Engineering Hydrology with a Real-World Perspective

I regularly integrate engineering and geoscience in my junior-level Water Resources Engineering course which is required for all civil engineering undergraduates. Specifically, I teach students that they must understand the fundamentals of hydrology because the natural distribution of water, in both space and time, is the basis for design of water conveyance and storage facilities. Simply stated, the wrong amount of water is often in the wrong place at the wrong time. Water resources engineers must quantify the natural supply of water both spatially and temporally to design the man-made facilities that move it or store it for future use.

Engineering hydrology can be very formulaic – from use of design storms to synthetic unit hydrographs to simple rainfall-runoff relationships like the SCS curve number method and the Rational method. While it would be a disservice to my students to NOT teach them these fundamental techniques that underlie civil engineering design, I do not teach the procedural methods without first spending time teaching students about the spatially and temporally variable natural processes of rainfall and runoff generation.

My general approach to integrating these natural hydrologic processes and engineering design is to discuss current and recent hydrologic events – storms, floods and droughts – and their impact on society and the natural and built environment. I begin this approach on the first day of class by reading headlines from a stack of recent articles torn from the *New York Times*. These newspaper clippings are augmented by photographs and maps that I embed in my Powerpoint lessons throughout the term. During the first three weeks of this current term I have already had several opportunities to use Hurricane Sandy as the context for several hydrology and design lessons.

I carry this real-world link into homework assignments throughout the term. For example, rather than assigning a textbook problem about a generic "reservoir with a volume of x acre-ft" to the students for a mass balance analysis, I give students specific data about a real reservoir. A recent problem statement began as follows: "Lake Powell, located on the Colorado River upriver of the Grand Canyon, is the second largest reservoir in the United States. … At midnight on Jan 18, 2012, the water surface in Lake Powell was at an elevation of 3637.86 ft above MSL and the volume of water stored in the reservoir was approximately 15,752,000 ac-ft. Average inflows and outflows for the next seven days are tabulated below…" I follow up problems of this sort with photographs during lecture and with comments in later lectures and occasionally follow-up problems.

This approach of putting problems in a real-world context makes the problems more challenging, but also more representative of the types of analyses the students may need to do in their future careers. I provide students who are accustomed to cut and dry textbook problems that only give enough information to "plug and chug" in a single equation with the opportunity to answer questions that begin with the words “estimate” and “explain.” These real-world problems also force students to grapple with the real-world uncertainty of some of the variables in an equation.

I also try to inform the students of the wealth of hydrologic data available from government agency websites. Every term I require students to download several days worth of real-time streamflow data from the USGS website and to discuss the shapes of the hydrographs in the context of what they have learned in class. I recently added a unit hydrograph assignment that uses real streamflow data from a local gaging station instead of “textbook numbers”. The students see the date/time stamp of the data and need to search online for the watershed area to do their computations. Sending the students online to find hydrologic data will hopefully pay off when these students graduate because they will understand how to search for information needed to solve more open-ended problems.

I currently also integrate some aspects of geosciences in the GIS lab which I teach as part of our Introduction to Civil Engineering course. In the lessons about coordinate systems and map projections, students learn a bit about physical models of the three-dimensional earth. The assignments I give in this class can readily lend themselves to use of data from the fields of geosciences – like satellite imagery or soil types or hydrologic features – but unfortunately those assignments are still beckoning to be prepared. The students currently use census data to prepare most of their maps in this course because the data are readily available and easy to manipulate. A complete revision of the tutorial-based 6-week syllabus would need to be prepared. It would naturally be a real-world application in line with my approach in water resources engineering because the data that the students use would be drawn from real online databases. I see this as a positive direction because many civil engineering applications now rely on GIS for data management and visualization.

An unfortunate teaching impact of my use of this current events real-world perspective is that the need to constantly update my Powerpoint lessons with recent hydrologic events and to create new real-world assignments is very time consuming. Adding a geosciences-database-driven component to the GIS lab will add a similar level of increased preparation. But I hope it pays off by providing a better integration of the real geoscience data with engineering design, and with students who are better able to understand the naturally uncertain world.