This course deals with subsurface contamination by hazardous industrial liquids such as PCB oils, gasoline, jet fuel, chlorinated solvents and coal tars. These compounds represent some of the most prevalent, toxic, and recalcitrant subsurface pollutants throughout the industrialized world. The fundamentals of multiphase/multicomponent flow and transport will be outlined followed by specific treatment of both denser-than-water and lighter-than-water non-aqueous phase liquids (DNAPLs and LNAPLs). The course will examine the fate of these contaminants in water, oil, and vapour phases and their subsurface distribution in both unconsolidated aquifers and fractured rock systems. Relevant analytical and numerical models are employed to better understand the concepts, their application, and the underlying mathematics. As well, the course covers field applications, including site investigation techniques as well as innovative clean-up technologies.

The objectives of the course are:

- Develop an understanding of the history, prevalence, sources, and regulatory framework surrounding industrial organic chemicals in the subsurface.
- Demonstrate knowledge of the range of compounds considered LNAPLs and DNAPLs, and the properties of the subsurface fluids (air, water, and contaminants) that influence the fate of these compounds in the subsurface.
- Recognize the differences that various subsurface environments (e.g., aquifers, aquitards, fractured bedrock) have on the fate of industrial chemicals.
- Solve mathematical relationships that describe multiphase flow in the subsurface and the partitioning of industrial liquids to other phases (vapour, soil, groundwater).
- Utilize mathematical and numerical modelling to investigate properties and problems related to the behaviour of these compounds.
- Demonstrate knowledge of established and innovative methods for site characterization and contaminant mapping and monitoring.
- Develop appreciation for a variety of established and innovative remediation techniques, both the processes that underpin them as well as their application;
- Explore how science, ethics, economics, and politics intersect to influence environmental policy and cleanup drivers.
- Appreciate the need for self-directed study and lifelong learning with respect to environmental issues and technologies.

Calendar Copy:
This course deals with soil and groundwater contamination by organic industrial liquids. Multiphase flow through porous media will be covered, linking key physics and chemistry to contaminant behaviour in the field. Relevant analytical and numerical models are employed. Practical aspects covered include site investigation techniques and innovative clean-up technologies.

Prerequisites:
For 4479 Students: CEE 3386a/b Numerical Modeling for Environmental Engineers
For 9890 Students: An upper year course in Groundwater Flow & Contaminant Transport
In exceptional circumstances, by permission of the instructor.

**Corequisites:**
None.

**Antirequisites:**
None

**Note:** It is the student’s responsibility to ensure that all Prerequisite 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 he/she has not taken a course listed as an Antirequisite. The student may be dropped from the course or not given credit for the course towards his/her degree if he/she violates the Prerequisite, Corequisite or Antirequisite conditions.

**Contact Hours:**
3 Lecture hours, 1 Tutorial hour
(average recommended additional personal study: 4-6 hrs/wk).

**Instructor:**
J.I. Gerhard, Ph.D., P.Eng.,
Spencer Engineering Building Room 3029
Email: jgerhard@uwo.ca

**Textbook:**
None required. Comprehensive notes will be provided and discussed during the class. Readings will be provided.

**General Learning Objectives**

<table>
<thead>
<tr>
<th>Problem Analysis</th>
<th>E = Evaluate</th>
<th>T = Teach</th>
<th>I = Introduce</th>
<th>Ethics and Equity</th>
<th>T = Teach</th>
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<td>Investigation</td>
<td>T = Teach</td>
<td>Communication</td>
<td>E = Evaluate</td>
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<tr>
<td>Design</td>
<td>T = Teach</td>
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<td>I = Introduce</td>
<td>Life-Long Learning</td>
<td>I = Introduce</td>
</tr>
<tr>
<td>Engineering Tools</td>
<td>E = Evaluate</td>
<td>Impact on Society</td>
<td>T = Teach</td>
<td>Knowledge Base</td>
<td>E = Evaluate</td>
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Course Schedule:

<table>
<thead>
<tr>
<th>Date</th>
<th>Lecture Topic</th>
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<tbody>
<tr>
<td>Week 1</td>
<td>Course outline, introduction, historical legacy</td>
</tr>
<tr>
<td>Week 2</td>
<td>NAPL physical properties</td>
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<tr>
<td>Week 3</td>
<td>NAPL chemical properties</td>
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<td>Week 4</td>
<td>Capillary pressure</td>
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<td>Phase Partitioning</td>
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<td>Week 7</td>
<td>DNAPL pools and multiphase flow equations</td>
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<td>Week 8</td>
<td>DNAPL modelling and field behaviour</td>
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<td>Week 9</td>
<td>Reading Week</td>
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<td>Week 10</td>
<td>Site investigation and assessing DNAPL presence</td>
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<tr>
<td>Week 11</td>
<td>Site remediation introduction</td>
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<tr>
<td>Week 12</td>
<td>Remediation presentations</td>
</tr>
<tr>
<td>Week 13</td>
<td>Remediation presentations &amp; Review</td>
</tr>
</tbody>
</table>

Assignments and Project:
Assignments will be distributed approximately every two weeks throughout the course. Tutorials will provide an opportunity to discuss tutorial questions that have been attempted in advance of the tutorial. Questions will be of a similar type to those on the midterm and exam.

Graduate students will, in addition, conduct a research project and present their findings via an oral presentation to the class on a specialized topic relevant to the course.

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

4479
- Participation 10%
- Assignments 20%
- Midterm 20%
- Final examination 50%

9890
- Participation 5%
- Assignments 15%
- Project 15%
- Midterm 15%
- Final examination 50%
Examination and Tests

One 1.5-hr midterm. Date and Location: TBA

One 3-hr final examination. Date and location: TBA

The Midterm and Final Examinations are Closed Book. Only approved (non-programmable) calculators are allowed (see list posted outside Civil Engineering Office). No other external sources of information, including books, notes or crib sheets, are permitted. A reference list of equations will be provided with both midterm and final exams, and will be posted one week before each exam.

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 individual assignments and projects 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 laboratory, assignment or test marks from previous years. Previously completed assignments and laboratories cannot be resubmitted. 
(d) Should any of the classes conflict with a religious holiday that a student wishes to observe, the student must inform the instructor of the conflict no later than two weeks before the scheduled class. 
(For further information on Accommodations for Religious Holidays see https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodations_on_religious.pdf)

Participation

Participation is an important component of this course. It will be assessed in three ways:  
a) Attendance at all lectures and presentations (including guest lectures and student presentations) using iClicker Cloud 
b) Participation in in-class polls conducted with iClicker Cloud  
c) Raising your hand and verbally contributing to class discussions

Information regarding iClicker Cloud

Classroom Polling
We will be using a cloud-based student response software by iClicker 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 be using this software to keep track of attendance. At the start of every class you will JOIN my class; only after you do this will you be able to answer any poll questions posted. It does not matter if you answer right or wrong, there are no marks assigned for correctness. You only get marks for participating. Participating in the polls also, at the same time, registers your attendance. Participating in the majority of questions asked each day shows you were present in class that day. You will need to create an iClicker Reef Student account to participate in class using your laptop, smart phone, or tablet connected to the university Wi-Fi.
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. Those using the mobile app must have it updated to version 5.0.4 (Oct 2018) or newer. You should use your university email address and your University ID (e.g., “jgerhard” for student jgerhard@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 University of Western Ontario when signing up.

Add This Course to Your Reef Account
● Use the + sign to search for my course in iClicker Reef.
● In the “Find Your Institution” field, enter Western University Ontario
● In the “Find Your Course” field, enter CEE 4479/9890 Subsurface Contamination
● Click “Add This Course” and it will be added to the main screen of your iClicker Reef account

Participating
● Each time our class meets, make sure you have selected my course from the main screen of your iClicker Reef account.
● When I start a session, click the Join button that appears on your screen, then answer each question I ask in iClicker Reef.
● For short answer and numeric questions, make sure you press Send.

Keep Track, Review, and Study
● You can review your grades, performance, and participation in iClicker Reef
● You can use the questions I asked during class as flashcards or practice tests in the Study Tools section of iClicker Reef.

Academic Integrity Information
iClicker activities fall under the provisions of our campus academic honesty policy. Students must not engage in academic dishonesty while participating in iClicker activities. This includes but is not limited to:
● Checking in while not physically in class
● Having another student check you into class
● Answering polling questions while not physically in class
● Looking at other students' devices while answering live questions
● Using more than one iClicker remote or account at a time

Any student found to be in violation of these rules will lose polling points for the entire term and may be reported to the Dean of Student Discipline.
Need help with iClicker Reef?

- If you are having issues connecting to iClicker Reef, check out these iClicker Reef Connectivity Tips.
- If you are having issues seeing your iClicker Reef points, check out this troubleshooting guide.
- Find answers to many of your questions and contact the iClicker Tech Support Team by visiting iclicker.com/support at any time.

Units:
SI units will be used in lectures and examinations.

Use of English:
In accordance with Senate and Faculty Policy, students may be penalized 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.

Attendance:
Any student, who, in the opinion of the instructor, is absent too frequently from class or laboratory periods in any course, 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 examination in the course.

Plagiarism:
Students must write their essays and assignments in their own words. Whenever students take an idea, or a passage from a source, they must acknowledge that source by proper referencing such as footnotes or citations. Plagiarism is a major academic offence (see Scholastic Offence Policy in the Western Academic Calendar).

Scholastic Offences (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. Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site: http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undgrad.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.

**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:

[https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_illness.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_illness.pdf)

**Notices:**
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 in tutorial sessions. Office hours will be arranged for the students to see the instructor and teaching assistants. Other individual consultation can be arranged by appointment with the appropriate instructor.

**Accreditation (AU) Breakdown**
- Engineering Science = 75%
- Engineering Design = 25%
- Total AU’s (57.3) = 100%

The document “Instruction for students unable to write tests or examinations or submit assignments as scheduled” IS ATTACHED AND IS PART OF THIS COURSE OUTLINE
INSTRUCTIONS FOR STUDENTS UNABLE TO WRITE TESTS OR EXAMINATIONS OR SUBMIT ASSIGNMENTS AS SCHEDULED

If, on medical or compassionate grounds, you are unable to write term tests or final examinations or complete course work by the due date, you should follow the instructions listed below. You should understand that academic relief will not be granted automatically on request. You must demonstrate to your department (or the Undergraduate Services Office) that there are compelling medical or compassionate grounds that can be documented before academic relief will be considered. Different regulations apply to term tests, final examinations and late assignments. Please read the instructions carefully.

NEW: Requests for Academic Consideration using the Self-Reported Absence Form

If you experience an unexpected illness or injury or an extenuating circumstance (48 hours or less) that is sufficiently severe to temporarily render you unable to meet academic requirements (e.g., attending lectures or labs, writing tests or midterm exams, completing and submitting assignments, participating in presentations) you should self-declare using the online Self-Reported Absence portal. This option should be used in situations where you expect to resume academic responsibilities within 48 hours or less.

Each student will be allowed a maximum of two self-reported absences between September and April and one self-reported absence between May and August. Self-reporting may not be used for final exams or assessments (e.g. midterm exams, tests, reports, presentations, or essays) worth more than 30% of any given course.

For full instructions about the Self-Reporting System refer to the Academic Calendar link here.

A. GENERAL REGULATIONS & PROCEDURES (other than self-reported absences)

1. All first year students will report to the Undergraduate Services Office, SEB 2097, for all instances.

2. If you are an upper year student and you are missing a test/assignment/lab or examination that is worth LESS THAN 10% of your mark, you should report to your department office to request relief. If your course work is worth MORE THAN 10% of your final grade, you will report to the Undergraduate Services Office, SEB 2097.

3. Check the course outline to see if the instructor has a policy for missed tests, examinations, late assignments or attendance.

4. Documentation must be provided as soon as possible. If no one is available in your department office or the Undergraduate Services Office, leave a message clearly stating your name & student number and reason for your call. The department telephone numbers are given at the end of these instructions.

5. If you decide to write a test or an examination you should be prepared to accept the mark you earn. Rewriting tests or examinations or having the value of a test or examination reweighted on a retroactive basis is not permitted.

B. TERM/MIDTERM TESTS (other than self-reported absences)

1. If you are in first year and you are unable to write a midterm/term test, contact the Undergraduate Services Office, SEB 2097 PRIOR to the scheduled date of the test.

2. If you are an upper year student and you are unable to write a midterm/term test, inform your instructor PRIOR to the scheduled date of the test. If the instructor is not available, leave a message for him/her at the department office. If the test is worth LESS THAN 10% of your mark, you should report to your department office to request relief. If the test is worth MORE THAN 10% of your final grade you will report to the Undergraduate Services Office, SEB 2097 to request relief.

3. Be prepared to provide supporting documentation to the Department Chair and/or the Undergraduate Services Office (see next page for information on documentation).

4. Discuss with the instructor if and when the test can be rescheduled. N.B. The approval of the Chair or the Undergraduate Services Office is required when rescheduling midterm/term tests.
C. **FINAL EXAMINATIONS (cannot be self-reported)**

1. If you are unable to write a final examination, contact the Undergraduate Services Office PRIOR TO THE SCHEDULED EXAMINATION TIME to request permission to write a Special Final Examination. If no one is available in the Undergraduate Services Office, leave a message clearly stating your name & student number.

2. Be prepared to provide the Undergraduate Services Office with supporting documentation (see next page for information on documentation) the next day, or as soon as possible (in cases where students are hospitalized). The following circumstances are not considered grounds for missing a final examination or requesting special examinations: common cold, headache, sleeping in, misreading timetable and travel arrangements.

3. In order to receive permission to write a Special Examination, you must obtain the approval of the Chair of the Department and the Associate Dean and in order to apply you must sign a "Recommendation for a Special Examination Form" available in the Undergraduate Services Office. The Undergraduate Services Office will then notify the course instructor(s) and reschedule the examination on your behalf.

   **PLEASE NOTE:** It is the student's responsibility to check the date, time and location of the Special Examination.

D. **LATE ASSIGNMENTS**

1. Advise the instructor if you are having problems completing the assignment on time (prior to the due date of the assignment).
2. Be prepared to provide documentation if requested by the instructor (see reverse side for information on documentation).
3. If you are granted an extension, establish a due date. The approval of the Chair of your Department (or the Assistant Dean, First Year Studies, if you are in first year) is not required if assignments will be completed prior to the last day of classes.
4. i) Extensions beyond the end of classes must have the consent of the instructor, the department Chair and the Associate Dean, Undergraduate Studies. Documentation is mandatory.
   ii) A Recommendation of Incomplete Form must be filled out indicating the work to be completed and the date by which it is due. This form must be signed by the student, the instructor, the department Chair and the Associate Dean, Undergraduate Studies.

E. **SHORT ABSENCES**

If you miss a class due to a minor illness or other problem, check your course outlines for information regarding attendance requirements and make sure you are not missing a test, laboratory or assignment. Cover any readings and arrange to borrow notes from a classmate.

F. **EXTENDED ABSENCES**

If you are absent more than one week or if you get too far behind to catch up, you should consider reducing your workload by dropping one or more courses. (Note drop deadlines listed below). You are strongly encouraged to seek advice from your Academic Counsellor in the Undergraduate Services Office.

G. **DOCUMENTATION**

If you consulted an off-campus doctor or Student Health Services regarding your illness or personal problem, you must provide the doctor with a Student Medical Certificate to complete at the time of your visit and then bring it to the Department (or the Undergraduate Services Office). This note must contain the following information: severity of illness, effect on academic studies and duration of absence. Regular doctor’s notes will not be accepted; only the Student Medical Certificate will be accepted.

   **In Case of Serious Illness of a Family Member:** Provide a Student Medical Certificate to your family member's physician to complete and bring it to the Department (or the Undergraduate Services Office if you are in first year).

   **In Case of a Death:** Obtain a copy of the death certificate or the notice provided by the funeral director's office. You must include your relationship to the deceased and bring it to the Department (or the Undergraduate Services Office if you are in first year).

   **For Other Extenuating Circumstances:** If you are not sure what documentation to provide, ask the Departmental Office (or the Undergraduate Services Office if you are in first year) for direction.

   **Note:** Forged notes and certificates will be dealt with severely. To submit a forged document is a scholastic offence (see below).
H. **ACADEMIC CONCERNS**

1. You need to know if your instructors have a policy on late penalties, missed tests, etc. This information may be included on the course outlines. If not, ask your instructor(s).

2. You should also be aware of attendance requirements in some courses. You can be debarred from writing the final examination if your attendance is not satisfactory.

3. If you are in academic difficulty, check out the minimum requirements for progression in the calendar. If in doubt, see your Academic Counsellor.

**Calendar References:** Check these regulations in your 2019 Western Academic Calendar available at [www.westerncalendar.uwo.ca](http://www.westerncalendar.uwo.ca).

- **Self-Reporting Absences**
- **Absences Due to Illness**
- **Academic Accommodations for Students with Disabilities**
- **Academic Accommodations for Religious or Holy Days**
- **Course Withdrawals**
- **Examinations**
- **Scheduling of Term Assignments**
- **Scholastic Offences**
- **Student Medical Certificate**
- **Engineering Academic Regulations**

**Note:** These instructions apply to all students registered in the Faculty of Engineering regardless of whether the courses are offered by the Faculty of Engineering or other faculties in the University.

**Add Deadlines:**
- First term half course (i.e. “A” or “F”) September 13, 2019
- Full courses and full-year half course (i.e. “E”, “Y” or no suffix) September 13, 2019
- Second term half course (i.e. “B” or “G”) January 14, 2020

**Drop Deadlines:**
- First term half course (i.e. “A” or “F”) November 12, 2019
- Full courses and full-year half courses (i.e. “E”, “Y” or no suffix) November 30, 2019
- Second term half or second term full course (i.e. “B” or “G”) March 7, 2020

**Contact Information:**

- Undergraduate Services Office: SEB 2097 Phone: 519-661-2130 E-mail: engugrad@uwo.ca
- Chemical & Green Process Engineering: TEB 477 Phone: 519-661-2131 E-mail: cbeugrad@uwo.ca
- Civil Engineering: SEB 3005 Phone: 519-661-2139 E-mail: civil@uwo.ca
- Computer, Electrical, Mechatronic Systems & Software Engineering TEB 279 Phone: 519-661-3758 E-mail: eceugrad@uwo.ca
- Integrated Engineering ACEB 2410 Phone: 519-661-6725 E-mail: engceli@uwo.ca
- Mechanical Engineering: SEB 3002 Phone: 519-661-4122 E-mail: mmeundergraduate@uwo.ca

Revised 08/01/19