

Carleton University
Department of Civil & Environmental Engineering

ENVE 5207: ENERGY DEVELOPMENT AND THE CRITICAL ZONE

Winter 2025

Professor: Dr. Cole Van De Ven
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Office Hours: Appointment by email

Lecture time: Mondays from 11:35 AM to 2:25 PM

Course Description (Calendar):

NOTE: If a student has not taken ENVE 5301 – Contaminant Hydrogeology (or equivalent graduate course), they will find ENVE 5207 very difficult. A student should not take this course without previous knowledge of contaminant hydrogeology. Student will also need to use MATLAB in this course.

Quantification of the environmental impacts of current and future energy resource development including groundwater, surface water and soil contamination and greenhouse gas emissions. Application of relevant theory (multiphase flow, mass transfer, fate and transport) to describe key environmental processes, detection, monitoring, and mitigation.

Course Learning Outcomes (CLOs):

By the end of the course, students will be able to:

1. Identify the key environmental impacts of the current and future energy development landscape in Canada.
2. Define and distinguish the physical, chemical, and biological processes occurring in the critical zone.
3. Formulate a clear conceptual and numerical model of the physical, chemical, and biological processes which drive the environmental impacts of energy development in the critical zone.
4. Critique relevant literature on the study of processes in the critical zone.
5. Assemble process-based knowledge to define, describe, and assess the environmental impact of energy development on the critical zone.

Course Modality

In-person lectures

Course Communication:

All class-wide communications will be posted on the news page of BrightSpace. You are welcome to email me with any questions, but emails should be used for important and/or time sensitive matters. If your question can wait until class time, that would be preferred.

All notes and assignments will be posted to BrightSpace.

Outline of course topic:

- 1) Introduction to critical zone and energy development (1.0 weeks)
 - What is the critical zone and why is it '*critical*'?
 - The energy landscape of Canada.
 - Energy development approaches
 - Concern for the environment
 - Types of contaminants
- 2) Environmental impacts of energy development on the critical zone (2.0 weeks)
 - Surface spills (fuels)
 - Stray gas migration

Paper discussion #1:

Molofsky, L. J.; Connor, J. A.; Van De Ven, C. J. C.; Hemingway, M. P.; Richardson, S. D.; Strasert, B. A.; McGuire, T. M.; Paquette, S. M. A Review of Physical, Chemical, and Hydrogeologic Characteristics of Stray Gas Migration: Implications for Investigation and Remediation. *Science of The Total Environment* 2021, 779, 146234. <https://doi.org/10.1016/j.scitotenv.2021.146234>.

- 3) Key processes in the subsurface (6.0 weeks)
 - Multiphase flow (gases and non-aqueous phase liquids)

Paper discussion #2:

Glass, R. J.; Conrad, S. H.; Yarrington, L. Gravity-Destabilized Nonwetting Phase Invasion in Macroheterogeneous Porous Media: Near-Pore-Scale Macro Modified Invasion Percolation Simulation of Experiments. *Water Resour Res* 2001, 37 (5), 1197–1207. <https://doi.org/10.1029/2000WR900294>.

- Mass transfer
- Reactive transport

Paper discussion #3:

Mumford, K. G.; Smith, J. E.; Dickson, S. E. The Effect of Spontaneous Gas Expansion and Mobilization on the Aqueous-Phase Concentrations above a Dense Non-Aqueous Phase Liquid Pool. *Adv Water Resour* 2010, 33 (4), 504–513. <https://doi.org/10.1016/j.advwatres.2010.02.002>.

- 4) Detection, monitoring, management, and mitigation (2.0 weeks)
 - Signals to measure (dissolved gas, isotopes, composition)
 - Groundwater sampling techniques
 - Soil gas wells

- Surface effluxes
 - Natural source zone depletion
 - Remedies for stray gas
- 5) Energy and environment into the future (1.0 weeks)
- The end of oil and gas?
 - Hydrogen
 - Carbon sequestration

Please note that I reserve the right to change the approximate time devoted to each course topic as the course progresses.

Textbooks (not required, optional)

This course will refer to a variety of texts and journal papers throughout the course notes. For fundamental/seminal texts, please refer to (not required):

- Freeze, R.A., and Cherry J.A., 1979, Groundwater, Prentice-Hall
Available for **free** from The Groundwater Project
- Dullien, 1992, Porous Media: fluid transport and pore structure, Academic Press, Inc., San Diego.
No longer sold, can be taken out from library.
- Ho and Webb, 2006, Gas transport in porous media, Springer, The Netherlands.
Available for **free** from Carleton online database

Assessment

Assessment	Weight
1. Assignments (3)	45 %
2. Paper discussions (3) ¹	20 %
3. Take-home exam ²	35 %

¹These cannot be missed without a valid reason, discussed with me.

²Must get a 60% to pass the course.

Brief descriptions:

Assignments:

These will be assignments that are both conceptual and numerical in nature (calculations, modeling, etc.). I encourage you to work together to solve these problems. However, I expect you to submit your own unique answers to the problems for grading. These will be marked using an answer key with part marks. These assignments will be large and require considerable effort (you can think of them as mini projects)

1. *Assignment #1:* You will research and briefly describe the processes and impacts that are a result of stray gas migration in a short (4-page max) report. One page should be dedicated to developing the conceptual model for your topic and the remaining pages discussing the components of your conceptual model.
2. *Assignment #2:* Using MATLAB you will implement the macroscopic invasion percolation model.
3. *Assignment #3:* Using MATLAB you will implement the multicomponent mass transfer model of Cirpka and Kitanidis (2001) and recreate the results of the SF₆ experiment they simulated.

Paper discussion:

You will each read three (3) research papers on topics presented in this course to augment your learning. During the discussion weeks, you (as a collective group) will lead a discussion on the paper, and we will all participate in assessing the methods, results, and overall conclusions. These discussions can include the approach to achieve the objectives of the study, good aspects, aspects which could be improved, or anything else you think is important to discuss. A rubric will be provided for grading.

Take-home exam:

A traditional exam will be given that will be take home. You will have 1 week to complete the exam and submit your answers. The questions will be numerical and conceptual in nature.

Missed Term Work

Students who claim illness, injury or other extraordinary circumstances beyond their control as a reason for missed term work are held responsible for immediately informing the instructor concerned and for alternate arrangements with the instructor and in all cases, this must occur no later than **three (3) calendar days** after the term work was due. The alternate arrangement must be made before the last day of classes in the term as published in the academic schedule. The accommodation provided will be shifting the weight to the final exam, only if a self-declaration form has been received within 3 calendar days. To request academic consideration for a missed assessment, please submit a "Self-Declaration Form" (found [here](#)) to me with 3 calendar days. Consult [Section 4.4 of the University Calendar](#).

Late Submission Policy

Without a valid or recognized accommodation or if no self-declaration form is submitted within 3 calendar days, a penalty of 10% per day will be given for all assessments (this, of course, does not apply to paper discussions and take-home exam which are given 0, if missed).

Appeals

Please bring any grading appeals to my attention within **5 calendar days** of grades being posted. Please write a brief description of your concern and submit to me. I will then review and discuss with you, if needed.

Course Material Copyright

Classroom teaching and learning activities, including lectures, discussions, presentations, etc., by both instructors, guest lecturers and students, are copyright protected and remain the intellectual property of their respective author(s). **All course materials, including notes, outlines, recordings, and other materials, are also protected by copyright and remain the intellectual property of their respective author(s).**

Students registered in the course may take notes and make copies of course materials for their own educational use only. Students are not permitted to record lectures on their own. Students are not permitted to reproduce or distribute lecture notes, recordings, and course materials publicly for commercial or non-commercial purposes without express written consent from the copyright holder(s).

Academic dates

Students should be aware of the academic dates (e.g., last day for academic withdrawal) posted on the Registrar's office web site <https://carleton.ca/registrar/registration/dates/academic-dates/>

Academic Integrity

The University Academic Integrity Policy defines plagiarism as “presenting, whether intentionally or not, the ideas, expression of ideas or work of others as one’s own.” This includes reproducing or paraphrasing portions of someone else’s published or unpublished material, regardless of the source, and presenting these as one’s own without proper citation or reference to the original source. Examples of sources from which the ideas, expressions of ideas or works of others may be drawn from include but are not limited to: books, articles, papers, literary compositions and phrases, performance compositions, chemical compounds, art works, laboratory reports, research results, calculations and the results of calculations, diagrams, constructions, computer reports, computer code/software, material on the internet and/or conversations.

Examples of plagiarism include, but are not limited to:

- any submission prepared in whole or in part, by someone else;
- using ideas or direct, verbatim quotations, paraphrased material, algorithms, formulae, scientific or mathematical concepts, or ideas without appropriate acknowledgment in any academic assignment;
- using another’s data or research findings without appropriate acknowledgement;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one’s own; and
- failing to acknowledge sources through the use of proper citations when using another’s work and/or failing to use quotations marks.

Plagiarism is a serious offence that cannot be resolved directly by the course’s instructor. The Associate Dean of the Faculty conducts a rigorous investigation, including an interview with the student, when an instructor suspects a piece of work has been plagiarized. Penalties are not trivial. They can include a final grade of “F” for the course or even suspension or expulsion from the University.

Final Grades

Standing in a course is determined by the course instructor subject to the approval of the Faculty Dean. This means that grades submitted by the instructor may be subject to revision. No grades are final until they have been approved by the Dean.

Addressing Human Rights Concerns

The University and all members of the University community share responsibility for ensuring that the University's educational, work and living environments are free from discrimination and harassment. Should you have concerns about harassment or discrimination relating to your age, ancestry, citizenship, colour, creed (religion), disability, ethnic origin, family status, gender expression, gender identity, marital status, place of origin, race, sex (including pregnancy), or sexual orientation, please contact the [Department of Equity and Inclusive Communities](#) at equity@carleton.ca.

We will strive to create an environment of mutual respect for all through equity, diversity, and inclusion within this course. The space which we work in will be safe for everyone. Please be considerate of everyone's personal beliefs, choices, and opinions.

Academic Accommodation

Students with diverse learning styles and needs are welcome in this course. You may need special arrangements to meet your academic obligations during the term. For an accommodation request, the processes are as follows. For more information, please consult: <http://students.carleton.ca/course-outline>

Pregnancy Obligation

Please contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please consult: <http://students.carleton.ca/course-outline>

Religious Obligation

Please contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more details, please consult: <http://students.carleton.ca/course-outline>

Accommodations for Students with Disabilities

The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision. If you have a disability requiring academic accommodations in this course, please contact PMC at 613- 520-6608 or pmc@carleton.ca for a formal evaluation. If you are already registered with the PMC, contact your PMC coordinator to send me your *Letter of Accommodation* at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). *Requests made within two weeks will be reviewed on a case-by-case basis.* After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC website (<http://www.carleton.ca/pmc>) for the deadline to request accommodations for the formally scheduled exam (if applicable).

Survivors of Sexual Violence

As a community, Carleton University is committed to maintaining a positive learning, working, and living environment where sexual violence will not be tolerated, and survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available and to obtain information about sexual violence and/or support, please visit: <http://www.carleton.ca/sexual-violence-support>

Accommodation for Student Activities

Carleton University recognizes the substantial benefits, both to the individual student and for the university, that result from a student participating in activities beyond the classroom experience. Reasonable accommodation must be provided to students who compete or perform at the national or international level. Please contact the instructor with any requests for academic accommodation during the first two weeks of class, or as soon as possible after the need for accommodation is known to exist. For more information, please consult: <http://students.carleton.ca/course-outline>

Mental Wellness

If you find yourself suffering during this or any other term from anxiety, stress, or issues related to mental health, this is nothing to be ashamed of. It is highly recommended that you seek help; refer to [Counselling Services](#). You are also welcome to reach out to me to discuss on-campus resources.

Here is a list of on-campus and off-campus resources:

1. **Carleton's Health and Counselling Services:** To book an appointment contact the main clinic by calling (613) 520-6674. If urgent, let the Patient Care Coordinator know or go in person to the main clinic (2500 Carleton Technology and Training Centre Building) and indicate that they are in crisis and need to speak to someone right away. For more information, please see <https://carleton.ca/health/>
2. [Emergencies and Crisis](#) and [Emergency Numbers](#)
3. **Good2Talk (1-866-925-5454):** Good2Talk is a free, confidential helpline providing professional counselling and information and referrals for mental health, addictions and well-being to post-secondary students in Ontario, 24/7/36 <https://good2talk.ca/>
4. **Empower Me:** Undergraduate students have access to free counselling services in the community through Empower Me, either in person, by telephone, video-counselling or e-counselling. **This free service is accessible 24/7, 365 days per year.** Call **1-844-741-6389 (toll free)** to make an appointment with a counsellor in the community. More information is available <https://students.carleton.ca/services/empower-me-counselling-services/>
5. **The Walk-In Counselling Clinic (off-campus community resource):** The walk-in Counselling Clinic have offices in various locations across Ottawa and the greater Champlain region that are open 7 days a week. Individuals will be assisted, with no appointment, on a first-come, first-serve basis during the Walk-in Counselling Clinic hours. The Walk-in Counselling Clinic **offers services in many languages** and is free and confidential. More information can be found at: <https://walkincounselling.com/>

6. **Distress Centre of Ottawa and Region:** Available 10am-11pm, 7 days/week, 365 days/year.
Distress Line: 613-238-3311, **Crisis Line:** 613-722-6914 or 1-866-996-0991, **Text:** 343-306-5550.
<https://www.dcottawa.on.ca/>
7. **Distress and Crisis Ontario, Available for chat 2 pm – 2 am EST.** <https://www.dcontario.org/>
8. **BounceBack Ontario (Toll-Free: 1-866-345-0224) is a free skill-building program managed by the Canadian Mental Health Association (CMHA). It is designed to help adults and youth 15+ manage low mood, mild to moderate depression and anxiety, stress or worry. Delivered over the phone with a coach and through online videos, you will get access to tools that will support you on your path to mental wellness.** <https://bouncebackontario.ca/>.