Syllabus

CIVE 638 - Groundwater Quality and Contaminant Transport

Fall Semester 2014 Begin Time	End Time	Days	Building	Room	Start Date	End Date
12:00 PM	12:50 PM	M W F	Microbiology A 114		Aug. 26	Dec. 13

Course number and title: CIVE 638 – Groundwater Quality and Contaminant Transport

Credits: 3

Term(s) to be offered: Fall 2014

Prerequisite(s): Groundwater Hydrology (CIVE 423, CIVE 531, or GEOL 452), Fluid Mechanics (CIVE 300 or CBE331 or MECH342), Calculus through differential equation recommended; exceptions by instructor.

Course Description: This is a graduate level course addressing contaminant transport in natural geologic media. The central theme is a first principles review of governing processes including: contaminant partition between nonaqueous, aqueous, sorbed and vapor phase; multiple phase flow; and advective-diffusive-reactive transport of solute in unsaturated and saturated media.

Instructor: Tom Sale – Associate Professor/Civil and Environmental Engineering - PhD Agricultural Engineering, MS Hydrology, BA Chemistry, BA Geology - Director of the Center for Contaminant Hydrology in Civil and Environmental Engineering at CSU - Principle Investigator in the University Consortium for Field-Focused Groundwater Contaminant Research since 2000.

Text: None

Additional Class Material: Handouts, PowerPoint presentations, and worksheets provided by the instructor.

Course Objective(s): Objectives for this course include:

- Providing knowledge needed to understand and find solutions for contaminants in natural geologic media
- Developing the skills needed for life-time learning

Course Topics/Weekly Schedule: Fifty minute lecture will be given three times a week through the semester. All lectures and/or presentation material will be posted to a class folder in advance of the lectures.

Setup and Basic Principle (5)

Lecture #1

Course setup

- **Syllabus**

Retrospection (Cherry's 2010 Consortium Talk)

- Radionuclides
- Landfills
- Modeling transport with Thesis assumptions
- RCRA and CERCLA
- Early Numerical Models
- DNAPL
- A return to high resolution

Lecture #2

Review of critical principles

- Mathematics
- Advection
    - Single fluid
    - Multiple fluids

Lecture #3

Complete review of critical principles (Cont.)

- More Math Concepts
- Diffusion

MathCAD Review

Lecture #4

MathCAD Review
Begin partitioning between Phases

Lecture # 5

Wrap up partitioning between phases

Multiphase Flow (10)

Lecture # 6

Introduction to Art Corey's world (Multiphase Flow)

Lecture # 7

Capillarity

Lecture # 8

Capillarity (finish)
Wettability
Immicible Fluids in Static Systems
    Mechanical Equilibrium
    Distribution of Pressure in a Static Two Phase System

Lecture # 9

Immicible Fluids in Static Systems (Continued)
    Hysteresis
    Entry Pressure (P_e)
    Residual Saturations and Effective Saturation
    Measurement of Capillary Pressure as a Function of Saturation

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Lecture # 10

Empirical Representations of P_c vs S_w
    Brooks Corey

Lecture # 11

Empirical Representations of P_c vs S_w (Cont.)
    van Genuchten

Lecture # 12

Wrap up Chapter 2 - Hydrostatic (Petroleum Reservoirs)
Start Chapter 3 - Theroy of Steady State Fluid Motion

Lecture # 13

Wrap up Steady State Fluid Motion (Chapter 2)
    Tortuosity
    Darcy's Equation

Lecture # 14

Flow Example 1 - Dual Drain Waterflood DNAPL Recovery

Lecture # 15

Flow Example 2 - Downward Flow of Water Through a Homogeneous Soil Profile to a Water Table

Lecture # 16

DNAPLs

- Source of dissolved and vapor plumes
- Entry Pressure
- Necessary upward gradients
- Impacts of NAPL losses on NAPL Stability

Transport of Aqueous Phase Constituents (19)

(Note two additional guest lecture were given in the section on thermodynamic control of reaction and reaction kinectic)

Lecture # 17

Introduction to Source Terms for Transport Models

Lecture # 18

Sources (continued) - Flow over NAPL pools

Lecture # 19

More mass transfer from NAPLs

Lecture # 20

Wrap up source terms
Start matrix diffusion

Lecture # 21

Continue matrix diffusion

Lecture # 22

Continue matrix diffusion

Lecture # 23

Summary of presentations from the University Consortium 2010 Modeling Focus Meeting (Cherry, Bredehoft, Parker, Payne, Huyakorn, Chapman …)
An Analytic Solution for Transport in a Two Layer System

Lecture # 24

Break through curves - with and without contaminant storage in low k zones

Lecture # 25

Field Scale Plumes - Chapman and Parker WRR (2005)
Field Scale break through curves
Wrap up Sources

Lecture # 26

Introduction to Advective-Diffusive-Reactive (ADiR) Transport
Reactions
- Contaminant Stable Isotope Analysis (CSIA)

Lecture # 27

Reaction (continued)
- Sorption

Lecture # 28

Advection
- Hydraulic Controls
- Structural (Geologic) Controls

Lecture # 29

Advection (Continued)
- Flow Nets
- Mass Flux
- Sand tank visualization studies

Lecture # 30

Advection (Wrap up)
Start Advective-Dispersive-Reactive Transport

Lecture # 31

Advective-Dispersive-Reactive Transport (Cont.)
- 1-D transport calculations
- Start Math for 3-D transport

Lecture # 32

Wrap up Advective-Dispersive-Reactive Transport (Cont.)

Lecture # 33

High Resolution Numerical Models

Transport of Gas Phase Constituents (3)

Lecture # 34

Introduction to Vapor Transport
- Processes
- Relevance

Lecture # 35

Vapor Transport Continued
- Layered systems with varying water content
- Numerical approaches

Lecture # 36

Vapor Transport Continued
- Layered systems with varying water content
- Numerical approaches

Selection of Site Remedies (2)

Lecture # 37

Projecting future conditions based on past trends
Introduction to the 14 Compartment Model

Lecture # 38

A Priori prediction of the performance of remedies using the 14 Compartment Model

Course Wrap Up (1)

Lecture # 39

Reivew and Closing Comments

Mode of Delivery: Instructor lectures, classroom discussion, supplementary readings, weekly homework, and guest speakers.

Methods of Evaluation: Mid term (30%), Final (30%), Homework (30%), and Class Participation (10%).