MACHAKOS UNIVERSITY

University Examinations for 2021/2022

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF BUILDING & CIVIL ENGINEERING

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (CIVIL ENGINEERING)

ECV: 410: IRRIGATION ENGINEERING 11

DATE: **TIME:**

INSTRUCTIONS

- *This paper comprises of FIVE questions. Answer **THREE** questions*
- *Question one is **compulsory** and carry 30 marks*
- *Answer any other **TWO** questions*

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define the term surface irrigation. (2 marks)
b) Discuss the effects of poor drainage. (2 marks)
c) Discuss with illustrations, the four (4) distinct hydraulic phases as used in the design of surface irrigation systems. (6 marks)
d) With a use of a well labelled diagram, explain the various components of Total Dynamic Head (TDH) (4 marks)
e) Discuss the design criteria that must be satisfied while designing a land drainage system. (4 marks)
f) Outline the main procedures that you would follow when designing a complete sprinkler irrigation system. (6 marks)

g) An irrigation scheme of 100 ha with sandy loam soils and a general slope of less than 5% has a main drain of 2.5 km long with a difference in elevation of 10 m.

(i) Calculate the time of concentration? (3 marks)

(ii) If the rainfall with a time of concentration as calculated in (i) above is estimated at 8.5mm with a return period of 5 years, what would be the design discharge of the drain if the runoff coefficient is 0.30. (3 marks)

QUESTION TWO (20 MARKS)

a) From the manufactures catalogue, the following was derived for a 4lph emitter, the emitter exponent x is 0.42, q =4lph at H=10M.The desired average flow rate for the most economical option, with the 4lph emitter is 4.32lph. Calculate the pressure required to deliver the 4.32lph. (2 marks)

A certain crop under drip irrigation has spacing of (6*6) m with a percentage wetted area of 50%. The area wetted by one emitter is $4m^2$.

i) What will be the number of emitters per plant? (2 marks)

ii) Assuming that you are using a single lateral with emitter spaced along the lateral at equal distances. Calculate the emitter spacing. (2 marks)

b) Discuss the factors to consider when designing a furrow length (4 marks)

c) A 20-hectare area has medium texture loam soil grown with beans. Daily water use of beans is 6.2 mm/day. The available soil moisture is 120 mm/m. The allowable soil moisture depletion is 50%. The crop root zone depth is 0.8 m. Soil infiltration rate is 6 mm/hr. The other climatic data are: average wind speed 10 km/hr.

i) Determine the maximum net depth of water application. (2 marks)

ii) Determine the Irrigation Frequency (IF) and cycle. (2 marks)

iii) Using an application efficiency of 75%, calculate the gross depth of water application (2 marks)

iv) The volume of irrigation water needed to bring the moisture content to the field capacity. (2 marks)

v) Assuming that the irrigation system operates for 11 hours per shift. Two shifts per day during peak demand is used in each irrigation cycle of 7 days to complete irrigation in 20 ha area. Determine the capacity of irrigation system. (2 marks)

QUESTION THREE (20 MARKS)

a) Outline the major components of surface irrigation systems. (2 marks)

b) In modern drip irrigation systems, what are some of the major emitter characteristics that affect the system efficiency that should be considered during emitter selection process. (3 marks)

c) A proposed sprinkler irrigation system requires a flow rate of 70 m^3/hr against a total dynamic head (H) of 40 m. The pump will be located at an elevation of 1500m above mean sea level, the static suction is 2.2 m, the frictional head loss in the suction line is 1.1 m and prevailing air temperatures at the site is 30^0C (vapour pressure = 0.43 m)

i) Explain how you would develop a system curve to enable you get the (Q, H) for the proposed system. (3 marks)

ii) What does the determination of (Q, H) imply about the design process of a pumped irrigation system? (2 marks)

iii) Using the information given in (c) above and the characteristics curves provided for the three centrifugal pumps model A, B and C, redraw and fill up the following table. (5 marks)

Parameter	Pump A	Pump B	Pump C
Net Positive Suction Head Required (NPSHR)			
Net Positive Suction Head Available (NPSHA)	4.98	4.98	4.98
Efficiency (%)			
Brake Power (BP) - kW			
Impeller diameter			

iv) Which pump among the three would you select and why? (3 marks)

v) What modification if any would you suggest for the selected pump? (2 marks)

QUESTION FOUR (20 MARKS)

a) Define the following terms

i. Time of concentration (2 marks)

ii. Runoff coefficient (2 marks)

b) Discuss the common problems that can reduce the field application efficiency in surface irrigation methods. (4 marks)

c) A sprinkler irrigation system is to be designed for a flat rectangular field measuring (600*300) m. The soil is medium loam with a basic infiltration rate of 6mm/hr. The crop water requirement is 5.9mm/day. The available moisture is 140mm/m and maximum allowable depletion (MAD) is 50%. The effective root zone depth is 75 cm and irrigation efficiency of 75%. Stating the appropriate assumptions and adopting a convenient layout, determine the preliminary system capacity (4 marks)

d) The net peak crop water requirement for a scheme is 6.0mm/day. The available moisture for the clay loam is 120mm/m and depletion is allowed up to around 50%. The root zone depth is 0.9m.

i. After how many days should irrigation take place to replenish the soil moisture. (3 marks)

ii. Using the infiltration curves provided and assuming a field application efficiency of 70%, what is the gross irrigation requirement and the time required to replenish the soil moisture calculated above. (3 marks)

iii. After how long should the water reach the end of the furrow assuming a non-erosive furrow length of 100m. (state the assumption). (2 marks)

QUESTION FIVE (20 MARKS)

a) Discuss the functions of the following hydraulic structures in a typical surface irrigation system.

i) Head works for river offtakes (2 marks)

ii) Division boxes (2 marks)

iii) Drop structures (2 marks)

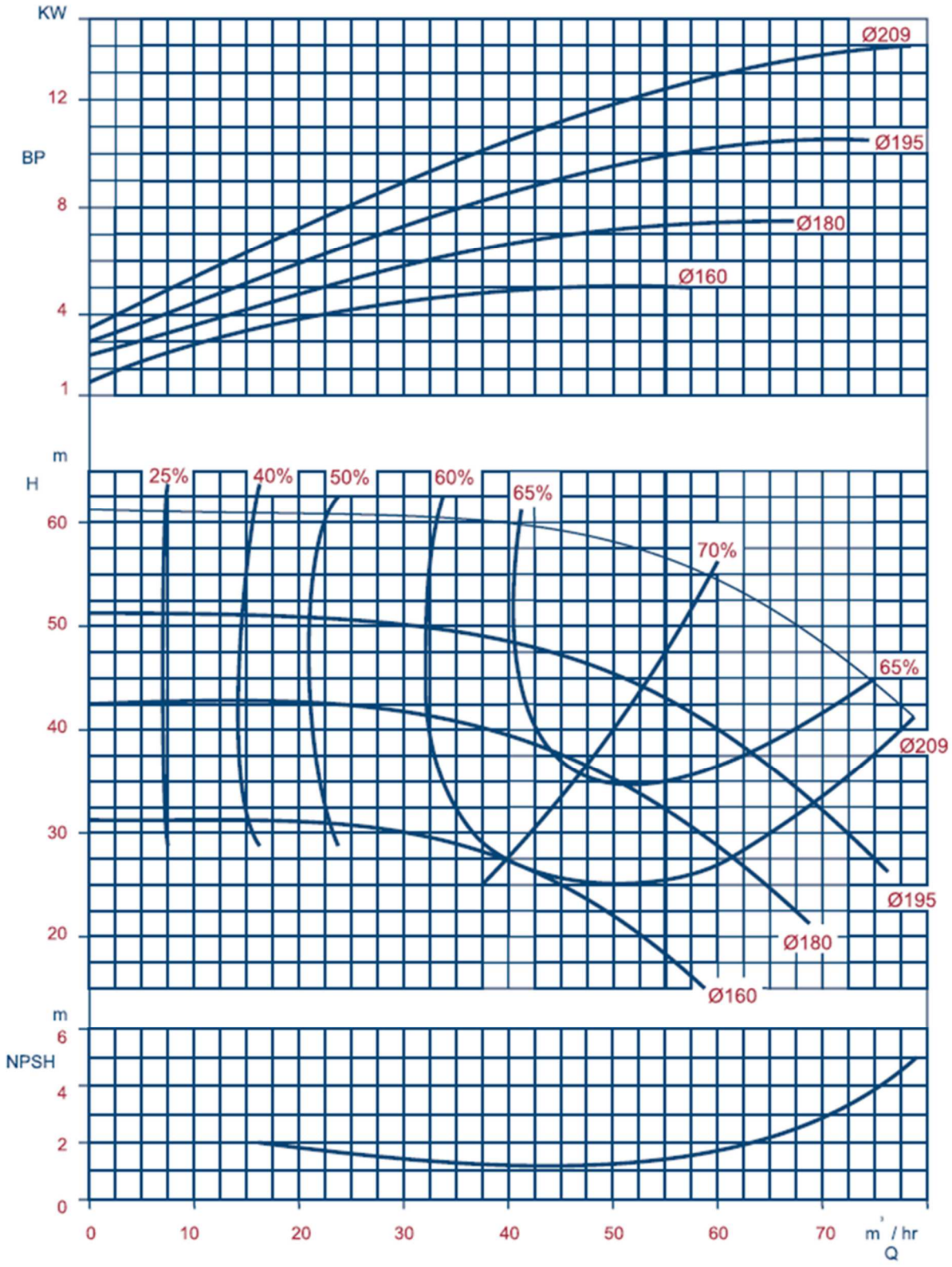
iv) Diversion and side weirs (2 marks)

v) Crossing like bridges, culverts and inverted syphons (2 marks)

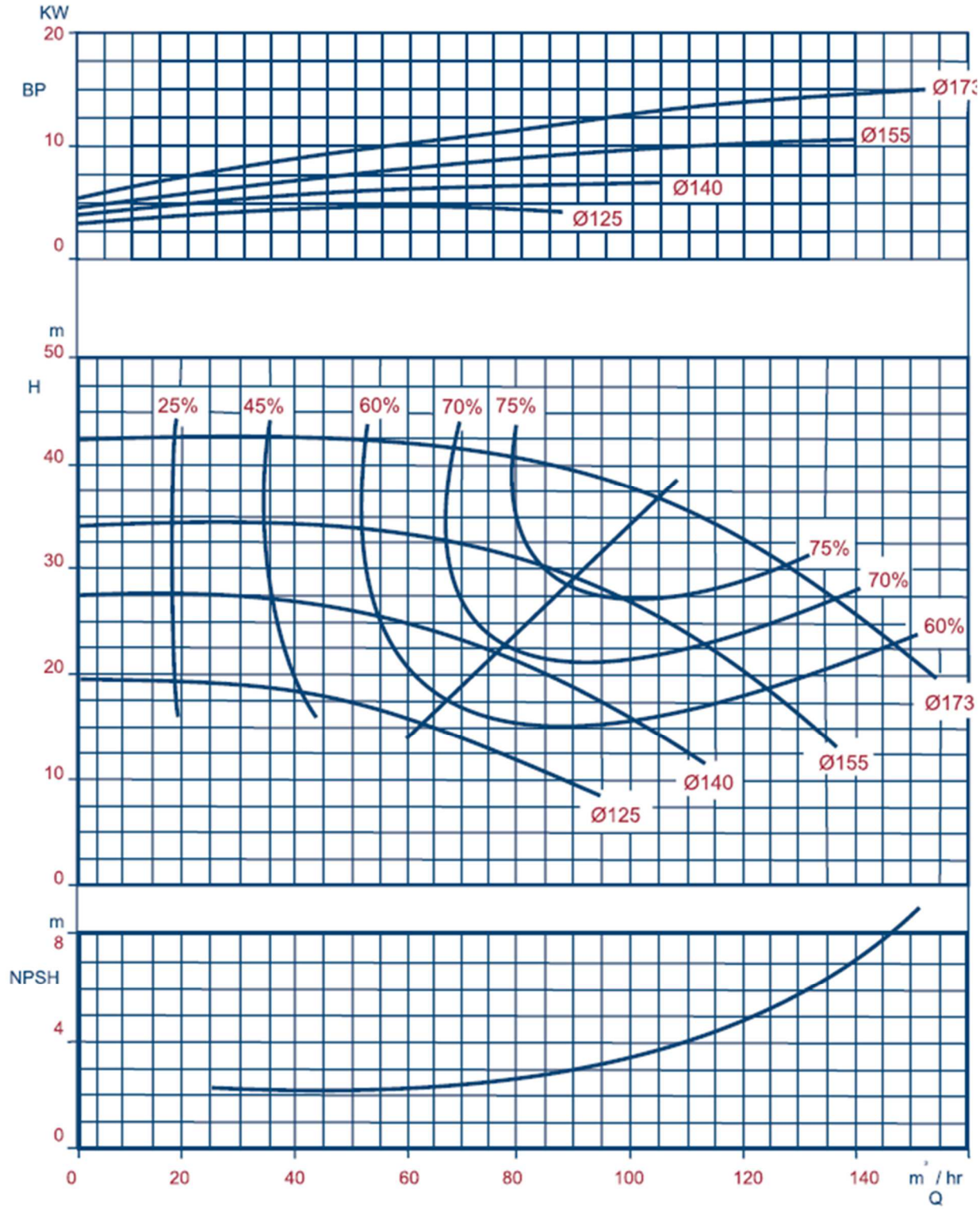
b) Define the term cavitation in irrigation pumps and explain how it can be avoided. (3 marks)

c) The efficiency of pumps is very important for safe delivery of irrigation water to the irrigation fields. Discuss the factors that influences efficiency of a pump. (3 marks)

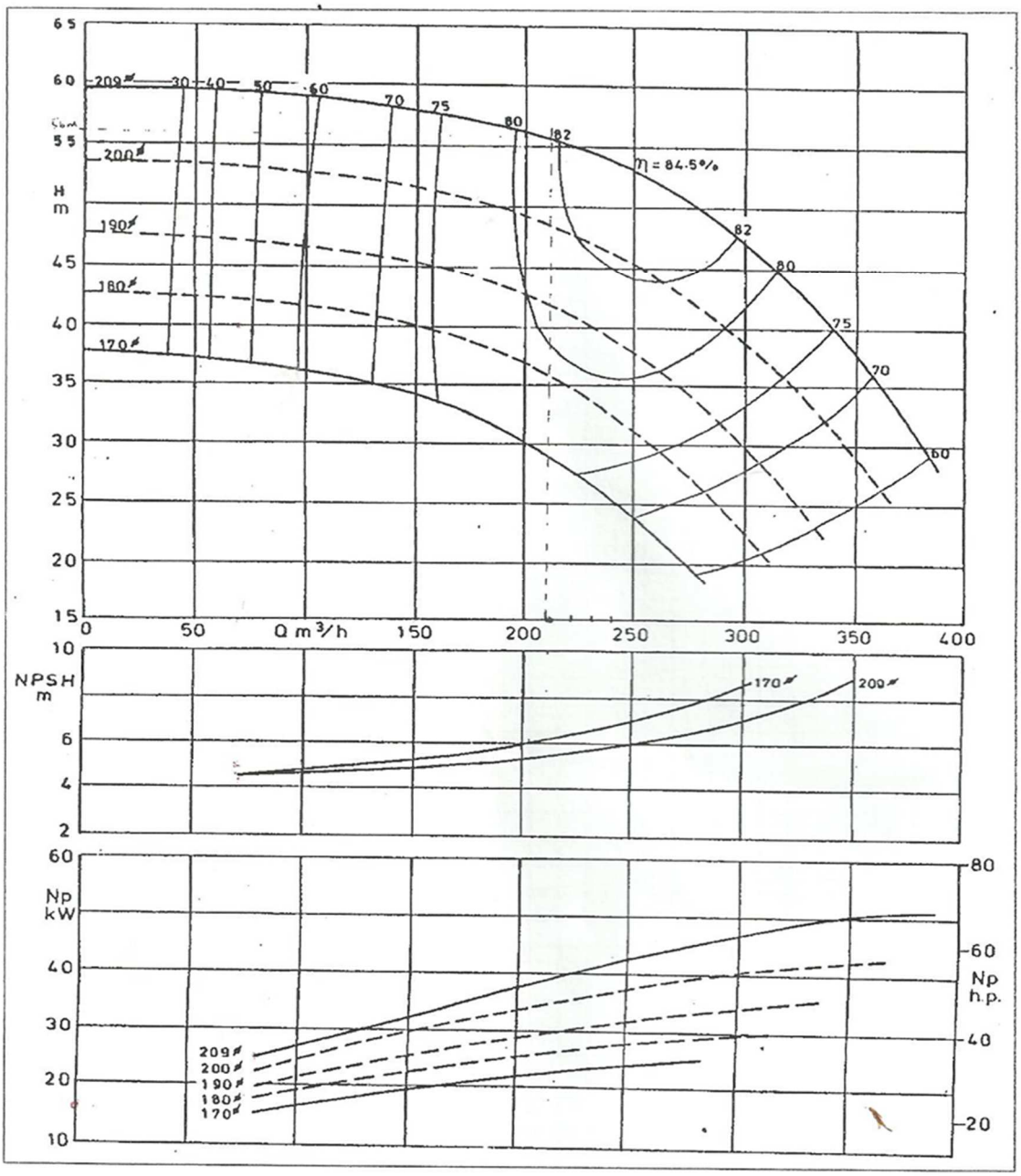
d) Calculate the NPSHA (Net Positive Suction Head Available) for a pump to operate at an elevation of 2000 m, under 35°C temperature. The friction losses in the suction pipe were calculated to be 0.7 m and the suction lift to be 2 m. State whether cavitation will occur if the NPSHR of this pump is 1.2m. (4 marks)


KW
BP
12
8
4
1
Ø209
Ø195
Ø180
Ø160
m
H
60
50
40
30
20
25%
40%
50%
60%
65%
70%
65%
Ø209
Ø195
Ø180
Ø160
m
NPSH
6
4
2
0
0
10
20
30
40
50
60
70
m³/hr
Q

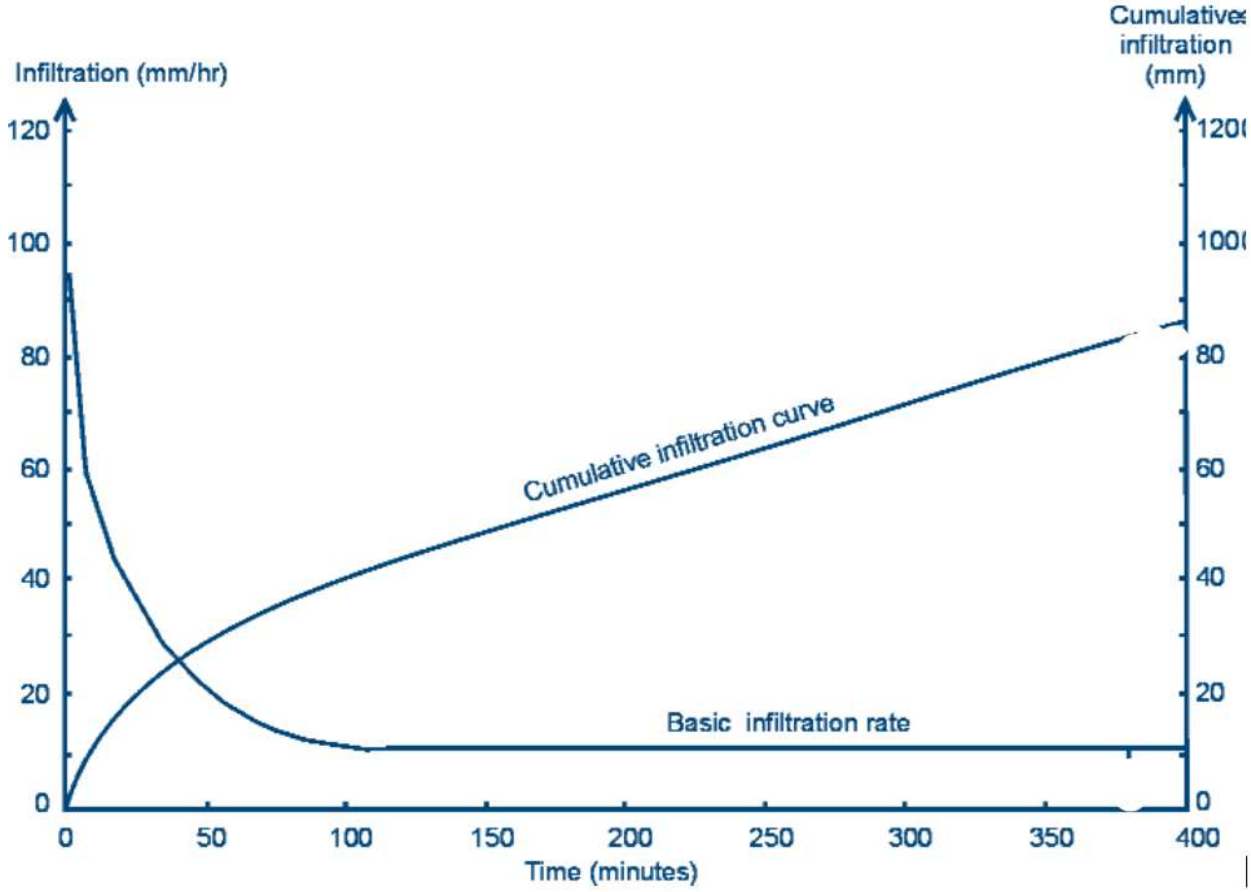
PUMP MODEL A


KW
20
BP
10
0
Ø173
Ø155
Ø140
Ø125
m
50
H
40
30
20
10
0
25%
45%
60%
70%
75%
75%
70%
60%
Ø173
Ø155
Ø140
Ø125
m
8
NPSH
4
0
0
20
40
60
80
100
120
140
m³ / hr
Q

PUMP MODEL B



PUMP MODEL C


Infiltration (mm/hr)
Cumulative infiltration (mm)
120
100
80
60
40
20
0
Cumulative infiltration curve
Basic infiltration rate
0
50
100
150
200
250
300
350
400
Time (minutes)