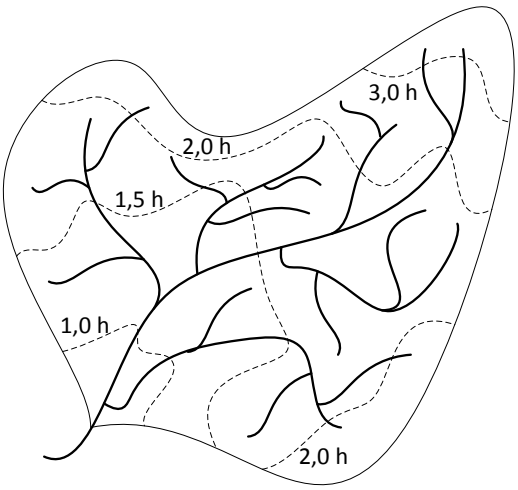
INSTITUTO SUPERIOR TÉCNICO
MESTRADO INTEGRADO EM ENGENHARIA DO AMBIENTE
Hidrologia, Ambiente e Recursos Hídricos
School year 2013/14 – Exam 2 – Total duration: 2 hours

(The grade of each question is 2/20)

1. The Tagus rive catchment of the River Tagus has 80'600 km^2 distributed over 24'800 km^2 in Portugal and in Spain 55'800 km2. The average annual precipitation in Portugal and Spain is, respectively, 875 mm and 655 mm. In natural conditions, the module of the Tagus River at the border and at the mouth of the river is, respectively, 280 and 700 m^3/s. Estimate evapotranspiration in Portugal and Spain, in mm.

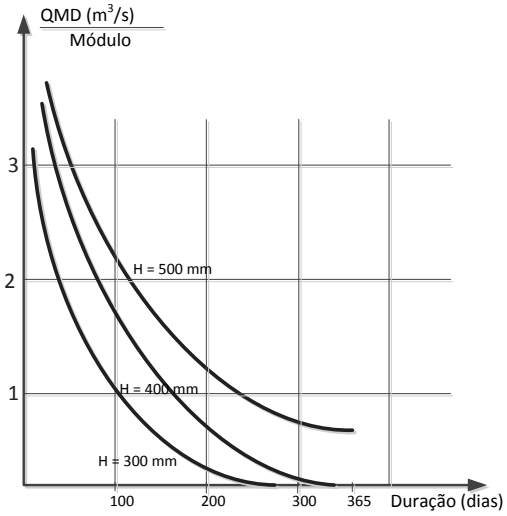


2. The figure shows a watershed with its river network and isochrones (dashed lines). Determine the average bifurcation rate and the time of concentration of the watershed.

3. The Penman equation for calculating evaporation is the sum of two parts. Explain the physical meaning of each parcel referencing the variables included in them.

$$E = \frac{\Delta}{\Delta+\gamma}\cdot\frac{24\cdot 60\cdot R}{L}+\frac{\gamma}{\Delta+\gamma}\cdot 0{,}35\cdot(e_a^*-e_a)\cdot\left(1+\frac{V}{100}\right)$$

4. The figure shows the average annual duration curves of the daily average flow of three watersheds in mainland Portugal. Considering a hydroelectric plant installed in a river cross section with a upstream catchment area of 350 km^2 that produces a flow with a module of 4.4 m^3/s, estimate the average number of days per year that the plant can operate if its operating range is 2 to 4 m^3/s.



5. The record of annual maxima discharge of a hydrometric station reveals that the Gumbel function, shown in the graph, can represent the values distribution. Calculate the mean and standard deviation of maxima discharge and the return period associated with a flow rate of 300 m^3/s.

6. Estimate the amount of water in mm, existing in 60 cm soil, with a porosity of 0.5 and a degree of saturation of 0.8. Knowing that the density of the soil particles is 2650 kg/m3, calculate the apparent density of the moistened soil, in kg/m^3.

7. Consider a soil with a saturated soil moisture of 0.4 and a permeability of 0.5 mm/min, when saturated. At a given moment, when the volumetric moisture content of the soil is equal to 0.25, there is an extreme rainfall event with a duration of 30 min and a uniform precipitation intensity equal to 80 mm/h. This event generates almost immediately surface runoff that amounts to 17 mm at the end of rainstorm. Estimate the suction head at the wetting front, in mm.

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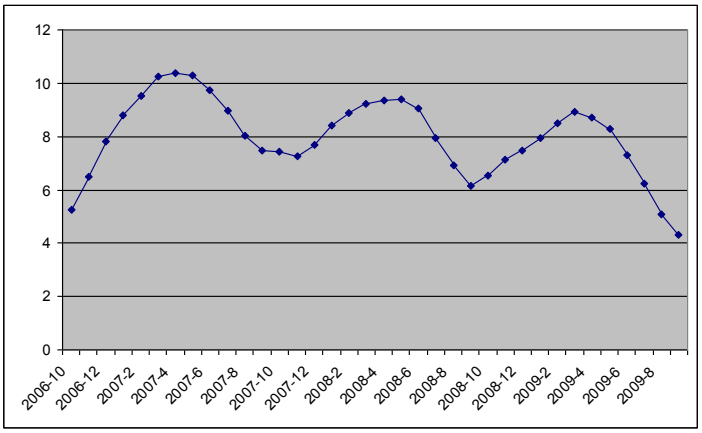
8. Consider the piezometric (values in m) time series observed in 595/1028 well in Querença-Silves aquifer. Calculate the mean recharge rate for the first two hydrological years using the Water Table Fluctuation method. The value of specific yield is 0,12



9. Consider a basin with an area of 300 km2 and a course of water main 100 km long and average slope of 0.005. Knowing that possibility curve udométrica for a return period of 100 years assumes the formula, with P in mm and D in hours, $P = 38 \cdot D^{0.48}$, determine the peak flood flow assuming a non-uniform precipitation. Use to the Kirpich formula and the rational formula with C equal to 0.7.

10. Consider a basin where a net rainfall of 30 mm with a duration of 20 min generates the hydrograph shown in the table.
    a. What is the concentration time of the basin, in hours?
    b. What is the catchment area?
    c. Determine the hydrograph resulting from an event of rainy 30 mm and a length of 40 min.

T (min)	0	10	20	30	40	50	60	70
Q (m3/s)	0	30	90	105	75	45	15	0

Useful formulas:

Standard Normal:

p	0.01	0.05	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	0.95	0.99
z	-2.33	-1.64	-1.28	-0.84	-0.52	-0.25	0.00	0.25	0.52	0.84	1.28	1.64	2.33

Gumbel probability factor:

$$K_G = -\frac{\sqrt{6}}{\pi}\left\{0{,}5772 + ln\left(ln\left(\frac{1}{F}\right)\right)\right\}$$

Green and Ampt equation:

$$f = K_s - \frac{K_s \Psi_f (\theta_s - \theta_i)}{F} \qquad F = K_s t + \frac{b}{K_s} \ln\left(1 + \frac{K_s \cdot F}{b}\right) \qquad b = -K_s \Psi_f (\theta_s - \theta_i) \qquad t_e = \frac{(-\Psi_f)(\theta_s - \theta_i)}{p\left(\frac{p}{K_s} - 1\right)} \quad , p > K_s$$

Kirpich formula: $T_c = 0{,}3 \cdot \left(\frac{L}{d^{0,3}}\right)^{0,76}$, Tc in hours, L in km, d without units.

Rational formula majoration coeficient: $f = 2 - \sqrt{n}$