**The Groundwater Hydraulics Course**

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| **LU1: Fundamental concepts of groundwater hydraulics** |
| **Module** | **Topic** | **Key content/concepts** |
| 1 | [***Introduction to general concepts***](#Session1) | Review of pre-requisite knowledge: aquifers (confined, unconfined), aquitards, types of boreholes etc.; key concepts of water balance, movement, and storage introduced through steady-state and transient groundwater management case studies |
| 2 | [***Hydraulic head; overview of hydraulic parameters***](#Session2) | Definition of hydraulic head for an incompressible constant density fluid; introduction to the concept that flow, and storage changes are functions of hydraulic head; overview of key hydraulic parameters |
| 3 | [***Groundwater flow***](#Session3) | Physical basis for groundwater movement (Darcy); hydraulic properties at point and aquifer scales (K, T); sub-horizontal flow equations |
| 4 | [***Groundwater storage***](#Session4) | Storage/release mechanisms in confined and unconfined aquifers; effective stress and aquifer compressibility; hydraulic properties at point and aquifer scales (Ss,S,Sy) |
| 5 | ***Recharge and unsaturated zone processes*** | Overview of recharge processes; hydraulics of the unsaturated zone and the water table; overview of recharge estimation methods |
| 6 | [***Advective contaminant transport***](#Session6) | How water molecules move in porous media; distinction between water velocity and pressure wave propagation; essential concepts of advective contaminant transport and brief introduction to dispersion |

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| **LU2: Applied groundwater hydraulics in real hydrogeological settings** |
| **Module** | **Topic** | **Key content/concepts** |
| 1 | [***Groundwater in the hydrological cycle***](#Session1) | Groundwater as a resource within a catchment context; groundwater boundaries; groundwater-surface water interactions; conjunctive use of groundwater and surface water; aquifer diffusivity |
| 2 | [***Groundwater level maps***](#Session2) | Principles and practice of drawing groundwater contours in plan view and cross-sections; effects of abstraction wells and boundaries; interpretation of groundwater contour maps |
| 3 | ***[Flow nets](#Session3)*** | Construction of flow nets in different hydrogeological settings; spatial recharge and discharge zones; flow tube calculations; case study examples for water resources and contaminant movement (SPZs and contaminated sites) |
| 4 | ***[Groundwater flow in layered and fissured aquifers](#Session4)*** | Theory and practice of groundwater calculations for layered and fissured aquifers, representing sedimentary bedrock aquifers, some superficial deposit settings, Chalk and limestones; limitations of Darcy law for high turbulent flows; Reynolds number; REV concept; use (and misuse) of equivalent porous media assumptions |
| 5 | [***Groundwater fluctuations***](#Session5) | Introduction to causes of groundwater level fluctuations (due to changes in storage and in effective stress); baseflow recession analysis; interpretation of case study data sets |
| 6 | [***Measuring / estimating hydraulic properties***](#Session6) | Introductory overview of lab and field methods for measuring hydraulic properties; selection of which tests to use; theory for selected methods (excluding pumping tests which are covered later); lab methods including bulk density and porosity, soil permeameters, particle size methods |

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| **LU3: Further topics in groundwater hydraulics** |
| **Module** | **Topic** | **Key content/concepts** |
| 1 | [***Aquifer pumping tests: general principles***](#Session1) | Introduction to types and purposes of aquifer pumping tests; overview of general principles and practical issues; introduction to well efficiency and specific capacity  |
| 2 | [***Aquifer test analyses: theory***](#Session2) ***and applications Part 1*** | Theoretical development of constant rate aquifer test equations, including Thiem analyses for confined and unconfined aquifers; estimation of zone of influence; principles of superposition for multiple abstractions and in the presence of boundaries |
| 3 | [***Aquifer test analyses: theory and application***](#Session3)***s Part 2*** | Theoretical development of transient aquifer test equations, including Theiss and Cooper-Jacob time-drawdown analyses, and constant rate Cooper-Jacob distance-drawdown analysis, for confined aquifers. Constant rate and transient aquifer test analyses using simplified case study data sets; borehole and boundary effects in time-series data |
| 4 | [***3D Darcy***](#Session4) ***flow equations*** | Extending Darcy equation to general 3D constant density flow for anisotropic and heterogeneous cases; implications of anisotropy/heterogeneity for flow direction calculations |
| 5 | [***Density-dependent flow***](#Session5) | Review of density-dependent applications, and causes of water density variations; form of Darcy law for density-dependent flow; equivalent freshwater head |
| 6 | ***[Groundwater flow equations](#Session6)***  | Principles of derivation of groundwater flow equations (principle of water conservation at the point scale, Darcy, storage relationships); example derivation of a transient flow equation; familiarisation with some flow equations under different assumptions, domains, and boundary conditions |

**Hydrogeological Conceptual Modelling Course Outline**

**Please Note: This course is currently in development.**

**Block of 2 days number 2**

Day 1

* Discussion of pre course reading
* Long session on pictorial review of terminology used throughout training
* Common misconceptions in abstraction impact (why it matters)
* Conceptual modelling process
* Source-Pathway-Receptor model
* End of day story discussion on Cryalls Lane online video

Day 2:

* Recharge introduction
* Recharge calculation
* Water balance development
* River aquifer interaction, accretion and stream controls
* Hydrogeological environments and settings. Part 1

OWNTIME LEARNING

* ‘lab 1’ in piezometry development
* ‘lab 2’ Interactive learning through provided sectional and recharge models.

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**Block of 2 days number 2**

Day 3:

* Discussion of owntime ‘lab’ submissions
* Hydrogeological environments and settings. Part 2
* Wetland Discussion
* Afternoon of ‘lab’ in piezometry development (uses the above)

Day 4:

* The Groundwater Project, navigating the resources
* Update on what data are available to us, where it can be sourced, data quality
* Litigation what to expect from barristers and the court setting
* Conceptual story of farming and water resources impact assessment.
* Discussion on translation of concept to numerical models.
* Discussion on conceptual model development and overview of points of delegate interest.