In-Class Exercise: Introduction to Watershed Morphometry Exercise

ES322 Introduction to Watershed Morphometry

Morphometric analysis of watersheds involves the quantification of the channel network and related parameters such as drainage area, gradient and relief. See attached handout p. 168-169 for overview of stream ordering and the types of morphometric calculations that are commonly used in analyzing watersheds.

Review the attached topographic map of the hypothetical Mingo Creek drainage basin. In this mythical world, the drainage divide surrounding Mingo Creek is perfectly rectangular (labeled as "drainage boundary" on the base map). Observe the landmarks, benchmarks (BM X and BM Y), and control points (A, B, C, D). The drainage network and contour lines are also shown on the map. The maximum basin elevation as measured at one of the bench marks is 1286 ft AMSL; the lowest basin elevation as measured at one of the bench marks is 1118 ft AMSL. Note each stream channel segment is labeled with a number ranging from 1 to 15.

Using ruler, engineers scale, calculator and thinking caps; calculate/determine/otherwise answer the following questions related to watershed morphometry and channel configuration. SHOW ALL OF YOUR MATH WORK AND UNIT ALGEBRA!!

1. Which direction is the Mingo Creek drainage flowing? Explain your answer.

   South, V's point upstream, tributaries feed to south

2. What is the elevation of BM "X"

   1286 ft

3. What is the elevation of BM "Y"   Relief =

   1118 ft

4. Calculate the fractional scale of the map.

   $\frac{2.4 \text{ cm}}{4 \text{ km}} \times \frac{1 \text{ km}}{1000 \text{ m}} \times \frac{1 \text{ m}}{100 \text{ cm}} = \frac{2.4 \text{ cm}}{400,000 \text{ cm}} = 1 : 166,667$

5. Given the contour interval, label the elevation of each contour line on the map.

   ✓

6. Calculate the stream gradient in m/m (dimensionless ratio) between the following control points:
   a. A to D   a) $\frac{21.8 \text{ cm}}{3} \times 166,667 \times \frac{1 \text{ m}}{100 \text{ cm}} = 12111 \text{ m} \times$
   b. B to D
   c. A to C
   d. B to C
   e. C to D   See attached

7. Using a red colored pencil, draw the internal drainage divide for the Whiskey Run sub-basin.

8. Examine the grid network on the base map,
   a. what is the map distance between each tic in the Easting direction? (inches)
   b. What is the ground distance between each tic in the Easting direction? (meters)
   c. What is the map distance between each tic in the Northing direction? (inches)
   d. What is the ground distance between each tic in the Northing direction? (meters)

   See attached

9. What is the total basin relief of the drainage basin? (in feet? In meters? In km?)

See attached

10. Calculate the total drainage area for the Mingo Creek Basin:
    a. Square meters: 9.0×10^8
    b. Hectares: 90,000
    c. Square km: 900
    d. Square mi: 347.6 mi²
    e. Acres: 2.22×10^5

11. On the map, label each stream segment with the corresponding Strahler Stream Order. Fill in the data table below:

Channel ID	Order	Length (m)	Gradient (m/m)
1	4		
2	3		
3	2		
4	1		
5	1		
6	2		
7	1		
8	1		
9	3		
10	2		
11	1		
12	1		
13	2		
14	1		
15	1		

See attached

Total Stream Length (m) 114182 m
Total Stream Length (km) 114.2 km

12. Calculate the sub-basin area for Whiskey Run, upstream from control point C:
    a. Square meters:
    b. Hectares:
    c. Square km:
    d. Square mi:
    e. Acres:

Need Planimeter

13. Calculate the drainage density (total stream length / basin area) for the entire Mingo Creek basin (km^{-1})

~~Planimeter~~

$$\frac{114.2\ km}{900\ km^2} = 0.127\ km^{-1}$$

14. What is the highest stream order attained in the entire Mingo basin?

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15. Calculate the drainage density (total stream length / basin area) for the Whiskey Run sub-basin (km^{-1})

Need planimeter for sub-basin.

16. What is the highest stream order attained in the Whiskey Run sub-basin?

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17. Calculate the Basin Ruggedness for the Mingo Creek basin (drainage density x basin relief) (km^{-1} * km)

0.127 km^{-1} x .512 km = 0.065

18. Plot the follow X-Y Graphs based on your data:
    a. Gradient (Y axis) vs. Stream Order (X axis)
    b. Stream Length (Y axis) vs. Stream Order (X axis)

Part 2. Thinking Questions... to follow in separate handout

6) a) $\overline{AD} = \frac{21.8\text{ cm}}{3} \times 166{,}667 \times \frac{1\text{ m}}{100\text{ cm}} = 12111\text{ m}$ $(1235\text{ ft} - 1120\text{ ft}) \times \frac{1\text{ m}}{3.28\text{ ft}} = 35.1\text{ m}$

$$\frac{35.1\text{ m}}{12111\text{ m}} = 2.89 \times 10^{-3}$$

b) $\overline{BD}$ $\frac{19.9\text{ cm}}{3} \times 166{,}667 \times \frac{1\text{ m}}{100\text{ cm}} = 11056\text{ m}$ $(1240\text{ ft} - 1120\text{ ft}) \times \frac{1\text{ m}}{3.28\text{ ft}} = 36.6\text{ m}$

$$\frac{36.6\text{ m}}{11056\text{ m}} = 3.31 \times 10^{-3}$$

c) $\overline{AC}$ $\frac{14.7\text{ cm}}{3} \times 166667 \times \frac{1\text{ m}}{100\text{ cm}} = 8167\text{ m}$ $(1235\text{ ft} - 1155\text{ ft}) \times \frac{1\text{ m}}{3.28\text{ ft}} = 24.4\text{ m}$

$$\frac{24.4\text{ m}}{8167\text{ m}} = 2.99 \times 10^{-3}$$

d) $\overline{BC}$ $\frac{14.5\text{ cm}}{3} \times 166{,}667 \times \frac{1\text{ m}}{100\text{ cm}} = 8056\text{ m}$ $(1240\text{ ft} - 1155\text{ ft}) \times \frac{1\text{ m}}{3.28\text{ ft}} = 25.9\text{ m}$

$$\frac{25.9\text{ m}}{8056\text{ m}} = 3.22 \times 10^{-3}$$

e) $\overline{CD}$ $\frac{7.1\text{ cm}}{3} \times 166{,}667 \times \frac{1\text{ m}}{100\text{ cm}} = 3944\text{ m}$ $(1155\text{ ft} - 1120\text{ ft}) \times \frac{1\text{ m}}{3.28\text{ ft}} = 10.7\text{ m}$

$$\frac{10.7\text{ m}}{3944\text{ m}} = 2.71 \times 10^{-3}$$

8) a) $\frac{1}{10}$ in

b) $\frac{1}{10 \text{ in}} \times 166667 \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 423 \text{ m}$

c) $\frac{1}{10}$ in

d) 423 m

9) 1,286 ft − 1118 ft = **168 ft**

$168 \text{ ft} \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 51.2 \text{ m} \times \frac{1 \text{ m}}{1000 \text{ km}} = 0.512 \text{ km}$

10 $6.2 \text{ in} \times 166667 \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 26253 \text{ m}$

$8.1 \text{ in} \times 166667 \times \frac{1 \text{ ft}}{12 \text{ in}} \times \frac{1 \text{ m}}{3.28 \text{ ft}} = 32299 \text{ m}$

} $9.00 \times 10^8 \text{ m}^2$

$9.0 \times 10^8 \text{ m}^2 \times \frac{1^2 \text{ km}^2}{1000^2 \text{ m}^2} = 900 \text{ km}^2$

$900 \text{ km}^2 \times \frac{1^2 \text{ mi}^2}{1.609^2 \text{ km}^2} = 347.6 \text{ mi}^2$

$900 \text{ km}^2 \times \frac{100 \text{ Hectares}}{1 \text{ km}^2} = 90{,}000 \text{ Hectares}$

$900 \text{ km}^2 \times \frac{1 \text{ acre}}{.00405 \text{ km}^2} = 2.22 \times 10^5 \text{ acres}$

Stream

1. ~~13,333 m~~ ~~4444 m~~ ~~1.83~~ $\frac{8}{3}$ in × 166667 × $\frac{1 \text{ ft}}{12 \text{ in}}$ × $\frac{1 \text{ m}}{3.28 \text{ ft}}$ = ~~7763 m~~ 11292 m
2. 7763 m
3. 6351 m
4. 3451 m
5. 3951 m
6. 10727 m
7. 3951 m
8. 5504 m
9. 7763 m
10. ($\frac{13}{3}$ in ×) = 18349 m
11. 5504 m
12. 5646 m
13. 11715 m
14. 5787 m
15. 5928 m

total: 114182 m × $\frac{1 \text{ km}}{1000 \text{ m}}$ = 114.2 km