Exam 1
Environmental Science 218
Applied Hydrogeology

1. A large puddle that is 0.05m thick and 20 m on each side goes from being a liquid at 20 degrees C to being ice at -5 degrees C. How much heat must be removed from the water for this to happen.

We calculate the mass and then the heat removed to go from water at 20 to water at 0, water at 0 to ice at 0 and ice at 0 to ice at -5.

$$m = \rho V = 1\frac{g}{cm^3}\cdot(5cm\cdot 2000cm\cdot 2000cm) = 2\times 10^7 g$$

$$Q = mc\Delta T = 2\times 10^7 g\cdot\frac{1cal}{g^\circ C}\cdot(0-20) = -4\times 10^8 cal$$

$$Q = -m\,L = -2\times 10^7 g\cdot 79.7\frac{cal}{g} = -1.594\times 10^9 cal$$

$$Q = mc\Delta T = 2\times 10^7 g\cdot\frac{0.5cal}{g^\circ C}\cdot(-5-0) = -5\times 10^7 cal$$

$$Q = -4\times 10^8 cal - 1.594\times 10^9 cal - 5\times 10^7 cal = -2.044\times 10^9 cal$$

2. A stream hydrograph is shown below.

a) Find t_1 from the graph and use it to compute the total potential groundwater recharge via the baseflow method.

t_1 is the time for one decade loss. In this picture, t_1 =105 days.

$$V_{tp} = \frac{Q_0\,t_1}{2.3026} \quad (potential\ groundwater\ dischg)$$

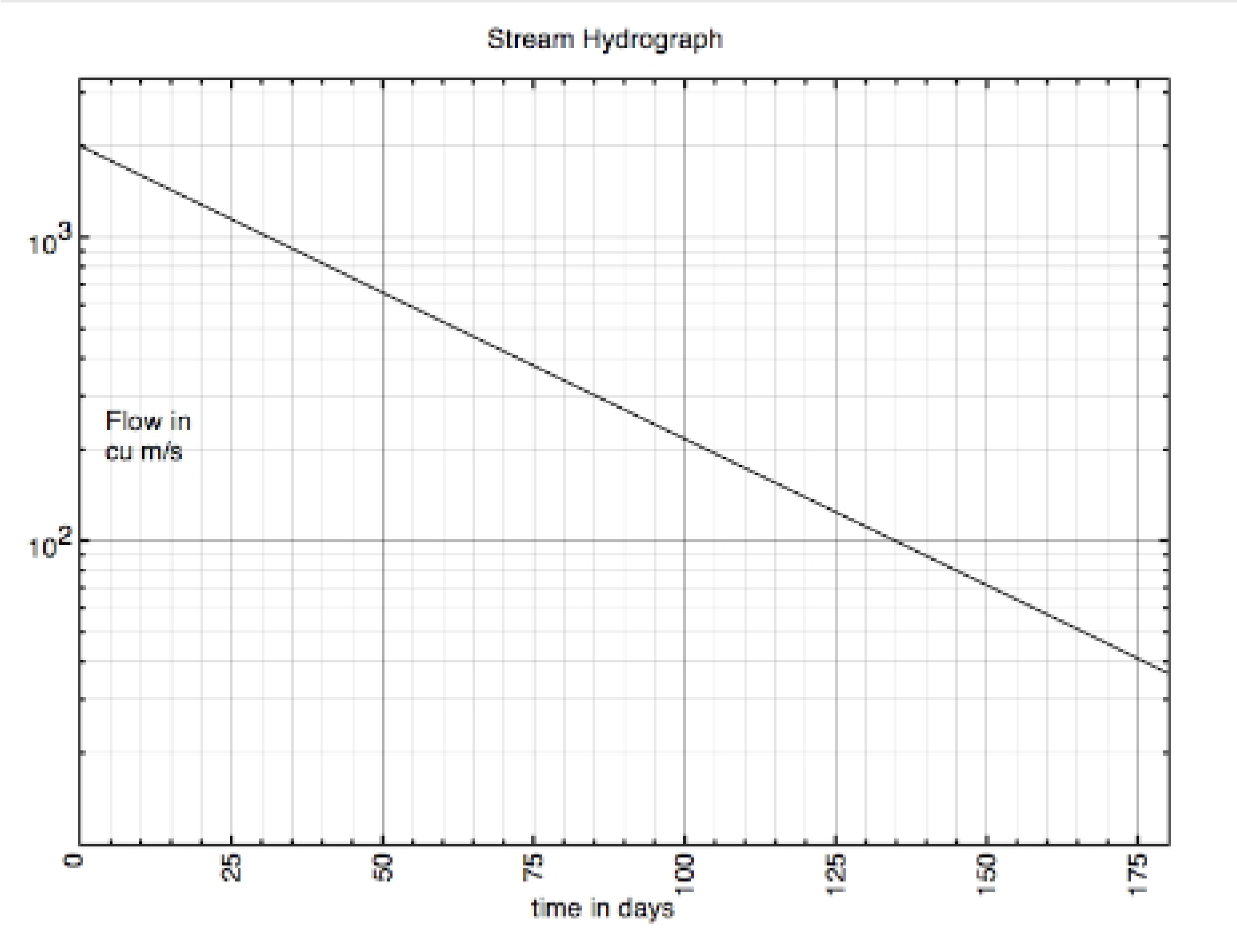
$$t_1 = 105\ days\cdot\frac{24hrs}{1\ day}\cdot\frac{3600s}{1\ hr} = 9.07\times 10^6 s$$

$$V_{tp} = \frac{\frac{2000m^3}{s}\cdot 9.07\times 10^6 s}{2.3026} = 7.88\times 10^9 m^3$$

b) If the recession were to be interrupted at time 100 days, what is the remaining potential baseflow?

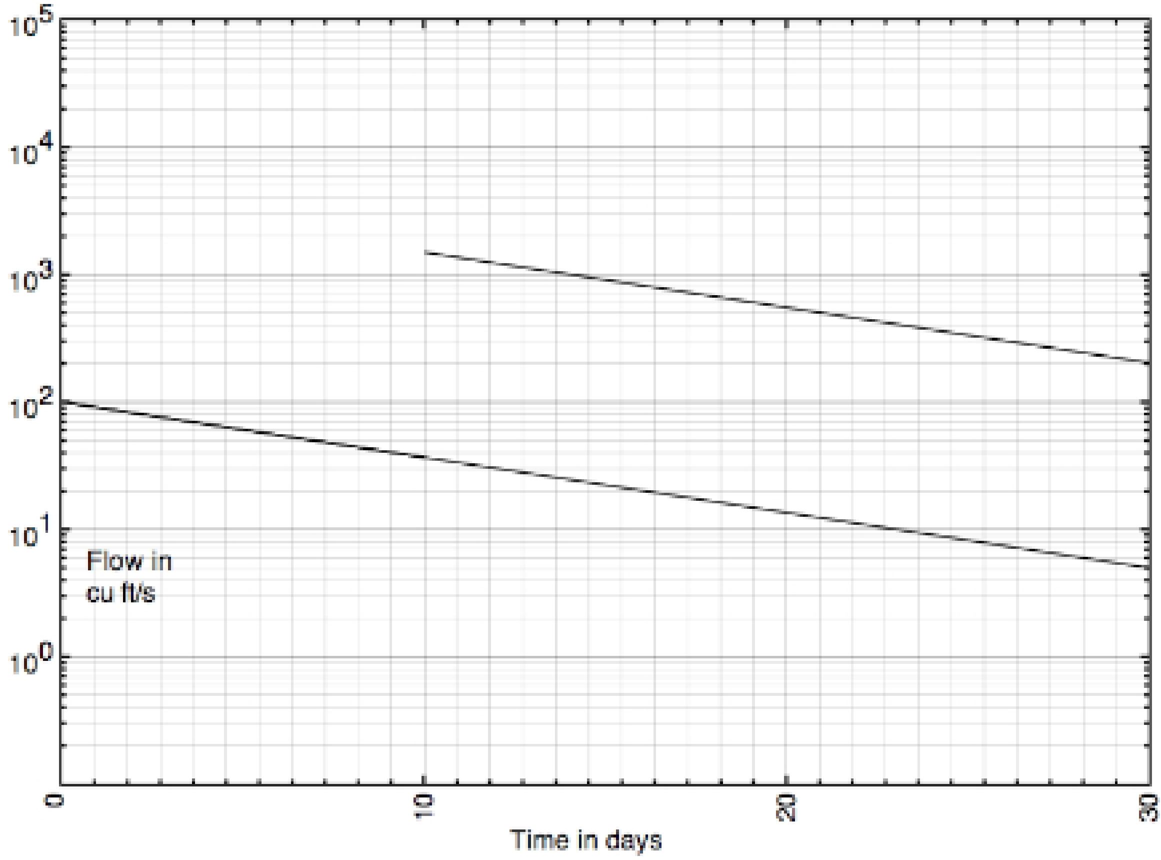
$$V_t = \frac{V_{tp}}{10^{(t/t_1)}}\ (volume\ of\ dischg\ remaining\ at\ time\ t)$$

$$V_t = \frac{7.88\times 10^9 m^3}{10^{(100/105)}} =$$



3. Consider the stream hydrograph below. Use the Rorabaugh method to find the total recharge. Recall that the steps are:

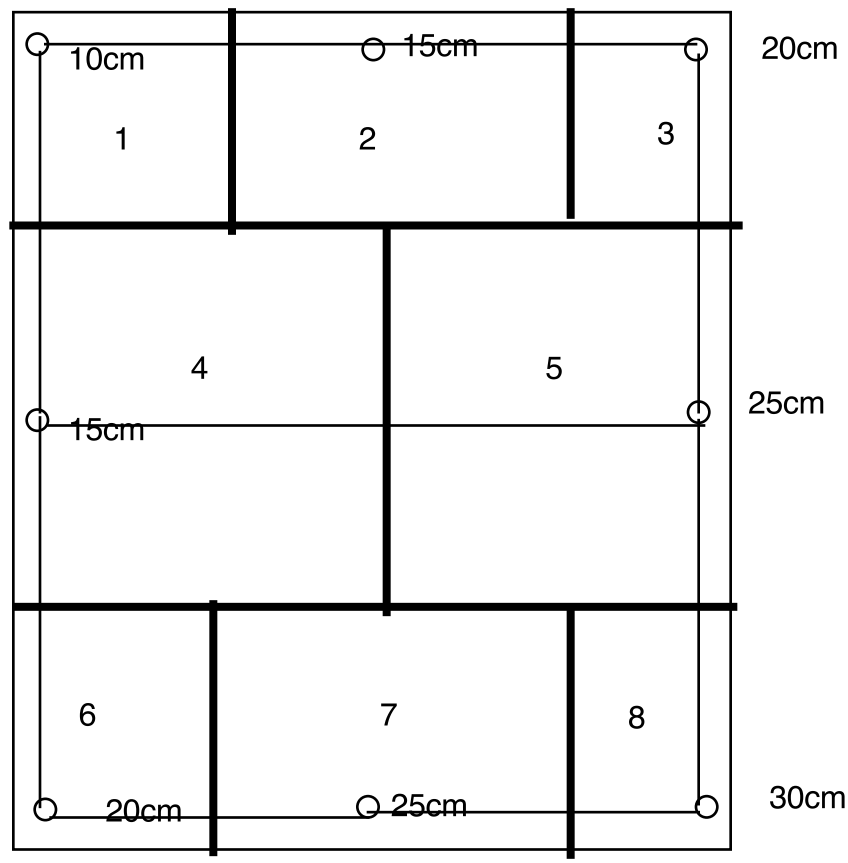
a) Find t_1 for the first recession.
b) Use t_1 to find the critical time t_c.
c) Locate the time t_c past the peak for B.
c) Extrapolate using the lines given to find Q_A and Q_B for the time t_c past the peak
Find the recharge



4. Consider the basin map shown at the end of the test.
a) Compute the effective uniform depth of precipitation using the simple average

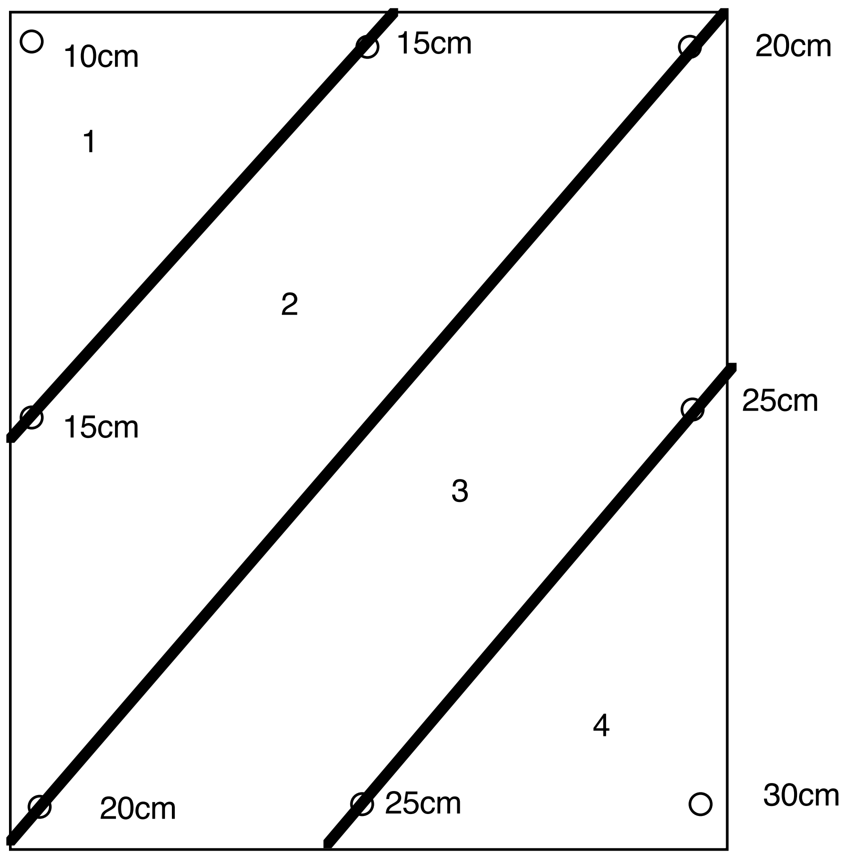
$$EUD = \frac{10cm + 15cm + 20cm + 15cm + 25cm + 20cm + 25cm + 30cm}{8} = 20cm$$

b) Draw a Thiessen diagram and explain how to use the areas to find the EUD **(label areas but do no measure them)**.



$$EUD = \frac{A_1 \cdot 10cm + A_2 \cdot 15cm + A_3 \cdot 20cm + A_4 \cdot 15cm + A_5 \cdot 25cm + A_6 \cdot 10cm + A_7 \cdot 10cm + A_8 \cdot 10cm}{A_1 + A_2 + A_3 + A_4 + A_5 + A_6 + A_7 + A_8}$$

c) Draw an Isohyetal map and explain how to use the areas to find the EUD **(label the areas but do not measure them)**.



$$EUD = \frac{A_1 \cdot 12.5cm + A_2 \cdot 17.5cm + A_3 \cdot 22.5cm + A_4 \cdot 27.5cm}{A_1 + A_2 + A_3 + A_4}$$

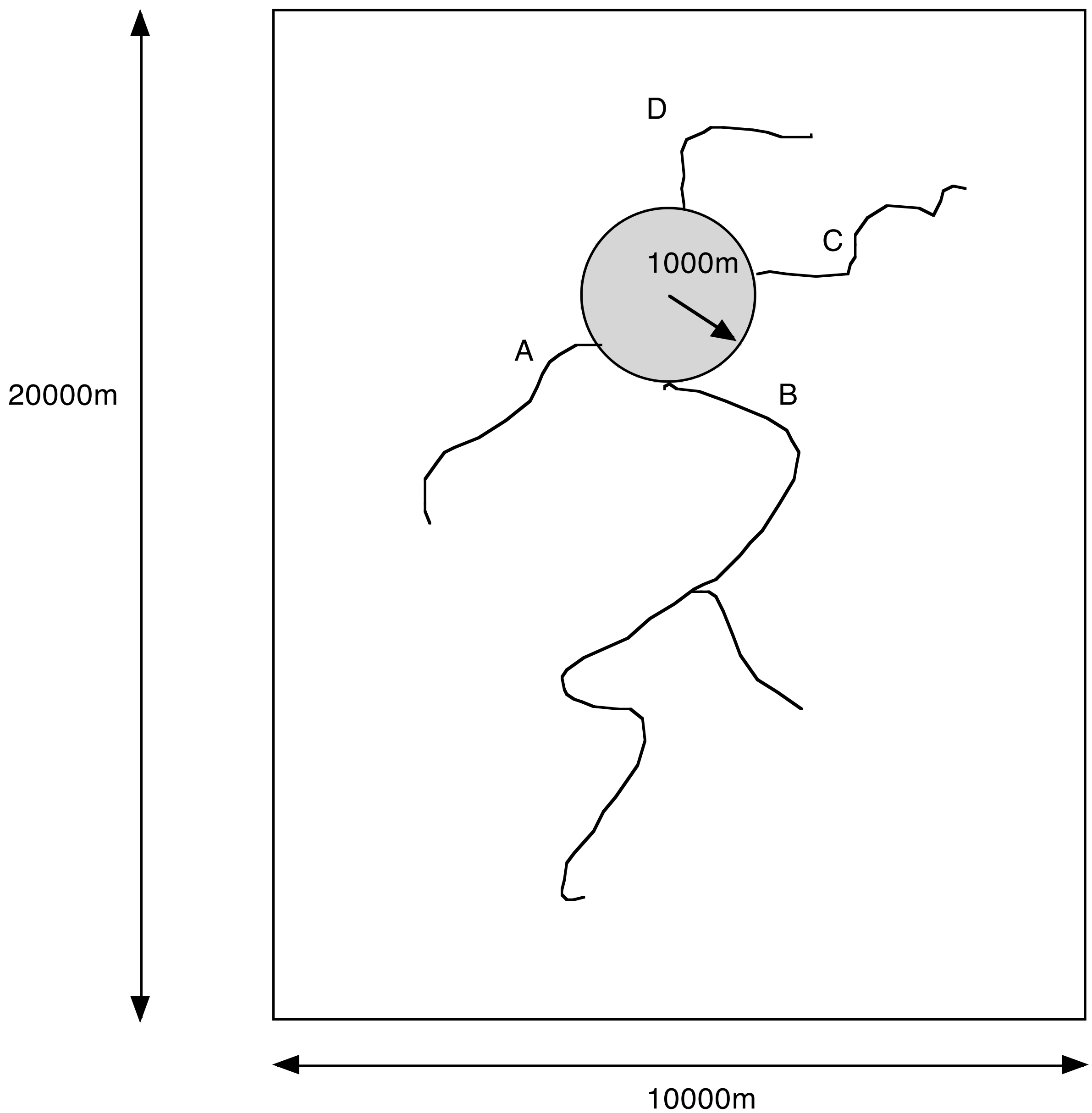
5. A V-notch weir is used to measure the flow of a stream. Explain how this is done. If the height of the water is 0.25 ft, what is the flow?

$$Q = 2.54\, h^{3/2} = 2.54(0.25)^{3/2} = 0.3175$$

6. The hydrologic equation is

$$\Delta S = I - O$$
$$\Delta S = Change\ in\ storage$$
$$I = Inflow$$
$$O = Outflow$$

Consider the Basin below:


D
C
1000m
A
B
20000m
10000m

Inflow	Outflow	Change in Storage
Stream A: 10 cu m/s	Evaporation=30cm/yr	0
Stream B: 30 cu m/s	Groundwater=?	
Stream C: 20 cu m/s		
Stream D: 5 cu m/s		
Direct Precip: EUD =20cm/yr		
Groundwater=?		

a) What is the net inflow due to streams for a year?

$$V = (10 + 30 + 20 + 5)m^3 / s \cdot 3.15 \times 10^7 s = 2.05 \times 10^9$$

b) What is the net inflow due to drect precipitation for a year?

$$V = 0.2m / yr \cdot \pi \cdot (1000m)^2 = 6.28 \times 10^5$$

c) What is the net outflow due to Evaporation for a year?

$$V = 0.3m / yr \cdot (10{,}000m \times 20000m) = 6.0 \times 10^7 m^3$$

d) If the change in storage is zero, what must the net groundwater flow be?

$$0 = 2.05 \times 10^9 + 6.28 \times 10^6 - 6 \times 10^7 - V_{ground}$$

$$V_{ground} = 2.05 \times 10^9 + 6.28 \times 10^6 - 6 \times 10^7 = 1.996 \times 10^9$$

You may find the following helpful: $\# \sec / yr = 3.15 \times 10^7$

Conversions, equations, etc.

$$\rho_{water} = 1 g / cm^3$$

$Q = 2.54\, h^{3/2}$ for a triangular weir. h measured in ft, Q in cu ft/s

$$c_{water} = 1 \frac{cal}{g \cdot °C}$$

$$c_{ice} = 0.5 \frac{cal}{g \cdot °C}$$

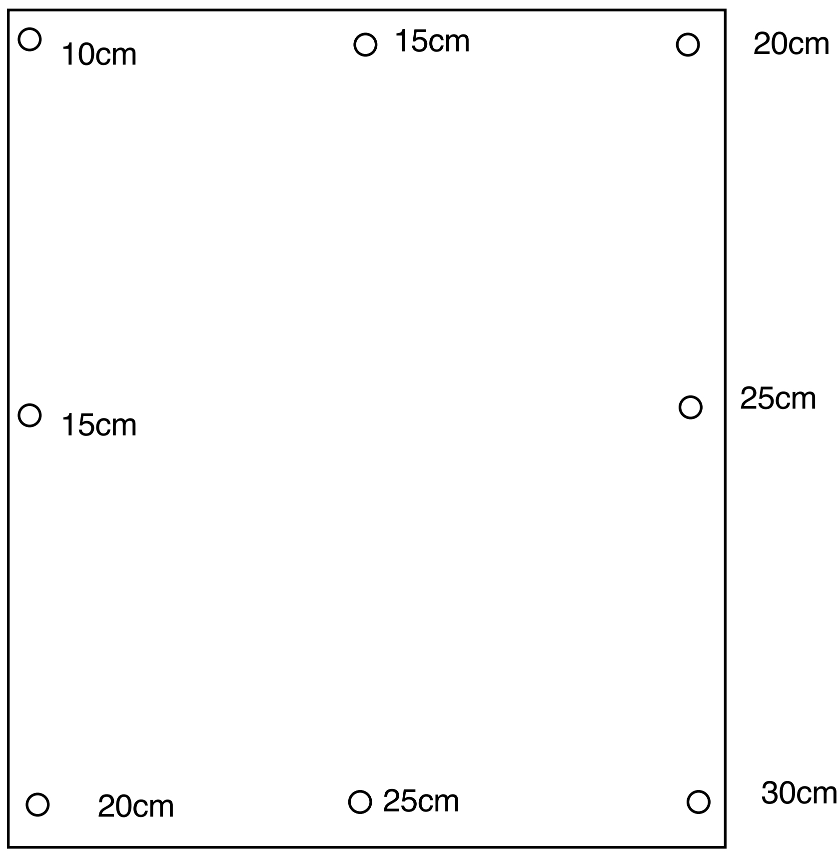
$$L_{fusion} = 79.7 \frac{cal}{g}$$

$$V_{tp} = \frac{Q_0 t_1}{2.3026} \quad (potential\ groundwater\ dischg)$$

$$V_t = \frac{V_{tp}}{10^{(t/t_1)}} (volume\ of\ dischg\ remaining\ at\ time\ t)$$

$$G = \frac{2(Q_B - Q_A) t_1}{2.3026} \ (Rorabaugh\ Method)$$

$$t_c = .2144\, t_1$$


10cm
15cm
20cm
15cm
25cm
20cm
25cm
30cm