Student Name: ____________________________________ SPRING 2016

CE 3354 Engineering Hydrology
Exam 2, Spring 2016 – CLOSED COMPUTER PORTION

Students should write their name on all sheets of paper. Students are may use printed notes and book excerpts to help answer questions. Students are **NOT** permitted to use laptops, tablets, phones to access the internet or communicate during the closed-computer portion of the exam.

When you complete this portion of the exam (closed computer), you may trade these sheets for the open computer portion of the exam.

1. What is a hyetograph (as used in this class)?
   A) A record of rainfall rates (inches/hour) versus time.
   B) A record of cumulative rainfall depth (inches) versus time.
   C) A record of discharge rate (cubic feet/second) versus time.
   D) A and B
2. What is a hydrograph (as used in this class)?
   A) A record of rainfall rates (inches/hour) versus time.
   B) A record of cumulative rainfall depth (inches) versus time.
   C) A record of discharge rate (cubic feet/second) versus time.
   D) A and B
3. What is excess precipitation?
   A) The amount of precipitation that falls upon a watershed.
   B) The amount of runoff that is produced from a watershed.
   C) The equivalent depth of uniformly distributed precipitation.
   D) A and B

4. You have been asked to develop a hydrologic model for a watershed to estimate the impacts of several different development scenarios. The available data includes topographic maps, the county soil survey, detailed hydraulic conductivity and infiltration data for each soil type, and aerial photography.

   Which is the best method to calculate excess precipitation?

   A) Blaney-Criddle Evapotranspiration Model

   B) NRCS Dimensionless Unit Hydrograph Model

   C) Snyder Unit Hydrograph Model

   D) Green-Ampt Infiltration Model

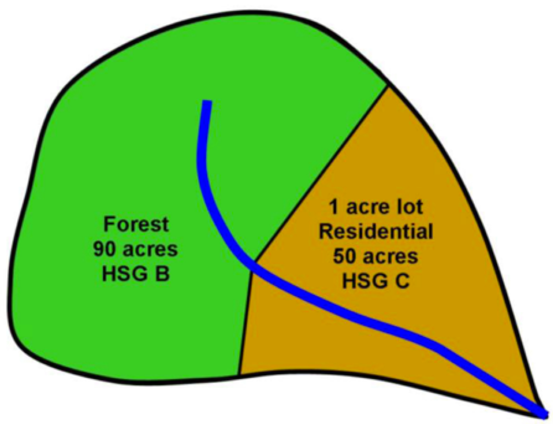

Figure 1: Small watershed comprised of two distinct land cover types

Figure 1 is a study watershed comprised of two distinct land uses. Both portions of the watershed are in FAIR hydrologic conditions. Figure 2 is a set of curve numbers for rural (agricultural) areas. Figure 3 is a set of curve numbers for urban areas.

5. Which table should you use for the rural (agricultural) portion of the watershed?

   A) Figure 2

   B) Figure 3

   C) Periodic table of elements

   D) Fluid properties for CO_2

Table 4-21: Runoff Curve Numbers For Other Agricultural Lands

Cover type	Hydrologic condition	A	B	C	D
Pasture, grassland, or range-continuous forage for grazing	Poor	68	79	86	89
	Fair	49	69	79	84
	Good	39	61	74	80
Meadow – continuous grass, protected from grazing and generally mowed for hay	-	30	58	71	78
Brush – brush-weed-grass mixture, with brush the major element	Poor	48	67	77	83
	Fair	35	56	70	77
	Good	30	48	65	73
Woods – grass combination (orchard or tree farm)	Poor	57	73	82	86
	Fair	43	65	76	82
	Good	32	58	72	79
Woods	Poor	45	66	77	83
	Fair	36	60	73	79
	Good	30	55	70	77
Farmsteads – buildings, lanes, driveways, and surrounding lots	-	59	74	82	86

Table 4-21 notes: Values are for average runoff condition, and $I_a = 0.2S$. Pasture: Poor is < 50% ground cover or heavily grazed with no mulch, Fair is 50% to 75% ground cover and not heavily grazed, and Good is > 75% ground cover and lightly or only occasionally grazed. Meadow: Poor is < 50% ground cover, Fair is 50% to 75% ground cover, Good is > 75% ground cover. Woods/grass: CNs shown were computed for areas with 50 percent grass (pasture) cover. Other combinations of conditions may be computed from CNs for woods and pasture. Woods: Poor = forest litter, small trees, and brush destroyed by heavy grazing or regular burning. Fair = woods grazed but not burned and with some forest litter covering the soil. Good = woods protected from grazing and with litter and brush adequately covering soil.

Figure 2: Rural area curve number table.

Table 4-19: Runoff Curve Numbers For Urban Areas

Cover type and hydrologic condition	Average percent impervious area	A	B	C	D
Dirt (including right-of-way)		72	82	87	89
Western desert urban areas:					
Natural desert landscaping (pervious areas only)		63	77	85	88
Artificial desert landscaping (impervious weed barrier, desert shrub with 1- to 2-in. sand or gravel mulch and basin borders)		96	96	96	96
Urban districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential districts by average lot size:					
1/8 acre or less (townhouses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Developing urban areas: Newly graded areas (pervious area only, no vegetation)		77	86	91	94

Table 4-19 notes: Values are for average runoff condition, and $I_a = 0.2S$.
The average percent impervious area shown was used to develop the composite CNs.
Other assumptions are: impervious areas are directly connected to the drainage system, impervious areas have a CN of 98, and pervious areas are considered equivalent to open space in good hydrologic condition.

Figure 3: Urban area curve number table.

6. Which table should you use for the residential portion of the watershed?
   A) Figure 2
   B) Figure 3
   C) Periodic table of elements
   D) Fluid properties for CO_2
7. What is the best value for a curve number for the stated conditions for the residential portion of the watershed?
   A) 59
   B) 69
   C) 79
   D) 89
8. What is the best value for a curve number for the stated conditions for the forest portion of the watershed?
   A) 50
   B) 60
   C) 70
   D) 80
9. The equation for composite curve number is

$$CN_{composite} = \frac{CN_1 * A_1 + CN_2 * A_2}{A_1 + A_2} \tag{1}$$

   Using the values you just determined for the two portions of the watershed (rural is portion 1, residential is portion 2) what is the best value for the composite curve number for the watershed?[1]
   A) 47
   B) 57
   C) 67
   D) 77

[1] Show calculations for full credit

10. The equation for watershed retention is

$$S = \frac{1000}{CN} - 10 \tag{2}$$

Using this equation and the composite curve number, the best value of S for the watershed in Figure 1 is[2]

A) 2.9

B) 3.9

C) 4.9

D) 5.9

11. The equation for watershed excess, if the total raw precipitation is P, is

$$P_e = \frac{(P - 0.2S)^2}{P + 0.8S} \tag{3}$$

What is the anticipated excess precipitation (cumulative runoff volume) for the watershed in Figure 1, if the raw precipitation is 9-inches?[3]

A) 2.9 watershed inches

B) 3.9 watershed inches

C) 4.9 watershed inches

D) 5.9 watershed inches

12. What three conceptual components are used for unit hydrograph rainfall-runoff modeling?

A) A unit hydrograph, a stage-discharge curve, and a curve number

B) A unit hydrograph, a hyetograph, and a loss model

C) A unit hydrograph, a watershed delineation, and the precipitation

D) A rainfall time series, an observed hydrograph, and a curve number

[2]Show calculations for full credit
[3]Show calculations for full credit

Figure 4 is a one-hour unit hydrograph for a watershed. Use the unit hydrograph to predict the direct runoff that would result from a 1-hour long storm that produces 2.5 watershed inches of excess precipitation, followed by a 1-hour long storm that produces 2.5 watershed inches of excess precipitation.

	A	B	C	D	E	F
1	UNIT HYDROGRAPH APPLICATION					
2	TIME (HRS)	1-HOUR UH (CFS)	EXCESSRAINFALL DEPTH (INCHES)	DRH-STORM 1 (CFS)	DRH-STORM 2 (CFS)	COMPOSITE HYDROGRAPH (CFS)
3	0	0	2.5			
4	1	8.5	2.5			
5	2	84.8	0			
6	3	331	0			
7	4	379	0			
8	5	229	0			
9	6	129	0			
10	7	65	0			
11	8	35.3	0			
12	9	4.9	0			
13	10	0	0			

Figure 4: Unit hydrograph for a watershed

13. Which value is closest to the computed peak discharge of the composite outflow hydrography?[4]

A) 233 cfs

B) 1040 cfs

C) 1775 cfs

D) 5280 cfs

[4]Show calculations (i.e. complete the table) for full credit

14. Which value is closest to the time when the peak discharge occurs?

    A) Hour 2

    B) Hour 3

    C) Hour 4

    D) Hour 5

15. What is the watershed area, in acres, based on the input excess precipitation and the predicted composite outflow hydrograph?[5]

    A) 12 acres

    B) 125 acres

    C) 1250 acres

    D) 2500 acres

16. Figure 5 is a plot of rainfall intensity (vertical axis) and elapsed time (horizontal axis) for four different cases. Which plot best represents a constant rate storm for the indicated time period (24 hours)?

    A) Panel A

    B) Panel B

    C) Panel C

    D) Panel D

17. For the watershed in Figure 1, what is the constant intensity (inches-per-hour) for a storm that is 24 hours long and produces the excess precipitation determined in Question 11?[6]

    A) 0.02 inches per hour

    B) 0.20 inches per hour

    C) 2.00 inches per hour

    D) 20.0 inches per hour

[5] Show calculations for full credit
[6] Show calculations for full credit

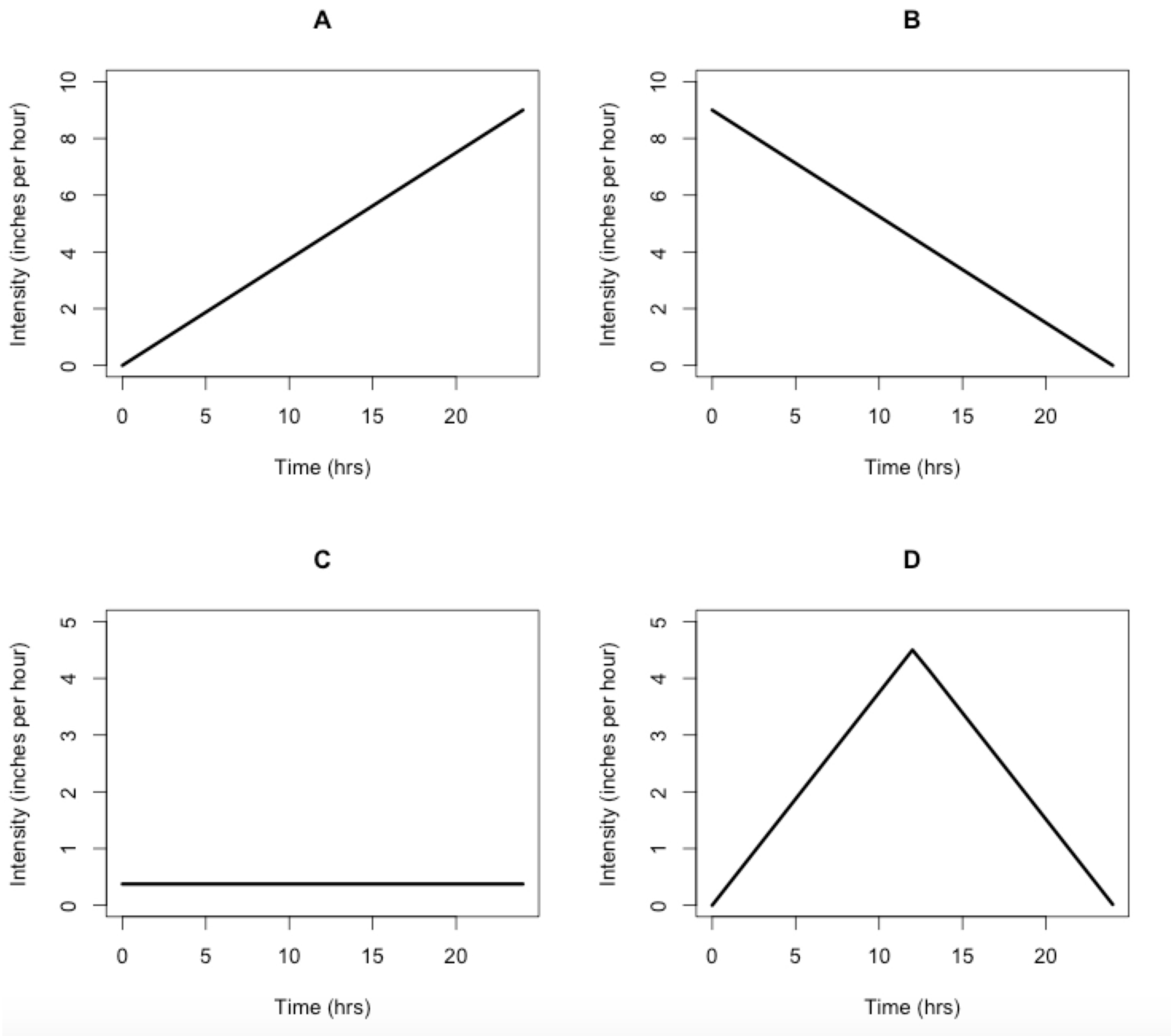

Figure 5: Intensity versus time for 4 different cases

18. A HEC-HMS model must have which of the following components to run

    A) A specified hyetograph, sub-basin, and loss model.

    B) A paired-data model, basin model and control specifications.

    C) A specified hyetograph, basin model and control specifications.

    D) A meteorological model, basin model, and control specification.

19. HEC-HMS contains various types of loss models; the model type is selected in which of the following components?

    A) A gage in the time-series manager component.

    B) A time-window in the control specifications component.

    C) A process in the sub-basin component.

    D) A specified hyetograph in the meteorological model.

20. Obtaining sufficient data to set model input parameters are always a challenge in hydrologic modeling. Which of the following approaches would help make a model more accurate?

    A) Calibrate to observed data

    B) Use a deterministic rather than stochastic approach

    C) Select a method that is lumped rather than spatially distributed

    D) Throw darts at reference tables to select input parameters

21. You have developed a HEC-HMS model for an approximate 100 sq mi watershed, comprised of several sub-basins and routing elements. The time to peak of the hydrograph in your **simulation** is occurring substantially earlier (in time) than a stream gage of measured flow. How should you adjust your model to bring it closer to agreement with the measured data?

    A) Decrease the time step of the model calculations

    B) Increase the value of the CN parameter

    C) Decrease the value of the CN parameter

    D) Increase the value of the basin lag time parameter

22. You have build a HEC-HMS model for a 150 acre watershed, comprised of a single sub-basin, using a composite curve number, and you wish to apply a constant rate rainfall. The use of a composite curve number implies which loss model?

    A) Initial Abstraction, Constant Rate model

    B) Green-Ampt Infiltration model

    C) Exponential Loss Rate model

    D) SCS Curve Number model

23. To apply a constant rate rainfall, the data (a hyetograph) are **entered** in which of the following components?

    A) A gage in the time-series manager component.

    B) A time-window in the control specifications component.

    C) A process in the sub-basin component.

    D) A SCS Type storm in the meteorological model.

The problems below all refer to the watershed in Figure 1.

24. The forest portion has a flow path length of 360 feet, at an average slope of 0.01 (1%) until it reaches the residential portion whose path length is 430 feet, at an average slope of 0.005 (0.5%). Using the NRCS Upland method estimate and choose an appropriate time of concentration from the list below.[7]

    A) 19 minutes

    B) 24 minutes

    C) 29 minutes

    D) 73 minutes

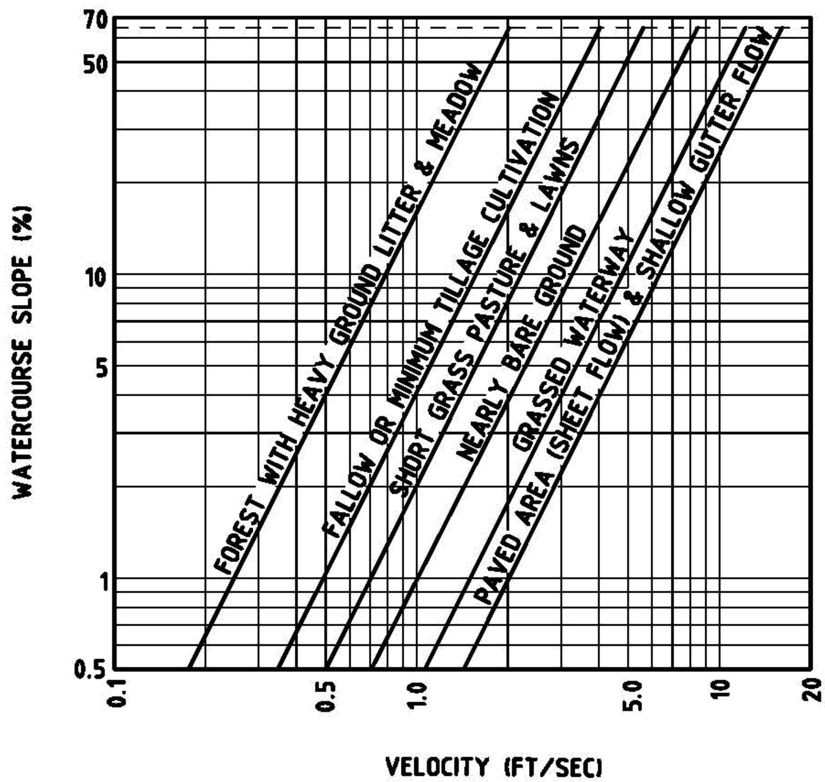

Figure 5-4. Velocities for Upland Method of Estimating Time of Concentration--English (Adapted from the National Engineering Handbook Volume 4)

Figure 6: Slope-Cover-Velocity chart for NRCS Upland Method of T_c estimation.

[7] The NRCS Upland chart is displayed in Figure 6; mark the two portions slope and cover type directly on the chart. Show calculations for full credit.

The problem below refers to the watershed in Figure 1, and refers to the build of a HEC-HMS model that will simulate a 48-hour period (24 hours of rainfall, followed by 24 hours of zero rainfall)

25. Complete the table below:

Item	Value	Units
Drainage Area	__________	Square Miles (show arithmetic)
Composite CN	__________	Dimensionless (Question 9)
Basin Lag	__________	Minutes (use $0.6 \times T_c$) (Question 24)
Rainfall Raw Rate (Hour 0 – Hour 24)	__________	Inches per hour
Rainfall Raw Rate (Hour 25 – Hour 48)	__________	Inches per hour