esm226 **Norm Brown, Winter 2019**

Tues & Thurs, 12:30–1:45, BH 1414

Groundwater Management

Syllabus – Administrative Items

Readings

We will incorporate readings from the scientific community, data summaries, news items, technical references and a variety of other sources. We will discuss in class the findings, purpose and implications of groundwater management topics addressed in the documents. Documents and reference items will be posted to the course's Gauchospace site, referenced from public sources, and/or reserved for esm226 at the Davidson Library.

Grading

- 40% - Problem sets (approximately six assignments)
  - Assignments may require mostly narrative responses (appx 2 pages text), or technical product (e.g., excel data files and graphs), or some combination.
- 50% - Final Project -- Case Study
  - Written report, based on a specific groundwater basin
  - Includes analysis, proposed actions and management criteria
  - Individual or 2-person effort
  - Final, written report (appx 15 pages plus any technical appendices)
- 10% - Final Project Presentation and Class Discussion
  - Oral presentation of final project study and findings. 10-12 min presentation, and 3-5 min Q&A.
  - Preparedness for class discussion
- All submitted materials should be concise and in a style appropriate to a professional client.

Calendar

Regular Lectures: Tu & Th, 12:30-1:45, BH1414.
First: Tuesday, January 8
Last: Thursday, March 14

Final Project Paper due: Friday, Mar 15, 2:00pm

Final Project Presentations: Monday, March 18, 12:00-3:00, BH1414

Prerequisite

Background coursework or reading in hydrogeology.

Office Hours

[*location tbd*] After class or by appointment

Contact

nnbrown@gmail.com

Norman N. Brown, Ph.D.
Bren School of Environmental Science and Management
University of California
Santa Barbara, California 93106

---

esm226, Winter 2019

Groundwater Management - Lecture Topics

This is not a sequential or comprehensive list of items we will cover during the quarter, but provides an idea of some topics that will be presented and discussed. There will be weekly lectures, readings and reference materials, and in-class discussion.

Part I: Hydrogeological foundation and relevance for groundwater management

A. Geology, Groundwater Basins and Aquifers
    1) Regional geological environments and occurrence of groundwater
    2) Basin types and scales
    3) Aquifers, hydrostratigraphy, basin/flow boundary conditions
    4) Natural water quality conditions and variability
    5) Uses and importance of groundwater

B. Groundwater Recharge and Storage
    1) Recharge sources and processes
    2) Storage volumes, storativity and confined/unconfined aquifers
    3) Time and extent scale differences
    4) Methods for estimation
    5) Use of groundwater as a drought buffer over wet-dry cycles

C. Aquifer Characterization and Water Wells
    1) Wells and well construction/completion
    2) Aquifer/groundwater response to pumping
    3) Aquifer characterization and aquifer types – from alluvial to bedrock
    4) Data sources and types

D. Yield and Water Balance Calculations
    1) Types and importance of differences between different yield types
    2) Water balance calculations and Bredehoeft's "water budget myth"
    3) Data types and potential errors
    4) Estimation methods and biases/sensitivities

E. Overdraft
    1) Definitions and importance
    2) Adverse impacts; reversible and permanent changes
    3) Quantitative methods for determination
    4) Focus topic: Subsidence

F. Groundwater Quality
    1) Water quality constituents and different implications for management
    2) Characterization; data sources and uses
    3) Seawater intrusion and brackish water

Part II: Topics and Methods in Groundwater Management

G. Goals and Types of Groundwater Management
    1) Managing for water supply, water quality, or both
    2) Different management strategies for different hydrogeological characteristics, resource limitations, infrastructure components and other conditions
    3) Short- and long-term solutions
    4) Climate change impacts
    5) Management approaches, authorities and tools. Political, economic, technical, institutional and legal examples from California, US and global basins

H. Hydrogeological Basis of Management Methods
    1) Basin boundaries, inflows, outflows and charges to groundwater in storage
    2) Water quality
    3) Interaction and exchange of surface water and groundwater
    4) Regional supplies

I. Managed/Artificial Recharge and Conjunctive Use
    1) Sources, timing and ecological limitations
    2) Surface infiltration characteristics, saturated and unsaturated flow
    3) Direct aquifer injection; aquifer storage & recovery
    4) Water quality and compatibility; constituents of concern

J. Supplemental Water and "Physical Solutions"
    1) Water reuse and recycling
    2) Desalination
    3) California's water conveyance infrastructure
    4) California's water banking infrastructure
    5) Other regional water transfers; e.g., Colorado River diversions, Colorado west-to-east slope diversions

K. Groundwater Storage Management
    1) Aquifer suitability, opportunities and limitations
    2) Monitoring
    3) Operations and management methods

L. Water Quality Management
    1) Contaminant classes and sources
    2) Regulatory structure and requirements
    3) Technologies for groundwater quality characterization and treatment
    4) Local and distributed water quality impacts
    5) Seawater intrusion and coastal aquifers
    6) Nitrate contamination
    7) Management strategies

M. Source Area and Aquifer Protection
    1) Source and recharge area protections
    2) Variations based on hydrogeological and potential contaminant characteristics

N. Monitoring and Performance Evaluation of Management Methods
    1) Monitoring devices and data
    2) Aquifer behavior for different extraction, injection and hydrogeological regimes
    3) Numerical evaluations, from simple spreadsheets to complex flow models

Special Topics and Case Studies – a sample of topics given special focus during the course

i. California Sustainable Groundwater Management law and program
ii. Coastal groundwater management and seawater intrusion examples
iii. Fractured crystalline rock aquifers -- use, analysis and management
iv. Hydraulic fracturing for oil and gas development; injection waste disposal wells
v. Groundwater management, drought & climate change
vi. Capital interests, water markets and regulatory frameworks