This course is an advanced course in groundwater flow and subsurface contamination. The general objectives are for the student to become able to:

- Develop an understanding of groundwater and its importance in the hydrologic cycle
- Recognize the wide range of technical and non-technical considerations associated with contaminated site remediation and to understand the impact of the engineering solution in a global and societal context
- Develop an understanding of the sources and characteristics of groundwater pollutants
- Understand the professional and ethical responsibility of an engineer with respect to contaminant site remediation including consideration of social, economic environmental, worker health and safety, and legislative and other regulatory issues
- Apply mathematical, scientific and engineering knowledge for contaminated site remediation design to meet specified needs and legislative requirements
- Improve communication skills by discussing current contaminated site remediation issues, and expressing and defending opinions before your peers
- Appreciate the rapidly changing nature of knowledge and technology in this field and the need for life-long learning

Topics:
Note that all topics may not be covered due to time constraints.

1. Darcy’s Law
2. Equations of Groundwater Flow
3. Generalized Groundwater Flow Equations
4. Flow Nets and Hubbard’s Potential
5. 2D Analytical Solutions and Numerical Modeling
6. Extensions to Anisotropy and Unconfined Flow
7. Aquifer Evaluation and Pump Tests
8. Transport Processes
9. Transport Equations
10. Analytical Solutions to the Transport Equation
11. Transport Processes at the Field Scale
12. Groundwater Contamination and Remediation

Prequisites: None

Corequisites: None

Antirequisite: None
Note: It is the student's responsibility to ensure that all Prerequisite and Corequisite conditions are met or that special permission to waive these requirements has been granted by the Faculty. It is also the student's responsibility to ensure that they have not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards their degree if they violate the Prerequisite, Corequisite or Antirequisite conditions.

Instructor:
Dr. Christopher Power, cpower24@uwo.ca, SEB 3039A

Administrative Support:
Kristen Edwards, SEB 3118

Calendar Copy:
Principles of model development and solution for environmental systems including river and lake water quality, groundwater flow and contamination, and atmospheric pollution. Application of these principles using a range of numerical techniques, including current commercial software packages, through all stages of the modeling process from conceptualization to calibration and validation.

Contact Hours:
3 lecture hours: Monday (1:30PM–3:30PM in ACEB 1415) and Thursday (1:30PM–2:30PM in SEB 2099)
1 tutorial hour: Thursday (2:30PM–3:30PM in SEB 2099)

Course Materials:
Prepared class notes that can be downloaded from the course website should be brought to each class.

Other References:

Units:
SI units will be used in lectures and examinations

Evaluation:
The final course mark will be determined as follows:

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<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Participation</td>
<td>10%</td>
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<tr>
<td>Assignments</td>
<td>30%</td>
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<tr>
<td>Quizzes</td>
<td>20%</td>
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<tr>
<td>Final Examination</td>
<td>40%</td>
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<tr>
<td>Total</td>
<td>100%</td>
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Note: (a) **Students must pass the final examination to pass this course.** Students who fail the final examination will be assigned the aggregate mark, as determined above, or 48%, whichever is less.

(b) **Students must turn in all assignments and achieve a passing grade in this component, to pass this course.** Students who do not satisfy this requirement will be assigned 48% or the aggregate mark, whichever is less.

(c) **Students who have failed this course previously must repeat all components of the course.** No special permissions will be granted enabling a student to retain assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted.

1. **Quizzes and Examinations:**

Two 50 minute quizzes will be scheduled during the lecture periods. Unless otherwise notified the quizzes and the final examination will be **CLOSED BOOK: no programmable calculators or other external sources of information, including books, notes or crib sheets, are permitted.** A list of acceptable calculators for closed book exams will be posted on the bulletin board across from the Department of Civil and Environmental Engineering Office: please be sure your calculator is on it!

2. **Assignments**

The assignments may involve: (a) computer applications; (b) laboratory experiments; (c) discussion of contemporary issues related to groundwater flow and subsurface contamination. Assignments are to be done individually. Each assignment will be posted on the course website by Monday at 9:00AM. The computer laboratory for working on the assignments will be on the Thursday (2:30PM–3:30PM). You should review the assignment before the computer laboratory and may only ask for assistance on a question you have attempted.

**Late Assignments:** Late assignments will be accepted for 3 days following their due date. 10% per day will be deducted for late assignments. An assignment will not be accepted after 3 days. For extenuating circumstances, see details in the Faculty of Engineering Policy (attached). Extensions are to be negotiated with the course instructor, not the teaching assistants. If no assignment is received for a student, the mark assigned is zero for that week. The maximum number of missed assignments for each student will be three; if more than three assignments are missed than a student may be barred from writing the final exam.

**Plagiarism on Assignments:** Each person must hand in an assignment that contains only their own work. If an assignment is deemed to be similar to another from this year (in the opinion of the TA and the Prof.) this will be taken as a case of plagiarism. In such circumstances, both individuals (e.g., the person providing the answer and the person copying it) will both receive a mark of zero on the entire assignment. For a first offense, both individuals will receive a personal warning and the infraction will be recorded. For a second offense, further action will be taken.

3. **Participation**

As part of the course mark breakdown, 10% will be allocated to student participation in class. Participation is an important component of this course and will be assessed by: (i) attendance at lectures and la sessions, (ii) participation in in-class polls conducted with iClicker Cloud, and (iii) contributing in class.
4. Use of English
In accordance with Senate and Faculty Policy, students may be penalised up to 10% of the marks on all assignments, tests, and examinations for the improper use of English. Additionally, poorly written work with the exception of the final examination may be returned without grading. If resubmission of the work is permitted, it may be graded with marks deducted for poor English and/or late submission.

Plagiarism Checking:
The University of Western Ontario uses software for plagiarism checking. Students are required to submit their Laboratory Reports in electronic form to Turnitin.com for plagiarism checking.

Cheating:
University policy states that cheating is a scholastic offence. The commission of a scholastic offence is attended by academic penalties that might include expulsion from the program. If you are caught cheating, there will be no second warning.

For more information on scholastic offenses, please see:
http://www.uwo.ca/univsec/handbook/appeals/scholastic_discipline_undergrad.pdf

Attendance:
Any student who, in the opinion of the instructor, is absent too frequently from class, laboratory, or tutorial periods will be reported to the Dean (after due warning has been given). On the recommendation of the Department concerned, and with the permission of the Dean, the student will be debarred from taking the regular final examination in the course.

Information regarding iClicker Cloud:
Classroom Polling: We will be using iClicker Cloud, a cloud-based student response software, in class this semester. This will help me understand what you know, give everyone a chance to participate in class, and provide more interaction on concepts and example questions. We will also use this software to keep track of attendance. At the start of every class you will register your attendance; only after you do this will you be able to answer any poll questions posted.

You are required to bring a device connected to the university Wi-Fi to participate in iClicker Cloud during class, including a smartphone, tablet, laptop or iClicker remote. You will need to create an iClicker Reef Student account to participate in class.

Creating Your iClicker Reef Student Account: Go to iclicker.com/students or download the iClicker Reef Student app for your Apple or Android device to sign up for a Reef account. You should use your university email address and your University ID (e.g., “cpower24” for student cpower24@uwo.ca) in the Student ID field. You can edit your email address, password, or student ID from your account profile. Do not create and use more than one Reef account as you will only receive credit from a single account.

You do not need to purchase anything – iClicker Cloud is fully supported by Western and is free to all its students. Make sure you choose Western University Ontario when signing up.
Add This Course to Your Reef Account
Search with the following information to find this course and add it to your Reef account:
Institution: Western University Ontario
Course: CEE 9870 GW_Flow_Cont_Transport

**Use of laptop computers, tablets or smart mobile phones:**
Use of laptop computers, tablets or smart mobile phones is expected to be for the purpose of participating in the lecture explicitly. They can be used to fill in the gapped notes, participate in class polls, and to register your attendance. Students using the devices for activities not related to this class may be asked to leave.

**Accessibility:**
Please contact the course instructor if you require material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

**Conduct:**
Students are expected to arrive at lectures on time, and to conduct themselves during class in a professional and respectful manner that is not disruptive to others. Late comers may be asked to wait outside the classroom until being invited in by the Instructor. Please turn off your cell phone before coming to a class, tutorial, quiz or exam.

On the premises of the University or at a University-sponsored program, students must abide by the Student Code of Conduct: [http://www.uwo.ca/univsec/board/code.pdf](http://www.uwo.ca/univsec/board/code.pdf)

**Sickness and Other Problems:**
Students should immediately consult with the Instructor or Department Chair if they have any problems that could affect their performance in the course. Where appropriate, the problems should be documented (see attached). The student should seek advice from the Instructor or Department Chair regarding how best to deal with the problem. Failure to notify the Instructor or Department Chair immediately (or as soon as possible thereafter) will have a negative effect on any appeal.

For more information concerning medical accommodations, please see: [http://www.uwo.ca/univsec/handbook/appeals/accommodation_medical.pdf](http://www.uwo.ca/univsec/handbook/appeals/accommodation_medical.pdf)

**There will be no make-up midterm exam nor assignments.** If you are unable to write a test for medical or compassionate reasons, you must provide the appropriate documentation to the CEE Graduate Coordinator (SEB 3118). Upon recommendation from the service office, the weighting of the final exam will be adjusted accordingly. Failure to provide the adequate documentation will result in a mark of 0 for the missed exam/assignment.

**Support Services:**
There is an abundance of support services to help you with virtually any type of challenge you may experience. Here are a few:
Registrarial Services [http://www.registrar.uwo.ca](http://www.registrar.uwo.ca)
Student Support Services: [http://westernusc.ca/services/](http://westernusc.ca/services/)
Emotional/Mental Health Support [http://www.uwo.ca/uwocon/mentalhealth/](http://www.uwo.ca/uwocon/mentalhealth/)
Wellness Education Centre (WEC), connecting students with wellness resources [http://se.uwo.ca/wec.html](http://se.uwo.ca/wec.html)

Or contact your Departmental Graduate Coordinator, or the Course Instructor. If you feel you need help of some kind, do not hesitate to reach out. We are all here to help you overcome challenges and be healthy and successful. We can only help if you let us know.

**Notice:**
Students are responsible for regularly checking their email, course website ([https://owl.uwo.ca](https://owl.uwo.ca)) and notices posted outside the Civil and Environmental Engineering Department Office.

**Consultation:**
Students are encouraged to discuss problems with their teaching assistant and/or instructor during tutorial/laboratory sessions. In between these times, students are encouraged to use the online forum on the website for discussing specific course material. Individual consultation with the instructor and/or teaching assistant may be arranged by appointment requested via email.

The document “INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED” is part of this course outline.