historical and current contexts of natural resources use and perspectives in the United States, with consideration of worldwide distributions of resources. Environmental cognition and perception, water, public lands, conservation and preservation, food and hunger, human population, and alternative energy.

#### GEOS 3014 Environmental Geosciences

The roles of geology and geophysics in defining and monitoring the natural environment, with special application to interactions between humans and the geologic environment. Both descriptive treatment and quantitative concepts related to environmental processes involving the solid earth and earth's surface, with emphasis on geologic hazards (e.g., earthquakes, volcanoes, landslides and slope failures, flooding, groundwater problems, mineral and rock dusts).

#### GEOS 3034 Oceanography

Descriptive and quantitative treatment of the geological, physical, chemical and biological processes that occur in, or are influenced by, the oceans. The history of oceanic exploration and discovery is addressed.

#### GEOS 4804 Groundwater Hydrology

Physical principles of groundwater flow, including application of analytical solutions to real-world problems. Well hydraulics. Geologic controls on groundwater flow.

#### LAR 3154 Watershed Sensitive Site Design & Construction

Examines soil and water resource issues related to landscape architectural site planning and design. Key topics include watershed sensitive site design, estimation and management of storm water runoff, rainwater conservation, design of open channel conveyances for site planning applications, and erosion and sedimentation control.

#### NR/GEOG 4444 Practicing Sustainability

Practicum in sustainability. Synthesize and integrate knowledge from undergraduate career and apply to real world problems of sustainability. Topics and projects selected from opportunities to examine specific local and regional sustainability issues on the VT campus, in the New River Valley and the Commonwealth at large.

#### UAP 3354 Introduction to Environmental Policy and Planning

Introduction to the interdisciplinary principles of environmental policy, planning, economics, and ethics to address pollution abatement, resources conservation, habitat protection, and environmental restoration. The course will focus on practical means of identifying environmental problems and creatively solving them.

#### UAP 4344 Law of Critical Environmental Areas

This course examines the legal principles and policy debates involved in the regulation and protection of critical environmental resources. Specific topics vary but will likely include wetlands law and policy, endangered species habitat, open space, forestland and farmland protection, coastal zone management, and floodplain regulation and policy.

#### UAP 4374 Land Use & Environment: Planning & Policy

Environmental factors involved in land use planning and development, including topography, soils, geologic hazards, flooding and stormwater management, ecological features, and visual quality. Techniques used in conducting environmental land inventories and land suitability analyses. Policies and programs to protect environmental quality in land use planning and development.