M.E. (Water Resources & Hydraulic Engineering) Exam. (6 Semester), 2025

(4th Semester)

DESIGN OF WATER RESOURCES SYSTEM

(Paper – X)

Time : Three Hours Full Marks : 100

Answer any ***four*** questions.

1. a) Differentiate between check valve, flow control valve and throttle control valve.

   b) Why are surge tanks used and where? Explain the principle of orifice and differential surge tanks with neat sketches.

   c) A steel pipeline [roughness ε = 0.040 mm] 62 cm diameter and 3250 m long, discharges freely at its lower end under a head of 61 m. What waterhammer pressure would develop if a valve at the outlet were closed in 4 sec? 40 sec?
   Wall thickness is 5 mm for both cases of closure. Compute the stress that would develop in the walls of the pipe near the valve. If the working stress is taken as 1.1×10^8 N/m^2, what would be the minimum time of safe closure?
   Consider bulk modulus of elasticity of water (K) = 2.17×10^9 N/m^2 and Young's modulus of elasticity for the pipe material (E) = 1.9×10^{11} N/m^2. Assume, $\nu = 1.14\times10^{-6}$ m^2/s.

4+9+12=25

2. a) Derive the parameters for best hydraulic sections for a circular channel for both condition (maximum discharge and maximum velocity) in terms of depth of flow for a drainage channel.

   b) "Best hydraulic section might not be always most economical section"-Justify your answer.

   c) Design a lined trapezoidal drainage channel to accommodate a peak flow rate of 20 m^3/s and having a slope of 0.015. The lining of the channel is to be float finished concrete. Consider a section with side slopes of 1.5 H : 1 V. Local regulation requires that the side slope be no greater than 2.5:1 (H:V). A field investigation indicated that the native soil is non-cohesive and has a 50% grain size of 75 mm. Assume permissible shear stress of the bottom of the channel is equal to 39 Pascal. Assume Manning Roughness Co-efficient, n=0.015 and angle of repose 75^0. Also check shear stress at bed and side as per the guidelines.

10+2+13=25

[Turn over

3. a) A manhole is to be placed at a location where the slope of 0.76 m diameter pipe changes from 0.5% to 0.2%. When a sewer is laid for carrying domestic waste water. The design maximum flow rate 1746 m3/hr. The roughness height of pipe (concrete) is 0.1 cm. If the inflow and outflow pipes are located directly opposite each other, determine the minimum drop in the pipe invert that must be provided at the manhole as per the guideline given in CPHEEO Manual, 2013. Assume n = 0.013 and K =0.15.

   b) Find out the intensity vs. duration curve (ID Curve) for 6 months, 1 year and 2 years storm frequency. Analysis of the frequency of storms stated intensities and durations during 30 years for which rainfall data were available for a given town.

Duration in mins	**Intensity (mm/hr)**	**30**	**35**	**40**	**45**	**50**	**60**	**75**	**100**	**125**
		No of storm intensity or more for a period of 30 years								
5						100	40	18	10	2
10				90	72	41	25	10	5	1
15			82	75	45	20	12	5	1	
20		83	62	51	31	10	9	4	2	
30		73	40	22	10	8	4	2		
40		34	16	8	4	2	1			
50		14	8	4	3	1				
60		8	4	2	1					
90		4	2							

15+10=25

4. a) Reservoirs A, B, and C are connected as shown in Figure 1. The water elevations in reservoirs A, B, and C are 100 m, 80 m, and 60 m, respectively. The three pipes connecting the reservoirs meet at the junction J, with pipe AJ being 900 m long, BJ 800 m long, CJ 700 m long, and the diameter of all pipes equal to 850 mm. If all pipes are made of ductile iron and the water temperature is 20∘C, find the flow into or out of each reservoir in cumecs using second trial. Assume f =0.02 (for all pipes)

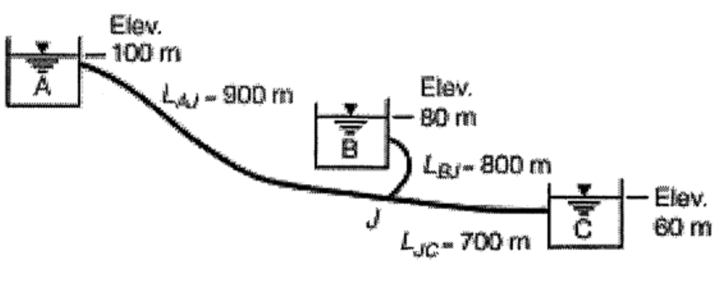


Figure 1

b) Design a suitable hand pump attached arsenic and iron removal plant to cater to the water requirement of a village consisting of 1000 people with a requirement of 10 LPCD. The necessary data are as follows

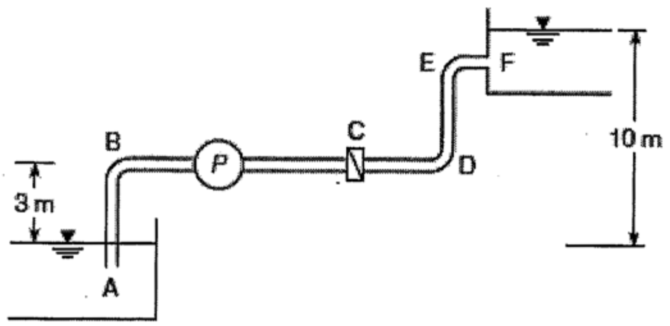
1. Raw water Arsenic concentration: 0.5 mg/l
2. Raw water Iron concentration: 5 mg/l
3. Daily Operational time: 8 hours
4. Treated water Arsenic concentration: 0.01 mg/l (as per IS 10500, 2012)
5. Treated water Iron concentration: 1 mg/l (as per IS 10500, 2012)

Consider a 2-stage water treatment with Oxidation-Coagulation-Filtration, followed by Adsorption (activated alumina).
Assume any data necessary as per the CPHEEO manual.
Provide a suitable schematic diagram of the treatment unit with proper dimensions.

10+15=25

5. a) Water is being pumped from reservoir A to reservoir F through a 30-m long PVC pipe of diameter 150 mm (see Figure). There is an open gate valve located at C; 90° bends (threaded) located at B, D, and E; and the pump performance curve is given by

$h_p = 20 - 4713Q^2$ where h_p is the head added by the pump in meters and Q is the flow rate in m^3/s



The specific speed of the pump is 3000. Assuming that the flow is turbulent (in the smooth, rough, or transition range) and the temperature of the water is 20°C, (a) write the energy equation between the upper and lower reservoirs, accounting for entrance, exit, and local losses between A and F; (b) calculate the flow rate and velocity in the pipe; and (c) use the affinity laws to estimate the pump performance curve when the motor on the pump is changed from 800 rpm to 1600 rpm.

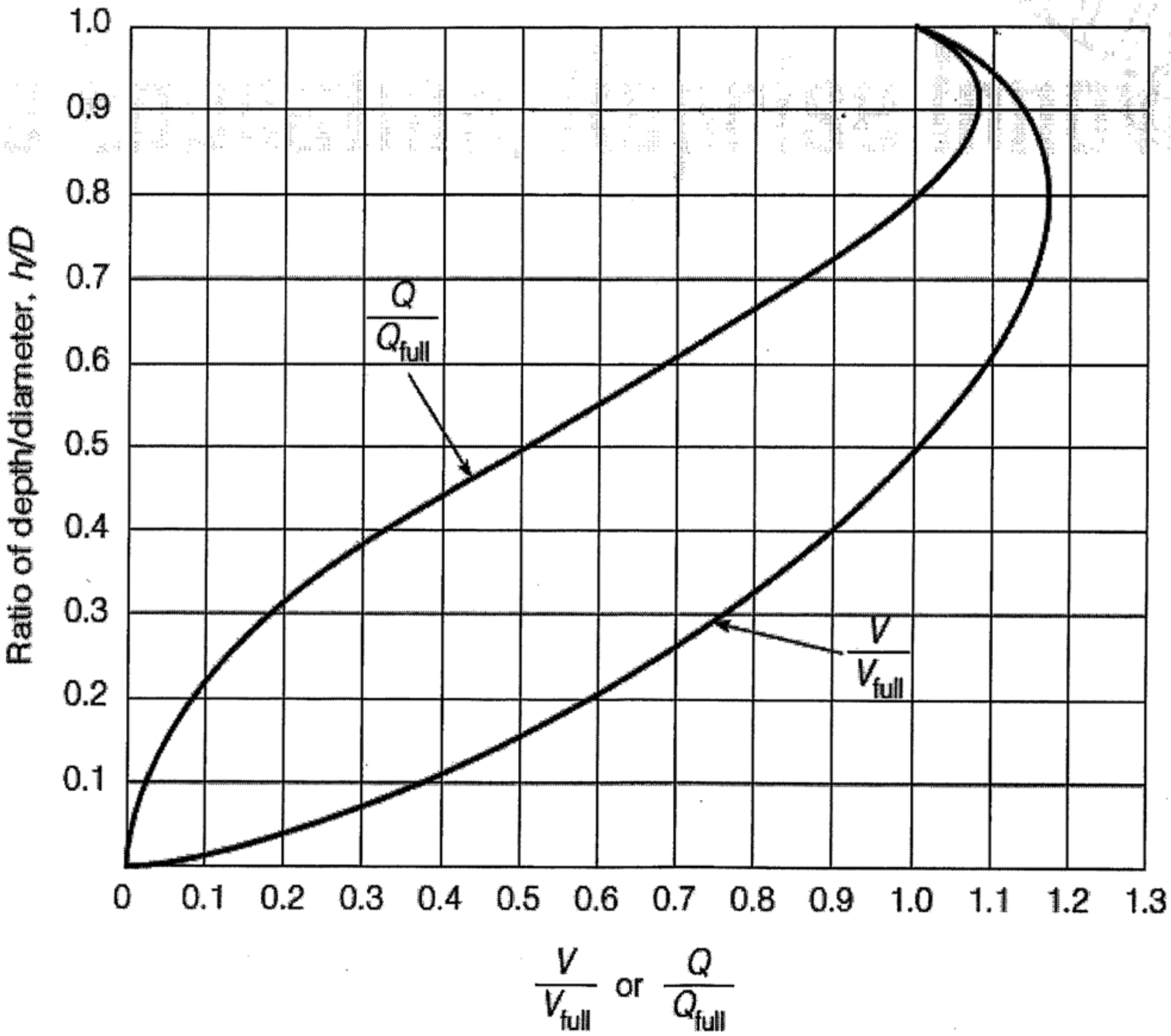
b) The performance curve for a variable-speed pump operating at 600 rpm is given by

$$h_p = 6 - 0.05Q^2$$

where h_p is the head added by the pump in m and Q is the flow rate in m^3/ min. This pump is installed in a system where energy considerations require a system curve given by

$$h_p = 3 + 0.042Q^2$$

Find the flow rate in the system when the pump is operating at 600 rpm and compare this with the flow rate. when the pump is operating at 1200 rpm.



18+7=25

6. a) i) What is specific Speed?
   ii) Find out the expression of specific speed (dimensionless) from the two dimensionless groups of turbo machine.
   iii) What is the expression of specific speed for pump used for industrial use.

   b) What do you mean by NPSH? Express with the help of neat diagram the dependency of different head on NPSH, and the zone of cavitation free operation on the diagram of $(NPSH)_a$ and $(NPSH)_r$

   c) A pump with a 1100 rpm motor has a performance curve of h=15-0.-0.3Q^2 where h is in m and Q is in cubic meter per minute (m^3/min). If the speed of the motor is change to 2200 rpm, estimate the new performance curve. What change will be there in the shutoff head.

7+8+10=25

7. Water is being pumped from reservoir A to reservoir F through a 30-m long PVC pipe of diameter 150 mm (see Figure 3). There is an open gate valve located at C; 90° bends (threaded) located at B, D, and E; and the pump performance curve is given by

$$\mathbf{hp = 20 - 4713Q^2}$$

where hp is the head added by the pump in meters and Q is the flow rate in m3/s. The specific speed of the pump (in U.S. Customary units) is 3000. Assuming that the flow is turbulent (in the smooth, rough, or transition range) and the temperature of the water is 20°C, (a) write the energy equation between the upper and lower reservoirs, accounting for entrance, exit, and local losses between A and F; (b) calculate the flow rate and velocity in the pipe; (c) if the required net positive suction head at the pump operating point is 3.0 m, assess the potential for cavitation in the pump (for this analysis you may assume that the head loss in the pipe is negligible between the intake and the pump); and (d) use the affinity laws to estimate the pump performance curve when the motor on the pump is changed from 800 rpm to 1600 rpm

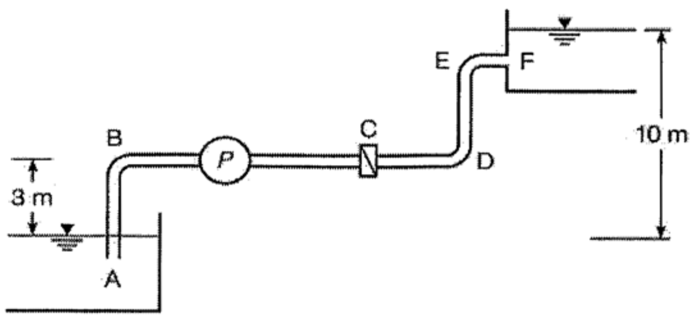


Figure : Water-delivery system

25

8. a) Briefly describe the design procedure of well field design.
   b) An urban housing is to be developed in an unconfined sand aquifer with a transmissivity 1495 m^2/day, saturated thickness of 30 m, and specific yield of 0.2. A service demand of 5000 people is required from the wellfield, and the diameter of each well is to be 20 cm. If the drawdown in the aquifer is not to exceed 3.5 m when the wellfield is operational, develop a proposed layout for the wells. There are no nearby surface-water bodies.

5+20=25

9. a) Briefly describe the working function of collectorwell with diagram.
   b) A radial water collector is to be designed for extraction of 15000 m3/day from the groundwater stored in riverbed which has an aquifer extending up to 13 m below the bed with width limited to actual riverbed itself, which is 600 m wide. Along duration pump test indicates a transmissibility of 3.6 ×106 lpd/m for the saturated thickness of 12 m when the water table is 1 m below the riverbed and storage coefficient of 33 % for the aquifer as confirmed by laboratory tests. The water table goes down by 4.2 m over a period of 250 days during which period the summer rain fall amounts tom40 cm.

5+20=25

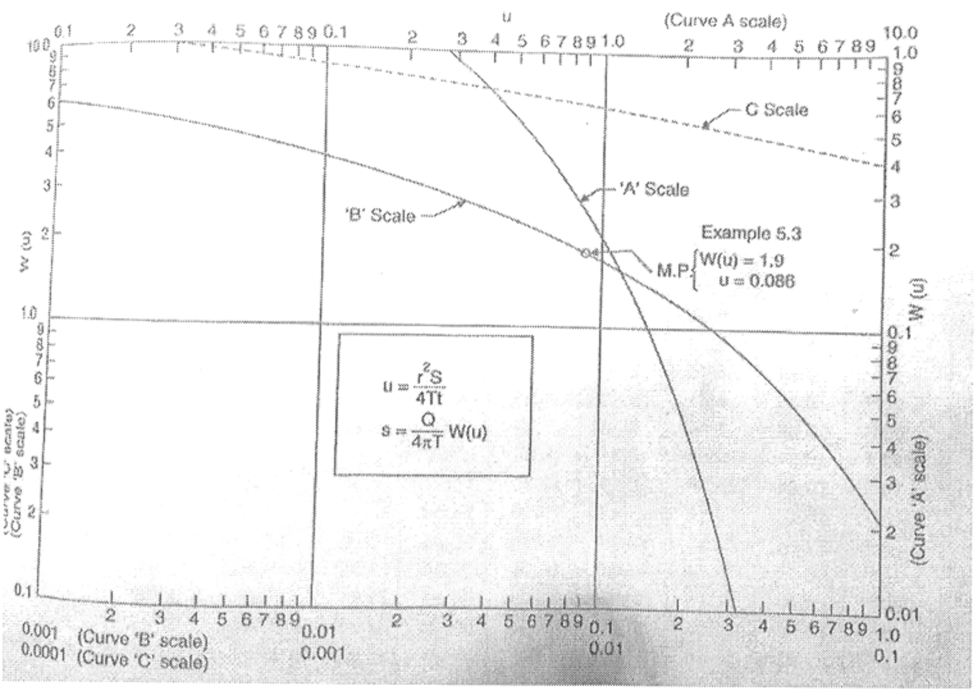


Table 5.1 Values of $W(u)$ for values of u (abridged, after Wenzel, 1942)

u	1.0	2.0	3.0	4.0	5.0	6.0	7.0	8.0	9.0
$\times 1$	0.219	0.049	0.013	0.0038	0.0011	0.00036	0.00012	0.000038	0.000012
$\times 10^{-1}$	1.82	1.22	0.91	0.70	0.56	0.45	0.37	0.31	0.26
$\times 10^{-2}$	4.04	3.35	2.96	2.68	2.47	2.30	2.15	2.03	1.92
$\times 10^{-3}$	6.33	5.64	5.22	4.95	4.73	4.54	4.39	4.26	4.14
$\times 10^{-4}$	8.63	7.94	7.53	7.25	7.02	6.84	6.69	6.55	6.44
$\times 10^{-5}$	10.94	10.24	9.84	9.55	9.33	9.14	8.99	8.86	8.74
$\times 10^{-6}$	13.24	12.55	12.14	11.85	11.63	11.45	11.29	11.16	11.04
$\times 10^{-7}$	15.54	14.85	14.44	14.15	13.93	13.75	13.60	13.46	13.34
$\times 10^{-8}$	17.84	17.15	16.74	16.46	16.23	16.05	15.90	15.76	15.65
$\times 10^{-9}$	20.15	19.45	19.05	18.76	18.54	18.35	18.20	18.07	17.95
$\times 10^{-10}$	22.45	21.76	21.35	21.06	20.84	20.66	20.50	20.37	20.25
$\times 10^{-11}$	24.75	24.06	23.65	23.36	23.14	22.96	22.81	22.67	22.55
$\times 10^{-12}$	27.05	26.36	25.96	25.67	25.44	25.26	25.11	24.97	24.86
$\times 10^{-13}$	29.36	28.66	28.26	27.97	27.75	27.56	27.41	27.28	27.16
$\times 10^{-14}$	31.66	30.97	30.56	30.27	30.05	29.87	29.71	29.58	29.46
$\times 10^{-15}$	33.96	33.27	32.86	32.58	32.35	32.17	32.02	31.88	31.76

Example: For $u = 3.0 \times 10^{-4}$, $W(u) = 7.53$

10. Water is to be pumped out of a well and stored in an above-ground reservoir. The water surface in the well is 3 m below the ground surface, water is to be pumped through a 100m long 50-mm diameter galvanized iron line and exit 19.3 m above the ground, and water is to be delivered to the upper reservoir at a rate of at least 370 L/min when the reservoir is empty. The sum of the local loss coefficients in the system is 1.8. A local pump salesman suggests a pump model with performance curves shown in Figurer 1. Determine if this pump will meet the demands of the project and, if so, the pump size that is required. What is the maximum height that the pump can be placed above ground?

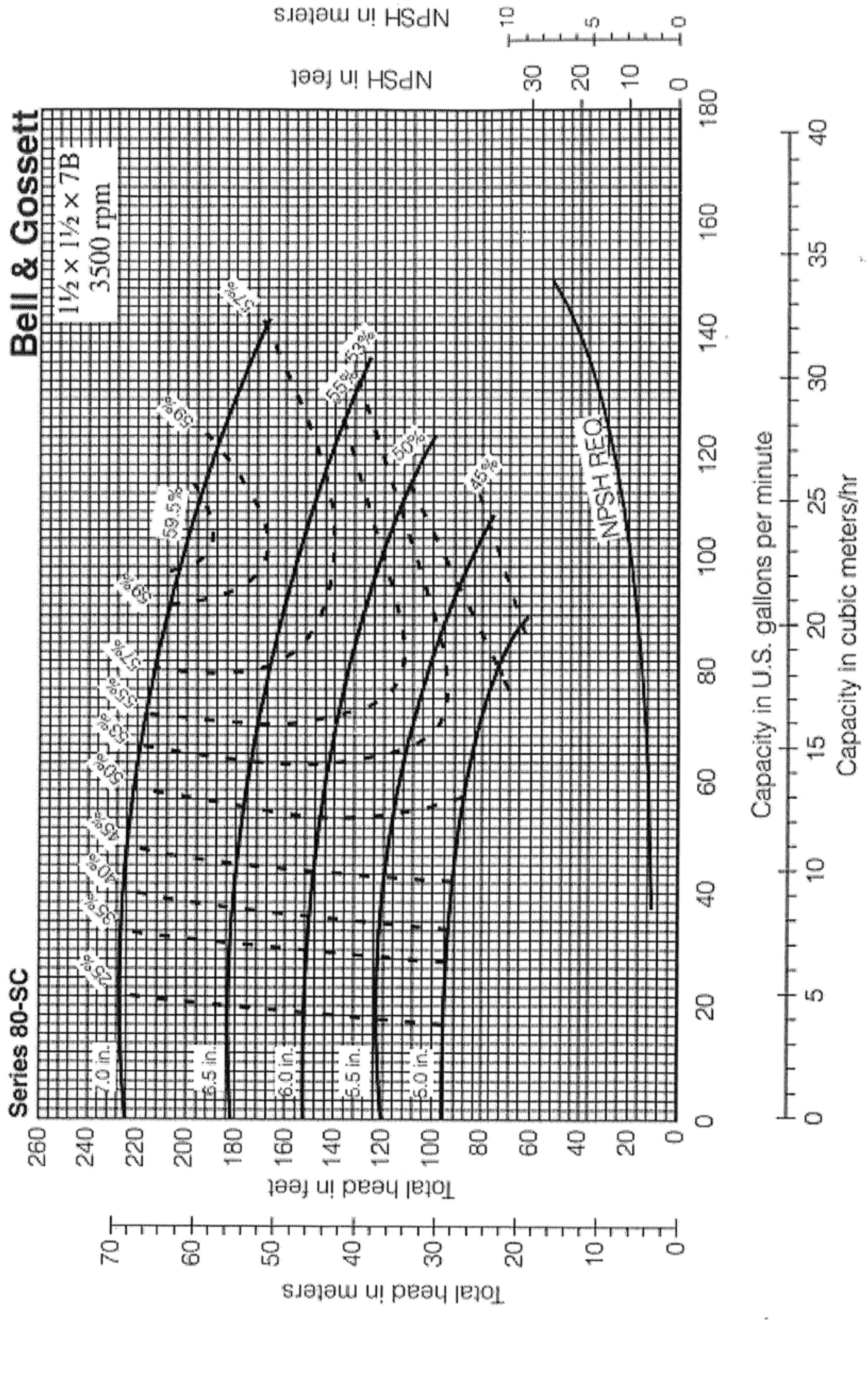


Figure : Pump performance curves