Hydrologic Engineering Center
Training Course on

Groundwater Hydrology

Davis, California

Contents and Objectives

This course provides instruction on: basic principles of groundwater hydrology; theory of groundwater flow; aquifer characterization; analysis of seepage and drainage problems; and modeling of groundwater aquifers. Case studies are presented to illustrate the application of basic principles.

8:00-8:45 a.m.	**Welcome and Introduction**	
8:45- 9:45 a.m.	1.1 Lecture	**General Geology Review**
	Historic Geology; Physical Geology; Structural Geology; Geomorphology.	
9:45-10:00 a.m.	Break	
10:00-10:50 a.m.	1.2 Lecture	**Geology and Aquifer Materials**
	Sand and Gravel; Sandstone and Conglomerate; Carbonate Rocks; Volcanics; Fractured Rock.	
11:00-12:00 p.m.	1.3 Workshop	**Geology and Aquifer Materials**
12:00-1:00 p.m.	Lunch	
1:00-2:00 p.m.	1.4 Lecture	**Movement of Groundwater I**
	Porosity and Specific Yield; Porosity; Darcy's Law and Hydraulic Conductivity; Flow and Transmissivity; Homogeneity and Isotropy; Flow in Stratified Media.	
2:00-2:45 p.m.	1.5 Workshop	**Movement of Groundwater I**
	Hand calculations covering above lecture (1.4) material.	
2:45 – 3:00 p.m.	Break	
3:00-3:50 p.m.	1.6 Lecture	**Movement of Groundwater II**
	Aquifer Storage; General Flow Equations; Numerical Solution Methods; Flow Lines and Flow Nets; Analysis of Seepage and Drainage Problems; Determination of Potentiometric Surface; Effect of Barometric Pressure Fluctuations on Confined Aquifers	
4:00-5:00 p.m.	1.7 Workshop	**Advanced Concepts/Flow Nets**
	Aquifer Storage; Flow Net Construction; Three-Point Problem.	

8:00-9:00 a.m.	2.1 Lecture	**Review of Basic Groundwater Concepts** Review of general concepts; questions from previous day.
9:00-9:45 a.m.	2.2 Lecture	**Advanced Groundwater Concepts** Infiltration; Unsaturated flow; Variable density flow; Salt-water intrusion; Fracture flow; Analytical Methods.
9:45-10:00 a.m.	Break	
10:00-10:45 a.m.	2.3 Lecture	**Conjunctive Use** Water supply planning; Analytical methodology.
10:45-11:00 a.m.	Break	
11:00-12:00 p.m.	2.4 Lecture	**Case Study- Aquifer Characterization** Characterization methods; Conceptual model development; Analysis of results.
12:00-1:00 p.m.	Lunch	
1:00-1:50 p.m.	2.5 Lecture	**Well Construction/Pumping Tests** Drilling Methods; Material Sampling; Well Design; Well Completion; Methods for Well Development; Monitoring Wells; Flow to Pumping Wells; Pumping Test Design.
2:00-2:45 p.m.	2.6 Workshop	**Flow to Pumping Wells** Flow net construction; Hand plots and calculations.
2:45-3:00 p.m.	Break	
3:00-3:50 p.m.	2.7 Lecture	**Analysis of Pumping Test Results** Flow to wells; Analysis of pumping test results; Slug tests.
4:00-5:00 p.m.	2.8 Workshop	**Analysis of Pumping Test Results** Determine aquifer properties using the Theis, Cooper-Jacob, and Neuman methods.

8:00-8:30 a.m. 3.1 **Field Trip Overview**

8:30 – 9:00 a.m. Bus to field trip site at Sacramento State University, Sacramento.

9:00-12:00 p.m. 3.2 **Field Trip**

Measuring water levels; Estimating hydraulic conductivity; Water quality sampling; Performing pumping tests.

12:00-1:00 p.m. Lunch

1:00-2:30 p.m. 3.3 Workshop **Analysis of Field Trip Results**

Plot well drawdown measurements on graph paper. Perform analysis using Theis method.

2:30 – 3:00 p.m. Bus to HEC classroom.

3:00-3:50 p.m. 3.4 Lecture **Cone Penetrometers/Geophysical Methods**

Borehole geophysical methods; Surface geophysical methods.

4:00-5:00 p.m. 3.5 Workshop **Advanced Concepts/Aquifer Characterization**

Estimate aquifer parameters given time-drawdown data from a pumping test.

8:00-8:50 a.m.	4.1	Lecture	**Water Chemistry**

Methods for estimating hydrogeological parameters using geochemical processes and environmental isotopes.

9:00-10:00 a.m.	4.2	Field Trip	**Davis Municipal Well System**

Overview of city of Davis water supply system; Measurement of flow rate at well; Water sample and quality analysis

10:00-10:50 a.m.	4.3	Lecture	**Occurrence and Transport of Contaminants**

Advection; Dispersion; Diffusion; Retardation.

11:00-12:00 p.m.	4.4	Lecture	**Numerical Modeling of Groundwater Flow**

Numerical and analytical methods; Appropriate use of models; Review of general flow equations; Solution techniques/numerical methods; Available groundwater flow models.

12:00-1:00 p.m. Lunch

1:00-1:50 p.m.	4.5	Lecture	**The Development and Application of Numerical Groundwater Flow Models**

Conceptual model; Code selection; Grid design; Boundary and initial conditions; Calibration/parameter estimation; Sensitivity analysis; Execution and interpretation of results; Post-audits.

2:00-2:45 p.m.	4.6	Lecture	**Pre- and Post-Processors**

Purpose, types, and applications in groundwater modeling.

2:45-3:00 p.m. Break

3:00-3:40 p.m.	4.7	Field Example	**Case Study- Groundwater Modeling**

Development and application of Tooele Army Depot model.

3:45-5:00 p.m.	4.8	Workshop	**The Department of Defense Groundwater Modeling System (GMS)**

Create data sets for the models MODFLOW and FEMWATER and interpret model results.

8:00-8:50 a.m.	5.1 Lecture	**Case Study – HTRW Clean-up**
	Identify steps in assessing and remediating groundwater contamination; Illustrate typical challenges from real site examples.	
9:00-9:45 a.m.	5.2 Lecture	**Reviewing Groundwater Modeling Projects**
	Use of field examples to demonstration correct/incorrect ways to develop a groundwater flow model	
9:45-10:00 a.m.	Break	
10:00-11:00 a.m.	5.3 Interactive Lecture	**Approaches and Solutions to Field Studies**
	Review of weeks material; Simple hand calculations; Determine appropriate approaches to various site characterization studies (i.e. aquifer tests, geophysics etc..) and appropriate analysis methods (i.e. analytical, numerical, etc..)	
11:00-11:20 a.m.	**Critique and Closing**	