CENTRAL STATE UNIVERSITY

DEPARTMENT OF WATER RESOURCES MANAGEMENT

COURSE DESCRIPTIONS

2020-2021

COURSE NUMBERING SYSTEM
Courses numbered from 1000-2099 are introductory courses or courses normally taken in the freshman and sophomore years. Courses numbered from 3000-3099 are normally taken in the junior and senior years. Courses numbered from 4000-4099 are senior-level courses.

PREREQUISITES
Students must make certain that they have the necessary prerequisites for each course. Failure to do so may result in inadequate preparation and thus failure of the course. Prerequisites are indicated at the end of each course description.

NOTE: The University reserves the right to cancel courses that have insufficient enrollment.

The curriculum may also be subject to change as a result of ongoing curricular revisions and program development.

Please consult the University Web site (www.centralstate.edu) for the most recent course descriptions and class schedules.

ENVIRONMENTAL ENGINEERING

ENE 2200. Introduction to Environmental Engineering (I; 3) An introductory course that gives students some basic understanding of stoichiometry, chemical equilibrium, mass balances and kinetics (chemical and biological) in continuous and batch unit operations pertaining to environmental systems. Characterization of pollution in open systems such as streams, lakes and soil will be covered. Applications include drinking water, wastewater, municipal and industrial landfills, and hazardous waste operations. Site characteristics, risk analysis and assessment, toxicology, and site remediation will be briefly addressed. Students will work on generating an environmental impact statement for a construction project. *Prerequisites: CHM 1201, MTH 2503.*

ENE 3305. Fluid Mechanics and Hydraulics (I; 3) First course that deals with statics and dynamics of incompressible fluids in general, and water in particular. Fluid properties; Principles of hydrostatics; Kinematics and dynamics of fluid flows; Flow visualization; Mass, momentum, and energy conservation; Bernoulli's principle; Introduction to fluid flow in closed conduits and open channels; Introduction to turbo-machinery - pumps and turbines. Laboratory work includes demonstration of Bernoulli's principle and Reynold's laminar and turbulent flow concepts; estimating pipe friction; energy principles in open channel flow and steady flow formulas - Chezy and Manning's formulas; Hydraulic behavior of turbo machinery. Additional two contact hours are required for laboratory experiments. Three one hour lectures/one two-hour lab. *Prerequisites: MTH 2503 and PHY 2411. Equivalent to OET009.*

ENE 3309. Water Chemistry (I; 3) This is an applied course in chemistry dealing with chemical reactions in water. Chemical equilibrium speciation studies - Aqueous speciation, Precipitation-Dissolution, Oxidation Reduction in both natural and impaired aqueous environments. Rate laws and kinetics of aquatic reactions of environmental importance – Hardness Removal, Acid mine drainage, Disinfection. Laboratory experiments include estimation of total metals using atomic absorption spectrometer, organics using HPLC and Gas chromatograph/Mass spectrometer using EPA approved methods. Estimation of pH, dissolved oxygen, and conductivity. Colorimetric methods for estimation of chloride, nitrite, and nitrates in water. Use of a water chemistry model, MINTEQA2 to estimate species concentrations given the total metal, pH, and redox conditions. Two additional contact hours for the laboratory is required. Three one-hour lecture/one two-hour lab. *Prerequisite: CHM 1202.*

ENE 3315. Fundamentals of Air Quality Engineering (II; 3) Characterization and control of air pollution problems. Analysis of fundamental chemical and physical processes governing pollutant transport and dispersion in air. Combustion chemistry of hydrocarbon fuels. Air pollution control systems. Pollution sources, control techniques with introduction to sensors. Transformations, atmospheric transport, deposition and modeling. Indoor Air quality management. Three one-hour lecture.

ENE 3320. Engineering Hydrology (I; 3) Physical hydrology phases hydrologic cycle -evaporation, precipitation, infiltration and runoff. Physical and empirical models of evaporation from water bodies, evapotranspiration models; Precipitation measurement and assessment of temporal and spatial variability; Infiltration theory and modeling; rainfall runoff correlation in watersheds - overland flow, hydrographs and flow routing; Empirical models of rainfall-runoff correlation; statistical hydrology concepts; Environmental Hydrology. Three one-hour lecture/one two-hour lab. *Prerequisites: ENE 3305 and MTH 2001.*

ENE 3325. Groundwater Hydraulics (II; 3) Study of aquifers and their characteristics- porosity, specific yield and specific retention, permeability and transmissivity. Darcy's law and fluid continuum in soils; steady flow through confined/ unconfined/artesian aquifers with and without recharge; hydraulics of wells in confined and unconfined aquifers; design of wells; estimating groundwater characteristics using pumping data; groundwater contamination - site assessment, geologic study, plume delineation and remedial action. Introduction to groundwater flow models using MODFLOW; Well-head protection. Three one-hour lecture/one two-hour lab. *Prerequisites: ENE 3305, and GEL 1101 or instructor's permission.*

ENE 4405. Applied Hydraulics (II; 3) Application of principles of fluid mechanics to flow in pipes, pipe networks, open channels and hydro-machinery. Estimation of pressure distribution in pipe networks; Design of pipe networks; friction loss computation using Darcy-Weisbach, Hazen-Williams and Manning equations, solutions to pipe network problems using Hardy-Cross method, and use of computer models for the hydraulic design of pipe networks. Nonuniform flow in open channels and its application to flooding in rivers; introduction to unsteady flow in pipes and

open channels; dimensional analysis; hydraulics of pumps and turbines; and introduction to sediment transport in rivers. *Prerequisite: ENE 3305.*

ENE 4410. Water Model Applications (I; 4) This will be an applied course in the use of various water quality and water quantity models used in the water industry. The areas will cover hydrology, hydraulics, and groundwater and water quality. Emphasis on problem solving with real world conditions. Models considered include HEC-HMS and RAS, GMS, QUAL2EU, EPANET, WMS. *Prerequisite: ENE 3325 or permission of the instructor.*

ENE 4415. Water Supply (I; 3) The course will focus on the design and operation of water supply facilities-collection, treatment, and distribution. US EPA regulations on water quality, water quality standards, clean water act; water abstraction systems; theory and design of physical and chemical treatment systems-screening, sedimentation, coagulation, filtration, softening and disinfection. Water distribution pipe networks; laboratory experiments include jar testing for coagulants, and also an analysis of trihalomethanes. Three one-hour lecture/one two-hour for laboratory work and design calculations. Field trip to a local water treatment plant. *Prerequisites: ENE 3309 and ENE 3305.*

ENE 4425. Solid and Hazardous Waste Management (II; 3) Municipal solid waste topics include history, regulations, sources, composition, properties, engineering principles in handling, transferring and transporting, material separation, processing technologies, recycling, thermal conversions, design of incinerators, biological and chemical conversions, and remediation. Topics related to hazardous waste including identification, segregation, labeling, storing, disposal and clean up, and related hazardous waste regulations. Three one-hour lecture classes. *Prerequisite: CHM 1202.*

ENE 4430. Wastewater Treatment Systems (II; 3) A process design approach to studying wastewater treatment systems. Study of wastewater flows- quantity and quality. Study of sewer system design and maintenance. Fundamentals of reactor design with illustrations from wastewater treatment systems. Theory and design of key unit operations in wastewater treatment plant. Primary treatment processes-grit settling chambers and Parshall flume design, mechanically agitated screens, primary clarifier and odor control unit; Secondary treatment suspended growth systems; activated sludge with various configurations on feed and oxygen introduction, and oxidation ditch; attached growth systems theory of biofilms, design of trickling filters and rotating biological contactors. Solids handling: sludge digester theory and design, sludge loading and dewatering, digester gas and cogeneration. Field trip to a wastewater treatment plant. Laboratory experiments include wastewater characterization and disinfection bi-products identification using gas chromatograph/mass spectrophotometer. Three one-hour lecture/one two-hour for laboratory work and design calculations. *Prerequisites: BIO 2650, ENE 4415.*

ENE 4435. Soil and Water Pollution Control (II; 4) An advanced course that deals with physical and chemical characteristics of pollutants in soil and water and their fate and transport; thermodynamic properties of organic and inorganic pollutants in soil and water; equilibrium partitioning of pollutants in the environment; air to water partitioning using Henry's Law; vapor pure liquid partitioning using Raoult's Law; soil-water partitioning using Freundlich, Langmuir and BET sorption isotherms; modeling fate and transport of pollutants in soil and water, non-aqueous phase liquids. Use of 1-D groundwater models such as CXTFIT; Groundwater contamination using CHEMFLO and MODFLOW; Overview of remedial technologies discussion on engineering controls such as pump and treat and soil washing, biological treatments such as bioremediation and phytoremediation; case study on non-point source pollution. *Prerequisites: ENE 3309 and ENE 3325.*

ENE 4440. Environmental Professionals Seminar (I, II; 1) Discussions led by working professionals in the field of Environmental Engineering on selected topics in the field. Designed to expose students to a wide range of practitioners and issues.

ENE 4496. Senior Capstone Design Project I (I; 1) The first part of a two course sequence. It is designed for graduating seniors to integrate the knowledge they had gained in all ENE courses and apply in a field application/capstone design project related to a topic of interest within the field. Each student/student team will be required to work on an engineering project such as designing a typical environmental engineering system or recommending improvements in the operation of an environmental control system. Students will be expected to submit a formal report and an oral presentation to the Environmental Engineering Professionals class. This course involves selection of a topic and advisor(s), conducting literature search, understanding codes and regulations, conceptual design, selection of design tools, plan of work, and securing necessary resources.

ENE 4497. Special Problems in Environmental Engineering (I, II, III; 3) Individual study in advanced water resources management research. Open only to juniors and seniors.

ENE 4498. Senior Capstone Design Project II (II; 2) The second part of a two course sequence. It is designed for graduating seniors to integrate the knowledge they had gained in all ENE courses and apply in a field application/capstone design project related to a topic of interest within the field. Each student /student team will be required to work on an engineering project such as designing a typical environmental engineering system or recommending improvements in the operation of an environmental control system. Students will be expected to submit a formal final report and an oral presentation to the Environmental Engineering Professional class. This course involves design implementation, evaluation of alternatives, economic analysis, and inclusion of public health, safety and welfare aspects. *Prerequisite: ENE 4496.*

ENE 4596. Internship (I, II, III; 3) On the job training in agencies and/or companies engaged in activities related to environmental engineering/ water resources management. Not open to students who have participated in the co-op program.

GEOGRAPHY

GEO 1101. World Geography: Western geographic **Hemisphere (I; 3)** A survey of the western hemisphere to acquaint non-majors with cultural and geopolitical facts and principles that will assist them in interpreting contemporary events. *Equivalent to TAG OSS008.*

GEO 1103. World Geography: Eastern Hemisphere (II; 3)
A geographic survey of the eastern hemisphere to acquaint non-majors with cultural and geopolitical facts and principles that will assist them in interpreting contemporary events in Africa, Asia and Oceania.

GEO 1110. Fundamentals of Geography (I, II; 4) The course gives students an understanding and appreciation of the earth as the home of man, and studies the rudiments of the physical and cultural environment and the cognate and coordinating character of geography among the social sciences. This course serves as a point of departure for future studies in geography. *Equivalent to TAG OSS006.*

GEO 2202. Economic Geography (II; 3 - Even Years) A study of the geographic environment as related to the economic activities and pursuits of mankind. The major economic activities of man as well as the resource patterns of the earth are studied.

GEO 2203. Geography of Latin America (II; 3 - Odd Years) A study of the geographic factors, physical and cultural, that are basic to an understanding of the historical and contemporary development of Mexico and the countries of Central America, the West Indies, and South America.

GEO 2204. The Geography of Anglo-America (I; 3 – Even Years) A regional study of the U.S., Canada and U.S. territories which emphasizes analysis of the geographic environment and its impact on the socioeconomic development of regions.

GEO 3302. The Geography of Asia (II; 3 - Odd Years)
A regional study of the Near, Middle and Far East. Emphasis is placed upon the interpretation of the environmental elements of the continent, and their relevance to the socioeconomic and geopolitical aspects of the continent.

GEO 3313. Weather and Climate (II; 3) Designed to give some understanding of the elements and control of climate, climatic phenomena, climatic types, and the characteristics of the major types and classifications of climates as they are found on the continents. Daily observations will be made by the student in the laboratory and a log will be kept.

GEO 3323. The Geography of Europe (II; 3 - Even Years)
A regional study of Europe with an emphasis on the analysis of the geographic environment of Northern, Western, Southern and Eastern Europe and its impact on the socio-economic and geopolitical aspects of the continents.

GEO 3370. Introduction to Geographic Information System (I; 3) Topics of instruction will include analyses of selected, spatially distributed information of national resources and other societal parameters. Nature, characteristics, specification, types, acquisition, processing, organization, and management of spatial or geographic data. Application of the basic functional and analytical capabilities of GI systems using raster methods and vector methods and vector methods. The course will include practical instruction on commonly used geographic information software (GIS). *Prerequisite: MATH 2500 or Higher.*

GEO 4370. Advanced Geographic Information Systems (II; 3) This course is designed for advanced learning of the Geographic Information Systems (GIS), covering the upper-level topics in GIS, including network analysis, spatial statistics, spatial analysis, 3D visualization, integration of the Global Positioning System (GPS), and Remote Sensing, as well as applications in transportation, public health, hydrology, and marine science. The course will focus on the advanced spatial analytical feature and tools of the foremost GIS software. *Prerequisite: GEO 3370.*

GEO 4404. Conservation of World Natural Resources (I; 3 - Odd Years) Economic and geographical appraisal of resource conservation in the world. Geography of reserves, production, and the uses of the world's metallic and non-metallic minerals. *Prerequisites: GEO 1110 and GEO 2202, or 10 hours of social science or permission of the instructor.*

GEO 4405. World Political Geography (II; 3 - Odd Years) The geographical character of the nation-state. The relation of geopolitics to political geography. *Prerequisites: GEO 1110 and GEO 2202, or permission of the instructor.*

GEO 4406. World Cultural Geography (I; 3 - Even Years) A study of the geographic occupation, settlement and development of selected regions of the world.

GEO 4411. Urban Geography (I; 3 - Odd Years) Origin and growth of cities. Structure and function of urban centers, their area expansion, and trade interrelationships; examples will be studied in relation to city planning. *Prerequisites: Junior or senior standing, GEO 1110 and GEO 2202.*

GEO 4413. Geography of Russia and the Commonwealth (II; 3 - Even Years) The study of the major Soviet regions. The resource base in relation to the economic and political structures or aspects in the Soviet regions. *Prerequisites: Junior or senior standing, or GEO 1110 and GEO 2202.*

GEO 4414. Geography of Africa and Its Problems (I; 4 - Even Years) A regional study of the many geographies of Africa, its environments, the development of its culture and economic life, and its problems; analysis of western and Islamic impact on the creation and development of geographic regions. *Prerequisites: Junior or senior standing, or GEO 1110 and GEO 2202.*

GEO 4415. The Political Geography of Africa (II; 3 – Odd Years) A survey of the geographic factors in the settlement, formation, structure and intraAfrican relations of African States. The relation of geopolitics to Africa's political geography.

GEO 4450. Special Problems in Geography (I, III, III; 3) Individual research in the area of the student's interest. *Prerequisites: Senior major or minor and permission of the instructor.*

GEO 4470. Applied Remote Sensing (II; 3) This course students will learn about different instrument systems attached to aircraft and satellites that collect environmental data. Practical instruction on how the remotely acquired data sets are processed and interpreted using appropriate software will be given. Interpretation of multi-spectral scanners, RADAR and thermal imagery data; Data analysis for detection of changes; image interpretation; study of spectral characteristics of vegetation, soils water, minerals, and other materials. Case studies will be presented for the different types of application. *Prerequisite: MTH 2501.*

GEO 4495. Senior Project in Geography (On Demand; 3) This course is designed for graduating seniors to integrate the knowledge they gained in all Geography courses and apply it to a topic of interest in a field application project. Students will be required to choose a topic from a variety of projects pertaining to the field of Geography. *Prerequisite: Senior standing in the major field.*

GEOLOGY

GEL 1101. Physical Geology (I; 4) The origin of the earth, the solar system and the universe; the interior of the earth and its materials. A study of the agents, including the atmosphere, the oceans, surface water on land and their effects on shaping the surface of the earth. There will be one all-day field trip. Lab is required. The lab includes plate tectonics, mineral and rock identification, geologic time relationships, interpretation of topographic maps, identification and interpretation of geologic structures and groundwater. *Equivalent to TAG OSC011.*

GEL 1105. Historical Geology (II; 4) The history of the earth and how geologists have learned to interpret it. The origin of life and the history of organic evolution. Physiographic and tectonic changes through earth history with special emphasis on North America. Three hours of lecture and a two-hour laboratory per week and one all-day field trip. *Equivalent to TAG OSC012.*

GEL 1110. Oceanography (I; 3) Physiography of the ocean floors. Composition and structure of the ocean crust. Field and laboratory methods in marine geology. Marine sedimentation and the hydrodynamic, chemical and biochemical processes involved. Origin and evolution of the oceans and the ocean basins.

GEL 1240. Natural Disasters (I, II; 3) An examination of the causes, effects, and options available to mitigate natural disasters such as earthquakes, volcanic eruptions, landslides, subsidence, flooding, severe weather, and meteoritic impacts. No prerequisites are required and the course does not include a lab.

GEL 2205. Environmental Geology (II; 3) Covers broad range of topics, all related by the interactions between geologic processes and society. These include natural hazards, natural resources, and their policy implications in the face of an unrelenting increase in human population and economic growth. Students will be able to define and discuss fundamental geologic principles. *Prerequisite: GEL 1101 or permission of the instructor.*

GEL 3305. Introduction to Geophysics (II; 3)
This course is an introduction to methods used to visualize and understand the history, shape, mechanical structure, and dynamics of the solid-earth system. We will discuss how geophysical tools, including seismology, gravity, magnetism, heat flow, geochronology, and geodesy, are used to understand the age, whole-earth and near-surface structure, and to quantify the kinematics and dynamics of plate tectonics. Students will explore the most common geophysical methods applied in environmental studies, geohazards, water resources and engineering studies; physical parameters are measured using each method. Supplemental math instruction included. *Prerequisite: GEL 1101, MTH 1750 or PHY 1181.*

GEL 3311. Paleontology (I; 4 - Odd Years) A detailed study of fossils. Special emphasis is given to more stratigraphically significant types, especially invertebrates. Three one-hour lectures and one two-hour laboratory per week. Lab is required and is part of the five-hour credit. *Prerequisite: GEL 1105.*

GEL 3321. Mineralogy (I; 4 - Even Years) Description, properties, occurrences and methods of determination of the more important minerals, and an introduction to the principles of crystallography: Lab is required and is part of the four-hour credit. *Prerequisite: CHM 1201 and GEL 1101 or permission of the instructor. Equivalent to OSC013.*

GEL 4401. Stratigraphy and Sedimentation (I; 3 – Even Years) The principles of stratigraphy; correlation, facies relationships, fossil distribution and stratigraphic maps. The principles of sedimentation; nature of sedimentary rocks; and environmental controls on their composition, texture and distribution. *Prerequisites: GEL 1101 and GEL 1105.*

GEL 4421. Petrology (II; 3 - Odd Years) Study of origin, formation an occurrences of igneous, sedimentary and metamorphic rocks with particular reference to modern geochemical investigations. Examination and description of hand specimens and thin sections under the petrographic microscope. *Prerequisite: GEL 3321.*

GEL 4435. Mineral Deposits (II; 3 - Odd Years) A study of the geology, economics and politics of mineral deposits, including their genesis, classification and description. *Prerequisites: GEL 1101, 1105 and 3321 or permission of the instructor.*

GEL 4450. Special Problems in Geology (I, II, III; 3) Individual research in the of the student's interest. *Prerequisites: Senior standing (major or minor in geography) and permission of the instructor.*

GEL 4460. Process Geomorphology (II; 4) This course is a study and analysis of the origin, characteristics, and modification of landform on Earth's surface by dynamic systems through geologic time. Includes Earth's dynamic surface systems, such as orogenesis (mountain building); tectonics; erosion; shoreline processes; landslides; and transport and deposition by rivers, glaciers, wind, and gravity. The analysis of landforms and processes in this course will be directed using a largely quantitative approach, with written reports and a field-oriented project. Supplemental math instruction included. Field trips will provide opportunities for students to observe Ohio and Kentucky examples of several geologic processes and their resulting landforms. *Prerequisites: GEL 1101, MTH 1750 or PHY 1181.*

GEL 4495. Senior Project in Geology (II; 3) This course is designed for graduating seniors to integrate the knowledge they have gained in all geology courses and apply it in a field application project related to a topic of interest within the field. Students will be required to choose a topic from a variety of projects pertaining to the field of geology.

WATER RESOURCES MANAGEMENT

WRM 2200. Introduction to Water Resources Management (I, II, III; 3) Introductory course in water resources management designed to give students an interdisciplinary view of the nature of water as a resource. Topics include: Hydrologic Cycle, soil ecology, hydrogeology, irrigation and crop water requirements, water pollution and economics of water policy.

WRM/AGR 2450. Soil Science (I, II, III; 4) This course introduces students to soils; their formation, classification and survey. It covers physical, chemical, and biological characteristics; soil management and its role in crop production. Lab is required as part of the four-hour course credit. Students are to register for both course and laboratory. Three-hour lecture and two lab contact hours. *Prerequisite: CHM 1202, PHY 2612, and BIO 1500 or permission of the instructor.*

WRM 3302. Water Resources Policy (II; 3) An examination of major issues in water management and the development of policies at various levels of government that attempt to deal with those issues. Emphasis on the political aspects of policy development. Consideration of land use policy as it relates to water management issues. *Prerequisite: WRM 2200.*

WRM 3306. Socio-Economic Issues in Water Management (I; 3) A review of social, economic and other factors which influence the development of water management programs and the implementation of water management technologies. Problem solving in the selection and application of appropriate technologies given certain social and economic constraints. *Prerequisite: WRM 2200 or permission of the instructor.*

WRM/AGR 3308. Environmental Law (II; 3)
A case by case study of state and federal legislation relative to water use. Federal laws relating to water and environment; Land use legislation as it impacts the management of water resources and environment is also considered. *Prerequisites: WRM 2200 or AGR 1150 or Co-requisite: ENE 2200.*

WRM 3310. Streams and Lakes (II; 3) Introduction to the physical, chemical and biological ecology of streams and lakes. Emphasis on the structure and functions of natural ecosystems and man's impact on his natural environment. Field laboratory experience includes the use of nets, seines, traps and chemical and electronic monitoring equipment and the analysis of ecological data. Three one hour lectures/one two-hour lab. *Prerequisites: BI0 1500 and WRM 2200.*

WRM 3311. Water Resources Economics (I; 3) Principles of economics as applied to water supply and the regulation of water quality including cost-benefit analysis, pricing, discounting spillover effects, economic incentives, etc. *Prerequisites: AGR 1150 and WRM 2200.*

WRM 3312. World Water Resources (II; 3) A survey of world water resources by geographical area. An examination of the relationship of the availability of water resources to the political and economic stability of regions and nations. *Prerequisite: WRM 2200.*

WRM/AGR 3330. Soil and Water Conservation (II; 4) Hydrological processes in agricultural fields - rainfall, infiltration, evaporation, evapotranspiration and runoff; Ground Water Processes; Water conservation practices; Soil erosion due to rainfall, its effect on agricultural productivity and water quality-estimating soil loss from agricultural lands using Agriculture Research Service (ARS-USDA) models - Universal Soil Loss Equation (USLE) and its revisions; Practices to mitigate soil erosion; Design of grassed waterways, terraces and conservation structures; Wind erosion -estimation using ARS-USDA models and its mitigation; An examination of the federal, state and local organizations which carry out soil and water conservation programs. Field experience includes on-site observation of soil and water conservation practices. Three-hour lecture and one-hour lab/field work. *Prerequisites: MTH 1750 and WRM 2200 or AGR 1150.*

WRM/AGR 3335. Irrigation and Drainage (I; 3) A first course in the study of irrigation and drainage and practices. Soil structure, soil moisture processes and infiltration; evapotranspiration processes and their applications in irrigation and drainage; Models for evapotranspiration and introduction to irrigation scheduling; Irrigation and drainage practices in different parts of the world; Introduction to on farm and main systems in large scale irrigation projects. Water control and distribution in large scale systems. Sprinkler irrigation for non-agricultural purposes and the on-site observation of irrigation and drainage systems in the area. *Prerequisites: MTH 1750 and WRM 2200 or AGR 1150.*

WRM 3340. Hydrometry (II; 2) Techniques for the measurement of water in the atmosphere, and surface and sub-surface media; Soil moisture estimation, humidity measurement; rainfall measurement using recording gages and remote sensing techniques; Discharge measurement in constructed systems - weirs and flumes; Stream flow measurement using current meters, electro-magnetic and acoustic instrumentation; Aquifer parameters estimation using drawdown tests; Accuracy of and errors in measurement; Assurance and control of quality of water data. One-hour lecture/one two-hour lab. *Prerequisites: WRM 3330.*

WRM /GEO 3370. Introduction to Geographic Information System (I; 3) Topics of instruction will include analyses of selected, spatially distributed information of natural resources and other societal parameters. Nature, characteristics, specification, types, acquisition, processing, organization, and management of spatial or geographic data. Application of the basic functional and analytical capabilities of GI systems using raster methods and vector methods. The course will include practical instruction on commonly used geographic information software (GIS). *Prerequisite: MATH 2500 or Higher.*

WRM 4402. Urban Water Problems (II; 4) An examination of water problems faced by urban America and solutions to those problems. Urban Hydrology, Wastewater treatment, the supply of quality drinking water, storm water management, flood protection, water for recreation, urban fishing, economic development and infrastructure requirements as pertaining to urban areas and the integrated management. Water infrastructure rehabilitation assessment; Causative water and environmental factors on health. *Prerequisites: MTH 1750 and WRM 2200.*

WRM 4403. Water Transportation Systems (II; 3) A survey of water transportation principles and projects including deep and shallow draft ports, small boat harbors, locks and dams, and river control structures. The economic, physical and political aspects of transportation systems are emphasized. *Prerequisites: WRM 3306 and 3330.*

WRM 4404. Water Resources for Recreation (II; 3) A study of the use of water for recreational purposes. Concepts of leisure play and recreation are defined and related to recreation behaviors which are dependent upon water. Social, political, economic and environmental policies affecting the recreational use of water are reviewed and discussed. *Prerequisite: WRM 3306.*

WRM/AGR 4406. Agricultural Development (I; 3) The role of agriculture in the economic development in the world. The course examines theories of agricultural growth and agriculture policy issues, with extensive use of case studies. Emphasis will be placed on the use of economic theory and its application to specific problems in the field of agriculture. *Prerequisite: WRM 2200 or AGR 1150 or permission of the instructor.*

WRM/AGR 4420. Irrigation Systems Design (II; 4) An applied course in the design, of on-farm irrigation systems. Advanced evapotranspiration modeling and irrigation scheduling; Design and operational principles of surface, sprinkler and drip irrigation systems; Water losses in irrigation systems and the definitions of various efficiencies associated with on-farm and main irrigation systems. Hydraulic structures associated with distribution of water systems. On-farm application equipment selection and maintenance. Irrigation system performance and irrigation water management impacts on design; Introduction to irrigation water quality. Field visits to sprinkler irrigation systems in the area. *Prerequisites: WRM/AGR 3335 or permission of the instructor.*

WRM/AGR 4425. Agricultural Drainage Systems Design (II; 4) An applied course in the design, construction and maintenance of drainage systems for agricultural fields. Surface drainage systems layout and design. Design of hydraulic structures associated with surface drainage systems - chutes, drops, outlet structures and culverts. Surface drainage systems in irrigated areas. Sub-surface system design principles. Steady state and unsteady state theories of tile drainage. Introduction to analysis of oxygen transport in root zone and the effect of submergence. Salt balance and water quality issues in subsurface drainage. System layout, construction materials and methods. Design of structures associated with subsurface drainage systems. Cost recovery of drainage systems and maintenance issues. Field visits to drainage systems in the area. *Prerequisite: WRM/AGR 3335 or permission of the instructor.*

WRM 4435. Soil and Water Pollution Control (II; 4) An advanced course that deals with physical and chemical characteristics of pollutants in soil and water and their fate and transport; thermodynamic properties of organic and inorganic pollutants in soil and water; equilibrium partitioning of pollutants in the environment; air to water partitioning using Henry's Law; vapor pure liquid partitioning using Raoult's Law; soil-water partitioning using Freundlich, Langmuir and BET sorption isotherms; modeling fate and transport of pollutants in soil and water, non-aqueous phase liquids. Use of 1-D groundwater models such as CXTFIT; Groundwater contamination using CHEMFLO and MODFLOW; Overview of remedial technologies discussion on engineering controls such as pump and treat and soil washing, biological treatments such as bioremediation and phytoremediation; case study on non-point source pollution. *Prerequisites: ENE 3309 and ENE 3325.*

WRM/GEO/GEL 4470. Applied Remote Sensing (II; 3) Students will learn about different instrument systems attached to aircraft and satellites that collect environment data. Practical instruction on how the remotely acquired data sets are processed and interpreted using appropriate software will be given. Interpretation of multi-spectral scanners, RADAR and thermal imagery data; Data analysis for detection of changes; image interpretation; study of spectral characteristics of vegetation, soils, water, minerals, and other materials. Case studies will be presented for the different types of application. *Prerequisite: MTH 2501.*

WRM 4596. Internship (I, II, III; 3) On the job training in agencies and/or companies engaged in activities related to environmental engineering/ water resources management. Not open to students who have participated in the co-op program.