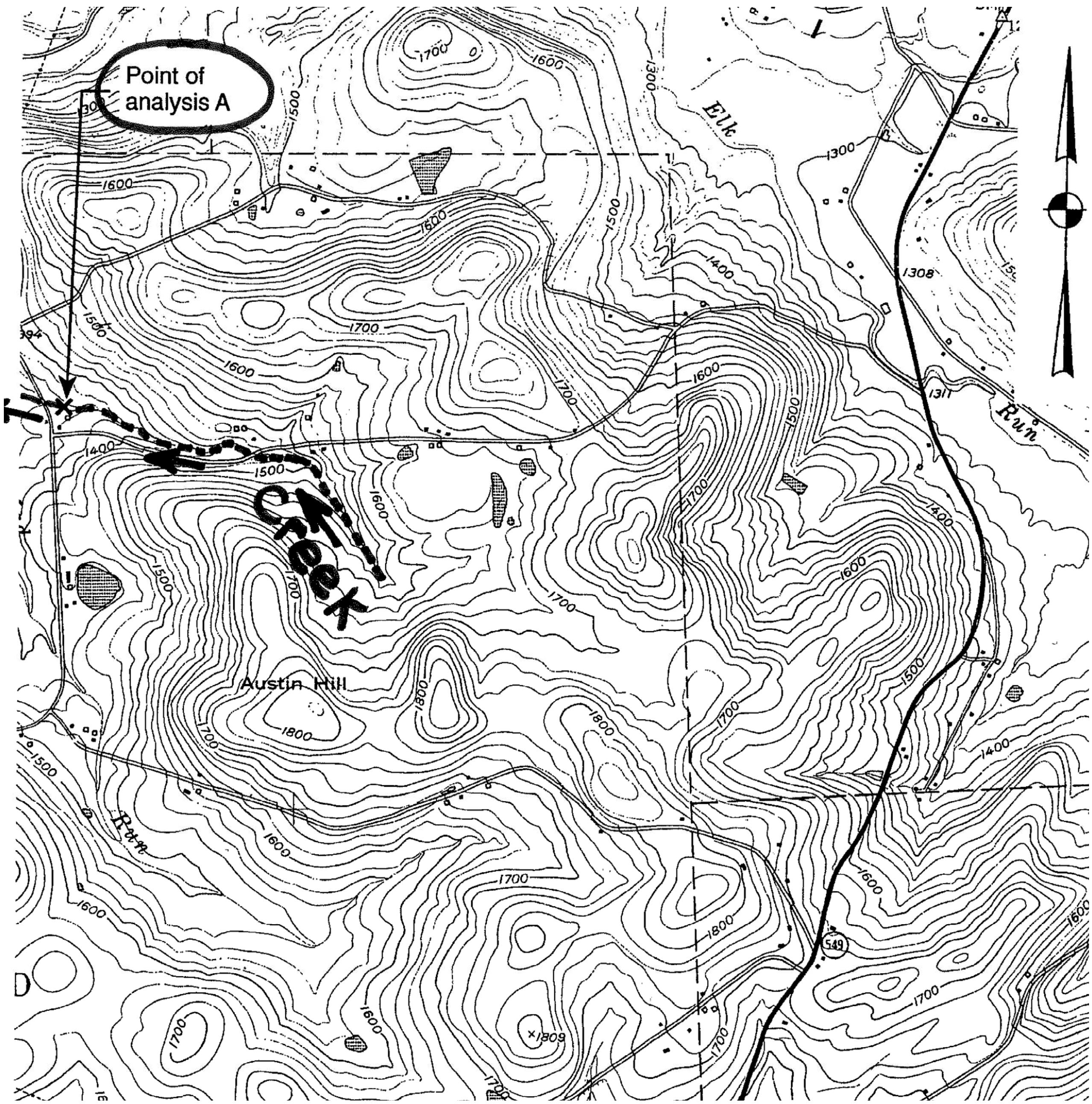
Instructor: Arturo Leon Name SOLUTION KEY

FINAL EXAM

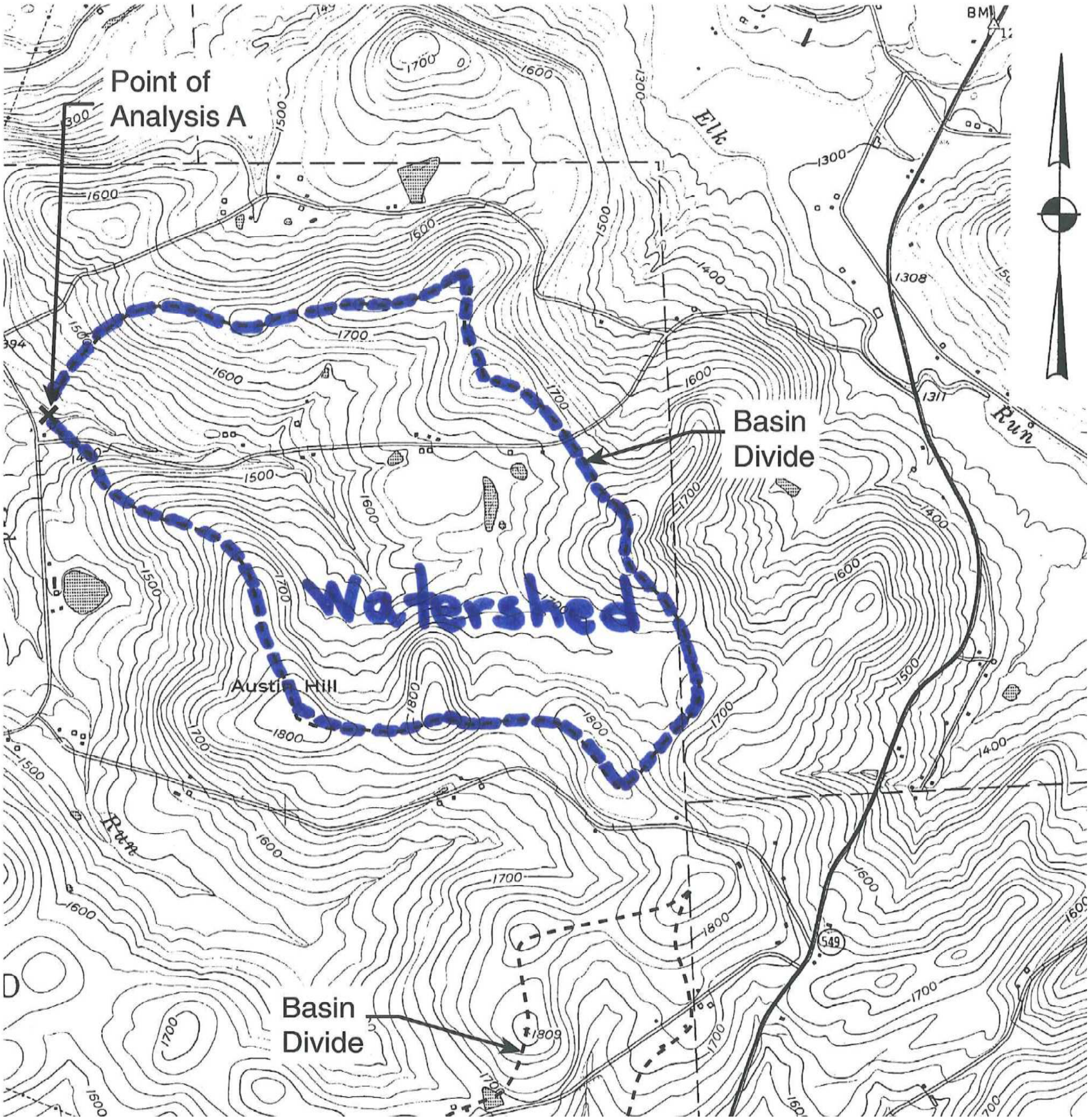
CE 412/512 Hydrology - Spring 2013

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

1. *(10 pts)* Delineate the watershed at the "Point of Analysis A"



SOLUTION:


Point of Analysis A
Basin Divide
Watershed
Austin Hill
Basin Divide
Elk
Run
Run
1700
1600
1500
1800
1300
1400
1308
1311
1809
549
BM

2. *(30 pts)* Assume that the peak flows for a stream near Corvallis fit a Log Pearson 3 distribution. Assuming that the following statistics holds for this stream, find:

Description	**Log_{10}Data (log cfs)**
Mean	$\mu = 4.2165$
Standard Deviation	$\sigma = 0.2019$
Skewness	$C_s = -1.3$

   a. Peak flow of the 100-year flood

From Table 3-4 → K = 1.383

$$\log(Q_{100}) = \mu + K\sigma = 4.2165 + 1.383 * 0.2019 = 4.496$$
$$Q_{100} = 10^{4.496} = \mathbf{31,333\ cfs}$$

   b. The probability that the peak flow will fall between 25,000 and 30,000 cfs.

$$Log_{10}(Q) = \mu + K\sigma$$
$$Log_{10}(25{,}000) = 4.2165 + K(0.2019)$$
$$K_{25,000} = 0.8987$$

$$Log_{10}(30{,}000) = 4.2165 + K(0.2019)$$
$$K_{30,000} = 1.2908$$

Using Table 3-4, for C_S = -1.3, find 1-F for $K_{25,000}$ and $K_{30,000}$:

$K_{25,000}$: 0.838 = 20 %
0.8987 = x → x = 17.32 %
1.064 = 10 %

$K_{30,000}$: 1.240 = 4 %
1.2908 = x → x = 2.79 %
1.324 = 2 %

$$1 - F_{25,000} = 0.1732 \rightarrow F_{25,000} = 0.827$$
$$1 - F_{30,000} = 0.0279 \rightarrow F_{30,000} = 0.9721$$
$$P_{25,000-30,000} = F_{30,000} - F_{25,000} = 0.972 - 0.827 = \mathbf{0.145} = \mathbf{14.5}\%$$

   c. Return period of a flow of 30,000 cfs

$$K = \frac{Log_{10}(Q) - \mu}{\sigma} = \frac{Log_{10}(30{,}000) - 4.2165}{0.2019} = 1.2908$$

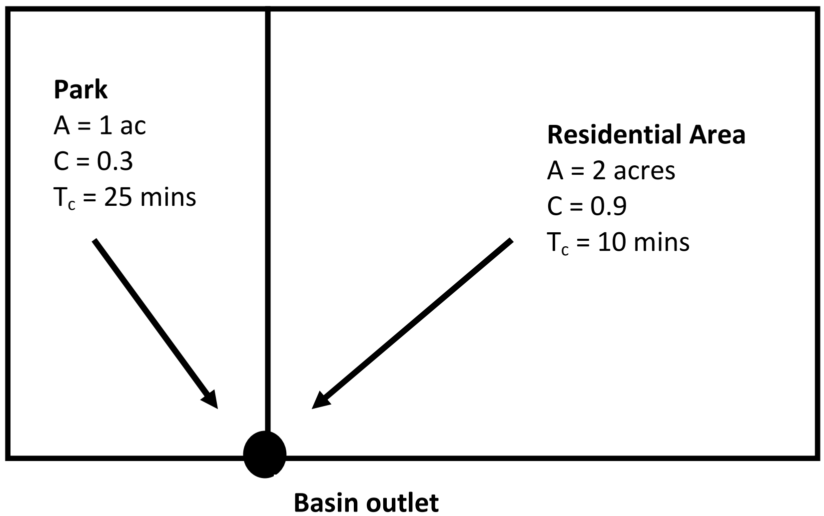
Interpolate from Table 3-4: $1 - F = 2.79\% = 0.0279$

$$F = 1 - 0.0279 = 0.9721$$
$$T = \frac{1}{1-F} = \frac{1}{0.0279} = \mathbf{35.8\ years}$$

   d. The probability that the peak flow will exceed 30,000 cfs **at least twice** in the next 5 years.

$$P = 1 - P_0 - P_1$$
$$P = 0.0279 \rightarrow 1 - P = 0.9721$$
$$P = 1 - (1-P)^5 - \frac{5!}{4! * 1!} P^1 (1-P)^4$$
$$P = 1 - 0.8681 - \frac{5 * 4!}{4!}(0.0279) * (0.9721)^4 = 1 - 0.8681 - 0.1246$$
$$P = \mathbf{0.0073} = \mathbf{0.73}\%$$

3. *(10 pts)* A basin in Corvallis has been developed into a 1-acre park (C=0.3) and 2 acres of residential use (C=0.9). The times of concentration (T_c) for the park and residential area are 25 and 10 minutes, respectively. Using the Intensity-Duration-Frequency (IDF) curve provided on the following page, what is the 25-year design peak flow at the basin outlet?



SOLUTION:

Find the weighted runoff coefficient:

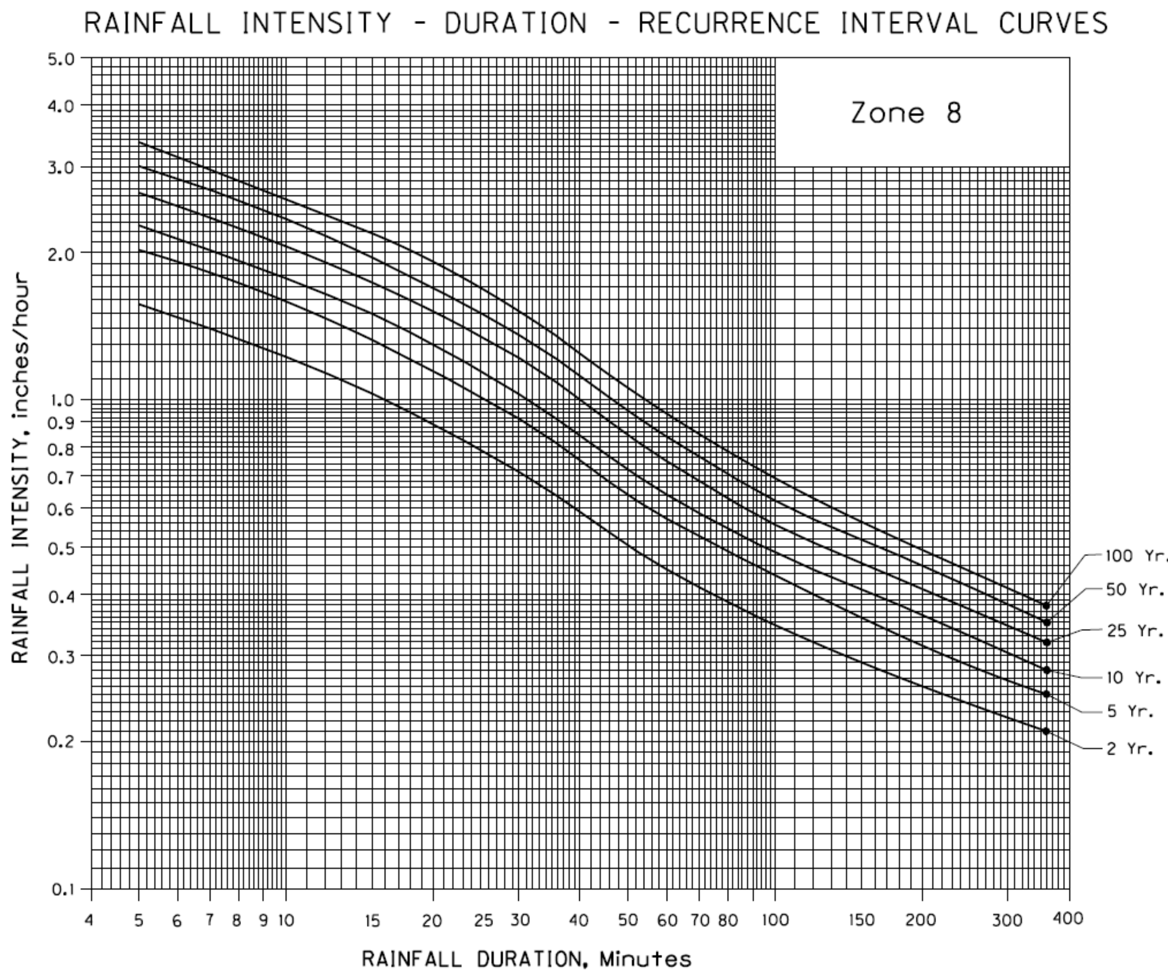
	Area (ac)	Area Ratio	C	Ratio * C
Park	1	0.333	0.3	0.1
Residential	2	0.667	0.9	0.6
Total	3			**0.7**

Use the rational method to find the discharge for each section separately and combined:

	Area (ac)	Tc (min)	*i* (in/hr)	C	Q = CiA (cfs)
Park	1	25	1.35	0.3	0.405
Residential	2	10	2.05	0.9	3.690
Both	3	25	1.35	0.7	2.835

The peak flow from the residential area is the greatest.

$\boxed{\mathbf{Q = 3.69\ cfs}}$


RAINFALL INTENSITY - DURATION - RECURRENCE INTERVAL CURVES
Zone 8
RAINFALL INTENSITY, inches/hour
5.0
4.0
3.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
4
5
6
7
8
9
10
15
20
25
30
40
50
60
70
80
100
150
200
300
400
RAINFALL DURATION, Minutes
100 Yr.
50 Yr.
25 Yr.
10 Yr.
5 Yr.
2 Yr.

4. *(20 pts)* A pedestrian path runs along a stream channel. The stream can carry the peak flow of the 25-year storm event of the watershed, which is 400 cfs. Find the following:

a. The probability that the path will flood next year.

$$= P = \frac{1}{T} = \frac{1}{25}$$
$$P = 0.04$$

b. The probability that the path will flood at least once in the next 10 years.

$$Risk = 1 - \left(1 - \frac{1}{T}\right)^n$$
$$= 1 - \left(1 - \frac{1}{25}\right)^{10} = 1 - 0.6648 = \mathbf{0.3352}$$

c. The probability that the path will **not** flood at all in the next 10 years.

$$Reliability = 1 - Risk$$
$$= 1 - 0.3352 = \mathbf{0.6648}$$

d. The probability that the path will flood exactly 4 times in the next 10 years.

$$P(x) = C_x^n * P^x(1-P)^{n-x} = \frac{n!}{(n-x)! * x!} * P^x(1-P)^{n-x}$$
$$= \frac{10!}{6! * 4!} * P^4(1-P)^6 = \frac{10!}{6! * 4!} * \left(\frac{1}{25}\right)^4 \left(1 - \frac{1}{25}\right)^6 = \mathbf{0.000421} = \mathbf{0.042}\%$$

e. The probability that the path will flood **at least three times** in the next 200 years

$$P = 1 - P_0 - P_1 - P_2$$
$$= 1 - (1-P)^{200} - C_1^{200}P^1(1-P)^{199} - C_2^{200}P^2(1-P)^{198}$$
$$= 1 - (1-0.04)^{200} - C_1^{200}(0.04)(1-0.04)^{199} - C_2^{200}(0.04)^2(1-0.04)^{198}$$
$$= 1 - (0.96)^{200} - \frac{200!}{199! * 1!}(0.04)^1(0.96)^{199} - \frac{200!}{198! * 2!}(0.04)^2(0.96)^{198}$$
$$= \mathbf{0.9875} = \mathbf{98.75}\ \%$$

5. *(30 pts)* Given the 2-hr unit hydrograph (UH) below, develop the 3-hr UH.

Time (hr)	Q (cfs)
0	0
1	15
2	35
3	50
4	40
5	10
6	0

SOLUTION:

Time (hr)	Q (cfs)	2 hr lagged UH			S-curve
0	0				0
1	15				15
2	35	0			35
3	50	15			65
4	40	35	0		75
5	10	50	15		75
6	0	40	35	0	75
7		10	50	15	75

Time (hr)	S-curve	S-curve Lagged 3 hrs	Difference	3-hr UH (Diff*D/D')
0	0		0	0
1	15		15	10
2	35		35	23.33
3	65	0	65	43.33
4	75	15	60	40
5	75	35	40	26.67
6	75	65	10	6.67
7	75	75	0	0