New One-Year Hydrogeology Master's Program at the University of Arizona

The one-year Hydrogeology Master's program at the University of Arizona takes a fresh approach to teaching knowledge and skills students need to be career-ready or go on to a PhD. Whereas traditional MS education is delivered as a series of independent courses, this program is based on ten highly integrated courses. Each week, topics and skills are aligned across all classes and are in context of monthly program-wide real-world projects. These projects are designed collaboratively by all instructors, and synthesize the skills learned across the curriculum that month to address a hydrogeologic question or problem.

Every student in the program is required to complete all ten courses and there are no electives. This allows us to build the cohesive structure that sets this program apart, while also encouraging students in the program to form a cohort that will form a life-long network of colleagues. The ten courses are delivered in two terms. Each of the following courses are offered in two parts, starting in the Fall and then continued in the Spring. Below are broad descriptions of the content of the five topics.

Physical Hydrogeology: teaches the fundamental concepts of water flow and solute transport through geologic media. This includes both saturated and unsaturated conditions and interactions with surface water.

Chemical Hydrogeology: teaches the fundamental concepts of geochemistry in a groundwater context. This includes the geochemistry of natural waters, contaminant hydrogeology, isotopic and dating methods, and water quality risk assessment.

Measurement Methods: teaches the concepts and procedures needed to collect samples and conduct physical and chemical hydrogeologic analyses in the laboratory and the field. Emphasis is placed on developing an understanding of measurements and how they relate to conceptual understanding and quantitative analyses.

Analysis Tools: teaches technical and software skills needed to conduct hydrogeologic investigations using real-world data. Skills and topics include scientific python programming, exploratory data analysis, data management, numerical modeling of hydrogeologic systems, and geostatistics/GIS.

Communication: Because practicing professionals and academics stress that a successful hydrogeologist should have strong communication skills, we have formalized training in written and oral communication, data visualization, and audience analysis to support students' professional development throughout this program.

The program includes seven projects. The first six are month-long projects that will occur during the regular term (three are completed during the Fall semester, and three during the Spring semester). The five courses are taught in the context of this sequence of projects. There are three routes to completing the final independent research project.

Project 1 (Fall Semester) – getting to know your watershed: students will trace the path of groundwater from its sources to a point beneath a place that they have lived. Students may extend their analysis to consider possible sources of contamination and the travel time of the water depending upon their previous hydrogeologic training.

Project 2 (Fall Semester) – mass balance: students will complete a water and chemical mass balance for the Tucson basin based on published data.

Project 3 (Fall Semester) – the effects of pumping on groundwater flow: students will use a published model and data for a real-world site to examine the historic impacts of pumping or managed aquifer recharge on groundwater flow paths. This may include examination of impacts on surface water flow and water availability for other stakeholders.

Project 4 (Spring Semester) – the effects of pumping on solute transport: students will examine the same basin that they studied in Project 3, extending their investigations to the impacts of pumping and/or recharge on solute transport. This may include examination of impacts on surface water quality and the quality of water extracted by other stakeholders.

Project 5 (Spring Semester) – the effects of land use change on groundwater flow: students will examine how changes at the ground surface related to mining operations and/or agricultural practices affect both the quantity and quality of groundwater. This project will make use of extensive hydrogeologic and meteorological datasets and published models related to flow and transport in groundwater and the vadose zone.

Project 6 (Spring Semester) – propose an independent scientific investigation: the program is built around a model of MS-level education that is focused on student learning. We believe that this should include the opportunity to propose a study that is based on their interests. The students will spend one month planning their independent research project; once their plan is approved, they may begin work.

Project 7 (Summer) Students have three options to complete their independent research investigation:

> The standard model is designed to ensure that students can complete the MS within one year. Students may choose any topic, but they will be encouraged to study some aspect of one of the month-long projects used during the program to save time in familiarization. Faculty will work with the students to identify a challenging, but focused topic to examine in detail. This may be based on reanalysis of data, reinterpretation of analyses, imposition of different forcings, recalibration of a model, or any other focus that is of most interest to the student. The student will work with the faculty to define a project that can be completed within six weeks of full-time work. They may begin work on the project as soon as their proposal is approved.
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> Some students may find an opportunity to join a faculty member's research group on a funded project. Funding may be provided on a research project or in the form of a teaching assistantship for the following year. Funding and duration of the project along with the detailed project scope would be agreed upon before the

student commits to this path. The student will develop a proposal to be completed under the guidance of the faculty member in completion of the research element of their MS degree.

Some students may find an opportunity to work as a paid intern in a consulting company or government organization. Funding and duration of the project along with the detailed project scope would be agreed upon before the student commits to this path. The student will develop a proposal to be completed under the joint guidance of a mentor in the external organization and a member of faculty in completion of the research element of their MS degree.

The faculty involved with the one-year MS Hydrogeology program at the University of Arizona have committed to taking a new approach to MS-level education that brings together improved approaches to teaching with increased collaboration with future employers.