



## Course guide

# 250MAG007 - 250MAG007 - Aquifer-Dependant Natural Systems

Last modified: 21/06/2025

**Unit in charge:** Barcelona School of Civil Engineering  
**Teaching unit:** 751 - DECA - Department of Civil and Environmental Engineering.  
**Degree:** MASTER'S DEGREE IN WATER ENGINEERING (Syllabus 2025). (Optional subject).  
**Academic year:** 2025    **ECTS Credits:** 5.0    **Languages:** Spanish

### LECTURER

**Coordinating lecturer:** GUILLEM SOLÉ MARÍ

**Others:** GUILLEM SOLÉ MARÍ  
XAVIER SANCHEZ VILA  
DANIEL FERNÁNDEZ GARCIA  
MAARTEEN SAALTINK  
MICHELE STARNONI

### TEACHING METHODOLOGY

There are 3 hours per week of face-to-face classes in the classroom. In these classes, concepts and content are explained, with examples and problem solving.

Three modelling sessions will take place in the computer lab, unless all students prefer to use their laptops in the classroom.

The main and supplementary support materials will be provided through the ATENEA virtual campus.

### LEARNING OBJECTIVES OF THE SUBJECT

Understand the physical, chemical, and biological processes associated with the interaction between aquifers and other natural systems.

Gain in-depth knowledge of the hydrological functioning of the unsaturated zone, the hyporheic zone, and coastal systems, and how they interact with the aquifer.

Develop skills to model and assess the behaviour of these systems under natural and human-impacted conditions.

Be able to interpret problems and use data for diagnosis and decision-making.

### STUDY LOAD

Type	Hours	Percentage
Self study	80,0	64.00
Hours large group	45,0	36.00

**Total learning time:** 125 h



## CONTENTS

### Introduction

**Description:**

Introduction to natural systems dependent on aquifers. Hydroecological importance and ecosystem services. Relationship between surface and groundwater hydrology. Concepts of saturated zone, unsaturated zone, and hydraulic connection. Introduction to water balance and the spatial and temporal scale of processes.

**Full-or-part-time:** 8h 20m

Theory classes: 3h

Self study : 5h 20m

### Unsaturated flow and multiphase flow

**Description:**

Movement of water and gas in the unsaturated zone. Richards equation and boundary conditions. Retention curves and conductivity curves. Hysteresis and soil heterogeneity. Multiphase flow at the pore scale. Applications in contamination and recharge processes.

**Full-or-part-time:** 16h 40m

Theory classes: 6h

Self study : 10h 40m

### Recharge and unsaturated zone

**Description:**

Types of recharge: diffuse, focused, and event-based. Recharge estimation: empirical methods, balances, and modelling. Interaction between recharge and land use. Role of vegetation and evapotranspiration. Temporal analysis: seasonality and long-term trends.

**Full-or-part-time:** 16h 40m

Theory classes: 6h

Self study : 10h 40m

### Rivers, springs and wetlands

**Description:**

Groundwater-surface water exchange. Hyporheic zone and vertical flow. Springs as discharge points. Aquifer-fed wetlands. Influence of alluvium and river regime. Temporal variability of flow and hydraulic connection.

**Full-or-part-time:** 25h

Theory classes: 9h

Self study : 16h

### Variable density flow

**Description:**

Movement of water with different density due to salinity or temperature. Variable-density flow equations. Convection and instability in saturated media. Applications in coastal systems and saline contamination areas. Specific numerical modelling.

**Full-or-part-time:** 8h 20m

Theory classes: 3h

Self study : 5h 20m



### Submarine groundwater discharge and saltwater intrusion

**Description:**

Submarine groundwater discharge (SGD). Controlling factors: geology, gradient, and density. Seawater intrusion: salinity balance and intrusion front. Ghyben-Herzberg equation. Impacts of coastal groundwater extraction. Management and monitoring strategies.

**Full-or-part-time:** 25h

Theory classes: 9h

Self study : 16h

### Modeling

**Description:**

Conceptual and numerical modelling of natural systems. Flow and transport simulation tools (MODFLOW, SEAWAT, HYDRUS). Spatial and temporal scales. Validation with field data. Impact assessment and management scenarios. Model limitations and uncertainty.

**Full-or-part-time:** 25h

Theory classes: 16h

Self study : 9h

## GRADING SYSTEM

Four practical assignments are proposed to be completed at home during the course, and an exam is held at the end of the semester.

The final grade is calculated as

$$FG = 0.6 * EG + 0.4 * PG,$$

where EG is the exam grade and PG is the average grade of the practical assignments.

## BIBLIOGRAPHY

**Basic:**

- Freeze, R. Allan; Cherry, John A. Groundwater. Englewood Cliffs (N.J.): Prentice-Hall, cop. 1979. ISBN 9780133653120.
- Bear, Jacob. Dynamics of fluids in porous media [on line]. New York: Dover, 1972 [Consultation: 25/06/2025]. Available on: <https://research-ebSCO-com.recursos.biblioteca.upc.edu/c/ik5pvi/search/details/kavdybfjsz?db=nlebk>. ISBN 0486656756.
- Jury, William A; Horton, Robert. Soil physics. 6th ed. Hoboken, NJ: John Wiley & Sons, cop. 2004. ISBN 9780471059650.
- Bear, Jacob; Cheng, Alexander H.D. Modeling groundwater flow and contaminant transport. Dordrecht, [etc.]: Springer, cop. 2010. ISBN 9781402066818.
- Sophocleous, M.. "Interactions between groundwater and surface water: the state of the science". Hydrogeology Journal [on line]. vol. 10, p. 52-67 (2002) [Consultation: 25/06/2025]. Available on: <https://link-springer-com.recursos.biblioteca.upc.edu/article/10.1007/s10040-001-0170-8>.