ANALYZING A DRAINAGE BASIN TO UNDERSTAND FLOODING AND EROSION PROBLEMS: K-16 STUDENT LEVEL

Students in geologic courses at the University of Colorado, Colorado Springs spend a considerable portion of their time in field experiences and investigations throughout their undergraduate careers. Many of the courses have students spending more than 50 percent of the scheduled contact time completing field investigations. The topics of flooding and erosion along flowing water systems often are difficult for the students to develop a true understanding of the concepts and processes associated with drainage basin morphology. A week long assignment was designed to allow the students to obtain a real world experience by completing an engineering analysis of drainage basins in Colorado Springs and the surrounding areas. The use of hydrologic and civil engineering data to analyze the selected drainage basin helps the students to obtain an increased understanding of the mechanisms of flooding and erosion within the drainage basin. The use of appropriate equipment, internet searches, previous photographic data, and the actual field investigation lead the students to a thorough understanding of the many complex aspects of flooding and erosion. This assignment is used in several courses: Physical Geology, Environmental Geology, Geomorphology, and Engineering Geology. Different aspects of the assigned problem are focused on in each of the courses. In addition, the assignment has also been used in the Science Challenge program, with appropriate modifications, that incorporates geologic knowledge during field investigations completed by gifted and talented students at the fourth through eighth level in local public school districts during the regular school year. Whether at the university or public school level, the final evaluation of the knowledge gained by the students completing the assignment has shown considerable success in improving their knowledge of the problems of flooding and erosion.

The following section is a description of the first process to be completed in understanding drainage basin water processes.

GT ENGINEERING ASSIGNMENT ALONG TEMPLETON GAP

Fill out the columns and rows of the following table to determine the discharge (Q) for each of the indicated drainage basins. Once you have determined Q evaluate the need for mitigation engineering to control the amount of water that will flow down the stream channel during a 100-year flood. This will entail measuring the channel for width, depth, length (one foot), and speed.

Use the following instructions and handout materials to develop the quantities needed for some of the columns in the table below:

Nomograph of $t_{c:}$	Determine the relief (highest point to lowest point) of the drainage basin; determine the length of the path that water will flow from the highest to the lowest point and use these numbers to find the t_c in hours.
Figure of normal t_c	Note: this figure needs t_c in minutes, not hours. Change from hours to minutes by multiplying the number from the nomograph by 6. Find the determined number at the base of the figure and trace a vertical line to the curve representing the norm and then trace a line to the left, parallel to the bottom of the figure and read the value from the left side of the figure.
Figure of 100-year t_c	Complete the above instructions but trace the vertical line to the 100-year line.
Runoff coefficient of land use	Determine the percentage of the drainage basin that is covered by a particular land use. Determine the runoff coefficient of the land use and multiple the two numbers to get that particular runoff coefficient. After completing all the land uses total the numbers to determine the runoff coefficient. Note: the numbers in the table are based on 1.0 = 100%. Therefore, the number 0.3 = 30%.

The formula you will use is $Q = cia$

Where

Q = Discharge
c = Coefficient of runoff
i = Intensity of runoff

a = Area of the drainage basin

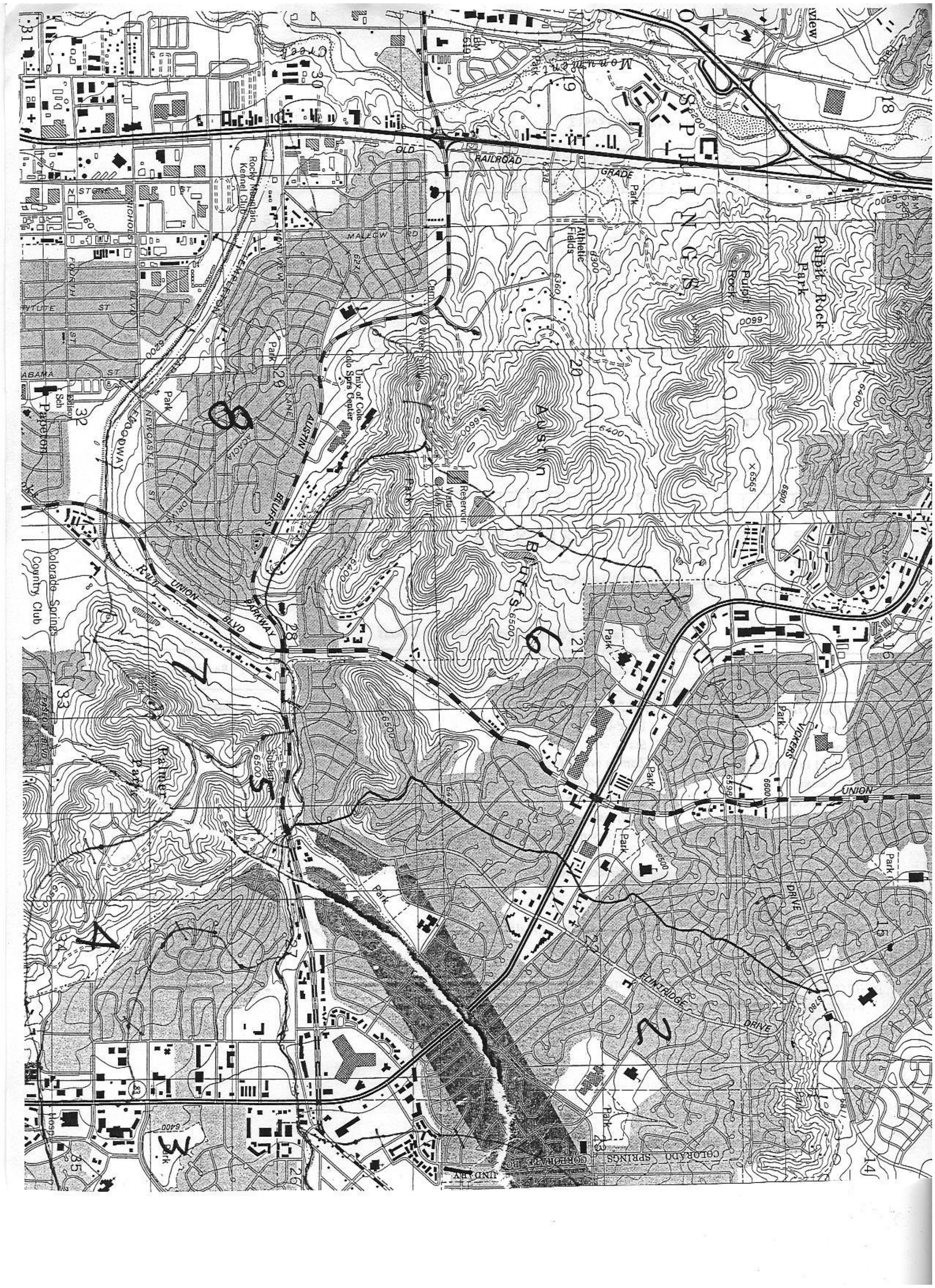
Fill in the appropriate information in the following table:

Table 1:

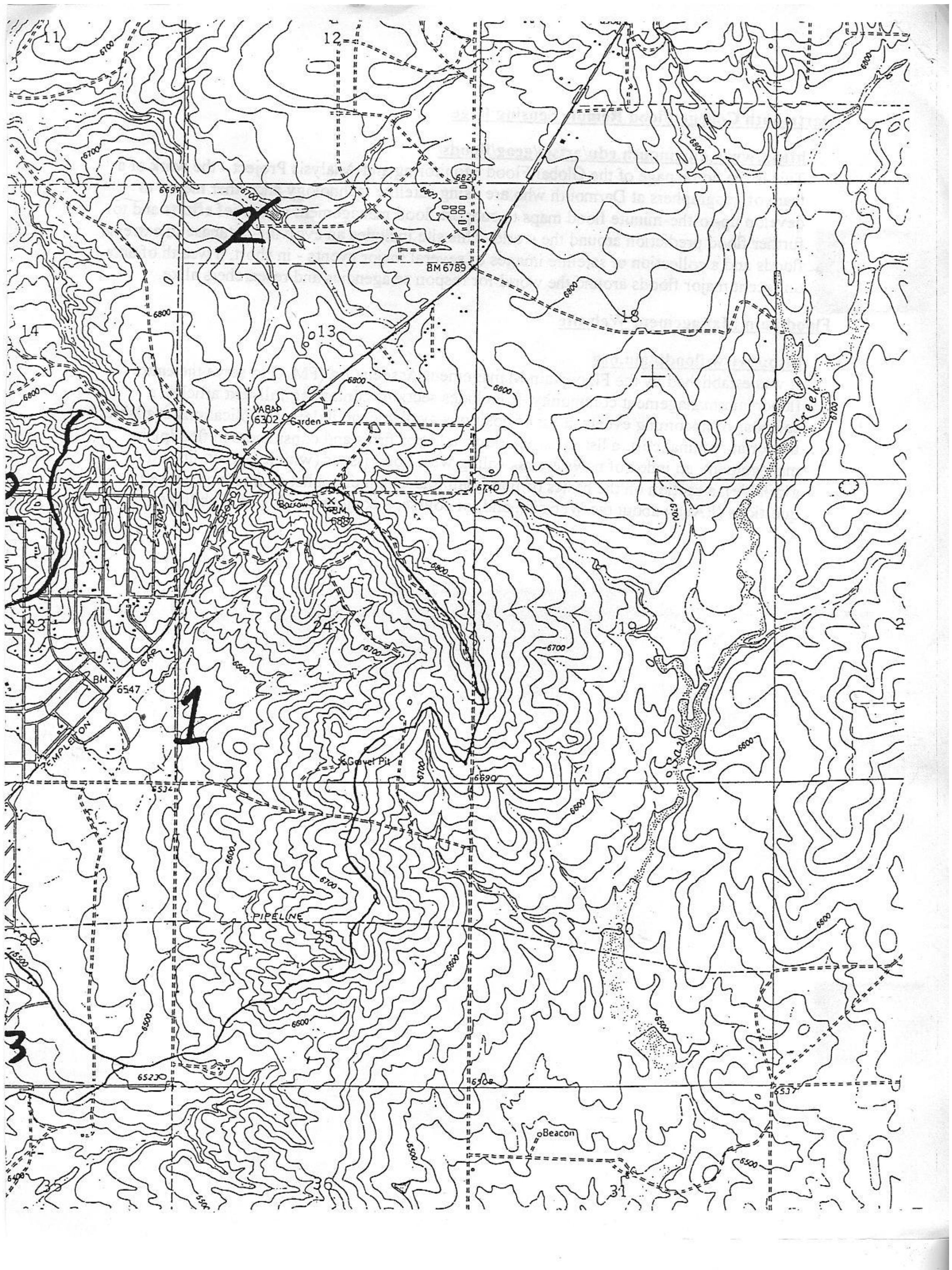
Drainage Basin	a = Area	Landuse Runoff Coef.	Landuse Percent	Coefficient of Runoff c	High Point	Low Point	Relief
1							
2							
3							
4							
5							
6							
7							
8							

Drainage Basin	Length of Stream Channel	t_c	Normal t_c	100-year t_c	i	Q for each Drainage	Q Total Drainage
1							
2							
3							
4							
5							
6							
7							
8							

Determine the acres in the selected drainage basin by using the two maps provided. Remember, 1 square mile = 640 acres which the area must be in. Next determine the coefficient of runoff by using the maps and the following table:



Colorado Springs Topography Map 1



Colorado Springs Topography Map 2

RUNOFF COEFICIENT FOR LANDUSE

LANDUSE	RUNOFF COEFFICIENT
Business/Commercial	
Downtown	0.70 – 0.95
Neighborhood	0.50 – 0.70
Residential	
Single-Family	0.30 – 0.50
Multi-units, detached	0.40 – 0.60
Multi-units, attached	0.60 – 0.75
Residential, suburban	0.25 – 0.40
Apartment	0.50 – 0.70
Industrial	
Light	0.50 – 0.80
Heavy	0.60 – 0.90
Parks, Cemeteries	0.10 – 0.25
Railroad Yards	0.20 – 0.35
Unimproved	0.10 – 0.30
Open Space	0.10 – 0.30

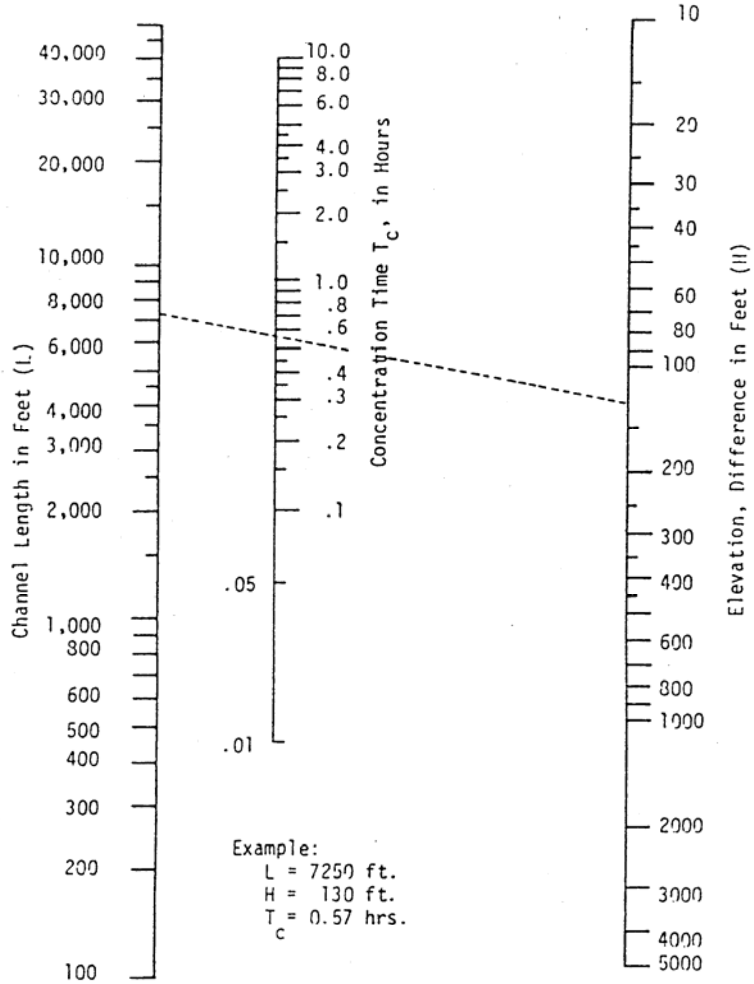
Make sure you realize that the highest number that any location can have is 100% for the runoff coefficient. Each drainage will likely have more than one landuse. Determine what percentage of the area each landuse covers and complete the necessary mathematics to obtain the final coefficient of runoff.

Example:	10% Unimproved (0.2) =	.02
	20% Parks (0.2) =	.04
	40% Apartments (0.6) =	.24
	30% Single Family (0.4) =	.12
	Total =	.42

Next complete the determination for i. Use the two maps, the nomograph, and graphs below:

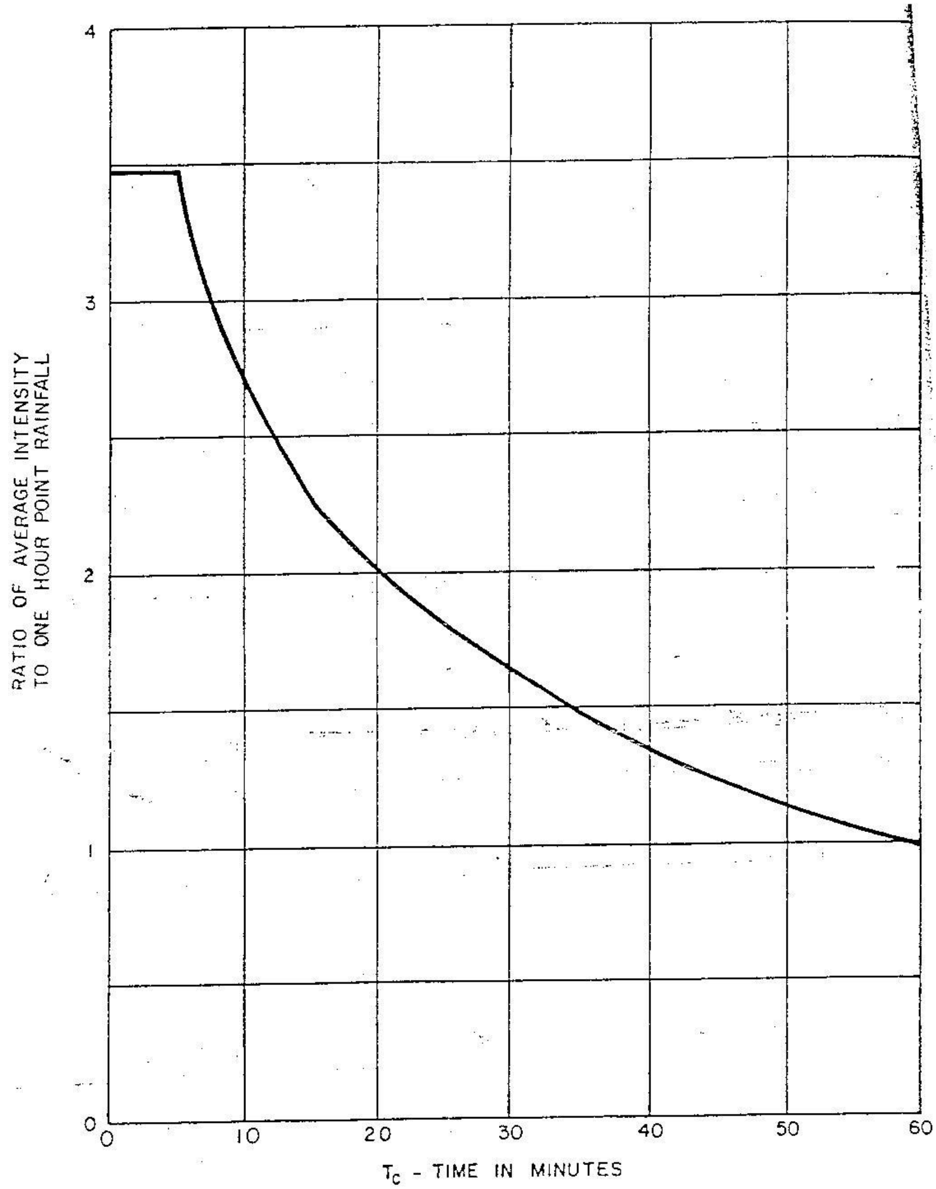
$$T = \left(\frac{11.9\ L^3}{H} \right)^{.385}$$

T = Tc in hours
L = Length of longest watercourse in miles
H = Elevation difference in feet



Estimating Tc from Lengths and Slopes of Natural Channels

Nomograph



RATIO OF AVERAGE INTENSITY
TO ONE HOUR POINT RAINFALL
0
1
2
3
4
0
10
20
30
40
50
60
T_c - TIME IN MINUTES

FIGURE III-3

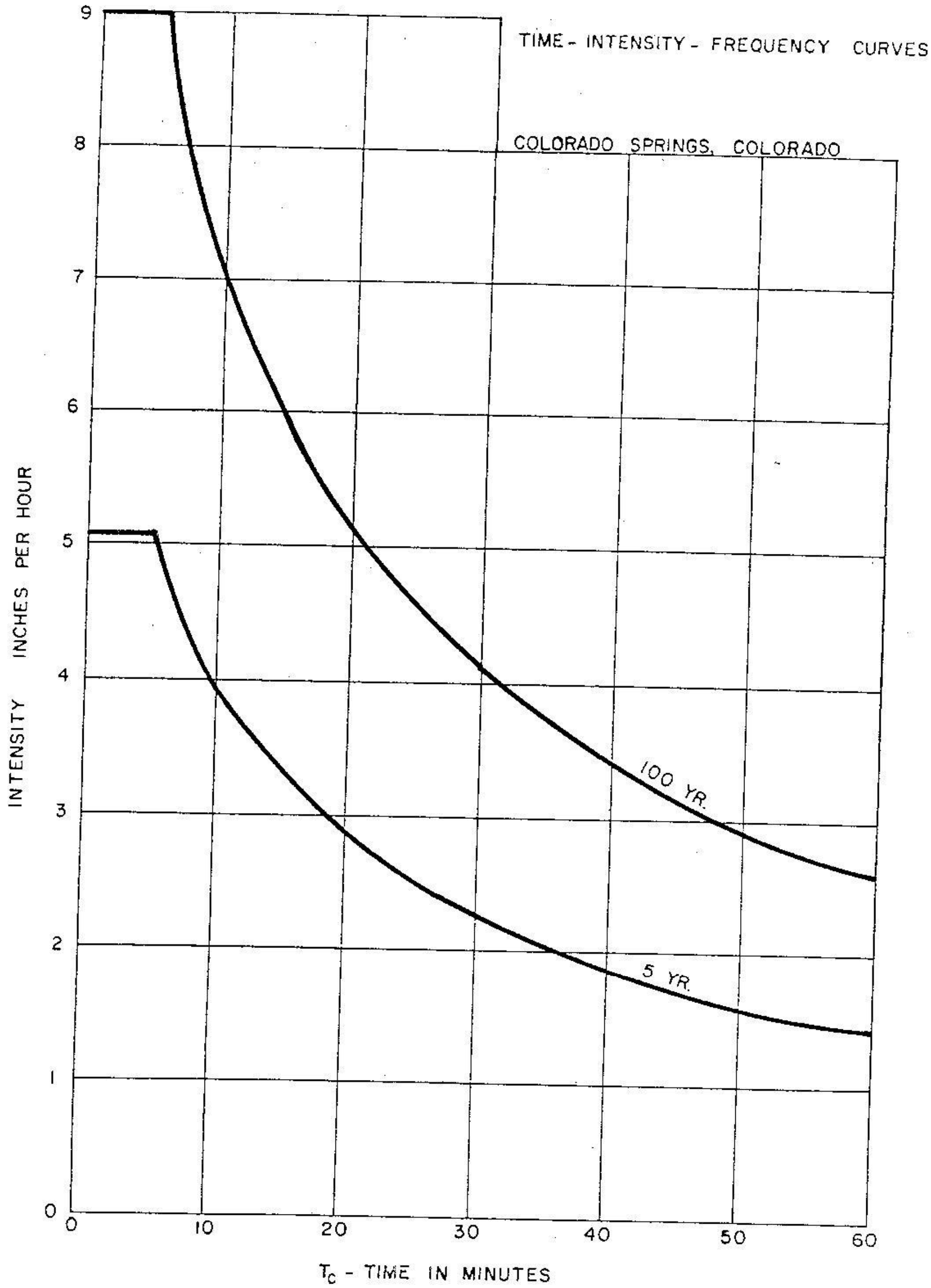
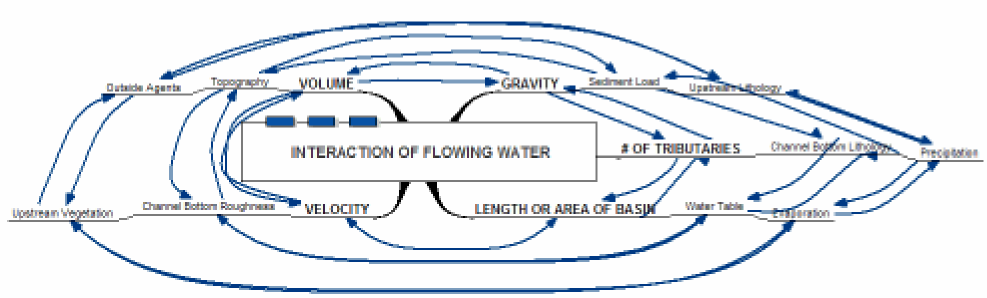

TIME - INTENSITY - FREQUENCY CURVES
COLORADO SPRINGS, COLORADO
INTENSITY INCHES PER HOUR
0
1
2
3
4
5
6
7
8
9
0
10
20
30
40
50
60
100 YR.
5 YR.
T_c - TIME IN MINUTES

FIGURE III - 2

As you complete the above determination of the discharge from each basin keep in mind the following illustration as you change from the possible to the actual.

INTERACTION OF FLOWING WATER



1 GRAVITY

See also: # OF TRIBUTARIES.
See also: VOLUME.

1.1 Sediment Load

See also: Channel Bottom Lithology.
See also: Topography.

1.1.1 Upstream Lithology

See also: Precipitation.
See also: Outside Agents.

2 # OF TRIBUTARIES

See also: LENGTH OR AREA OF BASIN.
See also: GRAVITY.

2.1 Channel Bottom Lithology

See also: Water Table.
See also: Sediment Load.

2.1.1 Precipitation

See also: Evaporation.
See also: Upstream Lithology.

3 LENGTH OR AREA OF BASIN

See also: VELOCITY.
See also: # OF TRIBUTARIES.

3.1 Water Table

See also: Channel Bottom Roughness.
See also: Channel Bottom Lithology.

3.1.1 Evaporation

See also: Upstream Vegetation.
See also: Precipitation.

4 VELOCITY

See also: VOLUME.
See also: LENGTH OR AREA OF BASIN.

4.1 Channel Bottom Roughness

See also: Topography.
See also: Water Table.

4.1.1 Upstream Vegetation

See also: Evaporation.
See also: Outside Agents.

5 VOLUME

See also: GRAVITY.
See also: VELOCITY.

5.1 Topography

See also: Sediment Load.
See also: Channel Bottom Roughness.

5.1.1 Outside Agents

See also: Upstream Lithology.
See also: Upstream Vegetation.

IN FIELD MEASUREMENTS

After completing an investigation of the possible amount of water that may flow down Templeton Gap, during a 100-year flood, the students must measure the actual capacity of the stream channel and determine if the channel will hold the possible water. If the channel will not hold the flood waters the possible damage is determined.

The possible solutions and mitigation factors are determined, evaluated and proposed. The actual placements of the structural modifications are located on the topographic maps and a written report is developed that discusses both structural and non-structural solutions.

When determining the possible stream flow by your field measurements of depth, width, the one foot thickness, and the velocity of the stream use the table below for recording your data.

DETERMINATION OF STREAMFLOW

The instructions for collecting and recording streamflow measurements in our field investigation follows:.

1. Measure and mark a 10-foot distance along a straight section of the stream to be investigated. Drop a stick (2 or 3 inches long) in the water above the upstream marker. Record the number of seconds it takes to float downstream between the markers. Record below. Now divide the 10-foot distance by the total seconds it took the stick to float between the markers.

10 ft. / _____________ = _______________ ft.per second
(distance) (total seconds to float 10 ft,) (number of feet stick floated each second)

2. Find the average width of your section of the stream. Measure the width of the stream at 3 places within the 10-foot section. Divide the total by 3 to get the average width of the stream. If there are dry areas in the line you measure make sure you subtract the dry distance from the overall distance.

First measurement___________________feet.
Second measurement_________________feet.
Third measurement__________________feet.
Total___________feet / 3 = _____________ft. (average width)

3. Find the average depth of your section of the stream. Measure the depth of the stream in at least 3 places across the stream in a straight line. Divide the total by 3 to get the average depth of the stream.

First measurement___________________feet.
Second measurement_________________feet.
Third measurement__________________feet.
Total___________feet / 3 = _____________ft. (average depth)

4. Find the cubic feet of water per second. Multiply the average width, average depth, thickness (one foot parallel to stream side), and the number of feet the stick floated each second.

_______________ft. X ________________ft. X ________________ = ______________cfs
Average width Average depth Number of feet per second Cubic feet of water flowing per second

Note: A cubic foot of water is the water in a container 1 foot wide, 1 foot high and 1 foot long, and contains 7.48 gallons.

Complete the table and develop your solutions or mitigations for all the determined problems.

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