CWR 6126, U01 (REF.: 18188) – ADVANCED GROUNDWATER HYDROLOGY
Prerequisites: Permission of the Instructor
Department of Civil and Environmental Engineering
Florida International University
Spring 2023

Instructor: Professor Fuentes, Ph.D., P.E., B.C.E.E.
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Office Hours: M, W: 1:00 - 2:30PM (first-come, first-served)
All other office hours by appointment.

Lecture location and time: EC-2420; Tuesday: 5:00 -7:40PM (two long lectures)

A. Course Description & Objective

Quantity and quality of water resources is vital to sustain the health, and welfare of individuals and communities. Their protection requires understanding laws, principles and methods that are needed to use it, sustainably, and protect its quality. The *overall learning objective* of the course is to provide the water resources engineer with a working knowledge of the phenomena and processes to understand transport of contaminants in groundwater. Contents will focus on several background themes, such as groundwater contamination, legal framework, basics of flow in saturated and unsaturated porous media, sources of contaminants, investigations, physical and chemical fate and transport processes, analytical modeling and introduction to the implementation of numerical models. The student will have the opportunity to either develop or implement a mathematical and computer model to solve a problem or answer questions in support of assessment, monitoring or remediation efforts. Some relevant questions are, for instance: What are the chemical and microbiological transformations that affect the fate of a contaminant in groundwater? How can those transformations be mathematically represented? What is the state of the art computer models that are used to assess, monitor and remedy groundwater contamination?

B. Textbook & Reading Assignments

Required textbook/material:

1. *Bedient, P. B., H. S. Rifai, and C. J. Newell, Ground Water Contamination. Prentice Hall PTR, Upper Saddle River, New Jersey, 1999. Due to the year of publication, public records and official data, such as statistical indicators, contamination or remediation cases, among others, should be updated as students deem most appropriate in their study.*

2. Selected Reference Handouts (students must make their own copies).

Although the textbook will assist you well during the course, students should supplement textbook content with class notes, handouts, and references; they are also responsible for the

timely study of all assigned material, in advance to all lectures. Careful study of the theory and solving problems are critical elements in achieving the learning objective.

C. Use & Management of Class Time

Class time is used to present and discuss theory and examples. Lectures will follow the sequence of topics, as listed below.

Theme	**Topic (Reading Assignment)**	**Estimated No. of Lecture (two long lectures on Tuesday)**
Part I – Introduction		
1.	Introduction (Chapter 1)	1
2.	Legal Framework (Chapter 14)	1
3.	Contaminant Sources & Types (Chapter 4)	1
Part II – Basic Background		
4.	Ground Water Hydrology (Chapter 2)	2
5.	Ground Water Flow (Chapter 3)	2
16.	Site Investigations (Chapter 5)	2
Part III – Processes		
7.	Transport Processes (Chapter 6)	3
8.	Fate Processes (Chapter 7)	3
9	Analytical Models (Chapter 6, Handouts, References)	3
Part IV – Modeling Contamination		
10	Numerical Modeling (Chapter 10)	4
Part V – Overview of Applications		
11.	Groundwater Remediation Technologies (Chapter 13)	2
12.	Biodegradation and Natural Attenuation (Chapter 8, 11, 12)	1

D. Grading Policies

Homework	15 (TBA, each graded over 100)
Exam 1	25 (T, February 21)
Exam 2	30 (T, March 28)
Project	30 (WR due April 21; OP on April 25th)
Total Maximum	*100 points*

Homework: a) is due and collected on the scheduled day at the beginning of the first lecture; b) must comply with template; c) if late, it will not be accepted, receiving zero points; and d) its completion or grading does not condition, in any way, the content of scheduled exams.

Questions and problems in exams will be based on all assigned material up to one week prior to

the scheduled day. Exams will be held on February 21 (No. 1) and on March 28 (No. 2), 2023.

For the project guidelines, refer to the attached Project Addendum (see course website). MS students will, either individually or in teams of up to 2 students (upon instructor's approval), will complete and present written and oral project reports of professional quality. PhD students have the option of writing a "review paper" (upon instructor's approval). Project proposal is due on March 7, 2023. The written project report is due on 04/21/23 at 11:59PM or earlier at the instructor's mailbox. The oral presentation of projects will be held on 04/25/23 at 5:00PM. The instructor may announce other criteria in advance to deadlines for homework, exams, and report.

BEGIN YOUR ASSIGNMENTS PROMPTLY. ALL YOUR WORK MUST BE AN INDIVIDUAL EFFORT, UNLESS OTHERWISE APPROVED BY THE INSTRUCTOR.

Final grade is a function of the total number of points accumulated by the student at the end of the course, as follows:

93.3	≤	A	≤ 100.0	76.7	≤	C+	< 80.0
90.0	≤	A-	< 93.3	70.0	≤	C	< 76.7
86.7	≤	B+	< 90.0	60.0	≤	D	< 70.0
83.3	≤	B	< 86.7			F	≤ 60.0
80.0	≤	B-	< 83.3				

QUESTIONS ABOUT GRADES WILL BE RESOLVED WITHIN THE FIVE WORKING DAYS FOLLOWING THEIR OFFICIAL ANNOUNCEMENT.

E. Other Performance Policies

Reading assignments, a prime student's responsibility, are expected to be completed prior to their presentation and discussion in class. It is important to remember that the class meets on Tuesday to attend two lectures. Class attendance is expected, and each student should use *FIU-Check-In* each scheduled Tuesday for each lecture (FIU Check-In).

A student with three unacceptable, unjustified absences may be dropped from the course with a DR by March 20. Students will automatically lose 0.4 points per unjustified absence after March 20, including those prior to March 20. No make-ups or incomplete grades will be considered, unless acceptable, justified absence. Please, be in time for all scheduled lectures and activities and keep all cellphones and unapproved electronic devices off.

Photographing and (audio- or video-) recording by any student are not allowed at any time during testing (i.e., exams). Any violation will be handled under *Student Conduct and Academic Integrity* policies and procedures.

Exams are open book and must be individually completed by each student, unless other instructions are announced by the instructor.
Students should always carry their *FIU One Card* for official identification purposes and be

ready to present it if requested by the Instructor or his representative during any scheduled activity, but most especially during exams.

F. Days to Remember (refer to the FIU 2022-2023 Academic Calendar for details)

UG_Academic_Calendar.pdf (fiu.edu)

January 9:	Classes begin
January 16:	Martin Luther King Holiday (University Closed)
February 27-March 4	Spring Break (University Open; No Classes)
March 20:	Deadline to drop a course with a DR grade. Deadline to withdraw from the University with a WI grade.
April 22:	Classes end
April 24-29:	Final week
April 25:	Project Oral Presentation and Defense (5:00 PM)
May 3:	Deadline (by 11:59 pm) for faculty to submit grades

The instructor will comply and enforce all applicable FIU's Policies and Regulations. It is the students' responsibility to know all applicable policies and requirements. All students should refer, for details, to the *FIU Student Handbook* (which includes the Student Code of Conduct) at https://studentaffairs.fiu.edu/about/student-handbook/index.php

Students are deemed by the university to understand that if they are found responsible for academic misconduct, they will be subject to the Academic Misconduct procedures and sanctions, as outlined in the FIU Student Handbook. Misconduct includes, among other, *cheating, plagiarism, misrepresentation misuse of computer services, bribery, conspiracy and collusion, falsification of records and academic dishonesty*. For details visit Student Conduct and Academic Integrity | Division of Academic & Student Affairs | Florida International University (fiu.edu)

Students should be aware of both Panthers Care and CAPS services for students, which support their well-being.

G. Some Recommended References

A good number of relevant references, for your consideration and use, are available at the Steve and Dorothea Green Library. In addition, selected items below may be checked out from the instructor, during his scheduled office hours, for up to 48 hours.

Aquifer Hydraulics, V. Batu, John Wiley & Sons (1998).
Applied Hydrogeology, C. W. Fetter, Prentice-Hall (2001).
Basic Ground Water Hydrology, USDOI, USGS, Water Supply Paper 2220 (1983).
Groundwater, R. A. Freeze and J. A. Cherry, Prentice-Hall (1979).
Ground Water Contamination Transport and Remediation, P. B. Bedient, H. S. Rifai, and C. J. Newell, Prentice-Hall PTR (1999).

Groundwater Hydrology, H. Bouwer, McGraw-Hill (1978).
Groundwater Hydrology & Hydraulics, D. B. McWhorter & D. K. Sunada, Water Resources Publications (1977).
Groundwater Hydraulics and Pollutant Transport, R. J. Chaberneau, Waveland press, Inc. (2000).
Hydraulics of Groundwater, J. Bear, McGraw-Hill (1979).
Subsurface Hydrology, G. F. Pinder and M. A. Celia, Wiley-Interscience (2006).
Applied Contaminant Transport Modeling, Theory and Practice, C. Zheng and G. D. Bennett, Van Nostrand Reinhold (1995).
Applied Ground Water Modeling, Simulation of Flow and Advective Transport, M. P. Anderson, W. W. Woessner and R. Hunt, Academic Press, Inc., W. (2015).
Determining Transport Parameters from Laboratory and Field Tracer Experiments, J. C. Parker and M. Th. Van Genuchten, Virginia Agricultural Experiment Station, Bulletin 84-3 (1984).
Groundwater Transport: Handbook of Mathematical Models, I. Javandel, C. Doughty and C. F. Tsang, American Geophysical Union, Water resources Monograph (1984).
Introduction to Ground Water Modeling, H. F. Wang and M. P. Anderson, Academic Press, Inc., (1982).

In addition, all graduate students should support their study, as it may be needed, identifying any relevant peer-reviewed journals (the higher the impact factor of a journal, the better the journal).

Important websites for computer models for groundwater flow and transport applications:

https://water.usgs.gov/software/lists/groundwater

https://www.epa.gov/land-research/ground-water-modeling-research

https://www.epa.gov/ceam/groundwater-models-assess-exposures

Important websites for remediation technologies for contaminated sites:

Table of Contents (frtr.gov)

Technology Screening Matrix | Federal Remediation Technologies Roundtable (frtr.gov)

Remediation Technologies for Cleaning Up Contaminated Sites | US EPA

Important federal agency and other websites, among others:

www.epa.gov, www.usgs.gov, www.ngwa.org,and

IGWMC Home - Integrated Groundwater Modeling Center (mines.edu),

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