

ENVSE 408 - CONTAMINANT HYDROLOGY SYLLABUS

Lecture: TuTh 1:35-2:50p (Blended course: both in-class and [online](#))
Location: 121 Earth and Engineering Sciences Building
Playlist: http://www.youtube.com/playlist?list=PLBMBY58d_Pxq0yNG7zCyalzfYtOzGCjRo
Resource page: <http://www.ems.psu.edu/~elsworth/courses/geoe408/cm/>
Text: *Contaminant Hydrogeology*, by C.W. Fetter, T. Boving, D. Kreamer
 3rd Edition, Waveland Press Inc., 645 pp., 2018.
 ISBN 978-1-4786-3279-5
 Selected texts on reserve in EMS Library.

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Prerequisites: Geosc. 452; or consent of instructor

Grading:

Assignments (~8 ~equally weighted)	35%
Mid-term exam	25%
Content quizzes (~18 or attendance)	15%
Remediation presentation	25%
Remediation quizzes (~6 as attendance)	<u>6%</u>
Total	~106%

	Topic	Sub-Topic	Reading ¹
1	Introduction	Overview of problems; scientific problems; economic perspective.	Fetter Chap. 1
2	Physical Hydrology	Review; Fracture hydrology; equivalent porous media concepts (EPM); representative elemental volume (REV). Partially saturated flow; capillary models; entry pressures; multiphase flow; relative permeabilities; immiscible penetration. Buckley-Leverett equations; Non-aqueous fluid penetration; NAPL and DNAPL penetration; Product recovery. Brooks-Corey and van Genuchten relations.	Fetter Chaps. 4 & 5; Bear Chap. 9
3	Contaminant Hydrology	Mass transport and attenuation mechanisms; Advection, diffusion, dispersion, adsorption, precipitation, biological attenuation, colloidal transport. Fractured media; solutions for 1-D and 2-D systems; density controlled transport.	Fetter 2 & 3
4	Retardation & Attenuation	Quantifying retardation and attenuation effects: Partitioning, dissolution, persistence. Equilibrium surface reactions; isotherms. Organic compounds, sorption, K_{oc} and K_{ow} ; multiple solute effects; dissolution rates. Half-lives and biodegradation.	Fetter 6 & 7
5	Vapor Mobility	Volatilization and Partitioning; Henry's and Raoult's Laws; Transport mechanisms; partitioning behavior; retardation factors; Differential retardation; dissolved plume advection and gas-phase advection.	Cohen and Mercer
6	Mathematical Models	Finite element models for flow and transport. Steady and transient behavior. Initial conditions and boundary conditions. Numerical stability. Problem solving.	Anderson & Woessner
7	Aquifer & Aquiclude Characterization	Geostatistical methods; Drilling, well & piezometer installation; Cone penetrometer testing; sampling; borehole and surface geophysical methods; magnetic, electric, seismic, gravity; vapor sampling; pump testing; natural geochemical techniques; water quality data; tracer testing, RTD and exotic methods.	Fetter 8
8	Remediation	Point source LNAPL/DNAPL contamination; vapor contamination. Groundwater Remediation: Biological processes; electrolyte processes; containment and ground modification; soil washing; air stripping; thermal processes.	Fetter 9; Grubb and Sitar

References¹:

1. Anderson, M.P. and Woessner, W.W., Applied Groundwater Modeling: Simulation of Flow and Advective Transport, Academic Press Inc, 1992.
2. J. Bear, Dynamics of Fluids in Porous Media, Chapter 9, pp. 439 - 478, Dover Publishing Co., 1988.
3. Cohen, R.M. and Mercer, J.W. DNAPL Site Investigation, Report to EPA, EPA/600/R-93/022, 1993. <http://tinyurl.com/DNAPLsiteevaluation>
4. Fetter, C.W., Boving, T., Kreamer, D. Contaminant Hydrogeology, Macmillan College Publishing Co., 2018.
5. Grubb, D.G. and Sitar, N. Evaluation of Technologies for in-situ Cleanup of DNAPL Contaminated Sites, Report to EPA, EPA/600/R-94/120, 1994. <http://tinyurl.com/EvalCleanupDNAPLFullReport>

Penn State's policy on academic integrity applies to all aspects of course deliverables. Students are encouraged to work together on all assignments but must submit independent work for all graded deliverables and exams. Further details are available for academic integrity and code of conduct at:

<https://www.ems.psu.edu/undergraduate/academic-advising/policies-procedures-and-forms/academic-integrity-undergraduates>

Per AD 42-27 class attendance for this course is encouraged. "A student should attend every class for which the student is scheduled and should be held responsible for all work covered in the courses taken." Absences/late deliverables should be appropriately corroborated (e.g. doctor's note, etc.).

This syllabus may be updated during the semester and you will be responsible for abiding with any such changes.

Additional generic Penn State policies: https://www.ems.psu.edu/~elsworth/courses/eme_303/outline_add.docx

Deliverables: Students will work in teams to complete one team project - a critical evaluation of one of six remediation methods to be presented in class by the team (one period each). Late assignments lose 10%/day.

Grade Divisions: A (>93.3%); A- (>90.0%), B+ (>86.6%); B (>83.3%); B- (>80.0%), C+ (>75.0%); C (>70.0%), D (>60.0%); F (<60.0%)

Spring 2023 Calendar - At-a-Glance [In-class and Online]

January 2023

Su	Mo	Tu	We	Th	Fr	Sa	Wk	Deliv	Tuesday	Thursday
7	8	9	10	11	12	13	1	I-c	1:1 Introduction	2:1 Capillary Behavior
14	15	16	17	18	19	20	2	I-c	2:2 Capillary Behavior	2:3 Multiphase Flow
21	22	23	24	25	26	27	3	I-c	2:4 Multiphase Flow	2:5 Multiphase Flow
28	29	30	31							

February 2023

Su	Mo	Tu	We	Th	Fr	Sa	Wk	Deliv	Tuesday	Thursday
				1	2	3	4	I-c	2:6 Multiphase Flow	2:7 Unsaturated Flow+Transp
4	5	6	7	8	9	10	5	I-c	3:1 Conservative Transp.	3:2 Conservative Transport
11	12	13	14	15	16	17	6	I-c	3:3 Conservative Transp.	4:1 N-C Transp. (organics)
18	19	20	21	22	23	24	7	I-c	4:2 Non-Conservative Transp.	5:1 Vadose Zone
25	26	27	28	29						

March 2023

Su	Mo	Tu	We	Th	Fr	Sa	Wk	Deliv	Tuesday	Thursday
25	26	27	28	29	1	2	8	I-c	6:1 Modeling	7:1 Drilling
3	4	5	6	7	8	9	10			
10	11	12	13	14	15	16	9	I-c	Free	Mid-term exam
17	18	19	20	21	22	23	10	O-A	7:2 Sampling & Profiling	7:3 Surface and B/h Geophys
24	25	26	27	28	29	30	11	O-A	8.0 Remediation - J. McNew	Group preparation

April 2023

Su	Mo	Tu	We	Th	Fr	Sa	Wk	Deliv	Remediation Presentations	
	1	2	3	4	5	6	12	I-c	Presentations due	8.1 Biological Methods
7	8	9	10	11	12	13	13	I-c	8:2 Electrolytic Methods (23)	8:3 Containment and Modification (23)
14	15	16	17	18	19	20	14	I-c	8:4 In Situ Soil Washing (23)	8:5 In Situ Air Stripping
21	22	23	24	25	26	27	15	I-c	8:6 Thermal Methods	

May 2023

Su	Mo	Tu	We	Th	Fr	Sa	Wk	Deliv
28	29	30	1	2	3	4		

○ Mid-term exam
 ○ Group presentations due

*Class modalities

I-c In-class or alternatively completed asynchronously online and verified by quiz

O-A Online-Asynchronous - no In-class meeting/no zoom broadcast but recorded lecture verified by quiz