Physical Hydrology - 2nd Test 2010/2011

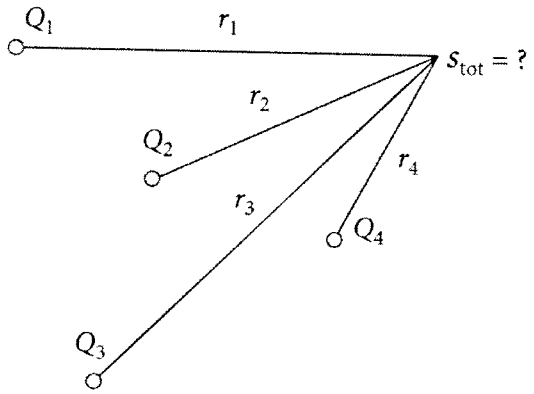
Duration of the exam: 2½ hours

Answer 5 of the following 7 questions; do not answer more than 5 questions! Only the first five, given answers will be marked! Provide clear answers and calculations!

Radial-symmetric steady groundwater flow

$h = h_R + \frac{Q_0}{2\pi T} \ln \frac{r}{R}$ for $r_w \le r \le R$ (for both confined and unconfined aquifers)

1. Drawdown in a piezometer (2 credits)



A plan view of a flat area with a piezometer and four fully penetrating wells

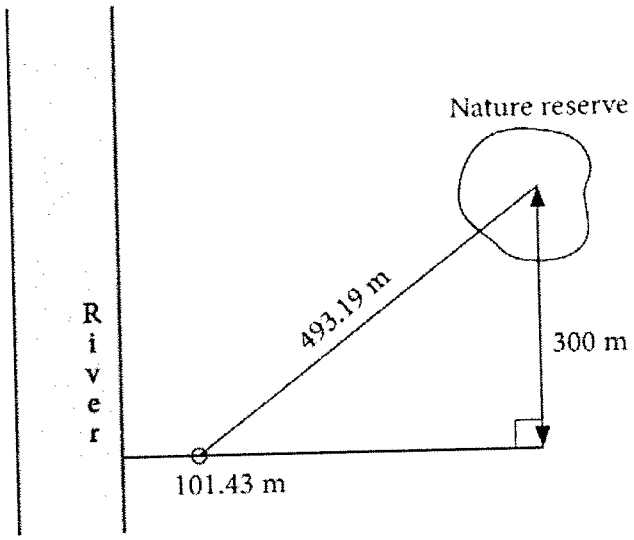
The aquifer from which water is pumped is confined.

$r_1 = 400$ m; $r_2 = 300$ m; $r_3 = 450$ m; $r_4 = 200$ m

For the wells: $R_1 = R_2 = R_3 = R_4 = 400$ m, and $\frac{Q_1}{2\pi T} = \frac{Q_2}{2\pi T} = \frac{Q_3}{2\pi T} = \frac{Q_4}{2\pi T} = 1$

Determine the total drawdown s_{tot} at the location of the piezometer.

2. **Drawdown near an open-water linear boundary** (2 credits)

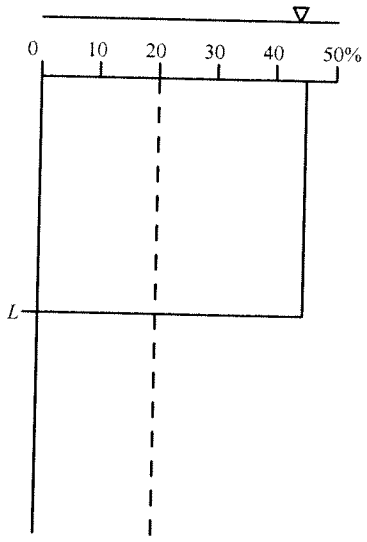


On behalf of the drinking water supply, groundwater is pumped from a confined aquifer.

The pumping discharge is 314.16 m^3 day^{-1}. At a radial distance of 2000 m from the well there is no lowering of the hydraulic head due to pumping. The saturated depth of the aquifer is 50 m; the hydraulic conductivity of the aquifer equals 10 m day^{-1}. A river is located at a distance of 101.43 m of the pumping well, and the midpoint of a nature reserve is located at a distance of 493.19 m from the pumping well, both as shown in the above figure.

Determine the lowering of the hydraulic head in the midpoint of the nature reserve given the above setup.

3. Ponded infiltration (Green and Ampt approach) (2 credits)



The water level above flat terrain during an experiment with a double ring infiltrometer is kept at 10 mm. The initial moisture content θ_i is 20% at all soil depths; the saturated moisture content θ_s equals 45%. The saturated hydraulic conductivity K of the soil is 25 mm hour^{-1}. During infiltration, the matric potential at the wetting front equals –50 mm. The wetting front is (assumed as) block-shaped: see the above figure (Green and Ampt approach).

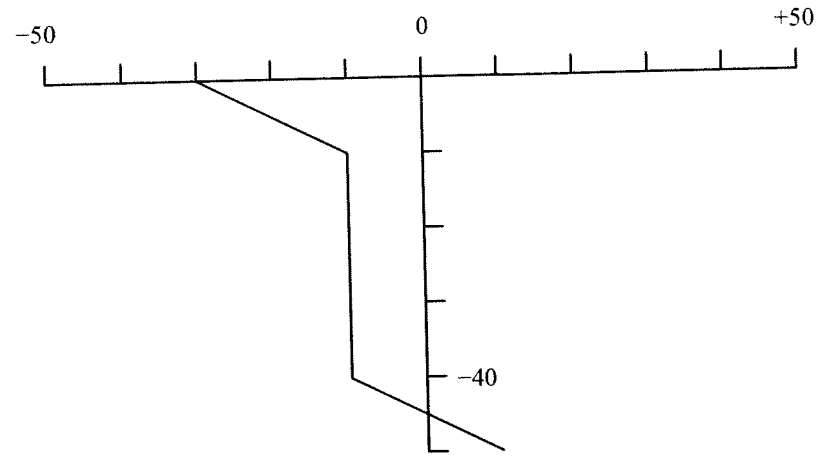
a. Apply and combine Bernoulli's law and Darcy's law to determine the infiltration rate (volume flux density in mm hour^{-1}) when the wetting front is 100 mm below the soil surface. (1 credit)

b. Determine the cumulative infiltration (mm) when the wetting front is 100 mm below the soil surface. (½ credit)

c. What is value of the infiltration rate (volume flux density; mm hour^{-1}) when the infiltration lasts very long ($t \rightarrow \infty$)? (½ credit)

4

4. **Potential diagram** (2 credits)



The above potential diagram shows values of the matric potential ψ (given along the horizontal axis) to vary from −30 to +10 cm with depth below the land surface (given along the vertical axis); values in the above figure are in cm.

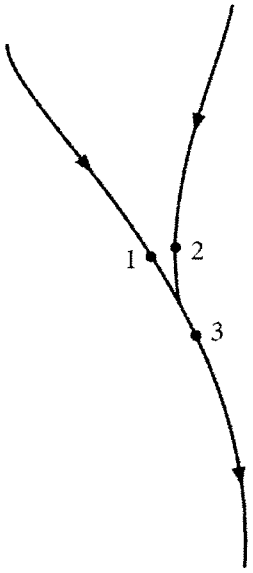
a. Select a reference level and use mm paper to draw the curve for the total potential h in cm. (1 credit)

b. In what range of depths is the soil influenced by evaporation? (½ credit)

c. At what depth is the water table? (½ credit)

Please do not forget to hand in your mm paper with your exam papers!

5. *EC*-routing (2 credits)

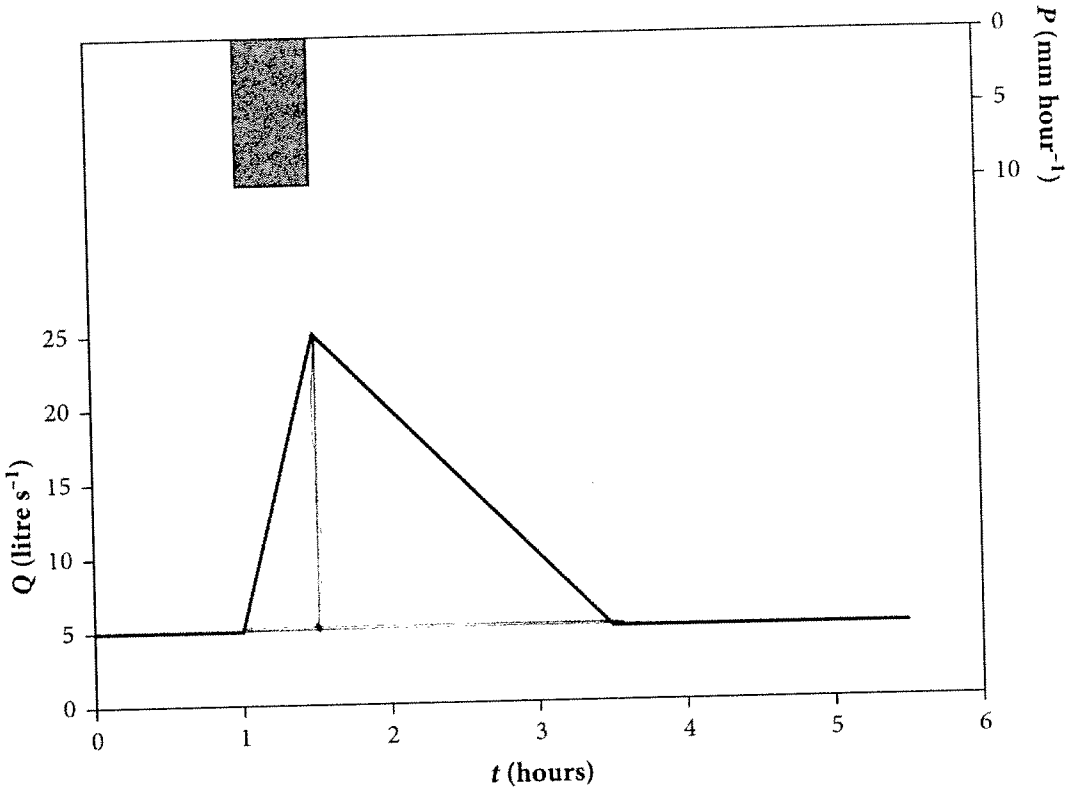


In a stream, the electrical conductivity (*EC*) is measured in two upstream branches at locations 1 and 2 and downstream at location 3, as shown in the above figure. The *EC* is linearly related to the salt concentration (mg litre^{-1}) of the stream. At location 2 the discharge Q_2 is measured.

EC_1 = 1200 µS cm^{-1}; EC_2 = 500 µS cm^{-1}; EC_3 = 900 µS cm^{-1}; Q_2 = 7.5 litre s^{-1}

Determine the discharge of the stream at locations 1 and 3.

6. **Runoff coefficient on a storm basis** (2 credits)



The Kribsbaach drainage basin near Eppeldorf, Luxembourg, has an area of 2 km^2. The above figure shows a hydrograph with a half hour rainfall event. The discharge on the vertical axis is in litres per second. Time on the horizontal axis is in hours. In the upper part of the above figure the rainfall intensity is given in mm $hour^{-1}$.

Determine the runoff coefficient for this rainfall event.

7. **Surface water** (2 credits)

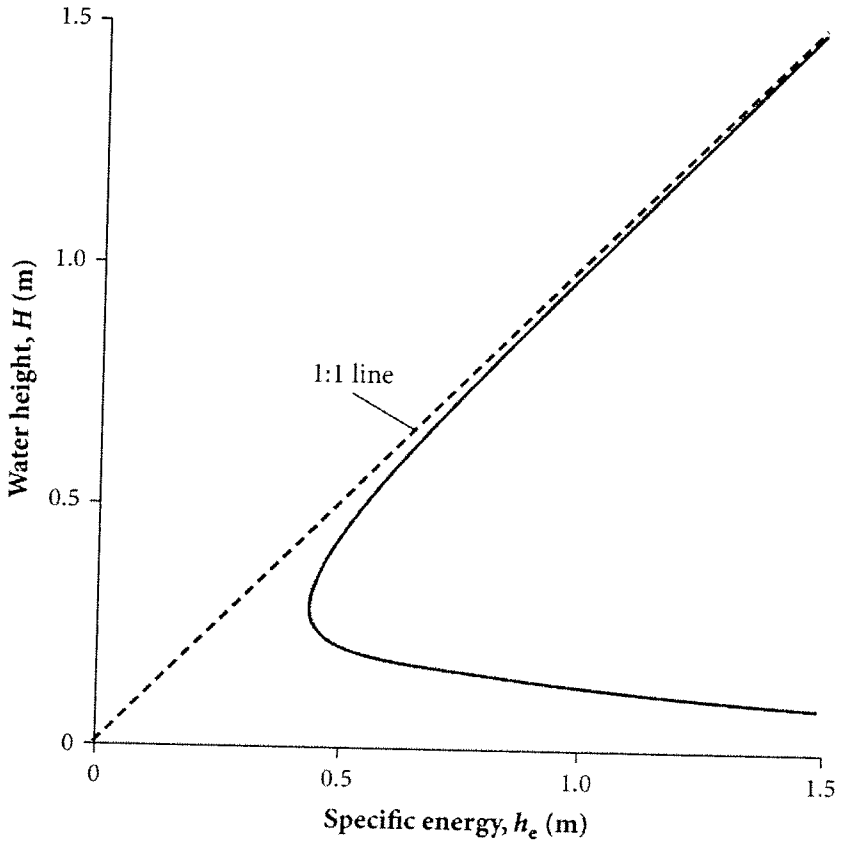
a. What extra energy term do we need to describe surface water flow in comparison to subsurface water flow? (0.4 credits)

b. Where in a river reach is the water flow critical? (0.4 credits)

c.. What is the hydraulic jump? (0.4 credits)

d. What are variable source areas? (0.4 credits)

e. What part of the below curve is for supercritical flow, and why? (0.4 credits)



The specific energy diagram for a specific discharge q_w of 0.5 m^2 s^{-1}

Please answer the course evaluation questions. Thank you!