Instructor: Arturo Leon Name ______SOLUTION KEY_______________

QUIZ 3

CE 412/512 Hydrology - Spring 2013

Quiz is closed book and closed notes. For all problems, **write the equations used**, **show your calculations**, **include units**, and **box your answers**.

1. *(30 pts)* Given the 1-hr unit (for 1 in. of net rainfall) hydrograph (UH) below, compute the storm hydrograph for a 3-hr precipitation with a constant net rainfall intensity of 0.5 in/hr.

SOLUTION:

Use hydrograph convolution (add and lag) to solve this. The precipitation is constant at 0.5 in/hr, so P_n = [0.5, 0.5, 0.5] in. To compute the storm hydrograph for a 3-hr precipitation, the UH must be multiplied by each precipitation value (P_n) and lagged.

Time (hr)	**UH (1 hr)** (cfs)	**P_1*UH**	**P_2*UH**	**P_3*UH**	**3-Hr Storm Hydrograph** (sum)
0	0	0	0	0	**0**
1	20	10	0	0	**10**
2	35	17.5	10	0	**27.5**
3	15	7.5	17.5	10	**35**
4	0	0	7.5	17.5	**25**
5	0	0	0	7.5	**7.5**

2. *(30 pts)* Given the S-curve below (developed from a 1-hr unit hydrograph), find the 2-hr unit hydrograph.

<u>**SOLUTION:**</u>

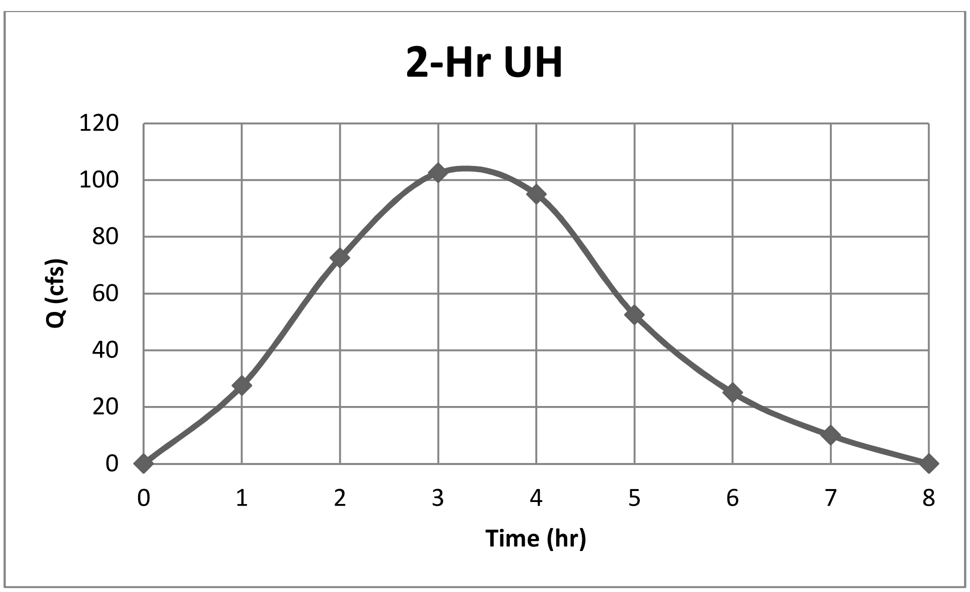
To calculate the 2-hr UH, the S-curve is lagged by 2 hours and then subtracted from the original S-curve. Then this value is multiplied by D/D'.

D = 1 hr

D' = 2 hr

D/D' = 1 hr/ 2 hr = 1/2

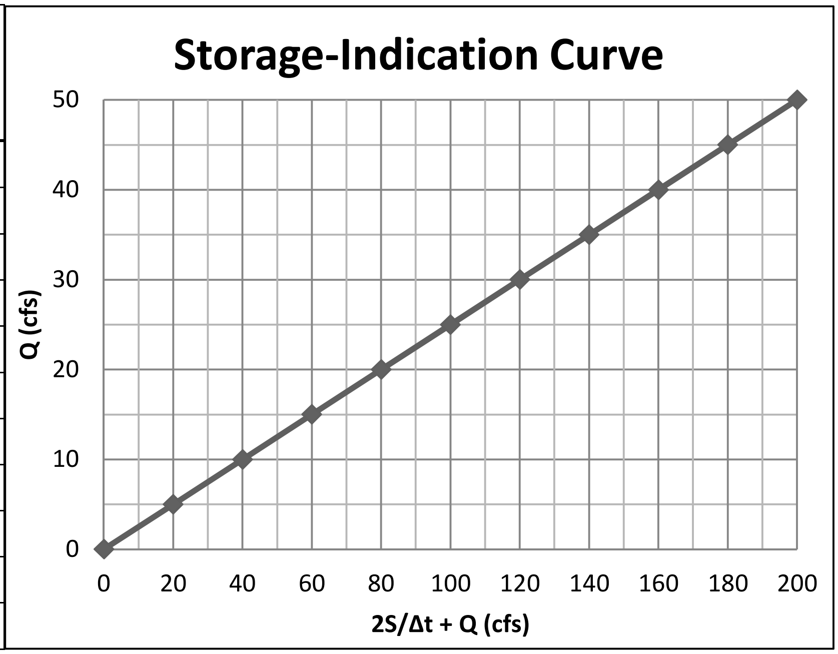
Time (hr)	**S-curve (cfs)**	**Lagged S-curve** *(lag 2 hrs)*	**Difference** *(S-curve - Lagged S-curve)*	**2-hr UH** *(Diff*1/2)*
0	0	0	0	**0**
1	55	0	55	**27.5**
2	145	0	145	**72.5**
3	260	55	205	**102.5**
4	335	145	190	**95**
5	365	260	105	**52.5**
6	385	335	50	**25**
7	385	365	20	**10**
8	385	385	0	**0**



3. *(40 pts)* A reservoir has the following storage-indication curve (S = 1.5*Q, where Q is in cfs and S is in cfs-hr). Given Δt = 1 hr., and initial conditions of $Q_0 = 0$ and $S_0 = 0$, route the inflow hydrograph given below through the reservoir using the storage-indication method. (HINT: fill in the table below). **Show sample calculations for partial credit.**

Storage-Indication Equation: $(I_n + I_{n+1}) + \left(\frac{2S_n}{\Delta t} - Q_n\right) = \left(\frac{2S_{n+1}}{\Delta t} + Q_{n+1}\right)$

Outflow (Q) (cfs)	**Storage (S)** (cfs-hr)	**2S/Δt + Q** (cfs)
0	0	0
5	7.5	20
10	15	40
15	22.5	60
20	30	80
25	37.5	100
30	45	120
35	52.5	140
40	60	160
45	67.5	180
50	75	200



SOLUTION:

Time (hr)	I_{n+1} (cfs)	$I_n + I_{n+1}$ (cfs)	$2S_n/\Delta t - Q_n$ (cfs)	$2S_{n+1}/\Delta t + Q_{n+1}$ (cfs)	Q_{n+1} (cfs)
0	0	0	0 (initial conditions)	0	0
1	10	10+0 = **10**	0-2*0 = **0**	10+0 = **10**	**2.5** (from S-I Curve)
2	20	10+20 = **30**	10-2*2.5 = **5**	30+ 5 = **35**	**8.75** (from curve)
3	30	20+30 = **50**	35-2*8.75 = **17.5**	50+17.5 = **67.5**	**16.875** (from curve)
4	20	30+20 = **50**	67.5-2*16.875 = **33.75**	50+33.75 = **83.75**	**20.938**
5	10	30	41.875	71.875	**17.969**
6	0	10	35.938	45.938	**11.484**
7	0	0	22.969	22.969	**5.742**

Solution Procedure:

($I_n + I_{n+1}$) column is found by adding I_{n+1} with the value before it. For the first row, this is 10+0 = 10.

($2S_n/\Delta t$ - Q_n) for the first row is calculated from the initial conditions, $Q_0 = 0$ and $S_0 = 0$.

$$\frac{2 * 0\, cfs - hr}{1\, hr} - 0\, cfs = 0\, cfs$$

($2S_{n+1}/\Delta t + Q_{n+1}$) column is found by using the Storage-Indication equation (summing the previous columns). Row 1 example below.

$$\left(\frac{2S_{n+1}}{\Delta t} + Q_{n+1}\right) = (I_n + I_{n+1}) + \left(\frac{2S_n}{\Delta t} - Q_n\right) = 10 + 0 = 10\, cfs$$

(Q_{n+1}) column is found from the Storage-Indication Curve. For row 1, ($2S_n/\Delta t + Q_n$) = 10 cfs, therefore Q (from the curve) = 2.5 cfs.

($2S_n/\Delta t$ - Q_n) for the remaining rows is calculated by twice subtracting the flow from the known value of ($2S_n/\Delta t + Q_n$) at the time step n (previous row). Row 1 example below.

$$\frac{2S_n}{\Delta t} - Q_n = \left(\frac{2S_n}{\Delta t} + Q_n\right) - 2Q_n$$

$$= 10\, cfs - 2 * 2.5\, cfs$$

$$= 5\, cfs$$