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:
   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:
   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:
   CLIM 5000 [1.0]  Climate Collaboration

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:
   CLIM 5000 [1.0]  Climate Collaboration

Total Credits 5.0

Requirements - Coursework option (5.0 credits)
1. 0.5 credit from:
   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

Total Credits 5.0

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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
5.  0.0 credit in:
   ENVE 5800 [0.0] Master's Seminar
6.  1.0 credit in:
   ENVE 5900 [1.0] Environmental Engineering Project (in the specialization)

Total Credits  5.0

Requirements - Coursework pathway
1.  1.0 credit in:
   CLIM 5000 [1.0] Climate Collaboration
2.  0.0 credit in:
   CLIM 5800 [0.0] Climate Seminar Series
3.  1.5 credits from:
   ENVE 5105 [0.5] Atmospheric Aerosols
   ENVE 5201 [0.5] Climate Change and 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

Total Credits  5.0

Ph.D. Environmental Engineering (2.0 credits)
Ph.D. Environmental Engineering (1.5 credits)
1.  1.5 credits in courses
2.  0.5 credits in:
   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:
   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 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 5605 (CVG 5124) Coastal Engineering
   ENVE 5301 (EVG 7301) Contaminant 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 5314) Geotechnical Hazards
   ENVE 5201 (EVG 7201) Geo-Environmental Engineering
   ENVE 5204 (EVG 7134) Resource Industry Waste Management
   ENVE 5205 (EVG 7132) Sludge Treatment and Disposal
<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>ENVJ 5903</td>
<td>Sludge Utilization and Disposal</td>
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<td>ENVJ 5906</td>
<td>Solid Waste Management</td>
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<td>ENVJ 5908</td>
<td>Anaerobic Digestion</td>
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<td>ENVJ 5900</td>
<td>Water and Wastewater Treatment</td>
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<td>ENVJ 5901</td>
<td>Unit Operations of Water Treatment</td>
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<td>ENVJ 5902</td>
<td>Advanced Water Treatment</td>
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<tr>
<td>ENVJ 5905</td>
<td>Water and Wastewater Treatment Process Analysis</td>
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<td>ENVJ 5907</td>
<td>Chemistry for Environmental Engineering</td>
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<tr>
<td>ENVJ 5900</td>
<td>Environmental Impact Assessment, Sustainability</td>
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<tr>
<td>ENVE 5004</td>
<td>Advanced Wastewater Treatment</td>
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<tr>
<td>ENVE 5007</td>
<td>Filtration and Membranes in Water Treatment</td>
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<tr>
<td>ENVE 5001</td>
<td>Biofilm Processes in Wastewater Treatment</td>
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<tr>
<td>ENVE 5302</td>
<td>Decentralized Wastewater Management</td>
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<tr>
<td>ENVE 5502</td>
<td>Membranes in Clean Processes</td>
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<tr>
<td>ENVE 5900</td>
<td>Wastewater Treatment Process Design</td>
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<td>ENVE 5901</td>
<td>Unit Operations of Water Treatment</td>
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<td>Chemistry for Environmental Engineering</td>
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<tr>
<td>ENVJ 5903</td>
<td>Research Methodology</td>
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<tr>
<td>ENVJ 5906</td>
<td>Membrane Liquid Separation Processes and Materials</td>
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<tr>
<td>ENVJ 5908</td>
<td>Advanced Numerical Methods in Chemical and Biological Engineering</td>
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<tr>
<td>ENVJ 5909</td>
<td>Interfacial Phenomena in Engineering</td>
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<td>GEOG 5804</td>
<td>Geographic Information Systems</td>
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<td>ENVE 5700</td>
<td>Environmental Engineering Project</td>
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<tr>
<td>ENVE 5909</td>
<td>Master's Thesis</td>
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<tr>
<td>ENVE 6909</td>
<td>Ph.D. Thesis</td>
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<td>ENVJ 6300</td>
<td>Special Topics in Environmental Engineering</td>
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<td>Special Topics in Environmental Engineering</td>
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<td>ENVJ 6303</td>
<td>Special Topics in Environmental Engineering</td>
</tr>
<tr>
<td>ENVJ 6304</td>
<td>Special Topics in Environmental Engineering</td>
</tr>
</tbody>
</table>

**Water and Wastewater Treatment**

- **Advanced Wastewater Treatment**
- **Filtration and Membranes in Water Treatment**
- **Biofilm Processes in Wastewater Treatment**
- **Decentralized Wastewater Management**
- **Membranes in Clean Processes**
- **Wastewater Treatment Process Design**
- **Advanced Water Treatment**
- **Water and Wastewater Treatment Process Analysis**
- **Chemistry for Environmental Engineering**

**Environmental Impact Assessment, Sustainability and Climate Change**

- **Climate Change and Engineering**
- **Energy and Resource Recovery from Waste**
- **Climate Change Impacts on Water Resources**
- **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**

- **Research Methodology**
- **Membrane Liquid Separation Processes and Materials**
- **Advanced Numerical Methods in Chemical and Biological Engineering**
- **Interfacial Phenomena in Engineering**
- **Geographic Information Systems**

**Seminars, Directed Studies and Special Topics**

- **Topics in Environmental Engineering**
- **Topics in Environmental Engineering**
- **Topics in Environmental Engineering**
- **Topics in Environmental Engineering**
- **Topics in Environmental Engineering**

**Projects and Theses**

- **Environmental Engineering Project**
- **Master's Thesis**
- **Ph.D. Thesis**

**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
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 fulfill 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**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Title</th>
<th>Credit</th>
<th>Notes</th>
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<tr>
<td>ENVJ 5001</td>
<td>Biofilm Processes in Wastewater Treatment</td>
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<td>(EVG 5001)</td>
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<tr>
<td>ENVJ 5105</td>
<td>Adsorption Separation Process</td>
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<td>(CHG 8132)</td>
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<td>ENVJ 5182</td>
<td>Water Resources Management</td>
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<td>(EVG 5182)</td>
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<td>ENVJ 5183</td>
<td>Mixing and Transport in Water Bodies</td>
<td>0.5</td>
<td>(EVG 5183)</td>
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<tr>
<td>ENVJ 5212</td>
<td>Climate Change Impacts on Water Resources</td>
<td>0.5</td>
<td>(EVG 5212)</td>
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<tr>
<td>ENVJ 5301</td>
<td>Soil and Water Conservation Engineering</td>
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<td>ENVJ 5302</td>
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<td>(EVG 5302)</td>
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<td>ENVJ 5502</td>
<td>Membranes in Clean Processes</td>
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<td>ENVJ 5504</td>
<td>Membrane Liquid Separation Processes and Materials</td>
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<td>(CHG 8194)</td>
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<td>ENVJ 5505</td>
<td>Advanced Numerical Methods in Chemical and Biological Engineering</td>
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<td>Interfacial Phenomena in Engineering</td>
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<td>ENVJ 5700</td>
<td>Environmental Assessment of Civil Engineering Projects</td>
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<td>(EVG 5139)</td>
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<td>ENVJ 5900</td>
<td>Wastewater Treatment Process Design</td>
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<tr>
<td>ENVJ 5901</td>
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<td>ENVJ 5903</td>
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<td>Sludge Utilization and Disposal</td>
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<td>ENVJ 5905</td>
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<td>ENVJ 5908</td>
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<td>ENVJ 6002</td>
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<td>Sludge Processing, Utilization</td>
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<td>ENVJ 8191</td>
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### Environmental Engineering (ENVE) Courses

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<td>ENVE 5004</td>
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<td>Advanced Wastewater Treatment</td>
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<tr>
<td>ENVE 5007</td>
<td>0.5</td>
<td>Filtration and Membranes in Water Treatment</td>
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<tr>
<td>ENVE 5101</td>
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<td>Air Pollution Control</td>
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<td>ENVE 5104</td>
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<td>Indoor Environmental Quality</td>
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<td>ENVE 5105</td>
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<td>Atmospheric Aerosols</td>
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<td>ENVE 5106</td>
<td>0.5</td>
<td>Atmospheric Chemical Transport Modelling</td>
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<tr>
<td>ENVE 5107</td>
<td>0.5</td>
<td>Radiative Transfer and Remote Sensing</td>
</tr>
<tr>
<td>ENVE 5200</td>
<td>0.5</td>
<td>Climate Change and Engineering</td>
</tr>
</tbody>
</table>

### Description

- **ENVJ 5901**: Unit Operations of Water Treatment
  - Focuses on the operational aspects of water treatment processes.

- **ENVJ 5902**: Advanced Water Treatment
  - Explores advanced technologies and methods in water treatment.

- **ENVJ 5903**: Sludge Utilization and Disposal
  - Covers the disposal and utilization of sludge.

- **ENVJ 5905**: Water and Wastewater Treatment Process Analysis
  - Analyzes water and wastewater treatment processes.

- **ENVJ 5906**: Solid Waste Management
  - Focuses on the management of solid waste.

- **ENVJ 5907**: Chemistry for Environmental Engineering
  - Provides a foundation in chemical aspects of environmental engineering.

- **ENVJ 5908**: Anaerobic Digestion
  - Studies anaerobic digestion in wastewater treatment.

- **ENVJ 6002**: Sludge Processing, Utilization
  - Focuses on the processing and utilization of sludge.

- **ENVJ 6300**: Special Topics in Environmental Engineering
  - Offers specialized topics in environmental engineering.

- **ENVE 5004**: Advanced Wastewater Treatment
  - Advanced treatment of domestic and industrial wastewater.

- **ENVE 5007**: Filtration and Membranes in Water Treatment
  - Discusses filtration processes in water treatment.

- **ENVE 5101**: Air Pollution Control
  - Focuses on air quality and pollution control.

- **ENVE 5104**: Indoor Environmental Quality
  - Focuses on indoor environmental quality.

- **ENVE 5105**: Atmospheric Aerosols
  - Studies atmospheric aerosol characteristics and processes.

- **ENVE 5106**: Atmospheric Chemical Transport Modelling
  - Focuses on chemical transport models and principles.

- **ENVE 5107**: Radiative Transfer and Remote Sensing
  - Analyzes radiative transfer and remote sensing techniques.

- **ENVE 5200**: Climate Change and Engineering
  - Focuses on climate change and its engineering impacts.
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 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 5206 [0.5 credit]
Energy and Resource Recovery from Waste
Principles, design and application of biochemical and thermal processes for recovery of energy and value-added materials from different solid wastes and wastewater. Biochemical processes; biotransformation pathways, reactor analysis and chemical kinetics. Thermal treatment systems; process design, thermodynamics of material recovery.

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 5303 [0.5 credit] (EVG 7303)
Multiphase Flow in Soils

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
Precludes additional credit for CIVE 6906.
Prerequisite(s): open only to students in the Environmental Engineering Ph.D. program.

ENVE 6909 [8.5 credits] (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.