

SYLLABUS
GROUNDWATER HYDROLOGY (476K)
AQUIFER TESTING (191W)
PHYSICAL HYDROGEOLOGY (391C)
Fall Semester, 2010

Instructor: Jack Sharp, EPS 3.150, JGB (GEO) 6.110 (jmsharp@jsg.utexas.edu)

Office hours: M & W 11-12 or by appointment

Teaching assistants:

Megan Franks - JGB 5.224 (meganfranks@mail.utexas.edu)

Mike Passarello – EPS 3.124A (mcpassarello@gmail.com)

Wendy Robertson-EPS 3.124B (wendyr@mail.utexas.edu)

Objectives: This course:

1. reviews the basic principles of groundwater hydrology/physical hydrogeology from geological, physical, mathematical, and geotechnical points of view;
2. (in 191W or the 476K lab) reviews or introduces students to basic computational and interpretative methods used in analyzing groundwater systems; scientific paper writing and presentation, and
3. examines at promising new areas of hydrogeologic research through lectures, assigned readings, and a student-selected project/term paper.

Meeting times:

The lecture is from 10:00-11:00 AM MWF in JGB/ GEO 3.222.

A weekly literature/research discussion meeting for the graduate students in 391C will be arranged.

Laboratory: 476K labs and 191 will meet in GEO 3.104.

| | |
|-------|---------------------|
| 26980 | Th 8-10 (Robertson) |
| 26985 | W 1-3 (Franks) |
| 26990 | T 2-4 (Robertson) |
| 26995 | W 3-5 (Passarello) |
| 27000 | T 5-7 (Passarello) |
| 27005 | W 5-7 (Franks) |

Texts: Two required texts:

1. Sharp, John M., Jr., 2010, A Glossary of Hydrogeological Terms: Department of Geological Sciences, The University of Texas, Austin, Texas, 70p.

2. Sharp, J. M., Jr., 2010, Hydrogeology Notes: Department of Geological Sciences, The University of Texas, Austin, Texas, 419p.

Inquiring students will supplement the above materials with pertinent portions of the texts listed on the additional references. Additional papers may be assigned during the semester.

Other talks/opportunities. Hydrogeology talks are given in a number of other venues - technical sessions and other seminars within the Department (including periodic hydrogeology brown bag seminars), at the BEG or UTIG, in other UT Departments (especially Petroleum and Geosystems Engineering, Civil

Engineering, and Geography), at other agencies (e.g., USGS), and still other venues (e.g., Austin Geological Society, SIPES, etc.).

I will keep you informed of these other opportunities that help UT hydrogeology unique. Classroom instruction and assignments should not be the only source of your (scientific) education. If you know of other pertinent seminars/talks, please bring them to the attention of the class.

Field trips: Optional field trips will be offered. These may include some of the following ½ or 1-day field trips:

1. Carbonate aquifers and karst: the local Edwards aquifer
2. Sediments and sedimentary rocks
3. Igneous rocks and fractured media

Because of student schedules and the size of this class, these are not required, but extra credit will be given for attendance. The exams will have optional questions that those who participate in the field trips may choose to answer. There may be an optional January term field trip for those who took this class.

Laboratory: All 476K students must attend one of the laboratory sessions. Graduate students who have not had several previous classes in physical hydrogeology should take Geology 191. Graduate students who take 191 almost always do better in the exams, have higher class rankings, and are more satisfied with the course. Geology 191 meets concurrently the 476K labs.

391C Graduate discussion: This consists of literature reviews of articles selected by faculty and student, an annotated bibliography, and a short (3-page) research proposal. Undergraduates are welcome to attend. The discussion session times will be arranged

Office hours: Formal office hours are: 11:00-noon - Monday and Wednesday or by appointment or feel free to come in and chat whenever the door to my office is open. *Informal* office hours:

1. when there are hydro speakers at Tech Sessions (typically, we take them out for a few beverages or dinner afterwards).
2. after the Hydrogeology Brown Bag Seminar.
3. I will have a few 5:00 PM meeting times to review or discuss tests, etc.

Lecture topics: The projected order of topics is below. Revisions to the syllabus will be announced in class as needed.

Grading:

| | <u>476K</u> | <u>391C</u> | <u>191</u> |
|--------------------------|-------------|-------------|------------|
| 2 examinations | 50% | 60% | - |
| Final examination** | (25%) | (30%) | - |
| Lab problem sets – | 25% | - | 100% |
| Term paper – writing * | 25% | - | |
| Literature reviews | - | 10% | - |
| Annotated bibliographies | - | 10% | - |
| Research proposal | - | 20% | - |

Note: Information pertinent to the exams, schedule revisions, and announcements of opportunities (talks, job interviews, etc.) will be presented in class lectures. Guest lecturers in hydrogeology will present material in class that will be included on exams. We try to take advantage of the visitors to our program.

Note: Geology 191 and the labs for GEO 476K will meet in JGB 3.104 and/or the computer laboratory.

* 476K is a substantial writing component class. The term paper draft, outline, and final paper are 25%, but there are also writing components in the laboratory.

** The optional final is comprehensive and can substitute for your lowest mid-term examination or if you missed one of the mid-term exams.

LECTURE/COURSE SCHEDULE

("He listens well who takes notes" - Dante Alighieri)

| <i>DATE:</i> | <i>TOPIC:</i> | <i>READINGS:</i> |
|----------------|---|--|
| | | ** will be on library reserve * will be handed out in lecture |
| BASIC CONCEPTS | | |
| Aug. 25 | The hydrological cycle | 1-14 |
| 27 | Porosity | 15-36 |
| 30 | Darcy's law | 37-50, 73-74 Darcy (1856**) |
| Sep. 1 | Permeability LAB: Introduction to regional flow and groundwater exploration laboratories | 51-72 |
| 3 | Permeability and flow nets | 85-90 |
| Sep. 6 | <i>Labor Day - no class</i> | - |
| 8 | Flow nets & Regional flow systems LAB: Porosity | 91-114 |
| 10 | Storativity; groundwater law (Suzanne Pierce) | 281-286 |
| 13 | Safe yield; sustainability, & groundwater law (Pierce) | 287-296 Mace et al., 2004** |
| 15 | Karst (Marcus Gary) LAB: Darcy's Law | GSA Special Paper 404, p. 123-136** |
| 17 | Yield, decision support systems (Pierce) <u>Case history</u> - Barton Springs | Sharp et al., 2008** |
| 20 | <u>Case history</u> - Zacatón (Gary) Meet at Visualization Lab | - |
| 22 | <u>Case history</u> - Hydrogeology of the Cuatro Ciénegas Basin LAB: Permeability | Wolaver et al., 2008** |
| 24 | Concept of storativity; subsidence | 115-134 |

BASIC PHYSICS

| | | |
|--------|--|-------------------------|
| 27 | <u>Case History</u> - Subsidence Tidal and barometric efficiencies | 135-140 |
| 29 | Review <u>First exam</u> (7:00-9 :00PM in another room) LAB: Flow nets | - |
| Oct. 1 | <i>Water New Years Day</i> Derivation of the main equations of flow | - |
| 4 | Derivation of the main equations of flow Due: Term paper rough draft and outline by 5:00PM | - |
| 6 | Pumping tests LAB: Consolidation | 141-166 |
| 8 | Pumping tests | - |
| 11 | <i>Columbus Day</i> Infiltrometer & piezometer tests | - |
| 13 | The unsaturated (vadose) zone LAB: Pumping Tests | 167-176 |
| 15 | Flow in fractures | 177-191 |
| 18 | Fractured rock systems | Krasny and Sharp, 2007* |
| 20 | Free convection | 191-194 |
| 20 | Fresh water / saline systems LAB: Vadose Zone | 195-200 |

TRANSPORT PHENOMENA

| | | |
|--------|--|-----------------------|
| 22 | Mass Transport | 201-216 |
| 25 | Diffusion and dispersion | 217-236 |
| 27 | Diffusion & dispersion – Mass transport reactions | - |
| 29 | Fracture skins; transport on fractured systems LAB: Mass transport LAB: Regional Flow (Due before 10:00 AM; 2 copies. Assigned on 1 September) | Robinson et al., 1998 |
| Nov. 1 | GSA - No Class (continue work on term papers, grant proposals, etc.) | |
| 2 | <i>Election day (if going to GSA be sure to vote absentee)</i> | |
| 3 | GSA - No Class (continue work on term papers, grant proposals, etc.) | |

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|-------|--|--|
| 5 | Energy transport and hydrothermal systems | 237-250 |
| 8 | Contaminant hydrogeology Due: 476K term paper/project final draft (2 copies <u>before</u> 5:00PM) | 267-276 |
| 10 | NAPLS LAB: Fractured systems | 277-280 |
| 11 | <i>Veterans Day</i> | |
| 12 | Petroleum migration Due: 391C Annotated bibliographies (2 copies <u>before</u> 5:00PM). | 345-352 |
| 15 | Sedimentary basins <u>Case history</u> – Gulf of Mexico Basin | DNAG, ** |
| 17 | <u>Case history:</u> Effects of urbanization LAB: NAPLS | Garcia-Fresca & Sharp, 2003 & 2005* Wiles & Sharp, 2008* |
| 19 | Urbanization field trip Due: 476K term paper/project student edits (2 copies <u>before</u> 5:00PM) | - |
| 22 | Groundwater geology | 297-308 |
| 24 | Groundwater exploration Due: 391C Geol. Soc. America grant proposals due (6 paper copies <u>before</u> 12:00 noon). | 309-322 |
| 25-26 | <i>Thanksgiving vacation & A&M game</i> | |
| 29 | Geostatistics Due: 476K Term papers (1 paper copy with copy of your draft and 1 electronic copy <u>before</u> 12:00 noon). | 407-419 |
| Dec.1 | Review <u>Second exam</u> (at 7:00- 9:00 PM in another room) LAB: Groundwater exploration (assigned on 1 September) | |
| 3 | Last class day | |
| 6-8 | tentative grades available | |
| 15 | OPTIONAL FINAL (time and site to be designated). | |

Note the final is optional.

- If you are satisfied with your tentative grade, you may skip the final.
- If you missed an exam, you must take the final.
- If you are dissatisfied with your grade on one of the other two exams or your class ranking, the final will substitute for your lowest grade.

Final will consist of: 50 multiple choice – 50 points & 5 (out of 8) short answers – 50 points

Substantial writing component: There will be a short paper on a selected aquifer as part of the first laboratory session. This is followed by a term paper selected from a list of topics. The term paper is expected to be approximately 20+ pages long and follow a specified format. The final paper will be submitted both electronically and in hard copy . 2 paper copies of the outline and the draft are required. Each paper will have a student editor (drawn at random) and a professional editor (me and/or a TA) review the draft.

The UT Undergraduate Writing Center (UWC) asked that I provide you this on the syllabus:

“The UWC is a service that can help your students write more effectively--and more independently. Because we share your commitment to improving undergraduate writing, we ask that you: 1) encourage but not require students to come to the UWC. While requiring a visit works in the short term to get students through our door, the actual goals of the writing consultation suffer: students do not engage in the writing process or effectively work toward becoming better writers; ...2) download and refer your students to helpful writing handouts from our main website: <http://uwc.utexas.edu/handouts>.”

Other: (I apologize – I know that we all know or be able to infer these but there is a UT directive that you are to be informed of the following:

1) *the honor code* (how it applies to each class, and develop a more thorough description of what constitutes acceptable practices in our classrooms.)

“The core values of The University of Texas at Austin are learning, discovery, freedom, leadership, individual opportunity and responsibility. Each member of The University is expected to hold these values through integrity, honest [*sic*], trust, fairness, and respect toward peers and community.”

No plagiarism or copying of others work for tests, term papers, pop quizzes, or laboratory problem sets is acceptable. Plagiarism or copying is subject to dismissal from the class with a zero grade.

Group learning can be beneficial, so I encourage you to work with each other on occasion, and not always in isolation. However, if it 3 of your team up to analyze, for example, the data from a Guelph permeameter or the Theis curve matching, you owe it to yourself to do the calculations yourself again from scratch.

2) *students with disabilities:*

The University of ... [Texas] provides upon request appropriate academic accommodations for qualified students with disabilities. For more information, contact the Office of the Dean of Students at 471-6259, 471-6441 TTY.”

3) *classroom etiquette:* (Chana Lee, reported in the Chronicle of Higher Education, 27 March 1998): “Please do not hold conversations with classmates when the professor or another student is speaking. Also refrain from passing notes, reading ...[The Daily Texan], or participating in disruptive classroom behavior. Your undivided attention is a must. An atmosphere of mutual respect is in order....”

4) *use of lap tops:* I have had complaints from students that the clatter of people typing on their laptops is very distracting or that the person next to or in front of the a student was answering email or playing video games (especially in large, beginning classes), which also caused distractions. Recall Tom Sawyer, Joe Harper, and the tick! Also, it can be distracting to whoever is lecturing. We can discuss this if you wish. If you have a disability that requires you to use a laptop or a recording device , please see me.

5) *my abridged curriculum vitae* (resumé), including teaching experience and contributions to professional journals: [See following pages].

ADDITIONAL REFERENCES

- Batu, V., 1998, Aquifer Hydraulics: John Wiley & Sons, New York, 727p.
- Bear, J., 1972, Dynamics of Fluids in Porous Media: American Elsevier (reprinted by Dover Pubs.), New York, 764p.
- Bear, J., Tsang, C.-F., and de Marsily, G. (eds.), 1993, Flow and Contaminant Transport in Fractured Rock: Academic Press, San Diego, 560p.
- Bouwer, H., 1978, Groundwater Hydrology: McGraw-Hill, New York, 480p.
- Davis, S.N., and DeWeist, R.J.M., 1966, Geohydrology: John Wiley & Sons, New York, 463p. [*One of the best written texts*]
- de Marsily, G., Quantitative Hydrogeology: Academic Press, Orlando, 440p.
- Deming, D., 2002, Introduction to Hydrogeology: McGraw-Hill, New York, 468p.
- DeWeist, R.J.M., 1967, Geohydrology: John Wiley & Sons, New York, 366p.
- Domenico, P.A., 1972, Concepts and Models in Groundwater Hydrology: McGraw-Hill, New York, 404p. [*One of the best written texts*]
- Domenico, P.A., and Schwartz, F.W., 1998, Physical and Chemical Hydrogeology (2nd ed.): John Wiley & Sons, New York, 506p. [*Comprehensive*]
- Fetter, C.W., 2001, Applied Hydrogeology (4th ed.): Prentice Hall, Upper Saddle River, NJ, 598p. [*Students enjoy his style*]
- Freeze, R.A., and Cherry, J.A., 1979, Groundwater: Prentice Hall, Englewood Cliffs, NJ, 604p. [*Still one of the best written texts*]
- Heath, R.C., 1983, Basic Ground-Water Hydrology: U.S. Geol. Survey Water-Supply Paper 2220, 859. [*Still a good very basic introduction.*]
- Hernance, J.F., A Mathematical Primer on Groundwater Flow: Prentice Hall, Upper Saddle River, NJ, 230p. [*This is a good introduction to mathematical analyses in hydrogeology*]
- Ingebritsen, S.E., and Sanford, W.E., Groundwater in Geologic Processes: Cambridge Univ. Press, Cambridge, UK, 341p.
- Kresic, N., Quantitative Solutions in Hydrogeology and Groundwater Modeling: CRC Press/Lewis Pub., Boca Raton, FL, 461p.
- Price, M., 1985, Introducing Groundwater (2nd ed.); Stanley Thornes, Cheltenham, UK, 278p. [*Excellent introduction and review at the introductory level*].
- Schwartz, F.W., and Zhang, H., 2003, Fundamentals of Groundwater: John Wiley & Sons, New York, 583p.
- Sen, Z. 1995, Applied Hydrogeology: CRC Press/Lewis Pub., Boca Raton, FL, 461p.

Soliman, M.M., LaMoreaux, P.E., Memon, B.A., Assaad, F.A., and LaMoreaux, J.W., 1998, Environmental Hydrogeology, CRC Press/Lewis Pub., Boca Raton, FL, 461p.

Todd, D.K., 1980, Groundwater Hydrology (2nd ed.): John Wiley & Sons, New York, 535p.

Tolman, C.F., 1937, Ground Water: McGraw-Hill, New York, 793p.

Walton, W.C., 1970, Groundwater Resource Evaluation: McGraw-Hill, New York, 664p. *[Excellent on pumping tests]*

GENERAL BOOKS ABOUT GEOLOGY AND ENVIRONMENTAL ISSUES

Barry, J.M., 1997, Rising Tide: Simon & Schuster paperbacks, New York, 524p. *[Discusses the huge Mississippi River flood of 1927 and its many ramifications. This also covered in the book by Saxon, 1927.]*

Gleick, James, 1987, Chaos: Making a New Science: Viking Press, New York, 352p.

Glennon, Robert, 2009, Unquenchable: Island Press, Washington, DC, 414p.

Leaky and Lewin, 1996, The Sixth Extinction: Weidenfeld and Nicolson, London, 271p.

Lomborg, Bjorn, 1998, The Skeptical Environmentalist: Cambridge University Press, Cambridge, UK, 515p. *[Interesting viewpoint that deserves consideration even if you don't agree with him.]*

McPhee, John, 1986, Rising From the Plains, The Noonday Press, New York, 214p. McPhee has written a number of other excellent books including In Suspect Terrain and Control of Nature *[This is probably his most water-oriented book]*

Olson, Randy, 2009, Don't Be Such a Scientist; Island Press, Washington, DV, 206p. *[How to talk to the general public! This can be a challenge for a scientist.]*

Saxon, L., 1927, Father Mississippi: The Century Co., New York, 427 p.

Soennichsen, J., 2008, Bretz's Flood: Sasquatch Books, Seattle, 222p. *[Meinzer, among others, r doesn't come off well in this book]*

Taleb,N., 2007, The B;ack Swan: The Impact of the Highly Improbable: Random House, New York *[Interesting reading - Q 375 T35 2007]*

Thorton, Joe, 2000, Pandora's Poison: MIT Press, Cambridge, MA, 599p.

Twain, M., 1874, Life on the Mississippi: H.O. Houghton & Co., New York, 465p. *[See his discussion of meanders]*

Winchester, Simon, 2001, The Map That Changed the World: Harper Collins Publishers, New York, 329p.

GENERAL BOOKS ABOUT HYDROGEOLOGY AND WATER RESOURCES

- Bowden, Charles, 1977, Killing the Hidden Waters: University of Texas Press, Austin, 174p.
- Brune, Gunnar, Springs of Texas: Texas A&M Press, College Station
- De Villiers, Marq, 2000, Water – the Fate of our Most Precious Resource: Houghton Mifflin Co., New York, 352p. [TD 345 D473 2000 MAIN]
- De Weist, R.J., 1981, Night Flight to Brussels: Philosophical Library, New York, 253p.
- Gleick, P.H., 1993, Water in Crisis: Oxford University Press, 473p.
- Glennon, R., 2002, Water Follies: Island Press, Washington, DC, 314p.
- Glennon, R., 2009, Unquenchable: Island Press, Washington, DC, 314p.
- Hall, G.E., 2002, High and Dry: University of New Mexico Press, Albuquerque, 291p.
- Harr, Jonathan, 1995, A Civil Action: Random House, New York, 500p. [Book is better than the movie]
- McDonald B. and Jehl, D. (ed.), 2003, Whose Water Is it? National Geographic Society, Washington, DC, 232p.
- Postel, S., 1997, Last Oasis: W.W. Norton, New York, 239p. [also a 1997 videocassette for in-library use only]
- Reisner, Marc, 1986, Cadillac Desert: Penguin Books, New York, 582p.
- Schneiderman, Jill (ed.), 2000, The Earth Around Us: W.H. Freeman, New York, 455p. [Sharp & Banner article]
- Westcoat, James. L., and White, Gilbert F., 2003, Water for Life: Cambridge University Press, Cambridge, UK, 322p.