HWRS 562B Chemical Hydrogeology II
Spring 2026

Catalog Description

This course focuses on of the chemistry of waters in the hydrologic cycle, emphasizing stable and radioisotopes, reactive transport, nutrient cycling, and contaminant migration. Students will learn to apply isotope techniques, modeling tools, and theoretical knowledge to analyze water quality issues across various environmental systems.

Course Prerequisites or Co-requisites

Pre-requisites: HWRS 562a Chemical Hydrogeology I

Must be enrolled in the MS Hydrogeology program

Required co-registration in HWRS 561b - Physical Hydrogeology II, HWRS 563b Hydrogeologic Measurement Methods II, HWRS 564b Hydrogeologic Analysis Tools & Methods II, and HWRS 565b Communications in Hydrogeology II

Required Textbooks/Materials

Specific chapters will be assigned from the following textbook, which is freely available online:

The Geochemistry of Natural Waters: Surface and Groundwater Environments
By James I. Drever (last updated in 1997)
https://gw-project.org/books/the-geochemistry-of-natural-waters/

Additional reading materials from other texts and articles will be provided for free on the course website.

Reference Readings (Optional)

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

Course Objectives

Students will…

1. be introduced to the principles and applications of stable and radioisotopes in hydrogeological studies to understand water sources, mixing processes, and groundwater age dating.
2. understand reactive transport processes, including chemical reactions, in groundwater systems and their implications for contaminant migration and environmental health.
3. explore techniques such as hydrograph separation and nutrient cycling models to assess the impacts of land use changes on water systems and quality.
4. know about common inorganic and organic contaminants, emerging contaminants, their sources, properties, regulations, and remediation techniques.
5. facilitate understanding of water quality risk assessment methodologies and tools for evaluating risks in agricultural, industrial, and drinking water contexts.
6. apply the theoretical knowledge to analyze and interpret real-world water quality and water pollution issues.

Expected Learning Outcomes

Students will be able to…

1. determine groundwater recharge locations, water travel times, and subsurface flow paths using isotopes and other natural tracers.
2. describe the sources, chemical properties, and fate of natural and anthropogenic contaminants in the environment.
3. evaluate potential for contamination by integrating geochemical and isotopic knowledge to conduct a risk assessment of water supplies.

Course Format and Teaching Methods

Lecture and in-class discussion. Students will work collaboratively on in-class practice problems.

Schedule of Topics & Activities

Week	Monday date	Project	Weekly Learning Objectives	Associated Activities	HW Due Date
0	[illegible]		-		N/A
1	[illegible]		- Stable water isotopes of atmospheric water vapor & precipitation	M – Introduction to stable isotopes and isotopic fractionation W - Stable isotopes of atmospheric water vapor (^{18}O, ^{2}H) F – Sources and processes affecting isotopic signatures in water vapor	
2	[illegible]	**4 – Define a wellhead protection area for a well**	- Stable water isotopes of surface waters and groundwater	M - ^{18}O and ^{2}H in surface waters (isotopic composition, influences of evaporation and mixing processes) W - ^{18}O and ^{2}H in groundwater (isotopic signatures in groundwater recharge, application in tracing groundwater sources and flow paths) F – Case study: Real-world examples illustrating isotopic analysis in hydrology **HW #1 – Project-relevant assignment:** Use ^{18}O and ^{2}H data to calculate groundwater travel time	[illegible]
3	[illegible]	**4 – Define a wellhead protection area for a well**	- Radioisotopes and their application as age tracers.	M – Intro to radioisotopes, radioactive decay, and groundwater dating W – Basics of ^{3}H, ^{3}He, and ^{4}He and their application in dating of groundwater F – Basics of ^{14}C and their application in dating of groundwater **HW #2 - Course assignment: groundwater aging**	[illegible]
4	[illegible]	**4 – Define a wellhead protection area for a well**	- Hydrograph separation using solute and isotope mixing models and age tracers	M – Intro to hydrograph separation techniques (definition, key objectives, general methodology) W – Solute and isotope mixing models for hydrograph separation	[illegible]

				F – Case studies of hydrograph separation to identify water source contributions **HW #3 – Course assignment:** Hydrograph separation	
5	[illegible]	**4 – Define a wellhead protection area for a well**	- Reactive transport from chemistry POV	M - Overview of chemical reactions involved in reactive transport and how it interacts with physical transport processes in the water environment W – Intro to reactive transport modeling F – Case study: Contaminant migration in groundwater **HW #4 – Project-relevant assignment:** Calculate retardation and decay rates of a chemical contaminant.	[illegible]
6	[illegible]	**5 – Effects of land use change**	- Nutrient cycling and transport	M – Overview of nutrient (N, P) cycling and transport with the hydrological cycle W – Key biological processes influencing nutrient cycling, transport, and fates F – Key physical processes influencing nutrient transport and fates **HW #5 – Project-relevant assignment:** Calculate the mass load of nutrient (N, P) into the stream with agriculture expansion.	[illegible]
7	[illegible]	**5 – Effects of land use change**	- Nutrient cycling and transport	M - Key chemical processes influencing nutrient transport and fates W – Nutrient cycling and transport modeling F – Case study: nutrient cycling and transport in agriculture and water pollution (e.g., eutrophication) **HW #6 – Project-relevant assignment:** Calculate how streamflow, nutrient concentrations, and chemical reaction rates affect nutrient levels over time.	[illegible]

				1st self-reflection is due by 3/9/2026	
8	[illegible]	**5 – Effects of land use change**	Spring Break		
9	[illegible]	**5 – Effects of land use change**	- 'Common' inorganic contaminants - sources, properties, regulations	M – Overview of common inorganic contaminants (metals, other inorganics) and their sources and properties in groundwater W – Discussion on the impact of inorganic contaminants on human society and regulatory standards F – Methods for removing inorganic contaminants from groundwater **HW #7 – Course assignment:** inorganic contaminants relevant	[illegible]
10	[illegible]	**5 – Effects of land use change**	- Behavior and partitioning of organic contaminants into various phases	M – Partitioning of organic contaminants W –Degradation of organic contaminants (chemical, biodegradation) F – Transport of organic contaminants **HW #8 – Course assignment:** organic contaminants relevant	[illegible]
11	[illegible]	**6 – Multifaceted, open-ended project**	- 'Common' organic contaminants - sources, properties, regulations	M – Overview of common organic contaminant, sources, and their properties W – Discussion on the impact of organic contaminants on the environment and human society and regulatory standards F – Methods for removing organic contaminants from groundwater **HW #9 – Course assignment:** organic contaminants relevant	[illegible]
12	[illegible]	**6 – Multifaceted, open-ended project**	- Emerging contaminants (e.g. PFAS) - sources, properties, regulations	M – Overview of emerging contaminants, sources, and their properties W – Discussion on the impact of emerging contaminants on the environment and human society and regulatory standards	[illegible]

				F – Methods for removing emerging contaminants from groundwater **HW #10 – Course assignment:** Emerging contaminants **2nd self-reflection is due by 4/13/2026**	
13	[illegible]	**6 – Multifaceted, open-ended project**	-Water quality risk assessment	M – Principles of risk assessment in hydrogeology W –Standards of water quality risk assessment F – Tools and models used in water quality risk assessment **HW #11 – Course assignment:** Investigate water quality risk assessment of your hometown.	[illegible]
14	[illegible]	**6 – Multifaceted, open-ended project**	-Water quality risk assessment	M – Case study 1: Water quality risk assessment in agriculture W – Case study 2: Water quality risk assessment in the industry (mine industry or building industry) F – Case study 3: Water quality risk assessment related to drinking water **HW #11 – Continued**	[illegible]
15	[illegible]	**Finals**			

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, investigations, and written elements. Course Assignments count toward your grade in the course and should be turned in on D2L with any extra documents that can reflect calculation processes (e.g., Excel calculation sheet, python code, Jupiter notebook, etc.). In this course, Course Assignments will be given at least one week in advance and due on Mondays at the beginning of class, including Homework #2, #3, #7, #8, #9, #10, and #11.

Project-Relevant Assignments 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, there is four Project-Relevant Assignment (Homework #1, #4, #5, #6), which are usually scheduled during the first two weeks of each project period. It will be given out one week in advance and due on the next Monday. Please turn in the assignment as a hardcopy with any extra documents that can reflect calculation processes (e.g., excel calculation sheet, python code, Jupiter notebook etc.).

Self-reflections: Two 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.

Class participation is expected that all students in the program will participate fully in all aspects of the course. This includes showing up in class, being present and engaged in discussion, answering and asking questions during class, and contributing to the culture of learning of the program. If a student is not meeting expectations, they will be notified by the instructor, given guidance on how to increase their participation, and given a chance to improve. Thereafter, if the student continues to fall below the expectations for participation, their class participation points will be reduced.

The percentage distribution of your grade will be as follows.

Course Assignments	(7)	: 56%
Project-relevant assignments	(4)	: 28%
Self-reflections	(2)	: 12%
Participation		: 4%

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

Final Examination or Project

There is no final examination in this course. However, students will be completing three 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 five courses to address a hydrogeologic question/problem. Presentation of the five and last Term

Project of the semester will take place on Apr 27, 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 in advance. Therefore, no late assignments will be accepted for credit. We do understand that life happens, so we will automatically drop your two lowest 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.