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Victoria Burnett

BSEN 3230 Natural Resource Conservation Engineering — Spring 2014

LAB #1: Watershed Boundary & Thiessen Method — Due: Monday 24 March, 2014 at start of class

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Objective:

1. Developing a watershed boundary from a contour map and
2. Determining weighted average rainfall by the Thiessen method. (Watershed boundary is important information to design hydraulic structures.)

*Contour lines on a contour map

Each contour line represents equal elevation. Contour lines have the following characteristics.

1. The bending section of a contour line which points toward lower elevation is a portion of ridge.
2. The bending section of a contour line which points higher elevation is a portion of valley.
3. A contour line which closes itself is either a hill top or an enclosed lowland, i.e. swamp o
   i. Hilltop – the adjacent contour line has a lower elevation.
   ii. Enclosed lowland – the adjacent contour line has a higher elevation.

Procedures to build watershed boundary and Thiessen polygons

A. Watershed boundary

1. From one end of the planned structure site, locate the nearest point on the next higher contour line. Connect the two points. This is the starting section of the watershed boundary to be built.
2. Locate the nearest point of the next higher contour line which bends toward the point found in step 1. Connect the two points. Continue this process.
3. When the watershed boundary line reaches at a contour line which closes itself, the top of a hill, divide the closed area equally or proportionally depending on the potential contribution of runoff toward the stream. This area is usually small and does not affect the overall size of the watershed.
4. Continue the above steps 2 and 3 until the W/S boundary closes on the other end of the structure. The above steps can be done from both ends of the structure until the two lines merge.
5. Now you have the watershed boundary within which all water flows into the Narrow Creek and toward the watershed outlet where the structure will be designed.

B. Thiessen method to determine weighted average rainfall

1. Draw straight lines between the gauging stations to form triangles –
   a. Do not cross the lines.
   b. Select the shorter line to connect within a rectangle.
2. Construct perpendicular bisectors of each line of the triangle. Remember that three perpendicular bisector (P-B) lines of a triangle merge at a common point.
3. The area surrounded by the perpendicular bisector lines and a portion of the watershed boundary is called Thiessen polygon which is represented by the gauging station within the polygon.

Then, the weighted average rainfall from multiple gauges is

$$P = \frac{\Sigma A_i P_i}{A} \qquad (2.11)$$

where, P is average depth of rainfall within a watershed,
A is total size of watershed,
A_i is the size of polygon i,
P_i is the depth of rainfall recorded at gauging station i,

Lab assignment:

1. Draw watershed boundary for the Narrow Creek. ✓
2. Draw Thiessen polygons for the four rain gauges at and around the watershed to calculate the weighted average of rainfall.

Location of a hydraulic structure – A water storage embankment will be installed across the Narrow Creek as shown on the attached quadrangle map. The designed top of the embankment will be 250 ft above MSL.

Report should include:

1. Watershed boundary and Thiessen polygons on the attached contour map for the designated site of the hydraulic structure to be built.
2. Please use a soft lead pencil for a clean result. Identify the polygons represented by each gauging station with colored pencil or similar method.
3. Calculate the weighted average rainfall with the following rainfall date measured at the gauging stations. Compare the weighted average with simple arithmetic average.
4. Write a mini-essay (3 paragraphs min) on why it is important, from a natural resource conservation perspective, why the delineation of a watershed boundary is crucial in the design of hydraulic structures
5. Grading will be based on the accuracy of the W/S boundary, Thiessen polygon of each gauging station and weighted average rainfall as well as the essay.

Recorded rainfall at the watershed, December 28, 2010

Gauging Station #	Size of Polygon ha	Recorded rainfall mm
1	24.5	20.7
2	11.2	30.5
3	12.5	25.6
4	48.8	18.3

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Contour intervals
Light lines - 10 ft contour interval
Dark lines - 50 ft contour interval
Scale: 1" = 1000 ft

/ Location of a hydraulic structure

X Location of Rain gauge

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Watershed Boundary and Thiessen Method Lab

March 24, 2014

Victoria Burnett

A watershed boundary is the highest point between any two or more river systems. The rain water will flow from this point downhill until it comes to a leveled off area. If water falls at any point within this boundary it will remain inside this watershed and will collect at the lowest areas. Usually all water within the watershed, except evapotranspiration, eventually reaches a dam at the outlet of the river.

Determining the watershed boundary is important in many ways. What happens upstream usually influences what happens downstream. By having knowledge of watersheds, we are able to better use the rainfall that falls in an area of land. We are also able to better protect and restore land within these watersheds.

By using estimated amounts of rainfall within a watershed, we are able to plan accordingly to restore or protect certain areas of the land. If water falls and there is any pollution on the ground, the water will runoff this area and take the pollutants with it. This same polluted water will eventually have to be cleaned for use by humans. OK

Waterfall also contributes to erosion of an area. If there is significant rainfall within a watershed, that area may need to be better examined to see the exact impacts of the rainfall so we can better protect the land. The watersheds also help because if there is a big storm coming through and hits two watersheds, one watershed might be effected more than another. Just because the watersheds are right beside one another, if there is pollutants or erosion problems in one, it does not mean the same problem is occurring in the adjacent watershed.

Lab Procedure

In this lab, I was able to use find the watershed boundaries. This was done first by locating the nearest point to the next higher contour line from the location of the hydraulic structure. From this point, I continued on until the peaks were reached. Remember, when the top of the hill is reached, divide the closed area equally or proportionally. A section of the peak should be included because water runoff from the peak directly above the watershed will still flow into the watershed.

Next, the rain gauge stations were used with the Thiessen Method to determine the weighted average rainfall. First all of the rain gauges were connected with a straight line. Then the two rain gauges that created two triangles were connected. By using the scale that one inch was equivalent to 1000 feet, the middle of the lines were determined. The math is shown below.

Rain gauge #1 and #2:

3.3" = 3300 feet. Divided by two designates the middle = 1650 feet which is 1.35"

Rain gauge #2 and #3:

2.7" = 2700 feet. Middle = 1350 feet which is 1.35"

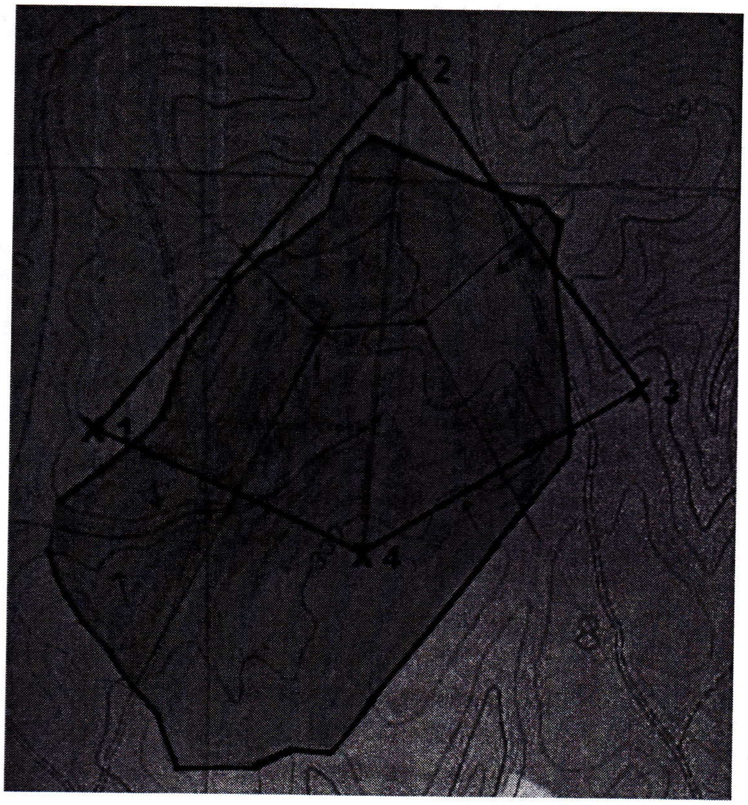
Rain gauge #3 and #4:

2.3" = 2300 feet. Middle = 1150 feet which is 1.15"

Rain gauge #1 to #4:

2.1" = 2100 feet. Middle = 1050 feet which is 1.05"

A protractor and ruler were used to follow the half way points of these original lines to the center of the watershed, at a 90 degree angle. This was done for all four midway points. The intersection of the two outside points are the separator points of the watershed. By connecting these two points and erasing the overlapping lines, I was left with four distinct parts of the watershed. The arrows on the graph indicates the direction of the watershed flow used for personal reference.



The weighted average rainfall was calculated to be 21.256mm and the arithmetic average rainfall was calculated to be 23.775mm. These are very close with 11.85% error.

Overall, this lab was educational and effective in understanding how the watershed and Thiessen Methods are used and the purpose of them.

the center of the watershed.

The intersection of the two outside points are the separator points of the watershed.

By connecting these two points and earasing any overlapping lines. you have 4 parts of the watershed.

Arrows on the graph indicate direction of waterhed flow for personell reference.

Calculate weighted average of rainfall

$$P = \frac{\Sigma A_1 P_1}{A_T}$$

$A_1 = 24.5$	$P_1 = 20.7$	$A_1P_1 = 507.15$
$A_2 = 11.2$	$P_2 = 30.5$	$A_2P_2 = 341.6$
$A_3 = 12.5$	$P_3 = 25.6$	$A_3P_3 = 320$
$A_4 = 48.8$	$P_4 = 18.3$	$A_4P_4 = 893.04$
ha	mm	ha·mm

$$P = \frac{507.15 + 341.6 + 320 + 893.04}{24.5 + 11.2 + 12.5 + 48.8}$$

$$P = \frac{2061.79}{97} = 21.256 \text{ mm}$$

Good!

The weighted average rainfall is $\boxed{21.256 \text{ mm}}$

The arithmetic average rainfall is..

$$\frac{20.7 + 30.5 + 25.6 + 18.3}{4} = 23.775 \text{ mm}$$

$$\% \text{ error} = \frac{23.775 - 21.256}{21.256}(100) = 11.85\% \text{ error}$$

Watershed

Draw the watershed first by locating the nearest pt to the next higher contour line follow them to the peaks. The peak should be included because runoff all the way to the peak (on the watersheds side) will flow into the watershed.

Remember: "When Reach top of a hill, divide the closed area equally or proportionally."

Rain gauges

connect all the rain gauges.
draw line to make 2 triangles.
Then use the scale 1" = 1000 ft
to divide the total length by 2

Rain gauge # 2 to 3 = 2.7" = 2700 ft

$$\frac{2700 \text{ ft}}{2} = 1350 \text{ ft.}$$

1 to 2 = 3.3" = 3300 ft

$$\frac{3300 \text{ ft}}{2} = 1650 \text{ ft.}$$

1 to 4 = 2.1" = 2100 ft

$$\frac{2100 \text{ ft}}{2} = 1050 \text{ ft}$$

4 to 3 = 2.3" = 2300 ft

$$\frac{2300 \text{ ft}}{2} = 1150 \text{ ft.}$$

Using protractor and ruler follow the half way points with a 90° angle from original line connecting 2 gauge stations, to