

**Course Outline**  
**Earth Sciences 4206**  
**Contaminant and Remediation Hydrogeology**  
**Winter 2024**

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**INSTRUCTOR**

Dr. Richard Amos  
Office: Herzberg 3347  
Email: [richard.amos@carleton.ca](mailto:richard.amos@carleton.ca)  
Office hours: upon request

**TIME AND PLACE**

Lectures: Wednesday and Friday 1:05 pm - 2:55 pm, Tory Building Room 431  
Tutorials: Tuesday 2:35 pm - 4:25 am pm, Tory Building Room 431  
(tutorials will not be every week but are mandatory when they are held; you will be notified ahead of time)

**Note: Lectures may be held online or in hybrid format to accommodate illness or other requirements. You are encouraged to stay away from class if you are sick or have any symptoms and attend the lecture online. However, you are expected in class otherwise.**

**Note 2: Speed the Therapy Dog will often be joining the class on Wednesdays – please let me know if this is a problem.**

**COURSE DESCRIPTION AND PREREQUISITES**

Geochemical and physical processes controlling contaminant release, migration, and fate in groundwater along with the processes and techniques used for contaminant mitigation and remediation. Examples will include organic and inorganic contaminants in a variety of settings.

Prerequisites: EARTH 3003 and EARTH 3205.

**LEARNING OUTCOMES**

Successful students in this course will demonstrate the ability to;

- 1) Explain the important processes controlling geochemical conditions in groundwater, including thermodynamics, kinetics, acid base reactions, redox reactions, mineral dissolution/precipitation, gas dissolution/exsolution, surface reactions and microbially mediated reactions.
- 2) Explain the relevant release, transport and attenuation mechanisms controlling contaminant concentrations in groundwater.
- 3) Apply geochemical speciation models to groundwater contaminant issues.
- 4) Design an appropriate remediation/mitigation strategy for a contaminated groundwater system.

**COURSE RESOURCES AND MATERIALS**

**Very Helpful Text:** Geochemistry Groundwater & Pollution 2nd Edition, C.A.J. Appelo, Dieke Postma

**Brightspace** will be used extensively to distribute information and communicate details on class assignments and other important information. Be sure to stay connected with your Carleton email to ensure that you receive class updates on a timely basis.

**Laptop Computer and Software:** We will be modelling hydrogeological and geochemical data using programs such as Excel and PHREEQCI. PHREEQCI is a windows-based program so you will need a computer capable of running windows programs. The software can be downloaded here.  
<https://www.usgs.gov/software/phreeqc-version-3>

## **EVALUATION**

Assignments (55%):	Approximately 6 to 10 assignments
Class participation (10%):	Includes in-class assignments and involvement in class (e.g. asking and answering questions and participating in discussions)
Presentations (15%)	Two 15 minute presentation on a scientific paper assigned (7.5% each)
Term Project (20%)	Details to follow

## **TOPICS**

The course will cover physical transport and geochemical processes controlling contaminant release, migrations and attenuation/remediation in the subsurface, including groundwater and unsaturated systems. Topics related to physical processes will include the hydrological cycle, infiltrations and recharge, saturated and unsaturated flow and diffusion and dispersion. Geochemical topics will cover thermodynamic and kinetic controls on intra-aqueous and mineral/water reactions that influence contaminant transport. Lectures materials and assignments will be focused around specific case studies such as acid mine drainage in tailings, remediation using permeable reactive barriers and natural attenuation of organic compounds. The geochemical model PHREEQC will be applied to several problems.

## **STUDENT RESPONSIBILITIES**

**Late Policy:** Late assignments will be penalized 10% per day (including weekends) up to a maximum of 30%. Assignments will be accepted until marked assignments have been returned to the class. No request for individual extensions will be granted but negotiations of due dates for the class will be considered if there are conflicts with major deadlines/assignments in other classes.

**Academic Integrity and Plagiarism:** Students are expected to know their responsibilities and rights under the academic integrity policy <https://carleton.ca/secretariat/wp-content/uploads/Academic-Integrity-Policy-2021.pdf>

*Any suspected instructional offence will be referred to the office of the Dean of Science.*

From the Academic Integrity Policy:

### **1. Plagiarism**

Plagiarism is presenting, whether intentional or not, the ideas, expression of ideas or work of others as one's own.

Plagiarism 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, and material on the internet.

Examples of plagiarism include, but are not limited to:

- submitting a take-home examination, essay, laboratory report or other assignment written, 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;
- submitting a computer program developed in whole or in part by someone else, with or without modifications, as one's own;
- failing to acknowledge sources through the use of proper citations when using another's works and/or failing to use quotation marks.

## **2. Unauthorized Resubmission of Work**

A student shall not submit substantially the same piece of work for academic credit more than once without prior written permission of the course instructor in which the submission occurs. Minor modifications and amendments, such as phraseology in an essay or paper do not constitute a significant and acceptable reworking of an assignment.

## **3. Unauthorized Co-operation or Collaboration**

An important and valuable component of the learning process is the progress a student can make as a result of interacting with other students. In struggling together to master similar concepts and problems and in being exposed to each other's views and approaches, a group of students can enhance and speed the learning process. Carleton University encourages students to benefit from these activities. However, it is also critically important that each individual student's abilities and achievements form the basis of the evaluation of that student's progress. As a result, while collaboration is supported as being beneficial for various components of a course and is generally encouraged, instructors typically limit the amount of collaboration allowed and communicate this to students in the course outlines.

To ensure fairness and equity in assessment of term work, students shall not co-operate or collaborate in the completion of an academic assignment, in whole or in part, when the instructor has indicated that the assignment is to be completed on an individual basis. Failure to follow the instructor's directions regarding which assignments, or parts of assignments, should be completed by the individual alone will be considered violation of the standards of academic integrity.

## **ACADEMIC ACCOMMODATION**

### **Requests for Academic Accommodation**

You may need special arrangements to meet your academic obligations during the term. For an accommodation request, the processes are as follows:

#### **Pregnancy obligation**

Please contact your 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, visit the Equity Services website: [carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf](http://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf)

#### **Religious obligation**

Please contact your 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, visit the Equity Services website: [carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf](http://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf)

### **Academic Accommodations for Students with Disabilities**

If you have a documented disability requiring academic accommodations in this course, please contact the Paul Menton Centre for Students with Disabilities (PMC) at 613-520-6608 or [pmc@carleton.ca](mailto:pmc@carleton.ca) for a

formal evaluation or contact your PMC coordinator to send your instructor your Letter of Accommodation at the beginning of the term. You must also contact the PMC no later than two weeks before the first in-class scheduled test or exam requiring accommodation (if applicable). After requesting accommodation from PMC, meet with your instructor as soon as possible to ensure accommodation arrangements are made. [carleton.ca/pmc](https://carleton.ca/pmc)

### **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 is survivors are supported through academic accommodations as per Carleton's Sexual Violence Policy. For more information about the services available at the university and to obtain information about sexual violence and/or support, visit: [carleton.ca/sexual-violence-support](https://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 your 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. <https://carleton.ca/senate/wp-content/uploads/Accommodation-for-Student-Activities-1.pdf>

For more information on academic accommodation, please contact the departmental administrator or visit: [students.carleton.ca/course-outline](https://students.carleton.ca/course-outline)