National Exams May 2010

04-Agric-B6, Irrigation, Drainage, & Erosion Control

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.

2. This is an OPEN BOOK EXAM.
   Any non-communicating calculator is permitted.

3. Any THREE (3) questions constitute a complete exam paper.
   The first three questions as they appear in the answer book will be marked.

4. Each question is of equal value.

5. One question (Number 1) requires answers in essay format. Clarity and organization of the answer are important.

6. Three questions require answers involving calculations. Clarity and organization of the answers are important.

1.1 Sketch soil water characteristics (soil water retention) and drainable porosity curves. Label the axes and describe the differences between them .

1.2 Drainable porosity and specific yield are often interchangeably used in design of drainage systems. Does it mean that they represent the same term? Explain why or why not?

1.3 Suppose you have been hired as a specialist in soil and water conservation engineering by the Ontario Ministry of Agriculture and Food. One of your responsibilities is to advise farmers regarding water management practices. A land owner with agricultural property, has experienced drought in a 50 ha field under cash crops cultivation during some summers. Her neighbour has advised her to irrigate this field. She wants your advice. **Clearly** identify the range of information which you would give to the land owner for irrigating this 50 ha field.

1.4 A farmer is using trickle irrigation to irrigate fruits and vegetable crops. The system worked well in the beginning but now the spatial application is not uniform. Preliminary investigations showed that there is a problem of clogging in the system. **Describe** the possible causes of clogging of emitters and pipe lines in his trickle irrigation system..

1.5 Sprinkler irrigation design procedure depends on the use of soil moisture reservoir and on varying the frequency of irrigation to meet the water demand. **Explain briefly**, how the trickle irrigation concept differs from sprinkler irrigation.

2. After graduation you have joined an Engineering Consulting company. Your primary responsibility is to design soil and water conservation systems. A rural land owner has approached your company for design of soil conservation systems on a 2000 ha farm.

2.1 A 60 ha field in this farm needs drainage. The drainage coefficient for soil and cropping system is 12.5 mm/d. The possible outlet available for this field a municipal (outlet) drain which could be connected to this field either with a ditch or by an underground concrete main.

a) **What flow rate** should the ditch or concrete main be designed for? List necessary assumptions required to provide a numerical answer.

b) If the concrete main is selected to transport water to the outlet drain **what would be** the adequate size to handle the drainage rate for this field? The available slope between the field and the outlet drain is 0.6%. The Manning's n for concrete is 0.011. Make and state any necessary assumptions,.

c) Is the design of the concrete main (in question 2.1c) a case of **design of a pipe on steep slope**? Give numerical justification for your answer.

2.2 A tile drainage system has been installed in a 30 ha field in this farm with silt loam soil

which has a saturated hydraulic conductivity of 0.6 m/d. The drain spacing is 20 m, the drain (tile) depth is 122 cm, and the effective or "equivalent" depth to an impermeable layer below the tile is 0.55 m. The laterals are 500 m long.

What minimum depth of watertable will be maintained if a drainage coefficient of 12.5 mm/d was used in the design? All distances are measured to the centre of the tile (pipe drain)..

2.3 A trapezoidal grassed waterway with a side slopes of 4:1 (H:V) has been proposed for soil and water conservation purposes on this farm. Hydrologic analysis has indicated that the waterway should be designed to handle a design flow of 5.66 m^3/s. The dominant soil along the proposed route (slope 3%) of the waterway is erosion resistant. The vegetation in the proposed waterway will be Bermuda grass which falls into retardance class D when mowed and retardance class B when unmowed. The maximum permissible velocity to design a stable channel for the soil and topographic conditions is 2.4 m/s. (20)

Determine the dimensions (base width and depth) of the grassed waterway to convey this discharge.

Approximate channel depth increment for grassed waterway with retardance increase from Class C (short) to Class B (long).

Slope Range, %	Channel correction and width		
	Triangular t = 2 to 6 m	Parabolic t = 6 to 27 m	Trapezoidal b = more than 27 m
	Trapezoidal b = 2 to 6 m	Trapezoidal b = 6 to 27 m	
	Incremental depth, m		
1 - 2	0.17	0.15	0.12
2 - 5	0.13	0.12	0.09
5	0.10	0.09	0.06

Note: For a change from retardance class D to retardance class B, add 0.03 m to the above values for all slopes and cross sections. For a change from retardance class D to retardance class C, use 0.03 m as the incremental depth for all slopes and cross sections.

3.1. A 10 ha cropped field (peak evapotranspiration demand 5 mm d^{-1} and rooting depth of 915 mm) has been irrigated by a hand moved portable sprinkler irrigation system. The soil in this field is a loam with field capacity soil water content (θ_{fc}) of 21% by volume and wilting point water content (θ_{wp}) of 7% by volume. Sprinklers each discharging 30 L/min, are used at 12.2

m spacing. The lateral spacing is 12.2 m. The irrigation efficiency is 70% and irrigation starts with 50% depletion of soil water reservoir.

Determine

a) The available soil water (moisture) capacity of the soil.
b) Maximum duration of the irrigation cycle.
c) Depth of water to be applied during each irrigation.
d) The quantity of water needed from the source, if the sprinkler system operates 12 hr/day each day during the irrigation cycle.
e) The rate of application of irrigation.

State any assumptions needed to complete the calculations:

3.2. Two irrigation systems have been installed to irrigate an apple orchard and a tomato field from a source of irrigation water with a pumping plant. The irrigation system for the apple orchard is a solid set sprinkler irrigation system and the tomatoe field is irrigated by a portable sprinkler system. Design specifications for these systems are given below.

Data/Specifications	Solid Set System	Portable System
Crop	Apple	Tomatoes
Area	10 ha	4 ha
Soil	Silt loam	Loam
Available Moisture Capacity over root zone	169 mm/m	125 mm/m
Rooting depth	900 mm	600 mm
ET	6.5 mm/d	5 mm/d
Duration of irrigation cycle	12 days	6 days
Depth of irrigation	108 mm	54 mm
Maximum hours of operation per day	No limit	8

Design of these systems indicated that due to more water demand for apples, the total dynamic head allowed in the solid set system is 1.5 times the total dynamic head in the portable system.

Determine how many hours each system should be operated per day. Give justifications for your answer. Assume for both systems that the pump operates at the same efficiency. Due to limited water supply, overlapping of operations of the two systems is not allowed .

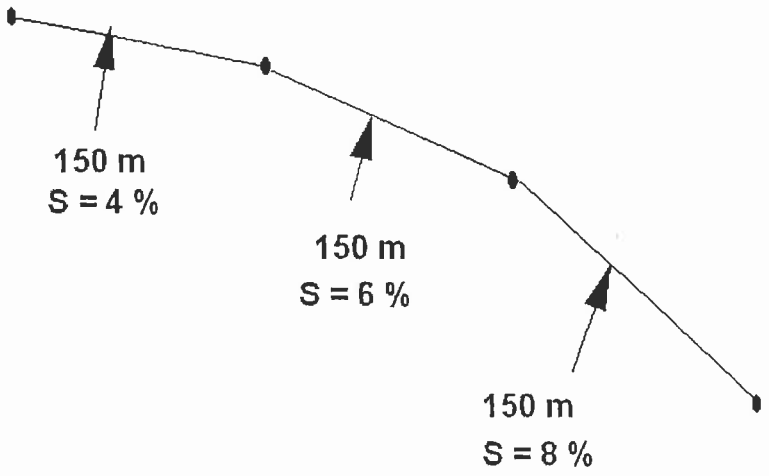
4. An owner of a farm near London, Ontario **needs an estimate of soil loss** (rate and amount) to develop conservation planning strategies for another 20 ha field. A slope profile, shown in Figure 1, covers the entire field. The particle size distribution data for the soil in this field

(Guelph loam) are given in Table 1.

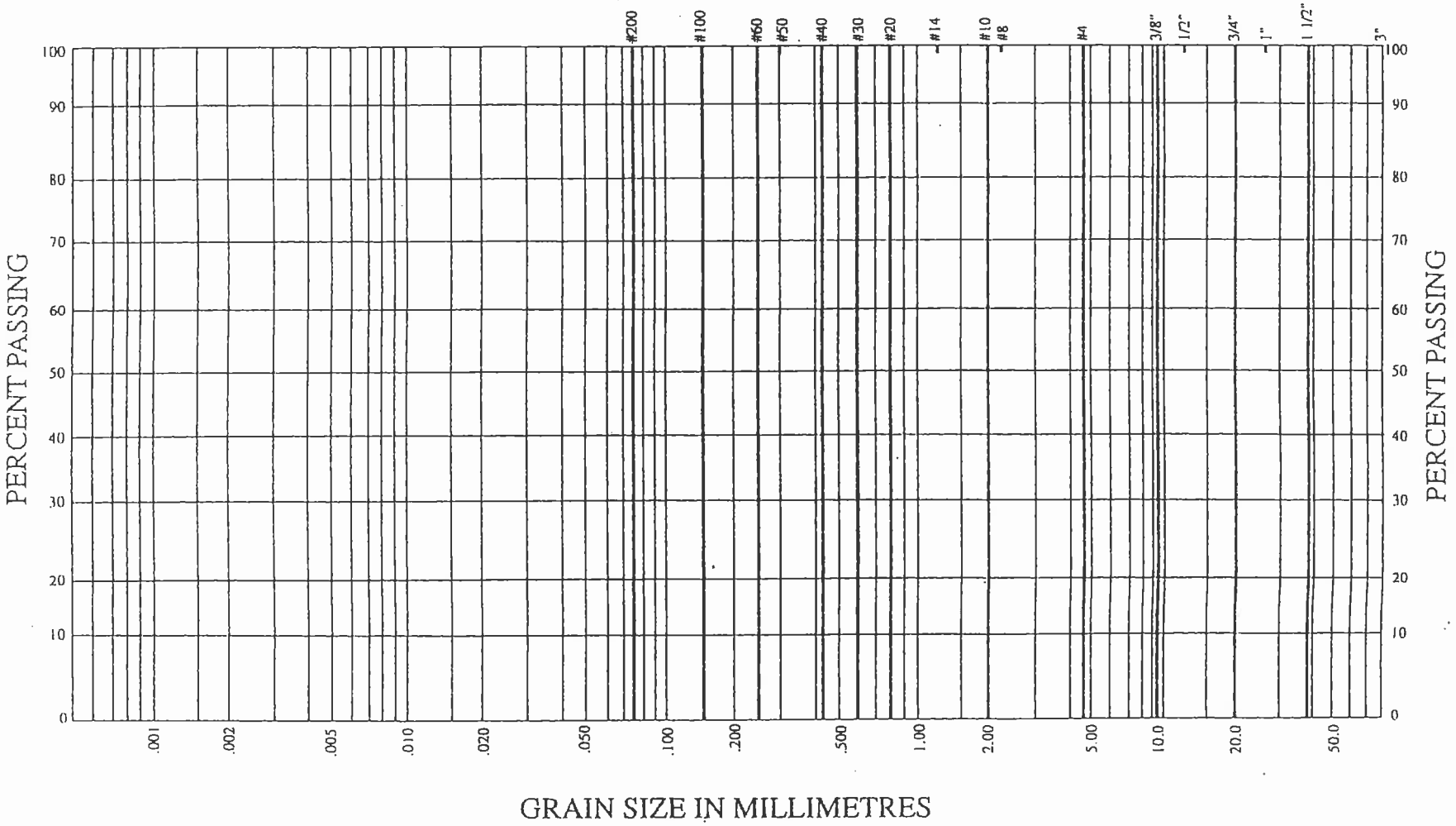
Table 1. Particle Size Distribution Data

Particle Size, mm	Percent
1.0 - 2.0	2.0
0.5 - 1.0	6.1
0.25 - 0.5	8.5
0.10 - .25	8.4
0.05 - 0.10	20.3
0.01 - 0.05	15.7
0.005 - 0.01	11.6
0.002 - 0.005	10.4
0.001 - 0.002	8.7
< 0.001	8.3

The organic matter content in the surface horizon is 3%.



At present, there is no conservation practice on this field. A Soil Conservation Specialist has recommended a 0.45 value for the Crop Management Factor for the present land use (corn) and land management conditions. Assume an R factor of the Universal Soil Loss Equation for London, Ontario is 1700 in SI units (100 in English units).


#200
#100
#60
#50
#40
#30
#20
#14
#10
#8
#4
3/8"
1/2"
3/4"
1"
1 1/2"
3"
100
90
80
70
60
50
40
30
20
10
0
PERCENT PASSING
.001
.002
.005
.010
.020
.050
.100
.200
.500
1.00
2.00
5.00
10.0
20.0
50.0
GRAIN SIZE IN MILLIMETRES