National University of Lesotho

Faculty of Agriculture – Department of Soil Science

Final Examination

SSR 325 – Watershed Management

May 2016 **100 Marks** **Time: 3 Hours**

Instructions:

This paper contains Seven (7) questions

Answer Five (5) questions ONLY

Section B question 3 is compulsory

Take at least one question from each section

Section A

Question 1 (20 marks)

a) Compare and contrast the hydrological and socio-political concept of a watershed (5 marks)
b) Compare and contrast a watershed and a river basin and give relevant examples (5 marks)
c) Discuss the functions and services of watersheds in the context of Lesotho (5 marks)
d) Discuss some conflicting and competing demands on watershed citing contextual examples for Lesotho (5 marks)

Question 2 (20 marks)

a) Discuss the following concepts in watershed management citing specific examples for Lesotho (10 marks each)

   i) Protection strategies
   ii) Conservation strategies

b) State and discuss four major watershed concerns for Lesotho watershed management (10 marks)

Section B

Question 3 (20 marks)

Compulsory

Hydrologic analyses concerning supply and floods require an estimate of the average depth of precipitation over a drainage basin during a storm, a year, or some other period. Spatial averages of hydrologic quantities measured at a point also need to be treated in this way. This typical problem, therefore, is concerned with calculation of the average precipitation over the drainage basin outlined in Fig. 2.4 from the plotted measurements at 9 rain gauges.

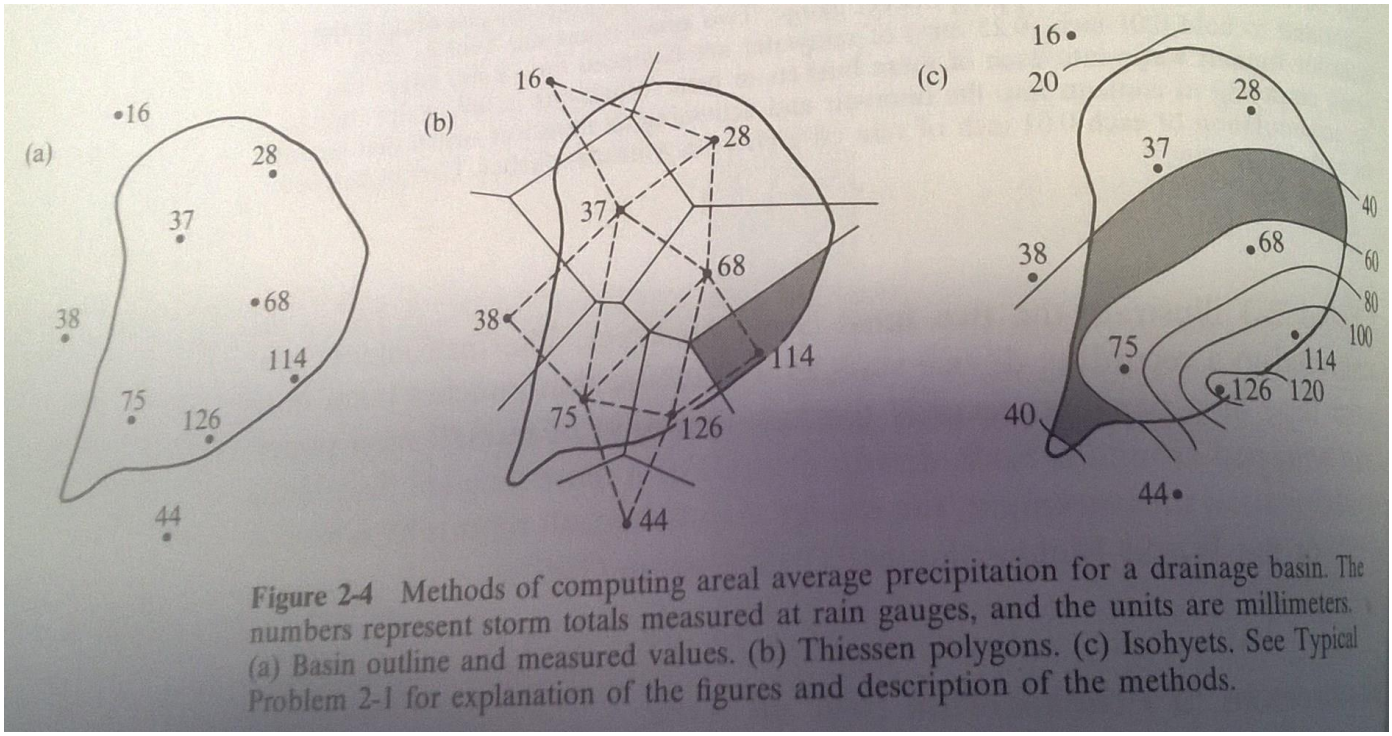

Figure 2-4 Methods of computing areal average precipitation for a drainage basin. The numbers represent storm totals measured at rain gauges, and the units are millimeters. (a) Basin outline and measured values. (b) Thiessen polygons. (c) Isohyets. See Typical Problem 2-1 for explanation of the figures and description of the methods.

a) Calculate the arithmetic average using only the rain gauges within the basin (5 marks)

b) Calculate the Thiessen-weighted average (Fig. 2.4b) (5 marks)

Data for calculating the Thiessen-weighted average rainfall				
Rainfall at Gauge (mm)	Area of Polygon (km^2)			
16	0.15			
28	0.89			
73	1.05			
38	0.15			
68	1.10			
75	0.85			
114	0.41			
126	0.15			
44	0.00			
Total				

c) Calculate the isohyetal average precipitation (Fig. 2.4c). (10 marks)

Data for calculating the isohyetal average precipitation			
Isohyetal Range (mm)	Average rainfall between isohyets (mm)	Area of each isohyet	
20-40	30		
40-60	50	1.4	
60-80	70		
80-100	90		
100-120	110		
120-126	123		
Total	-		

Section C

Question 4 (20 marks)

a) Hillslopes cover the whole landscape. They are a land to be managed for forestry, agriculture, urban and road construction. Failure to manage these landscapes properly could lead to catastrophes such as landslides or mass wasting.

i) Define the concept of mass wasting (2 marks)
ii) Interpret the statement: “The stability of hill slopes is constantly in a state of approximation”. (3 marks)
iii) State four factors contributing to mass wasting and briefly discuss how each of these factors effects the process. (10 marks)
iv) Mention five types of mass wasting and provide a brief explanation for each (5 marks)

Question 5 (20 marks)

Water balance/ budget is the balance between the inflows of water from precipitation and outflows of water by evaporation, transpiration, groundwater recharge and stream flow. It could be calculated using this equation:

$$\mathbf{P = I + AET + OF + \Delta SM + \Delta GWS + GWR}$$

However, due to constraints of time and resources, some of these components could not be measured, except for rainfall, interception and evapotranspiration which are easily measured. Thus water balance is easily determined by way of examples.

a) Data for rainfall, potential evapotranspiration and soil moisture content were determined from a certain area. Annual rainfall for this area was 1840 mm, soil texture was clay-loam with a rooting depth of 0.80 m. Available water capacity was 200 mm. From Table 1 below, fill some of the missing data for change in soil moisture (ΔSM), actual evapotranspiration (AET), water deficit (D) water surplus (S) as the components of water balance. (15 marks)

Table 1. Long-term average monthly water balance at Mahobong, Leribe, for a soil with an available water capacity of 200mm. The soil is a clay-loam under sorghum production with a rooting depth of 0.80m. All the values in the table are in millimeters.

(mm)	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec	Year
P	65	95	155	270	250	155	150	180	155	140	130	95	1840
PET	138	138	150	108	114	114	108	108	114	126	114	132	1464
P – PEP	-73	-43	5	162	136	41	42	72	41	14	16	-37	376
Acc. Pot WL	-110	-153	0	0	0	0	0	0	0	0	0	-37	
SM	115	92	97	200	200	200	200	200	200	200	200	166	
ΔSM													
AET													1419
D													45
S													421
Tot. avail. For RO	13	7	3	59	165	124	104	124	103	65	49	25	
RO	6	4	2	30	82	62	52	62	52	32	24	12	420
Detention	7	3	1	29	83	62	52	62	51	33	25	13	

P= precipitation; PET=potential evapotranspiration; P – PET = difference by subtraction; Acc. Pot. WL=accumulated potential water loss derived by accumulating negative values in row 3; SM=Soil moisture; ΔSM=change in soil moisture during the month; AET = actual evapotranspiration; D=Soil moisture deficit; Soil moisture surplus; RO=runoff; Tot. available for RO=Total available water for runoff

b) Provide a brief discussion that shows the applications of water balance in watershed planning. (5)

Question 6 (20 marks)

Interception is one component of hydrologic cycle, though there are different school of thoughts as to whether it is a loss or gain in the whole cycle. However, it is important in water use planning especially in agriculture. Assuming a gross rainfall of 275 mm and 10% of that gross rainfall is lost through evaporation.

a) If 36% of the remaining rainfall after evaporation loss becomes intercepted, what is the actual amount of intercepted rainfall in mm? (5 marks)

b) Of the intercepted amount of rainfall (mm), assume 70% to be a through fall, 25% to be a stem flow and the amount of rainfall reaching the ground was 80.19 mm. What is the amount of rainfall in mm that was lost through a litter interception? (15 marks)

Question 7 (20 marks)

a) Though watershed management is part of hydrology, watershed planners do not concentrate much on engineering aspects but rather on the fundamentals and basics that are of importance to planning. From the list below, match each process with its appropriate definition (1 mark each).

i) Laminar flow
ii) Wetting front
iii) Runoff
iv) Base flow
v) Interception storage
vi) Percolation
vii) Storm flow
viii) Water saturation
ix) Available water capacity
x) Interception loss

A. …… A clear water divide with a wetted region overlying a drier region.
B. ……. A type of water flow in a river which the velocity at a given point varies erratically in magnitude and direction
C. …… A process resulting from the inability of soil in a given condition to absorb a portion of rainfall storm after a portion of it has been infiltrated.
D. ……Water that subsequently evaporates back into the atmosphere before reaching the ground surface after lodging on leave canopy and litter.
E. …….A rainfall water that collects over the hillslope and reaching the stream channel resulting in high rates of discharge in the channel

b) From the following questions, which is the correct answer? (1 mark each)

i) Infiltration is a controlled process. Which of the following is a factor NOT a controlling infiltration?

A. Soil Shear strength
B. Rainfall frequency
C. Soil particle density
D. Soil bulk density
E. Both A and C
F. Both A and D

ii) Control of sediment load and transport into the water reservoirs through buffer strips along the rivers is one of the land management used to maintain water quality. Which of the following from the list below is NOT a type of sediment load?

A. Wash load
B. Bed load
C. Saltation load
D. Brownian load
E. Suspension load

iii) Infiltration capacity curve is a graph showing the time variation of infiltration if water supply were continually in excess of infiltration capacity. Which of the following affects the shape of the curve?

A. Soil properties
B. Soil management
C. Land use
D. Tillage regimes
E. All of the above

iv) For a particle to be suspended in a flow water to form a sediment load, they are different forces acting together to keep it in suspension. Which of the following is not such a force?

A. Buoyancy force
B. Fluid drag force
C. Gravitational force
D. Particle resistance force
E. Particle aerodynamic force

iv) Once the rainfall water has entered the soil, it is subject to different forces acting on it to determine its storage and fate. Of the following types of forces, one is NOT such a force. Which one is it?

A. Gravitational force
B. Frictional force
C. Osmotic force
D. Capillarity force
E. Tension force

c) For the following questions, show whether the statement is true or false. (1 mark each)

i) Base flow is the rainfall water that flows over the land after a portion of it infiltrates into the soil while the remaining portion infiltrates into the soil……. T / F

ii) When rainfall water gets to the ground, it is subject to different paths before reaching streams, rivers and lakes. Groundwater flow is one such a path…… T / F

iii) Horton overland flow results when the groundwater becomes a return flow and thus combining with the direct precipitation on saturated area to become an overland flow…… . T / F

iv) Sub-surface overland flow is a combination of return flow and direct precipitation falling on saturated area……. T / F

v) Hydrograph is a graph that shows a rate of runoff (discharge) plotted against time for a particular point in a channel or hillslope …… T / F

vi) Terminal fall velocity is the point at which the river or channel loses its fluid drag force and thus depositing the sediment load……. T / F

vii) Recession limb forms part of the hydrograph. On the hydrograph, it is that part showing the retreating water from the storage built up during the earlier phase of runoff …… T / F

viii) Though saturated overland flow constitutes two processes, namely return flow and direct precipitation on saturated area and thus becoming an overland flow, its flow velocity is smaller than that of Horton overland flow……. T / F

ix) Soil creep is a type of mass wasting that occurs along a surface or within a narrow zone of hillslope deformation…… T / F

x) Gelisols are the type soils that normally become part of landslide when Solifluction occurs ____T/F