CWR6537 CONTAMINANT SUBSURFACE HYDROLOGY

3 credits/Fall Semester 2021

T 5-6 (11:45 AM - 1:40 PM), R 6 (12:50 PM – 1:40 PM) Room: 415 Black Hall

Instructor: Michael D. Annable, Professor
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This is a registered in-person class that will be taught primarily in the face-to-face mode in room 415 Black Hall at the scheduled times (T 5-6 (11:45 AM - 1:40 PM), R 6 (12:50 PM – 1:40 PM). The class will employ HyFlex to record and provide synchronous remote access to face-to-face lectures. Recordings will be made available through Canvas shortly after the live classes. Students may elect to attend class either F2F (face to face) or virtually over Zoom. Full credit for participation and assignments is available either way.

Zoom office hours will follow class lecture. (approximately 1:45 PM)

Course Description: This course describes solute transport in porous media from granular to karst aquifers. The course material should be of interest to graduate students in both science and engineering. Course discussion topics will include:

- Description and quantification of solute transport processes (diffusion, dispersion, advection, sorption, transformations, etc.)
- Formulation and solution of solute transport equations
- Modeling of water flow and solute transport
- Ground water Surface water exchange, hyporheic zone processes
- Variable density flow and saltwater intrusion
- Multiphase flow in porous media, Non-Aqueous Phase Liquid (NAPL)
- Applications: Groundwater contamination, remediation, and nutrient point and non-point sources
- Emerging contaminants including 1,4-Dioxane and Perfluorinated Compounds (PFOS Perfluorooctane Sulfonate and PFOA Perfluorooctanoic Acid often used in AFFF Aqueous Film-Forming Foam).

Prerequisites and Expected Background: Students should be familiar with the physics of water flow in the subsurface and should be comfortable with the use of differential equations to describe physics and chemistry problems. Mathematics is the language of physics, and the problems of interest are transient and spatially variable so partial differential equations result. Some familiarity with solution techniques (both analytical and numerical) is beneficial but these techniques are not the focus of this course. Contact instructor if there are problems registering due to prerequisites.

Course Objectives

(a) Learn advanced concepts of water and solute retention and transport in the vadose zone (unsaturated media) and groundwater (saturated media).
(b) Explore the theoretical aspects of water and solute transport in porous media.
(c) Examine the inter-relationships among various physical, chemical, and biological processes that influence solute retention, transformations, and transport in porous media.
(d) Discuss the theoretical bases for experimental methods used to measure various physical and chemical properties relevant to water retention & flow and solute retention & transport in porous media.
(e) Apply analytical and numerical modeling approaches to solve laboratory- and field-scale problems, including process coupling and the design and evaluation of management strategies.
(f) Investigate emerging contaminant behavior including 1,4-Dioxane and PFAS/PFOA site conceptual models.

Grading System: Two midterm exams (25% each), homework (30%), contaminant transport project (20%). No final exam.

Grades on assignments submitted after the due date will be penalized in proportion to the elapsed time after the due date. The UF policy on points assigned for letter grades can be found here https://catalog.ufl.edu/ugrad/current/regulations/info/grades.aspx

Textbook not Required: There is no required textbook for the course. Additional lecture notes and references to specific papers will be provided during the semester. The following texts may provide useful background and additional reference information.

It is emphasized that this course will not follow any of these books in a traditional textbook manner. Purchase of any of these books is recommended for students who appreciate the value of a supplemental text and reference. If such additional materials are not useful for you, then you should not feel compelled to purchase one of these books.

1. Fetter, C. W., *Contaminant Hydrogeology* (1993) Macmillan, NY.
2. Domenico, P. A. and F. W. Schwartz, *Physical and Chemical Hydrology* (1990) Wiley, NY.
3. Charbeneau, R. J., *Groundwater Hydraulics and Pollutant Transport* (2000) Prentice Hall, NJ.
4. Bedient, P. B., et al. *Ground Water Contamination* (1994) Prentice Hall, NJ.
5. Freeze, R. A. and J. A. Cherry, *Groundwater* (1979) Prentice Hall, NJ.
6. Chiang, W-H., and W. Kinzelbach, *3D-Groundwater Modeling with PMWIN* (2001), Springer-Verlag, New York
7. Kutilek, M. and D. R. Nielsen, *Soil Hydrology* (1994) Catena Verlag, Germany.
8. Hillel, D., *Environmental Soil Physics* (1998) Academic Press, New York.
9. Bear, Cheng, Alexander, Modeling Groundwater Flow and Contaminant Transport, 2010

10. Chlorinated Solvent Source Zone Remediation, (2014). DOI: 10.1007/978-1-4614-6922-3; ISBN: 978-1-4614-6921-6, Bernard H. Kueper, Hans Stroo Hans Stroo, Catherine M. Vogel, C. Herb WardC. Herb Ward, SERDP/ESTCP publication.

Reading and Homework Assignments: Approximately 6 quantitative homework problems will be assigned throughout the semester. The expected effort to solve these problems varies between 2 to 8 hrs.

Contaminant Transport Project: Each student will independently analyze an interesting contaminated site (or general contaminant transport problem). Analyses must include discussion of each of the following elements: site history, contaminant origins, sources at the site, exposures (past, present, future), impacts from exposure, actions to minimize risk (past, present, future) and regulatory process description. All projects should include mathematical modeling of transport processes. Sites may be under active study, from the literature or from other sources. *Students are encouraged to exercise their creativity*.

Academic Honesty

As a result of completing the registration form at the University of Florida, every student has signed the following statements: "I understand that the University of Florida expects its students to be honest in all their academic work. I agree to adhere to academic honesty and understand that my failure to comply with this commitment may result in disciplinary action up to and including expulsion from the University."

UF Counseling Services

Resources are available on-campus for students having personal problems or lacking clear career and academic goals which interfere with their academic performance. There resources include:

1. *University Counseling Center, 301 Peabody Hall, 392-1575, personal and career counseling;*
2. *Student Mental Health, Student Health Care Center, 392-1171, personal counseling;*
3. *Sexual Assault Recovery Services (SARS), Student Health Care Center, 392-1161, sexual assault counseling; and*
4. *Career Resources Center, Reitz Union, 392-1601, career development assistance and counseling.*

Accomodation for Students with Disabilities

Students requesting classroom accommodation must first register with the Dean of Students Office. The Dean of Students Office will provide documentation to the student who must then provide this documentation to the Instructor when requesting accommodation.

Software Use

All faculty, staff and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida, pledge to hold ourselves and our peers to the highest standards of honesty and integrity.

Online Course Recording

Our class sessions may be audio visually recorded for students in the class to refer back and for enrolled students who are unable to attend live. Students who participate with their camera engaged or utilize a profile image are agreeing to have their video or image recorded. If you are unwilling to consent to have your profile or video image recorded, be sure to keep your camera off and do not use a profile image. Likewise, students who un-mute during class and participate orally are agreeing to have their voices recorded. If you are not willing to consent to have your voice recorded during class, you will need to keep your mute button activated and communicate exclusively using the "chat" feature, which allows students to type questions and comments live. The chat will not be recorded or shared. As in all courses, unauthorized recording and unauthorized sharing of recorded materials is prohibited.

Health and Wellness:

- You are expected to wear approved face coverings at all times during class and within buildings even if you are vaccinated. Please continue to follow healthy habits, including best practices like frequent hand washing. Following these practices is our responsibility as Gators.
- If you are sick, stay home and self-quarantine. Please visit the UF Health Screen, Test & Protect website about next steps, retake the questionnaire and schedule your test for no sooner than 24 hours after your symptoms began. Please call your primary care provider if you are ill and need immediate care or the UF Student Health Care Center at 352-392-1161 (or email covid@shcc.ufl.edu) to be evaluated for testing and to receive further instructions about returning to campus. UF Health Screen, Test & Protect offers guidance when you are sick, have been exposed to someone who has tested positive or have tested positive yourself. Visit theUF Health Screen, Test & Protect websitefor more information.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A “class lecture” is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and

delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.