Environmental Engineering

This section presents the requirements for programs in:

- M.A.Sc. Environmental Engineering
- M.Eng. Environmental Engineering
- M.A.Sc. Environmental Engineering with Collaborative Specialization in Climate Change
- M.Eng. Environmental Engineering with Collaborative Specialization in Climate Change
- Ph.D. Environmental Engineering

Program Requirements

M.A.Sc. Environmental Engineering (5.0 credits)

Study at the master's level can be pursued through a thesis leading to a M.A.Sc., a project option leading to a M.Eng., or a coursework option leading to a M. Eng. The requirements for coursework are specified in terms of credits. At Carleton University, 1.0 credit typically comprises three hours of lectures or seminars a week for two terms, or the equivalent. At the University of Ottawa, 1.0 course credit is one hour of instruction per week for one term. Thus 1.0 credit in Carleton University notation is equivalent to 6 course credits in the University of Ottawa notation. The requirements are:

Requirements - Thesis option:		
1. 2.5 credits in courses, with at least 0.5 credit from each of at least three of the areas of study listed below		2.5
2. Participation in the graduate seminar series:		0.0
ENVE 5800 [0.0]	Master's Seminar (participation in the graduate seminar series)	
3. 2.5 credits in:		2.5
ENVE 5909 [2.5]	Master's Thesis (including successful oral defence)	
Total Credits		**5.0**

M.Eng. Environmental Engineering (5.0 credits)

Requirements - Project option (5.0 credits)		
1. 4.0 credits in courses		4.0
2. 1.0 credit in:		1.0
ENVE 5900 [1.0]	Environmental Engineering Project	
3. Participation in the graduate student seminar series:		0.0
ENVE 5800 [0.0]	Master's Seminar	
Total Credits		**5.0**

Requirements - Coursework option (5.0 credits)		
1. Completion of a minimum of 5.0 credits by course		5.0
Total Credits		**5.0**

Breadth Requirement

In keeping with the objective of ensuring a breadth of knowledge for graduates of the program, students in the master's program are expected to take at least one graduate level course from each of at least three of the following areas of study:

- Air Pollution
- Water Resources Management, Groundwater Management and Contaminant Transport
- Management of Solid, Hazardous, and Radioactive Waste, and Pollution Prevention
- Water and Wastewater Treatment
- Environmental Impact Assessment, Sustainability and Climate Change

This requirement serves the objectives of educating graduate professionals who are not only specialized in one area but who are sufficiently familiar with problems and different approaches in the other areas to enable them to interact readily at a technical level with colleagues working in those areas. In addition to the courses associated with the individual areas, students will be encouraged to select courses from fundamental areas such as chemistry, numerical modelling, and applied statistics.

Master's candidates transferring from another university must take at least half their courses at the Institute.

M.A.Sc. Environmental Engineering with Collaborative Specialization in Climate Change (5.0 credits)

Requirements:		
1. 1.0 credit in:		1.0
CLIM 5000 [1.0]	Climate Collaboration	
2. 0.0 credit in:		
CLIM 5800 [0.0]	Climate Seminar Series	
3. 1.5 credits in courses, with at least 0.5 credit from two different areas of study listed below outside the area of EIA, Sustainability and Climate Change		1.5
4. 0.0 credit in:		
ENVE 5800 [0.0]	Master's Seminar (participation in the graduate student seminar series)	
5. 2.5 credits in:		2.5
ENVE 5909 [2.5]	Master's Thesis (in the specialization)	
Total Credits		**5.0**

M.Eng. Environmental Engineering with Collaborative Specialization in Climate Change (5.0 credits)

Requirements - Project pathway		
1. 1.0 credit in:		1.0
CLIM 5000 [1.0]	Climate Collaboration	
2. 0.0 credit in:		
CLIM 5800 [0.0]	Climate Seminar Series	
3. 0.5 credit from:		0.5
ENVE 5105 [0.5]	Atmospheric Aerosols	
ENVE 5200 [0.5]	Climate Change and Engineering	
ENVE 5201 [0.5]	Geo-Environmental Engineering	
ENVE 5205 [0.5]	Sludge Treatment and Disposal	
ENVJ 5908 [0.5]	Anaerobic Digestion	
ENVJ 5212 [0.5]	Climate Change Impacts on Water Resources	

or approved Special Topics in the area of climate change

4. 2.5 credits in courses, with at least 0.5 credit from two different areas of study listed below outside the area of EIA, Sustainability and Climate Change		2.5
5. 0.0 credit in:		
ENVE 5800 [0.0]	Master's Seminar	
6. 1.0 credit in:		1.0
ENVE 5900 [1.0]	Environmental Engineering Project (in the specialization)	
Total Credits		**5.0**

Requirements - Coursework pathway

1. 1.0 credit in:		1.0
CLIM 5000 [1.0]	Climate Collaboration	
2. 0.0 credit in:		
CLIM 5800 [0.0]	Climate Seminar Series	
3. 1.5 credits from:		1.5
ENVE 5105 [0.5]	Atmospheric Aerosols	
ENVE 5200 [0.5]	Climate Change and Engineering	
ENVE 5201 [0.5]	Geo-Environmental Engineering	
ENVE 5205 [0.5]	Sludge Treatment and Disposal	
ENVJ 5908 [0.5]	Anaerobic Digestion	
ENVJ 5212 [0.5]	Climate Change Impacts on Water Resources	
or approved Special Topics in the area of climate change		
4. 2.5 credits in courses, with at least 0.5 credit from two different areas of study listed below outside the area of EIA, Sustainability and Climate Change		2.5
Total Credits		**5.0**

Ph.D. Environmental Engineering (2.0 credits)

Ph.D. Environmental Engineering (1.5 credits)

1. 1.5 credits in courses		1.5
2. 0.5 credits in:		0.5
ENVE 7800 [0.5]	Ph.D. Seminar	
3. Successful completion of the comprehensive examination, which consists of a presentation of a Ph.D. research proposal followed by an oral examination to assess any academic deficiencies in the student's background related to the proposed research project and to assess the originality and feasibility of the proposed research project. The comprehensive examination should be completed within the first 16 months (or the equivalent of four full-time terms) of the student's program		
4. 0.0 credits in:		0.0
ENVE 6909 [0.0]	Ph.D. Thesis (Including successful oral defence)	
Total Credits		**2.0**

Ph.D. candidates transferring from another university must take at least half their courses at the Institute.

Graduate Courses

Course selection is subject to the approval of the adviser or the Advisory committee. Students may choose courses offered at either university from among those listed below.

The courses listed below are grouped by area of study. Master's students must complete at least one course in three of the five areas. The program's Associate Chair (graduate affairs), in consultation with the Institute's Director or Associate Director, will decide when a course offered outside the Institute or offered under a Special Topics or Directed Studies heading can be considered to meet the requirements of a given area. Course descriptions may be found in the departmental sections of the calendars concerned. Course codes in parentheses are for University of Ottawa (EVG, CVG and CHG), and those that begin with the prefix "ENVE" or "CIVE" are offered at Carleton. Only a selection of courses is given in a particular academic year.

Full course descriptions for courses offered at Carleton can be found in the relevant courses section of this calendar.

Air Pollution

ENVE 5101 (EVG 7101)	Air Pollution Control
ENVE 5102 (EVG 7161)	Traffic-Related Air Pollution
ENVE 5103 (EVG 7162)	Air Quality Modeling
ENVE 5104 (EVG 7104)	Indoor Environmental Quality
ENVE 5105 (EVG 7105)	Atmospheric Aerosols
ENVE 5106 (EVG 7106)	Atmospheric Chemical Transport Modelling
ENVJ 5105 (CHG 8132)	Adsorption Separation Process

Water Resources Management, Groundwater Management, and Contaminant Transport

CIVJ 5502 (CVG 5112)	Computational Hydrodynamics
CIVJ 5503 (CVG 5160)	Sediment Transport
CIVJ 5504 (CVG 5162)	River Hydraulics
CIVJ 5601 (EVG 5125)	Statistical Methods in Hydrology
CIVJ 5602 (CVG 5126)	Stochastic Hydrology
CIVJ 5605 (CVG 5124)	Coastal Engineering
ENVE 5301 (EVG 7301)	Contaminant Hydrogeology
ENVE 5302 (EVG 7163)	Case Studies in Hydrogeology
ENVE 5303 (EVG 7303)	Multiphase Flow in Soils
ENVJ 5182 (EVG 5182)	Water Resources Management
ENVJ 5183 (EVG 5183)	Mixing and Transport in Water Bodies
ENVJ 5301 (EVG 5301)	Soil and Water Conservation Engineering
ERTH 5403 (GEO 5143)	Environmental Isotopes and Groundwater Geochemistry
ERTH 5407 (GEO 5147)	Aqueous Inorganic Geochemistry and Modelling
ERTH 5503 (GEO 5153)	Computer Techniques in the Earth Sciences

Management of Solid, Hazardous, and Radioactive Waste and Pollution Prevention

CIVJ 5109 (CVG 5109)	Geotechnical Hazards
ENVE 5201 (EVG 7201)	Geo-Environmental Engineering
ENVE 5203 (EVG 7164)	Hazardous and Radioactive Wastes
ENVE 5204 (EVG 7134)	Resource Industry Waste Management
ENVE 5205 (EVG 7132)	Sludge Treatment and Disposal
ENVJ 5903 (EVG 5331)	Sludge Utilization and Disposal
ENVJ 5906 (EVG 5133)	Solid Waste Management
ENVJ 5908 (EVG 5179)	Anaerobic Digestion

Water and Wastewater Treatment

ENVE 5001 (CVG 7160)	Biofilm Processes
ENVE 5003 (EVG 7143)	Advanced Ultraviolet Processes
ENVE 5004 (EVG 7144)	Advanced Wastewater Treatment
ENVJ 5302 (EVG 5302)	Decentralized Wastewater Management
ENVJ 5502 (CHG 8192)	Membranes in Clean Processes
ENVJ 5900 (EVG 5130)	Wastewater Treatment Process Design
ENVJ 5901 (EVG 5132)	Unit Operations of Water Treatment
ENVJ 5902 (EVG 5138)	Advanced Water Treatment
ENVJ 5905 (EVG 5137)	Water and Wastewater Treatment Process Analysis
ENVJ 5907 (EVG 5134)	Chemistry for Environmental Engineering

Environmental Impact Assessment, Sustainability and Climate Change

ENVE 5200 (EVG 7200)	Climate Change and Engineering
ENVJ 5212	Climate Change Impacts on Water Resources
ENVJ 5700 (CVG 5139)	Environmental Assessment of Civil Engineering Projects

To fulfill the requirements beyond the 1.5 credits of area courses, students may choose from the following:

Other Institute Courses

CIVE 5601 (CVG 7140)	Engineering, Statistics, and Probabilities
ENVE 5402 (EVG 7402)	Finite Elements in Field Problems
ENVJ 5504 (CVG 8194)	Membrane Liquid Separation Processes and Materials
ENVJ 5505 (CHG 8195)	Advanced Numerical Methods in Chemical and Biological Engineering
ENVJ 5507 (CHG 8196)	Interfacial Phenomena in Engineering
GEOG 5804	Geographic Information Systems

Seminars, Directed Studies and Special Topics

ENVE 5701 (EVG 7001)	Topics in Environmental Engineering
ENVE 5702 (EVG 7002)	Topics in Environmental Engineering
ENVE 5704 (EVG 7004)	Topics in Environmental Engineering
ENVE 5703 (EVG 7003)	Topics in Environmental Engineering
ENVE 5705 (EVG 7005)	Topics in Environmental Engineering
ENVE 5800 (EVG 7305)	Master's Seminar
ENVE 5906 (EVG 6108)	Directed Studies 1
ENVE 6906 (EVG 6109)	Directed Studies 2
ENVE 7800 (EVG 6109)	Ph.D. Seminar
ENVJ 6300 (EVG 6300)	Special Topics in Environmental Engineering
ENVJ 6301 (EVG 6301)	Special Topics in Environmental Engineering
ENVJ 6302 (EVG 6302)	Special Topics in Environmental Engineering
ENVJ 6303 (EVG 6303)	Special Topics in Environmental Engineering
ENVJ 6304 (EVG 6304)	Special Topics in Environmental Engineering

Special Topics courses in Civil or Chemical Engineering will count as Institute courses only if approved by the program's Associate Chair (graduate affairs), in consultation with the Institute's Director or Associate Director.

Projects and Theses

ENVE 5900 (EVG 6001)	Environmental Engineering Project
ENVE 5909 (EVG 7999)	Master's Thesis
ENVE 6909 (EVG 9999)	Ph.D. Thesis

(EVG 9998) Comprehensive Examination

Non-Institute Courses

Students may also, subject to approval, select courses from the graduate programs in Civil, Chemical and Mechanical Engineering, as well as in Biology, Chemistry, Earth Sciences, Computer Sciences, Geography and Public Policy and Administration at both universities. Courses taken outside the Institute will not count towards the degree requirements unless approved by the adviser or the advisory committee and the program's Associate Chair (graduate affairs). In all programs, at least one half of the course work must be taken from the Institute.

Regulations

See the General Regulations section of this Calendar.

Regularly Scheduled Break

For immigration purposes, the summer term (May to August) for the M.Eng. Environmental Engineering including all specializations/concentrations is considered a regularly scheduled break approved by the University. Students should resume full-time studies in September.

Admission

The requirement for admission to the master's program in Environmental Engineering is a four-year bachelor's degree in Environmental Engineering, other related engineering disciplines (Civil, Chemical, Mechanical, etc.), or Environmental Science disciplines.

All students entering the program are required to have courses in mathematics, probability and statistics equivalent to courses required in undergraduate engineering programs. Students admitted without full equivalency in these areas are expected to take appropriate undergraduate courses early in their studies. These courses will be additional to the normal degree requirements.

For applicants to the M.A.Sc. program without a bachelor's degree in environmental, civil or chemical engineering, up to 3 undergraduate courses may be required in addition to the graduate program requirements. These may include a course in fluid mechanics, a course in environmental engineering fundamentals and a senior level undergraduate course in environmental engineering to be identified jointly by the supervisor, Associate Chair for Graduate Studies, and Director or Associate Director for OCIENE in the department.

For applicants to the MEng program without a bachelor's degree in environmental, civil or chemical engineering, up to 3 undergraduate courses may be specified in addition to the graduate program requirements at admission by the Director or Associate Director for OCIENE in the department. These will include a course in fluid mechanics, and course in chemical/biochemical kinetics and reactors if required.

Accelerated Pathway

The accelerated pathway in Environmental Engineering is a flexible and individualized plan of graduate study. Students in the final year of Bachelor of Engineering in Civil, Environmental, or Architectural Conservation and Sustainability Engineering with demonstrated excellent aptitude for graduate studies and research may qualify for this option.

Students with a CGPA of 10.0 or higher, going into their final year of undergraduate study, and intending to apply to a Master's degree in Environmental Engineering in the following academic year should consult with both the Undergraduate and Graduate Associate Chairs to determine if the accelerated pathway is appropriate for them and to confirm their selection of courses.

Upon approval for the accelerated pathway, students will replace a maximum of 1.0 credit of their engineering electives with 5000 level ENVE courses. Students will receive advanced standing for the approved 5000 level courses in which they receive a grade of A- or higher.

Admission

The normal requirement for admission into the Ph.D. Program in Environmental Engineering is completion of either a Master's degree in Environmental Engineering, or a Master's degree in an engineering discipline with an environmental specialization.

- Students wishing to enter the program who do not have either of these backgrounds will be evaluated on a case-by-case basis. Additional course requirements may be specified in some cases.
- Students who have been admitted to a master's program may be admitted into the Ph.D. program, without completing their master's program, if they demonstrate: (1) outstanding academic performance by completing at least 2.5 credits of course work that fulfil the breadth requirements as specified in the Master's degree requirements with a CGPA of A- or higher, and (2) significant promise for advanced research and the ability to defend their Ph.D. proposal in the first year of their Ph.D. program.

Environmental Engineering - Joint (ENVJ) Courses

ENVJ 5001 [0.5 credit] (EVG 5001)
Biofilm Processes in Wastewater Treatment
Lecture

ENVJ 5105 [0.5 credit] (CHG 8132)
Adsorption Separation Process

ENVJ 5182 [0.5 credit] (EVG 5182)
Water Resources Management
Also listed as CIVJ 5182.

ENVJ 5183 [0.5 credit] (EVG 5183)
Mixing and Transport in Water Bodies

ENVJ 5212 [0.5 credit]
Climate Change Impacts on Water Resources

ENVJ 5301 [0.5 credit] (EVG 5301)
Soil and Water Conservation Engineering

ENVJ 5302 [0.5 credit] (EVG 5302)
Decentralized Wastewater Management

ENVJ 5304 [0.5 credit] (CHG 8158)
Porous Media

ENVJ 5502 [0.5 credit] (CHG 8192)
Membranes in Clean Processes

ENVJ 5503 [0.5 credit]
Reverse Osmosis

ENVJ 5504 [0.5 credit] (CHG 8194)
Membrane Liquid Separation Processes and Materials

ENVJ 5505 [0.5 credit] (CHG 8195)
Advanced Numerical Methods in Chemical and Biological Engineering
Includes: Experiential Learning Activity

ENVJ 5507 [0.5 credit] (CHG 8196)
Interfacial Phenomena in Engineering

ENVJ 5700 [0.5 credit] (EVG 5139)
Environmental Assessment of Civil Engineering Projects

ENVJ 5900 [0.5 credit] (EVG 5130)
Wastewater Treatment Process Design

ENVJ 5901 [0.5 credit] (EVG 5132)
Unit Operations of Water Treatment

ENVJ 5902 [0.5 credit] (EVG 5138)
Advanced Water Treatment

ENVJ 5903 [0.5 credit] (EVG 5331)
Sludge Utilization and Disposal

ENVJ 5905 [0.5 credit] (EVG 5137)
Water and Wastewater Treatment Process Analysis

ENVJ 5906 [0.5 credit] (EVG 5133)
Solid Waste Management

ENVJ 5907 [0.5 credit] (EVG 5134)
Chemistry for Environmental Engineering

ENVJ 5908 [0.5 credit] (EVG 5179)
Anaerobic Digestion

ENVJ 5909 [0.5 credit]
Biological Nutrient Removal

ENVJ 6002 [0.5 credit]
Sludge Processing, Utilization

ENVJ 6300 [0.5 credit] (EVG 6300)
Special Topics in Environmental Engineering

ENVJ 6301 [0.5 credit] (EVG 6301)
Special Topics in Environmental Engineering

ENVJ 6302 [0.5 credit] (EVG 6302)
Special Topics in Environmental Engineering

ENVJ 6303 [0.5 credit] (EVG 6303)
Special Topics in Environmental Engineering

ENVJ 6304 [0.5 credit] (EVG 6304)
Special Topics in Environmental Engineering

ENVJ 8191 [0.5 credit] (CHG 8191)
Selected Topics in Chemical Engineering

Environmental Engineering (ENVE) Courses

ENVE 5001 [0.5 credit] (CVG 7160)
Biofilm Processes
Physical, chemical properties, microbial ecology of biofilms. Biofilm processes, attachment, growth, sloughing. Transport and interfacial transfer phenomena; mass transfer models, mass transport in biofilms, deposition of solids. Modeling biofilm systems; species models, mass balance equations, boundary conditions, moving boundary problem, analytical and numerical solutions.

ENVE 5003 [0.5 credit] (EVG 7143)
Advanced Ultraviolet Processes
Fundamentals and applications of ultraviolet (UV) light-based processes for water and wastewater treatment; principles of photochemistry and photobiology, methods of UV dose determination, UV disinfection of microorganisms, advanced oxidation processes, and design of UV disinfection systems and reactors.

ENVE 5004 [0.5 credit] (EVG 7144)
Advanced Wastewater Treatment
Fundamentals, applications, and design of biological, physical, and chemical treatment processes employed for advanced treatment of domestic and industrial wastewater. Reuse applications and guidelines.

ENVE 5007 [0.5 credit]
Filtration and Membranes in Water Treatment
Filtration is a key process for removal of contaminants from water sources. This course discusses various filtration processes including slow sand filtration, conventional filtration, biological filtration, and low and high pressure membrane applications in a lecture and seminar format. Previous water related course knowledge expected.

ENVE 5101 [0.5 credit] (EVG 7101)
Air Pollution Control
Air quality and pollution; definitions, measurement and monitoring methods. Criteria pollutants, air toxics, particulate matter, secondary pollutants. Pollutant formation mechanisms. Major sources and control methods. Meteorology and principles of dispersion modeling. Principles of receptor modeling. Indoor air quality.
Also offered at the undergraduate level, with different requirements, as ENVE 4003, for which additional credit is precluded.

ENVE 5102 [0.5 credit] (EVG 7161)
Traffic-Related Air Pollution
Pollutant formation, emission characterization, emission control technology and emission modeling from motor vehicles. Dispersion and receptor modeling for conservative pollutants in urban microenvironments. Personal exposure and health risk assessment.

ENVE 5103 [0.5 credit] (EVG 7162)
Air Quality Modeling
Dispersion modeling for simple and complex sources and complex terrain. Physical and chemical transformations for pollutants in the atmosphere. Urban and regional air pollution modeling for reactive pollutants. The urban air shed model. Regional air quality modeling case studies.

ENVE 5104 [0.5 credit] (EVG 7104)
Indoor Environmental Quality
Indoor environmental quality (air quality, thermal, visual, and acoustic comfort); physical and chemical parameters for characterization. Types and sources of indoor air pollution and discomfort; measurement techniques. Heating, ventilation, air conditioning, lighting practices and issues. Modeling of and design for indoor environmental quality.

ENVE 5105 [0.5 credit] (EVG 7105)
Atmospheric Aerosols
Atmospheric aerosol characterization and size distribution, theoretical fundamentals of physical and chemical processes that govern formation and transformation of aerosols in the atmosphere such as nucleation, coagulation, condensation/evaporation, and aerosol thermodynamics; interactions between aerosols and climate, aerosol sampling and measurement.

ENVE 5106 [0.5 credit] (EVG 7106)
Atmospheric Chemical Transport Modelling
Fundamentals of Eulerian atmospheric modelling; overview of global and regional atmospheric models, basic principles of numerical methods used in air quality models; applications of air quality models; uncertainty and sensitivity analysis in air quality modelling.

ENVE 5200 [0.5 credit] (EVG 7200)
Climate Change and Engineering
Survey of the physical science of climate change, impacts on the built environment, and climate adaptation in engineering. Greenhouse gases, global warming, paleoclimatology, and Earth system responses. Climate change impacts on structural, water, transportation, and energy systems. Climate vulnerability assessment, examples of design adaptation.
Also offered at the undergraduate level, with different requirements, as ENVE 4200, for which additional credit is precluded.

ENVE 5201 [0.5 credit] (EVG 7201)
Geo-Environmental Engineering
Landfill design; hydrogeologic principles, water budget, landfill liners, geosynthetics, landfill covers, quality control and quality assurance, clay/leachate interaction, composite liner design and leachate collection systems. Landfill operation, maintenance and monitoring. Design of environmental control and containment systems; slurry walls, grout curtains, Case studies.
Includes: Experiential Learning Activity
Also offered at the undergraduate level, with different requirements, as ENVE 4002, for which additional credit is precluded.

ENVE 5203 [0.5 credit] (EVG 5203)
Hazardous and Radioactive Wastes
Classification of hazardous, radioactive and mixed wastes, hazardous waste treatment processes, wastes generated in the nuclear fuel cycle, radioactive waste classification, radioactive waste treatment and management of residuals, engineered systems for long-term isolation and disposal, mixed waste management.
Also offered at the undergraduate level, with different requirements, as ENVE 4101, for which additional credit is precluded.

ENVE 5204 [0.5 credit] (EVG 7134)
Resource Industry Waste Management
Application of geotechnique and hydraulics to management of resource extraction residuals such as tailings, waste rock, and sludge from hard rock mines and bitumen extraction operations. Geotechnique of conventional and high density tailings disposal. Pipeline transport of concentrated suspensions. Closure technologies for mine waste impoundments.

ENVE 5205 [0.5 credit] (EVG 7132)
Sludge Treatment and Disposal
Aspects of sludge treatment, management, and disposal; sludge generation and characterization, thickening, preliminary treatment processes, aerobic and anaerobic digestion, lime stabilization, conditioning, dewatering, composting, land application and other disposal options, and thermal processes.

ENVE 5301 [0.5 credit] (EVG 7301)
Contaminant Hydrogeology
Theory of flow through porous media; soil characterization, soil properties, anisotropy, heterogeneity. Contaminant transport. Well hydraulics and pump tests. Introduction to numerical modeling; finite difference, finite elements, conceptual model, boundary conditions. Site remediation and remediation technologies.
Also offered at the undergraduate level, with different requirements, as ENVE 4006, for which additional credit is precluded.

ENVE 5302 [0.5 credit] (EVG 7163)
Case Studies in Hydrogeology
Development of a conceptual model; chemistry, geology and hydrology, site characterization, initial and boundary conditions. Application of industry-recognized computer codes to model flow and contaminant transport at a particular site. Evaluation of remedial alternatives at a site. Modeling of the more common remediation technologies.
Includes: Experiential Learning Activity

ENVE 5303 [0.5 credit] (EVG 7303)
Multiphase Flow in Soils
Theory of unsaturated flow and multiphase flow; capillary pressure-saturation relationships, relative permeability relationships, wettability, hysteresis, fluid entrapment, residual saturations, governing equations for flow and transport. Richard's Equation for unsaturated flow. Modeling of multiphase flow.

ENVE 5402 [0.5 credit] (EVG 7402)
Finite Elements in Field Problems
Use of Galerkin and Ritz finite element formulations to solve one and two dimensional field problems. Steady state and time-dependent phenomena involving heat transfer, fluid flow, diffusion, and dispersion with emphasis on practical applications. Basic knowledge of third year-level undergraduate engineering mathematics and physics required.
Also listed as CIVE 5107.

ENVE 5701 [0.5 credit] (EVG 7001)
Topics in Environmental Engineering
Courses in special topics in environmental engineering not covered by other graduate courses.

ENVE 5702 [0.5 credit] (EVG 7002)
Topics in Environmental Engineering
Courses in special topics in environmental engineering not covered by other graduate courses.

ENVE 5703 [0.5 credit] (EVG 7003)
Topics in Environmental Engineering
Courses in special topics in environmental engineering not covered by other graduate courses.

ENVE 5704 [0.5 credit] (EVG 7004)
Topics in Environmental Engineering
Courses in special topics in environmental engineering not covered by other graduate courses.

ENVE 5705 [0.5 credit] (EVG 7005)
Topics in Environmental Engineering
Courses in special topics in environmental engineering not covered by other graduate courses.

ENVE 5800 [0.0 credit] (EVG 7305)
Master's Seminar
M.A.Sc. and M.Eng (project option) students in the Environmental Engineering program are required to participate in these seminar series by attending all seminars and making at least one presentation during their graduate studies.
Registration in the course should be in the term that the presentation will take place.

ENVE 5900 [1.0 credit] (EVG 6001)
Environmental Engineering Project
Students enrolled in the M.Eng. program by course work will conduct an engineering study, analysis, or design project under the general supervision of a member of the Department.
Includes: Experiential Learning Activity

ENVE 5906 [0.5 credit] (EVG 6108)
Directed Studies 1
Precludes additional credit for CIVE 5906.
Prerequisite(s): open only to students in an Environmental Engineering Master's program.

ENVE 5909 [2.5 credits] (EVG 7999)
Master's Thesis
Includes: Experiential Learning Activity

ENVE 6906 [0.5 credit] (EVG 6109)
Directed Studies 2
Precludes additional credit for CIVE 6906.
Prerequisite(s): open only to students in the Environmental Engineering Ph.D. program.

ENVE 6909 [0.0 credit] (EVG 9999)
Ph.D. Thesis
Includes: Experiential Learning Activity

ENVE 7800 [0.5 credit] (EVG 6109)
Ph.D. Seminar
Ph.D. students in the Environmental Engineering program are required to participate in these seminar series by attending all seminars and making at least one presentation during their graduate studies.
Registration in the course should be in the term that the presentation will take place.