HWRS 563B Hydrogeologic Measurement Methods II
Spring 2026

Catalog Description

This course will present foundational measurement methods related to unsaturated flow along with laboratory methods to provide hands on learning related to solute transport. In addition, students will be exposed to drilling methods, chemical analyses, and measurement methods related to hydroclimatology.

Course Prerequisites or Co-requisites

HWRS 563a Hydrogeologic Measurement Methods I

Student must be enrolled in the MS Hydrogeology program.

Required co-registration in HWRS 599 Section 001 (Recitation), HWRS 561b - Physical Hydrogeology II, HWRS 562b Chemical Hydrogeology II, HWRS 564b Hydrogeologic Analysis Tools & Methods II, and HWRS 565b Communications in Hydrogeology II

Required Textbooks/Materials

None

Reference Readings (Optional)

References will be provided as needed through D2L. You will not need to purchase these references.

Course Objectives

Students will…

1. conduct laboratory column experiments to examine solute transport with and without sorption.
2. conduct laboratory experiments to quantify sorption.
3. measure water content and unsaturated hydraulic conductivity.
4. learn the capabilities and limitations of the instruments used in state-of-the-art chemical analyses.
5. investigate methods for designing monitoring networks.
6. practice taking samples for inorganic and organic analyses.
7. conduct a water mass balance experiment for a system including evapotranspiration.

Expected Learning Outcomes

Students will be able to…

1. Design and conduct laboratory column experiments to define solute transport properties for conservative and retarded species.
2. Identify the appropriate instruments and procedures and collect measurements to determine unsaturated hydraulic properties
3. Design a measurement campaign or monitoring network to achieve specific project objectives, taking into consideration measurement uncertainty.

Course Format and Teaching Methods

Lecture, in-class discussion and laboratory and field exercises. Students will work in small teams, the composition of which will change every month. For some projects, students will have defined roles: project management, analyst, and data gatherer. Each student will fill each role at least once during this course.

Planned Field Trips

The class will have one planned field trip on 2/24/26 to give students first-hand experience making hydrogeologic field measurements. The timing of trip is coordinated with students' schedules and the instructors of the other courses in the MS Hydrogeology program. Please plan accordingly. Other field-based exercises will take place during the scheduled laboratory times.

Schedule of Topics & Activities

The course will be organized around month long projects that give a learning context for all five co-convened classes. The scheduled activities are follows.

Week	Monday date	Project	Weekly Learning Objectives	Associated Activities	HW Due Date
1	1/19/2026		- column transport experiment – conservative solutes	Tu – Set up column experiment on common porous medium given to all groups. Th – Conduct column experiment with red dyed water. CLASS HW – Fit an analytical solution of the ADE to data and report transport parameters with uncertainty.	1/27/2026
2	1/26/2026	4 – Wellhead protection	- column transport experiment – reactive solutes	Tu – Repeat conservative solute transport experiment, improved based on observations of last week. Th – Repeat column experiment with green dyed water. CLASS HW – Analyze red and green column experiments. Determine solute transport parameters for soil and for each dye. Discuss how you could determine if any of the dyes was conservative.	2/3/2026
3	2/2/2026	4 – Wellhead protection	- batch sorption - field sampling protocols for isotopes - field sampling protocols for inorganic compounds	Tu – Conduct batch sorption experiments. Discuss and analyze field sampling protocols for organic compounds. Th – Collect samples following isotopic sampling protocols. CLASS HW – Use isotopic age dating from literature to update your conceptual model of flow in the Tucson Basin. PROJECT RELEVANT HW – Consider a range of flow and transport properties to comment on the conditions for which particle tracking is appropriate to characterize solute movement.	2/20/2026
4	2/9/2026	4 – Wellhead protection	- volumetric content with TDR - tensiometers - borehole permeameters - disc infiltrometers	Tu – Set up columns with common soil among all groups including a tensiometer and TDR probe. Set up automated monitoring of pressure head, water content, and outflow volume. Th – each group add a different volume of water to their column (amount, rate). Monitor with TDR and pressure transducer.	2/17/2026

				Conduct borehole permeameter and disc infiltrometer measurements in the field. CLASS HW – collect all column results and plot on common sets of axes. Provide qualitative explanations of key differences based on the characteristics of how water was added to each column.	
5	2/16/2026	4 – Wellhead protection	- related methods including: o sap flow o eddy covariance o snow pillows o basic hydromet measurements	Tu – set up met station, download local met data Th – demonstration of sap flow and/or snow pillows CLASS HW – find data to estimate monthly P and PET in Tucson. Then find climate projections of P and ET. Comment on how these changes might impact the monthly water balance of the Tucson Basin. First course-specific self-reflection.	2/24/2026
6	2/23/2026	5 – Effects of land use change	- nitrate and related sampling protocols - well purging - perhaps a trip to the Santa Catalina Mountains to talk about soil development? - perhaps field trip to an ag site?	Tu – Field trip to the Santa Catalina Mountains to talk about soil development and to a farm to see impacts of Ag on the water cycle. (Extended class.) Th – No class to make up for extended Tu class CLASS HW – Replace basin wide monthly P and ET estimates with crop specific irrigation schedule and ET for a limited area to assess likely impact of land use change on local water balance.	3/3/2026
7	3/2/2026	5 – Effects of land use change	- K determination by 1D steady state unsaturated flow method	Tu – set up columns with TDR and tensiometer for steady state flow experiments. Same soil in multiple columns with different boundary conditions. Maybe same flow with different column diameters? Th – conduct steady state flow experiments. CLASS HW – combine data as a class to construct K(theta) or K(psi) and theta(psi) curves and determine vG parameters for the soil.	3/17/2026
8	3/9/2026		Spring break		N/A
9	3/16/2026	5 – Effects of land use change	- See GCMS and ion chromatography, discuss: o operating concepts o costs o sampling considerations	Tu – tour of chemistry lab to see GCMS and IC Th – Set up plant drying experiment. Collect initial weights of soil, plant material, characterize pot. Keep plant alive without adding soil until week 12!	3/24/2026

				CLASS HW – TBD PROJECT RELEVANT HW: donduct a simple, spreadsheet-based analysis of the influence of root uptake properties on the generation of recharge for a range of precipitation time series.	
10	3/23/2026	5 – Effects of land use change	- Evaporation and one step outflow methods for unsat property estimation	Tu – set up columns with TDR and tensiometer for steady state flow experiments. Same soil in multiple columns begin fully saturated. Place TDR/tensiometer at different depth. Th – conduct one step outflow experiments. CLASS HW – combine data as a class to construct K(theta) or K(psi) and theta(psi) curves and determine vG parameters for the soil. Forward model evaporation experiment based on soil hydraulic properties and comment on advantages and disadvantages of two approaches. Second course-specific self-reflection.	3/31/2026
11	3/30/2026	6 – Develop independent research proposal	- Discuss how to choose the right drilling approach	Tu – visit to drilling company or remote lecture on drilling methods Th – log core in the lab and do PSD on select samples CLASS HW – determine equivalent vertical and horizontal K for cored section and determine anisotropy.	4/7/2026
12	4/6/2026	6 – Develop independent research proposal	- plant drying experiment	Tu – initial measurements on plant. Plan experimental steps to investigate the mass balance of the system. Th – Set up monitoring of plants. CLASS HW – write procedures and anticipated results from plant experiment.	4/14/2026
13	4/13/2026	6 – Develop independent research proposal	- Discuss sampling for specific contaminants	Tu – TBD Th – TBD CLASS HW – TBD	4/21/2026
14	4/20/2026	6 – Develop independent research proposal	- Designing measurement campaigns and networks	Tu – Complete plant experiment. Analyze mass balance through time. Th – Discuss results among groups. Critique and use the results for your CLASS HW.	4/28/2026

				CLASS HW – redesign your plant experiment. Critique weaknesses of first design. Explain changes including anticipated benefits of redesign.	
15	4/27/2026	6 – Develop independent research proposal	- Measurement-related support for student projects	Tu – no assignments, work on project 6 Th – no assignments, work on project 6	N/A
16	5/4/2026	6 – Develop independent research proposal	- Measurement-related support for student projects	Tu – no assignments, work on project 6 Th – no assignments, work on project 6	N/A

Course Assessments and Grading Breakdown

You will be assessed on the basis of weekly assignments. You will also be assessed based on how you apply the understanding gained in this class to the projects.

Course Assignments: are designed to develop your understanding of elements of the course and to give you practice in applying that knowledge. A time budget will be given for each Course Assignment. They may include calculations, analysis, synthesis, and written elements. Course Assignments count toward your grade in the course and should be turned in through the D2L site for this course unless otherwise indicated by the instructor. The instructor may provide specific format requirements for assignments. In this course, Course Assignments will be given on Thursday. Assignments that are to be turned in online through D2L will be due the following Tuesday at 11:59 pm. Assignments that are to be turned in as hardcopy are due at the beginning of class on the due date.

Project-Relevant are designed to help you to apply the content of this class to the program-wide projects. In some cases, these Project-Relevant Assignments will produce outcomes that can be included directly in your project. In other cases, the Project-Relevant Assignments will act as a bridge between the course material and the project requirements. Even if the project is team-based, every student must complete all Project-Relevant Assignments. A time budget will be given for each Project-Relevant Assignments. They may include calculations, analysis, synthesis, and written elements. Project-Relevant Assignments count toward your grade in the course and should be turned in through the D2L site unless otherwise indicated by the instructor. The instructor may provide specific format requirements for assignments. In this course, Project-Relevant Assignments will be given on Mondays. Assignments that are to be turned in online are to be submitted, through D2L, by Sunday at 11:59 pm. Assignments that are to be turned in as hardcopy are due at the beginning of class on the due date.

Self-Reflections: A couple of self-reflections are required specifically for this course throughout the term. These will be announced at least one week in advance and will be worth relatively few points. The intent of these self-reflections is to provide an opportunity for the students and instructors to check in on the progress and expectations of the course.

The percentage distribution of your grade will be as follows.

Course Assignments	(13)	: 65%
Project-relevant measurement assignments	(2)	: 20%
Course-specific self-reflections	(2)	: 15%

University policy regarding grades and grading systems is available at this link.

Other Course-Related Activities – Not Graded/Assessed

Practice Exercises: are designed to help you develop the ability to apply concepts and calculations presented in class. These exercises are NOT GRADED – the answers are provided with the questions. No time budget is given for these assignments. Rather, they are provided as an aide in case you feel that you need help. You may be directed to complete these exercises based on the instructor's assessment.

Final Examination or Project

There is no final examination in this course. However, students will be completing 3 projects this semester that cut across all courses in the MS Hydrogeology program, and will require students to utilize and synthesize the skills they learned in all 5 courses to address a hydrogeologic question/problem. Presentation of the third and last Term Project of the semester will take place on May 6, 2026, the last scheduled day of classes. These presentations will be organized as a mini-conference and professional hydrogeologists will be invited to attend in person or online.

Grading Scale

Your final grade will be informed via D2L. Letter grades are determined using the following scale:

A:	>= 90.0%
B:	>= 80 - 89%
C:	>= 70 – 79 %
D:	>= 60 to 69 %
E:	below 59 %

University policy regarding grades and grading systems is available at https://catalog.arizona.edu/policy/courses-credit/grading/grading-system.

Late Work Policy

This class and the entire program depend strongly on student participation and you are only able to participate fully if you have done the homework on time. Therefore, no late assignments will be accepted for credit. We do understand that life happens, so we will automatically drop your **two** lowest course assignment grades for this course when calculating your final grade.

Incomplete (I) or Withdrawal (W):

Requests for incomplete (I) or withdrawal (W) must be made in accordance with University policies, which are available at this link associated with the registrar.

University of Arizona Course Policies

All University of Arizona course and syllabi policies, as well as other helpful information and resources, can be found at this link.

If you are in need of basic needs care, here is another helpful link, in addition to what you can find at the policy link above.

Subject to Change Statement

Information contained in the course syllabus, other than the grade and absence policy, may be subject to change with advance notice, as deemed appropriate by the instructor.